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SITE

SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION

Technology Demonstration Summary

International Waste Technologies/Geo-Con In Situ Stabilization/Solidification Update Report

In April 1988, the U.S. Environmental Protection Agency (EPA), under the Superfund Innovative Technology Evaluation (SITE) Program, evaluated the effectiveness of the International Waste Technologies (IWT)/Geo-Con combined technologies for immobilizing polychlorinated biphenyls (PCBs) in soil. At a former electric service shop in Hialeah, FL, IWT's soil additive was mixed with contaminated soil with the use of the Geo-Con deep-soil-mixing system. Physical and chemical analyses of the soil were performed on samples collected before the demonstration and at 2 wk and 1 yr after the treatment.

The report concludes that, after 1 yr, PCB mobility remained unchanged and that long-term durability of the treated soil appears greater than originally estimated.

This Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce the key findings of this SITE demonstration. These findings are fully documented in five separate reports (see ordering information at back).

Introduction

In 1986, the U.S. Environmental Protection Agency (EPA) established the Superfund Innovative Technology Evaluation (SITE) Program to promote the development and use of innovative technologies to cleanup Superfund sites. This update report summary highlights the results obtained 1 yr after the SITE demonstration of the International Waste Technologies (IWT)/Geo-Con in situ stabilization/solidification technology and compares them with data contained in the earlier, related technology evaluation report and applications analysis report.

The most extensive testing of the combined technologies was performed during the SITE demonstration, which occurred at a General Electric Co. (GE) electric service shop in Hialeah, FL, in April 1988. The process involved the in situ injection and mixing of the IWT additive HWT-20 (a pozzolanic-based material containing treated clay adsorbents) with the contaminated soil. The demonstration was performed on two areas, each 200 ft², that were relatively high in PCBs (a maximum of 950 mg/kg in the untreated soil), the primary contaminant. The major objectives of the entire SITE project were to evaluate the

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IWT/Geo-Con in situ stabilization/solidification technology for:

1. Immobilization of PCBs and, if detected, immobilization of volatile organic compounds (VOCs) and heavy metals.
2. Effectiveness and reliability of the in situ operation of the Geo-Con deep-soil-mixing equipment.
3. Degree of soil solidification caused by the IWT chemical additive HWT-20.
4. Comparative effectiveness of the stabilization/solidification for unconsolidated sand and limestone; comparative effectiveness above and below the water table.
5. Cost for commercial-scale applications.
6. Viability of the technology for use at other sites.
7. Continuing, long-term stability and integrity of the solidified soil over a 5-yr period.

The 12-mo sampling and analysis work respond to the last objective. Samples were collected 1 yr after the demonstration. The test results were compared with those from samples collected 1 mo after (posttreatment) and 2 wk before (pretreatment) the demonstration.

The following technical criteria were used to evaluate the effectiveness of the in situ stabilization/solidification process:

- Mobility of the contaminants as measured by leaching and permeability tests.
- Durability of the solidified soil mass based upon information obtained from weathering tests (wet/dry and freeze/thaw), measurements of unconfined compressive strength, and analysis of microstructural characteristics (porosity, degree of mixing and crystalline structure).

Procedure

The demonstration of the IWT/Geo-Con technology was performed on two 10- x 20-ft test sectors. One sector was treated to a depth of 18 ft (sector B) and the other to a depth of 14 ft (sector C). The local regulatory authority Metropolitan Dade County Environmental Resources Management (MDCERM) required GE to remediate the site for PCBs, with the two sectors to be tested before full site cleanup began. The objectives of the SITE project, however, were broader than GE's. Thus, three different leaching tests, microstructural analyses, and measurements for VOCs and heavy metals were performed (if the latter two were detected).

The Geo-Con's deep-soil mechanical-mixing and injection machine consisted of one set of cutting blades and two sets of mixing blades (each set, 3 ft in diameter) attached to a vertical drive auger, which rotated at approximately 15 rpm. Two conduits in the auger allowed low-pressure injection of the additive slurry and supplemental water. The additive and water were injected on the downstroke and mixed into the soil with additional mixing on the upstroke.

A batch-mixing system processed the feed additives. The HWT-20 was air-conveyed from the supply truck to a storage silo. It was then slurried with water at a solids to water ratio of 4:3 in a 1000-gal mixing tank. The tank held enough slurry sufficient for three or four columns of soil treatment. The slurry and supplemental water were then pumped to the drill rig at a dry solids rate of 0.18 lb of HWT-20/lb of dry soil.

