White Paper and Case Study

Making the Case for Ecological Enhancements

January 2004

Prepared by
The Interstate Technology & Regulatory Council
Alternative Landfill Covers, Constructed Treatment Wetlands,
and Phytotechnology Teams
and the Wildlife Habitat Council

ABOUT ITRC

Established in 1995, the Interstate Technology & Regulatory Council (ITRC) is a state-led, national coalition of personnel from the environmental regulatory agencies of some 40 states and the District of Columbia; three federal agencies; tribes; and public and industry stakeholders. The organization is devoted to reducing barriers to, and speeding interstate deployment of, better, more cost-effective, innovative environmental techniques. ITRC operates as a committee of the Environmental Research Institute of the States (ERIS), a Section 501(c)(3) public charity that supports the Environmental Council of the States (ECOS) through its educational and research activities aimed at improving the environment in the United States and providing a forum for state environmental policy makers. More information about ITRC and its available products and services can be found on the Internet at **www.itrcweb.org.**

DISCLAIMER

This document is designed to help regulators and others develop a consistent approach to their evaluation, regulatory approval, and deployment of specific technologies at specific sites. Although the information in this document is believed to be reliable and accurate, this document and all material set forth herein are provided without warranties of any kind, either express or implied, including but not limited to warranties of the accuracy or completeness of information contained in the document. The technical implications of any information or guidance contained in this document may vary widely based on the specific facts involved and should not be used as a substitute for consultation with professional and competent advisors. Although this document attempts to address what the authors believe to be all relevant points, it is not intended to be an exhaustive treatise on the subject. Interested readers should do their own research, and a list of references may be provided as a starting point. This document does not necessarily address all applicable heath and safety risks and precautions with respect to particular materials, conditions, or procedures in specific applications of any technology. Consequently, ITRC recommends also consulting applicable standards, laws, regulations, suppliers of materials, and material safety data sheets for information concerning safety and health risks and precautions and compliance with then-applicable laws and regulations. The use of this document and the materials set forth herein is at the user's own risk. ECOS, ERIS, and ITRC shall not be liable for any direct, indirect, incidental, special, consequential, or punitive damages arising out of the use of any information, apparatus, method, or process discussed in this document. This document may be revised or withdrawn at any time without prior notice.

ECOS, ERIS, and ITRC do not endorse the use of, nor do they attempt to determine the merits of, any specific technology or technology provider through publication of this guidance document or any other ITRC document. The type of work described in this document should be performed by trained professionals, and federal, state, and municipal laws should be consulted. ECOS, ERIS, and ITRC shall not be liable in the event of any conflict between this guidance document and such laws, regulations, and/or ordinances. Mention of trade names or commercial products does not constitute endorsement or recommendation of use by ECOS, ERIS, or ITRC.

Making the Case for Ecological Enhancements

January 2004

Prepared by
The Interstate Technology & Regulatory Council
Alternative Landfill Covers, Constructed Treatment Wetlands,
and Phytotechnology Teams
and the Wildlife Habitat Council

ACKNOWLEDGEMENTS

The members of the Interstate Technology & Regulatory Council (ITRC) Alternative Landfill Covers, Constructed Treatment Wetlands, and Phytotechnology Teams wish to acknowledge the individuals, organizations, and agencies that contributed to this document and collection of case studies.

The Alternative Landfill Covers, Constructed Treatment Wetlands, and Phytotechnology Teams' efforts, as part of the broader ITRC effort, are funded primarily by the U.S. Department of Energy. Additional funding and support have been provided by the U.S. Department of Defense and the U.S. Environmental Protection Agency. ITRC operates as a committee of the Environmental Research Institute of the States (ERIS), a Section 501(c)(3) public charity that supports the Environmental Council of the States (ECOS) through its educational and research activities aimed at improving the environment in the United States and providing a forum for state environmental policy makers.

The work team also wishes to recognize the efforts of the Wildlife Habitat Council, which led the development of this white paper to demonstrate how federal, state, and local governments, industry and community groups can use ecological enhancements to facilitate the restoration of private and public (state, tribal, local) lands for a variety of reuses that include wildlife habitat.

EXECUTIVE SUMMARY

Ecological enhancements considered at the inception of planning for environmental remediation at Superfund, RCRA, and brownfield sites can be a cost-effective and efficient way to increase, create, and/or improve wildlife habitat. A remedial plan that embraces the concepts presented in this white paper can contribute greatly to protection of human health and the environment. An ecological enhancement modifies a site to increase/improve habitat for plants and animals while protecting human health and the environment. An ecological enhancement can include natural remediation technologies and/or also represent an end use which restores/increases the ecological value of the land. Incorporation of ecological enhancements can benefit multiple stakeholders, such as regulatory agencies, the regulated community, local communities, and the general public.

An *ecological enhancement* modifies a site to increase/improve habitat for plants and animals while protecting human health and the environment. An ecological enhancement can include natural remediation technologies and/or also represent an end use which restores/increases the ecological value of the land.

As illustrated in the case studies in Appendix D, ecological enhancements can efficiently and effectively contribute to the success of many projects via the harnessing of remediation technologies, thereby facilitating the attainment of specified remediation goals.

Providing ecological enhancements is not a "one size fits all" process. Site-specific considerations and engineering evaluation of goals and objectives, regulatory constraints, potential technologies, probable costs, and likely benefits need to be objectively studied at each potential site.

TABLE OF CONTENTS

APPENDICES

MAKING THE CASE FOR ECOLOGICAL ENHANCEMENTS

1.0 INTRODUCTION

The Wildlife Habitat Council (WHC) has entered into a cooperative agreement with the U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) and the Office of Underground Storage Tanks (OUST). Under the agreement, WHC will present the latest technologies for applying ecological enhancements to site remediation. An ecological enhancement modifies a site to increase/improve habitat for plants and animals while protecting human health and the environment. An ecological enhancement can include natural remediation technologies and/or also represent an end use which restores/increases the ecological value of the land. WHC's goal is to demonstrate how federal, state, and local governments, industry and community groups can use ecological enhancements to facilitate the restoration of private and public (state, tribal, local) lands for a variety of reuses that include wildlife habitat.

WHC will address the objectives specified in the *Objectives and Action Agenda for Implementing Ecological Enhancements* generated during WHC's 2002 Conference, "Restoring Green Space: Using Ecological Enhancements at Superfund, RCRA and Brownfield Sites." These objectives are to (1) achieve greater regulatory flexibility and support for use of ecological enhancements, (2) develop a strategy for obtaining constructive and meaningful stakeholder involvements, (3) ensure sound scientific and technical support for ecological enhancement practices and (4) promote the value of ecological enhancements through a broad array of communication tools.

The purpose of this paper is to present natural alternatives to traditional remediation processes, thus allowing the incorporation of ecological enhancements as integral components of the remediation process, as well as the incorporation of ecological enhancements in the reuse of environmentally impacted sites. By presenting such alternatives, the white paper can be used to facilitate expeditious site reuse based on successful projects, such as those illustrated in the case studies (Appendix D). To achieve this goal, WHC assembled a technical committee of recognized national experts (Appendix A), with experience and expertise in remediation projects and techniques, in particular those including ecological enhancements. This technical committee includes a cross section of stakeholders, including the regulated community, government regulatory agencies, nongovernmental organizations, and other government agencies.

