LAFARGE
Building better cities™

Turning Soil Liabilities into Opportunities

A member of LafargeHolcim

Brownfield Site – Definition

Solidification / Stabilization (S/S) – *Processing Soil*

Common Objectives – *What We Can Achieve*

– *How We Can Achieve It*

Success Stories – *Project Profiles*

✓ **Turning Liabilities into Opportunities**

- "A brownfield site is an abandoned or under-utilized property that cannot be easily redeveloped because it is contaminated with hazardous substances.
- Solidification and Stabilization (S/S) using cementitious matererials can turn such environmental liabilities into economic opportunities.
- S/S has been applied successfully at many brownfield areas in North America, allowing the treated soil to be reused safely at the site.
- This reduces the need to remove hazardous materials and to transport such materials through communities.
- A variety of S/S application methods make the treatment suitable for a wide range of projects.
- With S/S, environmentally contaminated sites that once were thought unusable can be redeveloped safely and economically. "

Solidification / Stabilization (S/S) : Processing Soil

Solidification

- **Solidification** dramatically reduces porosity, hydraulic conductivity, and permeability of soil
- A reduction in free liquid, solubility, leachability, and mobility of contaminants is achieved
- Physically entraps contaminants
- Provides a very stable base for additional engineered controls
- Changes physical properties of contaminated soil