The deep-soil-mixing machine was tracked into position and the horizontal and vertical alignments checked. The elevation measurements were made by using a small tracking wheel attached to a digital tachometer. Machine locations were verified by the use of a stationary laser.

Soil samples in the treated sectors were taken 2 wk before the demonstration and approximately 1 mo after the demonstration. The latter samples were collected from points at the same locations as the pretreatment samples. The 12-mo samples were collected from points very close to the posttreatment sample locations so that the impact of the technology could be evaluated from predemonstration through long-term monitoring.

Sampling and Analysis Program

Fewer locations were selected for sampling during the 12-mo monitoring than were selected during the demonstration. The 12-mo sample points were at areas of high PCB concentration, where VOCs were measured, and at points of soil treatment column overlap. Seven samples were collected from sector B and six from sector C.

The sampling depths for the collected samples were as follows:

Samples	Sampling depth, ft below grade
B-6, B-6 duplicate, B-21, C-15	1-2
B-7, B-22, C-1, C-3, C-7, C-16	7-8
B-8, C-17	11-12
B-9	16-17

The water table depth is 5 to 7 ft below grade.

The 12-mo samples were collected for the following analyses:

- Toxicity characteristic leach procedure (TCLP) for PCBs (also VOCs and heavy metals, where applicable)
- Permeability
- Acid neutralization capacity (not performed during the demonstration)
- Unconfined compressive strength (UCS)
- Moisture
- Bulk density
- Specific gravity (not performed during the demonstration) to allow the calculation of porosity
- Wet/dry weathering test
- Freeze/thaw weathering test
- Post weathering tests
  - TCLP for PCBs (not performed on the posttreatment samples)
  - UCS
  - Permeability
- Total PCBs in soil
- Total VOCs in soil (B-6,7,8 only)
- Metals in soil (B-6,7,8 only)
- Microstructural, X-ray diffraction, microscopy

Results and Discussion

The chemical test results are highlighted in Table 1 and summarized as follows:

1. After 1 yr, the treated soil compositions for PCBs ranged from less than 1.0 to 180 mg/kg and agreed favorably with treated soil samples obtained during the demonstration. The PCB concen-

trations in the TCLP leachates for the 12-mo samples were usually below the detection limit of 0.1 µg/L. The results appear to agree with those measured from postdemonstration samples. (Only a few samples were measured to a detection limit of 0.1 µg/L with the remainder to 1.0 µg/L.) TCLP leach tests performed after the weathering tests on the 12-mo samples also measured PCB concentrations at or below detection limits. Thus, at the concentration levels existing at the site, the mobility of the PCBs in pretreatment, posttreatment, 12-mo, and weathered 12-mo samples were all at or below the detection limits. Therefore, a determination about the immobilization of PCBs could not be made.

2. The total VOC concentrations (chlorobenzene, ethylbenzene, and total xylenes) in samples collected at locations B-6, B-7, and B-8 were equivalent to the postdemonstration results for each component and for the total concentration. They ranged from a total of 10.4 to 44.6 mg/kg. This indicates that VOCs were not being lost from the treated soil.

   The TCLP leachate concentrations for each component of the 12-mo samples appear to be considerably greater--by a factor greater than 2 on the average--than the postdemonstration samples. Since the VOC concentrations in the treated soil are only a small fraction of those in the untreated soil (less than 10 wt%), concentration comparisons in the leachates between treated and untreated soil samples are not practical. In addition, conclusions on the ability of the IWT additive to treat VOCs should not be made, since IWT indicated that its formulation was designed for treating only PCBs.

3. The soil and TCLP leachate values for the heavy metals (chromium, copper, lead, and zinc) were approximately the same for the 12-mo samples as for the posttreatment samples. The total metals in the 12-mo TCLP leachates ranged from 0.1 to 0.2 mg/L for soil concentrations ranging from 122 to 592 mg/kg.

4. The acid neutralization capacity test was performed only on the 12-mo samples. The results showed a high alkalinity in the treated soil; this usually reduces heavy metals leachability.

The physical test results are highlighted in Table 2 and summarized as follows:

1. The moisture content and bulk density of the 12-mo samples were the same as those for the postdemonstration samples, with values of approximately 18 wt% and 1.9 g/mL, respectively. The constant moisture content indicates that curing was essentially complete when the posttreatment samples were analyzed.

