Environmental Remediation
Cement Solidification/Stabilization

LafargeHolcim

After decades of improper waste management, an industrial location in Sydney Harbor became severely contaminated

- Throughout the 20th century, runoffs from coke ovens of the steel industry filled the estuary with a variety of coal-based contaminants and sludge, making this area a hazardous waste site
- 800,000 metric tons of contaminated material needed to be treated due to the presence of pollutants like Polychlorinated Biphenyls (PCBs), raw sewage and benzene

LafargeHolcim helped transform the Sydney Tar Ponds into a 250 acres park for public use

- In 2009, cleaning operations using Solidification/Stabilization (S/S) with cement began
- The cleanup was completed in 2013, transforming the area into a Non-hazardous stabilized site, with 250 acres remediated
- This is the largest brownfield redevelopment project in North America to date and transformed the area into the Open Hearth Park, a green space with a sports field, outdoor concert stage and a playground

Solidification / Stabilization with Cement
How it Works

Depending of the type of contaminants, the material will need to be solidified and/or stabilized. This is achieved by mixing the soil with cementitious products

Organic Contaminants

- Oil
- Solvents
- Raw Sewage
- Polychlorinated Biphenyls (PCBs)
- Benzene

Heavy Metal Contaminants

- Lead
- Mercury
- Cadmium
- Arsenic
- Chromium
- Zinc

Solidification

- Encapsulation of organic contaminants physically changing the properties of contaminated soil
- Reduces porosity, hydraulic conductivity and permeability of soil
- Reduces free liquid, solubility, leachability, mobility of contaminants and provides a stable base for additional engineered controls

Stabilization

- Converts heavy metals into non-hazardous forms
- Chemically changes soil and/or contaminants. The high pH converts heavy metals to hydroxides (insoluble and non-leachable)
- Changes soil physical character making it more amenable to solidification

Cementitious products that can be used in Solidification/Stabilization

- Type I/II - General-Use cement
- Type III and Type V cement
- Limestone cement
- Slag cement
- Cement Kiln Dust (CKD)
- Fly Ash
- Combination of any of the above

Solidification / Stabilization with Cement
Process and Equipment

The main objective of this process is to provide a good mixing of the contaminated soil with the liquefied cement that will ensure the solidification and/or stabilization of the impacted material

High Depth Method

Low Depth Method

Solidification / Stabilization is Considered a Viable Solution by EPA and its Advantages Include Traffic Reduction and Material Reutilization

REDUCE

- **95% reduction in truck traffic** on the roads around our towns and cities. For Example:

Traditional Solution →  60 000 m³ =  20 m³ / truck x (3 000 *Incoming virgin material* + 3 000 *Outgoing hazardous material*) **= 6 000 trips**

With S/S →  60 000 m³ =  40 MT / truck **= 290 trips**

Less Traffic

REUSE

- An **on-site** solution means material is *treated* and not relegated to outside landfills. Waste material becomes an engineered construction product.