Solidification / Stabilization (S/S) : Processing Soil

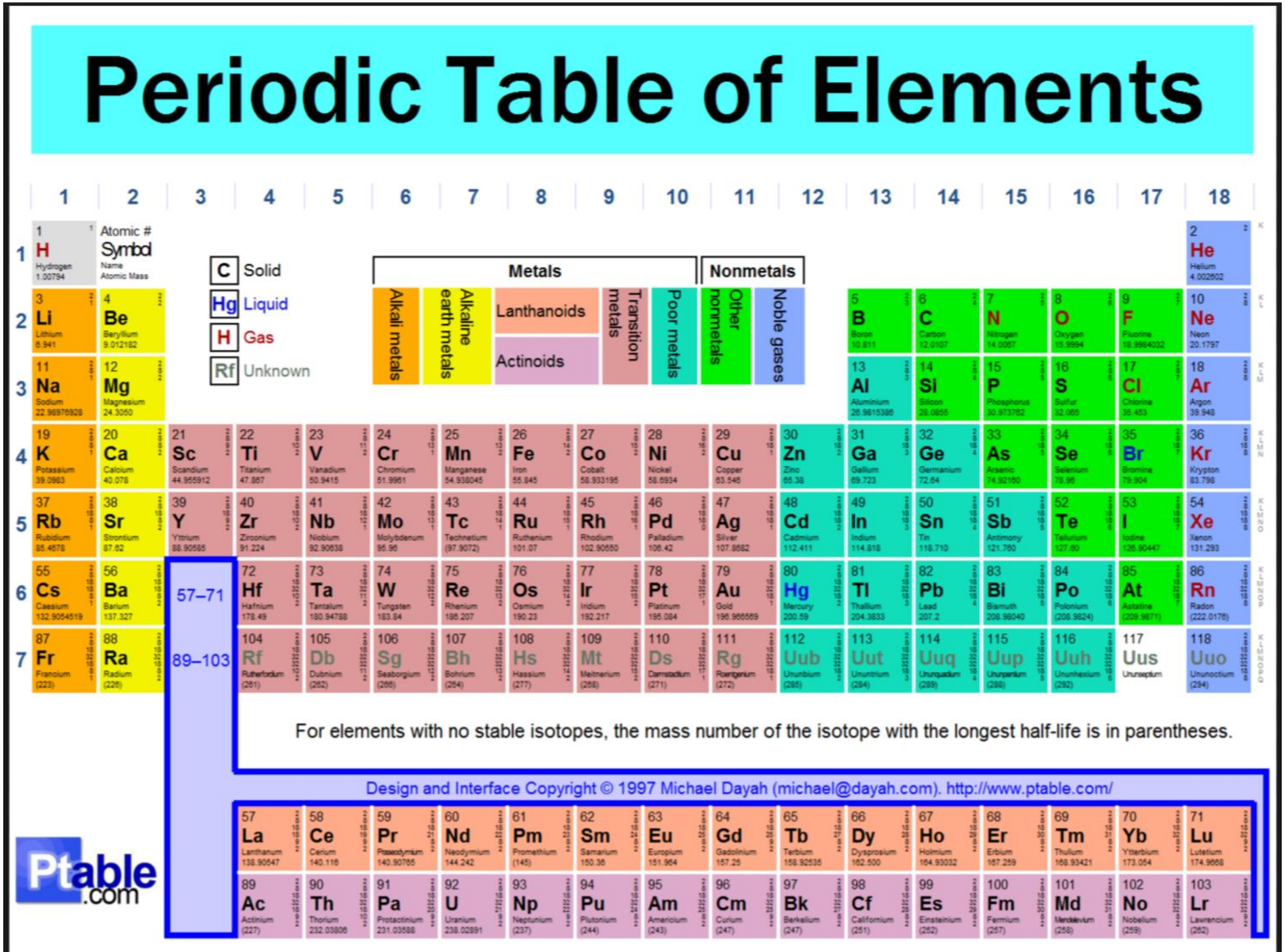
Stabilization

- ***Stabilization*** chemically changes soil and/or contaminants
- The high pH converts heavy metals to insoluble hydroxides
- Hydroxides are insoluble and non-leachable (remember the solubility rules!)
- Changes soil chemistry making it more amenable to solidification

Solidification / Stabilization (S/S) : Solubility Rules

- ✓ All common compounds of Group I and ammonium ions are soluble. (Li, Na, K, Rb, Cs)
- ✓ All nitrates, acetates, and chlorates are soluble.
- ✓ All binary compounds of the halogens (other than F) with metals are soluble, except those of Ag, Hg(I), and Pb. Pb halides are soluble in hot water.)
- ✓ All sulfates are soluble, except those of barium, strontium, calcium, lead, silver, and mercury (I). The latter three are slightly soluble.
- ✓ **Except for rule 1**, carbonates, **hydroxides**, oxides, silicates, and phosphates **are insoluble**.
- ✓ Sulfides are insoluble except for Group 1 and 2 plus ammonium

Solidification / Stabilization (S/S) : Solubility Rules



Reference: Google.ca Ptable.com

Solidification / Stabilization (S/S) : Processing Soil

- ✓ **Reduces hazardous soil contaminants to non-hazardous levels**
  - Also known as "Brownfield" remediation, in order to proceed with construction development initiatives or restore land back to its natural state

- ✓ **Brings about physical and chemical changes to soil impacted with either organic or inorganic hazardous constituents**
  - Mixing in a cementitious product as a binding reagent

- ✓ **Improves overall community health and environment by remediating the Brownfield in a sustainable fashion**
  - Reduced truck traffic, conservation of virgin material, etc.

- ✓ **Identifies an economic solution for *In Situ* or *Ex Situ* soil treatment and/or disposal**

Solidification / Stabilization (S/S) : Processing Soil

" Cement-based S/S has been used to treat a wide variety of contaminants, including inorganics —heavy metals like lead and arsenic —and organic contaminants, like creosote and petroleum products " - *Cement Association of Canada*

