Cost and Performance Summary Report - Interim
In Situ Solidification/Stabilization at Koppers Co. (Charleston Plant) Ashley River Superfund Site, South Carolina

Summary Information [1,3,4,5,6,8]

The Koppers Co., Inc. Charleston Plant is located on 102 acres north of downtown Charleston, South Carolina. The site includes a part of the Ashley River used as a barge canal. Koppers operated the site as a wood-treating facility from 1940 to 1977, primarily treating raw lumber and utility poles with creosote, as well as pentachlorophenol and copper-chromated-arsenate (CCA). The majority of wood-treating operations were conducted in the eastern portion of the site, identified as the Former Treatment Area. Wastewater from these processes was discharged into a ditch, which flowed eastward to the intertidal Ashley River. In 1994, Beazer East acquired three parcels at the site including the Ashley River area.

From 1978 to the early 1980s, the site was used for storing wastes, including waste oil. Results of site investigations showed that the Ashley River sediments were contaminated with polycyclic aromatic hydrocarbons (PAH) and dense non-aqueous phase liquids (DNAPL), such as creosote stringers, in several Areas of Potential Ecological Concern (APEC). The maximum total PAH concentration was 500 mg/kg. Creosote and DNAPL stringers were identified as deep as 17 feet below the sediment interface. The defined APEC was approximately 3 acres, stretching along 1,500 linear feet of shoreline and with an approximate width of 100 feet.

To assess the nature and extent of impacts to sediments in the Ashley River, samples were collected during remedial investigation (RI) activities from 0-12 inches and up to 18 ft below the sediment interface using a vibra-core. APEC were identified using results from whole sediment toxicity testing on benthic macroinvertebrates such as *Neanthes arenaceodentata* and *Mysidopsis bahia*. In addition, samples from 0-12 inches were compared against relevant benchmarks such as EPA's draft Sediment Quality Criteria.

The site was placed on the National Priorities List (NPL) in December 1994. A Record of Decision (ROD) was signed in April 1998 that specified enhanced sedimentation of Ashley River sediments.

Further analysis of the design for the enhanced sedimentation remedy showed that installation would be technically challenging and cost prohibitive due to the steep slopes of the Ashley River channel and depth of soft sediments. Therefore, an Explanation of Significant Difference (ESD) was issued in August 2001 changing the selected remedy to an engineered subaqueous cap. However, during the design phase of the cap, concern was raised about the cap interfering with barge activity in an active marine area in the river. In this area "spud barges" are used, and these are held in place by dropping thick-walled pipes (spuds) into the riverbed. The concern was that these spuds would not be able to penetrate the cap.

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Type of Action:	Remedial
Lead:	PRP-lead
Oversight:	EPA

As a result, the remedy for one acre in the marine area was changed to in situ solidification/stabilization (S/S), which is the subject of this report. The EPA Remedial Project Manager (RPM) indicated that use of the spuds would not significantly affect the solidified/stabilized material.

For the remaining two acres, an engineered sand cap was constructed. The one-acre in situ S/S was completed first, followed by construction of the sand cap on either side of the solidified sediment for the other two acres. The sand cap overlapped the solidified sediment a few feet where they joined. Figures 1 and 2 show a plan view of the layout of the solidified sediment and sand cap. The figures line up at match line "B", to show the 1-acre of solidified sediment in the active marine area, flanked on either side by the sand cap. The adjacent figure lining up to match line "A" was not provided.

Prior to implementing in situ solidification/stabilization, bench- and pilot-scale testing was performed to develop a suitable grout and to assess the effectiveness of the remedy at full-scale.

Timeline [1,3,4]

December 1994	NPL listing
April 1998	ROD signed
August 2001	ESD issued
September – December 2001	Solidification/stabilization performed

Figure 1. Plan View of Layout of Solidified Sediment and Sand Cap (Sheet 1 of 2) [6]