2. The specific gravity of the 12-mo samples was 2.53 g/mL. From specific gravity and bulk density, porosity can be calculated. It averaged 0.37, which is relatively good compared with a typical value for concrete of 0.20. The lower the value, the less porous the sample.

3. The permeability of the thirteen 12-mo samples was very low, averaging 1.4×10^{-7} cm/s; this is approximately one-half the average permeability value obtained for the postdemonstration samples. Many of the values for the 12-mo samples were close to 1×10^{-8} cm/s.

4. The UCS values ranged from 521 psi for sample location B-22 to 1,703 psi at C-1 and averaged 980 psi. This is a 150% increase over the postdemonstration samples, which indicates curing (although not seen in the free moisture values) continued between sample collection periods.

5. Freeze/thaw and wet/dry weathering tests performed on the 12-mo samples showed the following results:

   - The relative and absolute weight losses for the wet/dry samples remained unchanged. The relative weight loss (difference of test specimen and control) was 0.1 wt%.
   - The freeze/thaw weight losses of the test specimens were large, averaging 4.1%. This is comparable to the posttreatment samples, average value of 6.6 wt%. The weight loss of the controls in both instances averaged 0.3%.
   - TCLP leach test results for PCBs on weathered samples were usually below detection limits, which is equivalent to those on the unweathered samples.
   - The results of the UCS and permeability tests on the postweathering 12-mo samples were equivalent to those on the postdemonstration samples.

Microstructural analyses of the 12-mo samples appear substantially similar to those of the postdemonstration samples, and deterioration of the solid mass was not observed.

Overall, the physical test results on the 12-mo samples for UCS, permeability, and weathering have improved indicating that the durability of the two solidified masses at the Hialeah site appears to be greater than expected, based upon the posttreatment results from the demonstration.

Obtaining further data on Geo-Con in situ operations was not applicable to the 12-mo sampling program.

Conclusions

The following conclusions were drawn from comparing the 12-mo monitoring data with the pretreatment and posttreatment results:

1. PCB mobility did not increase between the posttreatment and 12-mo samples. The TCLP leachate concentrations for 12-mo, posttreatment, and pretreatment samples were at or below the detection limits. Thus PCB immobilization still could not be confirmed.
2. The physical properties of the treated soil--UCS, permeability, and wet/dry and freeze/thaw weathering--greatly improved after 1 yr of curing. The freeze/thaw test specimen weight losses, however, were still unsatisfactorily high. Permeability and TCLP leaching tests performed after the weathering tests provided results equivalent to those performed on unweathered samples.
3. The microstructural analyses confirmed that the 12-mo durability of the treated soil is probably satisfactory. The structure of the 12-mo samples appeared unchanged from those of the postdemonstration samples.

The overall conclusions drawn from the 12-mo monitoring results are that PCB mobility after 1 yr in the field is unchanged and that the potential long-term durability appears to be greater than estimated, based on the postdemonstration samples.

Table 1. *PCB Concentrations in Soils and Leachates*

Sample Designation	Soil Samples 12-Mo Posttreatment*					Soil Samples 1-Mo Posttreatment*†			
		TCLP Leachate, µg/L							
	Soil, mg/kg	Unweathered‡	Freeze/Thaw†§	Freeze/Thaw Control†§	Wet/Dry†§	Treated Soil, mg/kg	Treated Soil, TCLP Leachate, µg/L	Untreated Soil, mg/kg	Untreated Soil, TCLP Leachate, µg/L
B-6	99	<0.10	<0.10	--	<0.10	35	<1.0	650	15
B-6 Dupl.	82	0.12	0.11	--	--	63	0.15	--	--
B-7	89	<0.10	<0.10	0.12	--	82	0.12	460	250
B-8	20	0.13	--	--	--	9.6	<1.0	220	<1.0
B-9	<1.0	<0.10	<0.10	--	--	<1.0	<1.0	16	<1.0
B-21	80	0.13	--	--	0.36	60	<1.0	--	--
B-22	180	0.16	0.41	0.28	--	130	<1.0	--	--
C-1	17	<0.10	<0.10	--	--	20	<1.0	98	<1.0
C-3	45	<0.10	<0.10	--	--	110	<1.0	96	<1.0
C-7	24	<0.10	0.12	--	0.12	16	<1.0	150	<1.0
C-15	16	0.16	<0.10	--	--	17	<1.0	80	<1.0
C-16	3.8	<0.10	<0.10	--	--	6.0	<1.0	13	<1.0
C-17	0.84	<0.10	<1.0	<0.10	--	<1.0	<1.0	<1.0	<1.0