www.cement.ca/images/stories/Cement-Base%20Remediation%20Solutions.pdf

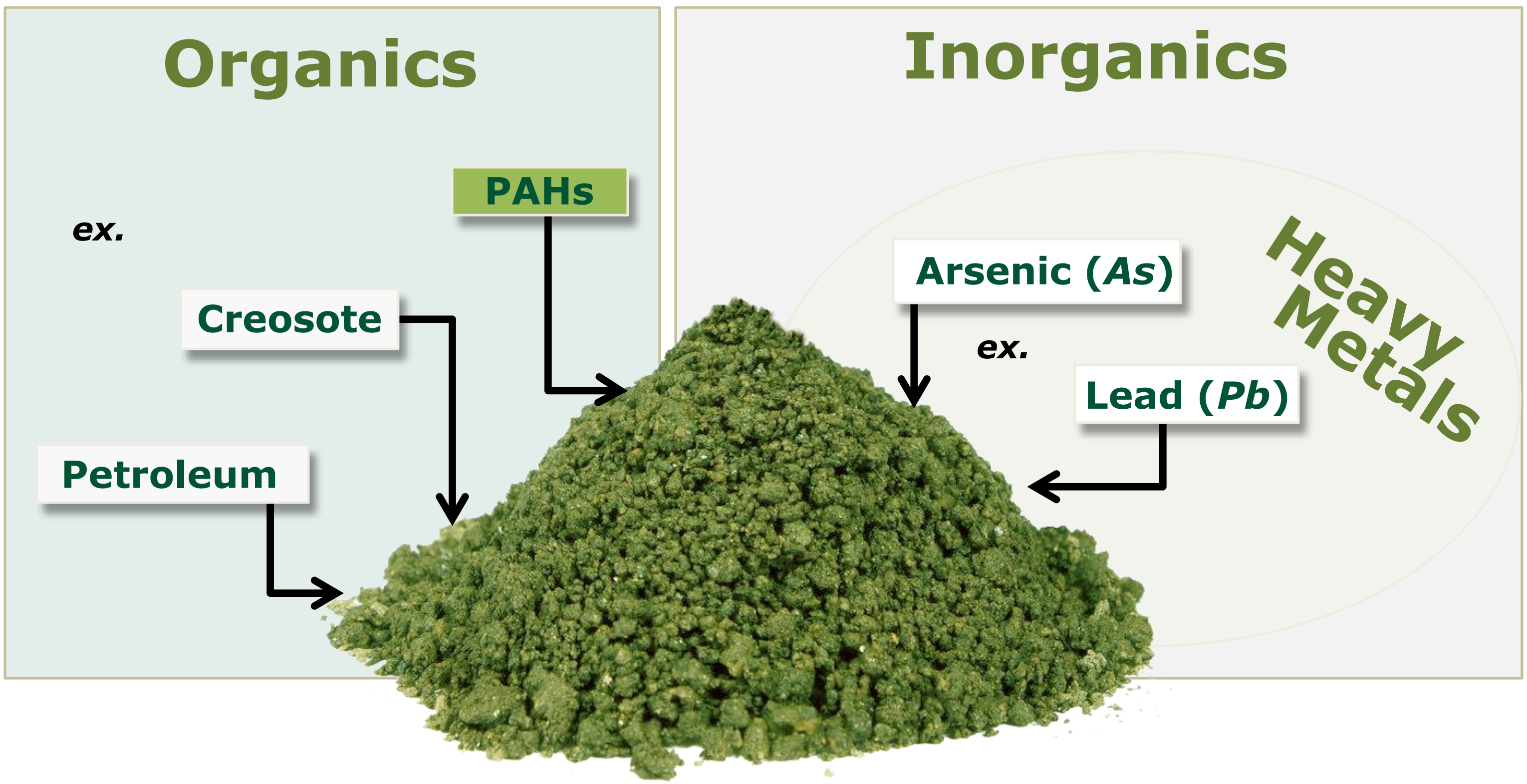


Table 2-1. Documented effectiveness of S/S treatment for chemical groups

Chemical groups	Citations for treatment effectiveness[a]		
	EPA 1993a[b]	EPA 2009b[b]	Other references[c]
Organic chemicals			
HVOCs[d]	N	N	D, with pretreatment (Paria and Yuet 2006)
N-HVOCs[d]	N	N	D, with pretreatment (Paria and Yuet 2006)
HSVOCs[d]	D	D	
N-HSVOCs, N-VOCs[d]	D	D	
PCBs	P	D	
Pesticides	P	D	
Dioxins/furans	P	P	D (Bates, Akindele, and Sprinkle 2002, PASSiFy Project 2010)
Organic cyanides	P	P*	D (Wilk 2007)
Organic corrosives	P	P*	D (Wilk 2007)
Pentachlorophenol	–	–	D (Bates, Akindele, and Sprinkle 2002, Wilk 2007)
Creosotes, coal tar	–	–	D (Bates, Akindele, and Sprinkle 2002,Wilk 2007)
Heavy oils	–	–	D (Wilk 2003)
Inorganic chemicals			
Volatile metals	D	D*	
Nonvolatile metals	D	D	
Asbestos	D	D*	
Radioactive materials	D	D	
Inorganic corrosives[d]	D	D*	
Inorganic cyanides[d]	D	D*	
Mercury	D	D*	EPA 2007b
Reactive chemicals			
Oxidizers	D	D*	
Reducers	D	D*	

[a] Key:

- N = no expected effectiveness, P = potential effectiveness, D = demonstrated effectiveness.
- P*/D* = S/S effectiveness was specifically stated in EPA 1993a but not in EPA 2009b; effectiveness is assumed to be the same in 2009. EPA 2007b documents the selection and use of S/S at National Priorities List (NPL) sites, but EPA does not indicate the effectiveness of the remedy.
- – = This chemical was not specifically discussed in EPA 1993a or 2009b, but effectiveness has been documented in other references (see rightmost column).

