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Sevenson

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TREATABILITY STUDY WORK PLAN

Area I Phase II

Trap Range Stabilization Project

Prepared For:

Fluor Daniel Fernald

Cincinnati, Ohio

Prepared By:

Sevenson Environmental Services, Inc.

Midwest Division

February 1999

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APPROVAL FORM

Treatability Study Work Plan
Area I Phase II
Trap Range Stabilization Project

2/11/99

Mike Lock, Sevenson Environmental Services, Inc.
Project Manager

2/12/99

Mike Heinen, Project Engineer
Trap Range Stabilization

2/12/99

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Project Manager

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1.0 INTRODUCTION

Sevenson Environmental Services, Inc. (Sevenson) presents this treatability study work plan for the stabilization of soils at the Area I, Phase II Trap Range site located in Fernald, Ohio. The plan presents the treatability study goals, the treatability study facility and analytical laboratory location, a sample collection plan, a description of the treatability testing, and the treatability study schedule. Project descriptions and references for the MAECTITE® process are included in Appendix A. A selected publication on the MAECTITE® process may be found in Appendix B.

2.0 TREATABILITY STUDY GOALS

The goals of the treatability study are to select a treatment mix design that will:

1. Meet or exceed the requirements of the Toxicity Characteristic Leaching Procedure (TCLP) test for lead (5.0 mg/L) and arsenic (5.0 mg/L).
2. Pass the EPA Paint Filter Liquids Test.
3. Minimize volume increase and/or dilution levels of the soils.

3.0 TREATABILITY STUDY AND ANALYTICAL LABORATORY FACILITY

Sevenson proposes to use its wholly-owned subsidiary, Waste Stream Technology, Inc. (WST) of Buffalo, New York, to perform the treatability testing, including all analytical testing. WST is located at the following address:

Waste Stream Technology, Inc.
302 Grote Street
Buffalo, NY 14207
Phone: (716) 876-5290
USEPA ID number: NYD0021100062

Facility Director: Edward Oddo
Treatability Study Director:
James Hyzy, Ph.D.
Facsimile: (716) 876-2412

WST has the following accreditations:

U.S. Army Corps of Engineers
New York State Department of Health
New Jersey Department of Environmental Protection and Energy
California Department of Health Services
Florida Department of Health
USEPA Region II - approved PCB R&D Treatability Laboratory

The laboratory is capable of analyzing multi-media samples that include soil (surface and subsurface), aqueous (ground and surface waters), drum content screening, compatibility and characterization testing, and analysis of sludges and other materials.

4.0 SAMPLE COLLECTION PLAN

Upon approval of the Treatability Study Work Plan, Sevenson will mobilize to the Trap Range Site to direct the Construction Manager in collecting samples necessary to perform the treatability study. The objective of the sampling event will be to collect soil which is representative of site contamination and, if excavated without treatment, would be defined as a RCRA D008 characteristically hazardous waste.

A composite sample will be obtained for treatability testing. Because of the variability in soil contamination at the site, a composite sample from three of the most highly contaminated areas, based on data from previous site investigations, offers assurance that a representative, characteristically hazardous sample will be collected. Using data from Table 2, Section 5.1 of the *Characterization Summary of the Area 1 Phase II Trap Range,* composite samples will be collected at or near sample locations A1P2TRAP-28-1-M, A1P2TRAP-20-1-M, and A1P2TRAP-5S-1-M in the 0-3" depth interval as shown on construction drawing G002 of the bid documents.

Sample locations will be determined by a Sevenson representative, and will be collected by a Fluor Daniel Fernald (FDF) sampling team. Each sample will be collected with a soil trier composed of a stainless steel coring tube, a stainless steel bucket auger, or trowel. Sampling instruments will be decontaminated prior to sample collection.

Samples from each of the locations will be composited into a single bulk sample container. Sevenson will utilize a decontaminated 5-gallon container fitted with a locking lid, which is amenable for shipping. Sevenson anticipates that one (1) 5-gallon container filled 3/4 full will be a sufficient volume of material to complete the treatability study. This represents approximately 35-45 lbs. of material. The material will be mixed to apparent homogeneity in the field with a spatula prior to being sealed with the locking lid. Alternatively, if frozen soil precludes homogenization on-site, soil may be homogenized upon receipt at WST. FDF will provide a radiation technician to ensure samples are in compliance prior to shipping. As part of routine procedure, WST scans all incoming samples for alpha and beta emissions.

The bulk sample, designated as FERA1P2TRAPTS, will be shipped under chain-of-custody by common carrier to WST. The chain-of-custody form that accompanies the sample will indicate whether homogenization will be required by WST laboratory personnel.

5.0 TREATABILITY TESTING

Treatability testing will be performed on soils from the project site in accordance with the contract documents. Treatability testing will consist of the following general steps:

1. Initial soil characterization.
2. Phase I - soil treatments.
3. Analyses of Phase I soil treatments.
4. Phase II - volume change analysis.

5.1 Initial Soil Characterization

Upon receipt at WST the samples will be logged and weighed. The container will then be opened and, if necessary, the contents will be thoroughly mixed to apparent homogeneity. Aliquots of material will be removed from the 5-gallon pail as needed for both characterization and treatability mix design preparation. The bulk sample will be mixed prior to removal of any aliquot. After sub samples are removed for analysis or preparation of a mix design, the 5-gallon sample container will remain sealed. Initial characterization parameters and methods are listed in Table 1. Should the initial soil characterization indicate that the sample does not fail any TCLP criteria for lead, the site soils will be re-sampled.

Table 1
Initial Soil Characterization
Area I Phase II Trap Range

Parameter	Method
Soil Digestion	USEPA SW-846 Method 3051
Total Metals (Pb, As)	USEPA SW-846 Method 6010
TCLP Extraction	USEPA SW-846 Method 1311
Metals in TCLP Extraction Fluid (Pb,As)	USEPA SW-846 Method 6000/7000
pH (TCLP Fluid Determination)	USEPA SW-846 Method 9040
pH of Soil	USEPA SW-846 Method 9045
Specific Gravity	SM 2710F
Moisture Content	ASTM D2216
Bulk Density	ASTM D4254

Other observations that will be made during the initial soil characterization will include a physical description of the soil sample, any handling problems, physical and chemical uniformity of the material, and volatile emissions of concern.

5.2 Phase I - Soil Treatments

WST will investigate the use of various concentrations of MAECTITE® liquid reagent over various reaction times in order to determine the most technically feasible and cost-effective *in situ* regimen. Specifically, five dosage rates by weight (0.5%, 1%, 2%, 3%, and 4%) over four reaction intervals (1, 3, 7, and 14 days) will be evaluated. Dosage rates and reaction times are listed in Table 2. In addition, a control microcosm, amended with deionized water alone, will be run in parallel to the MAECTITE® treated microcosms. Because water is usually added to distribute MAECTITE® throughout the soil, the control microcosm will be useful in interpreting volume changes associated with MAECTITE® plus water versus those attributable to the addition of water alone. The quantity of water added will be documented for use during full-scale application.

Table 2
Stabilization Mix Design Formulations to be Evaluated
Area I Phase II Trap Range

Reagent Type	Dosage (% mass)	Reaction Time (days)
MAECTITE® Liquid	0.5	1, 3, 7, 14
MAECTITE® Liquid	1.0	1, 3, 7, 14
MAECTITE® Liquid	2.0	1, 3, 7, 14
MAECTITE® Liquid	3.0	1, 3, 7, 14
MAECTITE® Liquid	4.0	1, 3, 7, 14

Preparation of treatability samples will consist of removing a 500g aliquot from the bulk sample container for every treatment mixture to be evaluated. The material will then transferred to a polypropylene mixing basin where reagents and water will be added to the sample. The sample will be mixed with a wooden spatula until the treatment chemical is incorporated fully into the soil/water admixture. The mixing will be performed using a back-and-forth folding motion to simulate the mixing technique to be used in the field during full-scale processing (back-and-forth folding motion with excavator bucket). Test samples will then be allowed to react at ambient conditions for the specified curing time prior to analysis.

5.3 Analyses of Phase I Soil Treatments

Phase I analyses will assess TCLP leachability of lead and arsenic and other parameters for each MAECTITE® liquid reagent dosage rate and reaction interval listed in Table 2. Phase I will examine the change in moisture content of the different reaction times primarily to identify the quantity for dust control and reagent distribution which are needed during full-scale operations. Treated soil characterization parameters and methods are listed in Table 3.

