Innovations in Solidification Treatment For Closure of Refinery Lagoons and Pits

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PRESENTED BY:

Charles Wilk
ALLU Group

What is S/S Treatment?

Involves mixing a binding agent into contaminated media such as soil, sediment, sludge or industrial waste.

S/S treatment protects human health and the environment by immobilizing hazardous constituents within treated material.

Physical (solidification) and chemical (stabilization) changes to the treated material.

Mobility Reduction Terms: Stabilisation (UK), Inertage (France), Immobilization (EU).

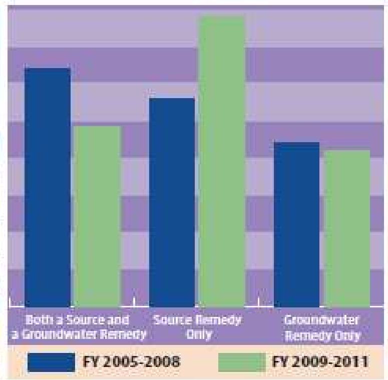
State of Remediation Technologies

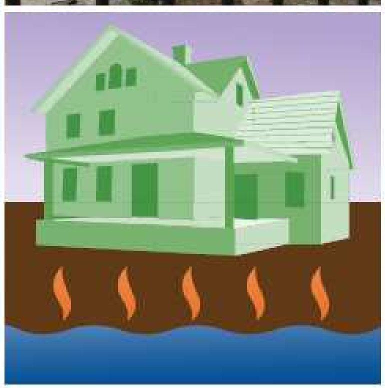
EPA 542-R-13-016
November 2013
Solid Waste and Emergency Response
www.clu-in.org/asr
www.epa.gov/superfund

United States
Environmental Protection
Agency

Superfund Remedy Report

FOURTEENTH EDITION





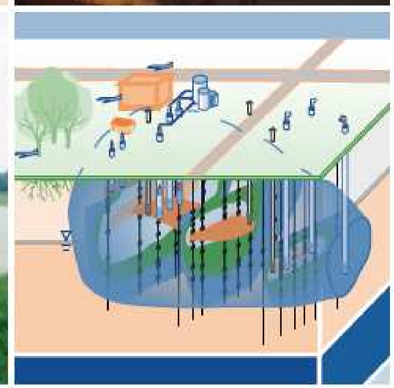
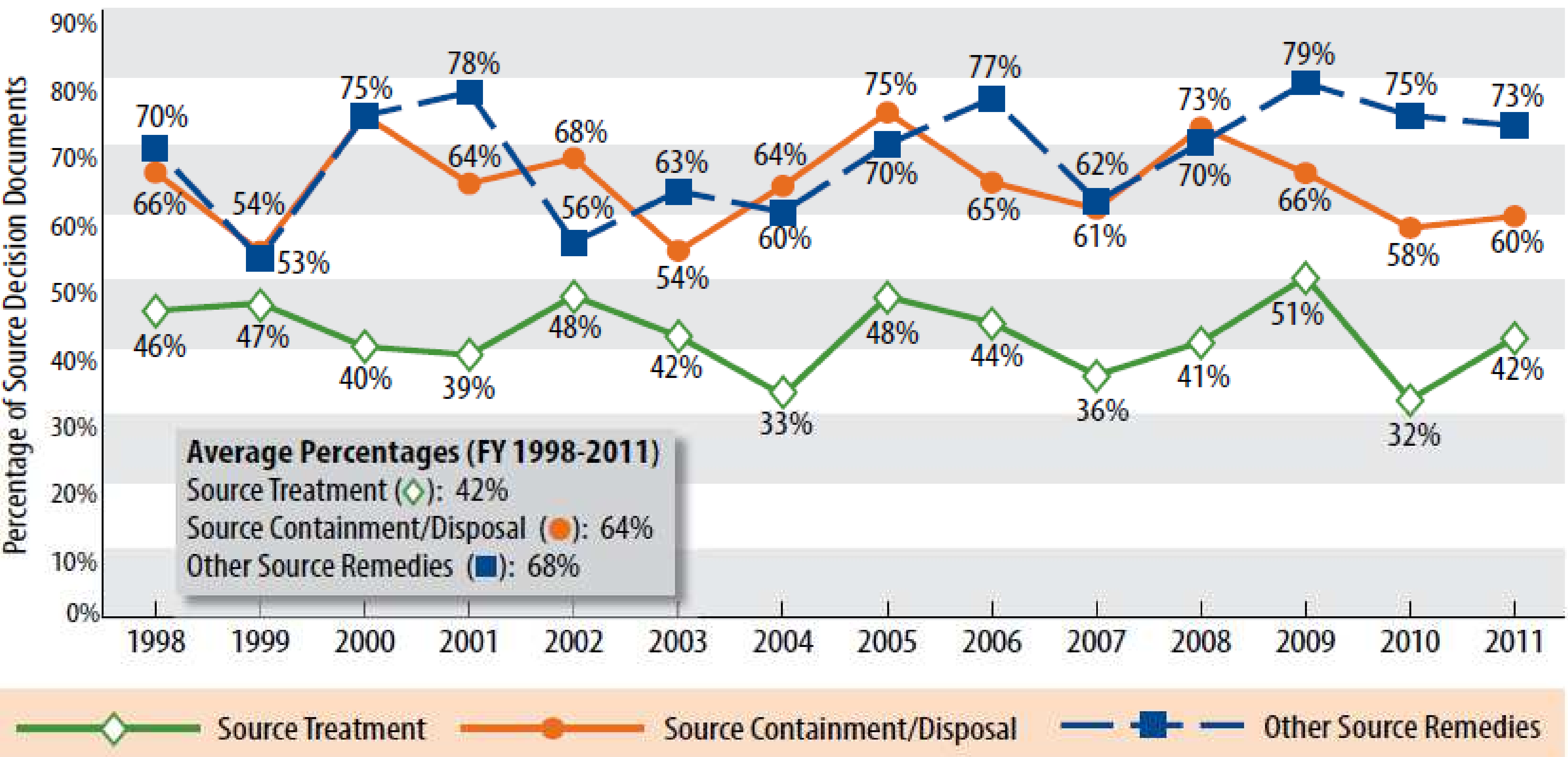
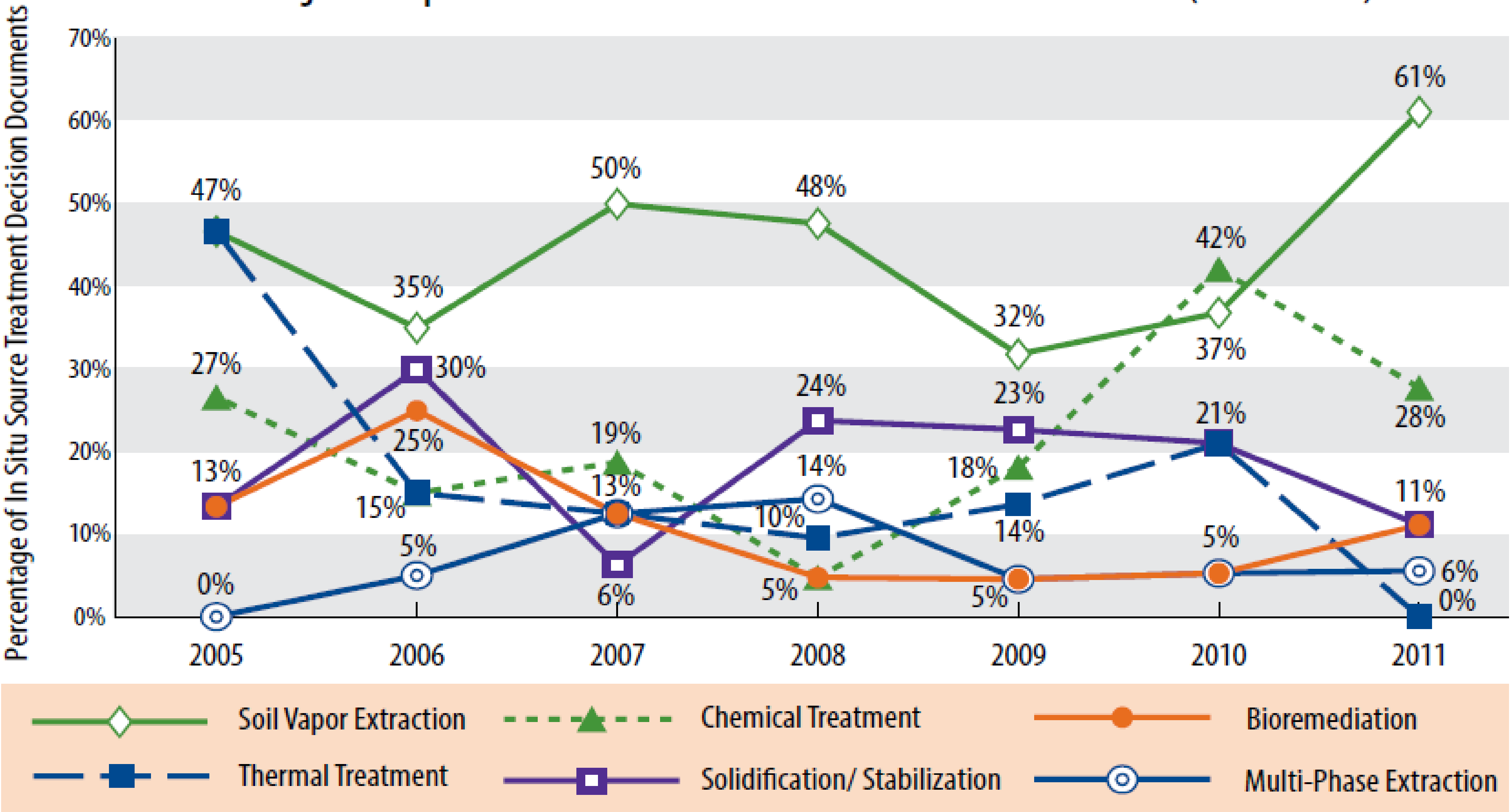