This paper seeks to accomplish the following goals:

- Identify benefits, incentives, and limitations for implementing ecological enhancements at environmentally impacted sites.
- Present case studies where the implementation of ecological enhancements as a component of the remedial design and/or end use has been successful or unsuccessful or is currently being tested.
- Make recommendations for the successful use of ecological enhancements at environmentally impacted properties. These recommendations include a matrix that will help

users identify which sites are the best candidates for ecological enhancements and that will identify demonstration projects that hold the best potential for the successful incorporation of ecological enhancements.
- Make recommendations for regulatory improvements to foster greater acceptance and flexibility for the incorporation of ecological enhancements as a component of remedial actions and end use.
- Identify areas where additional scientific research is still needed.

2.0 USING ECOLOGICAL ENHANCEMENTS

Ecological enhancements can be applied in three ways to address impacted properties. One application is to create or restore a safe sustainable wildlife habitat as a final cleanup goal. A second is to use sustainable wildlife habitat as a complement to a traditional remedy. The technologies and controls used to arrive at the habitat may or may not be green technologies. The final application is to use natural or green technologies to remove contaminants or secure sites while providing viable wildlife habitat, though the final use may not be habitat. While these applications are different in their objectives and approach, they all provide ecological benefits.

2.1 Creating or Restoring Wildlife Habitat as a Final Cleanup Goal

Many former and active industrial sites include wetlands and other sensitive habitats within their boundaries. As developmental pressures continue on these sites, these associated habitats have seen significant degradation and loss as a result of the release of hazardous substances. The goal of creating and maintaining habitat in these areas has become increasingly important.

Designing a site restoration project with the goal of creating long-term wildlife habitat offers the advantage of creating and protecting habitat found in previously impacted areas, as well as mitigating the continued encroachment of urban development. Maintaining and improving habitat quality and associated ecological functions as an end use can present challenges as cleanup standards applicable to habitat creation can require complex analyses, and the cleanup goals for ecological protection are often more stringent than those for protection of human health. However, tailoring the cleanup to a specific end use can also avoid unnecessary actions that otherwise increase costs and delay progress.

Habitat creation is like other site cleanups in that there are two ways to achieve the objective. One is to remove all impacted soils to a level where all theoretical risks have been eliminated. This can be cost-prohibitive and can involve significant disturbance of the habitat one is attempting to enhance. The other way is to allow contaminants to remain but ensure that exposure routes are eliminated through engineered or institutional controls. This “complete with control” approach to cleanup is described in EPA’s guidance on completing (Resource Conservation and Recovery Act) RCRA corrective action (68 FR 8757). In the guidance, EPA emphasizes that the ultimate goal of corrective action is to satisfy the “protection of human health and the environment” standard. EPA makes clear that the protection standard can be achieved using engineered and institutional controls.

A complete with controls approach would generally need to apply net environmental benefits analysis (NEBA) concepts. A NEBA evaluation allows one to weigh the cost of various remedial options (e.g., contaminant removal, engineered controls, or institutional controls) against the environmental costs and benefits of each alternative. Using NEBA, acceptance for restoring to a nonpristine baseline can be obtained if the benefit from having some habitat value at the site outweighs the potential for adverse effects from contaminants left in place. The NEBA approach is consistent with EPA's guidance on completing RCRA corrective action and fills the gap in EPA's guidance (i.e., the consideration of the ecological consequences of the possible approaches or alternatives).

In the context of habitat restoration, cleanup objectives can be targeted at eliminating exposure routes to wildlife, while ensuring that land is maintained in perpetuity solely as habitat. The actions needed to eliminate relevant exposure routes can be focused and noninvasive while allowing for existing habitat to thrive as future habitat is enhanced.

Guidance is needed that will provide the flexibility required in cleanup standards where it is demonstrated that preserving existing habitat or creating new habitat has an overall benefit to humans and the environment.

2.2 Creating Habitat as a Complement to a Traditional Remedy

Ecological enhancement may have the greatest benefit in supplementing or complementing conventional remedial technologies. Typically, remedial technologies provide environmental relief through source control or removal of residual contaminants to acceptable levels. The ability of the remediated resource, particularly surface soil, surface water and sediments, to return to a prerelease functional level is seldom addressed in the remedial process. The use of ecological enhancement techniques such as improvement of in-stream cover for fish and macroinvertebrates following sediment excavation, the installation of nesting boxes on a landfill cap, or the implementation of a woodlot program will cost-effectively return the resource to a productive capacity that would exceed that developed by the simple remediation of the impacted media. As community acceptance is one of the nine criteria used in selecting a remedy, such measures would receive high marks at sites where local stakeholders are actively involved in the remedial process. Additionally, the implementation of ecological enhancements during remedial construction has the benefit of limiting costs required for mobilization.

Ecological enhancements as part of remedial measures have the additional benefit of limiting potential environmental liabilities related to Natural Resource Damage Claims (NRDC). Under the NRDC process, natural resource trustees have the authority to assess damages for ecological services lost as a result of environmental degradation. The use of ecological enhancements can be used as part of a negotiated settlement to off-set or mitigate potential claims following the remedial process.

2.3 Using Natural Remediation as a Cleanup Technology

The ultimate goal of a treatment technology is to address either past or ongoing releases of chemical substances in a manner that is protective of human health and the environment. Under

most state or federal regulatory processes, the cleanup remedy must be cost-effective and must use permanent solutions and/or alternative technologies to the extent practicable. A remedial approach to an environmentally impacted site is decided on during a feasibility study process that is intended to evaluate the potential alternatives to site remediation with respect to nine selection criteria identified by EPA under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (or seven selection criteria under RCRA corrective action).

In certain instances, ecological enhancements may be used as the remedy if applied as an alternative technology. To be accepted under most federal or state hazardous waste programs as an alternative technology, ecological enhancement or a similar green technology would have to first satisfy the goals and requirements of applicable federal or state hazardous waste management regulations; would have to consider the persistence, toxicity, mobility and bioaccumulative potential of site-related constituents; and would have to consider short- and long-term potential threats to human health.

For example, a constructed wetland that offered treatment of relatively immobile and nonbioaccumulative constituents, as well as habitat for aquatic and semiaquatic wildlife, could be a cost-effective, ecologically viable alternative to more costly conventional technologies such as groundwater pump and treat. Likewise, phytoremediation, where the selected plant species are considered with respect to the potential habitat they offer, can be a cost-effective alternative for surface soil source treatment. In both of these instances, an ecological risk assessment or monitoring program may be necessary to demonstrate that constituents of concern are not accumulating to levels that might be toxic to wildlife attracted by the habitat enhancement. There are two questions that would remain, however:

- Are the enhanced habitat and the resulting wildlife population or diversity positive for the remediation system and the surrounding ecology?
- Is this enhancement a fortuitous event or can benefits be designed into the system cost-effectively?

