Treatability Study Work Plan:

Cedartown Industries Superfund Site

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1 Introduction

This describes a Treatability Study Work Plan to develop a waste form for the solidification/stabilization of the heavy metal contaminated soils at the Cedartown Industries Superfund Site. This site is located at 404 Furnace Street in Cedartown, Polk County, Georgia and encompasses about 6.8 acres. This site is identified as United States of America (U.S.) Environmental Protection Agency (EPA) Region IV Site № 04-2W and Department of Justice (DoJ) Case № 90-11-3-119. A Record of Decision (ROD), issued on May 7, 1993, specifies ex-situ solidification/stabilization as the remediation technology is to be used at this site.

1.1 Purpose and Scope

This treatability study work plan will develop a formulation for the solidification/stabilization of the contaminated soils at the Cedartown Industries Superfund Site. Using locally available reagents, a series of mixes will be tested in order to determine the appropriate mix ratios of contaminated-soil, binders, additives, and mix-water. This mixture will result in a flowable grout that will form a monolithic solid. This soil-grout will be mixed on the site and emplaced into the soil's original excavation. The soil-grout mixture will solidify in-place. The final cured waste form will meet all the site-specific performance criteria and the Applicable or Relevant and Appropriate Requirements (ARARs).

In four phases, this treatability study will (1) develop an initial solidification/stabilization formula for the Cedartown Industries Superfund Site and document the selection of site-specific mix components, (2) report the resulting physical properties of the design-basis mix and the resulting cured monolith, (3) verify regulatory compliance and that the site-specific performance requirements of the waste form are met at the bench scale, and (4) perform measurements that will allow assessment of the remedy's potential impacts on human health and the environment.

Before its implementation, this work plan and its waste form, site-specific performance criteria are subject to review, comment, and concurrence by the U.S. EPA and the Georgia Environmental Protection Division (GEPD).

1.2 Site Background

The Cedartown Industries Superfund Site was founded as a foundry in 1874, known as the Cherokee Furnace. Ore for the foundry came from iron mines northwest of the site, among them the Cherokee Mine. In the 1930's, the site became known as the Cedartown Foundry and manufactured water pumps and plow blades. Also, this site has been used as a machine shop. For about two years from January 1978 to May 1980, the site was used for secondary lead smelting. The site accepted lead materials from a variety of suppliers and recycled the lead through various melting and skimming operations. The site had installed a battery cutting operation, but closed before operating it. During its operating history, slag, coke, and debris were piled on the site.

Under the direction of the U.S. EPA, an Interim Waste Removal action was completed in May, 1990. During this clean-up, 6,700 yd^3 (8,380 tons) of slag, coke, contaminated soils, wastewater and impoundment sediments were sent off-site to a landfill. Soils remaining on the site are contaminated with heavy metals, and they will be treated on-site by ex-situ solidification/stabilization.

1.2.1 Geology

The Cedartown Industries Superfund Site lies in the Ridge and Valley Province of Northwestern Georgia. The undifferentiated Knox Group forms the bed rock in this region. The Knox group is a sequence of Cambrian to early Ordivician cherty limestone and dolomite strata. These folded Paleozoic marine and continental shelf sediments are covered with a residuum that is 25 to 150 feet thick. This residuum contains clays, mainly smectites, illites and kaolinites with chert.

In the vicinity of the site, the residuum is unstratified and associated with the Cedar Creek flood-plain and channel alluvium. Cedar Creek is associated with a silted karst feature that forms a deeper aquifer at 70—100 feet. These alluvial deposits are poorly sorted silt, clay, sand, pebble and gravel. The upper surface of the site is filled up to 14 feet deep with soils from local borrow pits. The heavy metal contamination at this site is confined to the upper four to eight feet of this fill.

1.2.2 Hydrogeology

The Cedartown Industries Superfund Site is down gradient from the Cedartown water wells at Cedar Springs. There are two distinct hydrologic units at the Cedartown Industries Superfund Site. The deeper aquifer at a depth below 70—100 feet is associated with a silted karst feature. Since there is no contiguous impermeable barrier between the upper residuum and the deeper aquifer, these units are hydraulically connected. The lower aquifer is used as a local supply of drinking water.

As is common in karst regions, there is a measurable upward gradient from the deeper karst aquifer into the aquifer in the surface residuum. In evidence of this, their groundwater chemistries are very different. Therefore, there is local hydraulic gradient that forms an effective barrier preventing contamination of the lower aquifer from above. Also, site evidence indicates that the clays in the residuum are effective in retarding the movement of contaminants.

The upper surface aquifer in the residuum and fill is recharged by precipitation and discharges into Cedar Creek. This aquifer is recharged by approximately 51 inches of rain per year at Cedartown. On this site, the surface recharge is approximately 1,258,900 ft^3 per year or 9,415,200 gallon per year. The Darcy permeability in the upper aquifer ranges from $3.3x10^{-3}$ cm/s to $9.8x10^{-5}$ cm/s, which is characteristic of silty to clayey sands.

1.2.3 Contaminates of Concern (COCs)

In the two-phase Remedial Investigation, 80 samples of soil were collected from 20 boring that ranged from 6.5 to 8.5 feet deep. The principal soil contaminates that were identified above the local background included lead (Pb), cadmium (Cd), antimony (Sb), arsenic (As), and beryllium (Be). Table 1.1 summarizes some of the RI metal analyses.