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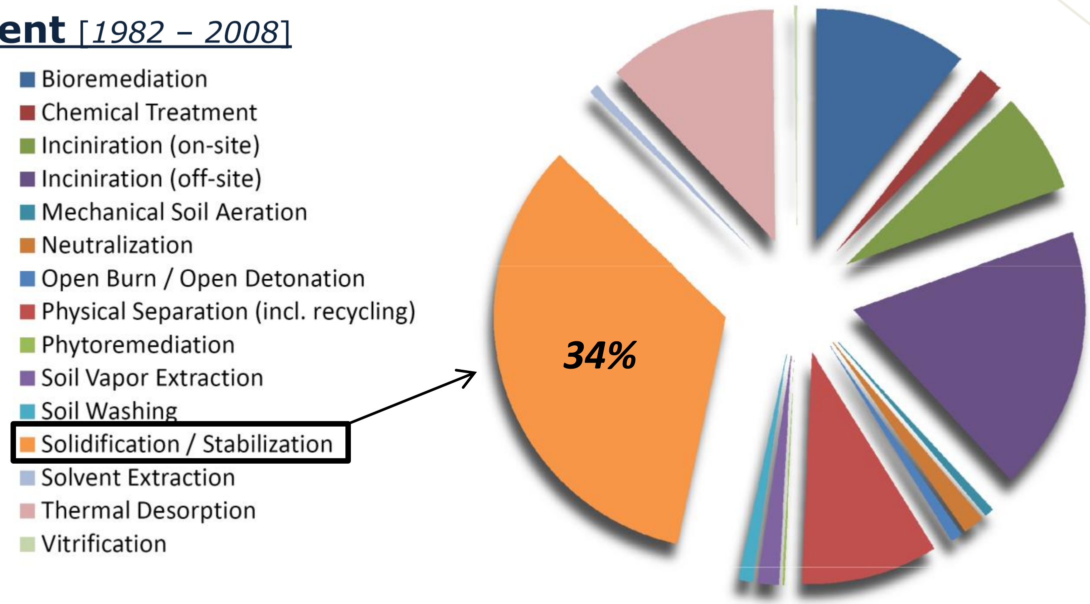
Common Objectives : *What We Can Achieve*

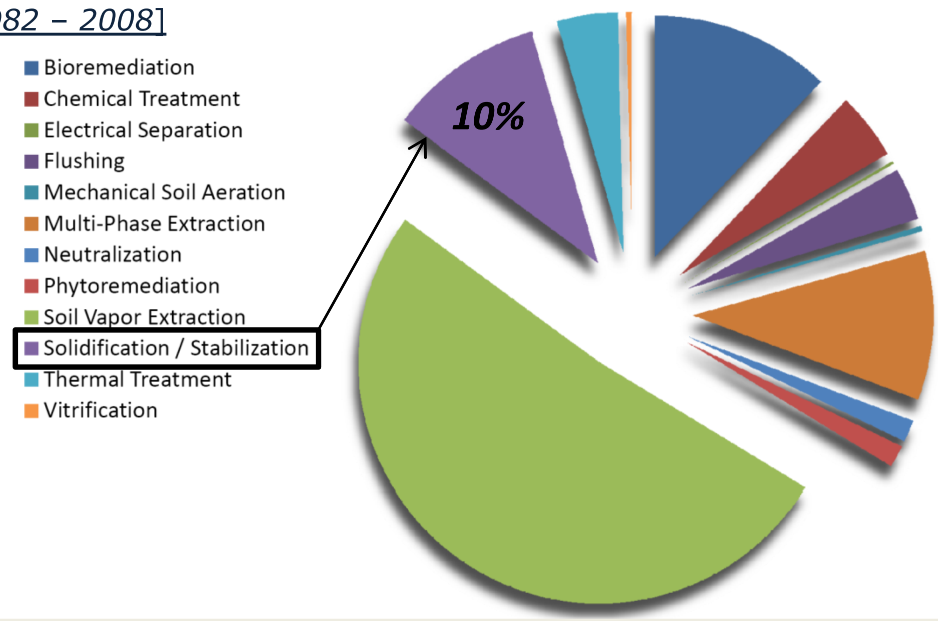
Ex Situ Treatment [*1982 – 2008*]

53% (598 sites)