Table 3 Treated Soil Characterization Area I Phase II Trap Range	
Parameter	**Method**
Soil Digestion	USEPA SW-846 Method 3051
Total Metals (Pb, As)	USEPA SW-846 Method 6010
TCLP Extraction	USEPA SW-846 Method 1311
Metals in TCLP Extraction Fluid (Pb, As)	USEPA SW-846 Method 6000/7000
pH (TCLP Fluid Determination)	USEPA SW-846 Method 9040
pH of Soil	USEPA SW-846 Method 9045
Paint Filter Test	USEPA SW-846 Method 9095
Specific Gravity	SM 2710F
Moisture Content	ASTM D2216
Bulk Density	ASTM D4254

Other observations that will be made during the treated soil characterization will include a physical description of the soil sample, any handling problems, physical and chemical uniformity of the material, and volatile emissions of concern. Sevenson will utilize the results of the Phase I analyses to determine which dosage rates and reaction times are appropriate for evaluation during the Phase II volume change analysis. If a dosage rate fails to meet the TCLP and/or Paint Filter criteria in Phase I, it will be not be included in the Phase II analysis.

5.4 Phase II - Volume Change Analysis

Phase II of the treatability testing will be conducted in order to determine the change in volume as a result of soil remediation. Sevenson will determine the number of samples to be implemented in Phase II based on the ability of the treatment designs to meet TCLP objectives and reduce analyte

mobility. A minimum of two samples will be utilized in Phase II. The objective of the volume change analysis is to determine the percentage volume change as measured at the earliest reaction time that the mix design achieves acceptable TCLP results. These volume changes will be compared to any changes observed in a deionized water control microcosm.

The analysis will be conducted by measuring the volume that 1000 g of untreated material occupies within a cylinder of known volume. This will be known as V_1. Percentage moisture will also be measured and recorded in the raw sample and recorded as M_1. Selected Phase II mix designs will then be replicated using 1000g samples and allowed to cure for the optimal set-time. The material will also be placed in the cylinder of known volume and the volume occupied by the sample will be recorded as V_2. $V_2 - V_1$ will determine the change in volume as a result of treatment, and the percentage change can be calculated as follows:

$$\% \text{ Volume Change} = (V_2/V_1 \times 100) - 100$$

(+) value = volume expansion

(-) value = consolidation

Sevenson believes that this is most representative of the true increase in volume at optimal reaction time as a result of treatment. However, moisture content will also be measured in the treated sample after optimal reaction time and recorded as M_2. If the percentage moisture in treated material at optimal reaction time is greater than the percentage moisture in untreated material ($M_2 - M_1 = \Delta M$), then the volume that ΔM occupies in a graduated cylinder will be subtracted from V_2 and the percentage volume change will be calculated with this correction.

6.0 TREATABILITY STUDY SCHEDULE

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A Sevenson representative will be sent to the site upon approval of the Treatability Study Work Plan. Initial soil characterization will proceed upon receipt of the soil sample from the site. It is expected that the soil treatments and analyses will take place over a period of 3 to 4 weeks.

A Treatability Study Report will be submitted to FDF no longer than 15 calender days after completion of the treatability study. A final report will be submitted after review and comment by representatives of FDF.

APPENDIX A

Project Descriptions and References

SEVENSON ENVIRONMENTAL SERVICES, INC.
MAECTITE® TREATMENT PROCESS
AGENCY REFERENCES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

- Headquarters

  PQOPS FSS Technical Evaluation Manager
  Dr. Harry Compton
  Telephone: 732-321-6751

- Region I

  On-Scene Coordinator
  Mr. Richard Leighton
  Telephone: 617-573-9654

- Region V

  On-Scene Coordinator
  Fred Bartman
  Telephone: 312-886-0776

- Region VII

  On-Scene Coordinator
  Jim Kudlinski
  Telephone: 913-551-5152

- Region VIII

  On-Scene Coordinator
  Dave Christenson
  Telephone: 302-294-1154

Summary of Experience: STABILIZATION, SOLIDIFICATION, AND CHEMICAL FIXATION

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Project Name and Location	*Scope of Work*	*Contact for Reference*	*Contract Value (000's)*	*Year Completed*
MASSACHUSETTS MILITARY RESERVATION Cape Cod, MA	In-situ and ex-situ MAECTITE® treatment of 36,500 tons of military firing range soils. Prior to ex-situ treatment lead fragments were screened and stockpiled for potential lead reclamation. Treated material was returned to the berms for reuse.	Mr. Richard Leighton USEPA, Region I 617-573-9654	$3,000	1998
PCB SEDIMENT REMOVAL RIVER RAISIN Monroe, MI	Dredge, decant, and solidify 30,000 cy of PCB contaminated river sediments. Construct a 150 gpm PCB/TSS wastewater treatment facility, a 3.5 acre sediment containment unit for landfilling of solidified sediments	Ms. Pamela Dodt 313-323-7808	$6,000	1998
BP CHEMICAL, INC. MIXED WASTE POND CLOSURE Lima, OH	Construct 2 on-site lined cells. Excavate and stabilize 30,000 cy mixed waste sludge; place treated sludge and contaminated material into cells; cap cells and restore site.	Mr. Larry Vanderembse 419-226-1234	7,800	1998
CHAMBERS WORK "B" BASIN/DITCH Deepwater, NJ	Construct a temporary enclosure to isolate material handling activities. Excavate 1,200 linear feet of ditch and sidewall sediments. Mix spoils with reagents and transfer to onsite vault. Install new drain pipe and restore site.	Mr. James Ackes 302-992-5829	3,000	1997
BURLINGTON NORTHERN Crawford County., MO	In-situ chemical fixation of leachable lead and cadmium contaminated soil and debris utilizing the MAECTITE® process. Treatment, transportation and disposal of 60,000 tons of impacted material.	Ms. LaDonna Sawyer 770-454-1810	3,400	1997
PUROLATOR PRODUCTS Elmira, NY	Construct a 1 acre landfill cap. Excavate creek sediment, stabilize, and transport and dispose offsite. Install a groundwater recovery and treatment system.	Mr. Jim Skaggs 918-481-2565	3,700	1997
WHITEMAN AIR FORCE BASE Whiteman Air Force Base, MO	Ex-situ chemical fixation of highly contaminated rifle range soils. Leachable lead ranging up to 15,500 mg/l TCLP. Preprocessing followed by ex-situ treatment of 5,400 tons of heavy clay material. All material treated to below 5 mg/l TCLP.	Mr. Stace Daul 513-595-7523	350	1997
DOE RUN RESOURCE RECOVERY CORP. Boss, MO	In-situ chemical fixation of 4,200 tons of highly contaminated slag and matte process residuals from secondary lead smelting operations.	Mr. Doug Bice 573-626-3406	150	1997
LAWRENCE LEAD Lawrence, KS	In-situ chemical fixation of lead contaminated soil immediately adjacent to homes. Treatment, excavation, transportation and disposal of 250 yards of lead impacted soil.	Mr. Morris Kay 913-341-8240	20	1997

Project Name and Location	*Scope of Work*	*Contact for Reference*	*Contract Value (000's)*	*Year Completed*
MYRTLE BEACH AIR FORCE BASE Myrtle Beach, SC	In-situ chemical fixation of lead contaminated rifle range and ditch soils. Treatment of 5,500 tons of soil to below 5 mg/l TCLP.	Mr. Dan Bowholtz 423-694-7320	200	1997
YONKELOWITZ JUNKYARD Hoopston, IL	Contracted to provide MAECTITE® chemicals and technical support for treatment of 6,000 tons of lead contaminated soil. Work completed by USEPA Region V ERCS contractor.	Mr. Fred Bartman 312-886-0776	$50	1997
LORD CORPORATION PONDS SITE Bowling Green, KY	In-situ remediation of 5,300cy of clay and 160,000gal pond water contaminated with lead and oil using the MAECTITE® process. Reduced leachable lead form 420 mg/l to <5 mg/l prior to bioremediation of oil and disposal offsite. Soils less than 2,000 ppm total lead were treated and left onsite under an impermeable clay cap and vegetative cover.	Mr. George Kickel 814-868-0924 Ext. 3393	600	1996
RED RIVER ARMY DEPOT Texarkana, TX	In-situ remediation of ~5,000 cy of soil contaminated with lead and TPH using the MAECTITE® process. Reduced leachable lead from 460 mg/l to <1.5 mg/l.	Ms. Renita Foster 903-334-4117	150	1996
BLACKHAWK IRON & METAL SITE Waterloo, IA	In-situ remediation of 50,000 cy of soil contaminated with lead using the MAECTITE® process.	Mr. Jim Kudlinski 913-551-5152	600	1996
BASIN A-3 CLOSURE Nitro, WV	Ex-situ solidification of 15,000 cyds non-hazardous sludge. Construction 2 acres cap.	Mr. Anthony Tuk 304-759-4204	500	1996
FRONTIER CHEMICAL PENDELTON SITE Pendleton, NY	Dewater 40 million gallon Quarry Lake. Excavate and stabilize 35,000 cy lake sediment. Excavate 20,000 cy lake perimeter soils; place soils and stabilize sediments under cap. Construct 8 acre multi-layer cap. Construct 1,300' collection trench and leachate treatment plant.	Mr. John Burns 615-336-4057	3,600	1996
ROBINS AIR FORCE BASE Warner-Robins, GA	In-situ solidification of 23,000 cy of sludge in a 1.5 acre lagoon. Treated sludge is excavated and transferred to an existing on-site landfill.	Mr. Robert Evers 615-435-3198	7,400	1996
RCRA LAGOON CLOSURE Trenton, Michigan	RCRA lagoon closure requiring dredging and dewatering of 35,000 cyds lagoon sludge; wastewater treatment of 25 million gallons to comply with NPDES permit; solidification of cake and sediments.	Mr. Pat Pearce 313-671-4509	5,500	1995