Table 1.1 Summary of Remedial Investigation soil analyses

Element	Concentration Range, mg/Kg	Number of Hits	Range of Background, mg/Kg
Arsenic*	1.70**—142	80/80	.32—5.5
Barium*	11.6—4080	80/80	47—72.6
Beryllium	.059—11.3	80/80	.4—.56
Cadmium*	.43—362	58/80	.46
Chromium*	3.2—54.8	80/80	12.2—13.9
Copper	3.2**—1,150	77/80	6.5—20
Lead*	18.8—260,000	80/80	19.1—31.9
Manganese	14.9—2,840	80/80	446—492
Mercury*	.02**—.28	41/47	.03—.04
Nickel	3.7**—808	77/80	3.3—8.3
Selenium*	.64*—.81	1/47	.67**—.69**
Silver*	.54**—105	25/80	ND
Vanadium	11.2—65.2	80/80	13.7—19.2
Zinc	71.6—6,710	79/80	18.1—39.1
* Listed in Table I of 40CFR261.24 Subpart C			
** Below limit of detection for the sample.			

In general, soil contamination by lead is found at depths of two to four feet with an exception where lead was found to a depth of 6 to 8 feet (boring BH–7). Lead is the principal hazard at this site and the basis for establishing the solidification/stabilization remediation level of 500 ppm (see the ROD issued on May 7, 1993).

The locations of the highest contamination of the other metals generally follow the locations of the highest lead contamination. Figure 1 shows the site and the locations of the borings used in the RI. The highest lead contamination was found at borehole BH–4, where the lead level was 260,000 ppm. Samples for the treatability study will be collected from the soil in the vicinity of borehole BH–4 to a depth of 2—4 feet (see box in Figure 1).

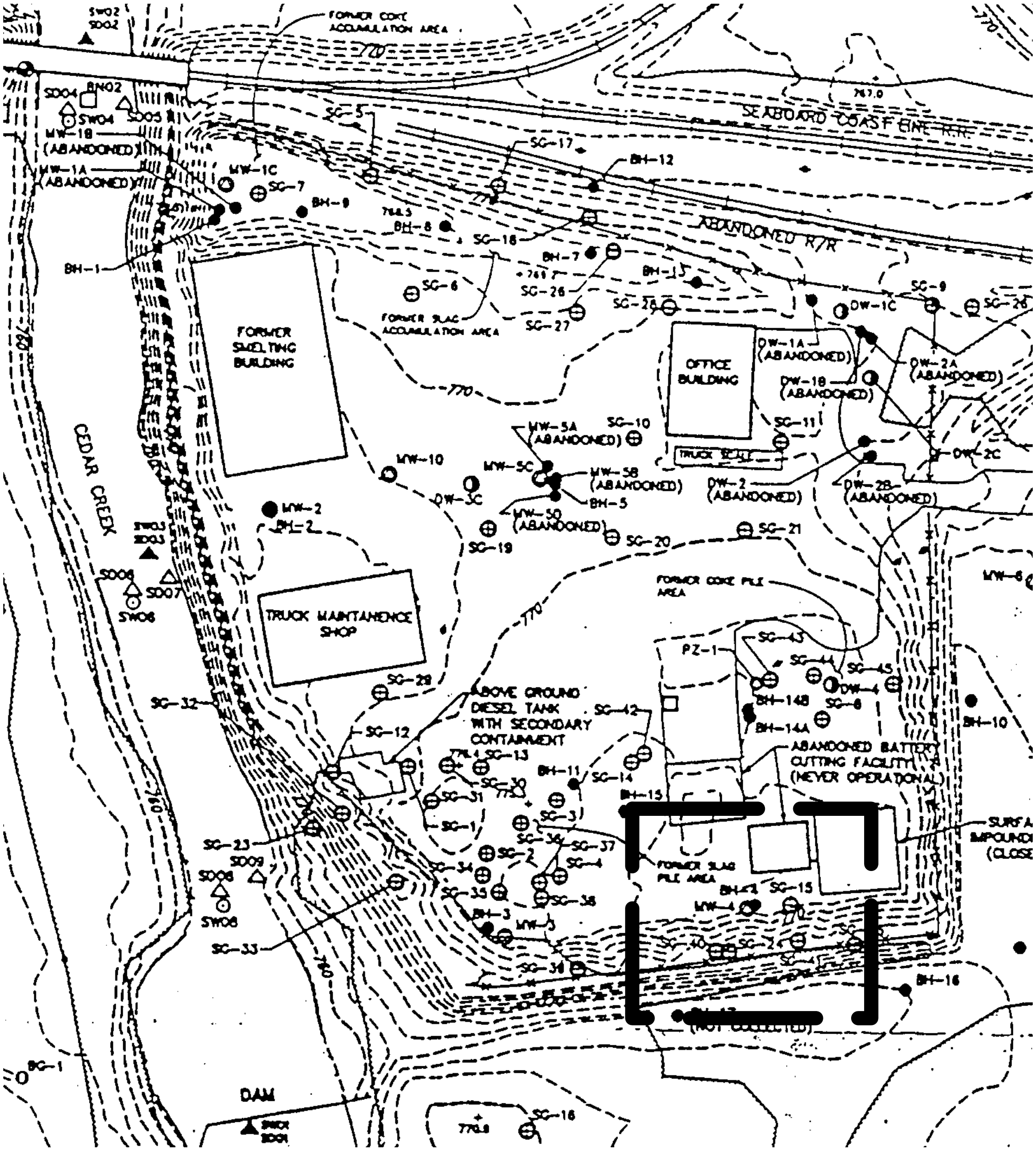

Figure 1 Site map of the Cedartown with sample locations and the treatability study sample area within the box.

