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19 November 1992

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BUREAU OF SOLID -
HAZARDOUS WASTE MANAGEMENT

Work Copy

Ms. Bonnie L. Eleder
U.S. Environmental Protection Agency
Remedial Project Manager
HSRW-6J
77 W. Jackson Blvd.
Chicago, Illinois 60604-3590

Re: Revised Pages - Test Plan - Phase I Treatability
Study of Soil Washing Treatment Technology
Moss-American Site
Milwaukee, Wisconsin

Dear Ms. Eleder:

Roy F. Weston, Inc. (WESTON®) on behalf of the settling defendant, Kerr-McGee Chemical Corp. (KMCC), is hereby transmitting highlighted revised pages of the above-referenced Test Plan for U.S. EPA review and approval.

These revised pages have been prepared in response to U.S. EPA review comments dated 9 September 1992 and are consistent with the point-by-point responses transmitted by WESTON on 3 November 1992, and discussed in our group meeting on 5 December 1992.

KMCC, WESTON, and Bergmann USA look forward to U.S. EPA's approval of these revisions, as we are ready to initiate the treatability testing program. Following U.S. EPA approval of these revisions, we will transmit the final Test Plan document, in full. Please feel free to contact the undersigned should you have further comments or questions on this transmittal.

Very truly yours,

ROY F. WESTON, INC.

Gary J. Deigan
Senior Project Manager

Kurt S. Stimpson
Project Director

GJD:KSS:slr
Enclosure

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Bergmann will provide all services necessary to plan, implement, analyze and report the results of treatability testing of the soil washing treatment process. The intent of testing is to determine the ability of such processes to treat creosote-contaminated soils from the Moss-American site. The polycyclic aromatic hydrocarbon (PAH) components of creosote and carcinogenic polycyclic aromatic hydrocarbons (CPAH) are the site contaminants of concern. According to the RI, the maximum PAH concentration is 32,000 milligrams per kilogram (mg/kg); BTX concentrations range up to 17 mg/kg. The average CPAH concentrations are 300 to 400 mg/kg. According to the RI, maximum CPAH concentrations are approximately 1,900 mg/kg. The SOW requires treatment of contaminated site soils and sediments to 6.1 mg/kg of total CPAHs.

Bergmann BV (Holland) is the world's leading company in the field of soils and sediment washing technology, having designed and fabricated 18 full-scale, commercial installations ranging in size from 5 to 350 TPH. Bergmann USA has been established as the soils/sediment washing and volumetric reduction technology center for all North American projects and has provided two 10 TPH transportable systems, a 250 kg/day mobile pilot plant for radioactive applications and is fabricating a new 10 TPH soils washing plant for a lead battery Superfund Site remedial project. Our staff includes internationally recognized specialists in the field.

Bergmann USA was invited to present an overview on river and harbor sediment treatment technology to the joint U.S. EPA and Army Corps of Engineers' ARCS (Assessment and Remediation of Contaminated Sediments) Workgroup in March 1991. A great deal of interest has been generated by our presentation, and we were contracted by Jim Galloway, ACOE - Detroit for Pilot Sediment Washing Demonstration on the Saginaw River Project. We performed an in-house, bench-scale treatability evaluation which was followed by the design and fabrication of a 5-10 TPH pilot-scale Bergmann USA field demonstration sediment washing plant to effectively separate contaminated fines from coarse fractions of river dredge sediments.

This plant was placed into operation in October 1991 a mile and a half off shore aboard a 120 ft by 33 ft Army Corps of Engineers dredge support barge. Preliminary results indicate a reduction of 91% of the initial PCB concentration with only 2 mg/kg of PCBs remaining in the "clean" coarse +44 micron (325 mesh) fraction. The -44 micron fines were enriched to a level of 14 mg/kg PCBs, and the humic fraction (leaves, twigs, roots, grasses, etc.) contained 24 mg/kg of PCBs. These materials are scheduled for a biodegradation during the summer of 1992.

Working with Jack Hubbard of the EPA Hazardous Waste Engineering Research Laboratory in Cincinnati, this Bergmann USA system was evaluated by the Superfund Innovative Technology Evaluation (SITE) Program in May/June 1992. Preliminary analytical test results are available followed by the EPA-SITE Applications Analysis Report in November 1992 and the Technology Evaluation Report in February 1993.

Bergmann USA was contracted with the Toronto Harbor Commission in the operation of a 5-10 TPH pilot-scale soils washing system for the demonstration of volumetric remedial operations coupled with an innovative metal extraction and biodegradation technologies for the treatment of the -63 micron fines fractions.

With the receipt of permits from the Ontario Ministry on the Environment, the demonstration commenced the first week of January 1992 concluding the initial Phase I operations in September. John Martin of EPA Superfund Innovative Technology Evaluation (SITE) coordinated the evaluation of the Bergmann plant at the Toronto project location during April.

Based upon the results of this demonstration project, it is anticipated that a full-scale plant would then be designed for installation for a three year, 85 TPH (300,000 tons per year) remedial project of the Toronto harbor front area. Environment Canada contracted to have the Bergmann plant process 500 tons of contaminated Toronto harbor sediment, and the Canadian Ministry of Defense had the Bergmann plant process lead contaminated material shipped in from Montreal from the Longue Pointe Garrison Site. The 10 TPH pilot-plant is currently available from the Toronto project.

SECTION 3

TEST OBJECTIVES

The test objective of the Phase I laboratory-scale treatability test program is to demonstrate the ability of the aqueous soil washing process to produce a clean sand product that will pass the currently established "clean-up criterion" for the excavated site materials of 6.1 mg/kg of the carcinogenic polycyclic aromatic hydrocarbon (CPAHs) fraction. Feasibility will be determined on the basis of both achievement of the cleanup criterion and an evaluation of overall removal/treatment efficacy.

This testing will emphasize the aqueous, size classification soil washing process ~~(without added chemical reagents/surfactants)~~. Initial screening evaluation of selected reagents will be included. The need for chemical reagents/surfactants to achieve contaminant separation may negatively affect feasibility and implementability of the soil washing option. Phase I testing will provide an assessment of whether purely aqueous soil washing will provide adequate separation.

The initial objective of the Phase I bench-scale treatability evaluation is to demonstrate that soils washing will produce a clean sand/gravel product that will pass the established "clean-up criterion" for the Moss-American contaminated site materials of 6.1 mg/kg of the carcinogenic PAH (CPAH) fraction. The performance is to be based upon both the achievement of the cleanup standard and the overall removal/treatment efficacy.

Soils/sediment washing is an aqueous-based process for scrubbing contaminated soils and sediments in order to provide volumetric reduction and waste minimization and feedstock preparation of enriched contaminated fine (clay, silt, and colloidal) fractions for subsequent treatment, immobilization, or regulated disposal. Clean, coarse (+63 micron) material is returned to the site as a backfill material. Soils washing is generally not a stand-alone technology and, therefore, is used in conjunction with a subsequent "fines" treatment system by providing an enriched contaminated fines material which has been screened to remove difficult-to-process oversized fractions, along with a feedstock which has been homogenized with respect to contaminant concentration levels.

The quantities of products and residual materials generated by a soils washing plant will vary directly in proportion to the grain-size distribution of primary feed material to be processed. The quantities of these streams can be estimated by rapid bench-scale wet sieve analysis and elutriation (upflow classification) for organic vegetative quantification.

Contaminated clay fines and sludges resulting from the process may require further treatment using any one, or a combination of treatment technologies.

Dependent upon site-specific soils conditions, the majority of contaminated feed material requires removal of the organic vegetative material utilizing specific gravity separation. This material, although a relatively small amount of the mass of contaminated feed material, will typically partition the greatest quantity of contaminants due to this material's very porous nature and carbon-based adsorptive characteristics.

Specific findings/data that are anticipated to be determined during this treatability study include:

- Particle Size Distribution for Site Soils.
- Identification of Process for Contaminant Removal.
- Contaminant Removal Efficiency.
- Pilot/Full Scale Plant Process Flow Diagrams.
- Identification of Unit Process Modules & Operational Sequences.
- Full-Scale Operational System Mass Balance Calculations.

Their findings/data will be presented in a Technical Memorandum (TM). This TM will be transmitted to U.S. EPA and WDNR for review and comment. Section 12 shows the anticipated schedule for the TM transmittal.

SECTION 4

EXPERIMENTAL DESIGN AND PROCEDURES

4.1 SAMPLE PROCUREMENT AND INITIAL CHARACTERIZATION (BY WESTON)

The test material employed in the soil washing studies will be collected from the Moss-American site. Two representative, composite samples will be collected, with one composite soil sample containing carcinogenic polycyclic aromatic hydrocarbons (CPAH) in the range of 300 to 600 milligrams per kilogram (mg/kg) and one sample containing CPAH in the range of 1,000 to 1,500 mg/kg. Initial characterization of the samples will be conducted immediately following sample collection. Test parameters will include bulk density, particle size distribution, porosity, moisture, liquid/plastic limits, pH, total organic carbon (TOC), and total (heterotrophic) microbial population level and specific polycyclic aromatic hydrocarbons (PAH)-degrading microbial population~~s~~ level. A detailed description of WESTON's Protocol for Collection and Characterization of Treatability Study Test Matrix can be found in Appendix A. WESTON will conduct an initial ~~single combined~~ sampling and analysis ~~for~~ to physically and chemically characterize the bioslurry and soil washing test matrix. Appendix D of this Test Plan presents the initial characterization data. This initial characterization is intended to provide preliminary data on the characteristics of the test matrix, and to verify that it contains appropriate levels of the target compounds. These data are not intended to provide pretesting (T=O) analyses for purposes of performance evaluation for the soil wash process. The soil washing test protocol presented in Section 4.2 includes all necessary pretesting (T=O) characterization.

The two composite soil samples, collected and characterized by WESTON, will be shipped to Bergmann's testing laboratory ~~via a licensed commercial carrier~~ in accordance with sample custody tracking protocols approved by WDNR. Approximately 110 pounds of each sample composite will be shipped to the laboratory to conduct the soil washing treatability testing. Appropriate shipping documentation will accompany the sample shipment from the

Moss-American site to the Bergmann USA testing laboratory in ~~Stafford Springs, Connecticut~~ Gallatin, Tennessee.

4.2 CHARACTERIZATION AND SOIL WASHING TESTS

The following protocol will be followed by Bergmann for each of the two soil sample composites.

Table 4-1 presents the ~~anticipated~~ physical/chemical analysis ~~of the soil~~ to be conducted by Bergmann on the as-received site soil samples. The soils will be characterized to determine the size range of the soil components and the distribution of PAH contamination. This characterization will serve as the T=O analysis of the site soils prior to initiating the soil wash treatability tests. Figure 4-1 provides a schematic diagram showing the characterization process. Each sample will be homogenized by blending, and a sample will be split out for feed soil ~~assay~~ sieve analysis. The remaining material will be screened at 1/4 inch; the undersize material will be sampled for ~~screen~~ sieve analysis, and the remaining material will be advanced to the treatment program. The selection of 1/4 inch as a separation size break of material not to advance to the attrition scrubbing portion of the soils washing treatability is based upon standard practice of full-scale commercial soils washing plants. Material greater than 1/4 inch will not effectively transfer or flow through the attrition scrubbing circuit. Full-scale commercial soils washing plants typically utilize a grizzly screen to scalp (remove) oversized (+1/4 inch) debris material fractions. Although these fractions generally do not amount to a significant portion of the contaminated feed material, the weights of these oversized fractions can be separately recorded and recombined in order to provide a good mass balance on material treated.

Figure 4-2 illustrates the test procedure to be used on the minus 1/4 inch soils. Tests will be run on soil samples from two locations, resulting in a total of 20 tests. The soils will be screened at 200 mesh to produce a coarse and fine fraction. This "break" or size split at 200 mesh (74 micron) represents the typical minimum performance level of Bergmann's full-

Table 4-1

Physical/Chemical Analyses Plan
for Bergmann's T=O Characterization

Test Parameter	Analytical Method
Soil Grain Size Analyses	ASTM D4749-87 Standard Method for Performing Wet Sieve Analyses
pH analyses of both residual and filtrate fractions	EPA Method 9040
Polycyclic aromatic hydrocarbons (PAHs) analyses of both residual and filtrate fractions	EPA Method 8310
Benzene-toluene-xylene (BTX) analyses of both residual and filtrate fractions	EPA Method 8020
Oil and grease analyses of both residual and filtrate fractions	EPA Method 9071
Moisture analyses of residual fractions	ASTM D2216

scale (± 15 TPH) commercial soils washing plants. Tests will be run on the coarse fraction using ~~chemical formulations~~ additives supplied by Bergmann USA. Each ~~chemical formulation~~ additive will be designed to remove the PAH compounds from the coarse sand fraction of the soil so that the clean product sand will pass the clean-up criterion concentration of 6.1 mg/kg of the CPAH fraction. The soils washing additives for the Moss-American Phase I study are biodegradable surfactants. Two surfactant groups have been selected: a citrus based surfactant and a dodacyl sulfate surfactant. Each has been successfully utilized in conjunction with bioslurry treatment of fine materials with no deleterious effects to the biomass. Concentrations of the surfactants are varied from a low concentration of 2#/ton (.01%) to a high of 4#/ton (.02%).

The fines fraction will be filtered to produce a filter cake. This cake will be returned to WESTON for storage at the Moss-American site pending potential future treatment tests which may be undertaken if the washing tests are successful. Prior to any future tests being conducted, the suitability of this stored sample will be evaluated.

Step 1.0 Characterization

The soil characterization process is shown schematically in Figure 4-1. Sampling and analytical requirements are detailed in Table 4-2.

Step 1.1: Blend and split ("cone & quarter") a sample of feed soil for analysis.

Step 1.2: Dry ~~screen~~ sieve the remaining material to remove 1/4-inch top size material. Weigh the +1/4 inch oversize, and the -1/4 inch undersize.

Step 1.3: Cone and quarter the minus 1/4-inch undersize material. Blend two opposing quarters, and cone and quarter again. Repeat this procedure to generate sufficient sample for wet screening and chemical analysis.

Table 4-2

Soil Characterization Analytical Requirements
(After Initial Sample Sieving)

Material	Weight/Volume	Sample A	Sample B	Duplicates
Feed Soil	Dry Weight			
Dry Screening				
-1/4 Inch	Dry Weight	1	1	0
+1/4 Inch	Dry Weight	1	1	0
Wet Screen Analysis (-1/4 Inch Soils)				
Size Fraction:				
+10 Mesh	Dry Weight	1	1	0
+50 Mesh	Dry Weight	1	1	0
+100 Mesh	Dry Weight	1	1	0
+200 Mesh	Dry Weight	1	1	0
+325 Mesh	Dry Weight	1	1	0
-325 Mesh	Dry Weight	1	1	0
TOTALS		8	8	0

* ASTM D4749-87 - Standard Method for Performing Wet Sieve Analysis.

Step 1.4: If clay lumps form during dry screening, subject fractions to ultrasonic bath until lumps are broken up. The application of ultrasonic disruption to break up clay lumps during the bench-scale evaluations is intended to act as a substitute for either a full-scale "log washer" or rotary trommel screen. These two pieces of equipment are utilized to deagglomerate clayey materials in full-scale plants.

Step 2.0 Soil Washing Tests

The soil washing process is shown schematically in Figure 4-2. Sampling and analytical requirements are detailed in Table 4-3.

Step 2.1: Sample the feed soil and analyze as shown in Table 4-3.

Step 2.2: Wet ~~screen~~ sieve the 1/4-inch material at 200 mesh to remove the fine fraction. Filter the -200 mesh slurry for sampling and analyses according to Table 4-3.

Step 2.3: Blend and split the +200 mesh fraction into 10 samples of approximately equal weight. The samples will be tested according to the test program presented in Table 4-3.

Step 2.3.1: Mix the samples with water and/or reagents to a pulp density of 75 percent solids.

Step 2.3.2: Attrition scrub for 15 minutes. Attrition Scrubbing is a high energy unit process operation which contacts -1/4 inch contaminated material with chemical wash additives to effectively solubilize appropriate contaminants and to "deslime" or mobilize the highly contaminated fines [<63 micron (230 mesh)] material. The attrition cells function at a 75-80% solids content. This technology has been cost effectively applied in mineral and ore enrichment operations for nearly 100 years (see attached process description).

Step 2.3.3: Wet screen the pulp at 200 mesh. Measure the weight (wet and dry) of the +200 mesh clean sand product. Blend the wash water with -200 mesh fines fraction.

