Phytotechnology: Current Trends and Prospects

U.S. EPA Third International
Phytotechnologies Conference
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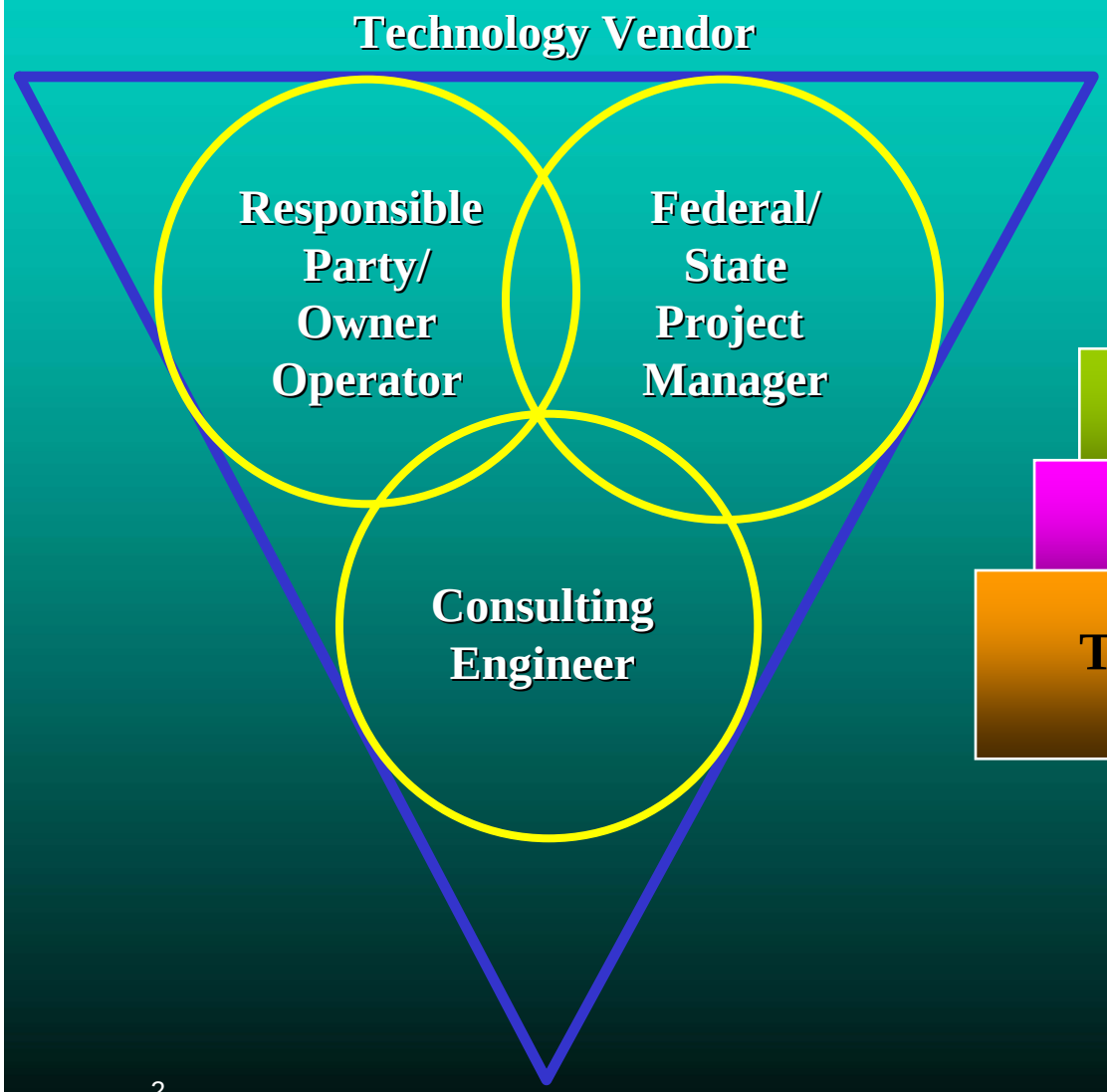
Walter W. Kovalick Jr. PhD.
Technology Innovation and Field Services Division
Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency

Technology Innovation Office

Clients for Information on Technology Innovations



Technology Innovation Thrusts

- Advocate “smarter” technologies for the characterization and cleanup of contaminated sites
- Work with clients to identify and understand better, faster, and cheaper options
- Seek to identify and reduce barriers to the use of innovative technologies