2 *Treatability Study*

For this study, 75 to 100 pounds of site sample will be taken from the areas of highest contamination (BH-4). From the vicinity of Cedartown, Georgia, local binding materials and additives will be tested in a series of mixes in order to determine the appropriate mix ratios of contaminated-soil, binders, additives, and mix-water. The selected soil-grout mix and resulting monolith will meet the site-specific performance requirements.

2.1 General Approach

Solidification/stabilization immobilization technologies have three goals. The first goal is to seal the hazardous materials into an impermeable monolith. This prevents the direct contact with leachants, like groundwater and percolating rain. Then, diffusion through the waste form's mass is the only mechanism by which a contaminant can reach the biosphere and affect human health and the environment.

The second goal is to design a solid matrix that binds with the specific hazardous elements. Several mechanisms result in chemical binding in these matrices. These mechanisms shown in Figure 2 include (1) partitioning, (2) co-precipitation, (3) ion exchange, (4) mole-sieve effects, and (5) chemical reactions. These reduce the mobility of the hazards within the monoliths. Then, hazards can only leach into the biosphere below rates that can result in harmful concentrations.

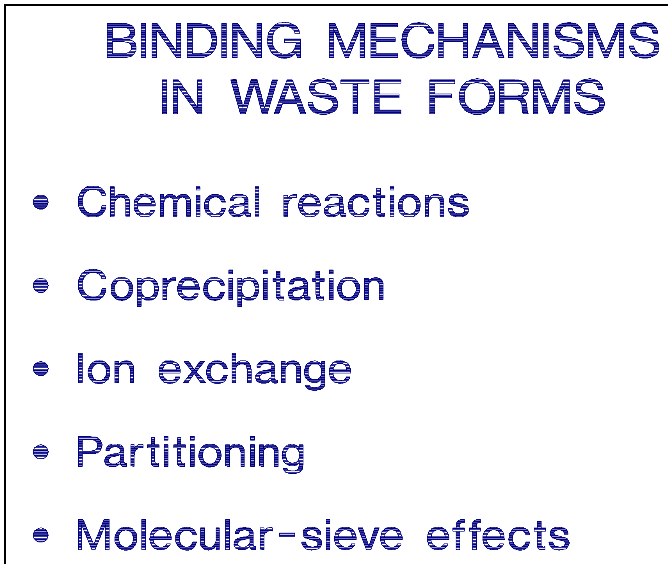

Figure 2 Summary of major binding mechanisms working in the soil-grout matrix.

The third goal is to make a durable monolith that weathers and resists environmental stresses. These stresses include (1) freeze/thaw, (2) immersion in groundwater, and (3) mechanical loads of the cap. Since these environments are site-specific, the monolith's performance requirements are specific to the requirements of that particular site. Therefore, the waste forms' physical specifications will depend on the site's climate and its geology and hydrogeology, the emplacement and disposal scenario, and the proposed final land use.

Using ancient pozzolanic building materials from Rome, Greece, and Cyprus as models, project material scientists formulate a durable, impermeable monoliths. These monoliths are compatible with the contaminated wastes and soils. These waste forms are also compatible with the site geochemistry. For example, high silica pozzolans, which are the preferred model systems, have endured between 2,500 and 5,000 years of weathering in a wide variety of climates and geochemistries from the Middle East to Scotland and northern Germany.

Using pozzolans and cement-based binders, this treatability study will be conducted in accordance with the following guidelines:

- Guide for Conducting Treatability Studies Under CERCLA, EPA/540/2-89/058, December 1989.
- Treatability Study Manual: Solidification/Stabilization, The PQ Quartz Corporation, M. Kovacs.
- Solidification And Stabilization of Wastes Using Portland Cement, Portland Cement Association, W. Adaska, S. Tresouthick, and P. West.
- Guidelines for Site Specific Treatability Studies, Environmental Remediation Consultant, L. Dole.

2.2 Proposed Performance Criteria

The waste form(s) developed by this study shall meet the following performance criteria. These requirements include federal standards and proposed site specific tests. Table 2.1 summarizes the site-specific performance criteria. Table 2.1 summarizes the site-specific performance criteria, identifies test methods, and indicates which phase of the Treatability Study applies these criteria and tests.

Table 2.1 Summary of the site specific performance criteria for the soil-grout and monolith at Cedartown Industries Superfund Site.

Performance Criteria	Test Protocol	Study Phase
TCLP: Pass	EPA SW-846 M1311	I, II, & III
Slump: 1—8", scenario specific	ASTM C143-78	I, II, & III
Free Liquid: 0%, at 24h	EPA SW-846 M9095	I, II, & III
Set-Time: 300 psi in 72h	SoilTest™ (CL700A/CT412A)	I, II, & III
Bulking: <40 vol. %	ASTM D558-82	I, II, & III
Unconf. Compress. Strength: UCS >50 psi at 28d	ASTM D1633-84	I, II, & III
Permeability: < $8x10^{-7}$ cm/s	EPA SW-846 M9100 CH	II & III
90d Immersion:<20% UCS loss	10CFR61 Reg.Guide	IV
Leach Index: >12	PSA Mod. ANS 16.1	IV

2.2.1 EPA Toxicity Characteristic Leaching Procedure (TCLP)

In the EPA Toxicity Characteristic Leaching Procedure (TCLP, EPA SW-846 Method 1311), the concentrations of all listed priority metals will be less than those listed in Table 1 of 40CFR261.24 (Toxicity Characteristic). Therefore, the final waste form will not be characteristically hazardous under 40CFR261. In the Phase I screening studies, the TCLP test will be applied to selected test specimens after 7 to 14 days of curing. In Phases II and III, the TCLP will be applied to specimens that have cured autogenically for 28 days.