It is important to note that habitat and the condition of a natural resource are not specifically considered as part of the selection criteria. A defensible argument must be made to gain regulatory support and acceptance of the added ecological enhancements in utilizing a green technology or as a component of a remedy. To date, the use of ecological enhancements to serve as the remedial alternative is not well accepted by regulators and often cannot be supported by the strict application of the remedial alternatives selection process.

Green technologies also run into the same regulatory impediments as other technologies when performing remediation on CERCLA and RCRA sites. For example, some sludges to be treated may be “listed” hazardous wastes. If the listed waste is “managed” in the legal definition, then it must be managed in accordance with stringent treatment standards and disposed in a landfill meeting RCRA standards. Plowing or even seeding can be considered management of the waste. Materials that are mixed or derived from these materials are also listed wastes. Therefore, harvesting plant growth may require managing the harvested material as a listed hazardous waste. Few policies have been developed to address these issues, and the regulatory impediments

associated with listed wastes have thwarted natural remediation efforts that would have been successful.

Sites with environmental impacts other than RCRA-listed wastes do not suffer the same regulatory impediments. At these sites, seeding and harvesting can be done as needed without triggering costly management standards. The harvested materials will still have to be characterized for relevant hazardous-waste characteristics, but generally, they would not have to be managed as hazardous waste.

As stewards of our natural resources, individuals responsible for addressing environmentally impacted sites have the ability to effect great changes in stressed ecological communities. While a traditional remedial technology may be required to resolve the potential short- and long-term threats to human health and the environment, ecological enhancements can be used as a good faith effort to promote environmental stewardship. They are a cost-effective means that can be used to increase the ability of restored property to support wildlife. In urban settings, where the availability of habitat is limited, islands of habitat on restored lands may prove invaluable in supporting both migratory and permanent resident species.

3.0 MAKING THE CASE

This section provides a rationale for using ecological enhancements during remediation and as an end use. Some of the benefits to be discussed include environmental, economic, and public relations benefits.

3.1 Environmental Benefits

Implementing ecological enhancements, both during the remedial process and as a final end use after remediation is complete, provides numerous environmental benefits potentially affecting soil, surface water, sediment, and groundwater quality, as well as human and ecological health.

- Attracts Wildlife – Both natural remediation technologies and end use plantings are attractive to wildlife, potentially providing significant habitat. However, in some cases, single species plantings such as those often used in phytoremediation can unintentionally encourage ecological imbalances such as increased attack by pests or disease. In addition, the natural remediation technologies plantings may have to be protected from wildlife consumption if the plantings will bioaccumulate potential toxins.

- Hydraulically Controls Landfill Leachate – Natural remediation technologies can help to draw down leachate head buildup in closed landfills, thereby eliminating side seepage.

- Biodegrades Environmental Contaminants – Natural remediation technologies enhance both aerobic and anaerobic biochemical degradation of various contaminants, including volatile organic compounds, polynuclear aromatics, and various other hydrocarbons, as well as some pesticides.

- Enhances Natural Attenuation/Biodegradation Remedies – As a component of some more complex remedies, natural remediation technologies can serve to facilitate attainment of specified remediation goals via final polishing.

- Controls Dust – Both natural remediation technologies and end use plantings reduce fugitive dust emissions, particularly if the soil is prepared with compost and/or mulch at the time of planting.

- Controls Sediment and Erosion – Both natural remediation technologies and end use plantings, once established, reduce sediment transport and soil erosion from storm events due to soil stabilization from plant roots and increased evapotranspiration.

- Stream Bank Buffer – Plantings can be used along stream banks to filter storm water runoff, which results in reduced contaminant loading to surface waters.

- Uses Atmospheric Carbon Dioxide– Both natural remediation technologies and end use plantings utilize atmospheric carbon dioxide and produce oxygen, which reduces greenhouse gases and mitigates global warming.

- Improves Ground Water Recharge – Both natural remediation technologies and end use plantings improve groundwater recharge as compared to mowed grass or paved areas.

- Minimizes Environmental Exposures – In situ natural remediation technologies reduce the need to excavate and haul impacted soil. Excavation and hauling potentially creates additional exposure pathways during the movement of the soil, thereby increasing environmental risk.

- Improves Environmental Stability – In situ natural remediation technologies avoid disrupting the soil as in excavation, thereby improving the stability of the local ecosystem.

- Provides Harvestable Resource – Metals can sometimes be recovered for reuse by harvesting natural remediation technologies biomass, thereby reducing resource mining elsewhere.

- Improves Aesthetics – Both natural remediation technologies and end use plantings are often more aesthetically pleasing than mowed grass or paved areas.

- Provides Educational Opportunity – Natural remediation technologies plantings can provide an educational opportunity for students wishing to learn about natural remediation technologies and environmental processes.

- Provides Recreational Area – End use plantings can provide an area for community or employee recreation.

- Provides Migratory Bird Pathways – Both natural remediation technologies and end use plantings can provide needed landscape ecology for migratory birds, depending on the size and location of the site.

3.2 Economic Benefits

- Cost Competitive – Both natural remediation technologies and end use plantings can be cost-competitive with other traditional remediation technologies and end uses. They also can be an important component of more complex remedies, particularly when addressing final polishing remedy requirements.

- Provides Use for Waste Materials – Composted waste materials (sewage sludge, fly ash, manure, yard waste, etc.) can be used as a soil amendment for both natural remediation technologies and end use plantings, thereby obviating the cost of waste disposal.

- Enables More Efficient Use of Limited Resources – Limited societal resources can be better deployed at a greater number of sites if those limited resources can be more cost-effectively deployed by harnessing natural attenuation and biodegradation processes.

- Uses Atmospheric Carbon Dioxide – Both natural remediation technologies and end use plantings use atmospheric carbon dioxide and produce oxygen, which reduces greenhouse gas production, thereby reducing costs associated with global warming.

- Provides Recreational Use – End use plantings can serve as a recreational area for the community, possibly with associated revenue.

- Attractive to Customers – Aesthetically pleasing planted areas may provide a competitive business edge by attracting more customers.

- Provides Marketing/Competitive Advantage – Ecological enhancements can be used as a marketing/competitive advantage to emphasize a company's environmental stewardship, thereby attracting environmentally conscious clients.

- Provides Source of Recoverable Resources – Harvested biomass from natural remediation technologies can provide a source of recoverable metals, while harvested biomass from natural remediation technologies and end use plantings can provide fuel, lumber, or other beneficial end products.

- Provides Opportunity to Obtain Environmental Offsets – The use of environmental enhancements can provide an opportunity to obtain environmental offsets when negotiating site cleanup objectives with regulators.

- Conservation Easements – Conservation easements can result in a one-time income tax credit and/or multiyear property tax savings (see Appendix B for additional information).