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Project Name and Location	Scope of Work	Contact for Reference	Contract Value (000's)	Year Completed
CARTER INDUSTRIALS INC. SITE Detroit, Michigan	Excavate, characterize, transport and dispose of 30,000 tons of non-hazardous waste; 30,000 tons of PCB contaminated material. Chemical treatment of 5,000 cyds lead waste using the MAECTITE® treatment process prior to disposal. Demolition of two smelter facilities and one incinerator.	Mr. Ian McRae 519-884-0510	$7,000	1995
MARATHON BATTERY SITE Cold Spring, NY	Dredge Hudson River cove; dewater and excavate marsh lands; excavate vault; stabilize 170,000 tons dewatered sediments and excavated soils; install 1,900' dike for tidal fluctuations in contaminated areas; demolish plant building.	Mr. Jim Cronmiller 216-953-5044 Mr. Paul Marano 610-558-3300	Confidential	1995
PETTIT FLUME SITE Phase II North Tonawanda, NY	Sheeting and shoring for deep excavation and removal of Lockport water line. Remove, stabilize, transport DNAPLs for disposal. Backfill, site restoration.	Mr. James Havass 716-286-3588	3,000	1995
WILKES COUNTY LANDFILL SITE North Wilkesboro, NC	Treatment of lead contaminated soil and debris using Sevenson's proprietary MAECTITE® chemical fixation process.	Mr. John Sapper 1-800-334-7245	100	1995
ANHEUSER BUSCH PROPERTIES, INC. Block 195 St. Louis, MO	In-situ chemical fixation of 2800 tons of lead contaminated soil exceeding the RCRA regulatory threshold of 5mg/1 TCLP using Sevenson's proprietary MAECTITE® process.	Mr. Joseph Abernathy 314-577-7026	250	1995
GM, INC. PLANT SITE REMEDIATION (Phase I & II) North American Truck Platform Janesville, WI	In-situ chemical fixation and staging of 7,700 tons of lead contaminated soils ranging from 6 - 85 mg/l TCLP lead using Sevenson's proprietary MAECTITE® process. Project completed in 2 phases to accommodate plant expansion project period.	Mr. Michael Merrick 608-756-7686	525	1994
ZABEL BATTERY SUPERFUND SITE (PQOPS) Sioux Falls, SD	Ex-situ chemical fixation of over 11,000 tons of lead contaminated soil and debris found to contain 96 mg/l TCLP lead using the one-step MAECTITE® chemical treatment process. Transportation and disposal of treated material as non-hazardous special waste.	Mr. Dave Christenson USEPA, Region VIII 302-294-1154	419	1994
BAY CORRUGATED CONTAINER SITE Monroe, MI	Excavation, treatment, and staging of 17,500 tons of lead contaminated soil using Sevenson's proprietary MAECTITE® chemical fixation process.	Mr. Jim Cronmiller 216-953-5044	1,000	1994
US FEDERAL COURTHOUSE AND OFFICE BUILDING St. Louis, MO	In-situ chemical fixation of 6850 metric tons of lead contaminated soil and building debris using Sevenson's proprietary MAECTITE® process. The process was applied in conjunction with excavation for a new building foundation for a 60 story courthouse structure.	Mr. Steve Paquette 314-421-5700	$530	1994

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Project Name and Location	*Scope of Work*	*Contact for Reference*	*Contract Value (000's)*	*Year Completed*
MELROSE HEIGHTS LEAD SITE City of Columbia, SC	In-situ chemical fixation of 1,000 tons of lead contaminated sandy soil containing 2.5% lead content using Sevenson's proprietary MAECTITE® treatment process. Post fixation excavation, and transportation and disposal to an offsite subtitle D landfill.	Ms. Jackie Pruitt 803-733-8232	240	1994
OLD SILT POND RCRA CLOSURE Baton Rouge, LA	This RCRA closure involved the in-situ solidification of oil refinery impoundment wastes. Volume of material exceeded 200,000 cy. Treatability studies indicated that generic reagents available locally would meet solidification criteria. A unique aspect of this project was the "teaming" arrangement between Sevenson and the owner, Exxon Company, USA.	Mr. James Attebury 713-656-7387	10,000	1993
CABLE FLUFF STABILIZATION AND REMOVAL PROJECT Orange, Texas	Treatment of 4,700 cy of lead contaminated cable fluff using MAECTITE®, a proprietary stabilization technology. Transportation and disposal of treated fluff.	Confidential per Client Request	550	1993
DIRTY WATER DETENTION BASIN RCRA CLOSURE Baton Rouge, LA	This RCRA closure involved the in-situ solidification of oil refinery impoundment wastes. Volume of sludge solidified exceeded 15,000 cy in a 2-acre impoundment. Depth of sludge exceeded 15 feet in spots. Treatability studies indicated that generic reagents available locally would achieve solidification criteria. This project was performed by Sevenson on a "teaming" basis with the owner, Exxon Company, USA.	Mr. James Attebury 713-656-7387	2,000	1992
WILDCAT LANDFILL SITE Dover, DE	Stabilize and cap a 5-acre contaminated wetlands area. Create a 5-acre wetlands area to replace the stabilized area. Place 30,000 cy of imported fill on landfill bare spots.	Mr. John Taylor 215-627-1443	2,430	1991
IMPOUNDMENT CLOSURE Waterford, NY	Stabilization/solidification of 10,000 cy of waste; cap; construct 6-acre landfill.	Mr. Mark Moses, P.E. 518-266-3520	4,000	1989
DRIPOLENE POND CLOSURE Ponce, Puerto Rico	This RCRA impoundment closure involved the solidification of 60,000 cy of hydrocarbon sludges. The solidified material was excavated and disposal of in an onsite vault. A 25-acre clay cap was constructed to cover the impoundment landfill, and plant site.	Mr. L. Scott Magelsson 203-794-5620	$5,000	1988

Rifle Range Cleanup
Whiteman Air Force Base, Missouri

Date Performed: 13 January 1997 - 13 April 1997
Specific Role of Company: Treatability Studies; Ex-situ treatment of soils; Incidental construction; Material handling; Disposal; Laboratory Services

ROLES OF KEY PERSONNEL FROM PROPOSAL	
Michael Lock	Project Manager
Chris Rice	Treatability Study Manager
Rance Sundquist	Site Superintendent

Client Contact: Mr. Stace Daul
Project Manager
Whiteman AFB, MO
513/595-7523

Treatability Studies Performed: Total Pb; TCLP Pb; pH, Moisture Content – before and after treatment. 9 different bench-scale mix studies with varying doses of reagent.

Quantity and Nature of Material Stabilized: 5,400 tons of firing range soils with high clay content.

Stabilization Method and Admixtures Used: MAECTITE® and MAECTITE® reagent

Contract No. : 22-K776-01-S97-0096
Contract Type: Firm/Fixed unit price - Catalog Price
Final Contact Amount: $329,460

In the Fall of 1996, Sevenson was awarded the remediation and ex-situ treatment of highly contaminated rifle range soils at Whiteman Air Force Base, Missouri. Total lead in the firing range soils at this site ranged up to 22.9% with leachable lead ranging up to 15,500 mg/l in the untreated soil. After treatment with the MAECTITE® process all soil met the treatment criteria of 5.0 mg/l TCLP. Ancillary site tasks included improvement of the haul road for site access, loading of untreated material into the treatment system, and off-loading/handling of treated material.