2.2.2 Slump (ASTM C143-78): Ranges depend on placement

Within 10 minutes of mixing, the initial soil-grout mixes shall have a slumps of 1 to 4 inches for a placement scenario that includes emplacement by front-end loaders or trucks. In the case where a pumpable grout will be used, the initial slump shall be 5 to 8 inches. Using a 3—5 kg batch in Phase III, the slump will be measured by the ASTM C143-78 standard method. These ranges of slump will ensure that the soil-grout mix is workable under the chosen emplacement technology.

2.2.3 No Free Liquid: EPA SW846 Method 9095 Paint Filter Liquids Test

After 24 hours of curing at ambient laboratory temperatures in a closed vessel, the waste form specimens will have no bleed water (free liquid) and will pass the EPA SW846 Method 9095 Paint Filter Liquids Test. The gel-shrinkage of the mix will be controlled to eliminate the syneresis of mix water from the soil-grout during initial curing. The presence or absence of bleed water will be recorded for each test batch.

2.2.4 Penetration Set-Time: 300 psi in less than 72 hours

The soil-grout will cure autogenically at ambient laboratory temperatures and achieve a penetration resistance of greater than 300 psi in less than 72 hours. The penetration resistances of the curing samples will be measured with SoilTest™ Pocket Penetrometers (CL700A and CT421A). Since the excavation(s) will be refilled with two or more lifts (sequential pours), track or wide-tire equipment will be able to operate on top of the solidified grout within 72 hours of its pouring.

2.2.5 Bulking Factor: Less than 40% volume increase over Maximum Density at Optimum Moisture

This study develops a formula that will minimize the mass additions of binders, additives, and mix water and that will meet the site-specific performance criteria. However, the high clay content of the site soils may result in a volume increase as high as 40 % by volume over the untreated soil's volume at its maximum density. The volume increase over the unconsolidated soils may be as much as 20—30 % volume.

The densities of the untreated, uncompacted soils and the stabilized soil-grout solids will be measured by weighing a calibrated volume of sample or specimen. The water content that results in the maximum-density of the untreated soils will be measure using the ASTM D558-82 method. Volume increases based on the maximum-density of the untreated soils are more consistent than on any other basis of comparison. However, the results reported are generally higher than usually reported in treatability studies.

The volume increases of the untreated-soil to treated-soil will be calculated using (1) both the uncompacted densities and maximum compacted densities, (2) the mass additions of binders, additives, and mix-water, and (3) the final densities of the solidified soil-grouts. Depending on the fraction of smectites and illites in the soil, the final waste form density may be very close to the maximum soil density at optimum moisture. There have even been cases of a volume decreases with stabilization.

2.2.6 Unconfined Compressive Strengths (UCS): Greater than 50 psi

Unconfined compressive strengths (UCS) of the curing specimens will be measured at 7, 14, 21 and/or 28 days using the ASTM D1633-84 standard method. The final waste form shall have greater than 50 psi unconfined compressive strength after 28 days of autogenic curing at ambient laboratory temperatures.

Only 16 to 21 psi UCSs are required to support a cap or footer, respectively. This site's higher UCS requirement of greater than 50 psi results from the more stringent requirements for the monolith's low permeability to groundwater and rain.

2.2.7 Permeability: Less than $8x10^{-7}$ cm/s (Darcy)

Permeability is the most important parameter that determines the long-term durability of the monolith. Any disruptive mechanisms, such as the infiltration of chloride, sulfate, or oxygen into the monolithic matrix, will be controlled by the permeability of the solidification/stabilization binder fabric. So, immersion resistance in groundwater is controlled by the permeability. Also, low permeability is the key factor that prevents water from percolating through the monolith's mass.

Therefore, low permeability prevents advection of percolating rain and groundwater through the monolith and direct contact with the contaminants. When the monolith is 100 times less permeable than the surrounding soils, a water particle must flow around the waste form rather than through it. Therefore, the only mechanism by which a contaminant can escape into the environment is by diffusion through the fabric of the monolith. This diffusion will be controlled by the binders and additives that immobilize the contaminated soil.

The site's soil and back-fills have permeabilities between $3.3x10^{-3}$ cm/s to $9.8x10^{-5}$ cm/s (Darcy), characteristic of silty to clayey sands. Thus, a monolith with a permeability of less than $8x10^{-7}$ cm/s (Darcy) will prevent advection through the monolith at this site. The permeability will be measured using the EPA SW-846 Method 9100 Constant Head (CH).

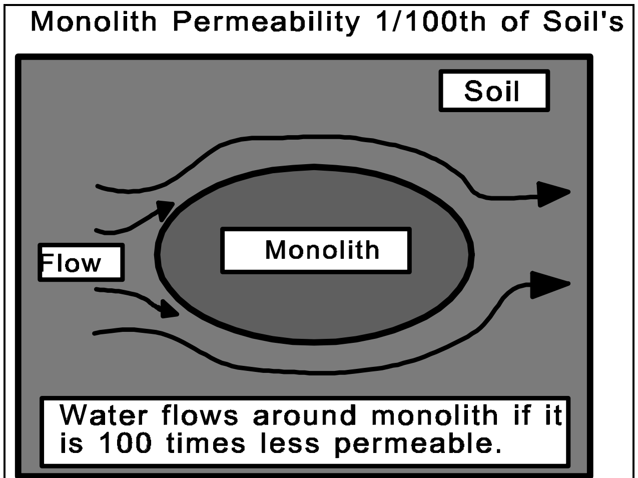

Figure 3 If the permeability of the monoltih is 100 less than the soil, advection is stopped.