Step 2.3.4: Filter the -200 mesh fines to form a filter cake for analyses. Record weights and volumes.

Table 4-3

Soil Washing Treatability Test Analytical Requirements

Test	Weight/ Volume	Moisture	Analyses			Duplicates		
			PAH	O&G	BTEX	PAH	O&G	BTEX
Feed[a]								
Soil to Test Program Solids	Dry Weight	2	2	2	2	--	--	--
Reject[a]								
-200 Mesh Screened Solids	Dry Weight	2	2	2	2	--	--	--
Filtrate	Volume	2	2	2	2	--	--	--
Test Program Products[b]								
Sands	Dry Weight	~~30~~ 10	~~30~~ 10	~~30~~ 10	~~30~~ 10	3	3	3
Fines	Dry Weight	~~30~~ 10	~~30~~ 10	~~30~~ 10	~~30~~ 10	3	3	3
Filtrate	Volume		~~30~~ 10	~~30~~ 10	~~30~~ 10	3	3	3
TOTALS		~~66~~ 26	~~96~~ 36	~~96~~ 36	~~96~~ 36	9	9	9

[a] - Tests and analyses run on two samples, A and B.

[b] - Test Program:

Test #1 - Water only, two attrition scrubs. Assay sand fraction of second scrub.
Test #2 - Citrikleen type surfactant, high concentration.
Test #3 - Citrikleen type surfactant, low concentration.
Test #4 - Dodacyl sulfate surfactant, high concentration.
Test #5 - Dodacyl sulfate surfactant, low concentration.

SECTION 5

PHASE I BENCH-SCALE SCREENING EQUIPMENT

Each contaminated site offers specific and unique characteristics for that location. The quantification and qualification of contaminants of interest, and their inter-relationship with the specific mineralogy of the soil require each new site to be evaluated individually for the optimum combination of washwater additives necessary to solubilize, mobilize, precipitate, or complex the organic and/or inorganic chemical constituents in site soils.

The Phase I Treatability Study for the Moss-American Site will utilize the following bench/pilot scale equipment which simulates the principal unit process operations of full-scale modular systems of Bergmann's commercial-scale (+15 TPH) transportable plants:

1. <u>Precision Sample Splitter</u> for mixing and accurately dividing granular material.
2. <u>Vibratory Scalping Screen</u> for removal of +1/4" material fraction.
3. <u>Frietsch Wet Sieve Stack and Vibratory Table</u> for wet sieving of sample material.
4. <u>Elutriation Separation Column</u> for specific gravity separation of contaminated organic materials (i.e., decayed leaves, twigs, wood, roots, etc.).
5. <u>Sedimentation/flocculation cells</u> for separation and concentration of suspended clay, silt and colloidal material.
6. <u>Fines Dewatering Pressure Filter</u> for concentration of clay, silt and colloidal materials for subsequent treatment technologies.

Of the current commercial-scale soils washing plant in operation today, both in Europe and North America, the standard unit process operations fall into one of the following categories:

1. Debris Scalping (Grizzly Screens).
2. Tramp Metal Separation.
3. Screen Separation of Oversized (3/8 to 2 inches) Fractions/Rotary Trommels.

4. Oil & Grease Separation - free product removal and oil/water separation.
5. Cyclone Separation - flash solids/liquids separation.
6. Attrition Scrubbing for desliming (clay fine separation) operation.
7. Froth Flotation for specific contamination separation.
8. Screening/dewatering of coarse sand products.
9. Dense media separation of organic vegetative materials.
10. Washwater flocculation/sedimentation for reuse.
11. Sludge densification/thickening for subsequent treatment/dewatering.
12. Dissolved air flotation for removal of dissolved inorganic metal hydroxides.
13. Sludge dewatering/filter cake production for subsequent fines treatment/disposal.

Variations in technology applications or equipment configurations include:

1. Low-frequency vibration unit for clay fines deagglomeration.
2. Screw auger washers.
3. High pressure water knives/blade washer.
4. Counter-current chemical extraction.
5. Sand filtration of washwater.
6. Ion-exchange treatment of wastewater.
7. Activated carbon adsorption of washwater and volatile air emissions.
8. Tabling/jigging for dense coarse soil fraction separation.
9. Spiral concentrators for dense and light soil fractions separation.
10. Ultrafiltration and reverse osmosis of washwater.
11. Crushing/sizing of coarse oversized fractions.

The primary Phase I Bench-Scale soils washing treatability study equipment will include, but not be limited to:

1. Universal Sample Splitter, Precision Sample Splitter Model SP-326.
2. Dry Sieve Vibrator for Debris Scalping, Gilson Model SS-23, or Gilson Lab Scalping Screen Model TS-10.
3. Vibratory Screen/Sieve Stack & Shaker, Frietsch Vibratory Wet Sieve System.
4. Attrition Scrubber Unit, Bergmann 3 kg Attrition Scrubbing Unit, Denver 1 kg Attrition Scrubbing Cell.
5. Elutriation Separation Column, Gilson Elutriation Sieve Model SV-48.
6. Sedimentation/Flocculation Cells, 6-Cell Illuminated Gang Stirrer/ Flocculator.
7. Fines Dewatering Filter, Hazen 12" Diameter Pressure Filter Assembly.

Additional information provided by Bergmann USA is included as appendix material of this Test Plan.

SECTION 6

SAMPLING AND ANALYSIS

Sampling and analysis during the soil washing treatability testing will be conducted by Lancaster Laboratories, Inc. of Lancaster, Pennsylvania. Lancaster Laboratories, Inc. will work as a lower tier subcontractor to Bergmann. The laboratory quality assurance plan and analytical method Standard Operating Procedures (SOPs) are presented in Appendix B of this test plan. Tables 4-1, 4-2, and 4-3 in Section 4 define the analytical methods of the test program. Lancaster Laboratories, Inc. is in the EPA CLP program.

SECTION 7

DATA MANAGEMENT

All data regarding these bench scale studies will be recorded on a standard laboratory data sheet, and placed in the appropriate file. A chain-of-custody document will accompany all samples being released to Lancaster Laboratories. Appendix B presents Lancaster Laboratories quality assurance plan (QAPP) which also addresses data management/data reporting procedures. QA/QC objectives for data are presented in Section 5 of the QAPP. Internal quality control checks are presented in Section 11 of the QAPP. Matrix spike and matrix spike duplicates are run by Lancaster Laboratories on each batch of 20 samples analyzed, with samples chosen at random. Acceptance criteria are presented in Section 11 of the QAPP.

SECTION 8

DATA ANALYSIS AND INTERPRETATION

The results of this test program will be used to assess the feasibility and applicability of soil washing as an adjunct to the bioslurry treatment process for the Moss-American Site. The need for extreme operating conditions with respect to equipment and materials (such as chemicals) in order to achieve satisfactory performance will indicate that the soil washing process is not feasible or implementable for this application.

If a positive determination with respect to feasibility is made, the data obtained from these bench scale treatability studies can be used to proceed with the preliminary design of a pilot test and/or of a full scale (±15 TPH) plant. The primary use of these data will be to identify the necessary unit process operations and their optimization required to meet the clean-up criterion and match these operations to both the mass flow rates and desired particle size separations.

Determination of the soil particle size distribution as a first order of business will allow for evaluation as to whether soils washing as a volumetric reduction/waste minimization step is economically practical. For example, should the contaminated soil contain a large amount of material finer than 74 microns (i.e., 40% or more) then soils washing may not provide significant volume reduction to support associated costs. If however the size distribution appears appropriate, then the treatability tests can proceed with washing and attrition test work. On the basis of the initial site sample characterization data prepared by WESTON (see Appendix D), the sample grain size distribution appears suitable for evaluating the soil wash process as described in this Test Plan.

The washing and attrition studies will allow identification of the following:

- Required unit operations (for soils washing and washwater treatment).
- Sequence of unit operations.
- Residence times.

- Reagents.
- Materials of construction.

Utilizing this information along with the particle size distribution will allow the preliminary design of a process flowsheet along with the mass balances. Computer programs, which have been developed by Bergmann and their sister company, Linatex, are used to simulate the performance of the various equipment employed in a full-scale plant operation. These design programs generate mass balances throughout the equipment configuration as well as track attributes of the size fractions (i.e., concentration of contaminant by size fractions). A typical computer-generated process mass balance, based upon Bergmann's SITE Program PCB sediment washing plant is presented in Figure 8-1. The four box figures within the diagram present process rate (tons/hour), relative density of the slurry, percent solids in the slurry, and flow rate in gallons per minute. This information is critical in selection, operation, and performance demonstration for each sub-unit assembly. Simulation or modeling programs involving separations are based on classification or partition curves which can generally be represented by a logistic function. The shape and position of these curves are modified by the programs to simulate performance for both process conditions encountered and various equipment configurations.

Saginaw Bay Demonstration -- Counter Current Operation

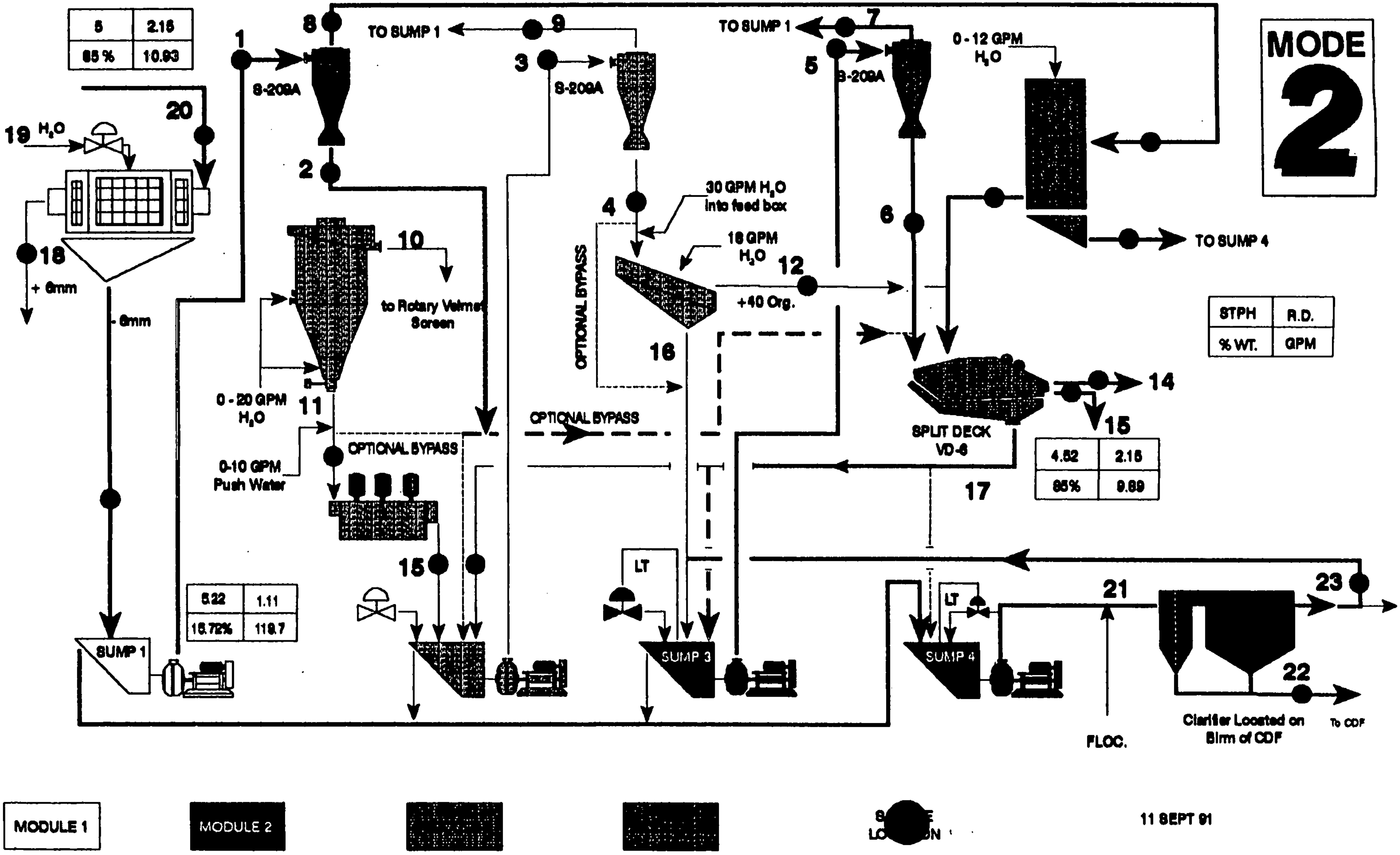


FIGURE 8-1

contains with an appropriate hazard warning. ~~Questions on the proper disposal method should be directed to the appropriate project personnel~~. Following the completion of Bergmann's Bench-scale evaluation, all unused sample, residuals, spent wash solutions, and laboratory generated debris [personal protective equipment (PPE)] will be returned to the Moss-American site and staged in containers with other RI and Predesign wastes.

SECTION 10

RESIDUALS MANAGEMENT

Following completion of treatability testing, all test residuals will be properly packaged and labeled and returned to the Moss-American site for storage with other predesign activity residuals. ~~pending final disposal~~.

The shipment of all wastes and treatment residuals will be done in compliance with applicable Department of Transportation (DOT) regulations. Chain-of-custody documentation will be utilized to monitor the transfer of treatability samples to and from the Moss-American Site.

APPENDIX A

PROTOCOL FOR COLLECTION AND CHARACTERIZATION OF TREATABILITY STUDY TEST MATRIX

PROTOCOL FOR COLLECTION AND CHARACTERIZATION OF TREATABILITY STUDY TEST MATRIX

Soil samples for the Phase I laboratory-scale treatability study will be collected from the Moss-American site. One sampling event will be conducted. Sufficient quantities of soils for all planned Phase I bioslurry and soil washing treatability tests will be obtained during this sampling event and placed into drums for transport, and/or intermediate storage at the site awaiting transport to the testing laboratories.

SAMPLING OBJECTIVE

The objective of this sampling event is to collect sufficient quantities of CPAH-contaminated soils from the site to conduct the planned Phase I treatability studies on the bioslurry and soil washing technologies. These soil portions will be characterized (initially by WESTON and again by the treatability study lab) prior to treatability testing, for parameters which are important in the treatability study program. Analytical data from this characterization will be used to support analyses and interpretation of treatability study results.

SOIL SAMPLE (TEST MATRIX) REQUIREMENTS

Two soil composites will be collected from the site. One composite is intended to provide soils exhibiting "average" CPAH concentrations in the range of 300-600 mg/kg. The second composite is intended to provide "high" CPAH concentrations in the range of 1,000-1,500 mg/kg. [Refer to findings of test matrix characterization in Appendix D] The selection of soil sampling locations to meet these criteria will be based upon existing RI/FS site characterization data and other predesign activities as these data may become available. The areas from which these samples will be taken include the former processing area and the former treated storage areas of the Moss-American site.

Due to possible RCRA restrictions on storage of soil quantities at the treatability test facility, soil quantities in excess of the permitted amount will be stored in tarp-covered drums and staged on the Moss-American site pending transport to the designated testing facilities.

SOIL SAMPLING PROCEDURE

The area selected for site sampling will be marked with pin flags by the field sampling team. Within this area, the required volume of soil will be excavated using hand tools. The excavated soils will be placed temporarily on plastic sheeting located adjacent to the excavated area. Large debris, rocks, and turf will be manually separated from the soils. The excavated soils will be manually mixed using ~~hand tools~~ a tilling machine to provide a relatively homogeneous mixture. Following mixing, the soils will be placed into drums and sample containers as appropriate, sealed, labeled, and moved to the temporary staging area while awaiting shipment. Large debris, rocks, and turf will be returned to the excavation. Additional borrow soil will be used as necessary to fill the excavated area. The "average" concentration soil composite will be collected first and the "high" concentration composite collected second in a similar manner.

Equipment and personnel decontamination procedures presented in the Interim Health and Safety Plan and the Predesign Phase Quality Assurance Project Plan will be followed.

SOIL SAMPLE (TEST MATRIX) CHARACTERIZATION

Soil composites collected from the site will be characterized in order to evaluate properties or conditions that may affect or determine the results of the treatability test. Properties or conditions that will be considered include the following:

- CPAH concentration, which could affect treatability performance and the statistical interpretation of treatability test results.
- Physical/chemical properties, such as particle size distribution, organic carbon content and the presence of other contaminants, that may interfere with the treatment processes.