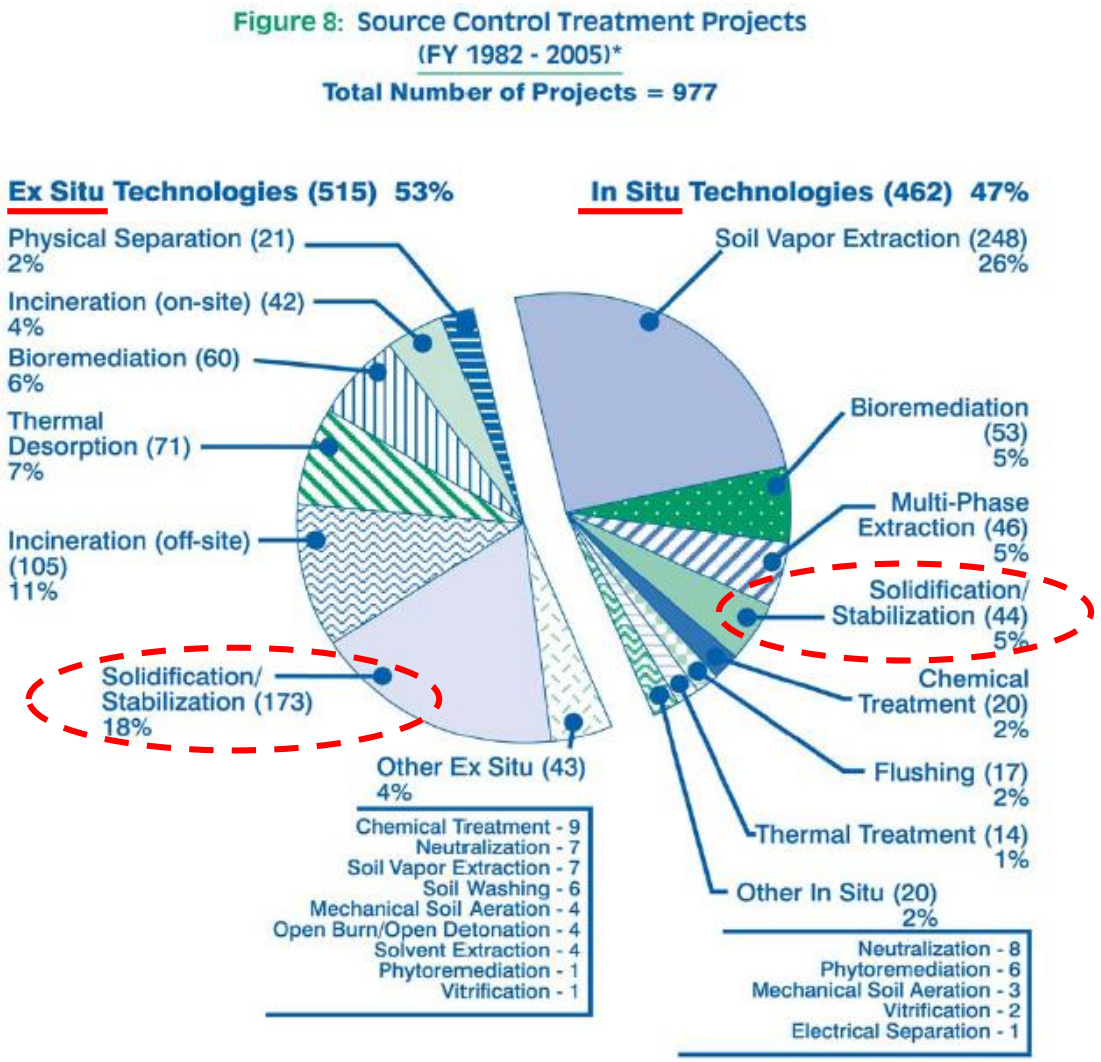
Recycled Material

RETHINK

- The U.S. Environmental Protection Agency (EPA) has identified S/S with cement as a *Best Demonstrated Available Technology* for **more than 50** Resource Conservation and Recovery Act (RCRA) listed wastes

Proven

23% of EPA Source Control Sites Used Solidification / Stabilization



LH Follows a Rigorous Sampling, Preparation and Testing Process

Sampling and Preparation

- Each *individual* sample in the blocks is a composition of randomly extracted samples from fresh test pits on site