Outline

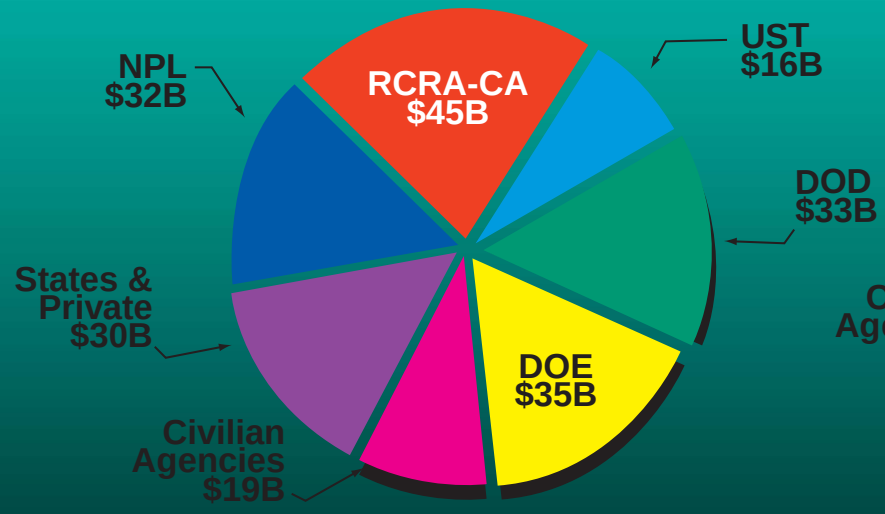
- Future Remediation Market
- Phytoremediation at Superfund Sites
- Remediation Technology Development Forum
- Conclusions
- Technology Innovation Program Information Sources

Estimated Number of Sites and Remediation Cost 2004-2033

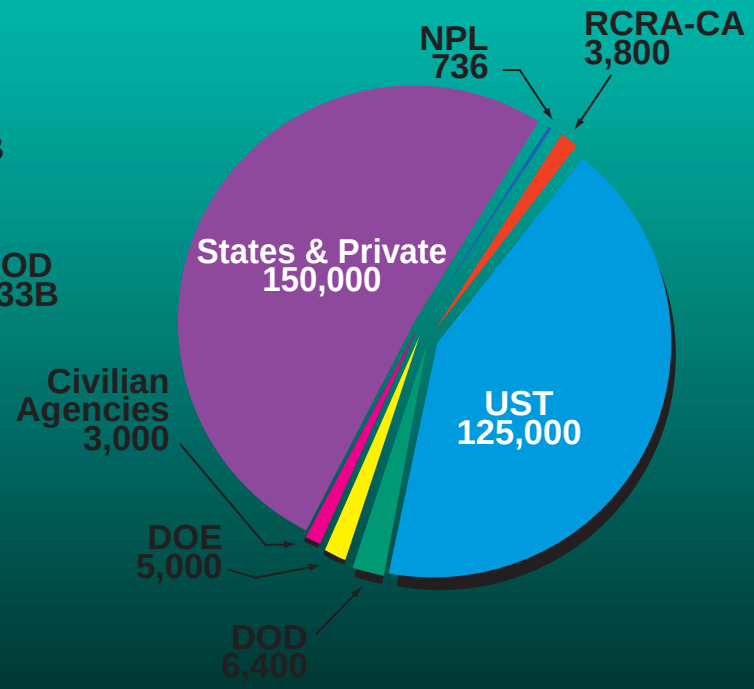
Program	Sites	Cleanup Cost
NPL	686 – 946	$24 – 50 B
RCRA, CA	3,800	$31 – 58 B
RCRA, UST	95,000 – 155,000	$12 – 19 B
DOD	6,400	$33 B
DOE	5,000	$35 B
Civilian Agencies	3,000	$15 – 22 B
States & Private	150,000	$30 B
Total Range Middle Value	235,000 – 355,000 294,000	$174 – 253 B $209 B