Once mobilization and system shakedown/optimization was completed, Sevenson processed an average of 250 tons/day of material under severe winter freeze/thaw and spring rain conditions without a batch failure. The contract was modified at the clients' request for an additional 3,000 tons of material. All work was completed by the stipulated contract date of April 15, 1997.

Lead Soils Treatment
General Motors North American Truck Platform
Janesville, Wisconsin

Date Performed: June - November 1994 (Phase I) and June 1995 (Phase II)
Specific Role of Company: Treatability Studies; Full-scale in-situ treatment of soils; Incidental construction; Material handling; Workplan development; Disposal; Laboratory Services

ROLES OF KEY PERSONNEL FROM PROPOSAL	
Michael Lock	Project Manager
Chris Rice	Treatability Study Manager
Rance Sundquist	Process/Site Superintendent

Client Contact: Mr. Michael Merrick
General Motors
608/756-7686

Treatability Studies Performed: Total Pb; TCLP Pb; pH; Moisture Content – before and after treatment. 3 different bench-scale mix studies using varying doses of MAECTITE®.

Quantity and Nature of Material Stabilized: 6,000 tons of loamy (with some clay) soil contaminated with paint cleaning operation residuals.

Stabilization Method and Admixtures Used: MAECTITE® and MAECTITE® reagents

Contract No. : N/A
Contract Type: Guaranteed Maximum
Final Contact Amount: $525,000

The General Motors North American Truck Platform Plant in Janesville, Wisconsin planned to expand its assembly operations for its highly popular Suburban vehicle. In the area of the intended facility expansion, soil containing leachable TCLP lead in the range of 6-85 mg/l was found. The construction schedule for the new facility could not be compromised to allow for the extended period needed for a hazardous waste treatment permit. In addition, the cost to excavate, transport, treat, and dispose of the hazardous waste off-site was significant. The MAECTITE® process was selected to insure that all material targeted for removal was excavated as a non-hazardous solid waste. The state of Wisconsin Department of Natural Resources was appraised of the remedial approach and provided its consent.

In order to accommodate ongoing assembly plant production, and the construction chronology, Sevenson applied the MAECTITE® process in-situ to affected soil in two (2) phases. Areas of soil that contained less than 5.0 mg/l TCLP lead limit were identified prior to Sevenson's mobilization. The in-situ application involved spraying the liquid reagent onto the soils in a grid pattern, followed by mixing the soils with a flat-edged excavator bucket in a back-and-forth folding motion.

The first phase consisted of approximately 4,000 tons and the second nearly 2,000 tons of soil. During each action, soil was determined to be non-hazardous by an independent laboratory as a result of MAECTITE® processing prior to its transportation by rail car to a licensed non-hazardous solid waste landfill. Each area was backfilled, compacted, and restored to comply with final grade specifications established by GM.

The in-situ MAECTITE® application allowed GM to meet construction schedules without jeopardizing ongoing vehicle production and resulted in savings by eliminating the need to transport and dispose contaminated soil as a hazardous RCRA waste.

Lead Soil Remediation
Phase I Crawford County Sites, Crawford County, MO

Date Performed: November 1996 - November 1997
Specific Role of Company: Treatability Studies; Full-scale treatment implementation; Workplans; Laboratory Services (including mobile lab); Regulatory support; Transportation, Disposal of treated materials

ROLES OF KEY PERSONNEL	
Michael Lock	Project Manager
Chris Rice	Treatability Study Manager
Rance Sundquist	Site Superintendent

Client Contacts: Mr. Dave Clark, Burlington Northern
(913) 435-2216
Ms. LaDonna Sawyer, Applied Environmental Science
(770) 454-1810

Treatability Studies Performed: Material was characterized for total, TCLP metals, pH, grain size distribution, and percent moisture. Bench-scale mix studies to determine appropriate amounts of reagent.

Quantity and Nature of Material Stabilized: 61,000 tons (for sites completed to date) of residues from metal mining operations

Stabilization Method and Admixtures Used: MAECTITE® and MAECTITE® reagents

Contract No.: N/A
Contract Type: Unit Price Contract
Final Contact Amount: $3,100,000 (for sites completed to date)

Sevenson was contracted to perform remediation operation at multiple sites. Treatability studies were conducted and Sevenson proposed an innovative processing technique that would allow material to be remediated in-place prior to excavation. The approach avoided RCRA part B permitting issues for the client, achieved quick approval from the Missouri Department of Natural Resources, and facilitated the fast-track removal efforts mandated by the state at these sites.

The cleanup effort began in the fall of 1996, when Burlington Northern selected Sevenson to remediate and remove material from two sites in Central Missouri. The primary contaminants at the site were lead and cadmium each leaching above the RCRA regulatory threshold of 5.0 and 1.0 mg/l TCLP respectively. Total lead ranged from 20,000 - >200,000 mg/kg and total cadmium ranged from 60-

500mg/kg. Leachable lead ranged from 10 - 500 mg/l TCLP and leachable cadmium ranged from 0.9 - 5.0 mg/l TCLP. The matrix consisted primarily of residues from metal mining operations to produce lead and zinc. Past practices utilized the material as fill in residential, commercial, and industrial settings without controls.

After completion of comprehensive treatability studies; preparation of Remediation Work Plan; Health and Safety Plan; and assistance in regulatory negotiations, Sevenson mobilized to a residential site where operations were initiated. A laboratory was mobilized to the site to provide expedited analytical services on a continuous basis throughout the project. Site haul roads were established, the site was cleared, and a building was demolished prior to in-situ MAECTITE® processing. Sevenson then processed 18,000 tons of contaminated soil prior to excavating. The in-situ application involved spraying the liquid reagent onto the soils in a grid pattern, followed by mixing the soils with a flat-edged excavator bucket in a back-and-forth folding motion. Once excavated all material passed the TCLP test and was transported offsite to a subtitle D landfill facility. The site was regraded and re-vegetated.

Sevenson then mobilized to a nearby industrial site. Treatability studies confirmed the same type of contamination existed at this site, at somewhat higher levels. The material was historically placed immediately adjacent to an active rail spur and extended nearly one mile along the rail line with no controls. An in-situ treatment method was again selected. Once excavated all material was loaded, transported, and disposed in a RCRA Subtitle D landfill. A total of sixty-one thousand tons of material (at both sites) was processed in-situ to below the RCRA regulatory threshold for lead and cadmium without a batch failure.

Sevenson is under contract to remediate an additional 26 sites for this client, expecting to treat more than 40,000 tons of lead-contaminated soils.

APPENDIX B

Selected Publication - MAECTITE® Process

2017

MAECTITE® CHEMICAL TREATMENT TECHNOLOGY: SELECTED CASE HISTORIES FOR LEAD AND CADMIUM

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MAECTITE® CHEMICAL TREATMENT TECHNOLOGY: SELECTED CASE HISTORIES FOR LEAD AND CADMIUM

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ABSTRACT

Chemical treatment for lead and other heavy metals, including cadmium, in soil and solid waste with the MAECTITE® process creates hard, insoluble mixed mineral forms. Heavy metals are rendered non-hazardous under RCRA definition, therefore, treated material may be disposed as a special waste. The MAECTITE® chemical treatment process forms non-leachable minerals through isomorphic reaction-series induced nucleation.

Unlike cementitious, silicic, and/or pozzolanic methods where contaminants are restrained in a mixture with binding agents or hydroxides subject to degradation from physical and chemical conditions, MAECTITE® utilizes true bonding and crystal nucleation from disassociated metal species and yields metal-substituted crystal compounds. The metal-substituted crystal precipitates are in the hexagonal and orthorhombic crystallographic systems that are stable in acidic, alkaline, and other environmental settings. Succinctly, mixtures are readily degraded/separated by physical and chemical forces; compounds are not.

Waste subjected to optimized MAECTITE® chemical treatment complies with RCRA limits as determined by USEPA's EPTOX and TCLP test methods, and the Multiple Extraction Procedure (MEP) that simulates 1000 year exposure to acidic environments. The MAECTITE® chemical treatment process often reduces waste volume by over 20% with limited or no mass increase partially due to increased particle density, eliminated interstitial space, dehydration of the waste matrix, and destruction of semi-stable carbonates. Although water is required as a reagent mixing lubricant, treated material complies with the paint filter test and chemically cures within 3-5 hours. Increased curing times allow liberated and reagent mixing waters to evaporate.