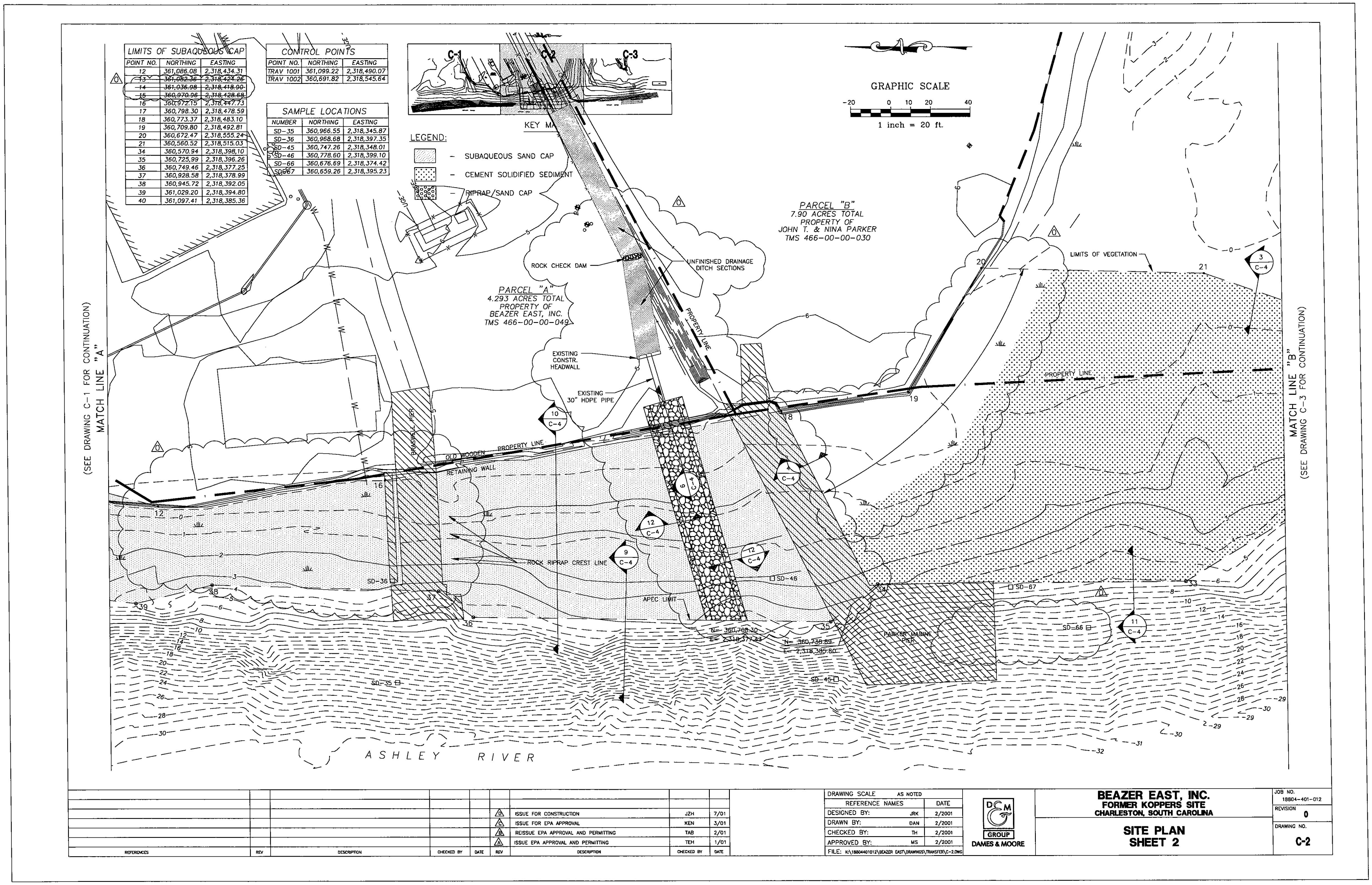
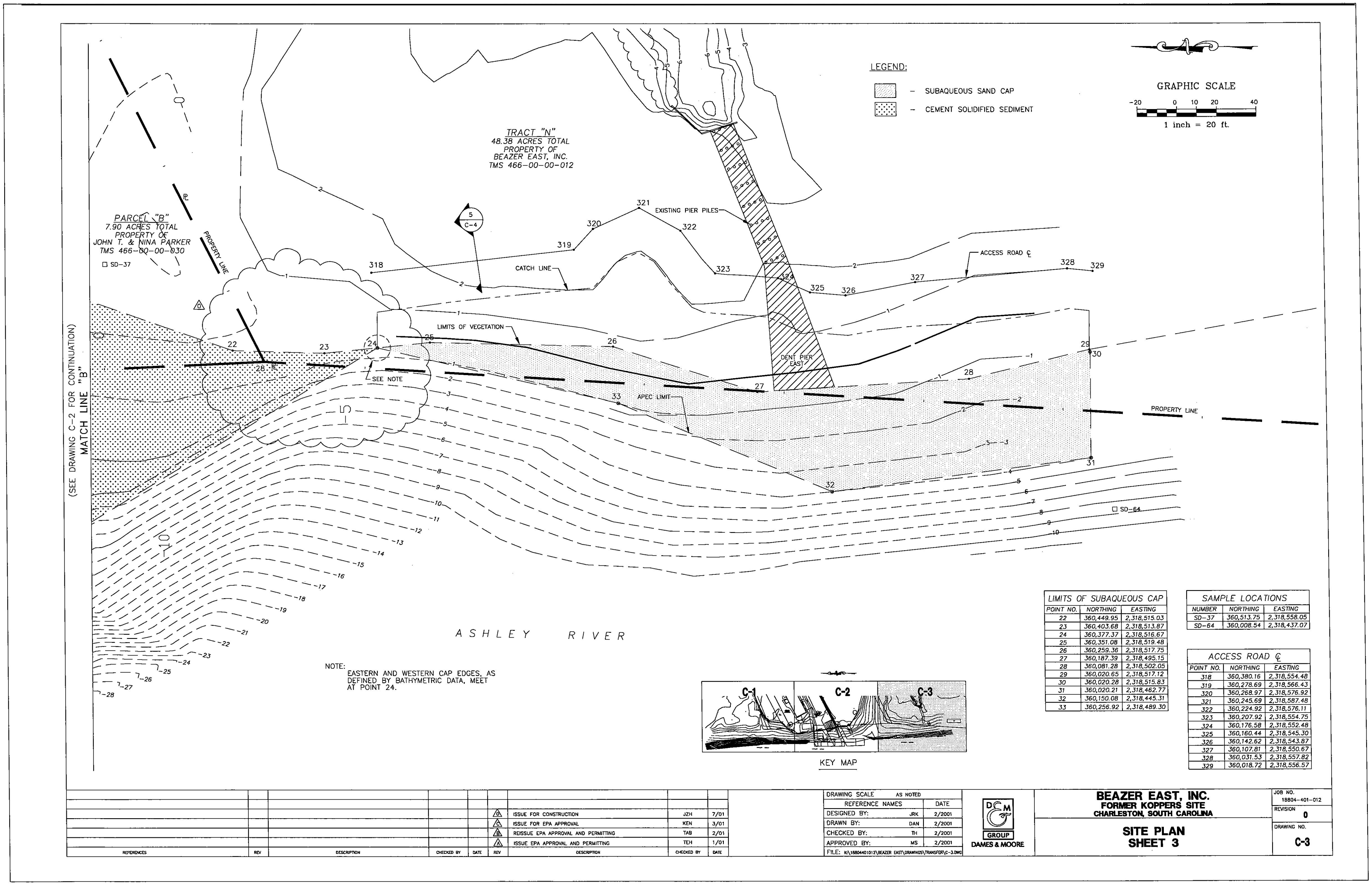