2.2.8 Immersion Resistance: Less than 20 % loss of UCS in 90 days

The immersion resistance of the 28–day cured waste form will be measured during Phase IV of this Treatability Study. Using the modified Nuclear Regulatory test given in 10CFR61, Regulatory Guide, May 1983, Revision 0, the UCS will be measured after 90 days of immersion. The modification to this protocol is that the immersion solutions be changed every thirty days. This prevents the distilled water immersion-solutions from becoming saturated. Therefore, this modification results in more stringent test conditions than in the original version of this method.

After 90 days of immersion, the UCS of the exposed test specimens of 28-day cured soil-grout will not be 20 percent lower than the unexposed controls. Since these soil-grouts take up to 90—160 days to achieve ultimate strengths, pozzolanic waste forms will normally increase in unconfined compressive strength during this test.

2.2.9 PSA Mod. ANS 16.1 Leach Index: greater than 12 for lead

In Phase IV of this Treatability Study, the effective mass transport coefficients of lead (Pb) will be measured in 28-day cured, design-basis soil-grout specimens. This measurement will use the PSA Modified American Nuclear Society ANS 16.1 multiple extraction leach protocol with distilled water as the leachant. The modification to the ANS 16.1 test are (1) sample prep of soft-grout specimens, (2) statistical design, and (3) multiple blanks. The sample preparation includes a short ultrasonic-washing to remove surface particles, which is followed by a humid-air re-equilibration of the surface pores.

Because of the very low effective diffusion coefficients and the lower sensitivity of non-radiometric analytical methods, the time steps in the sequential leaching are changed to 7d, 14d, 21d, 32d, 32d, and 34d, adding up to 120 days. This revised leaching schedule will allow the measurement of lead (Pb) concentrations expected for 1" diameter samples in 100 ml of distilled water leachant.

Distilled water is chosen as the leachant because it is more aggressive than the native ground water. The groundwater is high in calcium, magnesium, carbonates, aluminates, and silicates that will coat the soil-grout surface and slow leaching. Experience has shown that conservative estimates of the contaminant releases based on effective diffusion coefficients from approach are 25—100 times higher than actually observed in the field.

The measured leach index (LI) will be greater than 12 and the effective diffusion coefficient for lead will be less than $1x10^{-12}$ cm^2/s. The leach index is equal to the negative Log_{10} of the effective diffusion coefficient. This leach index (LI) is sufficiently low that the monolith will protect the environment and human health within the boundaries of the Cedartown Industries Superfund Site. With this low of an effective diffusion coefficient, lead level in the adjacent groundwater will reflect the local soil background, and no measurable contribution from the monolith will be detectable. These conclusion are consistent with the results for the Pepper' Steel and Alloys site in Medely, Florida, the 68^{th} Landfill in Tampa, Florida, and the Norco Battery site in Ontario, California.

2.2.10 Freeze/Thaw Durability: ***Not required***

The coldest month of the year in Cedartown, Georgia is January when the average daily low-high temperatures range between 32°—55°F. There are occasional, short cold periods of only a few days with the lowest-low recorded at -9°F. A buried monolith that is protected by 12—18 inches of cover will be below the frostline. Therefore, it will not be subjected to freezing and thawing cycles.

ASTM Method D560 and ASTM D4882-90 test conditions (-20^{0}C are for exposed road and bridge deck surfaces under extreme environmental exposures. While pozzolans have demonstrated freeze/thaw resistance for millennia and can be expected to pass this test, this test is irrelevant as a performance criterium at this site.

2.2.11 Wet/Dry Durability: ***Not required***

This site receives about 51 inches of rain each year. Furthermore, the Cedartown Industries Superfund Site is on the meander of Cedar Creek's alluvial channel and flood-plain. This is a wet site, and the soil moisture varies between 15—50 percent by weight.

Since the pore structure of the pozzolanic waste form is 1—100 times finer than the surrounding wet soils, there is no possibility that a buried monolith would experience wetting and drying cycles. The smaller capillary pore radii in the monolith will always draw water from the saturated soil and its humid, vadose-zone pore spaces. Therefore, the ASTM D559 or the ASTM D4843-88 Wet/Dry tests have no relevance as a performance criterium at this site.

2.3 Soil Sample Handling and Characterization

The samples will be taken at the Cedartown Industries Superfund Site with and auger or backhoe from the area around the BH-4 borehole between depths of 0.5 to 4.5 feet. Figure 4 shows this location, which is under one of the former slag storage-pile areas of this site. About 150 pounds of soils and debris will be collected and placed on a plastic sheet. The collected soils will be homogenized in batches with a mortar mixer. The homogenized soils will be screened on-site through quarter inch hardware cloth or equivalent. The weight-fraction of the debris greater than a quarter inch will be measured and recorded. Between the mortar mixer and the screening operation, a homogeneous sample that represents the soil column between 0.5 and 4.5 feet will collected. Between 75 and 100 pounds of screened soil will be drummed and shipped under a chain of custody to the treatability study laboratory.

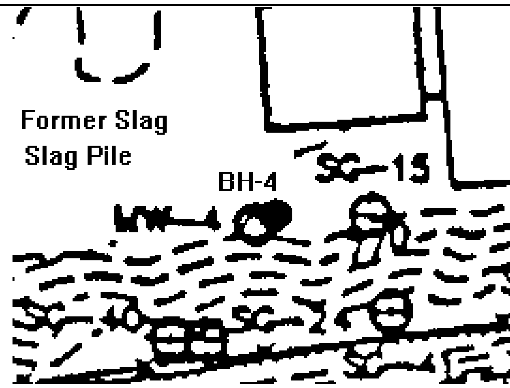

Figure 4 Treatability study samples are taken near borehole BH-4 in a former slag pile area.