Estimated Number of Sites and Cleanup Cost 2004-2033

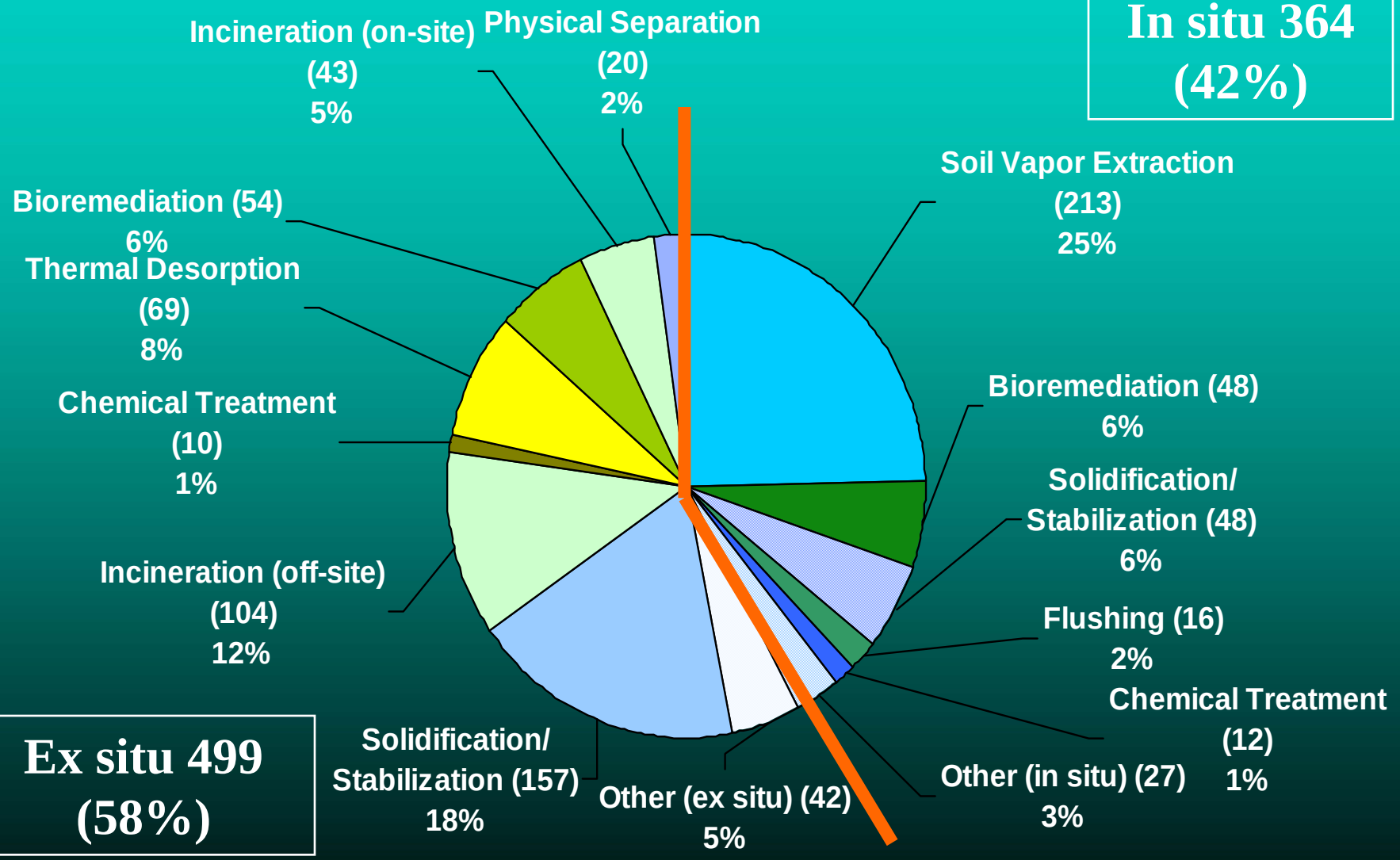
Total = $209 Billion



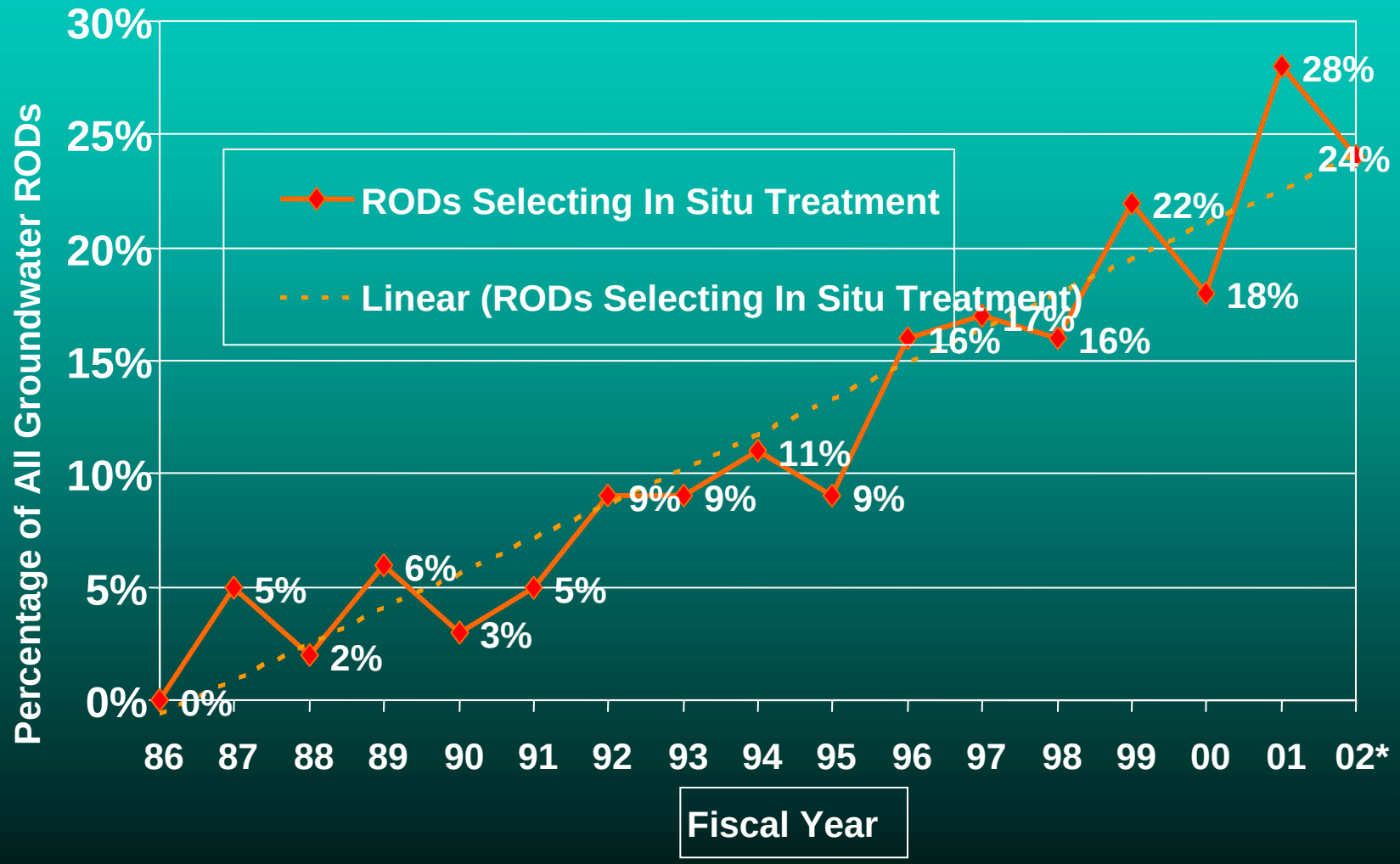
Total Sites = 294,000



Superfund Source Control Treatment Projects (FY 82-02)



Superfund: Trends in Percentage of Groundwater RODs Selecting In Situ Treatment (FY 1986 - 2002)*



* Includes information from an estimated 70% of FY 2002 RODs.

Phytoremediation at Superfund Sites

- Selected 18 times
- 17 different states
- Applications
  - 5 projects for soil only
  - 6 projects for groundwater only
  - 6 projects for both soil and groundwater
- Projects address chlorinated VOCs, metals, pesticides, and hydrocarbons
- Many use trees

Phytotechnologies at Superfund Sites (Cont'd)

- 2 Pre-design
- 4 Design
- 9 Ongoing
- 3 Completed

- Represent small portion of Superfund soil and groundwater remedies

Superfund Remedial Actions (FY 1982 – FY 2002*)

Site Name	Contaminants	Media	Vegetation	Status
Aberdeen Pesticide Dumps (OU5)	Pesticides	Groundwater	Hybrid Poplar	Operational
Aberdeen Proving Grounds (Edgewood Area, J-Field Soil OU)	PCA, PCE	Soil & Groundwater	Hybrid Poplar, Magnolia, & Silver Maple	Operational
Argonne National Lab. West 1	Cesium-137, Silver, Mercury, Chromium	Soil & Groundwater	Hybrid poplar, willow, gamagrass	Completed (99-02)
AT&SF Albuquerque Superfund Site	PAHs, Zn	Soil	NR	Pre-design
Atlas Tack Corp. (OU 1)	Benzene, Cr, Cu, Cyanide, Hg, Ni, Zn	Groundwater	NR	Design
Boarhead Farm	Benzene, Cd, Ni, TCE	Soil & Groundwater	NR	Designed/ Not Installed

NR = Not Reported

* - Includes remedies from 40% of expected FY 2002 RODs.