3.3 Public Benefits

During the remediation or redevelopment of environmentally impacted sites, nongovernment organizations and local community groups such as the Boy and Girl Scouts, schools, youth programs, bird watchers, nature conservationists, and prairie and wetland enthusiasts may express interest in pursuing reuse alternatives that incorporate ecological enhancements.

In many cases these organizations will desire to use the ecological enhancements as a means to provide educational opportunities, aesthetic benefits, and natural resources to the local area. Biology, horticulture, ecology, wetland hydrology, plant identification, and environmental remediation, are among the topics of interest. From the aesthetic point of view, ecological enhancements can improve the community image, bring in tourism, and provide recreational usage. The natural resources associated with these systems could operate as seed banks and breeding grounds for these groups.

For site owners and regulatory agencies, these alternatives can provide public relations benefits that may not be available from other strategic options. These benefits include enhanced reputation, "green" image, external validation, and sustainable operations. Reputation and image count. In 1999, the Conference Board, a worldwide business research network, asked consumers what matters most when forming an impression of a company. Most said reputation—it was the No. 1 response. People reward a good reputation and punish a bad one. Almost half said they had done business with a company in the preceding 12 months or supported it in some other way if they considered it socially responsible. Half said they had boycotted a company's products in the same period or had urged others to do so when they didn't agree with its actions or policies. Another study by James Gregory and Atlantic Research (2002) showed that business leaders in that year's Fortune top ten most admired companies ranked consumers as the most important influencers of corporate reputation. Even more than chief executive officer reputation, print media, employees, or analysts, the survey demonstrated the importance of reaching the consumer with strong corporate messages that contribute to market success and business results.

Reputation and image are built through actions taken and how they are presented to stakeholders. In many cases, nongovernment organizations can provide an impartial assessment of the activities agreed upon by site owners and regulatory agencies and can help the process to move forward with community acceptance. These organizations can also serve to ensure the continued operation and maintenance of these systems, either by monitoring the progress over time (during remediation) or accepting the responsibility directly (end use). In this manner, these efforts lead to sustainable operations and long-term advantages of beneficial public relations.

4.0 RELEVANT CONSIDERATIONS

As with any project, evaluation of the appropriateness, implementability, cost-effectiveness, and efficacy need to be considered with all remedies and ecological enhancements. Engineering analysis needs to consider potential limitations/constraints, as well as benefits, associated with any proposed remedy on a site-specific basis. Eight considerations, based on the "lessons

learned" through case studies and technical committee expertise were formulated during the technical symposium:

- Plan for and encourage ecological enhancement end uses from the beginning of each project.
- Plan for sustainability of ecological enhancement.
- Be persistent in finding allies among state and federal regulators and natural resources agencies early in the process.
- Plan for specific circumstances and design—incorporating ecological enhancements is not a "one size fits all" process.
- In using natural remediation technologies, be prepared to provide proof of concept.
- The current state of financial cost/benefit is not well defined.
- Expect to monitor and adapt.
- Educate and involve local community stakeholders from the beginning of the project.

Specific examples include appropriate consideration of food chain bioaccumulation/ bioavailability, animal foraging, biomass disposal, evapotranspiration dynamics, need for irrigation and fertilizing, use of pesticides, future land use, public access and site maintenance among others.

5.0 RECOMMENDATIONS

Five policy recommendations developed at the technical symposium and summarized below will be pursued by WHC and its partners. A list of issues that need addressed for guidance documents will be developed as an amendment to this white paper and serve as a basis for future work.

- Develop protocol for objective performance measures that are both quantitative and qualitative to evaluate ecological enhancement measurements. This protocol should delineate criteria for appropriate performance measurements, including those criteria set forth in Section 3 of this paper. Additionally, the protocol should consider the need and appropriateness of long-term monitoring to compare the performance and cost-effectiveness of natural versus conventional remedial techniques.

- Develop a guidance document to aid site managers, state and federal managers, and communities in the application of ecological enhancements at environmentally impacted properties. A proposal has been drafted by the Interstate Technology & Regulatory Council and WHC to develop such guidance materials as described in *Ecological Enhancements within the Design, Construction and Monitoring of Remediation Systems.* Funding to complete this guidance has not yet been secured.

- Conduct demonstration projects to clearly illustrate the process of ecological sustainability. In addition to demonstration projects, create a feedback mechanism through an online clearinghouse documenting performance and costs associated with remediation projects that incorporate ecological enhancements. Specifically, the clearinghouse would promote site-

specific analyses documenting benefits of ecological enhancements and comparing costs to other more traditional remediation technologies.

- Encourage EPA to develop a technical memorandum that addresses the applicability of ecological enhancements for regulatory decision making.

- Produce and disseminate information for lay audiences that clearly explains the science behind ecological enhancements and its applicability to cleanup and restoration projects of all kinds.

6.0 OTHER RESOURCES

- Research Technology Discussion Forum (RTDF) – http://www.rtdf.org/
- Technology Innovation Office (TIO) – http://www.epa.gov/swertio1/index.htm
- Low Impact Development/Center for Watershed Protection – http://www.cwp.org/
- Leadership in Energy and Environmental Design (LEED) Certification – http://www.usgbc.org/LEED/LEED_main.asp
- Interstate Technology & Regulatory Council (ITRC) – http://www.itrcweb.org
- Purdue University – http://bridge.ecn.purdue.edu/~mhsrc/page_mission.htm
- Clean-Up Information (Clu-in) – http://clu-in.org/
- EPA – Superfund – http://www.epa.gov/superfund/
- EPA RCRA – http://www.epa.gov/epaoswer/hazwaste/ca/index.htm
- EPA Brownfields – http://www.epa.gov/brownfields/
- Wildlife Habitat Council – http://www.wildlifehc.org/brownfield_restoration/
- Fish and Wildlife – http://www.fws.gov/
- Department of the Interior – http://www.doi.gov/
- Association of State and Territorial Solid Waste Management Officials (ASTSWMO) – http://www.astswmo.org/
- USDA, Sustainable Agriculture – http://www.usda.gov/
- "Phytotechnologies," Steve Rock, published by EPA – http://www.clu-in.org
- Michigan State University—Phytoremediation Research (Clayton Rugh) – http://www.css.msu.edu/phytoremediation/

APPENDIX A

Technical Committee

First Name	Last Name	Organization
Jerry	Amber	Ford Motor Company, Retired
Kathy	Banks	Purdue University
Judith	Bland	Merck
Kim	Brown	Naval Facilities Engineering Command
Sally	Brown	University of Washington
Mary Jane	Calvey	OKDEQ
Rufus	Chaney	USDA
George	Chmael II	EcoLogix Group
Harry	Compton	USEPA – ERT
Nicholas	DiPasquale	Brandywine Conservancy
Fran	Flanigan	EcoLogix Group
John	Fletcher	Oklahoma University
Scott	Fredericks	USEPA – ERT
Laurie	Haines	US Army
Charles	Harman	AMEC Earth & Environmental Inc.
Steve	Hill	ITRC Program Advisor – RegTech, Inc.
Bob	Hoyt	EcoLogix Group
Lucinda	Jackson	ChevronTexaco
Charles	Johnson	ITRC
Bob	Johnson	Wildlife Habitat Council
Mark	Luce	ChevronTexaco
Mark	Malender	ExxonMobil
Lori	Miller	USDA/ARS
Lee	Newman	University of South Carolina
Barbara	Padlo	BP
Rob	Pauline	Wildlife Habitat Council
Dan	Powell	USEPA Technology Innovation Office
Kenneth	Quinn	MWH
Steve	Rock	EPA
Heloisa	Schmidt	Wildlife Habitat Council
Sunil	Shah	Dow Chemical
Nina	Springer	ExxonMobil
Ralph	Stahl	DuPont
David	Tsao	BP
Victor	Wieszek	DoD