2.3.1 Sample Handling and Storage

The soil samples will be taken from between depths of 0.5—4.5 feet at an area near borehole BH-4 and will be homogenized and screened to a quarter inch on the site. Screening will remove stones, wood and metal debris. This will avoid their erratic interferences with the subsequent measurements. This coarse debris will cause the measurments on small solidified soil-grout specimens to be very erratic. The debris would make the determination of the optimum formula difficult if the data were scattered and trends were not observable.

Since many of the soil-grout test specimens are between 1—3 inches in diameter, such debris will give erratic results in the UCS, permeability, TCLP, and ANS 16.1 tests. The goal here is to limit the debris size to between one-fourth and one-tenth the diameter of the test specimens. This will eliminate much of the variations in tests that are used in the critical determination of compliance with the site performance criteria.

Under conditions during the site remediation, these soils may only be screened to 3—5 inches, depending on the final processing equipment and emplacement technologies. Nevertheless, the waste form's processing character, final physical properties, and performance will be determined mostly by the finer fractions of the contaminated soil.

Since the coarse debris introduces a great deal of variation in the specimens used for testing, it is recommended that all samples be screened to a quarter of an inch in order to improve the tests' reliability and consistency. This includes samples taken to make specimens for quality assurance and quality control (QA/QC) during the remediation.

While some debris may represent significant "hot-spots" of contamination, overall most of the heavy metal contamination will be associated with the fine grained materials from this site. Ultimately, this debris will become encapsulated within the monolith's matrix and be isolated from the environment. It is the finer fractions that determine the chemical and physical processing character of the site soils.

Also, most of the contaminants are ad/absorbed on to the fine particles that have a large surface areas and high ion-exchange capacities. Therefore, the Treatability Study will use the fine materials that are less than a quarter inch.

Then, the waste form matrix, which is formed by the fine-material, binders, and additives, will control any releases from the debris. So, the ultimate performance of the remedy will be determined by the character of the mixture with the clay, sand, ore, coke, slag and other fine components in the site soil.

Once delivered to the Treatability Study laboratory under a chain of custody from the Cedartown Industries Superfund Site, the drums will be stored in a secure area with access only by authorized personnel. The drum(s), used to collect and store this soil, will have a plastic liner or coating and will be sealed with a soft rubber gasket. The drums will be stored in a controlled environment to prevent freezing or over-heating. The drums are to remain sealed a much as possible to prevent moisture losses. The drums will be opened only for short periods to remove test samples for analyses or for soil-grout formula preparations.

2.3.2 Untreated Soil Sample Characterization

First, three aliquots of the untreated soils collected at the Cedartown Industries Superfund Site will be characterized for total metals (see Table 1.1) and TCLP leaching. This will establish if the screened, homogenized sample is representative of the soil and backfill materials at the site. Also, these test will verify that the sample has lead at the higher ranges expected at the site. If the sample proves to be unrepresentative, the sampling campaign will be repeated.

If the sample has the requisite contaminant levels, the second round of untreated soil analyses will be performed in preparation for the Treatability Study. These tests include the moisture content, pH, Oil & Grease, uncompacted and compacted density, sieve fractions, and silt and clay fractions. Also, the potential calcium adsorption capacity of the soil will be measured to determine how many grams of calcium oxide (CaO) must be added to 100 grams of soil to achieve a pH of greater than 9.5 units. These data will be used in preparing the initial formulation in Phase I of the Treatability Study.

The third round of untreated soil characterizations will measure the major mineral components, including silica, alumina, iron, and carbonate. Also, the total organic carbon (TOC), and nonmetallic inorganics, such as chloride, sulfate, phosphate, cyanide, etc. will be measured. Table 2.2 summarizes these characterization tests and the methods.

Table 2.2 Summary of the untreated soil characterizations that are preliminary to the treatability study.		
Property	**Phase**	**Method**
Total Metals	First	EPA SW-846 M3050/M6010/M7000(series)
TCLP Leaching	First	EPA SW-846 M1311/M6010
Moisture	Second	ASTM D2216-80
Density (Uncpt.)	Second	Weight of calibrated volume
Density (Cpct)	Second	ASTM-D698-78
pH	Second	EPA SW-846 M9045
Oil & Grease	Second	EPA SW-846 M9071
gCaO to PH>9.5	Second	QUAL**TEC** Procedure
Sieve analyses	Second	ASTM D422-63(1972) Coarse
Silt & Clay	Second	ASTM-D422-63(1972) Fine
Major Minerals	Third	EPA SW-846 M
TOC	Third	EPA SW-846 M9060
Nonmetallic In-organic	Third	As appropriate for >% by wgt

2.4 Multi-Phase Treatability Study

In four phases, this treatability study will (1) develop an initial solidification/stabilization formula for the Cedartown Industries Superfund Site and document the selection of site-specific mix components, (2) report the resulting physical properties of the design-basis mix and the resulting cured monolith, (3) verify regulatory compliance and that the site-specific perfor-