Superfund Remedial Actions (FY 1982 – FY 2002*)

Site Name	Contaminants	Media	Vegetation	Status
Bofors Nobel (OU1)	As, BTEX, Pesticides, Zn	Soil, Sludge, & Groundwater	NR	Design
Carswell Naval Air Station	TCE, DCE	Soil & Groundwater	Eastern cottonwood	Operational
Combustion, Inc	DCA, PCB, Benzene, Toluene, Lead, Mercury, Nickel, Silver	Groundwater	Eucalyptus, poplar, native willow	Operational
Del Monte Corp.	PAHs, Zn	NR	NR	Operational
East Palo Alto	Benzene, Cd, Ni, TCE	soil	Eucalyptus, Tamarisk	Operational
Fort Dix	Lead	Soil	Indian mustard, sunflower, grasses	Completed (field demo)

NR = Not Reported

* - Includes remedies from 40% of expected FY 2002 RODs.

Superfund Remedial Actions (Cont'd)

Site Name	Contaminants	Media	Vegetation	Status
Fort Wainwright	Pesticides, Petroleum Hydrocarbons	Soil	NR	Completed (97-01)
Idaho National Engineering Laboratory (USDOE, OU 21)	Ag, Cr, Cs-137, Hg, Se, Zn	Soil	Prairie Cascade, Willows, Kochia Scoparia	Operational
Naval Surface Warfare Center, Dahlgren, Site 17	Hg	Soil & Groundwater	Hybrid Poplar & Evergreen	Pre-design
Naval Undersea Warfare Station (4 Areas, OU1)	1,1,1-TCA	Groundwater	Poplar	Operational
Sangamo Electric Dump/Crab Orchard National Wildlife Refuge (PCB Areas OU)	DCE, PCE, Vinyl Chloride	Groundwater	Hybrid Poplar	Design/ Planned 2006
Tibbetts Road	TCE	Groundwater	Poplar	Operational

NR = Not Reported

* - Includes remedies from 40% of expected FY 2002 RODs.

Other Applications of Phytotechnologies

- Ecological Restoration
- Land Revitalization

http://www.epa.gov/oswer/landrevitalization

Ecological Restoration

Bunker Hill Mining and Metallurgical Complex

Land Revitalization

That was then….

Landfill

Fly Ash Disposal Field

Land Revitalization

This is now!

Wetlands

Soccer Field


RTDF
Latest Developments
Welcome to the Remediation Technologies Development Forum (RTDF) Web Site
General Information
Bioremediation Consortium
Lasagna™ Partnership
IINERT Soil-Metals Action Team
Phytoremediation of Organics Action Team
Permeable Reactive Barriers Action Team
In Situ Flushing Action Team
Sediments Remediation Action Team
The purpose of the RTDF is to identify what government and industry can do together to develop and improve the environmental technologies needed to address their mutual cleanup problems in the safest, most cost-effective manner. The RTDF fosters public and private sector partnerships to undertake the research, development, demonstration, and evaluation efforts needed to achieve common cleanup goals.

Remediation Technologies Development Forum

- Partnerships between private industry, universities, and government (EPA, DOE, DOD) — each party provides resources and expertise
- Mutual priorities/user needs are identified
- Action Teams formed to further technology development
- Phytoremediation of Organics Action Team (1997)
  - TPH in Soil
  - Alternative Cover Assessment Program (ACAP)
  - Chlorinated Solvents

http://www.rtdf.org

RTDF TPH Project

- Goal to assess efficacy of vegetation to enhance degradation of aged petroleum hydrocarbons in soil
- Uses standardized protocol
- Plants include grasses, legumes, and trees
- 13 sites evaluated under different climatic conditions for 3 growing seasons
- Lessons Learned:
  - HC losses were subtle and difficult to measure
  - Plants grew well
  - Best results for “younger” sites
  - plant roots facilitated deeper degradation