Table 2

Initial Characterization Test Matrix

Parameter	Laboratory[1]	Average Soils	"High" Soils	Total
Microbial Enumeration	FE	1	1	2
Particle Size Distribution	ETL	1	1	2
Porosity (Bulk Density/Specific Gravity)	ETL	1	2	2
Moisture Content	ETL	1	1	2
Liquid/Plastic Limits	ETL	1	1	2
Percent Solids	ETL	1	1	2
pH	WA	1	1	2
Total Organic Carbon (TOC)	WA	1	1	2
CPAH	WA	1	1	2
BETX	WA	1	1	2

[1] FE - WESTON Fate and Effects Laboratory
ETL - WESTON Environmental Technology Laboratory
WA - WESTON Analytics (Lionville) Laboratory

Table 3

Analytical Methods

Parameter	Method	Sample Requirements	Preservation
Microbial Enumeration	Plate Count (1)	100 g./ Sterile glass	Cool, 4°C
Particle Size Distribution	ASTM D422	1 l.	---
Porosity (Bulk Density/ Specific Gravity)	Method 18-2.1(2)	1 l.	None
Moisture Content	ASTM D2216	1 l.	None
Atterberg Limits	ASTM D423/D424	1 l.	None
Percent Solids	CLP SOW	250 ML/amber glass	Cool, 4°C
pH	9040	250 ML/amber glass	Cool, 4°C
Total Organic Carbon (TOC)	ASTM 2974/Method 415.1(3)	250 ML/amber glass	Cool, 4°C
CPAH	EPA Method 8310(4)	250 ML/amber glass	Cool, 4°C
BETX	EPA Method 8020(4)	2-125 ML/amber glass	Cool, 4°C

Notes:

(1) Refer to protocol presented in Appendix F.

(2) Method 18-2.1: Total Porosity, Calculation from Particle and Bulk Densities, Methods of Soil Analysis, Part 1 - Physical and Mineralogical Methods, Second Edition, American Society of Agronomy Inc. and Soil Science Society of America, Inc., Madison, Wisconsin, 1986.

(3) Confirmation, as necessary will utilize modified Method 415.1 using a Dohrmann TOC analyzer for soil samples.

(4) Sample extraction and preparation for CPAH analysis will follow methods 3540 and 3630. Method 5030 will be utilized to prepare BETX samples for analysis.

LIST OF APPENDICES

<u>Appendix</u>

APPENDIX D

INITIAL CHARACTERIZATION DATA FOR TREATABILITY STUDY TEST MATRIX

Moss-American Site
Milwaukee, Wisconsin

Initial Characterization Data for Treatability Study Test Matrix

(Predesign Task 16 - Bioslurry and Soil Washing Phase I Treatability Evaluation)

4 November 1992

Table 1

Summary of Test Pit Composite Samples Evaluated for Selection of Treatability Test Matrix

Composite Sample	Test Pits Sampled to Form Composite	Total CPAH Concentration (mg/kg)
S01	TP12, TP13, TP14, and TP15	57.4
S02	TP8	506.7
S03	TP3	197.4
S04	TP12, TP13, TP14, TP15, TP8, TP3	122.8

Notes:

- Composite samples "S02" and "S03" were selected as the treatability study test matrix designated as "IT-TS01" (Bioslurry) and "BRG-TS01" (Soil Washing).
- A second soil washing treatability study test matrix was formulated by compositing samples from test pits designated as TP4, TP5, TP6, TP11, TP12, and TP15. This test matrix is designated as "BRG-TS02".

Table 2

Summary of Bioslurry and Soil Washing Treatability Study Sample Chemical Characterization

Moss-American Site
Milwaukee, Wisconsin

Parameter	Units	Sample Designation		
		IT-TS01	BRG-TS01	BRG-TS02
% Solids	%	65.4	58.8	TBD
Total Organic Carbon	%	6.1	6.6	TBD
pH	pH Units	6.9	7.1	TBD
<u>PURGEABLE AROMATICS</u>				
Benzene	ug/kg	ND	ND	TBD
Ethylbenzene	ug/kg	ND	ND	TBD
Toluene	ug/kg	ND	ND	TBD
Xylene (total)	ug/kg	ND	ND	TBD

TBD - To be determined (sample currently being analyzed).

CH01\PUBLIC:\WO\MOSSAMER\B712.TB2

Table 2 (cont'd)

Parameter	Units	Sample Designation		
		IT-TS01	BRG-TS01	BRG-TS02
<u>PAH</u>				
Naphthalene	ug/kg	23000	30000	TBD
Acenaphthylene	ug/kg	180000	170000	TBD
Acenaphthene	ug/kg	130000	83000	TBD
Fluorene	ug/kg	34000	23000	TBD
Phenanthrene	ug/kg	120000	87000	TBD
Anthracene	ug/kg	220000	220000	TBD
Fluoranthene	ug/kg	320000	210000	TBD
Pyrene	ug/kg	180000	160000	TBD
Benzo(a)anthracene	ug/kg	30000	27000	TBD
Chrysene	ug/kg	96000	100000	TBD
Benzo(b)fluoranthrene	ug/kg	33000	48000	TBD
Benzo(k)fluoranthrene	ug/kg	9000	4100	TBD
Benzo(a)pyrene	ug/kg	34000	36000	TBD
Dibenzo(a,h)anthracene	ug/kg	8900	8600	TBD
Benzo(ghi)perylene	ug/kg	12000	11000	TBD
Indeno(1,2,3-cd)pyrene	ug/kg	11000	10000	TBD
Total PAH	mg/kg	1440.9	1227.7	TBD
Total CPAH	mg/kg	233.9	244.7	TBD

TBD - To be determined (sample currently being analyzed).

Table 3

Geotechnical Tests Performed, Reference Methods and Test Numbers

Test Parameter	Method[1]
Grain Size by Sieve and Hydrometer	D 421/422
Liquid and Plastic Limits	D 4318
Total Porosity	D 854/2937
Natural Moisture Content	D 2216

TABLE 4

SUMMARY OF TREATABILITY STUDY SAMPLE PHYSICAL CHARACTERIZATION

WESTON ENVIRONMENTAL TECHNOLOGY LABORATORY

GEOTECHNICAL TESTING DATA AND RESULTS

PROJECT	Moss American-Kerr McGee	PROJECT SAMPLE I.D.	Moss Amer-TS01	PROJECT ANALYST	SPM
JOB NUMBER	9209X011	ETL SAMPLE NUMBER	001	QA/QC ANALYST	RWF
W. O. NUMBER	02687-007-001	DATE RECEIVED	9/21/92	DATE COMPLETED	10/18/92

PARTICLE SIZE DISTRIBUTION

U. S. Standard Sieve Size	Diameter mm	% Finer
3"	75.00	100.0
1 1/2"	37.50	100.0
3/4"	19.00	96.7
3/8"	9.500	84.2
#4	4.750	75.5
#10	2.000	65.8
#20	0.850	55.9
#50	0.300	44.7
#100	0.150	37.4
#200	0.075	32.9
HYDROMETER	0.0497	27.0
	0.0360	24.4
	0.0260	21.9
	0.0193	16.1
	0.0144	13.6
	0.0104	10.2
	0.0074	9.4
	0.0053	7.7
	0.0038	6.0
	0.0027	4.4
	0.0016	3.5
	0.0011	2.7

EFFECTIVE SIZES

% Finer	Diameter mm
60	1.326
30	NA
10	NA
Uniformity Coefficient	Gradation Coefficient
NA	NA

NATURAL MOISTURE CONTENT, % dry basis

85.6

SPECIFIC GRAVITY

2.24

SAMPLE DESCRIPTION

dark brown gravelly silty SAND with 24% gravel and 33% silt, also contained organics(bark)

Unified Soil Classification System (USCS) Group Symbol

SM

INDEX PROPERTIES
% moisture dry basis

Liquid Limit	Plastic Limit	Plasticity Index
non-plastic, non-cohesive		

BULK UNIT WEIGHT (disturbed, uncompacted)

wet g/cc	wet pcf	dry pcf
0.96	59.6	32.1

POROSITY

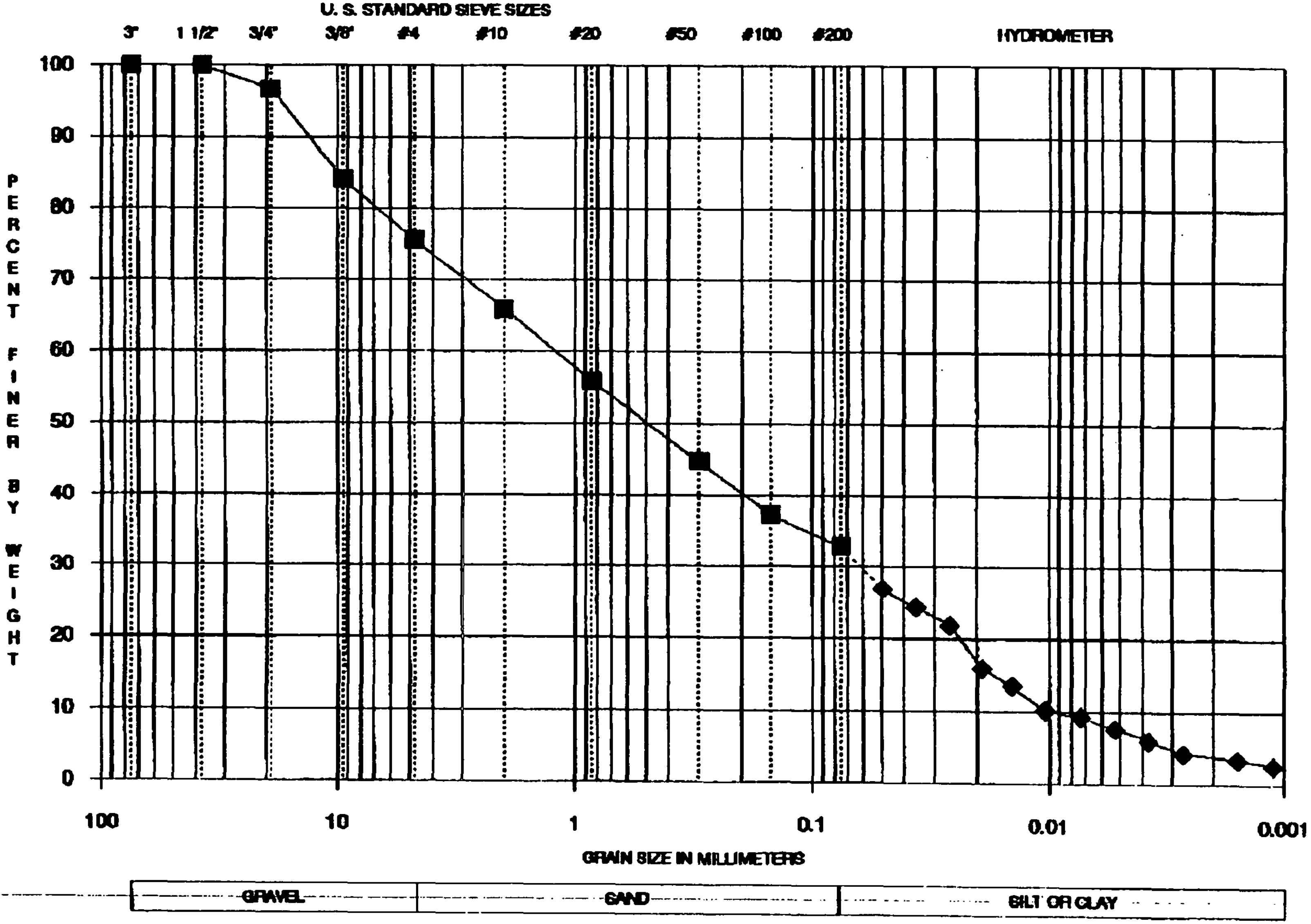
Void Ratio	Porosity,%	Saturation,%
3.359	77.1	57.2

NOTES

NA--NOT APPLICABLE

WESTON ENVIRONMENTAL TECHNOLOGY LABORATORY

PARTICLE-SIZE DISTRIBUTION CURVE FOR
MOSS AMERICAN-KERR MCGEE PROJECT SAMPLE MOSS AMER-TS01, ETL SAMPLE # 9209X011-001



WESTON ENVIRONMENTAL TECHNOLOGY LABORATORY

GEOTECHNICAL TESTING DATA AND RESULTS

PROJECT	KERR-McGEE	PROJECT SAMPLE I.D.	BRG-TSO2	PROJECT ANALYST	SPM
JOB NUMBER	9210X004	ETL SAMPLE NUMBER	001	QA/QC ANALYST	RWF
W. O. NUMBER	02687-007-001	DATE RECEIVED	10/26/92	DATE COMPLETED	11/08/92

PARTICLE SIZE DISTRIBUTION

U. S. Standard Sieve Size	Diameter mm	% Finer
3"	75.00	100.0
1 1/2"	37.50	100.0
3/4"	19.00	100.0
3/8"	9.500	95.4
#4	4.750	83.1
#10	2.000	67.7
#20	0.850	55.0
#50	0.300	41.8
#100	0.150	34.4
#200	0.075	30.1
HYDROMETER	0.0502	23.2
	0.0360	21.3
	0.0262	17.4
	0.0187	15.5
	0.0140	11.7
	0.0100	10.7
	0.0072	6.9
	0.0051	5.9
	0.0036	5.9
	0.0026	4.0
	0.0014	3.1
	0.0011	2.1

EFFECTIVE SIZES

% Finer	Diameter mm
60	1.304
30	NA
10	NA
Uniformity Coefficient	Gradation Coefficient
NA	NA

NATURAL MOISTURE CONTENT

% dry basis	% wet basis
37.1	27.1

TOTAL SOLIDS

% by weight
72.9

SPECIFIC GRAVITY

2.37

SAMPLE DESCRIPTION

brown gravelly silty SAND with 17% gravel and 30% silt of slight plasticity

Unified Soil Classification System (USCS) Group Symbol

SM

INDEX PROPERTIES
% moisture dry basis

Liquid Limit	Plastic Limit	Plasticity Index
44.6	38.2	6.4

BULK UNIT WEIGHT (disturbed, uncompacted)

wet g/cc	wet pcf	dry pcf
1.1	70.5	51.4

POROSITY

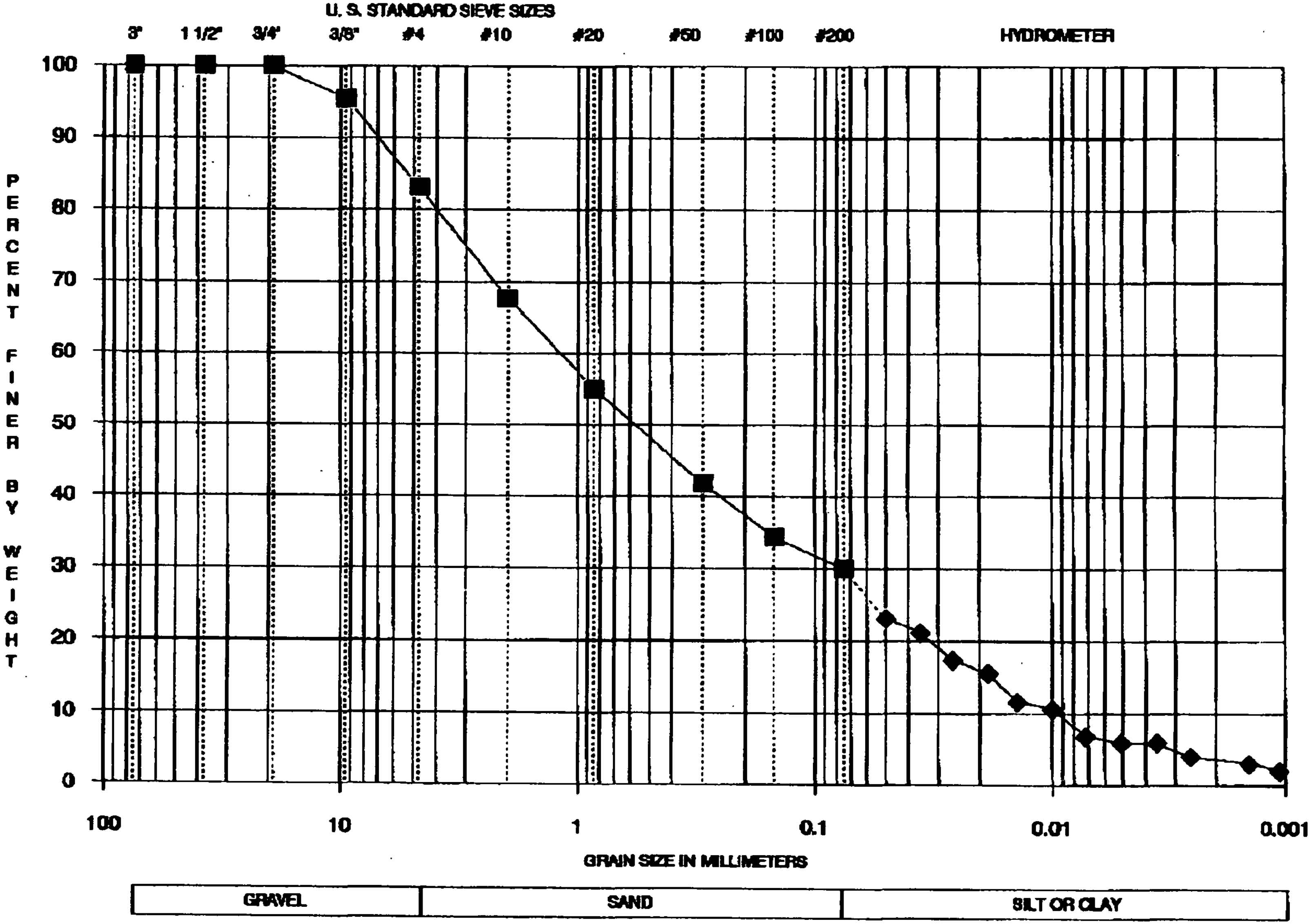
Void Ratio	Porosity,%	Saturation,%
1.9	65.3	46.9

