Limnofix In Situ Sediment Treatment Technology Potential Application to Confined Disposal Facilities

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Limnofix In Situ Sediment Treatment Technology

- Injection of **Oxidant** & **Amendments** to alter the bio-chemical-physical nature of the sediments

- Developed and patented by Environment Canada

- Licensed to Golder Associates

Treatment Objectives

- Oxidation of AVS, remove odors and acute toxicity
- Eutrophication control, reduce nutrient release
- Alter REDOX, enhance indigenous biological activity
- Bioremediation of organics (TPH, BTEX, PAHs)
- Enable beneficial reuse of sediments???

In Situ Treatment Applications

- Freshwater, Marine, and Industrial Environments
- Petroleum, Pulp/paper, Steel Mills, MGP Sites
- Harbors, Lakes, Rivers, Canals
- Confined Disposal Facilities (CDFs)???

Collins Cove MGP Site

Collins Cove Sediment Remediation

- Former Salem MGP site
- Intertidal zone sediments/mudflat
- Industrial/residential area
- Free phase coal tar NAPL migration
- PAHs (2-ring PAHs: 72%), DRO, GRO
- Sediment depth 8 -12 inches; ~ 1.5 acre area
- On-site interceptor trench installed
- Objective: Reduce volume/mass of NAPL
- Treatment in 1998 -1999
- Additional sampling and testing 2001

Collins Cove Summary

- Volume of NAPL and concentration of compounds have been considerably reduced

- Radiolabeled ^{14}C Phenanthrene Tests
  - Confirmed addition of calcium nitrate results in degradation of PAHs; higher dosages may be inhibitory

- Microbiological Tests
  - Variable populations; some areas still toxic to MicrotoxÔ
  - Calcium nitrate stimulated growth of aerobic heterotrophs & anaerobic PAH-degrading nitrate-reducers

- Discharge of NAPL from beach to tidal flats continues

- Extent of NAPL deeper/larger area

- Additional investigations/evaluate remedial options to meet IRA objectives

Source: IRA Status Report No.14; GEI Consultants, Inc. (9/14/01)

Shing Mun River, Hong Kong

Shing Mun River, Hong Kong

- Odors, low D.O. attributed to sediment
- Dredging will involve removal and disposal of 134,000 m^3 of sediment; working with local dredging contractor
- 22 hectares to be treated in situ to a depth of 1 meter
- Performance specifications to be finalized based on bench and field verification tests (2002):
  - Oxidize sulfides, increase REDOX
  - Decrease sediment toxicity (MicrotoxÔ)
  - Residual calcium nitrate

Oil Refinery Treatment Ponds Michigan

- Two ponds 1.6 acres
- 3-7 feet of sediment/sludge
- Volume 12,000 cu.yds.
- High reactive sulfide and lead
- Objective: Reduce sulfide/AVS concentration and TCLP lead for pond closure
- Teaming with other technology for Pb

Bench Treatability Results

Untreated (Left) Treated (Right)

TCLP Pb <5 mg/L

97% AVS reduction after 84 days

Treatment Results

Site	Scale	Contaminants	Concentration (mg/kg)		Year	% Reduction
			Initial	Final		
Aluminum Co.	Bench	TPH	27.7	5.4	1996	81
Aluminum Co.	Bench	PAHs	30,785	16,237	1996	47
Refinery Oil Lagoon Sludge (1)	Bench	PAHs	5,300	2,173	1994	59
Refinery Oil Lagoon Sludge (1)	Bench	TPHs	350,000	140,000	1994	60
Refinery Oil Pond Sediment	Bench	Sulfide	12,665	350	2000	97
Refinery Oil Pond Sediment	Bench	Sulfide	35,342-13.7	3,423-1.46	2001	91-99
Hamilton Harbour	Pilot	PAHs	730	260	1992-1994	64
Hamilton Harbour	Pilot	TPH	11,800	5,074	1992-1994	57
Hamilton Harbour	Pilot	BETX	0.243	0.051	1992-1994	79
Hong Kong Airport	Pilot	Sulfide	4,630	360	1997-1998	92
St. Mary's River	Pilot	Sulfide	1,450	290	1991-1993	80
Salem, Mass. (2)	Full	PAHs	115	10	1998-1999	90
Salem, Mass. (2)	Full	TPH	400	200	1998-1999	50
Shing Mun River	Bench	Sulfide	2092-668	50.2-21.2	2001	96-97

(1): After 2 months (2) : Average for six treatment areas

In Situ Sediment Treatment

Advantages:

- Simple equipment
- Various amendments can be injected
- With/without dredging
- No offsite disposal
- Lower cost (compared to removal & *ex situ* treatment/disposal; site specific)

Disadvantages:

- Site specific conditions/limitations
- Less process control
- Ultimate attainable contaminant levels/treatment objectives
- May require a series of treatments