Pre-engineering Testing

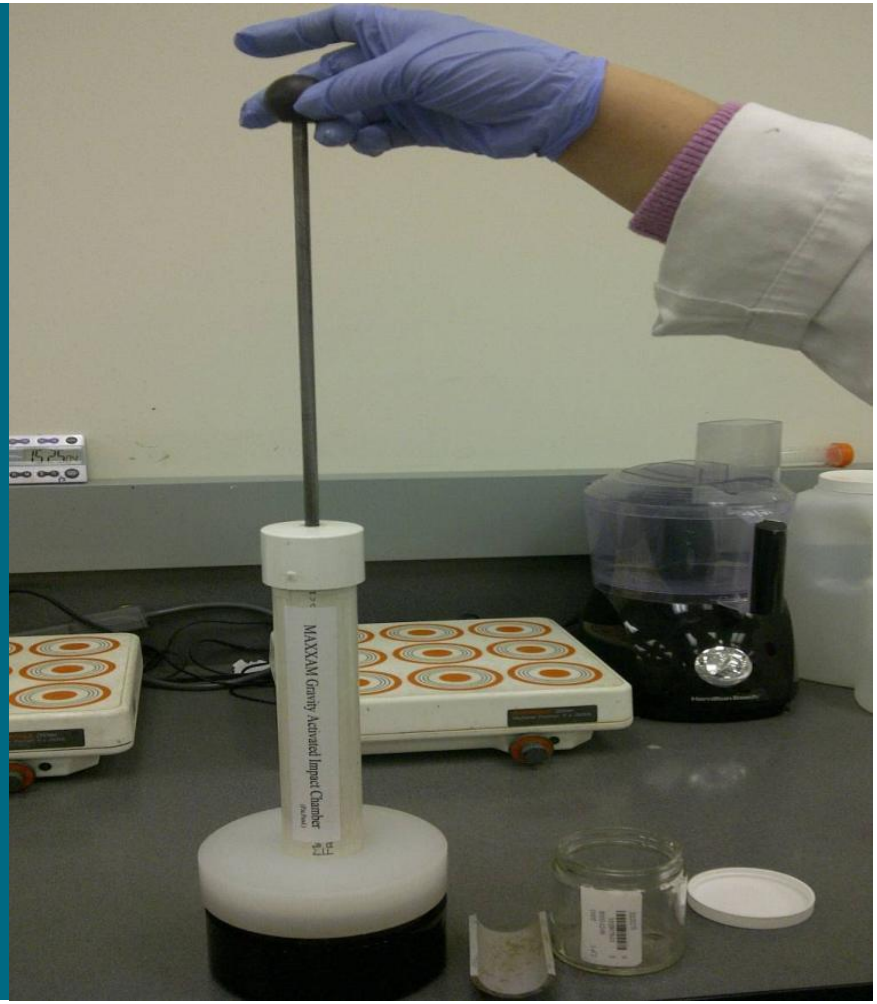
- Total organic carbon (*TOC*) of soil
- Compressive strengths 7/28 days
- Observed set time and workability
- Structural integrity test (*SIT*)
- Traditional synthetic precipitation leaching procedure (*SPLP*)
- *SPLP* extraction (on treated monolith)
- Proctor density curve & opt. moisture
- Gradation & in situ moisture content
- California bearing ratio (CBR)

Outgoing Material Testing

- Compressive strengths 7/28 days
- Structural integrity test (*SIT*)
- Traditional *SPLP*

Structural Integrity Test (SIT)

- U.S. EPA method 1310B
- Test method intent is to demonstrate treated soil will maintain structure in situ
- Relevant to treated soil that will be exposed only to acidified precipitation
- Core sample monolith tested using SPLP extraction
- Analytes tested are site specific
- Used successfully in compliance testing (e.g.: Sydney Tar Ponds, NS)



Impressive Reduction on Content of Hazardous Material

	BLOCK 1/14			
		SPLP SIT Sample [ug/L (*ppb*)]		
Metals	**Total Metals [ug/kg (*ppb*)]**	**5% Contempra**	**7% Contempra**	**9% Contempra**
Antimony (Sb)	1,800	0.7	0.7	0.6
Arsenic (As)	4,600	ND	ND	ND
Barium (Ba)	110,000	37	460	27
Beryllium (Be)	380	ND	ND	ND
Boron Hot Water Extraction	560			
Boron (B)	7,800	22	120	23
Cadmium (Cd)	260	ND	ND	ND
Chromium (Cr)	19,000	33	31	41
Cobalt (Co)	7,400	ND	2.0	1.3
Copper (Cu)	44,000	36	41	25
Lead (Pb)	110,000	ND	1.2	ND
Mercury (Hg)	140	ND	1.3	ND
Molybdenum (Mo)	780	10	7	6
Nickel (Ni)	20,000	17	22	13
Selenium (Se)	ND	ND	ND	ND
Silver (Ag)	ND	ND	ND	ND
Thallium (Tl)	130	ND	ND	ND
Vanadium (V)	26,000	14	10	5
Zinc (Zn)	110,000	ND	20	ND