Session 5B, Thursday 2:30pm
http://www.rtdf.org

RTDF Chlorinated Solvents

- Evaluation of Phytoremediation for Management of Chlorinated Solvents in Soil and Groundwater EPA 542-R-05-001
  - Brief introduction
  - Assess applicability
  - Design and placement
  - Monitoring and sampling
  - Reporting cost and performance
  - Answers to many frequently asked questions

http://www.rtdf.org

RTDF ACAP

- RTDF demonstrating effectiveness of 21 cover designs
- Nationwide side-by-side field demonstration of alternative covers for landfills and other waste sites
  - 11 sites in 7 states
  - Large (10 X 20 m) drainage lysimeters
- Focus on evapotranspiration (ET) type covers
  - Monolithic
  - Capillary barrier
- Conventional covers also being evaluated
  - Composite
  - Soil barrier
- Collect five years of data (2005 last year of data collection)

Session 6B, Friday 8:30am
http://www.acap.dri.edu

Inventory of Phytoremediation Field Studies

- Summer 2004 snapshot of projects in the field
- Chlorinated solvents, pesticides, explosives, and metals
- Full and pilot scale field projects
- U.S. and Canada
- No constructed wetlands or alternative landfill covers
- Info collected by two EPA grantees

Phytoremediation Field Studies

- Types of information collected:
  - Site name and location
  - Site characteristics
  - Planting date and description
  - Media treated
  - Vegetation types
  - Contaminants treated
  - Phytomechanism used
  - Project size, scale, and status
  - Operation and maintenance
  - Technology cost and performance
  - Lessons learned
  - Point of contact