Figure 2. Plan View of Layout of Solidified Sediment and Sand Cap (Sheet 2 of 2) [6]



LIMITS OF SUBAQUEOUS CAP		
POINT NO.	NORTHING	EASTING
22	360,449.95	2,318,515.03
23	360,403.68	2,318,513.87
24	360,377.37	2,318,516.67
25	360,351.08	2,318,519.48
26	360,259.36	2,318,517.75
27	360,187.39	2,318,495.15
28	360,081.28	2,318,502.05
29	360,020.65	2,318,517.12
30	360,020.28	2,318,515.83
31	360,020.21	2,318,462.77
32	360,150.08	2,318,445.31
33	360,256.92	2,318,489.30

SAMPLE LOCATIONS		
NUMBER	NORTHING	EASTING
SD-37	360,513.75	2,318,558.05
SD-64	360,008.54	2,318,437.07

ACCESS ROAD ℄		
POINT NO.	NORTHING	EASTING
318	360,380.16	2,318,554.48
319	360,278.69	2,318,566.43
320	360,268.97	2,318,576.92
321	360,245.69	2,318,587.48
322	360,224.92	2,318,576.11
323	360,207.92	2,318,554.75
324	360,176.58	2,318,552.48
325	360,160.44	2,318,545.30
326	360,142.62	2,318,543.87
327	360,107.81	2,318,550.67
328	360,031.53	2,318,557.82
329	360,018.72	2,318,556.57

Factors that Affected Cost or Performance of Treatment [1,5,6]

The key matrix characteristics that affect the cost or performance of this technology and the values measured for each are presented below.