NOTES

NA=NOT APPLICABLE

WESTON ENVIRONMENTAL TECHNOLOGY LABORATORY

PARTICLE-SIZE DISTRIBUTION CURVE FOR
KERR-MCGEE PROJECT SAMPLE BRG-TSO2, ETL SAMPLE # 9210X004-001



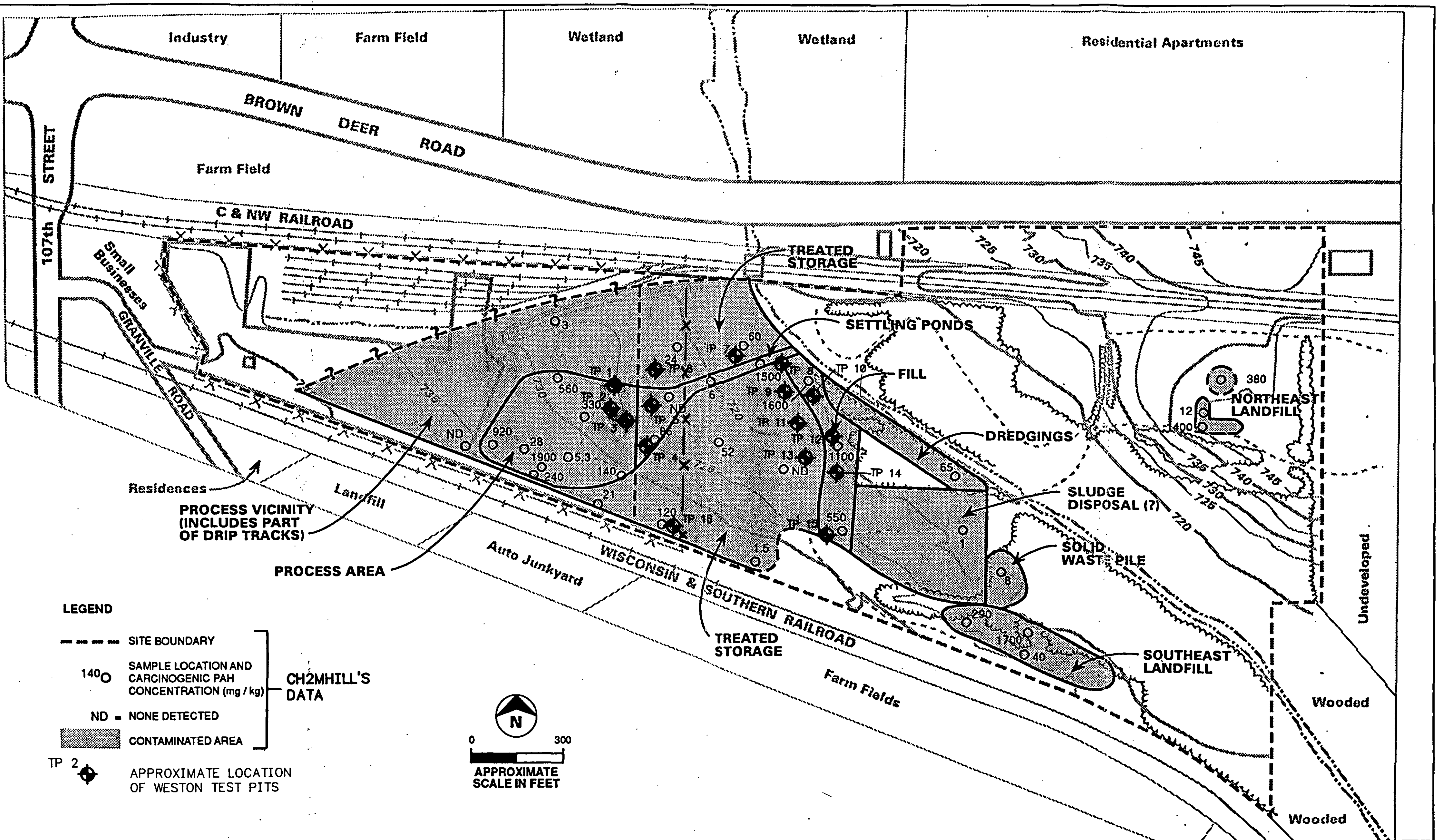


FIGURE 1

WESTON
MANAGERS DESIGNERS/CONSULTANTS

Three Hawthorn Parkway
Vernon Hills, Illinois
60061

LOCATION OF TREATABILITY STUDY SAMPLING TEST PITS

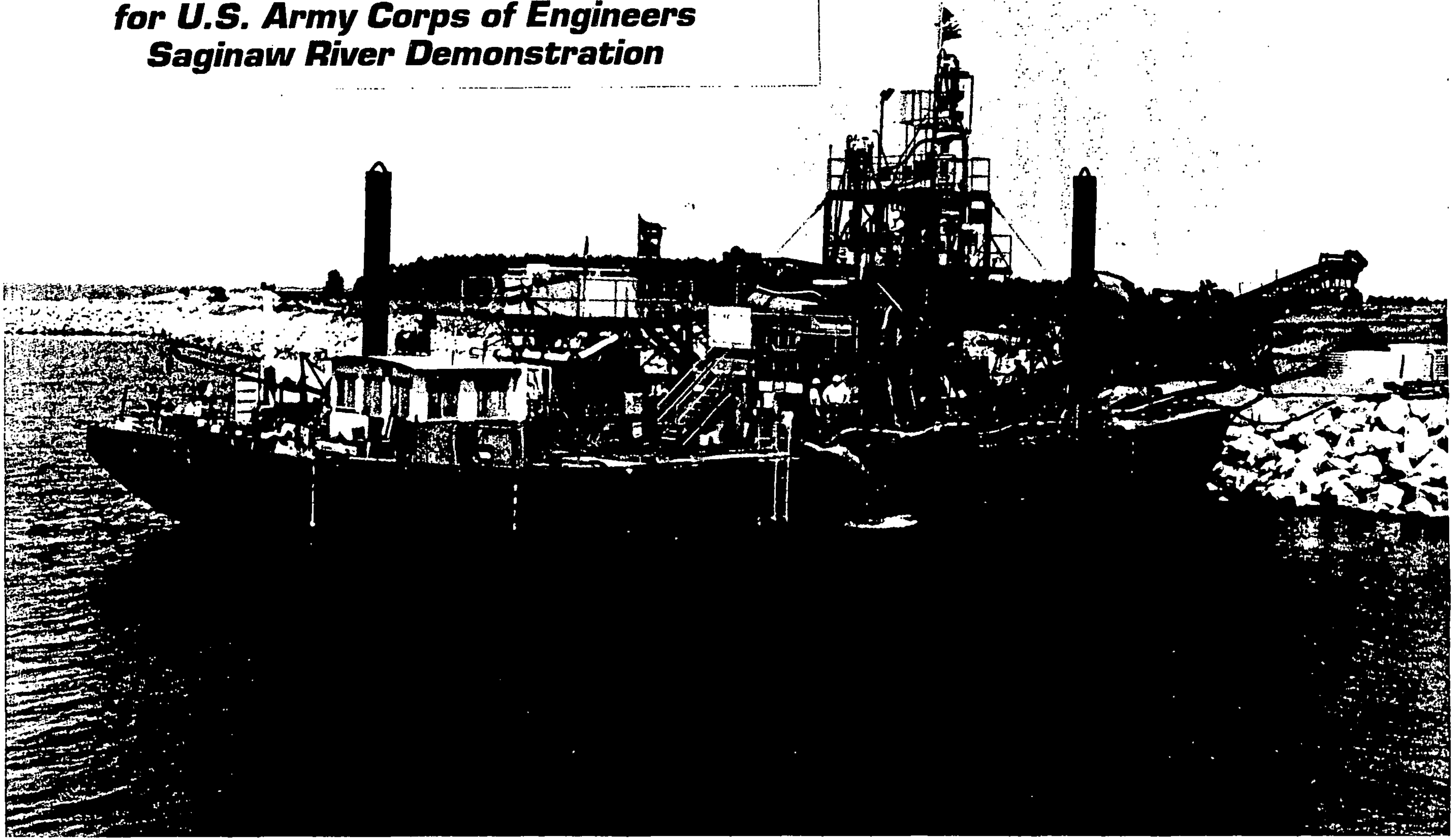
MOSS–AMERICAN SITE
Milwaukee, Wisconsin

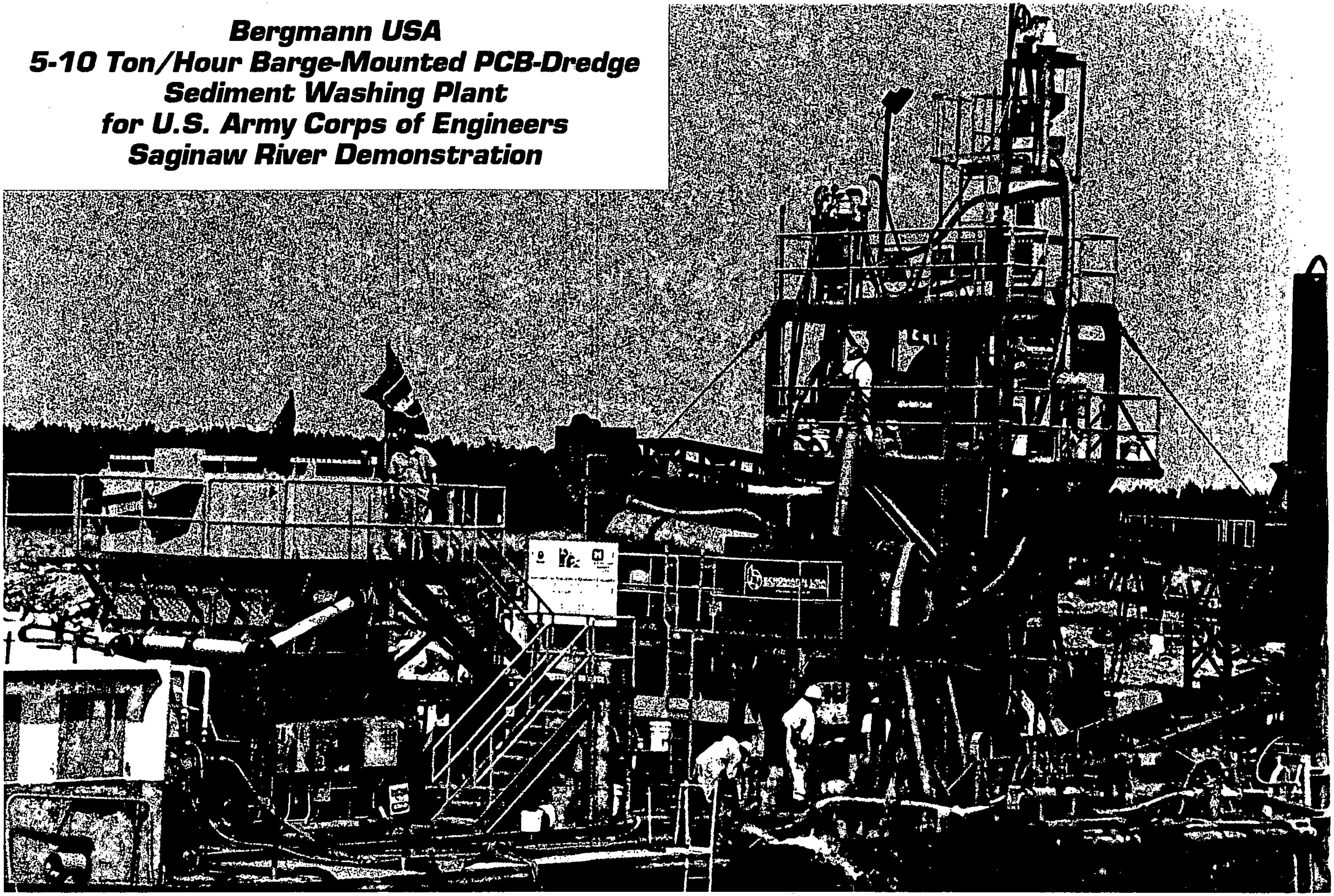
FIGURE ADAPTED FROM FS REPORT BY
CH2MHILL, INC. MAY 1990

APPENDIX E

SUPPLEMENTAL INFORMATION ON BERGMANN USA SOIL WASHING PROCESS

Bergmann USA
5-10 Ton/Hour Barge-Mounted PCB-Dredge Sediment Washing Plant for U.S. Army Corps of Engineers Saginaw River Demonstration



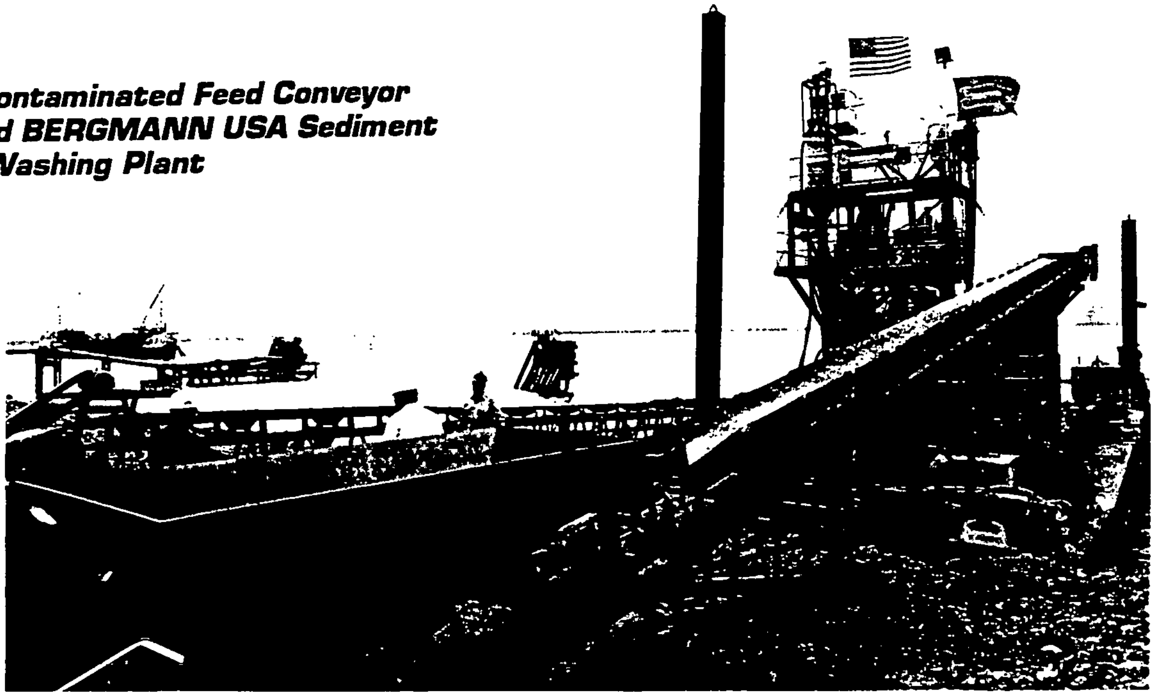


Bergmann USA
5-10 Ton/Hour Barge-Mounted PCB-Dredge
Sediment Washing Plant
for U.S. Army Corps of Engineers
Saginaw River Demonstration