APPENDIX B

Detailed Explanation and Illustrative Example of Conservation Easements

Detailed Explanation and Illustrative Example of Conservation Easements

In addition to their intrinsic wildlife utility, contribution to positive company image, and regional aesthetic improvements, conservation easements (a legal agreement a property owner makes to restrict the type and amount of development that may take place on his or her property) may add to a company's bottom line. The economic benefit is due to a one-time income tax savings and multiyear property tax savings. The actual savings vary on individual circumstances and should be carefully considered by qualified tax professionals. A small amount of planning could result in producing substantive value to a company.

The income tax savings are realized depending on how the easement is structured. The alternatives include whether the property is donated to a nonprofit organization or held. In the case of a donation, the fair market value (FMV) of the property is allowed as a deduction. In the case of company retention, the difference in the FMV of the commercial use and conservation use may be treated as a loss. In both cases there are rules and limitations that need to be considered by tax advisors.

Property tax savings are less complicated to understand. Property classified as commercial use has a higher tax basis than conservation property. Typically, county tax districts apply a nominal charge to properties if held by a taxable entity or zero to a qualified nonprofit. The value of the savings is the current value of the sum of future payments or net present value (NPV). The following example illustrates this calculation.

Basic Assumptions *(these values need to be supplied by owner)*

FMV as Commercial Property	50,000	*($/acre)*	Commercial Property Tax Rate	1,500	*($/acre)*
FMV as Conservation Property	19,000	*($/acre)*	Conservation Property Tax Rate	1	*($/acre)*
Total Acres Available	70	*(acres)*	Cost of Capital	9%	
Corporate Income Tax Rate	37%	*(State and Federal)*			

Calculated Values - of property reclassification from commercial to conservation use

Alternate 1 - Donate property to non profit for them to reclassify as conservation property

Value of Donated Property	3,500,000
Tax benefit of Donation	**1,295,000**

Alternate 2 - Hold onto property, but reclassify as conservation property

Impairment due to Reclassification	2,170,000
Reclassification tax benefit	**802,900**

Calculated Values - of property tax savings due to reclassification from commercial to conservation use

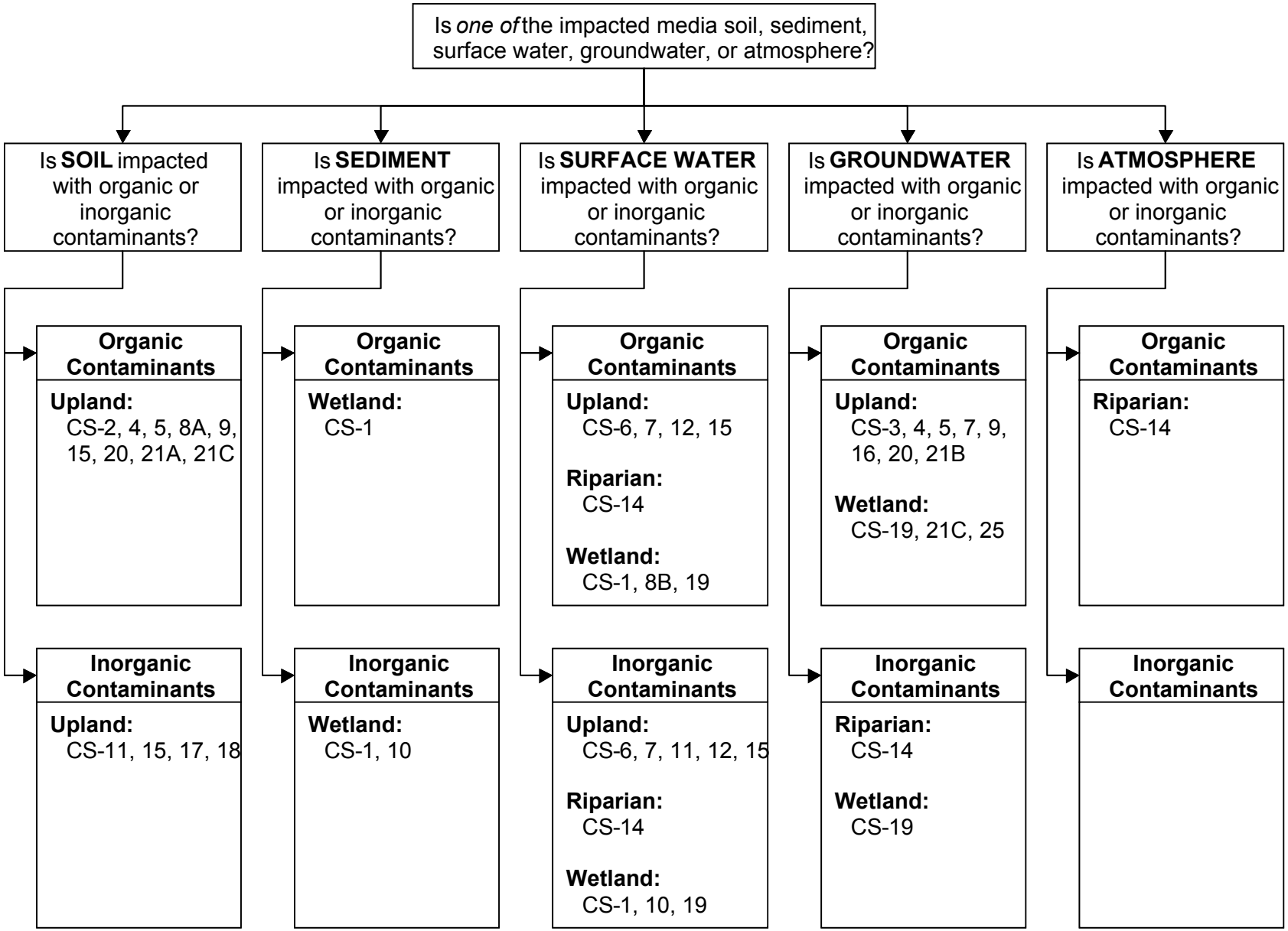
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Annual property tax savings	104,930	104,930	104,930	104,930	104,930	104,930	104,930	104,930	104,930	104,930
$NPV_{(at\ cost\ of\ capital)}$	**734,011**									