Figure 8: Selection Trends for Source Remedies (FY 1998–2011)



- Number of source decision documents for FY 1998-2011 = 1,293.
- Decision documents may be counted in more than one category.

Figure 9: Top 6 In Situ Source Treatment Remedies in Decision Documents (FY 2005-2011)



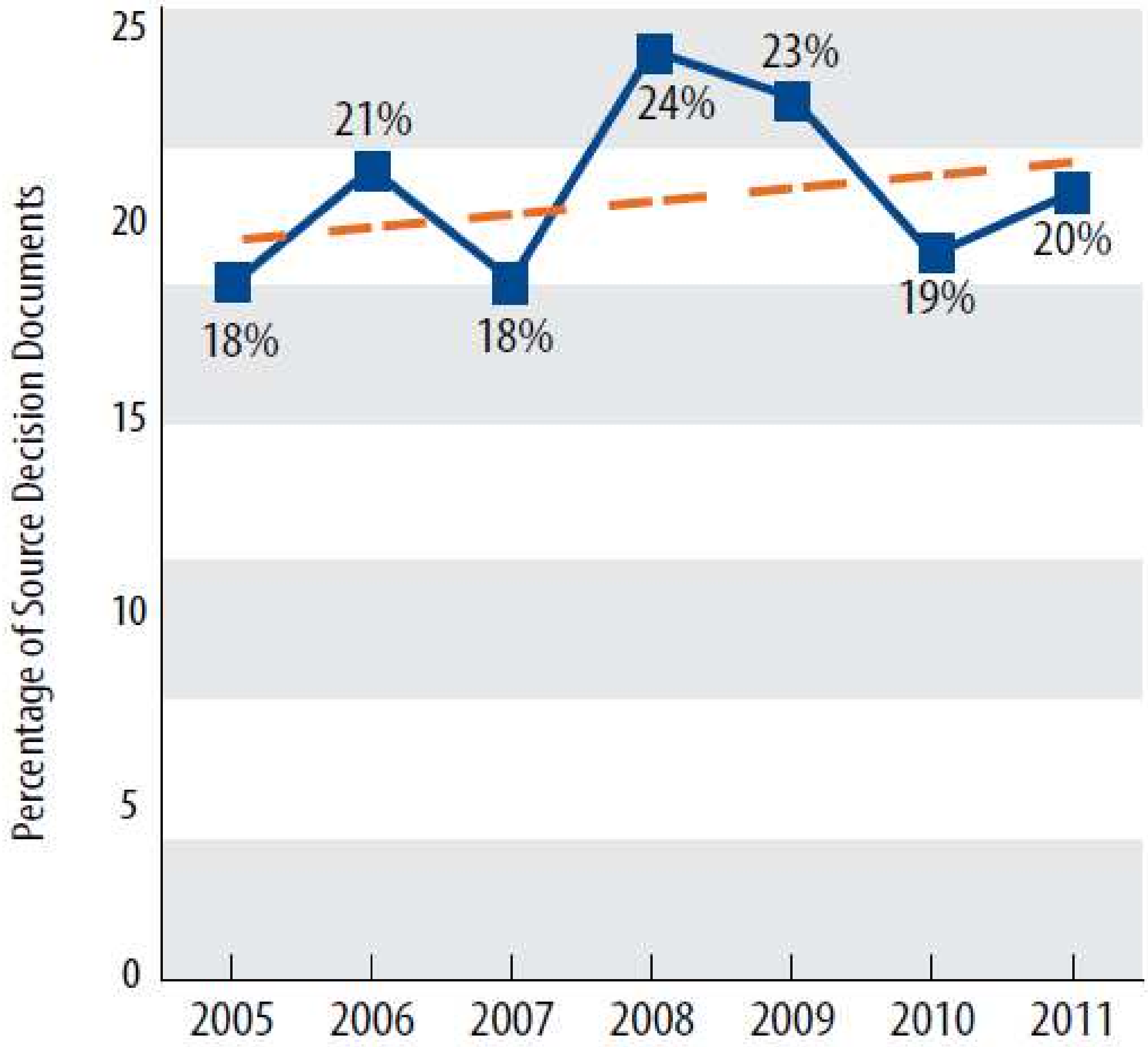
- Number of decision documents selecting in situ source treatment remedies = 131.
- Decision documents may be included in more than one category.