Bergmann USA
5 Tons/Hour Barge-Mounted PCB-Dredged Sediment Washing Plant for Army Corp of Engineers Saginaw River Demonstration

BERGMANN USA Sediment Washing Plant Aboard Army Corps 130'x 33' Barge

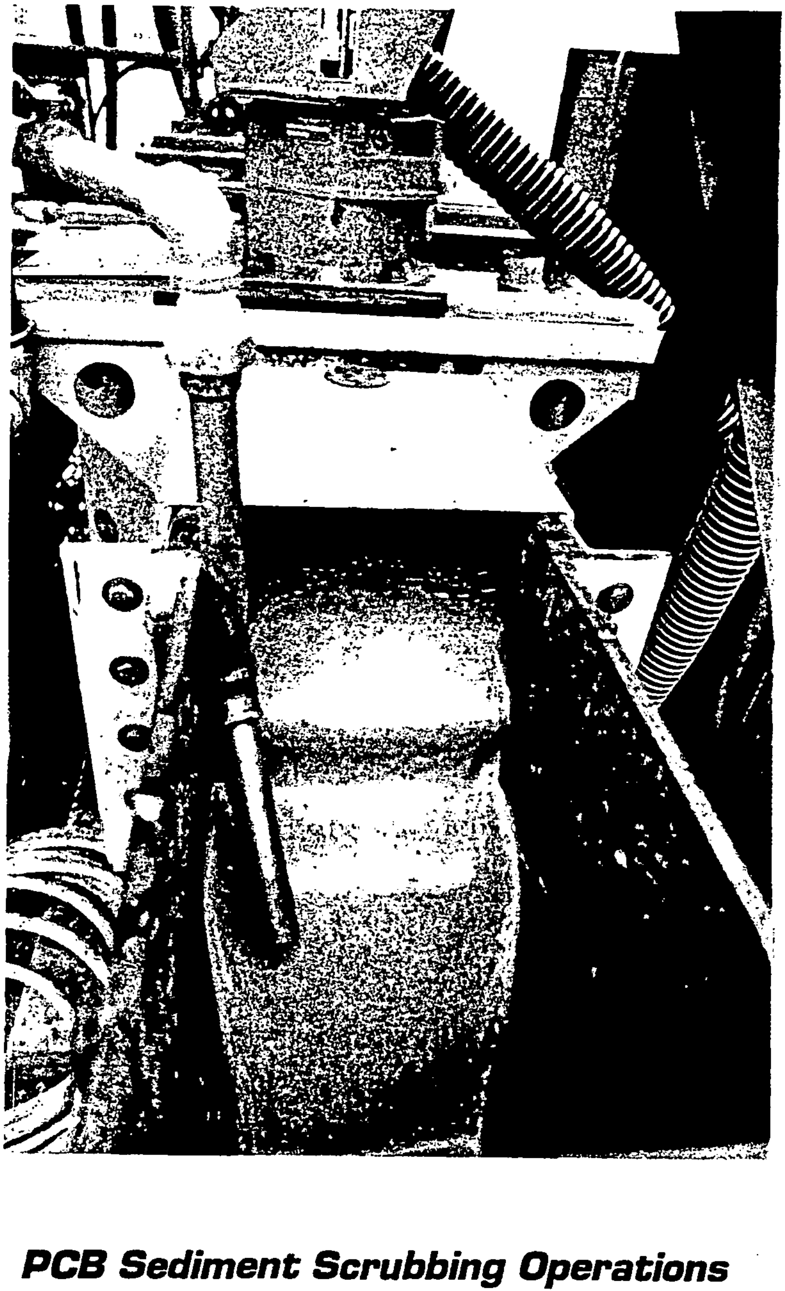
Shore-Based Contaminated Feed Conveyor to Barge Mounted BERGMANN USA Sediment Washing Plant



BERGMANN USA

Bergmann USA 5-10 TPH River/Harbor Sediment Washing Plant

U.S. Army Corps of Engineers Saginaw River PCB Contaminated Sediments Demonstration



PCB Sediment Scrubbing Operations within Bergmann Attrition Cell Module

BERGMANN USA Attrition Scrubbers

Introduction

BERGMANN USA Attrition Units were developed and designed specifically to provide a highly efficient method for scrubbing and release of highly contaminated fine soil fractions <63 micron (clays/slimes) from the coarse cleanable sand and gravel materials found at chemically/radioactively contaminated soils and sediments found at hazardous waste sites.

By using these opposed pitch propellers in an octagonal cell it is possible to scrub sand and gravel (-3/8") at high solids at relatively slow propeller tip speeds. The propellers turning at tip speeds of approximately 800 ft. per minute impart energy to the pulp mass and cause sand grains to attrition with minimum contact with the propellers. Wear on moving parts is thus kept to a minimum, yet scouring of the sand/gravel surface coating is very effective. The scouring is done by the sand/gravel grains in contact with each other with little direct contact of the sand/gravel grains against the propeller wearing surfaces.

Application

While the primary application of commercial attrition machines for more than 30 years has been for cleaning silica sand, other applications are in treating foundry sand, breaking up mud balls in clay and phosphate, and in breaking down burnt lime in the lime slaking process. Since 1982 Bergmann has applied the use of attrition cells in the removal of contaminated clay (desliming) from clean coarse soil/sediment fractions.

The action of attrition cell also provides high efficient dispersion and mixing of wash additives (i.e. surfactants, chelants, acids, alkalines, etc.) to aid in the mobilization of clay fines and the solubilization of selected contaminants of interest.

Operation

It is important and necessary to operate attrition scrubbers at the maximum pulp density at which the pulp will flow and can be kept in fluid suspension. Sand for example, is best handled at 70 to 80% solids. Some higher clay content materials must be at lower density otherwise the material will not flow and attrition effectively. Dilute and very fluid pulps are not desirable. These will splash and agitate violently and desired grain-to-grain attrition results are not attained.

The proper feed for an attrition machine is the underflow product from a BERGMANN Cyclone Separator. The underflow product will be uniform with solids at approximately 70% to 80%. The flow is generally even, and, if additional dilution is needed, it can be introduced at the feed box entrance of the attrition machine. Alternative feed units to the attrition cell can also be dry or wet sand from a belt can also be fed effectively under controlled conditions or a spiral classifier sand product.

Applications:

Soil and sediment washing process operations typically require intensive scrubbing of mixing action to remove surface contaminants from solids; to separate solids grains from cementing or agglomerated material; to disintegrate clay balls and other materials; or to condition materials with washing reagents and additives at high density.

Typical associated commercial/industrial applications include:

- Removal of iron stains and/or clay from glass sands.
- Upgrading uranium ores by liberating high grade slimes from low grade or barren sands.
- Removal of clay slimes from sands in the processing of potash, phosphate, and other ores.
- Intense high density reagent conditioning of solids ahead of the flotation process in the recovery of phosphate, potash, molybdenum, and other minerals.
- Repulping of reclaimed solids from tailings ponds for retreatment.
- Soils and sediment washing for removal of hazardously contaminate clays/slimes.

General Specifications:

BERGMANN USA has developed heavy duty highly efficient attrition scrubbers for bench-scale, pilot-batch plant and full-scale attrition applications in volumetric production/waste minimization for hazardous waste site remediation.

1. All BERGMANN USA attrition units are designed with opposed axial flow impellers of 100% and 150% pitch. Thus, a high impact-shear zone is created between the propellers and intense multiple grain-to-grain contact is present throughout the entire mass.

2. Full-scale (5 TPH+) cells are provided with large feed boxes for addition of wash solution additives and flanged discharges. Single cell units are furnished for batch operations.

3. Full-scale "ganged" units are designed with "down-flow" through the first cell, "up-flow" through the second, etc. Cells are available as single-cell through 4-cell units.

4. All Bergmann attrition tanks are of octagonal configuration supplying optimal baffling operations which "fold" the solids matrix back to the center for recirculation by the mixing impeller assembly.

5. All wetted components on Bergmann full-scale attrition scrubbers are supplied with replaceable rubber or neoprene linings for abrasive-corrosive applications. Covers are provided with inspection ports and evaluation visits to provide positive vapor emission collection and transfer for suitable treatment.

6. The specifications of the Bergmann Bench-scale Attrition Cell are as follows:

   Dimensions:

   Primary Unit: 10"w x 25"h x 14"d
   Attrition Cell: Hexagonal - 6" base x 8"h

   Materials of Construction:

   Primary Unit: Mild Steel with 5 mils two-part epoxy coating
   Attrition Cell: 316 Stainless Steel w/EB Welded Seams - 10 Gauge

Weight:

	Primary Unit:	35 pounds
	Attrition Cell:	4 pounds

Motor:

	Voltage:	120 VAC
	Amperage:	5 Amps
	Horsepower:	$^1/_3$ hp
	Speed:	800 fpm impeller tip speed

Double Insulated / UL Inspected

Capacity:

	Attrition Cell:	3 kg

Capital Cost:

	Primary Unit w/ 3 attrition cells:	$ 1,800

Monthly Lease:

$ 150/month with a 2 month minimum

6. The specifications of the Bergmann Pilot-Batch scale Attrition Cell are as follows:

Dimensions:

	Primary Unit:	24"w x 55"h x 27"d
	Attrition Cell:	Hexagonal - 10" base x 14"h

Materials of Construction:

	Primary Unit:	Mild Steel with 5 mils two-part epoxy coating
	Attrition Cell:	316 Stainless Steel w/EB Welded Seams - 10 Gauge

Weight:

	Primary Unit:	300 pounds
	Attrition Cell:	25 pounds - empty 150 pounds - full

Motor:

Voltage:	440 VAC
Amperage:	10 Amps
Horsepower:	2 hp
Speed:	800 fpm impeller tip speed

Double Insulated / UL Inspected

Capacity:

Attrition Cell:	25 kg / $3^1/_2$ gallons

Capital Cost:

Primary Unit w/ 3 attrition cells:	$ 9,800

Monthly Lease:

$ 550/month with a 2 month minimum

Attrition Scrubber

Function:

The Attrition Scrubber serves to liberate surficial contaminants from coarser sand grains.

Sand grains within a soil often become coated with the contaminant material or clays which host contaminants. The attrition scrubber aids in removal of these contaminants by subjecting the soil to a high shear environment in which the grains of sand are scoured against one another.

Operation:

To operate the attrition scrubber, nominal -1/4" X 170 mesh material is placed in a transfer container to the fill line. The solids concentration of the material in this container should be on the order of 65 to 75 % solids by weight. The transfer container is placed in position below the impellers of the attrition unit. The attrition unit is powered on at low RPM to assist the lowering of the impeller into the process material. Additives such as surfactants and/or pH modifiers may be added to the attrition cell at this time. Once the impellers are in position, the top of the cell will be sealed to prevent material from splashing out. At this time, the impeller speed can be increased by turning the variable speed control knob counter-clockwise. Attrition scrubbing time will vary with material characteristics. We suggest an initial scrub test duration of 15 minutes. After scrubbing the impeller is lifted out of the bucket and washed to remove sand from the blades. Now, attritioning of the material will by definition, produce fines and transfer contaminants into the water. In order to remove these, the cell contents should once again be washed. To do this, the cell is connected to the jib crane hoist and lifted to the trommel deck. The contents of the cell are poured once again into the trommel feed chute. This process will then serve to reslurry the cell contents and present them to the Derrick screen. Wash and spray water should be turned on as before. The Derrick screen oversize material is now the washed product.

Electrical: 2 HP, 440 Volt, 60HZ, TEFC Motor

Lubrication: Motor should be greased occasionally.
Gear Reducer should be filled with 90 weight gear oil.

BERGMANN USA

Bergmann USA 25 kg Pilot-Batch Attrition Scrubber

APPENDIX F

ADDITIONAL TEST METHOD REFERENCES

QUANTITATION OF POLYCYCLIC AROMATIC HYDROCARBON DEGRADING MICROBES IN CREOSOTE-CONTAMINATED SOILS

MATERIALS AND METHODS

Duplicate 1.0 gram soil samples will be weighed out in sterile 500 ml Erlenmeyer flasks and suspended in 100 ml sterile 2.5 mM phosphate buffer (pH 7.0). The soil suspensions will be incubated with shaking at 30°C for one hour at 200 rpm. The soil suspensions will then be serially diluted in 10-fold increments in sterile 2.5 mM phosphate buffer (pH 7.0) to a final dilution of 10^{-7}. Triplicate spread plates will be prepared on AB3 agar (Difco) from the 10^{-3} to 10^{-7} dilutions and incubated at 30°C for 72 hours to quantitate heterotrophic populations. After heterotrophic populations have been quantitated, the countable plates will be sprayed with an ethereal solution of 0.04% phenanthrene and incubated for an additional 72 hours at 30°C and scored for the number of microbial colonies producing clear "halos" in the opaque hydrocarbon film. The relative increases in total heterotrophs as well as phenanthrene degraders will be assessed throughout the study.

REFERENCES

1. Mueller, J.G., Chapman, P.J., and Pritchard, P.H. "Creosote-contaminated sites" Their Potential for Bioremediation," Environmental Science and Technology, Vol. 23, No. 10, 1989, pp. 1197-1201.

2. Sylvestre, M. "Isolation Method for Bacterial Isolates Capable of Growth on p-chlorobiphenyl" Applied and Environmental Microbiology, Vol., 39, No. 6, 1980, pp. 1223-1224.

3. Sharis, M.P., and Cooney, J.J. "Replica Plating Method for Estimating Phenanthrene-Utilizing and Phenanthrene-Cometabolizing Microorganisms" Applied and Environmental Microbiology, Vol. 45, No. 2, 1983, pp. 706-710.

4. Kiyohara, H., Nagao, K., and Yana, K. "Rapid Screen for Bacteria Degrading Water-Insoluble, Solid Hydrocarbons on Agar Plates" Applied and Environmental Microbiology, Vol. 43, No. 2, 1982, pp. 454-457.

5. Mueller, J.G., Lantz, S.E., Blattmann, B.O., and Chapman, P.J. "Bench-Scale Evaluation of Alternative Biological Treatment Processes for the Remediation of Pentachlorophenol- and Creosote-Contaminated Materials: Solid-Phase Bioremediation" Environmental Science and Technology, Vol. 25, No. 6, 1991, pp. 1046-1055.

Designation: D 4749 – 87

Standard Test Method for Performing the Sieve Analysis of Coal and Designating Coal Size[1]

This standard is issued under the fixed designation D 4749; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers procedures for determining the sieve analysis of coal and designating the size of coal from sieve analysis data. Raw as well as prepared (crushed, cleaned or screened) coals can be tested by this test method.

1.2 This test method explains how to designate coal sizes from the results of sieve analysis data in order to represent the condition of the coal as sold. In the case of special mixtures or coals with noncontinuous ranges of sizes, a sufficiently complete sieve analysis must be made to properly describe the size distribution.

1.3 This test method is not applicable for determining the sieve analysis nor for designating the size of pulverized coal.[2] Size fractions down to and including 38 µm (No. 400 U.S.A. Standard Series) can be treated by the methods discussed in this test method. Methods for handling size fractions below 38 µm (No. 400) will be developed by this committee.

1.4 The values stated in metric units shall be regarded as standard. The values shown in parentheses are provided for information only. The values stated in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining values in any way.

1.5 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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 197 Method of Sampling and Fineness Test of Pulverized Coal[3]

D 346 Method of Collection and Preparation of Coke Samples for Laboratory Analysis[3]

D 388 Classification of Coals by Rank[3]

D 2013 Method of Preparing Coal Samples for Analysis[3]

D 2234 Methods for Collection of a Gross Sample of Coal[3]

D 4371 Test Method for Determining the Washability Characteristics of Coal[3]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[4]

E 323 Specification for Perforated-Plate Sieves for Testing Purposes[4]

2.2 *Other Document:*

Specification C-80 Commonwealth of Pennsylvania, Department of General Services, Bureau of Purchases, Specification for Coal:Anthracite[5]

3. Descriptions of Terms Specific to this Standard

3.1 *as-mined coal*—same as ROM coal (3.8).