Complete success of the MAECTITE® process at full-scale production levels for all projects attempted to date is partially attributed to treatability studies that apply the technology to specific wastes at the viability, bench, and engineering-scale levels. Under extensive and rigid QA/QC, treatability results have been upscaled to full production on over 200,000 tons of hazardous material. Wastes treated have included: all types of soil; peat and humic material; debris and construction rubble (BDAT); paint and abrasives; foundry sands and smelter slag; auto fluff; ore processing residuals; lead shot and shooting range sand with spent projectiles; carbon dross; landfill contents; glass; battery casings and lead battery parts; wastewater; filter cake and sludges; aquatic sediments; wire chop; and organic API separator sludges with tetraethyl lead (TEL). No leachable lead bearing waste/material has been identified to be resistant to the MAECTITE® chemical treatment process.

Full-scale production rates onsite have ranged from a few (48) 55-gallon drums in one day to over 2000 tons in a 12-hour production shift. MAECTITE® processing is accomplished insitu or exsitu, and in batch or continuous modes of operation. Heavy metal levels in untreated material have ranged up to 29.9% total lead and TCLP lead to over 4,000 mg/l.

The patented MAECTITE® chemical treatment technology has been accepted into the USEPA SITE program, included in the US/German Bilateral Agreement, and was nominated for the 1991 President's Environment and Conservation Challenge Award. Technology improvements are currently patent-pending.

EXECUTIVE SUMMARY AND BACKGROUND

This paper presents typical approaches to the evaluation of the MAECTITE® technology for use on lead and heavy metal bearing waste streams and materials ranging from treatability scale viability demonstrations to full-scale project applications. In addition, a brief technology history and technical overview is presented with analytical data

supporting a range of applications to various lead bearing materials. Finally, two (2) full-scale projects are examined that depict a range of project magnitudes and complexities that incorporated common MAECTITE® technology application forms.

OVERVIEW OF MAECTITE® TECHNOLOGY

In the early to mid-1980's, traditional treatment of heavy metals in soil and solid waste utilized physical binding and hydration mechanisms to create structures that immobilized heavy metals by lattice containment, encapsulation, entrapment, absorption/adsorption, and/or aggregate interlock. Unfortunately, effective treatment results as indicated by the USEPA's EPTOX method were achieved at the expense of waste matrix mass and volume increase due to bulking (therefore, possible analyte dilution) from stabilization and solidification agents and hydrated water.

Although EPA leach tests (currently including TCLP and expanding to include MEP methods) were used to examine leachability of metal analytes in acidic conditions, material treated by cementitious, silicic, and pozzolanic methods required extended periods of curing prior to treatment compliance determinations by costly and lengthy geotechnical test methods. The geotechnical methods such as unconfined compressive strength and permeability were (and are) required to demonstrate that the physical binding mechanisms of the end-product mixtures central to the stabilization process could withstand rigorous physical conditions that may be encountered in final waste placement areas.

The elevated cost to site remediation projects stemming from treated-waste mass and volume increase (transportation and/or final disposition), prolonged project durations owing to treated waste curing times and analytical needs created a situation where an alternate treatment approach had to be found. Furthermore, treatment product longevity and stability concerns associated with physical mixtures raised liability issues for waste generators, PRP's, and waste disposal facilities. These issues led to a rethinking and reevaluation of traditional stabilization/solidification methods.

In industrial, accidental and landfill situations, the organic and inorganic components of a soil are not necessarily formed under chemical equilibrium. Likewise, the behavior of metal ions is even more highly involved with a large number of possible process interactions with ill-defined dissolved and particulate components.

The control of problem metal ions has been a long sought quest by a large number of researchers, especially physical chemists. An enormous effort has been spent by these researchers in determining and tabulating mineral solubility data and curves for pure-phase solids. Studied as absolutes, pure-phase solids are not natural; and certainly, pure-phase solids are not what one encounters in industrial, accidental and landfill situations. Researchers rigorously trained in basic mineralogy, geochemistry and material science have taken a different approach, non-pure and coprecipitated intertwinned mineral-solids.

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The MAECTITE® chemical treatment process is a classical mineralogy and geochemistry approach to control of problem inorganic ions through mineral dissolution-precipitation reactions by the formation of a suite of isomorphic mineral-solids through the manipulation of non-problem inorganic ions. As defined by the mineralogist, isomorphism occurs when an ion at high dilution is incorporated by mixed (unlike) crystal formation into a precipitate, even though such formation would not be predicted on the basis of crystallographic, and ionic radii. This is very different from that of the physical chemist, where isomorphism is a chemical state in which various elements or molecules enter into a greater or lesser degree the crystal-lattice of a mineral-solid without causing any marked change in the crystal morphology and stay within the same crystallographic system.

In the broader sense, the MAECTITE® chemical treatment process advantageously accesses the isomorphic relations that exist between a series of mineral-solids of analogous chemical formulas and crystallographic structures. This concept accounts for elements or molecules of distinctly different chemical character, and even of different valence, substituting for each other without changing the general geometry of the crystalline forms. The analogous formulas possess an equal number of atoms and of positive and negative components while analogous crystallographic structures are composed of geometrically similar basic crystal-units in which an equal number of atoms are arranged in a geometrically similar manner. Sometimes the crystallographic system does change, but only into a system with compatible basic crystal-units (e.g. a rhomb). To the mineralogist, this phenomenon is termed twinning.

When the relative size of the atoms and certain of their physical properties (e.g. specific gravity, optical properties, etc.) are nearly the same, one has a potential Isomorphic situation. This situation can be explained by Pauling's electronegativity potential. If two elements or molecules have a similar radii and the same charge, the one with the lower electronegativity potential will be preferentially concentrated in early formed specimens of the crystallizing mineral-suite.

Many have noted the undersaturated conditions of most waters encountered in nature. The control mechanism is not known, but is believed to be coprecipitation and the high electrostatic condition produced during precipitation events. The surface charges of particulates in natural waters, which may arise from chemical reactions at the surface, by lattice imperfections at the solid surface, by isomorphic replacements within the lattice structure and by adsorption of surfactant ions which is strongly Eh-pH dependent. Eh-pH relationships are the most definitive element in near or at surface soil conditions. Eh-pH

diagrams are constructed as "absolute-pure" mineral solids which is not the actual situation found in natural, industrial, accidental, and landfill settings. Eh reflects the abundance of available electrons in the environment; thus, a large number of electrons equates with a reducing environment while an absence of electrons equates with an oxidizing environment. Correspondingly, pH represents an abundance of accessible protons with a large number of protons representing an acid environment and a scarcity of protons representing a basic environment. Since electron and proton particles have opposite charges, one would expect that an abundance of one particle would translate into a shortage of the opposite particle. Thus a high Eh, an oxidizing situation, would have a concurringly low pH, an acidic situation.

Plainly, Eh-pH are effects of H+ ion activity which is the major control of solubility in the MAECTITE® chemical treatment process. The convenience of Eh-pH diagrams is the coincident plotting of the interactions of dissolved materials only, dissolved materials and other natural solids, and reactions between two or more solids. Crystallographic geometry, the type of bonding on and near the surface of crystals, the size of the individual mineral crystals, the chemical character of the participating solution, and pressure and temperature relationships are a few of the principal parameters controlling behavior of problem inorganic ions.

Thus, fixation of problem ions and simultaneous admittance into the solid phase is by: 1) unsatisfied valence produced by broken bonds at surfaces and edges of mineral-solids; 2) unbalanced charges caused by isomorphic substitution; 3) dissociation of OH- radicals, when the H+ may be readily exchanged; 4) accessibility of atoms in crystallographic positions when brought to the exchange site as a result of a change in environment; 5) availability of exchangeable constituents in the mobile phase; 6) Eh-pH relationship; 7) general chemistry of the environmental setting; and 8) pressure and temperature conditions.

True mineral dissolution-precipitation reactions have long been the ideal for control of problem inorganic ions. Precipitates tend to carry out of solution other constituents that are normally soluble, causing a coprecipitate. Barriers to precipitation commonly arise because of changes in pH, in oxidation potentials, or ionic concentrations of precipitating salts. Direct precipitation of metal compounds may take place when minor external changes occur, such as mixing with other waters, temperature change, addition or subtraction of gases (i.e. oxygen, carbon dioxide, methane, hydrogen sulfide) or interactions with solids.