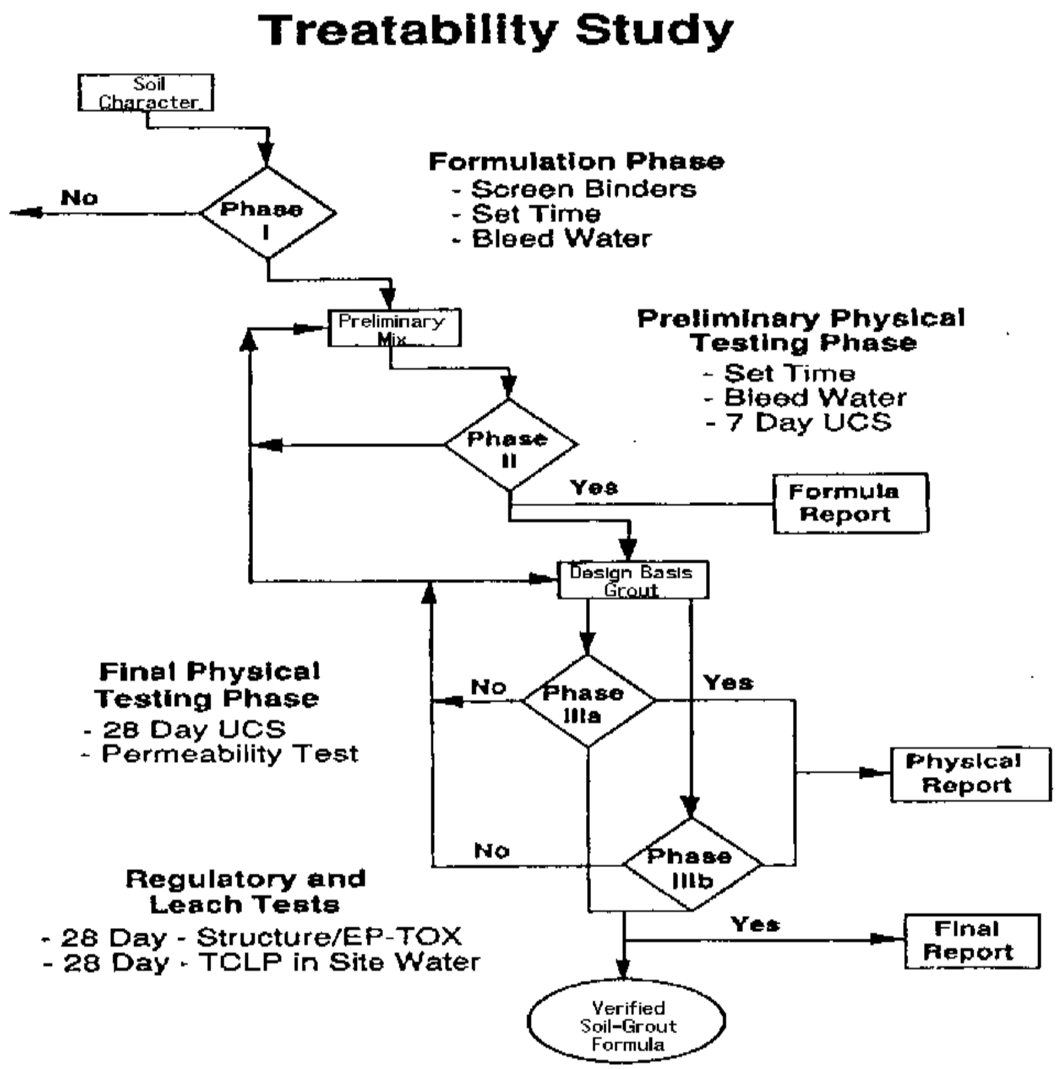

Figure 5 Treatability study logic flow diagram.

mance requirements of the waste form are met at the bench scale, and (4) perform measurements that will allow assessment of the remedy's potential impacts on human health and the environment. Figure 5 shows the decision flow diagram for the first three phases of the Treatability Study.

Using 75—100 pounds of homogenized soil, this Treatability Study performs systematic formulation and testing to ensure that a traceable and defendable waste form is chosen for the Cedartown Industries Superfund Site. This systematic approach ensures that the final remedy meets the site's specific performance requirements. Using standard methods for the measurement of performance parameters, formulations are varied to statistically determine the formula-waste interactions.

Before its implementation, this work plan and its waste form, site-specific performance criteria are subject to review, comment, and concurrence by the U.S. EPA and the Georgia Environmental Protection Division (GEPD).

2.4.1 Phase I: Initial Formulation Screening

Using the homogenized soils, a series of preliminary mixes will be made using one to two local Portland cements and two or three local pozzolans as the basic binders. In addition to these binders, two to three locally available additives will be tested. Two rounds of preliminary formulations will be prepared by varying the ratios of [a] pozzolans to cement (p/c), [b] water to binder (w/b), [c] binder to soil solids (b/s), and [d] the levels of specific additives (% by wgt.). A computer spread sheet is used to prepare and compare these parameters and convert them into a bench formula tickets. The parameters to be measured on the cured soil-grout specimens are as follows:

- Bleed water
- Set-time
- Slump (will be estimated)
- UCS (3d, 7d, and 14d)

- Bulk factor
- TCLP (7d, second round))

The composition parameters and results of the physical testing will be collated in a spread sheet. This will allow a systematic comparison of the effects of the variations in p/c, w/b, b/s and additive levels for the specific cements and pozzolans. Observable trends will be used to optimize the formulation in the second phase of this Treatability Study.

Additional rounds of formulations will be prepared if necessary to produce successful preliminary formulations that will meet or exceed the site performance criteria. At the end of Phase I, a letter report will issued that describes these preliminary formula(s).