Option #1 - Hydraulic Mixing

CDF Being Filled, Cleveland, OH

Hydraulic Mixing Considerations

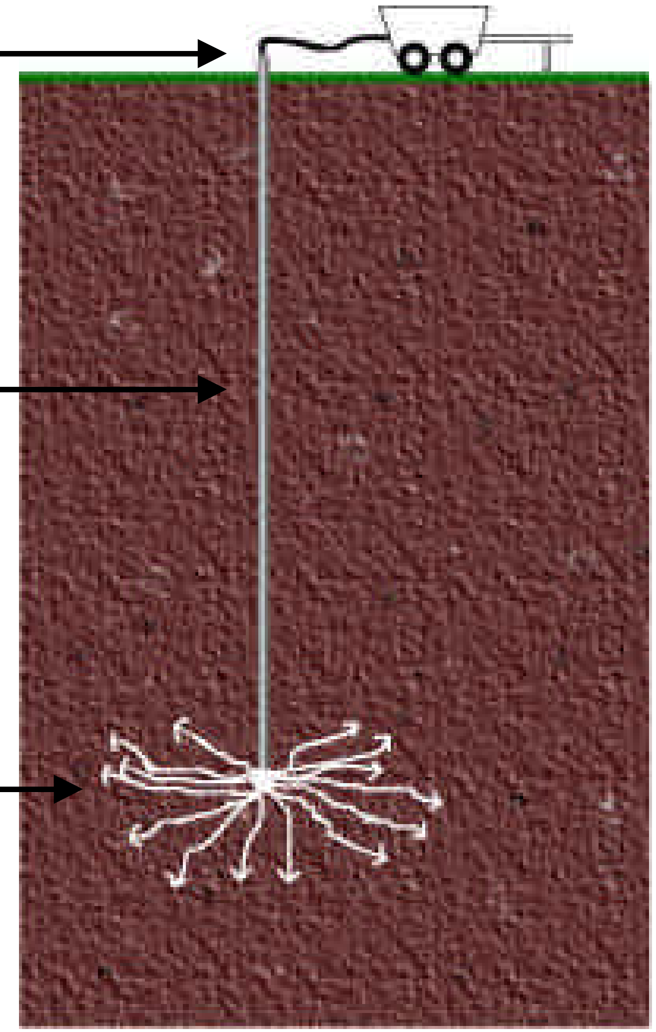
- Inject into sediments being hydraulically pumped into CDF
- Greater potential than other injection methods for reagent washout (could use solid reagent form)
- Likely uniform distribution of reagent versus other injection methods
- Low additional equipment costs

Option #2 - Well Injection

Limnofix Reagent Tank

Geoprobe™ Type Boring or Well Points

Dispersion/Diffusion of Reagent



Well Injection Considerations

- Injection Equipment
  - → Sediment Stability (will it support equipment?)
  - → Type of equipment (well point injection)
  - → Physical properties of sediment
- Likely less uniform reagent distribution than other injection/mixing approaches
  - → Radius of treatment zone from an injection point
  - → Grid type injection pattern to overlap
  - → Depth of injection required

Option #3 - Mechanical Mixing

Mechanical Mixing

Example of what a test grid might look like...

Mechanical Mixing Considerations

- Use of heavy equipment likely
  - → Sediment Stability (Will it support heavy equipment?)
  - → Mixing/removal with excavator (or other equipment, dragline, soil type auger), controlled dosing in grids
- Treatment depth depends on equipment and sediment characteristics
- Better process control than well injection
- More energy intensive
- Likely higher labor/equipment costs

Option #4 - Land Farming

Smoothing of Sediment to Minimize Washout

Land Farming Concept

- Inject reagents to top 1 foot or more (dependent on equipment type and sediment characteristics)
- Reagent will likely migrate deeper with time due to higher specific gravity
- Strip off treated layer/lift for beneficial reuse/repeat
- Treated sediment layer can be left in place as a cap, if desired.

Land Farming Considerations

- Ability of sediment to support equipment
- Shallow treatment depth
- May take more than one application
- Some additional equipment expense

Option #5 - Pre-disposal Mixing

Pre-disposal Mixing Concept

- Inject reagent as sediments are removed and being placed into transport vessel
- Reagents added/mixed during handling;
- “Pre-treated” sediment transferred into CDF

Pre-disposal Mixing Considerations

- Could reduce odors/exposures prior to placement
- Likely good process/reagent dosing control(batch type operation)
- Potential for some reagent washout upon disposal in CDFs.

Project Phases

- Determine CDF sediment treatment objectives (What is acceptance/reuse criteria?)
- Identify key issues and concerns
- Sampling to evaluate variability in physical, chemical, and biological parameters of sediments / in CDF
- Bench-scale testing to evaluate feasibility
- Pilot-scale testing and monitoring (test plot) based on bench tests

Bench Scale Testing

- Test for site specific constituents of concern:
  - Organics (TPH, VOCs/SVOCS, PAHs)
  - AVS, Phosphorous, Sediment Toxicity, Metals
- Nitrate
- REDOX and pH
- Microtox™ Toxicity
- Ammonia
- Radiolabeled ^{14}C phenanthrene testing
- Microbiological testing
  - Bacterial enumeration by species
- Typically 3-6 months for lab testing to determine feasibility
- ACOE testing requirements; evaluate leachate characteristics

Potential Benefits

- “Reactive/renewable CDF” for treatment of constituents of concern
- Beneficial reuse of sediments that may be marginally contaminated
- Increase CDF useful life; reduced costs
- Reduce potential environmental exposures to receptors