3.2 *as-shipped or produced coal*—raw or prepared coal in any state or condition at which it leaves the mine property or loading facility.

3.3 *bottomsize, nominal*—the sieve designating the lower limit or bottomsize shall be that sieve of the series given in Section 6 with the largest openings through which passes a total of less than 15 % of the sample. This defined bottomsize is not to be confused with the size of the smallest particles in the lot.

NOTE 1—Precaution: In the case of a commercial, double-screened product, for example, 37.5 by 9.5 mm (1½ by ⅜ in.), this designation may *not* be valid. In such commercial or contractual situations, the amount of allowable material smaller than the bottomsize (for example, 9.5 mm) must be specified by the contract under which the coal is bought and sold.

3.4 *dry sieving*—for the purposes of this test method, the test method for the sieving of coal after the sample has been air-dried under prescribed conditions; this is generally used when testing with coal particles larger than 600 µm. (No. 30 U.S.A. Standard Sieve Series.)

3.5 *opening*—for the purpose of this test method, openings and apertures shall be regarded as synonomous terms. Dimensions for round and square openings shall be determined as follows: for round holes, dimensions shall refer to the opening diameter; for square holes, dimensions shall refer to the distance between parallel wires.

3.6 *prepared coal*—any coal, regardless of its topsize, that has been manually or mechanically cleaned. This includes coal that has been processed over a picking table or air tables, through a breaker, jig, or other device which segregates according to size or density (specific gravity).

3.7 *raw coal*—any coal, regardless of its topsize, that has not been manually or mechanically cleaned. Crushed coal that has not been mechanically cleaned (including coal that

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[1] This test method is under the jurisdiction of ASTM Committee D-5 on Coal and Coke and is the direct responsibility of Subcommittee D05.07 on Physical Characterization and Beneficiation of Coal and Coal Slurries.

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[2] For powdered or pulverized coal as is fired into steam boilers, refer to Method D 197.

[3] *Annual Book of ASTM Standards*, Vol 05.05.

[4] *Annual Book of ASTM Standards*, Vols 05.05 and 14.02.

[5] Available from Commonwealth of Pennsylvania, Dept. of General Services, Bureau of Purchases, 414 N. Office Building, Harrisburg, PA 17125.

has not been through a breaker which normally rejects oversize) is considered to be raw coal. Coal delivered to the surface from an underground mine is considered to be raw coal even when crushing and grinding is done underground. Coal removed from the pit of a surface mine is considered to be raw coal even when breaking and crushing facilities are provided *in the pit.*

3.8 *run-of-mine (ROM) coal*—in the case of an underground mine, it is that coal delivered to the surface by a slope belt, hoist, etc. In the case of a surface mine, it is that coal as it exists after it has been removed from the pit and placed into the initial means of transportation whether it be an on-the-road or off-the-road haul truck, dump hopper which feeds a pit-to-plant conveyor, etc. For both underground and surface mines, ROM coal is as-mined and has not been exposed to any treatment such as breaking, crushing, or cleaning except for that done by the normal operations used to extract the coal from the ground, that is, blasting, ripping, loading, cutting, etc.

3.9 *topsize, nominal*—the sieve designating the upper limit or topsize shall be that sieve of the series given in Section 6 with the smallest openings upon which is cumulatively retained a total of less than 5 % of the sample. This defined topsize is not to be confused with the size of the largest particle in the lot.

3.10 *wet sieving*—for the purposes of this test method, the test method for the sieving of coal that uses water as a medium for facilitating the segregation of the sample into particle sizes; this is generally used when testing coal particles 600 μm (No. 30 U.S.A. Standard Series) or smaller.

4. Significance and Use

4.1 This test method concerns the sieving of coal into designated size fractions for the purpose of characterizing the material as to its particle size distribution for further processing or for commercial purposes. This is covered in Part A of this standard. Raw, as well as prepared (crushed, cleaned, or screened), coals can be tested by this test method.

4.2 This test method is applicable for all types of coals, except for pulverized coals (see Method D 197) such as fed into steam boilers. Low rank coals, that is, lignites, subbituminous, and high volatile bituminous C, must be dried with caution and handled with care to minimize deterioration or size degradation during sieving.

4.3 This test method is applicable for the wet or dry-sieving of coal at sizes from 200 mm (8 in.) to 38 μm (No. 400 U.S.A. Standard). Methods for sizing materials below 38 μm are outside the scope of this test method.

NOTE 2—The sizing of material that passes the 38 μm sieve is normally performed by optical microscopy, sedimentation, centrifugation, light scattering or obfuscation, surface area measurement, or other such methods. Subsieve techniques are also used sometimes.

4.4 This test method also concerns the designation of a coal sample as to its upper (nominal top-size) and lower (nominal bottom-size) limiting sizes for the purpose of characterizing the material for further processing or for commercial purposes. This is covered in Part B of this test method. Anthracite coal is further designated by a one word descriptive term (see 14.4).

4.5 Enough material may not be collected by this test method to meet subsequent test procedures, such as washability analyses (Test Method D 4371).

PART A. SIEVE ANALYSIS OF COAL

5. Apparatus

5.1 *Sieves:*

5.1.1 *Wire Cloth Sieves:*

5.1.1.1 Standard test sieves that conform to Specification E 11 shall always be used.

5.1.1.2 For most sieve tests, where the largest particle in the sample does not exceed 25 mm (1 in.), standard 203-mm (8-in.) diameter, 50-mm (2-in.) deep sieves or sieves with larger diameters (for example 300 mm (12 in.) or 450 mm (18 in.)) are recommended. For special cases, and with small samples, 75-mm (3-in.) and 150-mm (6-in.) diameter sieves are available.

5.1.1.3 Standard test sieves shall be made from either brass or stainless steel frames and either brass, phosphor bronze, or stainless steel cloth.

5.1.1.4 In general, these square mesh sieves are used when sizing with sieves with openings smaller than 6.3 mm (¼ in.). U.S.A. Standard Sieve Designations shall be used.

5.1.1.5 For more complete details of standard test sieves, including methods of checking and calibrating the sieves, see Specification E 11.

5.1.2 *Perforated Plate Sieves:*

5.1.2.1 Perforated plate sieves, made to conform to Specification E 323, are available with square apertures from 125 mm (5 in.) to 3.36 mm (0.132 in.) and with staggered round apertures from 125 mm (5 in.) to 1 mm (0.038 in.). The sizes of successive apertures in the series follow the same ratio as in Specification E 11 for sieves.

5.1.2.2 Standard frames for perforated plate sieves with apertures 4.00 mm and larger are made of hardwood or steel to hold 300-mm (12-in.), 400-mm (16-in.), or 450-mm (18-in.) square sieve plates. For apertures smaller than 4.00 mm, 203-mm (8-in.) circular frames as well as the above larger square frames may be used.

5.1.2.3 In general, round hole sieves with staggered openings are used when sizing with sieves with opening diameters of 6.3 mm (¼ in.) or larger.

5.1.2.4 Where perforated sieves and wire cloth sieves are used in the same test (for example, in an analysis from 125 mm (5 in.) to 250 μm (No. 60)) or where results with perforated sieves are to be compared with results with wire cloth sieves, it is better to use only square aperture sieves.

NOTE 3—This action should be taken primarily while performing sieving analyses on noncommercial samples, as, for instance, in preparation plant component studies (see 6.5.1). In commerce, mixed series are still customary (see 6.1.1 and 6.3.1).

5.1.2.5 Results with a given square aperture and with the same diameter round aperture are not compatible. Therefore, all reports of sieve analysis data are incomplete without designation as to the type of sieves employed (round or square openings).

5.1.2.6 Aperture sizes of some sieves for anthracitic coal (6.3.2.1) do not conform to Specification E 323.

5.2 *Mechanical Sieve Shaker:*

5.2.1 Mechanical sieve shakers are used in practically all laboratories where frequent tests are made. They not only eliminate tedious hand labor, but, when properly used, will produce more consistent results than hand sieving. They can, however, result in excessive sample degradation when proper precautions are not taken. Therefore it is important to establish and to monitor the sieving amplitude and the sieving time.

5.2.2 There are several general types of mechanical sieve shakers. One type is designed to simulate hand sieving by using a circular motion combined with a tapping action. This type of mechanical sieve shaker is acceptable.

5.2.3 A type of sieve shaker which will handle a stack of either round or rectangularly framed sieves and produces a vigorous agitation is especially suitable for handling large samples of coarse material. This type of mechanical sieve shaker is acceptable for handling large samples provided it is not overloaded and provided agitation time is limited so that degradation of the coal being sieved does not occur (see 11.3.5).

NOTE 4—Some manufacturers can supply machines with reduced amplitude of vibration or variable speeds, or both, for soft materials.

5.2.4 Mechanical sieve shakers can generally be classified into two types: batch (acceptable) and continuous (unacceptable).

5.2.4.1 *Batch*—Batch mechanical sieve shakers are those in which a controlled quantity of coal is placed into the apparatus and mechanical action is initiated. After a controlled time period, mechanical action is completed and the size fractions are removed from the horizontal sieves. These types of mechanical sieve shakers are acceptable.

5.2.4.2 *Continuous*—Continuous mechanical sieve shakers are unacceptable for the purpose of this test method. Continuous mechanical sieve shakers are those in which a continuous stream of coal is fed into the apparatus and over a set of inclined sieves. The retention time on these sieves depends upon the degree of inclination, the throw of the sieves, and the frequency of mechanical action. The various size fractions are collected in individual containers in a continuous stream.

6. Standard Series of Sieves

6.1 *Crushed Bituminous, Subbituminous, and Lignitic Coals:*

6.1.1 For crushed bituminous, subbituminous, and lignitic coals, the standard series of sieves shall utilize round-hole perforated plate sieves for sieves with opening diameters of 6.3 mm (¼ in.) or larger and wire-cloth (U.S.A. Standard) sieves with square openings for sieves with openings smaller than 6.3 mm (¼ in.).

TABLE 1 Size Designation, Anthracitic Coal

Size	Size of Round-Hole Openings in Testing Sieves, mm (in.)	
	Passing	Retained On
Egg	83 (3¼)[A]	62 (2 7/16)
Stove	62 (2 7/16)	41 (1⅝)
Chestnut	41 (1⅝)	21 (13/16)
Pea	21 (13/16)	14 (9/16)
Buckwheat #1	14 (9/16)	8 (5/16)[A]
Buckwheat #2 (Rice)	8 (5/16)[A]	4.8 (3/16)[A]
Buckwheat #3 (Barley)	4.8 (3/16)[A]	2.4 (3/32)
Buckwheat #4	2.4 (3/32)	1.2 (3/64)

[A] Listed in Specification E 323, Table 1.

6.1.2 For the purpose of simplifying communication between concerned parties, the following series of sieves shall be considered as the standard series for crushed bituminous, subbituminous and lignitic coals:

Round Hole Perforated Plate Sieves

200 mm (8 in.)
150 mm (6 in.)
125 mm (5 in.)
100 mm (4 in.)
75 mm (3 in.)
63 mm (2½ in.)
50 mm (2 in.)
37.5 mm (1½ in.)
31.5 mm (1¼ in.)
25.0 mm (1 in.)
19.0 mm (¾ in.)
12.5 mm (½ in.)
9.5 mm (⅜ in.)
6.3 mm (¼ in.)

Wire Cloth (U.S.A. Standard) Sieves with Square Openings

4.75 mm (No. 4)
2.36 mm (No. 8)
1.18 mm (No. 16)
600 μm (No. 30)
300 μm (No. 50)
150 μm (No. 100)
75 μm (No. 200)
38 μm (No. 400)

6.1.3 For crushed bituminous, subbituminous, and lignitic coals, an alternate standard series of sieves can utilize square-hole perforated plate or steel-wire sieves for sieves with openings of 6.3 mm (¼ in.) or larger and wire cloth (U.S.A. Standard) sieves for sieves with openings smaller than 6.3 mm (¼ in.). This alternate series shall use sieves with openings of the same dimensions as those given in 6.1.2. When this alternate series of square openings is used, the report must include this information.

6.1.3.1 Since round hole 6.3-mm (¼-in.) perforated plate sieves produce undersize of approximately the same amount as 4.75-mm (No. 4 U.S.A. Standard) wire cloth sieves, that is, these sieves are nearly equivalent, it is not necessary to utilize both 6.3-mm (¼ in. round) perforated plate and 4.75-mm (No. 4 U.S.A. Standard) wire cloth sieves simultaneously. The selection of either will be sufficient.

6.2 *Coal Used as Coke Oven Charge:*

6.2.1 For coal that will be used as a coke oven charge, the standard series of sieves shall utilize square-hole perforated plate or steel-wire sieves with openings of 6.3 mm (¼ in.) or larger and wire cloth (U.S.A. Standard) sieves for sieves with openings smaller than 6.3 mm (¼ in.).

6.2.1.1 Typical coke oven charge is 80 % minus 3.2 mm (⅛ in. round). For the purpose of identifying compliance with this criteria of 80 % passing ⅛ in. round, it should not be necessary to use sieves larger than 4.75 mm (No. 4 U.S.A. Standard). To designate the topsize of this charge according to Part B of this test method (Section 14), it may be necessary to use larger sieves. It is recommended that sieving be done initially at 4.75 mm (No. 4 U.S.A. Standard), then progressively sieve the oversize through the next larger sieve until the 5 % criteria of 4.8 is met.

6.2.2 For the purpose of simplifying communication between concerned parties, the following series of sieves shall be considered as the standard series for coal that will be used as a coke oven charge:

Square Hole Perforated Plate Sieves

50.0 mm (2 in.)
37.5 mm (1½ in.)
25.0 mm (1 in.)
19.0 mm (¾ in.)
12.5 mm (½ in.)
9.5 mm (⅜ in.)
6.3 mm (¼ in.)

6.2.2.1 Smaller sizes shall conform to specifications for wire-cloth sieves (U.S.A. Standard) with square openings, and are the same as those in 6.1.2.

6.3 *Anthracitic Coal:*

6.3.1 For anthracitic coal, the standard series of sieves shall utilize round-hole perforated plate sieves.

6.3.1.1 Sieve plates mounted in hardwood or steel box frames 40.6 to 50.8 cm (16 to 20 in.) square are satisfactory for testing chestnut, pea, and buckwheat sizes of anthracitic coal. For egg and stove sizes (see Table 1), it is more convenient to use sieves with frames that are square or rectangular in shape having an area of 0.37 to 0.56 m^2 (4 to 6 ft^2).

6.3.2 For the purpose of simplifying communication between concerned parties, the following series of sieves shall be considered as the standard series for anthracitic coal:

Round Hole Perforated Plate Sieves

83 mm (3¼ in.)
76 mm (3 in.)[A]
62 mm (2 7/16 in.)
41 mm (1⅝ in.)
21 mm (13/16 in.)
14 mm (9/16 in.)
8 mm (5/16 in.)[A]
4.8 mm (3/16 in.)[A]
2.4 mm (3/32 in.)
1.2 mm (3/64 in.)

[A] Listed in Specification E 323.

6.3.2.1 These standard anthracitic coal sieve sizes are those specified by Commonwealth of Pennsylvania Specification C 80.

6.4 *Additional Sieves*—Additional sieves are required if a discontinuity(ies) or deviation(s), or both, from a normal gradation of sizes is (are) found. For sieves below 6.3 mm (¼ in.), additional wire-cloth sieves can be selected from Table 1 of Specification E 11. For sieves above 6.3 mm (¼ in.), additional round or square hole perforated plate sieves may be selected from Table 1 of Specification E 323.

6.5 *Other Shapes*—Other opening shapes can more fully characterize the coal (oval, rectangular, etc.). They shall only be used by agreement between the concerned parties.

6.5.1 The use of round hole sieves in plant sizing operations has been a common practice and much data has been established. However, newer plants, most coking operations, and mathematical treatment of comminution studies use the square hole sieves. For comparison purposes, round hole openings may be calculated to an approximation of the square opening in accordance with the following formula:

$$\frac{\text{round opening, mm}}{1.25} = \text{square opening, mm}$$

6.5.1.1 Due to differences in particle shape peculiar to individual coal types, 1.25 is not always the best factor to use when converting between round hole and square hole openings. The normal range for this factor varies from 1.17 to 1.26. It is best to determine this conversion factor for any coal in question by determining the sieve analysis alternatively using first round and then square openings.