Table 1: Source Treatment Technologies Selected in Decision Documents

Technology	Total (FY 2005-08)	Percent Source Treatment Decision Documents (FY 2005-08)	Total (FY 2009-11)	Percent Source Treatment Decision Documents (FY 2009-11)
In Situ Treatment	**72**	**48%**	**59**	**50%**
Soil Vapor Extraction	32	21%	25	21%
Chemical Treatment	11	7%	17	14%
Solidification/Stabilization	14	9%	11	9%
Thermal Treatment	14	9%	7	6%
Bioremediation	10	7%	4	3%
Multi-Phase Extraction	6	4%	3	3%
Constructed Treatment Wetland	0	0%	2	2%
Subaqueous Reactive Cap	0	0%	2	2%
Flushing	2	1%	1	1%
Fracturing	1	1%	1	1%
Phytoremediation	2	1%	0	0%
Ex Situ Treatment	**98**	**65%**	**80**	**67%**
Physical Separation	31	21%	33	28%
Solidification/Stabilization	29	19%	15	13%
Pump and Treat	18	12%	13	11%
Unspecified Off-site Treatment	11	7%	11	9%
Recycling	15	10%	10	8%
Unspecified On-site Treatment	2	1%	6	5%
Phytoremediation	0	0%	5	4%
Chemical Treatment	5	3%	4	3%
Bioremediation	4	3%	3	3%
NAPL Recovery	1	1%	1	1%
Thermal Desorption	1	1%	1	1%
Unspecified Thermal Treatment	1	1%	1	1%
Other Ex Situ Technologies	13	9%	0	0%

The selection of ex situ S/S decreased from 19 to 13 percent for the recent time period but is still the second most commonly chosen ex situ remedial technology for sources. Solidification and stabilization are separate processes that are often used together; however, stabilization does not always result in solidification. When enough detail was provided in the decision document, stabilization was categorized as chemical treatment rather than as S/S for both FY 2005 to 2008 and FY 2009 to 2011 data. Although

Figure 10: Trends in Source Decision Documents Selecting In Situ Treatment (FY 2005-2011)



• Number of source decision documents = 645.

EPA-542-R-07-012

Technology	Total number of projects[a]	Polycyclic aromatic hydrocarbons (PAHs)	Other nonhalogenated semivolatile organic compounds[b]	Benzene-toluene-ethylbenzene-xylene (BTEX)	Other nonhalogenated volatile organic compounds[c]	Organic pesticides and herbicides	Other halogenated semivolatile organic compounds[d]	Halogenated volatile organic compounds	Polychlorinated biphenyls	Metals and metalloids
Bioremediation	113	37	51	33	33	24	17	22	2	5
Chemical Treatment	29	1	2	3	4	1	4	12	4	13
Multi-Phase Extraction	46	9	3	11	6	4	8	18	1	1
Electrical Separation	1	0	0	0	0	0	0	1	0	0
Flushing	17	3	5	5	5	1	3	11	0	5
Incineration	147	27	41	33	23	36	34	52	36	6
Mechanical Soil Aeration	7	0	0	3	1	0	1	7	0	0
Neutralization	15	2	0	0	0	0	0	0	0	6
Open Burn/ Open Detonation	4	0	1	0	0	0	0	0	0	0
Physical Separation	21	4	2	1	0	3	0	0	4	5
Phytoremediation	7	1	2	2	2	1	1	4	0	4
Soil Vapor Extraction	255	15	31	107	51	3	33	217	1	0
Soil Washing	6	1	1	0	0	2	0	0	1	2
Solidification/ Stabilization	**217**	**17**	**18**	**13**	**13**	**16**	**7**	**20**	**35**	**180**
Solvent Extraction	4	2	1	0	1	1	0	2	2	1
Thermal Desorption	71	21	17	24	15	8	12	33	16	0
In Situ Thermal Treatment	14	5	0	2	0	3	3	8	0	0
Vitrification	3	0	0	1	1	0	1	3	2	1
Total Projects	**977**	**145**	**175**	**238**	**155**	**103**	**124**	**410**	**104**	**229**

Types of Sites Applied

- Wood Preserving Sites
- Herbicide and Pesticide Sites
- Oil Refinery Sludge Lagoons
- Manufactured Gas Plants
- Sediment including PCB
- Metal Refining, Smelting, Plating, Recycling
- Residual Ash

S/S Agents

Portland cement, Cement kiln dust

Fly ash e.g. Class F and C (pozzolanic fly ashes)