Matrix Characteristics [6]

Parameter	Value
Sediment classification	High moisture and organic content, known locally as "Pluff mud"
Clay Content and/or Particle Size Distribution	2% gravel, 55% sands, 43% silts/clays
pH	No information available
Depth to Sediment	Up to 25 ft deep (in central channel)
Moisture content	315%[1]
Total Organic Carbon	0.4% - 3.9%
Oil and Grease or Total Petroleum Hydrocarbons	No information available

[1] Calculated using: (moisture mass/solids mass) X 100

Treatment Technology Description [1,5,6]

In situ solidification/stabilization using a slurry of cement-based grout augmented with proprietary chemicals was used to solidify the upper two feet of sediment in a one-acre area to create a solid, cohesive layer that would be less susceptible to erosion than natural sediments. The solid surface layer separates the underlying sediment from erosion to decrease the impact of contaminants on the benthic community and upper trophic level receptors.

A mixing device known as a "tubular injector" and a special amphibious excavator called a "marsh excavator" were used to inject and mix cement-based grout into the upper two feet of sediment (see Figure 3). The tubular injector was attached to the stick of the excavator and repeatedly raked through the material to be solidified until a pre-set amount of reagent was added and mixed. The marsh excavator was specially designed for use in swamps or other marshy areas. The flotation hull and wide tracks of the excavator increased its stability and allowed it to track on material too soft to support conventional excavators such as the Pluff mud at this site. A mixing plant was mobilized on site to prepare the slurry. Reagents were conveyed to the injector through a hose.

Solidification/stabilization of the sediments began at the riverbank and progressed towards the central channel, which was about 25 feet deep. Work time was scheduled

Figure 3. Marsh excavator mixing grout into sediment [1]

for approximately two hours on either side of low tide, when the excavator was best suited for use. During this time, the water depth over the sediment was less than 4 feet, allowing the excavator to track on the sediment without becoming buoyant. To control mixing depth, two workers in a boat probed to determine the depth of water in the area where grout was to be injected. The excavator operator used visual markings on the side of the injector to ensure that the injector was inserted two feet into the sediment.

A total of 181,303 gallons of grout were mixed with the sediment. The grout consisted of 632 tons of cement, 3,971 gallons of proprietary chemicals, and 160,000 gallons of water. No information was provided about the types of proprietary chemicals used. Approximately 2,450 cubic yards of sediment were solidified to a depth of 2 feet over 35 days, including the time to assemble and disassemble all equipment.

Bench- and pilot-scale tests

Bench-scale testing using conditions similar to those in the field was conducted to evaluate whether the conditions at the site were suitable for use of in situ solidification/stabilization. The tests focused on developing a grout that would: (1) cause the sediment's soil particles to agglomerate, thereby reducing the amount of cement needed; (2) cure rapidly to minimize erosion due to the river's current and rising and falling tides; and (3) modify the grout's rheology (consistency), making it pumpable using a minimal amount of water. Testing measured the sediment's strength over time when cured with and without water on top. The tests showed that grout augmented with a blend of proprietary chemicals produced a solid monolithic mass within hours, even when cured beneath water. The study also showed that the quantity of grout required to solidify the sediment would increase the surface elevation of the sediment by less than six inches above its current elevation.

A pilot test was performed prior to implementing the remedy at full-scale to demonstrate that the solidified sediment would not prevent spuds from holding a barge in place. A layer of sediment approximately 4 feet thick was solidified and a spud pipe was dropped onto the solidified material. According to the vendor and the RPM, the spud was able to puncture the solidified matrix successfully without significantly affecting its integrity, and continued to slide into the sediment for another 10 to 15 feet.

Operating Parameters [1]

Listed below are the key operating parameters at Ashley River that affected cost or performance and the values measured for each.