* PCB detection limits for soils is 1.0 mg/kg and for leachates is 0.10 µg/L. The untreated TCLP leachates and many of the treated soil leachates had detection limits of 1.0 µg/L.
† TCLP leachate analyses following freeze/thaw and wet/dry tests were not performed during the demonstration.
‡ Leachate result from same unweathered sample as used for soil analysis.
§ These TCLP results were obtained after the completion of the 12-cycle accelerated weathering tests. The controls cycle on a 24-hr basis between soaking in water and being in an ambient temperature humidification chamber. The control is in the humidification chamber when the test specimen is in the freezer. Both the test specimen and control are soaking in water at the same time, also for 24 hr.

Table 2. *Physical Test Results*

Sample Designation	Unconfined Compressive Strength, psi		Permeability, cm/s x 10^{7}†		Weathering - wt% Loss: Wet/Dry‡		Weathering - wt% Loss: Freeze/Thaw‡		12-Mo Freeze/Thaw*§ TCLP, µg/L PCBs	
	12-Mo*	Demo*	12-Mo	Demo	12-Mo	Demo	12-Mo	Demo	Weathered	Unweathered
B-6	647	114	2.4	4.2	0.43	0.43	1.19	2.17	<0.10	<0.10
B-6 Dupl.	620	115	5.6	--	0.48	0.49	0.88	1.52	0.11	0.12
B-7	841	173	0.07	5.9	0.35	--	2.86	1.52	<0.10	<0.10
B-8	649	303	0.5	--	0.26	0.34	13.88	27.92	--	0.13
B-9	786	470	1.8	--	3.19	0.39	24.79	29.53	<0.10	<0.10
B-21	1,555	479	0.05	8.3	0.64	0.39	1.47	1.34	--	0.13
B-22	521	428	0.13	4.1	0.40	0.39	2.71	4.64	0.41	0.16
C-1	1,703	866	0.06	0.24	0.30	0.35	0.60	2.06	<0.10	<0.10
C-3	1,147	482	2.7	--	0.26	0.27	1.41	3.94	<0.10	<0.10
C-7	1,017	343	2.8	4.1	0.30	0.31	0.74	0.30	0.12	<0.10
C-15	850	247	0.06	--	0.30	0.33	0.73	0.30	<0.10	0.16
C-16	1,220	435	0.13	4.6	0.25	0.30	1.81	0.28	<0.10	<0.10
C-17	1,185	521	2.5	2.5	0.23	0.29	0.75	0.18	<0.10	<0.10

*"12-mo" represents the 12-mo results and "Demo" represents 1-mo post demonstration.
†The actual results are shown multipled by 10^{7}.
‡Weight loss values reported are for the test specimens. The controls for both the wet/dry and freeze/thaw samples averaged as follows:

Wet/dry	Freeze/thaw
0.22 12-mo	0.34 12-mo
0.31 Demo	0.35 Demo

§Provides a comparison on the 12-mo samples of the TCLP leachate concentrations for PCBs of freeze/thaw weathered specimens to unweathered (not subjected to freeze/thaw cycling) samples.

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The complete update report, entitled "Technology Evaluation Report: International Waste Technologies/Geo-Con In Situ Stabilization/Solidification," consists of two volumes:

"Volume III" (Order No. PB 90-269 069/AS; Cost: $17.00, subject to change) discusses the results of the 12-mo monitoring tests and how they compare with the results of the demonstration.

"Volume IV" (Order No. PB 90-269 077/AS; Cost: $31.00, subject to change) contains the technical operating data--logs, laboratory analyses, and microstructural analyses.

Both volumes of this report will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

Three related reports discuss the demonstration and the applications:

"Technology Evaluation Report: SITE Program Demonstration Test, International Waste Technologies In Situ Stabilization/Solidification, Hialeah, Florida, Volumes I and II" (EPA/540/5-89/004a and b dated June 1989), and "SITE Program Applications Analysis Report, International Waste Technologies/Geo-Con In Situ Stabilization/Solidification" (EPA/540/A5-89/004 dated August 1990).

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