Lime e.g. quicklime, hydrated lime, lime kiln dust

Slag e.g. ground granulated blast furnace slag

Organoclay®

EnviroBlend®

Bentonite clay

Activated carbon

Cement-based proprietary mixtures

Silicate, phosphate, and sulfate
e.g. triple super phosphate

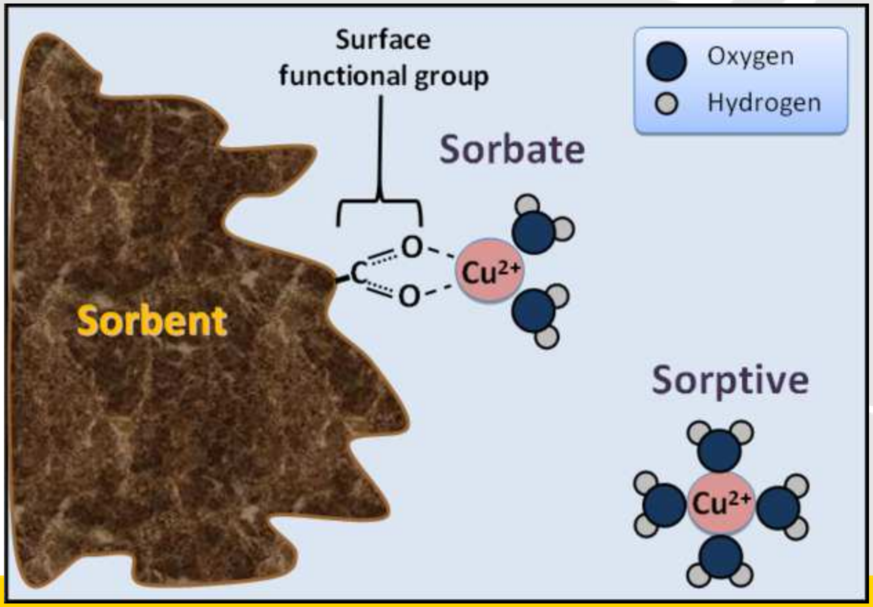
Sample Effects of Agents

- Mass strength development:
  - Cements, slags, fly ashes
- Mass hydraulic conductivity reduction:
  - Bentonite, cements, slags,
- Encapsulation: strength and lower hyd. cond.
- Sorption of hazardous constituents:
  - Activated carbon, organophilic clay
- Chemical changes to hazardous constituents
  - pH: hydroxides
  - Compounding, sulphates
  - Oxidation: insitu chemical oxidation: permanganates
  - Reducing: “hex” Cr to trivalent Cr

Effects of Agents

The effectiveness of S/S agents is improved by intimate contact within the treated mass and with the targeted hazardous constituents.

- Mass strength development:
- Mass hydraulic conductivity reduction:
- Sorption of hazardous constituents:
- Chemical changes to hazardous constituents



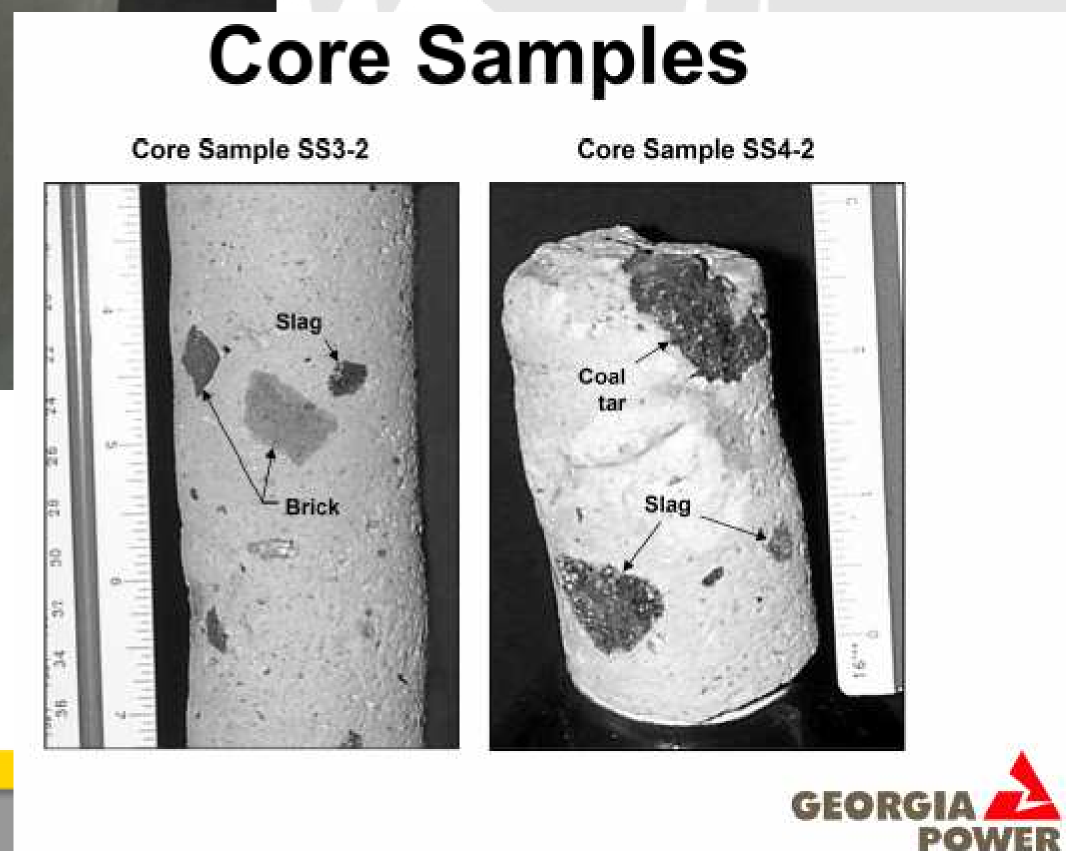
Sample S/S Agent Physical Properties

Agent	Specific Gravity	Bulk Density kg/m³	Fineness
Portland cement	3.10 to 3.25	1500	<45 microns
GGBFS (slag)	2.85 to 2.95	1050 to 1375	<45 microns
Organoclay® (PM200)	1.74	750 to 800	.3 to 2mm
Fly Ash	1.9 to 2.8	540 to 860	Generally <20 microns
Activated carbon	2 to 2.1	500 to 500	Granular to Powdered