*note: moisture content in 23% - 34% range

Foundry Sand Before / After Adding CKD

CASTING SAND	Lagoon 1	Lagoon 2	Lagoon 1 - 10%	Lagoon 1 - 15%	Lagoon 2 - 10%	Lagoon 2 - 15%
Parameter (PPM)	**1170076**	**1170077**	**1177257**	**1177258**	**1177260**	**1177262**
Antimony	<1.6	<1.6	0.05	0.05	0.02	0.02
Arsenic	**6.80**	**9.00**	**<0.010**	**<0.010**	**<0.010**	**<0.010**
Barium	201.00	182.00	0.83	0.72	0.40	0.51
Beryllium	0.80	1.30	<0.010	<0.010	<0.010	<0.010
Cadmium	7.00	14.50	0.07	0.04	0.06	0.04
Chromium	51.00	85.90	<0.020	<0.020	0.04	0.02
Cobalt	5.70	6.00	0.04	0.03	0.05	0.05
Copper	117.00	154.00	0.05	0.04	<0.030	<0.030
Iron	26,700.00	38,200.00	6.62	5.28	53.20	15.70
Lead	**193.00**	**483.00**	**0.03**	**0.01**	**0.57**	**0.18**
Manganese	666.00	2,010.00	6.30	5.05	17.10	13.20
Mercury	**0.39**	**0.85**	**<0.02**	**<0.02**	**<0.02**	**<0.02**
Molybdenum	6.70	9.00	0.04	0.05	<0.020	0.03
Nickel	40.80	57.90	0.19	0.15	0.49	0.41
Selenium	0.80	1.50	0.01	0.02	<0.010	<0.010
Silver	0.90	4.00	<0.010	<0.010	<0.010	<0.010
Strontium	130.00	135.00	4.12	3.71	3.82	3.91
Thallium	<0.4	<0.4	<0.010	<0.010	<0.010	<0.010
Titanium	96.00	147.00	<0.050	<0.050	<0.050	<0.050
Vanadium	11.50	36.00	<0.020	0.02	<0.020	<0.020
Zinc	1,420.00	7,040.00	12.30	7.18	81.40	70.20
pH	n/a	n/a	10.90	11.90	9.84	10.50

LafargeHolcim

Success Stories
Sydney Tar Ponds Clean Up

Site: Tar Ponds, Sydney, NS

Date: 2007 - 2013

Challenges:

- 800,000 tons of material needing to be excavated
- Cooling pond sludge from coke ovens
- Over 3.8 tons of PCBs, raw sewage and benzene

Requirements:

- Minimal dust, unconfined compressive strengths and permeability specs
- Future site uses: park, walking trails, sports fields, and wetlands

Project / Application:

- *Contractors*: GHD; Nordlys Environmental and Van Zutphen Construction / *Material Supplier*: Lafarge
- Remediate ~100-hectare (250 acres) surface area
- In situ treatment, stabilization and solidification of soil/sludge, filling ponds

Benefits to Customer:

- Site stabilized and hazardous chemicals immobilized
- Canada's largest S/S project, converted to parkland
- Avoided most widely used method of destroying PCBs via incineration

Canadian URBAN Institute
WINNER
Best Overall Project
- 2012 -

Success Stories
Recycle Barrel Facility

Site: Lansing, MI

Date: March 2012

Challenges:

- 10,000 tons of material of lead-contaminated soil; 1,900-8,000 mg/Kg total Pb
- 10-150 ug/L in TCLP extraction
- Proximity to commercial and residential properties

Requirements:

- Stabilize lead in soil to less than 5 mg/L in a TCLP extraction

Project / Application:

- *Contractor*: CRA (GHD) / *Material Supplier*: Lafarge
- In situ treatment and removal off-site due to economical cost advantage
- Soil remediation using 1,000 tons of CKD

Benefits to Customer:

- Reduced cost due to in situ treatment before removal
- Dramatic reduction in landfill cost; non-haz vs hazardous
- Project resulted in 50% savings vs original budget of dig and haul

Success Stories
Former Chemical Facility

Site: Bay City, MI

Date: Summer 2013

Challenges:

- 40,000 tons of impacted soil
- Former chemical manufacturing plant)
- Hazardous heavy metals, PAHs and other organics

Requirements:

- Remediated site required passing environmental assessment for TCLP
- Portland Cement to solidify and immobilize organic fraction
- CKD to stabilize heavy metals (originally Portland was specified)

Project / Application:

- *Contractor*: Job Site Services / *Material Supplier*: Lafarge
- Remediate 40,000 ton of impacted soil and sludge in a series of drainage ditches
- In situ remediation and treated soil left in place

Benefits to Customer:

- No off-site landfilling
- Project resulted in 50% cost-savings vs. original budget of dig and haul

Questions?

Paul Ruehl
Paul.ruehl@lafargeholcim.com;
Phone: 313-506-8495

LafargeHolcim