6.5.1.2 When specifying preparation plant components that utilize wire mesh, Tyler mesh designations are often used rather than U.S.A. Standard. Table 2 shows the comparison of Tyler mesh designations with the U.S.A. Standard designation based on the aperture sizes of each type. U.S.A. Standard Series designations shall always be used. Tyler mesh designations are also to be given where necessary for clarity.

TABLE 2 Comparison Table of U.S.A. Standard with Tyler Sieve Series

U.S.A. Standard Series		Tyler
Standard	Alternate	
5.60 mm	No. 3½	3½ mesh
4.75 mm	No. 4	4 mesh
4.00 mm	No. 5	5 mesh
3.35 mm	No. 6	6 mesh
2.80 mm	No. 7	7 mesh
2.36 mm	No. 8	8 mesh
2.00 mm	No. 10	9 mesh
1.70 mm	No. 12	10 mesh
1.40 mm	No. 14	12 mesh
1.18 mm	No. 16	14 mesh
1.00 mm	No. 18	16 mesh
850 µm	No. 20	20 mesh
710 µm	No. 25	24 mesh
600 µm	No. 30	28 mesh
500 µm	No. 35	32 mesh
425 µm	No. 40	35 mesh
355 µm	No. 45	42 mesh
300 µm	No. 50	48 mesh
250 µm	No. 60	60 mesh
212 µm	No. 70	65 mesh
180 µm	No. 80	80 mesh
150 µm	No. 100	100 mesh
125 µm	No. 120	115 mesh
106 µm	No. 140	150 mesh
90 µm	No. 170	170 mesh
75 µm	No. 200	200 mesh
63 µm	No. 230	250 mesh
53 µm	No. 270	270 mesh
45 µm	No. 325	325 mesh
38 µm	No. 400	400 mesh

6.6 Frames conforming to criteria in Specification E 11 or Specification E 323 shall be used with applicable sieves.

6.7 Suitable pans and covers as applicable to fit specific sieves shall be used as required by Specification E 11 or Specification E 323.

7. Gross Sample

7.1 Collect the gross sample in accordance with the principles of Methods D 2234.

NOTE 5—ASTM methods for collection of gross samples from stockpiles, cartops, etc. (stationary sampling) are being developed. When these methods are available, application of those standards will be required for stationary sampling.

7.2 Accurate sampling is of the greatest importance and is the basic requirement for reliable sieve analyses. Take great care to obtain samples that are representative of the batch or lot being tested. The greatest cause of inconsistencies in test results is improper sampling that does not represent the material being tested. Therefore, once a sampling procedure has been established, this same procedure is followed during subsequent sampling.

7.3 The quantity or mass of a gross sample will depend on the character of the material and the form in which it is available and also on whether the test is to determine the particle size distribution of a pile, batch, shipment, day's production, or a short span of time for production control.

The range of quantity or mass of a gross sample can be as much as several thousand kilograms or it may be as little as a fraction of a kilogram.

7.4 Collect increments regularly and systematically, so that the entire quantity of coal sampled will be represented proportionately in the gross sample, and with such frequency that a gross sample of the required amount shall be collected. Collect not less than the number of increments specified in Table 2 of Methods D 2234.

7.5 When the coal is passing over a conveyor or through a chute, take increments which include the full width and thickness of the stream of coal, either by stopping the conveyor and removing all coal from a transverse section of it, or by momentarily inserting a suitable container into the stream and withdrawing the sample. When it is impracticable to collect increments the full width and thickness of the coal stream, collect the increments systematically from all portions of the stream.

7.6 The method of collection of the gross sample shall be such as to produce a minimum of degradation.

7.7 The probability of collecting representative portions (samples) for sieve analysis is less from the surface of coal in piles or from loaded cars or bins than from a moving stream of coal. Where possible, sample such that the full volume of coal in the lot being sampled is represented in the final sample.

8. Weight of Gross Sample

8.1 The weight of the gross sample collected shall conform to the general principles of Methods D 2234. Usually the minimum masses to be collected are those given in Table 3. For lots of coal greater than 10 000 tons, the interested parties shall agree on the method to be used for collection and division of the gross sample prior to sieve analysis. In such cases, the following information shall be included on the analysis report:

8.1.1 Total weight of lot sampled.

8.1.2 Number of sampling increments taken.

8.1.3 Total weight of sample taken.

NOTE 6—**Precaution:** Enough material may not be collected by this method to meet subsequent test procedures, such as determining the washability characteristics of coal (Test Method D 4371). See the weight required by proposed subsequent test methods prior to sampling for the sieve analysis.

TABLE 3 Gross Sample Quantity to be Collected for Crushed Coals Other than Anthracitic Coal[A]

Type of Coal	Minimum Mass Required
Run-of-mine-coal	Not less than 1800 kg (4000 lb)
Screened coal with upper limit larger than 100 mm (4 in.) round	Not less than 1800 kg (4000 lb)
Coal smaller than 100 mm (4 in.) round	Not less than 900 kg (2000 lb)
Coal smaller than 50 mm (2 in.) round	Not less than 450 kg (1000 lb)
Coal smaller than 25 mm (1 in.) round	Not less than 215 kg (500 lb)
Coal smaller than 12.5 mm (½ in.) round	Not less than 45 kg (100 lb)
Coal smaller than 2.36 mm (No. 8 mesh, U.S.A. Standard)	Not less than 4.5 kg (10 lb)
Coal smaller than 600 µm (No. 30 mesh, U.S.A. Standard)	Not less than 0.5 kg (1 lb).

[A] For anthracitic coal, see 9.4.

9. Preparation and Division of Gross Sample into Test Sample for Sieving

9.1 When necessary for proper handling and division, air-dry the gross sample in accordance with Method D 2013.

9.2 In order to divide the gross sample into test samples, do sample division in accordance with the procedures outlined in Method D 2013 or Method D 2234.

NOTE 7—**Precaution:** Never reduce the topsize of a sample to be used for size analysis, that is, decreasing the quantity of a sample is allowed as long as the remaining portion is representative of the material sampled, but reduction in topsize is never allowed.

9.3 Samples may be divided according to the following schedule:

9.3.1 *Coal Larger than 25 mm (1 in.) Round*—Sieve without mixing or dividing.

9.3.2 *Coal Smaller than 25 mm (1 in.) Round*—Divide in amount to not less than 56.6 kg (125 lb) by riffling or by arranging the sample in a long, flat pile and successively halving it or quartering it by the alternate-shovel method as follows: Starting at one end of the long pile, take successive shovelfuls from the long pile using a flat, straight-edged shovel (advancing a distance equal to the width of the shovel for each shovelful), and retain alternate shovelfuls or every fourth shovelful for the sample (see Plate 1 of Method D 346).

9.3.3 *Coal Smaller than 12.5 mm (½ in.) Round*—Divide to not less than 11.4 kg (25 lb) by passing it through a riffle or equally accurate dividing device, or by the alternate-shovel method as described in 9.3.2.

9.3.4 *Coal Smaller than 4.75 mm (No. 4) Sieve*—Divide to not less than 1000 g (2 lb) by riffling.

9.3.5 *Coal Smaller than 2.36 mm (No. 8) Sieve*—Divide to not less than 500 g (1 lb) by riffling.

9.4 For anthracitic coal, the laboratory samples for sieving shall consist of the following approximate minimum amounts:

Sample Quantity: Anthracitic Coal

Size (see Table 1)	Laboratory Sample Approximate Minimum Mass, kg (lb)
pea	22.7 (50)
buckwheat #1	11.3 (25)
buckwheat #2 (rice)	4.5 (10)

9.4.1 For sizes larger than pea, use Table 3.

9.4.2 For sizes smaller than buckwheat #2 (rice) use Table 3.

10. Sample Preparation

10.1 When the test sample is not dry and free flowing because of moisture, dry in accordance with Method D 2013. The air drying apparatus shall conform to Method D 2013. For air-drying ovens, drying temperatures shall be maintained at 10 to 15°C (18 to 27°F) above room temperature with a maximum temperature of 40°C (104°F), unless ambient temperature is above 40°C (104°F) in which case ambient temperature shall be used.

10.1.1 Sufficient dryness for bituminous coals has been found to be that point during the drying process when all apparent wetness is gone and when dust appears when representative portions of the coal are dropped from a height of 150 mm (about 6 in.).

10.1.2 Where the temperature in 10.1 might have some adverse effect on the material, dry and handle with caution samples of low rank coal (for example, lignite, subbituminous, and high volatile C bituminous) (see Classification D 388) to prevent degradation during sieving. Normally, the criteria given in 10.1.1 for air drying of bituminous coals is also acceptable for subbituminous coals.

10.2 In general, sieve air-dried material; however when difficulty is encountered in obtaining reproducible results on materials difficult to sieve, particularly finer coal, and when the material is not physically altered in water, accurate sieving may be made by the wet method.

10.3 When necessary, do sample division in accordance with the procedures outlined in Method D 2013 or Method D 2234.

10.4 When subsequent testing or analysis, or both, is required, use careful judgement to ensure that sufficient material is present in all fractions.

11. Procedure

11.1 *General Considerations:*

11.1.1 Accurately weigh the test sample before sieving. Weigh with a precision equal to or better than 0.5 % of the fraction being weighed.

11.1.2 Start with the sieve having the largest required aperture (for an exception see 11.1.8).

11.1.3 Limit the portion of coal used for each sieving so that all coal particles will be in direct contact with the aperture at the completion of sieving on each successive sieve.

11.1.4 Sieve until all portions of the sample are used. Combine all separately sieved material representing a particular size-fraction but obtained from sieving separate portions of the same sample.

11.1.5 Whenever sieving through a series of sieves and the larger particles have been sieved from the test sample and the weight of the smaller sieve fraction(s) exceeds the weight for that fraction(s) as given in 9.3, it is permissible to divide the remaining portion of the test sample (the smaller sieve sizes) to not less than that weight given in 9.3 before sieving at the smaller sieve sizes.

11.1.6 Continue sieving with successive sieves having the desired size apertures until the sieve having the smallest desired size aperture is used.

11.1.7 Sieving can be done by grouping sieves having the desired size apertures, thus accomplishing the sieving in one operation known as nesting.

11.1.8 When utilizing smaller mesh sieves, especially when wet-sieving, use the smallest sieve first in order to remove clays and other extremely small materials that may blind and clog the larger mesh sieves, that is, when both 150 µm (No. 100) and 75 µm (No. 200) sieves are used, use the latter first in order to facilitate sieving. Additionally, where larger particles are present that can adversely affect the size of the sieve openings, use a cover sieve (protective sieve of a larger mesh) to keep coarse particles off the finer sieves.

11.1.9 Where possible, use sieve covers on sieve apparatus to limit dust and particle loss.

11.1.10 Weigh each size fraction of sieved coal with a precision equal to or better than 0.5 % of the fraction being weighed.

11.1.11 Note that the objective of shaking, either manually or mechanically, is to place all of the pieces of a given size on the appropriate sieve and to avoid size degradation. Coal particles greater than 600 µm (No. 30) are particularly susceptible to attrition; therefore, avoid excessive sieving time and amplitude (see 11.3.5).

11.2 *Hand Sieving:*

11.2.1 Hand sieve with a reciprocating, horizontal motion so that a particle travels over a distance of not more than 200 mm (about 8 in.). The maximum particle travel distance shall be 100 mm (4 in.) or less for 203-mm (8-in.) diameter sieves and 37.5 mm (1.5 in.) or less for 75-mm (3-in.) diameter sieves. Take care to prevent any of the coal particles from fracturing upon impact with the sieve frame or with other coal particles.

11.2.2 Manual (hand) sieving is performed slightly differently depending on the size of the coal particles.

11.2.3 *For Coal Larger than 63 mm (2½ in.) Round*—Manipulate pieces of coal not passing readily through sieves 63-mm (2½-in.) round and larger to see if they will pass through the opening in any position. Do not shake sieves 63-mm (2½-in.) round and larger except for whatever jiggling may be necessary to clear the sieves of fine coal.

11.2.4 *For Coal Smaller than 63 mm (2½ in.) Round but Larger than 6.3 mm (¼ in.) Round*—Test coal passing the 63-mm (2½-in.) round sieve with sieves down to and including 6.3-mm (¼-in.) round as follows: Move the sieve horizontally a distance of about 200 mm (8 in.) at just a sufficient rate to cause the pieces of coal to tumble or roll on the sieve. Stop the motion of the sieve without impact. After ten such shakes (five in each direction), sieving of the increment is complete.

11.2.5 *For Coal Particles Smaller than 6.3-mm (¼-in.) Round*—Use wire cloth sieves with square openings (see Table 1). Place the test sample on a clean dry sieve with the pan attached. Make, or at least complete, the test on one sieve at a time (11.2.7). While holding the uncovered sieve and pan in both hands, sieve with a gentle rotary motion until most of the finer material has passed through and the residue looks fairly free of finer particles. This operation usually takes only 1 or 2 min for sieves coarser than 150 µm (No. 100) and 3 or 4 min for sieves 150 µm (No. 100) and finer.

11.2.5.1 When the residue appears to be free of finer particles, replace the cover on the sieve, then carefully separate the sieve from the pan. Place the sieve onto a second pan that is clean and dry. Temporarily cover and move the original pan with contents aside. Hold the sieve, cover and pan firmly, turn the assembly upside down on the table, and remove the pan. Then, with the sieve and cover inverted and held firmly in one hand, gently tap the side of the sieve with the handle of the brush used for cleaning sieves. Dust adhering to the sieve and particles in the mesh will be dislodged by this action. Brush the underside of the sieve.

NOTE 8—**Precaution:** Particles could be lost while inverting the sieve or be trapped or broken. As an alternate procedure, the underside can be brushed by tilting the sieve to about a 30° angle.

11.2.5.2 Replace the empty pan onto the sieve and restore the assembly to an upright position. Tap the cover lightly and carefully remove the cover. Replace onto the sieve any coarse material remaining in the cover. Set the cover aside.

11.2.5.3 Continue the sieving without the cover, as described in 11.2.5.1 and 11.2.5.2, until not more than 1 mass percent of the material passes any sieve during 1 min of sieving operation. Combine any additional pan residue to the contents of the original pan temporarily set aside in 11.2.5.1 as product for eventual weighing. The gentle sieving motion involves no danger of spilling the residue, which is to be kept well distributed on the sieve. Continuously rotate the sieve during the sieving.

11.2.6 To determine when sieving is completed, perform the following End-Point Test: Hold the sieve, with pan and cover attached, in one hand at an angle of about 20° from the horizontal. Move the sieve up and down in the plane of inclination at the rate of about 150 times per minute, and strike the sieve against the palm of the other hand at the top of each stroke. To avoid losing particles that pass between the lid and the sieve, perform the sieving over a light-colored surface that will allow these particles to be seen and recovered. Return any material collecting on the surface to the sieve.

11.2.6.1 After every 25 strokes, turn the sieve one sixth of a revolution in the same direction. As an aid to proper sieve rotation, mark the sieve cover with three straight lines, intersecting at 60° through the center, with one of the lines marked with an arrowhead to indicate the starting point.

11.2.6.2 Continue the sieving operation until the additional material which passes through in 1 min of continuous sieving fails to change by more than 1.0 % the amount of material on that sieve. Remove material from the sieve as described in 11.2.5.1. Weigh and record the masses of these final sieve and pan products.

11.2.7 Hand sieving is the original basic method of making sieve analyses and can be used to check (calibrate) mechanical sieving results. In hand sieving, the tests are made, or at least completed, on one sieve at a time, that is, when a nest or stack of sieves is used initially, the test must still end with each individual sieve being treated in the manner prescribed in 11.2.6.2.

11.2.8 *Consistency Important to Hand Sieving*—The operator should try to be consistent with the hand sieving method to always reproduce the same circular motion and tapping action.

11.3 *Mechanical Dry Sieving:*

11.3.1 When sieving with the assistance of a mechanical sieve shaker, adhere to the general considerations given in 11.1.

11.3.2 When using mechanical sieve shakers, determine the length of sieving time best suited to the type of coal being tested, and, for shakers with variable controls, determine and establish the exact setting of the controller for best results, based on repeatability and completeness of sieving without degradation (see 11.3.5).

11.3.3 For routine plant control tests, 3 to 5 min is usually sufficient to give the desired result, while for other materials a sieving time of from 10 to 30 min is necessary. Avoid prolonged sieving time when testing friable materials subject to degradation (see 11.3.5).