Parameter	Value
Additives and dosage	181,303 gallons grout (632 tons cement, 3,971 gallons proprietary chemicals, 160,000 gallons water)
pH	Not determined
Temperature	Not determined
Curing time	24 to 48 hours
Compressive Strength	Penetration resistance of 3.25 to 4 tons per square foot within 24 hours (based on bench-scale test)
Volume Increase	Surface elevation of 1 acre treatment area increased by less than 6 inches
Permeability	Not determined

Performance Information [3]

The goal of the in situ solidification/stabilization treatment was to eliminate contaminant exposure to the benthic community and preclude further potential risks to upper trophic level receptors. No specific cleanup levels were identified.

No information was provided about the performance of the solidified sediment and whether/how it met the performance goals.

Cost Information [2]

According to the technology vendor, approximately 2,450 cubic yards of sediment were solidified (slightly less than 1 acre of surface area and a depth of two feet), at a cost of $561,154, or $229 per cubic yard. This cost included the use of a tubular injector and marsh excavator, as well as the grout chemicals, and $242,300 for equipment mobilization and demobilization

The vendor reported that the following factors tended to increase project cost:

- The marsh excavator was only used for two hours on either side of low tide (4 hours at a time) and was idle for most of the time on site
- The chemicals and marsh excavator were expensive
- The high moisture and organic content of the sediments
- The relatively small project scale (1 acre)

Observations and Lessons Learned [1,6,7]

This project used innovative construction techniques, including use of a marsh excavator and a tubular injector to solidify/stabilize sediments in a river. This equipment allowed grout to be injected at the required depths, and made it possible to use solidified sediment as a platform to reach untreated sediment.

The project represents one of a few documented applications in the U.S. to have used in situ solidification/stabilization to treat contaminated sediments in a riverbed.

According to the vendor, the following are factors that might have affected the performance or cost of the technology:

- Types and concentrations of compounds in the sediment—certain inorganic and organic compounds can affect cement chemistry (for example, high concentrations of sulfates attach to concrete through a chemical reaction termed ettringite formation).
- River current or velocity—the greater the current, the more difficult it is to keep equipment and reagents in place.
- Water depth—the type of equipment used is dependent upon the depth of water. For example, this project used an amphibious excavator because the depth of water overlaying the sediment was 4 feet or less. If the water were deeper, this type of equipment would not be suited for the work. Other equipment such as a long stick excavator on a platform barge would have to be used.

Contact Information [1,2]

EPA Contact
Craig Zeller
Remedial Project Manager
Environmental Protection Agency Region 4
61 Forsyth Street SW
Atlanta, GA 30303
Telephone: (404) 562-8827
Fax: (404) 562-8788
E-mail: zeller.craig@epa.gov

Technology Vendor
Mark A. Fleri, P.E.
Vice President
Williams Environmental Services, Inc.
2075 West Park Place
Stone Mountain, GA 30087
Telephone: (800) 247-4030/(770) 879-4075
Fax: (770) 879-4831
E-mail: mfleri@wmsgrpintl.com

References

The following references were used in the preparation of this report:

1. Williams Environmental Services, Inc. Subaqueous Sediment Cover – An Innovative Remedy for Contaminated Sediment. August 27, 2002.

2. E-mail from Thomas de Grood, Williams Environmental Services to Mark Fleri, Williams Environmental Services. August 27, 2002.

3. EPA Superfund Record of Decision. Koppers Co. Inc. (Charleston Plant), Charleston, SC. 4/29/1998. PB98-964022. EPA 541-R98-102. November 1998.

4. Explanation of Significant Difference to the Final Record of Decision. Koppers Co., Inc. (Charleston Plant) NPL Site. Charleston, South Carolina. August 2001.

5. E-mail from Craig Zeller, EPA RPM, to Sankalpa Nagaraja, Tetra Tech EM Inc. April 15, 2003.

6. E-mail from Thomas J. deGrood, Williams Environmental Services to Sankalpa Nagaraja, Tetra Tech EM Inc. April 23, 2003.

7. Renholds, Jon. National Network of Environmental Management Studies Fellow. 1998. In Situ Treatment of Contaminated Sediments. Prepared for U.S. EPA OSWER TIO.

8. E-mail from Craig Zeller, EPA RPM, to Kelly Madalinski, EPA/TIO. June 4, 2003.

Acknowledgments

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