2.4.2 Phase II: Optimization of Design Basis Formulation

Using the materials and formulas from Phase I, this phase of the Treatability Study optimizes the formula(s) in order to minimize the materials added and the bulking factor while still meeting the site specific performance criteria. a series of formulas will be prepared that test the lower limits of the binder to soil ratios (b/s) and the water added (w/b). This series will result in the selection of the design basis mix that establishes the threshold for a process control plan.

In the Process Control Plan (PCP), the field formula will take into consideration that the there are variations in the feeds of soil, binders, and additives. Therefore the field mix will be set at a higher b/s so that the lower bound on b/s and the upper bound on w/b are always met or exceeded. This ensures that the field mix always produces an acceptable monolithic waste form. The parameters to be measured in Phase II will be as follows:

- Bleed water
- Set-time

- Slump (will be estimated)
- UCS, (3d, 7d, 14d, and 28d)
- Bulk factor
- TCLP (28d)
- Permeability (28d)

The result of this phase is a design-basis mix. This mix becomes the basis for selecting the flow sheet and processing equipment. Then, a detailed and accurate cost analysis of the remedy can be made. This design basis formula and the expected variations in production are the basis for Phase III, which establishes the regulatory compliance of the selected formula(s). At the end of Phase II, a letter report will be issued that describes in detail the properties of the design-basis formula and reports all testing.

2.4.3 Phase III: Verification of Performance and Regulatory Compliance

Using at least two levels of binder to soil ratios (b/s), Phase II will make and test a final proof set of test specimens. These final round of testing will give a certified data set on all regulatory, site-specific performance criteria. The testing under Phase IV will run parallel and will collect data for risk/consequence analyses. The testing under Phase II will include the following:

Bleed water

- Set-time
- Slump (measured on 3—5 Kg batch))
- UCS (3d, 7d, 14d, and 28d)
- Bulk factor

- TCLP (28d)
- Permeability (28d)

At the end of phase III, all results will be collated and reported in a formal Final Formula Report that describes all the selection and verification testing. This includes Phases I through III. This report will describe in detail all testing and results taken during the development of the formula(s) for the solidification/stabilization remedy at Cedartown Industries Superfund Site. This report also will include all QA/QC reports, as well.

Because the Phase IV tests take so long, the results from this phase will be reported in an Addendum to the Final Formula Report. This addendum will be prepared after the completion of the ANS 16.1 and long-term immersion testing.

2.4.4 Phase IV: Measurement of Risk Assessment Data

This phase uses samples prepared during Phase III, and starts n parallel with the testing in Phase III. Phase IV takes optional longer-term data on the Leaching Index (LI) and the 90—120 immersion resistance. These tests may take as long as 100—160 days to complete, collate, and report. Therefore, their results will be included in the addendum to the final report that address the environmental consequences of the remedy at the Cedartown Industries Superfund Site.

The measurements that will be taken during Phase IV of the Treatability Study are as follows:

- PSA Modified ANS 16.1 for lead with distilled water (at 7d, 21d, 42d, 74d, 106d, and 140d - elapsed times, which are 7d, 14d, 21d, 32d, 32d, and 34d - intervals)
- NRC 10CFR61 Reg. Guide, Rev #0, 90-Immersion in distilled water (solutions change at 30d and 60d)

These data will be used in the Impact Analyses Report that will be included in the Addendum to the Final Formula Report.

2.5 Impact Models

Using the data from Phase IV, modeling of the potential effects of lead from the monolith on the environment at the Cedartown Industries Superfund Site will be done. This modeling will use the permeabilities and TCLP results from Phase III and the Leach Index for lead from Phase IV. Conservative models for water transport, rainfall, and diffusion from the monolith will predict the upper bound concentrations to be expected on this site as result of the solidification/stabilization remedy.

3 Reporting

The reporting requirements of the Treatability Study include monthly progress reports, interim letter reports on the preliminary and design-basis formulations, the Final Formula Report and the Addendum to the Final Formula Report.

3.1 Monthly Progress Report

Monthly progress reports will be submitted by the close of business (COB) on the fifth working day of each month, after the letting of the contract for the Treatability Study. This monthly report will be sent or faxed to the site manager for inclusion in the defendant's monthly report which is required under the Consent Decree from the United States District Court for Northern District of Georgia Rome division, Atlanta, Georgia.

3.2 Interim Letter Reports

Two interim letter reports shall be sent to the site manager. The first report identifies the materials tested during the screening in Phase I and reports the results of the physical tests. The second interim letter report gives a detailed account of both Phase I and II. This report will identify the design-basis formula and its physical and leaching properties.

3.3 Final Formula Report

At the end of Phase III, all results will be collated and reported in a formal Final Formula Report that describes all the selection and verification testing. This includes Phases I through III. This report will describe in detail all testing and results taken during the development of the formula(s) for the solidification/stabilization remedy at Cedartown Industries Superfund Site. This report also will include all QA/QC reports. This report will be the basis for determining the regulatory acceptability of this solidification/stabilization remedy at the Cedartown Industries Superfund Site.

3.4 Addendum to the Final Formula Report

The Phase IV long-term testing results and the Impact Analyses will be reported in an Addendum to the Final Formula Report. Because of the longer testing times of the ANS 16.1 and the 90d-immersion protocols, these data will come later than the end of Phase III. The results of Phase III will be sufficient to allow the mobilization on to the site and the initial on-site process testing. This report will be finished and approved before full-scale site operations begin.

4 *Schedule and Costs*

The following present the schedule and costs of the Treatability Study and its tasks.

4.1 Schedule

See Gantt chart , attached.

4.2 Costs

See Costs Spread sheet, attached.