11.3.4 To determine the sieving time necessary to produce acceptable analytical results, use the following procedure: from a gross sample, with the use of a sample divider, select four subsamples of a suitable mass or volume for the test. Sieve one of these samples for 4 min, a second for 10 min, a third for 15 min, and a fourth for 20 min. Tabulate the results of these tests by the percentages retained on each sieve, and the length of sieving time required to stabilize the sieving result will be readily apparent and can be established.

11.3.5 For most tests, a satisfactory time has been used when an additional 1 min of sieving fails to change by more than 1.0 % the mass on any of the sieves used.

11.3.6 Sieve tests where the ultimate in precision is desired can be set up on the basis of shaking the nest of sieves until not more than 0.5 % of the material on the finest sieve passes that sieve in a 5-min period. This is a good technique to follow when no control can be made on the type of mechanical sieve shaker to be used, or when hand and mechanical sieving are used interchangeably.

11.4 *Wet Sieving:*

11.4.1 Generally, do test sieving on air-dried (dry) material (9.1); however, if difficulty is encountered in obtaining reproducible results on materials below 600 µm (No. 30 U.S.A. Standard) and if the material is not altered physically in water, more accurate tests can be made by the wet method.

11.4.2 Wet sieving is required in any one of the following circumstances:

11.4.2.1 The material to be sieved cannot be dried because of expected deterioration or agglomeration.

11.4.2.2 The material is extremely fine and static electricity does not allow the material to be effectively dry-sieved.

11.4.2.3 Fine particles cling to coarse particles and the fine particles cannot be accurately sized with dry-sieving.

11.4.2.4 Clays are present.

11.4.3 In preparing for a wet sieve test, dry the sample to a constant mass at a temperature not to exceed 40°C (104°F) (see 10.1). Weigh to the nearest 0.1 g (for low rank coals, see 10.1.1.2). When the material readily mixes with water, place the test sample on the finest sieve, and wash it back and forth with a gentle stream from a hose in such a way that there is no loss by rising dust or splashing. For some coals, it may be necessary to use a wetting agent, such as isopropyl alcohol. When the water passing through the sieve is clear, dry the sieve containing the residue in an oven, if possible, to a constant mass and at a temperature not to exceed 40°C (104°F) (see 10.1). Avoid sample degradation that can be caused by overdrying (see 10.1.1.2). Weigh the residue to the nearest 0.1 g. Then, repeat this procedure on the coarsest sieve and then again on each sieve in descending size until the finest sieve again is reached. Combine the two segments passing the finest sieve.

11.4.4 This drying time will vary with the size of the sample and the characteristics of the coal and should be established by a series of weighing checks at intervals until no significant change occurs (less than 0.1 % of previous weight) (see Method D 2013).

11.4.5 When the material does not mix well with water, first place the dried, accurately weighed sample into an appropriate container and fill the container about three quarters full of water. Shake contents vigorously to mix the material with the water. Pour this mixture onto the sieve and perform the washing process as described above. The use of a wetting agent, such as isopropyl alcohol, providing said reagent causes no interference with sieving, can avoid this operation.

11.4.6 It is possible to perform wet sieving with a nest of sieves with a mechanical sieve shaker by equipping the shaker so that a small stream of water can be received through the top and drained from the bottom pan after passing through the nest.

11.4.7 When wet sieving, adhere to the general considerations given in 11.1.

11.5 *Combined Wet and Dry Sieving:*

11.5.1 When a sieve analysis to be made with a nest of sieves cannot be done on a dry basis because of the presence of fine particles which either agglomerate, adhere to the coarser particles, or cause blinding to the sieve openings, remove the fine particles first by wet sieving and then perform the rest of the analysis on a dry basis.

11.5.2 In the combined wet and dry method, in order to remove clays and other materials that blind or clog the larger mesh sieves, test the sample first on the finest sieve using the wet method described in 11.4.3 (use a protective sieve of larger mesh above the finest sieve to prevent damage to the finest sieve). Dry the coarse residue in accordance with 10.1 and sieve while dry in accordance with the appropriate method in 11.2 or 11.3. Express percentage results in terms of the original dry mass of the test sample before wet testing.

12. Calculation

12.1 Calculate the sum of the size fraction masses (from 11.1.9) and call the sum the combined mass.

12.1.1 Convert all masses to the same units before calculation, that is, kilograms, grams, pounds, or ounces.

12.1.2 Convert and utilize the masses of the size fractions by both multiplying and making proper use of significant figures. For example, if a size fraction weighed 11.25 kg, another 204 g, and another 148 g, determine all the masses to the nearest 0.01 kg (since 11.25 kg is reported to the nearest 0.01 kg) before proceeding with calculations, as follows:

$$\begin{array}{r} 11.25\text{ kg} \\ 0.20\text{ kg} \\ \underline{0.15\text{ kg}} \\ 11.60\text{ kg} \end{array}$$

12.2 If the percentage mass loss or gain is over 2 %, reject the analysis and make another test. The formula for the calculation of the percentage mass loss or gain is as follows:

$$\left(\frac{\Sigma M_f - M_i}{M_i}\right) 100 = \%\,M$$

where:

ΣM_f = combined air-dried mass of the size fractions (12.1), g (oz),

M_i = air-dried mass of gross sample prior to sieving, g (oz), and

$\%\,M$ = % mass loss or gain upon sieving, g (oz).

A mass gain will result in a positive percent while a mass loss will result in a negative percent. (For subbituminous coals, incorporate inherent moisture into these calculations if required.)

12.2.1 If the variation is greater than the above tolerance of 2 %, recheck the figures for possible errors in determining mass, calculating, blinding of the sieve apertures, or accidental spillage. If a calculation, transcription, or other error is detected and correctable, correct the error. If the resulting variation from initial sample weight is within the 2 % tolerance, accept and report the corrected results. If the source of error is not detected or if it is detected but uncorrectable, repeat the test. (In wet-sieving, there is often a high volume of water-coal-mineral slurry passing through the finest sieve. In some cases, where it is appropriate, flocculants can be added to the material passing the finest sieve during wet-sieving to facilitate settling of those solids.)

12.2.2 When working with small samples or when using 75-mm (3-in.) sieves, it is desirable to determine a tare mass for each sieve and pan to permit determination of masses without removal of the retained fractions. (Re-tare the sieves before each test.) There is great probability that loss of material during removal from the sieve will upset the precision of the test.

12.3 Convert the mass (11.1.10) of an individual size fraction to a percentage basis by dividing the mass of that portion by the combined fractional masses, or by the original mass and multiplying by 100. Calculate each mass (weight) percent to the nearest 0.01 % and then round to the nearest 0.1 %.

12.3.1 The sum of the fractional masses, rather than the original sample mass, can be used as a 100 % for calculation of the sieve analysis percentages. However, the percent mass loss or gain must be stated in the analytical report, and it must be stated that the sum of the fractional masses rather than the original sample mass was used to force the total of the fractional mass percentages to equal 100 %.

12.3.2 Alternatively, another common practice is to assume that a deficiency of up to a maximum of 0.5 % in the sum of the fractional masses compared to the mass of the original sample is lost as dust and can be added to the pan fraction. If this alternative practice is used, this assumption must be stated in the analytical report.

12.4 Calculate cumulative percent retained figures by adding the percentages of each individual size fraction from the largest size to the smallest size.

12.5 Calculate cumulative percent passing figures by adding the percentages of each individual size fraction from the smallest size to the largest size.

13. Graphic Presentation of Test Results

13.1 Sieve analyses often are presented graphically for comparison with specification requirements, or for general evaluation. By interpolation of the sieve analysis graph, percentage retained on or passing sieves not actually used in the test can be estimated. Similarly, the size of aperture which would theoretically retain or pass a selected percentage can be estimated, even though the sieve size was not used in the test or, for that matter, does not even exist. Determine at least six data points in order to make valid interpolations.

13.2 The abscissa of the sieve analysis graph usually represents the sieve sizes and the ordinate the cumulative mass percentages retained or passing. Scales used for the coordinates depend upon the use to be made of the results and the preferences of the user. The scale for sieve sizes can be linear (arithmetic) or logarithmic. The latter has the advantage of representing standard sieve sizes, which relate to one another by powers of the fourth root of two and an equally spaced scale (for example, the distances between the No. 4 and No. 8, the No. 8 and No. 16 and the 19-mm (¾-in.) and 9.5-mm (⅜-in.) are all the same since the larger sieve in each case has an aperture twice that of the smaller). The scale for percentages is usually linear but may occasionally be logarithmic. On the linear scale, equal differences in percentage are depicted as the same distance.

13.3 Among the several methods of graphical presentation of test results that have a wide acceptance are the Rosin-Rammler and the Gaudin-Schuhmann plots.

13.4 In the case of special mixtures, or where the sieve analysis indicates a substantial deviation from a normal gradation of sizes, a sufficiently complete sieve analysis to properly describe the size composition shall be made with sieves as indicated in 6.3 and the sieves used shall be reported as indicated in the following section, Part B "Designation of the Size of Coal from Sieve Analysis Data."

13.5 Report in accordance with Section 15.

PART B. DESIGNATION OF THE SIZE OF COAL FROM SIEVE ANALYSIS DATA

14. Size Designation

14.1 The size designation result applies only to natural continuous ranges of sizes as produced by mining, handling, crushing, screening, and beneficiation.

14.2 The designation shall indicate the range of the size by giving the upper and lower limiting sieves (topsize and bottomsize) between which 80 % or more of the sample is retained as determined by actual test data.

14.2.1 The sieve defining the upper limit shall be the smallest sieve of the series upon which is retained a total of less than 5 % of the sample.

14.2.2 The sieve defining the lower limit shall be at the largest sieve through which passes a total of less than 15 % of the sample.

NOTE 9—By contractual agreement, the percents used to designate topsize and bottomsize may be changed to meet specific requirements.

14.3 The terms for defining sizes shall be written with the upper limiting sieve first, followed by an "X" and finally the lower limiting sieve. The abbreviation "mm" or "in" shall follow the lower limiting sieve but may be omitted after the upper limiting sieve. For sieves of the U.S.A. Standard or Tyler sieve series (No. 4 and smaller), the abbreviation "No." or the word "mesh," respectively, shall be used each time a sieve is indicated.

NOTE 10—Care must be taken to designate the standard source of the sieve, for example, Tyler or U.S.A. Standard, in order to correlate the sieve number with the diameter of the openings.

14.3.1 When the total retained on the 200-mm (8-in.) sieve is 5 % or greater, the size shall be designated by reporting the lower limiting sieve preceded by "200 mm (8 in.) ×" and followed by an expression in parentheses giving the percentage over 200 mm (8 in.) to the nearest 1 % (see the first two examples of 14.3.5).

14.3.2 The size fraction of material which passes through the smallest sieve of a series, or of material which has been crushed to a certain topsize, shall be designated by the word "minus" preceding its topsize (for example "minus 28 mesh, Tyler sieve series." This size fraction can also be referred to synonomously as "−28 mesh, Tyler," "28 mesh x 0, Tyler," or "28 mesh by zero, Tyler").

14.3.3 The size fraction of material retained on the largest sieve of a series, or of material retained on any sieve in a series and all larger particles shall be designated by the word "plus" preceding the size designation (for example, "plus No. 30 U.S.A. Standard sieve series" refers to all material incapable of passing the No. 30 sieve. This size fraction can also be referred to as "+No. 30, U.S.A. Standard" or "+No. 30").

14.3.4 The type of perforated plate opening used for sizes of 6.3 mm (¼ in.) and larger shall be designated "rd" or "sq" to indicate round (rd) or square (sq) openings, respectively. This abbreviation of rd or sq shall follow the lower limiting sieve but may be omitted after the upper limiting sieve in a series where both sieves are round or square, for example, 75 mm x 12.5 mm sq.

14.3.5 The following examples illustrate the system of size designation:

200 mm x 12.5 mm sq (10 % over 200 mm)[8 in. x ½ in. sq (10 % over 8 in.)]
200 mm x 100 mm rd (24 % over 200 mm)[8 in. x 4 in. rd (24 % over 8 in.)]
100 mm x 50 mm sq (4 in. x 2 in. sq)
75 mm x 12.5 mm sq (3 in. x ½ in. sq)
50 mm sq x No. 4 (2 in. sq x No. 4)
100 x 200 mesh, Tyler
28 mesh by 0, Tyler
No. 4 x No. 30 U.S.A. Standard
25.0 mm sq x No. 50 (1 in. sq x No. 50)

14.4 Additionally, for anthracitic coal, size designation of the typically double-screened product can be defined by a descriptive, one-word term, as given in Table 1.

15. Report

15.1 Using the percentages calculated in Section 12, report the results to the nearest 0.1 %.

15.2 Use either the opening in millimetres (inches) or the number of the sieve. Designate the No. sieve by its standard source (that is, U.S.A. Standard or Tyler Series).

15.3 In the report, designate the type of perforated plate or steel-wire opening used for the sizes of 6.3 mm (¼ in.) and larger, either round or square (rd or sq).

15.4 The size designation as explained in Section 13 may be reported.

15.5 Further reports of calculations into cumulative percent passing and cumulative percent retained are also frequently requested and the analysis may be reported on this basis.

15.6 Further coal characterization tests are frequently required and these results may be reported beside the appropriate size portion percentage.

16. Precision and Bias

16.1 No precision statement (reproducibility) has been developed for this test method because of the impracticality of obtaining, transporting, and handling representative splits of the materials in the quantities that would be needed to establish the precision statement. The precision (repeatability) of this test method is being investigated by a task group. At this time, these values have not been determined. The lack of a reference material precludes a bias statement.

APPENDIX G

CORRESPONDENCE WITH WDNR REGARDING DOCUMENTATION OF TREATABILITY STUDY SAMPLE TRANSFER

WESTON®
MANAGERS DESIGNERS/CONSULTANTS
THREE HAWTHORN PARKWAY, SUITE 400
VERNON HILLS, IL 60061-1450
708-918-4000 • FAX: 708-918-4055

22 October 1992

Mr. Ed Lynch
Wisconsin Department of Natural Resources
Bureau of Solid and Hazardous Waste Management
101 South Webster Street
Box 7921
Madison, Wisconsin 53707

Re: Documenting Shipment of Treatability Study Samples
Moss-American Superfund Site (WID039052626)
Milwaukee, Wisconsin

Dear Mr. Lynch:

This letter is a follow-up to our phone conversation of 21 October 1992. During this conversation, we discussed our approach to meeting the intent of the NR 605 requirements for documenting the custody and transfer of treatability study samples from the Moss-American Superfund Site. We concluded that the use of chain-of-custody in lieu of hazardous waste manifesting would be acceptable to WDNR.

Roy F. Weston, Inc. (WESTON®) has been contracted by the settling defendant, Kerr-McGee Chemical Corp. to collect, package, and facilitate the transport of the samples to the following contractors:

- IT Corporation - Biotechnology Application Center
  9041 Executive Park Drive, Suite 309
  Knoxville, Tennessee 37923

- Bergmann USA
  1550 Airport Road
  Gallatin, Tennessee 37066

Each of these facilities holds the necessary permits and/or variances for receiving the materials and conducting such treatability studies.

The soil samples will be containerized in 20-gallon, steel drums complying with DOT-17C specifications. One 20-gallon drum will be shipped to IT Corporation and two 20-gallon drums will be shipped to Bergmann USA. The containerized samples will be appropriately labeled and transported as Environmental Hazardous Substance Solid - N.O.S. RQ, UN No. 3077, Class/Division 9. The transporter will be Federal Express Corporation.

The custody and transfer of the samples will be documented and tracked via chain-of-custody record. This document will be completed at the sample origin (Moss-American Site) and at each time the samples are relinquished. The receiving facilities (IT Corp. and Bergmann) will maintain the chain-of-custody document on file until the completion of the treatability studies. Upon completion of these studies, the samples will be recontainerized and returned to the Moss-American site utilizing similar documentation and shipping protocols.

This sample management approach has been developed and will be implemented to meet the full intent of the NR 605 requirements and thereby, will not pose any increased threat to human health and the environment.

As we discussed by telephone, I will contact you after you have received this letter, and prior to sample shipment to ensure that this information is consistent with the understanding conveyed during our discussion. If necessary, you may reach me at (708) 918-4114.

Very truly yours,

ROY F. WESTON, INC.

Gary Deigan

Gary J. Deigan
Senior Project Manager

GJD/lh

cc: G. Edelstein, WDNR
J. Schmidt, WDNR
W. Ebersohl, WDNR
B. Eleder, U.S. EPA
M. Krippel, KMCC
J. King, IT Corp.
R. Traver, Bergmann USA

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