Mineral-solids are said to be isomorphic if they have the same type of formula and crystallize in similar geometric forms. If the precipitating mineral-solids are within the same crystallographic system, or compatible systems, no interference to the precipitation event occurs, a phenomenon dreaded by industrial/analytical physical chemists and engineers, but long sought by remediation scientists.

Those cognizant of the problems with waste geochemistry felt that if metals in soil or solid waste could be converted to stable forms without waste bulking, water hydration, and physical binding mechanisms, remedial project costs and long-term stability issues could be resolved. Fundamental to the concept was the scientific differences between mixtures and compounds where mixtures are degradable by physical forces and compounds are not. Unfortunately, soils and solid wastes are mixtures and create parallel problems never encountered in chemical laboratory conditions as defined in the purest empirical or clinical sense.

Since the MAECTITE® chemical treatment technology incorporates the heavy metal species/ions into complexed molecular structures as compounds, they cannot be degraded or separated from the matrix in leachable form by simple physical forces, except under extreme pressure and heat. This is clearly supported by heavy metal concentration data obtained from extraction fluid after treated material exposure to intense ultrasonic energy for extended periods of time. Non-MAECTITE® treated material using physical binding mechanisms cannot withstand such ultrasonic energy as the endstructures are weakened and/or disintegrated allowing exposed analytes to disperse (Frick's First Law) into extraction fluids.

Long-term stability examined from the chemical perspective by evaluating treated waste integrity after prolonged exposure to acidic conditions becomes the critical component to treated waste longevity, not geotechnical testing. The MEP test was designed by EPA to simulate 1000 year exposure to acid rain and leachate. More importantly, the serial acid extractions chemically overcome the buffering capacity of treated material. Often, primarily with cements and hydroxide treatment methods, unnecessary and excessive treatment additives are applied to the waste so that the leaching test methods (e.g., EPTOX and TCLP) cannot overcome the buffering capacity of the treated waste during the limited extraction duration. Buffering capacity is of critical importance in all hydroxide and hydration treatment approaches.

Examination of published solubility products for metallic hydroxides will reveal that most all metals are insoluble at various alkaline pH ranges. Once the buffering capacity of a waste containing metals is exceeded with acidity, the hydroxides will disassociate, physical binding mechanisms weaken, and metals will leach. MAECTITE® formed mineral crystal compounds are not conducive to degradation in acidic, neutral, or alkaline conditions, hence they remain geologically stable.

Practical application of the MAECTITE® chemical treatment process is culminated by successful full-scale application on hazardous material and waste. Since the technology's inception, over 200 treatability studies have

been completed on various material matrices at bench, engineering, and pilot-scale projects with 15 projects addressed at full-scale. A summary of pre- and post-treatment analytical data lead for bearing material is presented in Table I.

CASE HISTORY I: MARATHON BATTERY SUPERFUND SITE, COLD SPRING, NY

The Marathon Battery Superfund Site in Cold Spring, New York is located on the east bank of the Hudson River approximately 50 miles north of New York City. The site's environmental significance is enhanced by its proximity to historic locations such as West Point and the Catskill Mountains. Part of the site contains "Constitution Marsh", a sensitive aquatic ecosystem that is characterized by tidal influence and backwater areas of the Hudson River fiord. Heavy metal presence, primarily cadmium and to a lesser degree, lead, were the result of operations from a now closed battery manufacturing plant.

The Marathon Battery Site consists of three (3) areas that required remediation. They include: the former battery plant facility grounds and vault; a continuous pond and cove area; and East Foundry Cove (EFC) Marsh.

Prior to site remedial activity, extensive site preparations were required. A wide range of work zone conditions were encountered from submerged sediments in quiescent backwaters and flowing river, soupy marsh material, dense clays, coarse gravels and fine sands, and rock cobble. Significant flexibility was required for material handling, preparation, and treatment processing. The magnitude of the site surface area, and the quantity of material to be treated and disposed further added to the complexity of the site. Of critical concern was the high tidal influence zone of the Hudson River as it fluctuated in the cove and marsh areas. This had to be controlled to prevent contaminant migration during excavation and erosion during restoration.

The command and control area for the site consisted of numerous support trailers for office space, decontamination facilities, meeting facilities, tool and spare part storage, a comprehensive onsite laboratory, and a sampling and archive facility. Other substantial support services including electrical power, telephone services, parking for over 100 site workers and visitors were required.

As part of the site setup, clearing and grubbing, and construction of a bermed, contoured and sumped seven (7) acre asphalted pad was required. This was used to stage the two 1000-ton per day MAECTITE® treatment systems, a 2000 gallon per minute water treatment system, and excavated waste soils and treated material during curing and testing phases. Sevenson also installed a two (2) mile railroad spur with railcar scales for treated material transport.

To delineate the horizontal and vertical extent of cadmium and lead contamination, all areas targeted for remediation in addition to those requiring installation of constructed site support services, had to be surveyed. The site was fenced for security purposes.

Prior to any site remediation, the MAECTITE® chemical treatment process had to be demonstrated to the satisfaction of the site PRP Committee, the USEPA, the U.S. Army Corps of Engineers, the state of New York, and the community of Cold Spring, New York for each area targeted for remediation. Since complete characterization of the site was not known (i.e., the highest levels of lead and cadmium that were to be encountered) treatment demonstration efforts were exasperating. For QA/QC purposes, Sevenson utilized a cadmium and lead spiking and treatment procedure that satisfied all concerned parties at the treatability level and before conducting 250-ton lot full-scale demonstration treatments on actual site materials.

In the laboratory at the engineering level, Sevenson was able to support treatment objectives for TCLP test methods stipulated by the lead regulatory agency. In addition, the selected disposal facility's operating permit required compliance with the EPTOX method, and the PRP Committee required that long-term stability of treated material be examined using the Multiple Extraction Procedure. Treatability data from the pre-remedial studies are presented in Tables II and III.

Sevenson implemented several value engineering cost saving elements. Most significant was the partial replacement of an earthen dike with a bladder water-structure that controlled water flow produced by tidal influences on the Hudson River. Sevenson substantially reduced the "footprint" of the dike, lowered the earthen material elevations, and brought the control measure in compliance with high-water levels and the 100 year floodplain limit. The water-structure was approximately 12 feet thick, 6 feet tall, and wrapped around the marsh:pond/cove interface (approximately 1700 linear feet), effectively isolating EFC Marsh. The water-structure's overall elevation could be adjusted by pumping in or releasing water until the correct surveyed elevation was achieved. The use of the water-structure eliminated the import of thousand's of yards of fill material to construct the dike, and its removal during final site restoration. Under the original design, a waiting period of 12 months was required for the earthen dike to settle in the marsh area prior to remedial implementation.

Another value engineering cost saving was the removal of rock and stone from excavated soil prior to treatment by the screening to diameters greater than 1.25 inch. The oversize material was washed and rinsed to remove all surficial total cadmium and lead (<20 mg/kg) verified by total metal testing followed by TCLP testing to insure it was not hazardous. Decontaminated material was then utilized for backfill during site restoration. This reduced the amount of material to be treated and transported off-site for disposal.

The most substantial value change to the project was the use of the MAECTITE® chemical treatment process.

Original remedial treatment designs for the site specified the use of Portland Type I cement at ratio's ranging up to 50 percent by weight with the waste to be treated. By demonstrating the effectiveness of the MAECTITE® process to all regulators and the PRP's, reagent costs were substantially reduced as was the final mass and volume of material transported offsite for disposal. Treatment dosages of MAECTITE® reagent averaged 3 to 5 percent, with the highest dose of 12 percent applied to select worst-case site material.

The application of MAECTITE® reagent was controlled onsite by a dedicated full-scale laboratory. Material prior to treatment was subjected to various treatment designs at the bench-scale level to verify required dosages. Optimized reagent addition was then utilized by treatment system operators to maximize process efficiency.

Health and safety concerns were of great importance, especially since residential homes were located along one perimeter of the site. A sound and dust isolation barrier was erected along this segment of the property. Comprehensive water spraying activities were used to prevent dry soil and control dust conditions.

For purpose of clarity in this paper, each of the site remedial areas will be discussed separately.

East Foundry Cove Marsh

The marsh presented a difficult remedial problem. Material from the area consisted of thick cattail and aquatic vegetation above contaminated marsh sediments entwined with significant tendril root mass. The sediments, peaty with high characteristic plasticity, were water saturated and could not bear any load associated with even foot traffic. Sevenson designed, built and operated an amphibious hydraulic backhoe excavator and amphibious dump vehicles. These tracked vehicles displaced only 4-6 inches when empty and operating in the marsh.