In Situ Treatment [*1982 – 2008*]

47% (537 sites)



**source*: U.S. EPA Superfund Remedy Report (13th ed.); 2010 "Treatment technologies by fiscal year, 1982 to 2008

TYPICAL PRODUCTS USED

- GU cement
- *GUL* (General-Use Limestone cement)
- GU / slag blends
- GU / Fly Ash Blends
- CKD

The Advantages of Cement in S/S

- Manufactured under strict CSA standards
- *50 years of use in a variety of projects*
- Long term performance record
- Minimize volume increase compared with other reagents
- Non-proprietary manufactured product readily available

TYPICAL SPECIFICATION REQUIREMENTS

- Unconfined compressive strength
- Leachability

Optimized mix design

- Technical expertise of Lafarge staff help in analyzing soil contaminates and selection of cement contents
- Sample preparation of contaminated material at Belleville lab
- Unconfined compressive strength tests
- Coordination of testing samples for hydraulic conductivity and leachability

Sampling and Preparation

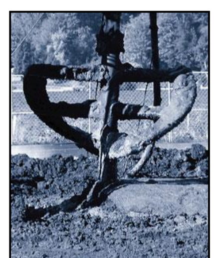
- PREPARATION -----
  Each *individual* sample in the blocks is a composition of randomly extracted samples from fresh test pits on site

Pre-engineering Testing

- ☑ TOTAL ORGANIC CARBON (*TOC*) OF SOIL
- ☑ COMPRESSIVE STRENGTHS 7 / 28 DAYS
- ☑ OBSERVED SET TIMES & WORKABILITY
- ☑ PROCTOR DENSITY CURVE & OPT. MOISTURE
- ☑ GRADATION & IN SITU MOISTURE CONTENT
- ☑ TCLP BEFORE AND AFTER