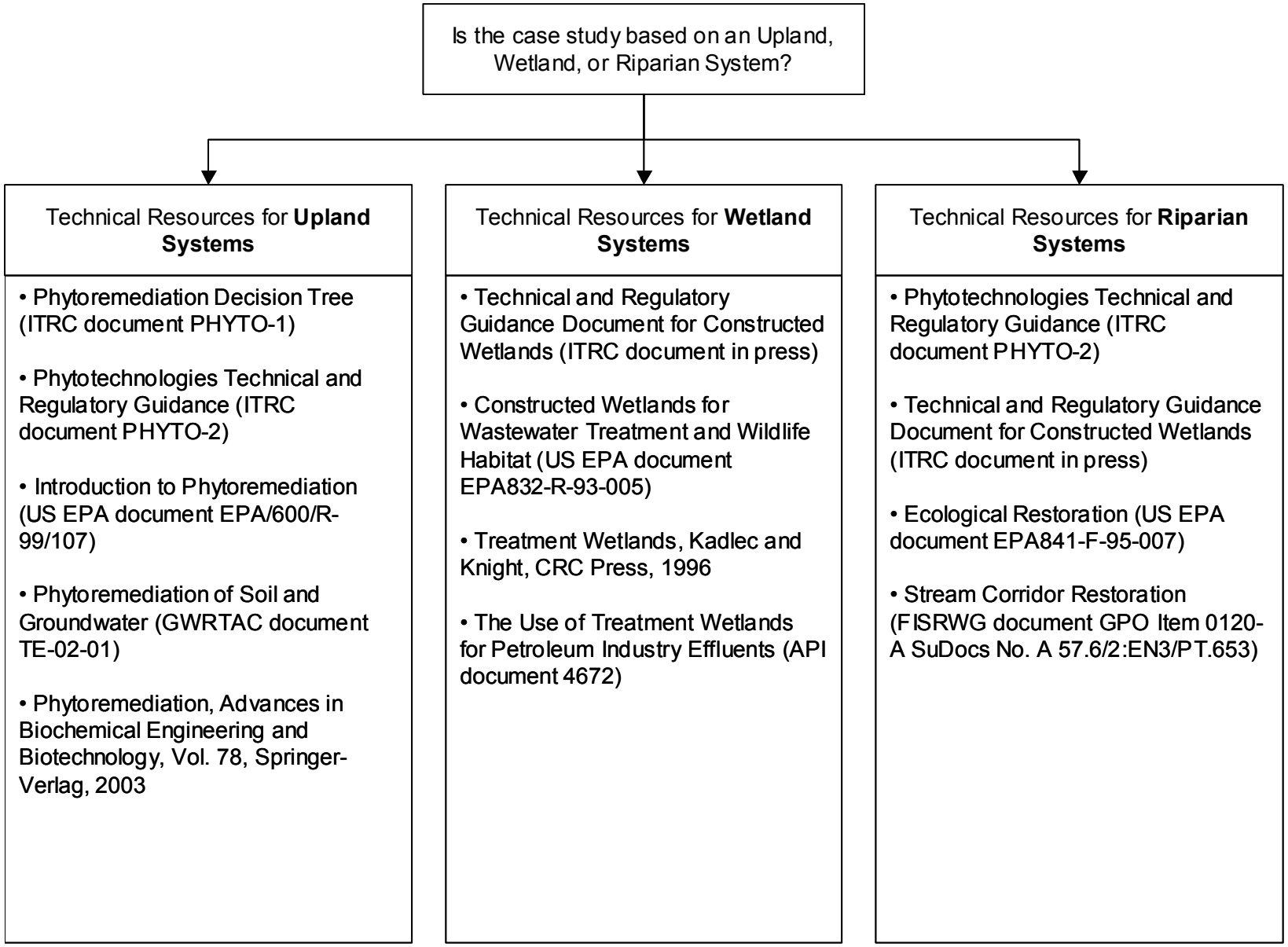
Total Calculated Values of property reclassification and property tax savings

Alternative 1	**2,029,011**
Alternative 2	**1,536,911**

APPENDIX C

Case Study Matrix


Is *one of* the impacted media soil, sediment, surface water, groundwater, or atmosphere?
Is **SOIL** impacted with organic or inorganic contaminants?
Is **SEDIMENT** impacted with organic or inorganic contaminants?
Is **SURFACE WATER** impacted with organic or inorganic contaminants?
Is **GROUNDWATER** impacted with organic or inorganic contaminants?
Is **ATMOSPHERE** impacted with organic or inorganic contaminants?
Organic Contaminants
Upland: CS-2, 4, 5, 8A, 9, 15, 20, 21A, 21C
Organic Contaminants
Wetland: CS-1
Organic Contaminants
Upland: CS-6, 7, 12, 15
Riparian: CS-14
Wetland: CS-1, 8B, 19
Organic Contaminants
Upland: CS-3, 4, 5, 7, 9, 16, 20, 21B
Wetland: CS-19, 21C, 25
Organic Contaminants
Riparian: CS-14
Inorganic Contaminants
Upland: CS-11, 15, 17, 18
Inorganic Contaminants
Wetland: CS-1, 10
Inorganic Contaminants
Upland: CS-6, 7, 11, 12, 15
Riparian: CS-14
Wetland: CS-1, 10, 19
Inorganic Contaminants
Riparian: CS-14
Wetland: CS-19
Inorganic Contaminants


Is the case study based on an Upland, Wetland, or Riparian System?
Technical Resources for **Upland Systems**
• Phytoremediation Decision Tree (ITRC document PHYTO-1)
• Phytotechnologies Technical and Regulatory Guidance (ITRC document PHYTO-2)
• Introduction to Phytoremediation (US EPA document EPA/600/R-99/107)
• Phytoremediation of Soil and Groundwater (GWRTAC document TE-02-01)
• Phytoremediation, Advances in Biochemical Engineering and Biotechnology, Vol. 78, Springer-Verlag, 2003
Technical Resources for **Wetland Systems**
• Technical and Regulatory Guidance Document for Constructed Wetlands (ITRC document in press)
• Constructed Wetlands for Wastewater Treatment and Wildlife Habitat (US EPA document EPA832-R-93-005)
• Treatment Wetlands, Kadlec and Knight, CRC Press, 1996
• The Use of Treatment Wetlands for Petroleum Industry Effluents (API document 4672)
Technical Resources for **Riparian Systems**
• Phytotechnologies Technical and Regulatory Guidance (ITRC document PHYTO-2)
• Technical and Regulatory Guidance Document for Constructed Wetlands (ITRC document in press)
• Ecological Restoration (US EPA document EPA841-F-95-007)
• Stream Corridor Restoration (FISRWG document GPO Item 0120-A SuDocs No. A 57.6/2:EN3/PT.653)