Variable Consistency of Subject Material

Inclusions

Former MGP Sites



Laboratory Formulation

Large scale laboratory mixing in drum

Solidified samples prepared for strength and permeability testing

Bench-Scale to Full-Scale

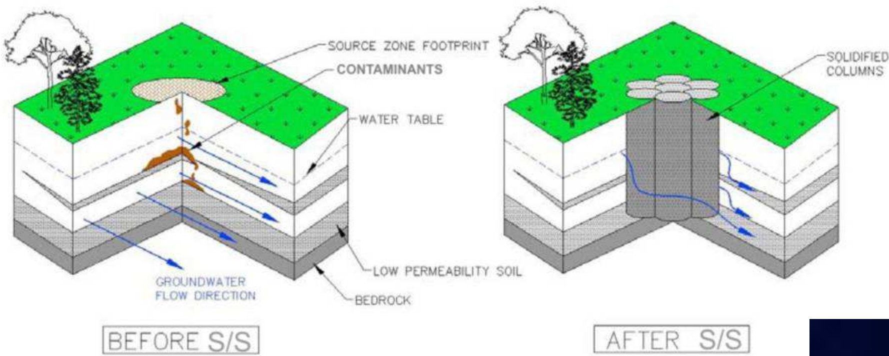
VS

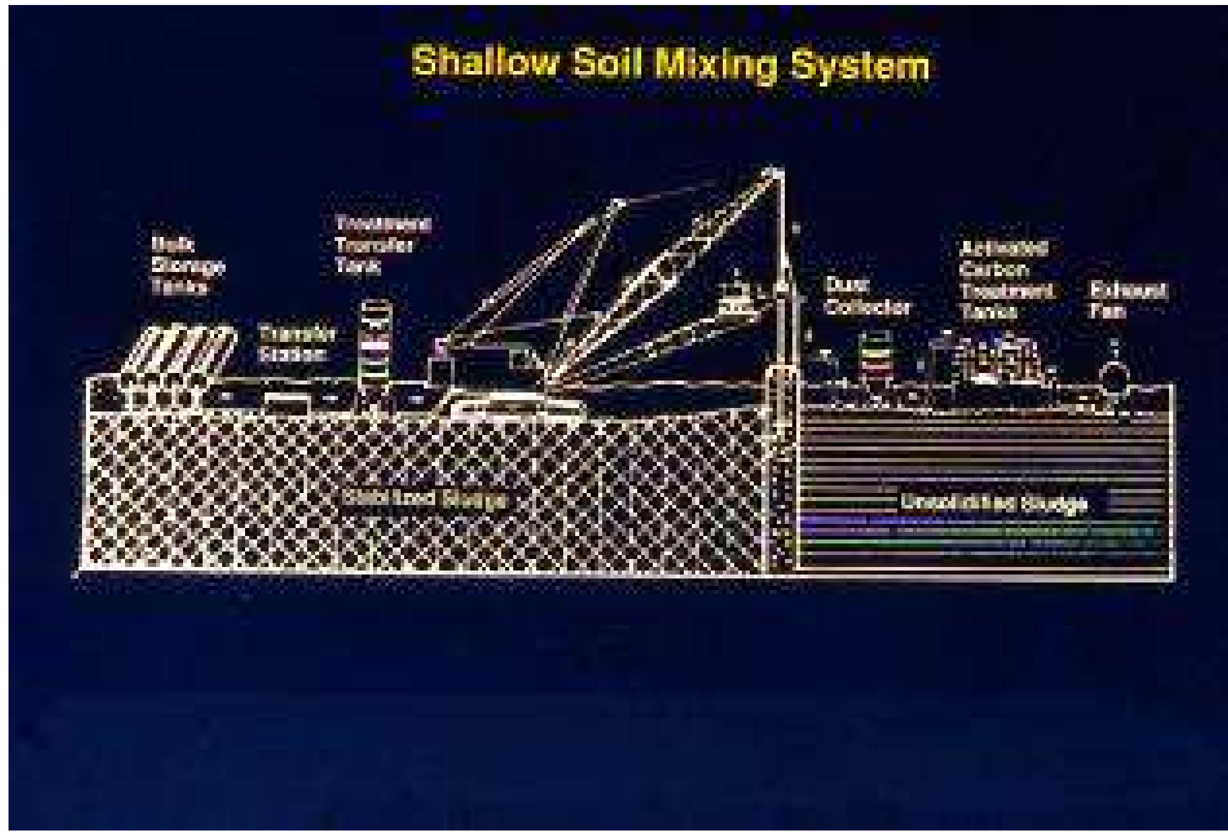
MIXING ENERGY/SHEAR

25-100 RPM
9000 FT-LBS Torque
Providing Mixing
Energy and Shear

Folding Mixing Action dependent on Operator's "Stroke"