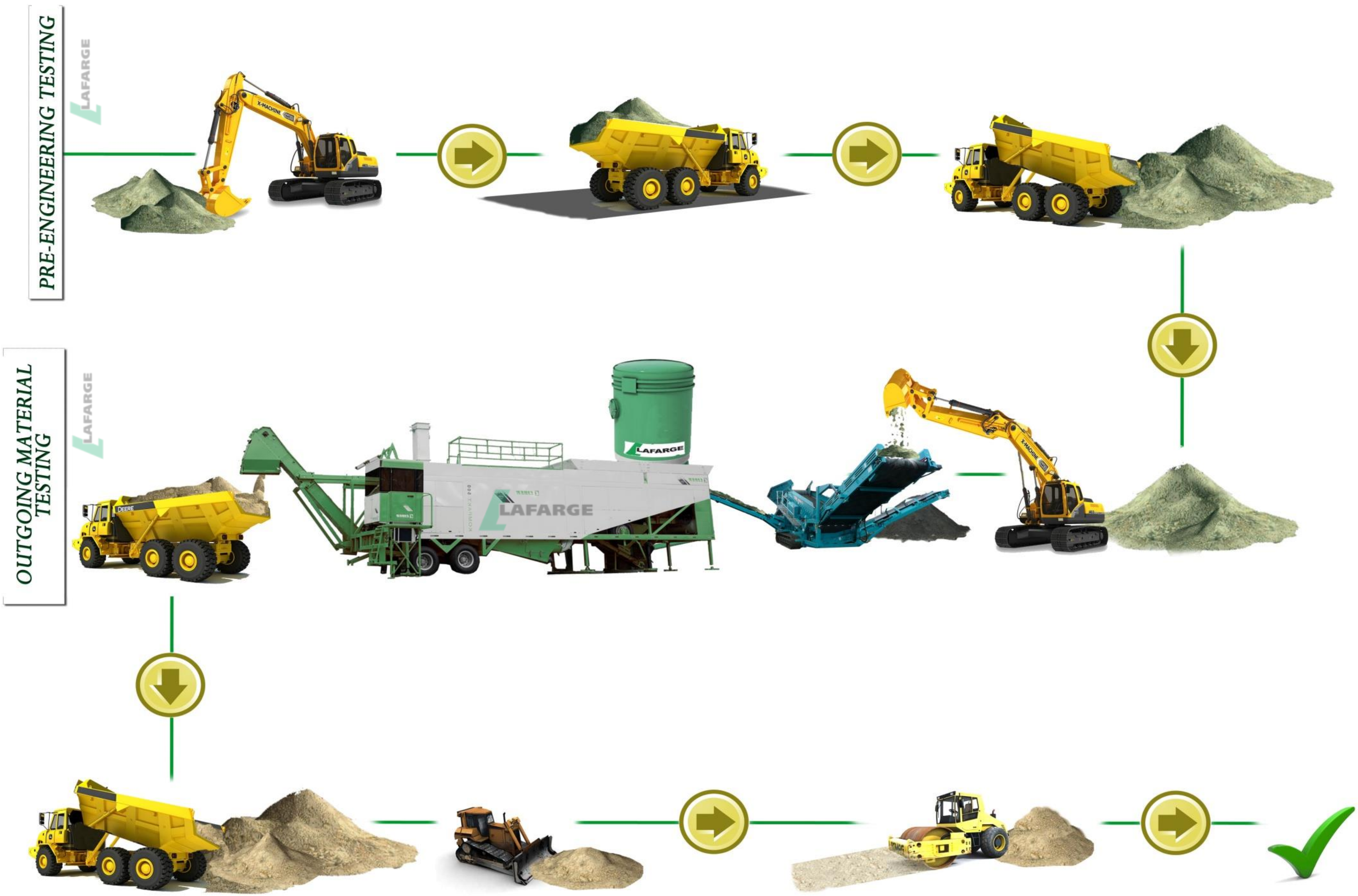
EQUIPMENT

Twin shaft pugmill

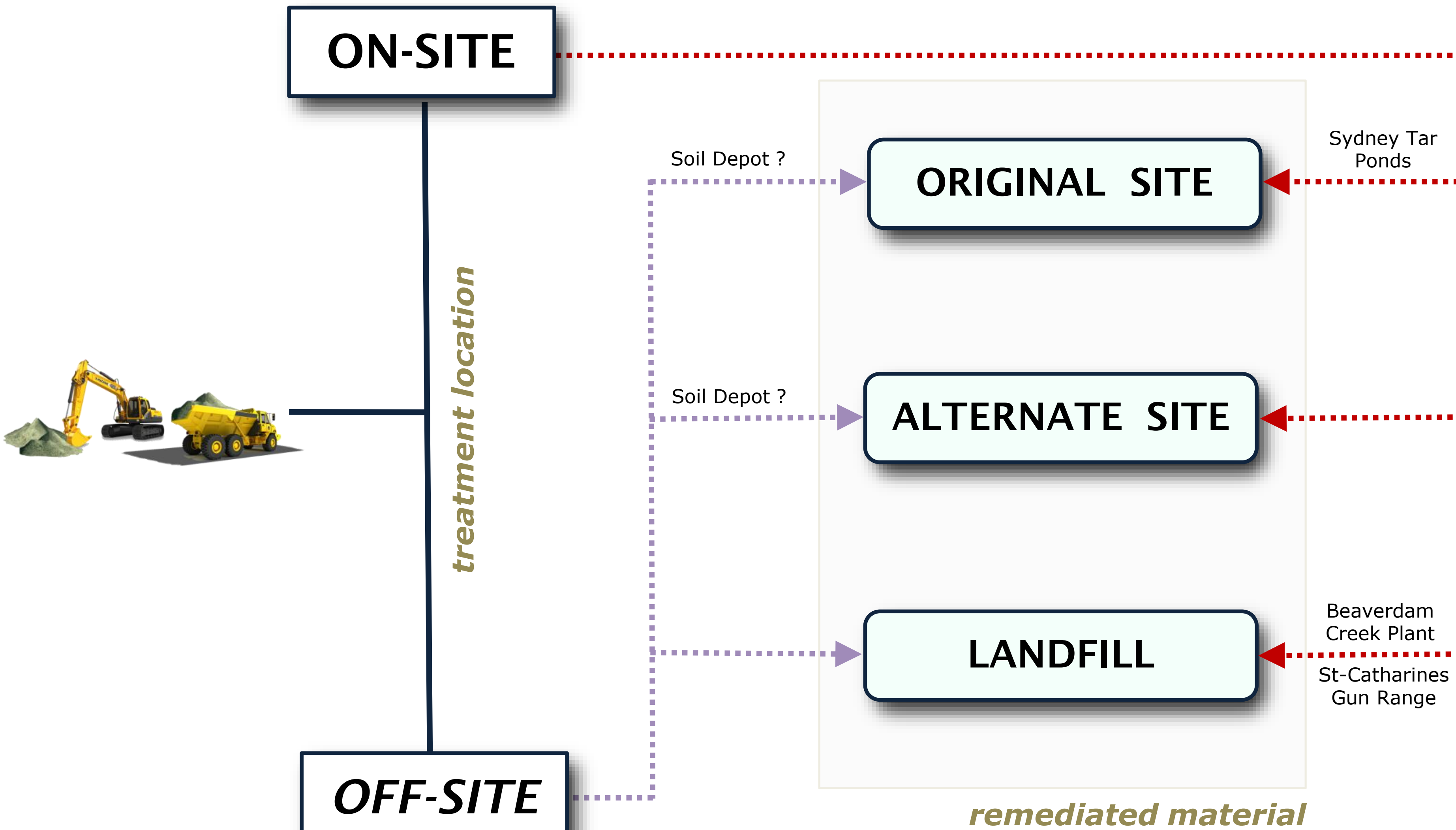


Methods recommended ensure proper dispersion and soil interaction

Common Objectives : *How We Can Achieve It*



Common Objectives : *How We Can Achieve It*



PROJECT

Steel Mill – Vancouver, BC

Site : Western Steel: 2013

Challenges :

- **Heavy metal** contaminants, and unstable geotechnical attributes

Requirements :

- Stabilization in situ and permits paving of top layer of RCC and asphalt

Project / Application :

- *Contractor* : BIRCO Environmental
- Used pugmill to blend GU
- Treated soil directly on site

Benefits to Customer :

- Provided high strength location for the stacking of shipping containers
- Reduced costs of traditional dig / haul to contaminate sites

CONTAMINANT LEVELS

Contaminant	Untreated	Regulatory Limit	After Treatment	% Reduction
Cadmium	1.2 mg/L	0.5 mg/L	<0.05 mg/L	-98%
Lead	14 mg/L	5 mg/L	<0.1 mg/L	-99%
Zinc	250 mg/L	500 mg/L	<0.05 mg/L	-99%

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PROJECT

Sydney Tar Ponds Clean Up

Canadian URBAN Institute
WINNER
Best Overall Project
- 2012 -

Site : Tar Ponds, Sydney, NS

Date : 2007 - Present

Challenges :

- 700 kMT of material needing to be excavated
- Cooling pond sludge from coke ovens
- Over 3.8 tonnes of **PCB**s, **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* : Nordlys Environmental and Van Zutphen Construction / *Material Supplier* : Lafarge