APPENDIX D

Case Studies

Case Study 1

West Coast Refinery Wetland Case Study	
Name and Location	**Site Name:** A West Coast Refinery **Site Location:** Refinery Effluent Treatment System
Site Description	An effluent treatment facultative lagoon, part of the refinery effluent treatment system (ETS), was converted to 90-acre wetlands. The ETS consisted of a primary facultative lagoon, followed by an aerated lagoon, and ending with a secondary facultative lagoon. The secondary, or post-treatment, facultative lagoon was built in 1963 from a tidal salt marsh by building a dike around the 90-acre area. Interior baffles and dividers were added to create three 30-acre sections or passes within the lagoon. The polishing lagoon was operated until 1985, when it was drained. It remained a dry lagoon bed, until 1989, when it was planted and converted to a freshwater wetland. The wetland is part of the ETS NPDES discharge permit and is considered treatment unit within the effluent treatment system. The water source to the polishing pond through 1985, and then as the constructed wetland, is treated refinery effluent water from the aerated biological treatment lagoon. The location is in an industrial area, near urban centers. The refinery is 200 acres in size. The wetland is 90 acres. 
Site Reuse Description	The site prior to 1989 was a 90 acre dry lagoon bottom. The soil was a slit- clay material, dried with deep cracks and no vegetation growing on it. The constructed wetlands was planned to provide treatment or polishing of the effluent from the aerated lagoon in the ETS. Provisions were made to include habitat for shore birds and water foul as part of the original design of the wetlands, e.g. open areas for resting, short grass areas to provide nesting areas, and a mud flat region for shore birds. Is the community involved in the end use decision making process? No, this was a Refinery project, because it was principally a modification to their wastewater treatment

West Coast Refinery Wetland Case Study	
Stakeholder Involvement	The refinery was the main stakeholder. This was a voluntary action to improve the ETS and make better use of an out-of-service 90-acre treatment lagoon. Agencies and nonprofit organization concerned with oversight of industrial water treatment, wetlands, and wildlife management were contacted to provide input into the design and end uses of the wetlands: Regional Water Quality Control Board, USEPA Region 9, State Fish and Wildlife Service, Audubon Society, and San Francisco State University. What were the concerns of these stakeholders and how were these resolved? Initially there were not many concerns. Local government and environmental agencies encouraged the conversion to the wetlands because of the potential restoration of 90 acres of wetlands to the area. Project funded by the refinery.
Site Assessment Approach and Cleanup	The site assessment was focused on the elements of planting and growing a wetland. The end use of the site was fresh water wetlands. This was dictated by the site being part of the effluent treatment system and that the source of the water to it was fresh water. Historically the site was a salt marsh, which posed some issues to planting freshwater plant species, due to the high salt content of the soil. Since this secondary lagoon was located after the aerated treatment lagoon, there were few organics that entered with the influent or deposited in the soil. There were some metals present in the soil, Ni, Cr, Se and Zinc. There was no mandated cleanup order. The site was a permitted part of the ETS and the action to create a wetlands was done to improve the wastewater treatment system and to provide habitat to the local bird wildlife. This site is part of the refinery, so access by the public is limited. What problems did you encounter during the corrective action? What was the nature of the problems encountered (e.g., regulatory, community perception, etc.) and how did you overcome these problems? The major problems encountered in creating the ecological enhancement of 90 acres of wetlands, was an unforeseen problem with selenium. The wetland was managed to encourage bird usage, especial migratory water fowl. In 1995, as a result of the Selenium problem in the California Central Valley agriculture drainage pond and wetlands, the Fish and Wildlife Service and Regional Water Quality Control Board requested a test of bird eggs within the wetlands to determine if there was a potential problem with selenium at this site. After 6 years of operation, there was evidence that the eggs of nesting birds in the wetlands had increased Selenium concentration, that were potentially harmful to the bird embryos. The RWQCB and Fish and Wildlife Service required a management plan and 5 year monitoring program be developed to demonstrate that the refinery could operate the wetland in a way to prevent selenium from harming the bird wildlife The resulting management plan was to turn the wetland into a treatment zone and a habitat zone. We successfully move the bird usage (feeding, resting, and nesting) from treatment zone (first 30 acres) to the habitat zone (second 60 acres) by controlling water levels to discourage bird nesting, reducing open land and water areas to discourage feeding and resting, creating reducing conditions within the water and sediments to remove selenium from the water phase in the treatment zone. Testing demonstrated that the reducing conditions in the treatment zone dropped all the selenium out of the water and contained it in the treatment zone.

West Coast Refinery Wetland Case Study	
	By creating appropriate bird management practices, in the habitat zone, we successfully move the migratory and shore bird usage to the habitat zones of the wetland (60 acres). Bird egg testing and bird usage surveys of the wetlands demonstrated that this strategy work. There was a reduction of selenium in the bird eggs to a safe level. The RWQCB and Fish and Wildlife Service approved the Wetland Management Plan and greatly reduced the monitoring required after demonstrating the successful operation during the required 5 year monitoring plan. Was a closure letter obtained for the site? If so what was issued and when? If not, are you currently seeking a closure letter?
Reuse	The end use is a wetland for treatment of refinery effluent, but more importantly it provides 60 acres of habitat for migratory water fowl and shore birds.
Costs and Funding	How was this project funded, i.e., were there any redevelopment funds or other resources used? Funded by the refinery. What was the total cost of the project? Approximately $1mm. The 5 year study to demonstrate wetland management plan would not harm birds cost ~ $200,000. If an ecological enhancement was used in the remediation, were there cost savings associated with the selection of this remedy. The ecological enhancement was a benefit that was planned into the project from the beginning. It was mainly to demonstrate the refineries commitment to the environment and to provide ecological benefits when and where possible in its construction projects and refinery operation. In this case, the desire to provide an ecological enhancement almost caused the whole operation to be stopped. The selenium issue almost shut down the wetland. The refinery spent ~$200,000 developing and demonstrating that with an appropriate management plan, the wetland could be operated in a way to protect wildlife and provide the ecological enhancement.
Time	How long did it take for this project to be completed? 1 year to build and 3 years to grow out the wetland plants. 5 years to demonstrate an acceptable wetland management plan to the RWQCB and Fish and Wildlife Service.
Other	List any other information that may be of value for this case study. This can be used to insert a “lessons learned” section, or highlight other information of interest.
Contact Information	Ross Smart, 510-242-2914 Will Gala, 510-242-4361