Prior to excavation, the area was surveyed, gridded at 50 feet nodes, and sampled for total cadmium and lead. Quadrants where contamination was identified to be above site action levels were labeled for removal and subsequent treatment.

The wetland classification of EFC Marsh required Sevenson to accommodate final restoration plans from project inception. After remediation and contour restoration, the area had to be replanted with offspring from the original vegetative plant species. Sevenson, in conjunction with the local Audubon Chapter, collected seeds and plants from the predominant species from throughout the marsh. Vegetative patterns associated with marsh contours and water levels had to be mapped for seed collection and project end restoration. Seeds and plants from the ecosystem were taken from the site, germinated and cultured in a controlled environment for later site replanting.

After seed and plant collection in the fall of 1993 by National Audubon Society volunteers, vegetation above the marsh grade was cut and removed prior to subgrade material removal. Each of the grids were excavated to the proper depth with the amphibious excavator and the material transferred directly to the flotation dump trucks. When full, the tracked flotation dump vehicles delivered material to the asphalted staging pad.

The excavated and staged marsh material was too wet, plastic, and clumped with root mass to allow for direct feed to the MAECTITE® treatment system. Sevenson utilized industrial disks and tracked vehicles to work the material in lifts and break up the root tendrils while staged on the pad. After material was prepared, it was transferred to piles adjacent to the MAECTITE® treatment system, ready for feed and treatment.

During marsh excavation, Sevenson maintained dewatering activities from surface water runoff, and groundwater intrusion to excavation areas. These fluids were pumped to the onsite treatment system, treated, and discharged under the former facility's NPDES discharge permit.

Upon completion of marsh excavation where the area was remediated to a total cadmium level of <100mg/kg, the site was graded and contoured to near pre-project conditions allowing for marsh water channels, "humps", and other distinct natural geomorphic features. A bentonite mat was then placed over all disturbed areas, and final fill material was placed in accordance with pre-construction soil/sediment profiles.

As the project nears completion, (~ 2.5 years ahead of schedule), and after the water-structure and dike removal, approximately 80,000 aquatic plants will be set at 2 feet centers in a vegetative pattern that replicates the marsh's original conditions. Currently, while remediation is still proceeding in the outer cove and pond areas, Sevenson is maintaining the water and siltation control measures. Erosion control of the exposed marsh surfaces has been accomplished by the seeding of the contoured areas with a rye grass.

With the marsh area remediation completed except for peripheral areas near material handling corridors, Sevenson has excavated, dewatered, prepared, and treated with the MAECTITE® process approximately 20,000 cubic yards of material. Cadmium was the predominant contaminant present in the material ranging up to 0.1% as a total metal, and 125.2 mg/l in TCLP extract in untreated material (See Table IV). All material was successfully treated to below 1.0 mg/l cadmium as measured by EPTOX and TCLP methods. All treated material was removed from the site by rail car and transported out-of-state for disposal by internment as a non-hazardous waste.

Plant Facility

Soil beneath and surrounding the former battery manufacturing facility contained elevated levels of leachable and total cadmium. In addition, previous site remediation activities resulted in the placement of highly

contaminated cadmium sediments in a vault area constructed onsite.

Sevenson utilized grid sampling methods to identify contaminated areas, and applied standard excavation methods to remove all impacted material above the site cleanup action level. Excavated material was screened to less than 1.25 inch nominal diameter. Soil fines were transported by dump truck to the treatment area for MAECTITE® processing.

Oversize material was decontaminated by washing and rinsing to remove cadmium and lead contaminated soil fines. Successful decontamination of the oversize material was verified by sampling and total metal analysis. The material was then staged for use in the final restoration phase of the project as backfill. All wash and rinse waters were pumped to Sevenson's water treatment system for subsequent discharge.

Cadmium levels in the plant ground and vault soils ranged from 0.25% to 14.68% total cadmium with TCLP cadmium ranging from about 5O mg/l to 180.2 mg/l. 25,000 cubic yards of material were successfully treated to below 1.0 mg/l TCLP and EPTOX cadmium.

Cove and Pond

Contaminated pond and cove sediments were located beneath the Hudson River's backwater extending to depths ranging from 3 to 7 feet below the water surface. These subsurface sediments were removed (currently in progress) using hydraulic dredging methods. The dredge was fitted with an adjustable cutter head that pumped solid material and liquids at a flow of up to 1800 gpm with a solid content of ranging from 3 to 8% by weight. Each pass of the dredge over a specific surveyed sampling grid removed approximately 6-12 inches of deposited sediment material. Root mass and woody materials were shredded by the dredge cutter head and pumping system. Oversize rocks (>6 inch nominal diameter) were removed by a rock box. Sediments and water were pumped by the dredge through 8 inch fusion-welded plastic piping over distances exceeding 5000 linear feet, depending upon location of removal operations.

All dredge fluids were originally planned to be dewatered by centrifuge technology. Resultant centrifuge cake was to be treated by the MAECTITE® process with aqueous residuals treated by Sevenson's water treatment. Substantial variation in sediment particle constituents (silt, sand, bits of vegetation, detrital material etc.) prevented efficient dewatering by the centrifuge approach.

Sevenson then constructed two dewatering basins (650,000 and 550,000 gallon capacities) piped in series for removal of dredge-spoil solids. The supernatant from the basins was treated in the water treatment system with clarified and settled solids dewatered in three (3) plate and frame filter presses. Cake from the presses was conveyed to the MAECTITE® treatment system for heavy metal treatment. Periodically, the settling basins were excavated of accumulated solids, which were, in turn, treated by the MAECTITE® process along with the filter cake.

Although the process change from centrifuge technology to plate and frame methods created some limited disruption, the end result was far superior than had been originally planned as significant volume reduction was achieved stemming from high solid content of the filter cake. This further minimized the amount of material requiring treatment and offsite disposal.

One isolated area distal from the contiguous site, where cadmium had been detected, was also remediated. A submerged discharge outfall from the former plant to the Hudson River in the vicinity of Cold Spring's municipal pier was identified. Sediments in the former outfall's plume area were removed by hydraulic dredge and clamshell methods within silt curtain control structures. Material was either pumped to the settling basins or delivered by barge to an offloading point and then trucked to the MAECTITE® treatment system pad. An estimated 10,000 cubic yards of material were removed from the pier area and treated by the MAECTITE® treatment process.

Dredging activities are still in progress in the cove and pond areas. It is anticipated that approximately 70,000 cubic yards of material will have been removed from beneath the standing/flowing water level, dewatered and treated with the MAECTITE® process. To date, total cadmium has ranged up to 1.35% and TCLP cadmium to 198 mg/l. All prepared material has been successfully treated to below the 1.0 mg/l limit for both TCLP and EPTOX cadmium.

Once the dredging has been completed, silt control fencing, and the dike and water-structure will be removed between the pond/cove and the marsh. The marsh replanting will then be initiated.

MAECTITE® Processing Equipment

To meet treatment production levels with confidence, two (2) process systems with a capacity of approximately 1000 tons per day were mobilized to the site, setup, and operated. By using two systems, planned equipment services, treatment reagent deliveries, and soil/material excavation schedules could further accelerate the project. It was felt that if only one larger system was used, mechanical problems and other downtime could compromise the overall site schedule.

Each MAECTITE® processing systems utilized a tracked excavator to introduce material to the feed hoppers from staged piles of prepared waste. Conveyors in the hoppers carried material through a dual shredder for sizing. The shredded material was then conveyed across a weigh-belt feeder where instantaneous and totalized mass were measured.

The weigh-belts were integrated to ratio controllers that activated MAECTITE® reagent storage silos and automated feeder belts. The logic center in the control panel was programmed on a regular basis, or as needed, depending

upon specific waste treatability results generated by the dedicated onsite laboratory. As the rate of waste feed varied, so did the rate of MAECTITE® reagent.

As the MAECTITE® reagent and the waste material were delivered in parallel to the pugmill mixer, water was added to insure proper mixing. Each mixer then directly discharged blended soil and reagent into a "Moxie" dump vehicle. When full, the dump vehicle transferred material to bins for curing, and subsequent confirmatory sampling and testing.

Storage bins were constructed with cement "jersey barriers" placed on the bermed, contoured, and sumped treatment pad. The 250-ton capacity bins were labeled for treatment "lot" tracking. When curing was completed after approximately 3-5 hours (longer in winter months), representative samples were collected and sent to an offsite laboratory for confirmation of treatment analyses. Any material that failed was retreated in the MAECTITE® system.