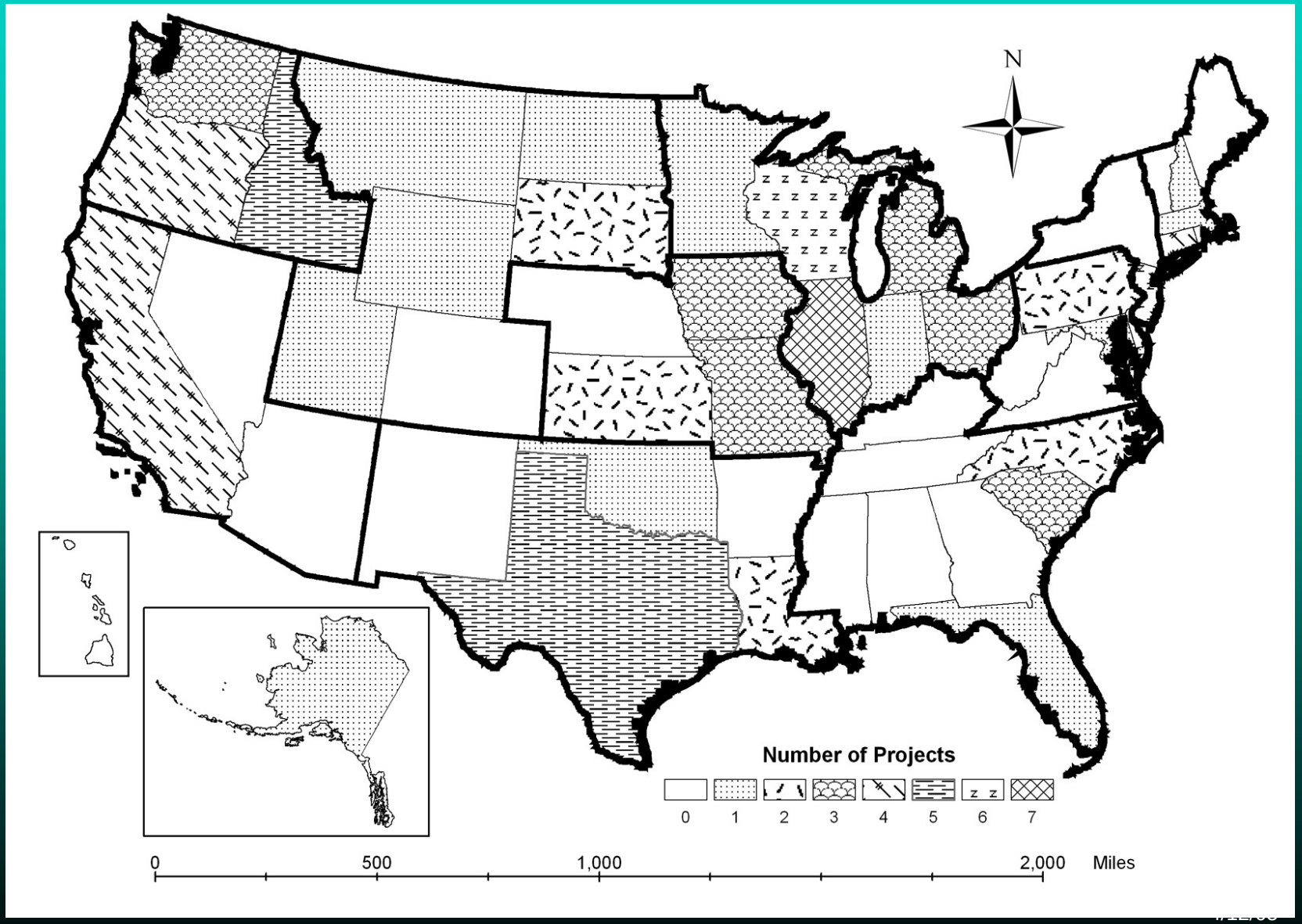
http://www.cluin.org/studentpapers

Phytoremediation Field Studies Fact Sheet

- Use of Field-Scale Phytotechnology for Chlorinated Solvents, Metals, Explosives and propellants, and Pesticides (EPA 542-R-05-002)
- 79 projects performed in 31 states
- Chlorinated solvents treated most frequently
- Most common mechanisms tried were phytoextraction and hydraulic control
- Peak in projects from 1996 to 2001
- Ranged in size from <0.5 acre to 1000 acres
- Found lack of published information on cost, performance and lessons learned
- If you have sites to add, see poster

http://www.cluin.org/

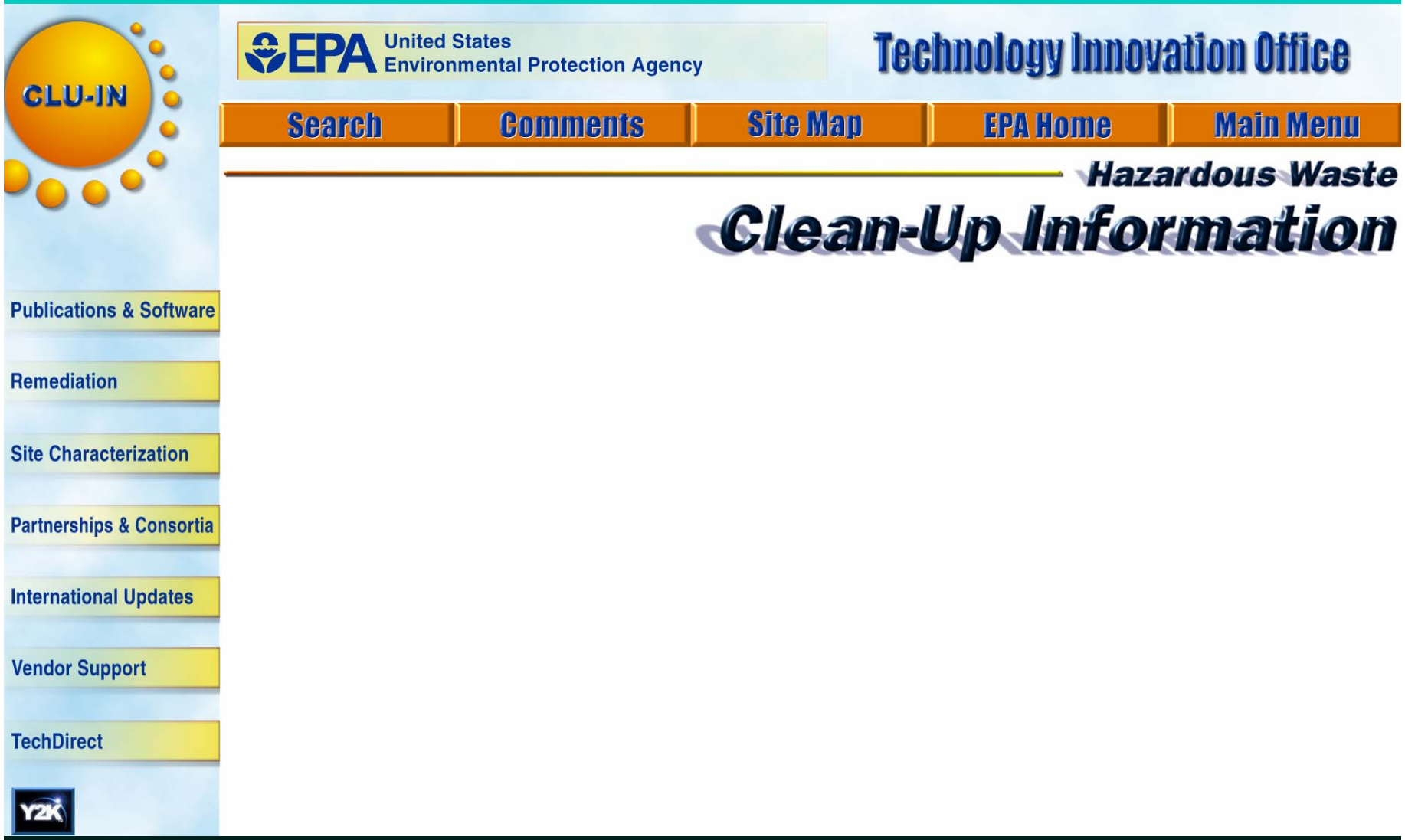
Locations of Phytotechnology Projects in the United States