Auger Mixing





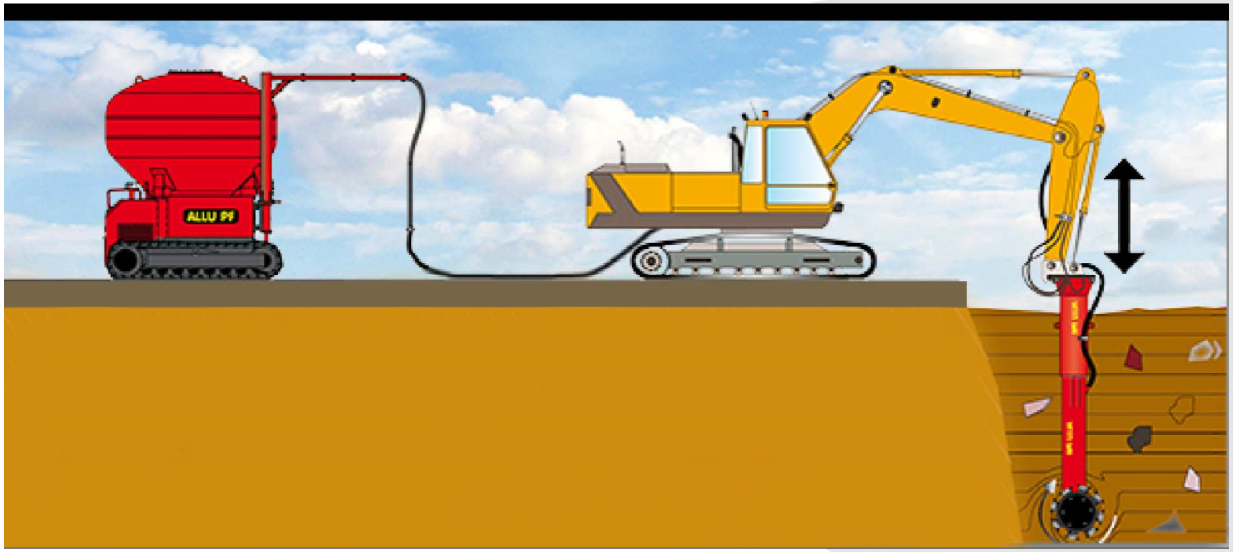
Road Reclaimer

Bucket Mixing

Injector Rake

”Folding Action” Mixing Methods

Horizontal Axis Insitu Mixers



Binding Agent Pricing

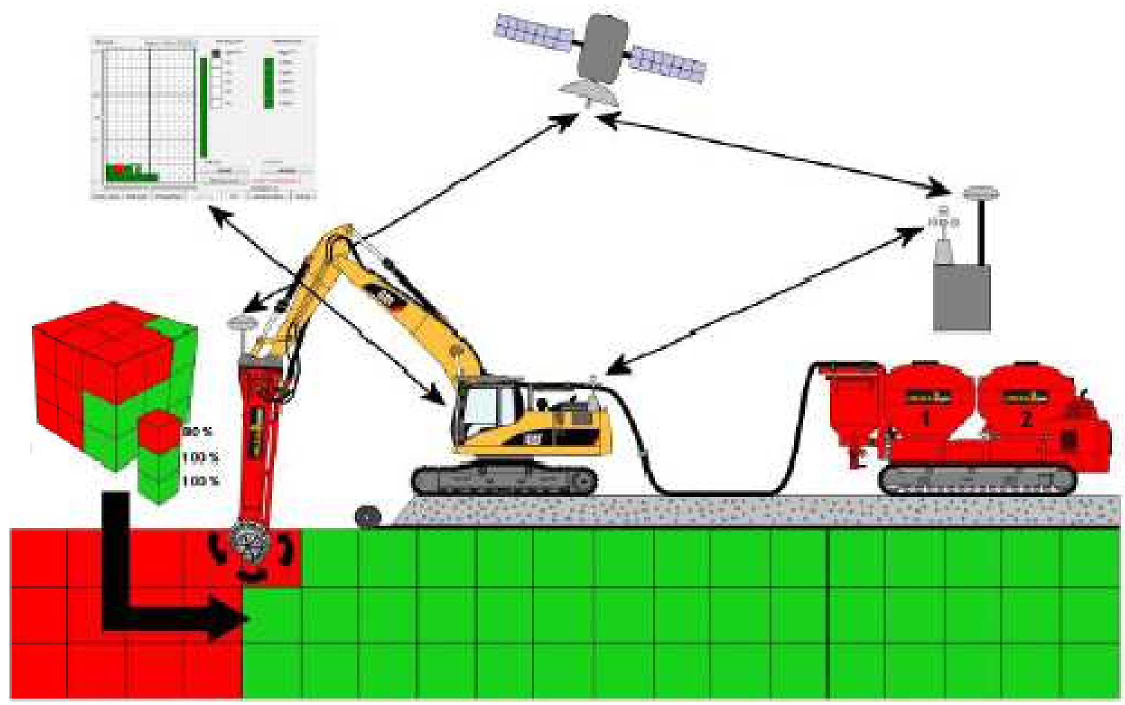
- Priced by transportation costs:
  - Industrial waste/byproducts, finely divided materials available on site, e.g. spent fullers earth, ash
- Priced per ton:
  - Common construction materials:
    - portland cement, blended cements, Class C or F fly ash, GGBFS, lime.
- Priced per pound:
  - Specialized materials, sorptive, reactive, or compounding
    - Carbons, organophilic clays, oxidizers, reducers

Efficient Use of Binders Matters

Most of the cost in a mass stabilization project comes from the binder, which represents about ***50-70 % of the total project cost.***

Efficiencies (Cost Savings) are **improved** by:

- Thorough mixing (mixing shear & energy) resulting in intimate contact of binder and subject material***.***
- Introduction of binder at mixing point.
- Locating and metering of binder to avoid under-dose and overdose.
- Use of dry binders in wet materials to conserve drying capacity of binders.



Ashtabula Harbor, Ohio

Dredge and S/S treat 120,000 cy ($92,000\ m^3$) of contaminated sediment.

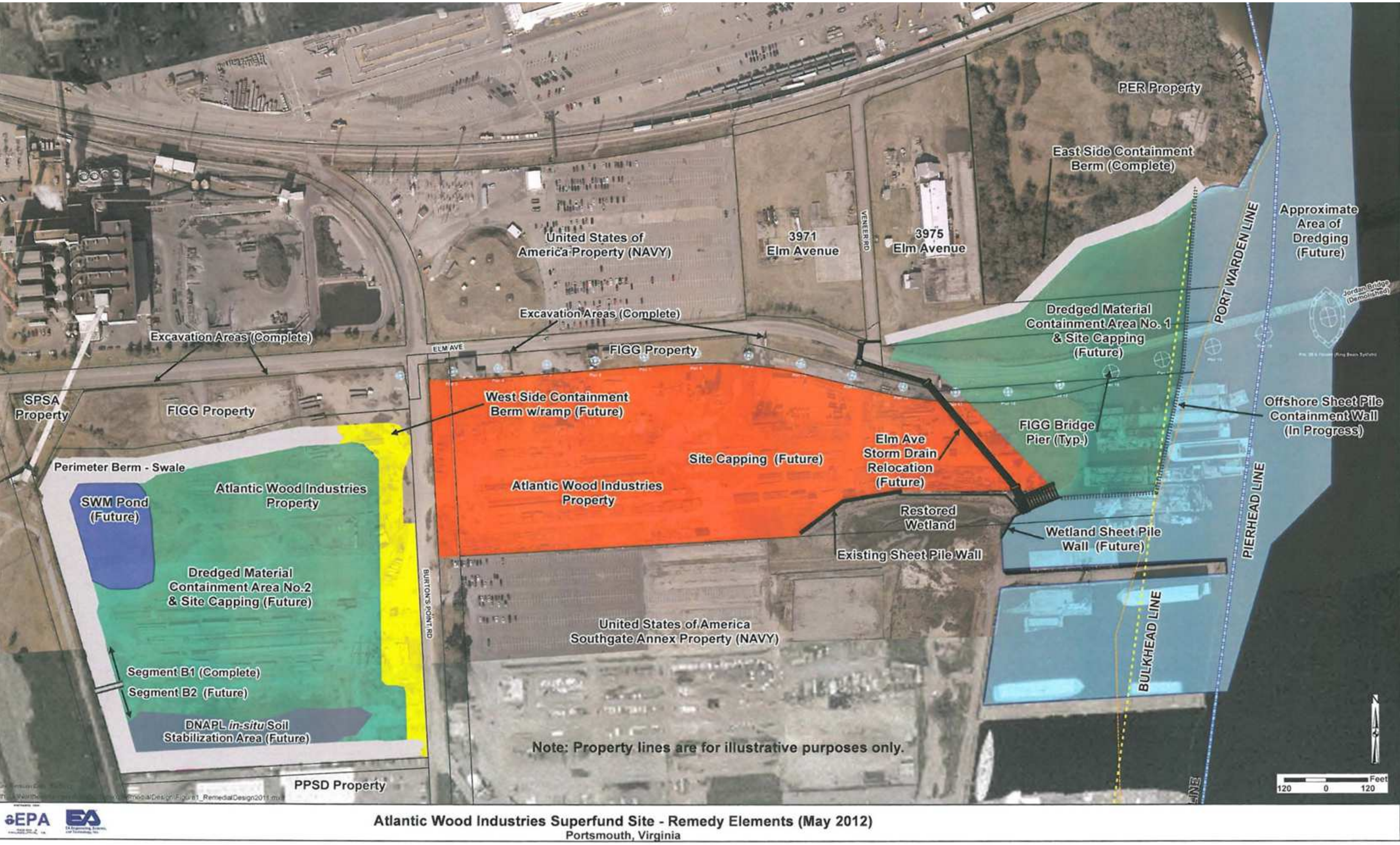
Placement of S/S treated dredge into Elkem 5C Pond, a 9-acre former settling pond. Additional material needed to facilitate closure of pond

Solidification of Elkem 5C Pond

Binder added dry 20% by weight. UCS goals range from 1,000 psf to 1,500 psf (0.05 to 0.07 MPa.
Unconsolidated shear strength goal of 1,250 psf (0.08 Mpa)
Mixing depths variable - 5 - 20 ft.