Material that passed TCLP testing was then loaded into lined gondola railcars, covered and tarped. Railcar scales installed in the spur erected onsite insured that car weight of 100 tons was not exceeded.

To insure that sufficient MAECTITE® reagent was available at all times during treatment operations, Sevenson utilized two (2) silos for reagent storage on each system. While one unit was in use, the other was serviced. This allowed for continuous treatment without interruption for reagent delivery.

When the Marathon Battery Superfund Site material remediation has been completed later this year (Fall of 1994), approximately 115,000-125,000 cubic yards will have been treated to non-hazardous characteristics by the MAECTITE® chemical treatment process. Total cadmium levels have been found ranging up to 1.36% with TCLP cadmium ranging up to almost 200 mg/l. All material will have been rendered non-hazardous by RCRA definition for characteristically hazardous waste to less than 1.0 mg/l TCLP cadmium by the MAECTITE® process.

CASE HISTORY II: TRAUB BATTERY AND AUTOBODY SUPERFUND SITE, SIOUX FALLS, SD

Remediation at the Traub Battery and Autobody Superfund Site in Sioux Falls, SD was initiated by the USEPA's ERCS contractor for Region VIII. The site was a former facility that was used to reclaim lead from batteries. The ERCS contractor was utilized to respond to the time critical nature of the site due to migratory lead and exposure risks to human health and the environment. When the contractor demobilized, soil contaminated with hazardous soil for lead had been staged in a pile of approximately 2600 to 2700 cubic yards of material.

USEPA (Region VIII) then utilized the Prequalified Offerors Procurement Strategy's (PQOPS) expedited contracting program to complete site remediation. The PQOPS program established by USEPA (Washington, D.C.) allows for lump sum cost competition for technically approved fixation/stabilization processes offered by contractors for use by the Agency. In order to become technically approved, contractors must submit detailed work plans, fixation/stabilization system designs, former project experiences, project management approaches, Health and Safety Plans and Quality Assurance Plans to the USEPA (Washington, D.C.) for technical review. Once approved and accepted into the PQOPS program by the USEPA (Washington, D.C.), the contractor is allowed to competitively bid on projects announced in the Commerce Business Daily.

The Traub Battery Site was the first PQOPS contract awarded by USEPA (Washington, D.C./Region VIII) for fixation/stabilization in the United States. The contract required that the staged soil material be treated to comply with the TCLP lead limit of 5.0 mg/l and Multiple Extraction Procedure limits of 5.0 mg/l lead in each of the methods 10 leaching steps. Once successful treatment was verified, material was to be transported to the local municipal licensed non-hazardous landfill for disposal. The site was then to be graded and seeded.

Mobilization and setup of the MAECTITE® system was initiated shortly after USEPA (Region VIII) had approved all site specific work plans and was completed within 5 days after initial site presence. Treatment of the nearly 4000 tons of staged material was completed in less than 10 days. Due to the long duration required for the MEP test results to be generated (15 days), final demobilization was not completed until receipt of final confirmational treatment data, including TCLP and MEP test results.

All material was successfully treated without the need for retreatment to below 5.0 mg/l TCLP lead. Total lead for the site material ranged up to 1256 mg/kg with TCLP lead ranging from 5.6 to 76 mg/l in untreated material. Treated material results for TCLP and MEP methods are presented in Table V.

The MAECTITE® process was successfully applied to the site with mobilization, equipment setup and optimization, full-scale treatment, and equipment demobilization completed in less than 30 days.

Epilogue

MAECTITE® treated material resembles untreated material in texture and consistency, but has improved structural properties. Often, material volume reduction is observed ranging up to 20 percent. Volume reduction is likely due to chemical rearrangement of the matrix, elimination interstitial soil space, destruction of carbonates, and increased particle density. Since the process is one where reagents cause waste matrix dehydration, the loss of water will also contribute to reductions if proper curing is allowed. Volume increases from MAECTITE® chemical treatment have been limited to approximately 1 percent, with mass increases never observed in excess of 5 percent as a result of MAECTITE® chemical treatment.

TABLE I
APPLICATION OF MAECTITE® CHEMICAL TREATMENT PROCESS
TO A DIVERSE VARIETY OF LEAD BEARING WASTE MEDIA

WASTE TYPE (MATRIX)	TOTAL LEAD %	LEACHABLE LEAD (mg/l)	
		Before Treatment	After Treatment
Sandy loam	2.2	163.7	1.5
Lead birdshot	16.1	3,720	ND
Lead buckshot	11.4	1,705	ND
Clayey slag	14.6	91.8	ND
Slag-lead smelter	6.6	21.3	2.0
Topsoil	15.8 14.6 0.344	44.5 91.8 83.5	1.4 ND 0.5
Silty sand/debris	0.56	34.6	ND
Battery casings	0.6 - 12 2.0	288 160	0.6 0.3
Organic humus soil	0.31 - 1.9	23.2	ND
Silty sand	4 - 5	687	0.7
Solid waste	1.1 0.4	9.7 72.4	0.01 3.4
Sludge-industrial waste	2.2	59.3	1.6
Filter cake	2.9	245.3	1.1
Gravel	0.16	7.5	0.5
Road gravel	0.34	46	ND
Gray clay	2.2	495	0.2
Grayish brown ash	9.5	520	0.3
Brown soil-gravel clay (till) Brown soil-gravel sand (till)	1.37 3.97	263 303	2.1 1.6
Soil with PbO	29.9	3,659	ND
Clarifier sludge	0.85	57.1	0.3
RCRA organic sludge	9.4	580	ND
Carbon with lead dross	12.6	105.6	0.5
Foundry sand with bentonite	1.96	461.2	ND
Wire fluff	0.33 - 0.134	15.9 - 130	0.7
Wire chip	0.3 - 0.7	28	1.9

TABLE II
MARATHON BATTERY
Engineering-Scale Study on High-Level Spiked Material

Sampling Area	Total Cadmium (%)	TCLP Cadmium (mg/l)	
		Untreated	Treated
Marsh	2.93	1596	0.709
Cove	2.9	1050	0.591
Pond	3.11	1072	< 0.1
Plant soil	2.19	1181	< 0.1

All methods by SW-846 procedures

TABLE III
MARATHON BATTERY
Role of MAECTITE® Treatment on MEP and EP TOX Cadmium

Source/Type	MEP-Cd (mg/l)*		EP TOX (mg/l)	
	Untreated	Treated	Untreated	Treated
Marsh Sediment	196.9	2.9	20.5	0.5
Plant Ground	58.2	0.81	30.9	0.45
Vault Material	206.9	0.1	76.9	< 0.01
Dredge Sediment	68.5	3.9	21.8	< 0.01

* MEP results equal sum of all ten extract concentrations
All methods by SW-846 procedures on unspiked samples

TABLE IV
MARATHON BATTERY
Results of Full-Scale MAECTITE® Treatment on Site Material at Marathon Battery

Waste Type (Matrix)	Total Cadmium (%)	TCLP Cadmium (mg/l)	
		Untreated	Treated
EF Cove Material	1.3552	198	BDL
Vault Sediment	0.25 - 14.68	121.3 - 180.2	< 1
Marsh Sediment	0.101	108.8 - 125.2	BDL
Marsh Cinders	0.0168	2.12	ND
Marsh Material	0.0184	9.07	ND

All methods by SW-846 procedures

TABLE V
TRAUB BATTERY AND AUTOBODY SUPERFUND SITE (PQOPS)
SIOUX FALLS, SOUTH DAKOTA
ROLE OF MAECTITE® TREATMENT PROCESS IN CHEMICAL TREATMENT
OF LEACHABLE LEAD AS MEASURED BY TCLP* AND MEP** TESTS

Sample ID# (500 ton lots of treated material)	TCLP LEAD			MEP LEAD	
	CONTRACTOR	EPA	CLP LAB	CONTRACTOR	CLP LAB
1 + 2	BDL+	0.46	0.14	0.46	0.85
3 + 4	BDL	0.55		0.57	
5 + 6	BDL	ND++		0.61	
7 + 8	BDL	0.47		0.54	
9 + 10	0.27	ND		0.78	
11 + 12	BDL		0.03	0.83	
13 + 14	BDL			0.37	
15 + 16	BDL			0.51	

* TCLP Test Method 1311, Detection limit as reported by the Pace Laboratory (CLP certified) is 0.025 mg/l.

** MEP Test Method 1320, Detection limit as reported by Pace Lab was 0.025 mg/l.

\+ BDL = Below Detection Limit

\+ + ND = Non Detectable