- Remediate ~100-hectare surface area
- In situ treatment, stabilization and solidification of soil/sludge, filling ponds

Benefits to Customer :

- Site stabilized and hazardous chemicals immobilized
- One of Canada's largest and more infamous sites, converted to parkland
- Avoided most widely used method of destroying PCBs via incineration

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Provisional items for the former Tar Ponds site include the following:

- Various sections of trails (eg along the west side of channel in a portion of Phase Two and Phase One, and some duplicate trails in Phase Three on the east side) and associated lighting
- Pedestrian bridge crossing the main channel in Phase One
- Creation of the wetland and wooden pedestrian bridges in Phase Three
- Amphitheater
- Synthetic surface for skating area
- Bike Park
- Sports field lighting
- Scoreboard

future use
Sowing the Seeds of Change

PROJECT

Port de Montréal

Site : Montréal, QC

Date : 2013

Challenges :

- **Heavy metal** contaminants, and unstable geotechnical attributes

Requirements :

- Stabilization in situ and permits paving of top layer of RCC and asphalt

Project / Application :

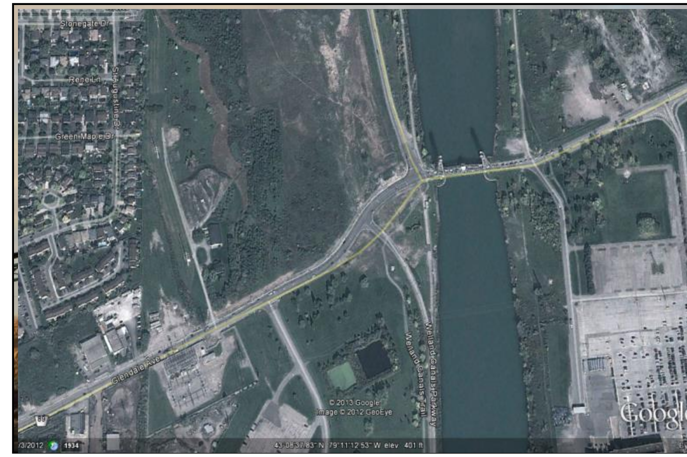
- *Contractor* : Pavages Chenail / *Material Supplier* : Lafarge
- Used pugmill to blend ~20% GUb-SF cement
- Treated soil was transported in dump trucks, and compacted directly on site