Conclusions

- Many more answers to practitioner's frequently asked questions (RTDF document)
- Phytotechnology has many potential roles in site cleanup:
  - Hydraulic plume control
  - Ecological restoration
  - Land revitalization
  - Niche applications
    - Arsenic
    - Core sampling for plume delineation
  - Alternative covers
- Need more cost and performance data

CLU-IN World Wide Web Site
http://clu-in.org



TechDirect

Technology Information Service

Highlights

- Broadcasts periodic e-mail messages to the list of 16,000 subscribers in 60 countries
- Highlights events of interest to site remediation and site assessment professionals.
- Describes new products and provides instructions on how to obtain them.

EPA REACH IT System

- Free information service, searchable on-line
- Information on 310 treatment and 168 characterization technology vendors
- Site information on 1,811 EPA Superfund remediation projects
- Flexible search options include by technology, contaminant, media, and sites
- 30 new technologies added in 2004
- Easier-to-use website made available October 2004
- Phytotechnology: 10 Vendors, 22 Vendor Source Sites, 11 EPA Source Sites

www.epareachit.org

Phytotechnology Resources

www.itrcweb.org

- Phytoremediation Decision Tree, Dec 99, ITRC
- Phytotechnology Technical and Regulatory Guidance Document, Apr 01, ITRC
- Technology Overview Using Case Studies of Alternative Landfill Technologies and Associated Regulatory Topics (March 2003)
- Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Landfill Covers (December 2003)
- Characterization, Design, Construction, and Monitoring of Mitigation Wetlands (February 2005)

www.rtdf.org

- Phytoremediation of Organics Action Team Information
- Evaluation of Phytoremediation for Management of Chlorinated Solvents in Soil and Groundwater
- RTDF Phytoremediation Bibliography (~1,400 citations)

www.gwrtac.org

- Technology Evaluation Report: Phytoremediation of Soil and Ground Water, Mar 02, GWRTAC

Phytotechnology Resources (Cont'd)

www.cluin.org

- Introduction to Phytoremediation, Feb 00, EPA
- Phytoremediation of Contaminated Soil and Groundwater at Hazardous Waste Sites, Feb 01, EPA
- Citizen's Guide to Phytoremediation, April 01, EPA
- Phytoremediation Resource Guide, Jun 99, EPA
- Phytotechnologies Internet Seminar, May 01, ITRC
- Phytoremediation of VOCs in Groundwater, Feb 03
- Radionuclide Biological Remediation Resource Guide, Aug. 04
- Brownfields Technology Primer: Selecting and Using Phytoremediation for Site Cleanups, July 01
- _D-Area Drip Irrigation-Phytoremediation Project: SRTC Final Report, Jan. 03
- Dredged Material Reclamation at the Jones Island Confined Disposal Facility. Innovative Technology Evaluation Report, Oct. 03.

Top 10 Websites For Hazardous Waste Management

1. http://cluin.org (or http://www.epa.gov/tio)
2. http://www.epareachit.org
3. http://www.frtr.gov
4. http://www.gwrtac.org
5. http://www.rtdf.org
6. http://www.epa.gov/ord/SITE
7. http://www.afcee.brooks.af.mil/products/techtrans/treatmenttechnologies.asp
8. http://www.itrcweb.org/
9. http://www.serdp.org/research/research.html
10. http://www.epa.gov/etv/