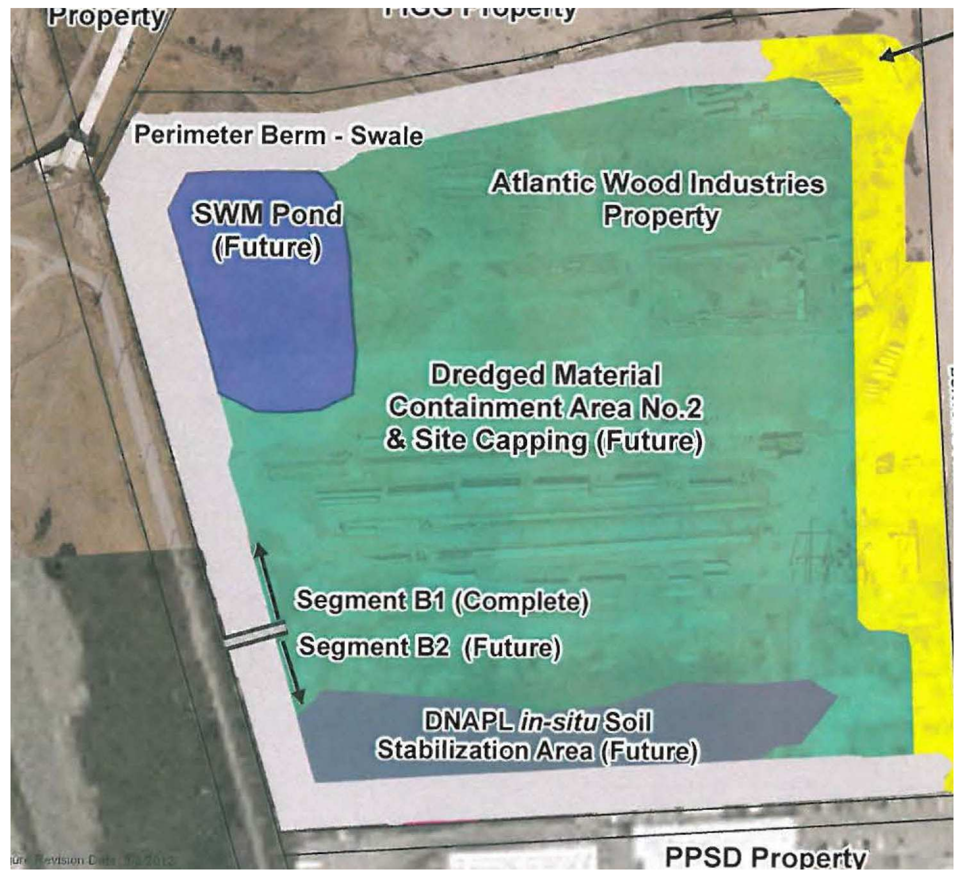
- Solidification of existing contents 153,000 m^3

Atlantic Wood Industries



AWI Project

- Insitu S/S of 47,000 cu yd creosote- and pentachlorophenol-impacted soils
- Treatment depths ranging from 8 to 27 feet.
- Performance standard
  - $\geq$50 psi UCS
  - $<4 \times 10^{-6}$ cm/sec