Benefits to Customer :

- Provided high strength location for the stacking of shipping containers
- Reduced costs of traditional dig / haul to contaminate sites
- Improved engineering properties
- Project cost savings of ~$3 000 000

PROJECT

St. Catharines Shooting Range



Site : Welland Canal, St. Catharines, ON

Date : Oct 2007

Challenges :

- 26 kMT of soil failed Ontario's residential standards test
- Previously a skeet shooting range (Brownfield classified)
- **Hazardous lead** and **PAH**s (**Polycyclic Aromatic Hydrocarbons**)

Requirements :

- Remediated site required passing environmental assessment for residential
- Cement product to stabilize and immobilize lead to acceptable levels

Project / Application :

- *Contractor* : Quantum Remediation / *Material Supplier* : Lafarge
- Remediate 5-hectare property (26 kMT soil)
- Reduce concentration of lead to a range below that of regulatory standards
- In situ treatment and removal of stabilized soil for off-site disposal

Benefits to Customer :

- Brownfield stabilized and hazardous chemicals immobilized
- Site prepped for residential housing
- Project resulted in 40% cost-savings vs. original budget

PROJECT

Beaverdam Creek Recycling Plant

Site : Thorold, ON

Date : Nov 2008 – Dec 2010

Challenges :

- 12 kMT of material of contaminated material
- Proximity to creek, potential water supply contamination

Requirements :

- Stabilize **PCB** contaminant from 1960s carbonless copy paper recycling plant

Project / Application :

- *Contractor* : Sevenson Environmental / *Material Supplier* : Lafarge
- In situ treatment and removal off-site due to economical cost advantage
- Soil remediation using 700 MT of cement

Benefits to Customer :

- Reduced cost due to in situ treatment before removal
- Protect water supply

PROJECT

U.S. Military Base Gun Range

Site : Michigan, U.S.

Date : 2004

Challenges :

- **Lead contamination** in first meter of soil

Requirements :

- Stabilization in situ and permits paving of top layer of asphalt

Project / Application :

- *Contractor* : Aker Contracting / *Material Supplier* : Lafarge
- Used pulverizer to blend 8% cement by dry weight in conjunction with water
- Treated soil was compacted using sheep's foot roller, then smooth drum

Benefits to Customer :

- Provided parking lot at a lower cost
- Reduced costs of original proposed dig / haul by roughly half
- Reduced long term liability, changing status of soil to non-hazardous

PROJECT

Old Dow Chemical Facility

Site : Bay City, MI

Date : Summer 2013

Challenges :

- 40 K tons of impacted soil
- Former chemical manufacturing plant)
- In-situ solidification/stabilization
- **Hazardous heavy metals, PAH**s 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)

Benefits to Customer :

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

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PROJECT

Recycled 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
- In-situ solidification/stabilization using CKD

Benefits to Customer :

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

REDUCE

Less Traffic

- Significantly **fewer trucks** on the roads around our towns and cities:

ex:

60 000 m^3 = [ x (3 000 + 3 000) = **6 000 trips**

20 m^3 / truck

Incoming virgin material

Outgoing hazardous material

- vs -

60 000 m^3 =  = **290 trips**

40 MT / truck

REUSE

Recycled Material

- An **on-site** solution means material is *treated* –and *not* condemned to outside unusable hazardous waste sites. Instead, producing an engineered construction product

RETHINK

Proven

- 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

CEMENT BASED SOLIDIFICTION/STABILIZATION : Benefits

- PROVEN TECHNOLOGY FOR MORE THAN 60 YEARS
- STABILIZES HEAVY METALS
- ELIMINATES HAZARDOUS CHARACTERISTIC
- SOLIDIFIES ORGANIC MATERIAL
- HYDRAULIC CONDUCTIVITY OF $<10^{-7}$cm/sec OR LESS
- PROVIDES STABILITY FOR FUTURE STRUCTURES
- LOWEST ENVIRONMENTAL REMEDIATION IMPACT
- USUALLY THE LOW COST OPTION

THANK YOU

ANY QUESTIONS

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