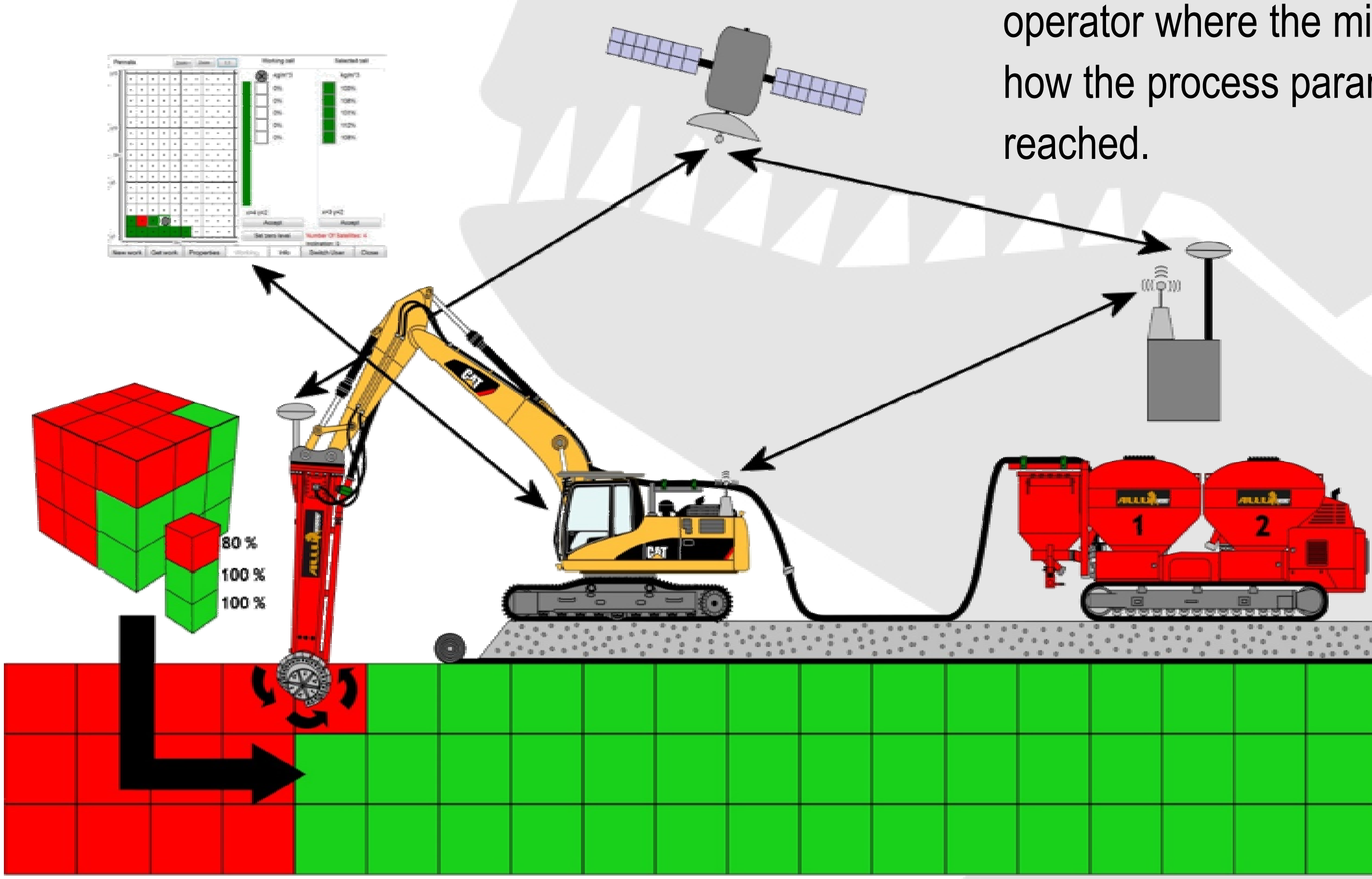
AWI Mix Design

- 30,500 cu yd treated with:
  - 8% portland cement/slag and
  - 1% CETCO Organoclay
- 15,200 cu yd treated with:
  - 8% portland cement/slag and
  - 3% CETCO Organoclay
- Mixture as slurry injected and mixed by ALLU PMX.

CONTROL SYSTEM

ALLU 3D Positioning System

The system shows to the PMX operator where the mixing head is and how the process parameters are reached.



One Step Ahead

Process difficult sludges & contaminated soils more efficiently than ever!
The new ALLU 3D Positioning System can be fitted to any ALLU Stabilization System, new or old. The 3D System consist of four modules:

GPS antennas (2 pcs), mounted on top of the ALLU PMX mixing unit
Base station, can be placed anywhere at the job site
Touch screen, inside the base machines' cabin

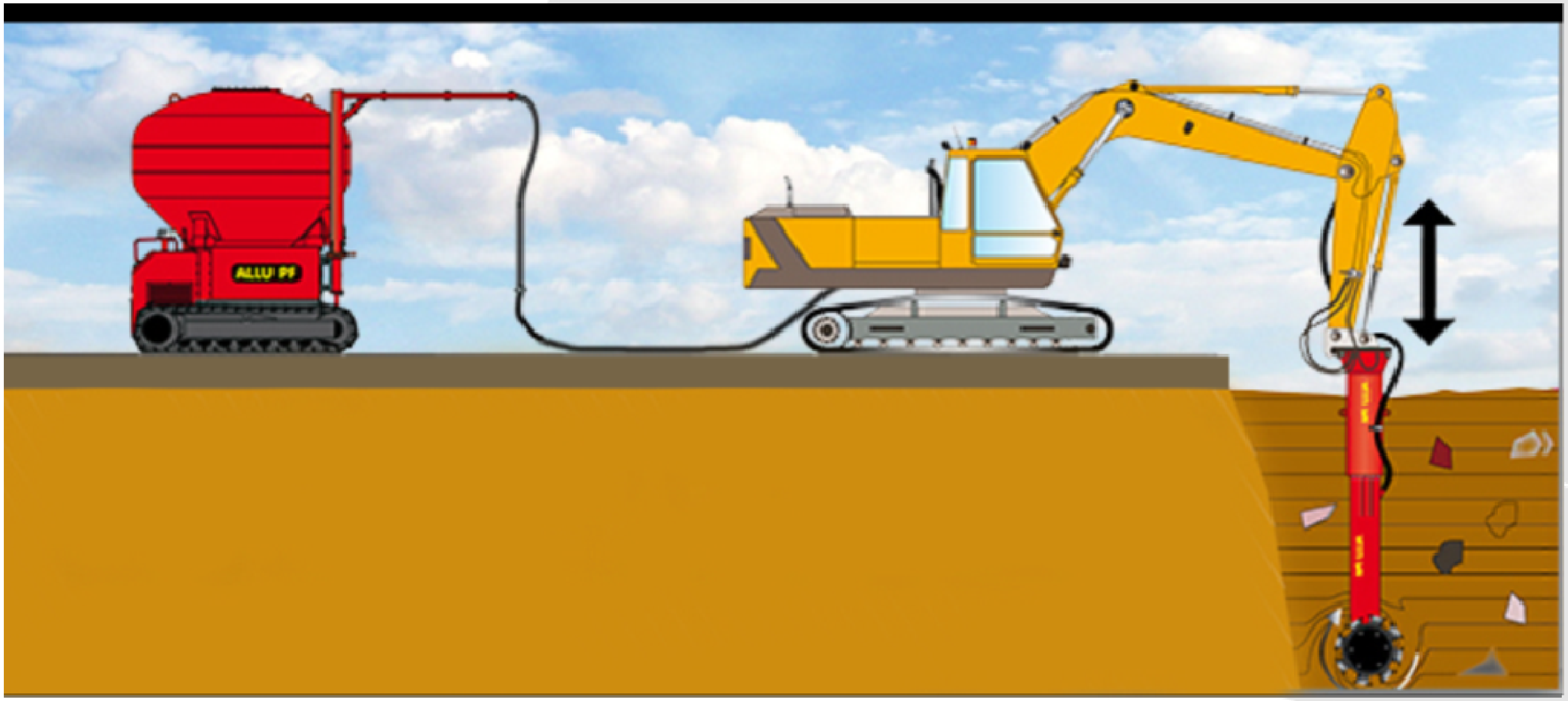
Computer unit with software, placed inside or outside the cabin

Benefits:

- Guides the base machine operator to feed right amount of binder and to mix adequately each block of the site
- Accurate binder distribution
- Reduced binder consumption
  - Tells when to change cell/block and start stabilising from another cell/ block
  - Advanced reporting by ALLU program, reports data from each block and cell processed
- The data is easy to collect from the computer unit with memory stick

□□***Higher quality and better job site economy can be reached***
□□***Excellent report and data from the stabilization work done***

Efficient Use of Binders Matters



Contact

Chuck Wilk

Manager, Stabilization and Remediation Applications

ALLU Group
847-714-2754
charlesw@allu.net