Case Study 2

West Coast Phytoremediation Case Study	
Name and Location	**Site Name:** A West Coast Refinery **Site Location:** Refinery Effluent Treatment System
Site Description	The refinery effluent treatment system (ETS) consisted of a primary facultative lagoon (No 1 Ox Pond), followed by an aerated lagoon, and ending with a secondary facultative lagoon. The 120-acre primary facultative lagoon served as an equalization basin and a pre-treatment lagoon for refinery process waters to be biologically treated in the aerated lagoon. The primary facultative lagoon was constructed in 1963 from a tidal salt marsh by building a dike around the 120-acre area. Interior baffles and dividers were added to create 5 sections ranging from 30 acres down to 5 acres. This primary lagoon was operated until approximately 1985, when it was drained. The first section of No 1 Ox Pond was excavated to create a clean storm water holding basin. The sediments from the storm water basin was distributed over the sections 2–5 of the remaining land of the No 1 Ox Pond, filling in most of it. Except for the storm water basin, the No 1 Ox Pond has remained dry since 1985. This site is within a refinery that is near an urban area. Refinery is ~ 500 acres and the No 1 Ox Pond is approximately 120 acres. 
Site Reuse Description	Site reuse plan is for continued use as a clean storm water holding basin (~30 acres) and to remediate and cover the remaining No. 1 Ox Pond with natural vegetation, grasses, bushes, and trees as a vegetative cap (~90 acres). The No 1 Ox Pond was a site for the USEPA/RTDF petroleum hydrocarbon phytoremediation

	study. A 0.8-acre study area was set up on part of the No 1 Ox Pond to look at phytoremediation of the oil in the sediments and to determine if phytoremediation was an alternative bioremediation method for clean-up of the No. 1 Ox Pond. The type of ecological restoration being sought is native grasses, bushes, and trees for the area. The community is not involved because site is part of the refinery ETS with restricted access by the public.
Stakeholder Involvement	The Regional Water Quality Control Board has regulatory control over the site because it is part of the ETS and NPDES permit. The Department of Toxic Substance Control because of oil and metals in the sediments from early operation as part of the ETS. USEPA/RTDF general oversight of the phytoremediation study. The site is part of the ETS and the refinery has the responsibility to clean up and restore site when it is no longer used as part of the ETS. There was no mandated action at the time by the RWQCB or DTSC to clean up the site. Stakeholders were concerned about developing a closure plan appropriate for the site that is protective of human health and the environment in the area. The refinery wanted to find a cost-effective closure plan that if possible, provided ecological upgrade of the No. 1 Ox Pond to natural habitat consistent with the area. The RTDF study was one part of this effort to understand the effectiveness of phytoremediation for cleanup and closure of the No. 1 Ox Pond and the focus of this case study. Only the RTDF contributed to the project by providing the data analysis and project support. Funding for the project was from the Refinery. No local, state, or federal funding was used.
Site Assessment Approach and Cleanup	The site assessment included soil core analysis, environmental risk evaluation, determining acceptable cleanup levels for the site, potential cleanup alternatives and land uses. The sources of contamination were from the refinery effluent treatment system 1963–1985. The contaminants of concern are petroleum hydrocarbons and some metals. This site is an inactive unit that contains hazardous waste. The No 1 Ox Pond stopped operation as a primary lagoon prior to "primary sludge" hazardous waste rules, which is at this location, was listed as a hazardous waste. The refinery worked with USEPA and the RWQCB and DTSC) to gain permission to do a phytoremediation demonstration at the site. The process required a complex coordination of letters by USEPA to state agencies, who then gave written permission to conduct the phytoremediation study without subjecting the site to hazardous waste permit requirements. The agencies supported this effort, as the data would help provide information for making decisions on this type of application at other sites in the future. The refinery is working with the RWQCB and DTSC to develop a voluntary corrective action plan for the site. An evaluation was performed to assess the potential feasibility of phytoremediation at the No. 1 Ox Pond. This evaluation was based on the following steps: 1. Identify risk based screening limits for constituents in soil

West Coast Phytoremediation Case Study	
	2. Use site data to calculate the 95% Upper Confidence Limit (UCL) for the concentration of constituents of concern. 3. Compare the proposed limits to the 95% UCL. 4. For constituents with UCL > risk limit, calculate the extent of treatment required to meet the limit. 5. Compare the required treatment to the amount of treatment expected by the remedial alternative. One barrier encountered in the site assessment of phytoremediation was the doing the right contaminant characterization to understand the state of the contaminants present. The total hydrocarbon analysis did not give a clear picture of the degree of biodegradation that has already occurred at the site prior to starting the phytoremediation study. The results from the first year's sampling and analysis indicated that the surface hydrocarbons were already weathered and almost completely biodegraded. Addition biodegradation in the near surface levels would be minimal by phytoremediation. The deeper layers had some biodegradation potential remaining, and as the plant roots reached the lower levels some phytoremediation would be expected. Groundwater movement through the site is contained by a slurry water containment wall and recovers wells around the site. Migration of groundwater down is contained by a natural clay liner of bay mud along the bottom of No 1 Ox Pond. The surface of the No 1 Ox Pond is planted in grasses to control erosion and rainwater run off or migration into the sediments. The area also has restricted to the public. The site is still in the process of assessing and developing a closure plan. The RTDF Phytoremediation Study is completed.
Reuse	The end use of the site would be added habitat of approximately 90 acres if a vegetative cap is selected as part of the closure alternative. Natural vegetation and habitat have been added to the site..
Costs and Funding	Project funded by the refinery. A PERF agreement with other oil companies to join the RTDF Phytoremediation Study provided $20,000 in founding. Phytoremediation study was ~ $100,000. A phytoremediation/green cap closure of the site would save ~ $3–5 MM over a tradition RCRA cap.
Time	The Phytoremediation Study took three years.
Other	• Proper characterization of hydrocarbons is important to assess the effectiveness of bioremediation and phytoremediation as cleanup alternatives. • Bioremediation and phytoremediation methods are effective cleanup methods if there is there is sufficient biodegradation potential of the remaining hydrocarbons to meet the cleanup level. • Health plant germination and growth was seen in soils with biodegraded/weathered 1-3% TPH.
Contact Information	Ross Smart – 510-242-2914 Kirk O'Reilly – 510-242-5365

Case Study 3

Rochelle Case Study	
Name and Location	**Site Name:** Rochelle, IL **Site Location:** Rochelle, IL
Ecological Enhancement	Poplar varieties, deep-rooted grasses and flowers.
Site Description	Rochelle is an operating terminal owned by BP. The groundwater is impacted by BTEX from a depth of 10–15 feet. Poplar varieties, deep-rooted grasses and flowers were planted in 2001-2 to remediate groundwater and provide hydraulic control.
Site Reuse Description	This site will continue to be used as an operating terminal.
Stakeholder Involvement	Stakeholders include BP and Illinois EPA. This project was funded by BP.
Site Assessment Approach and Cleanup	Groundwater potentially migrating offsite. Interception necessary to prevent. Other alternatives included physical GW extraction but at a higher cost.
Reuse	Site is located within local region where prairie restoration is ongoing.
Obstacles	Facility required that workers would have to be able to be maintained in visual contact with the operators control room. Therefore, low profile prairie species were selected.
Costs and Funding	Funded by BP. Costs for phytoremediation system substantially less than physical extraction alternative.
Economic and Other Incentives	Also helped to reduce expenses associated with mowing around the facility.
Time	Planting conducted over 2 seasons.
Other	
Contact Information	Dr. David T. Tsao, (630) 420-4321.

Case Study 4

Pocket Parks Case Study	
Name and Location	**Site Name:** Pocket Parks **Site Location:** Chicago, IL
Ecological Enhancement	Turned paved spaces into parks using native prairie species.
Site Description	Former service station facilities have been converted into small parks using native plantings.
Site Reuse Description	These parks are open to the general public for use.
Stakeholder Involvement	BP, Illinois EPA, City of Chicago.
Site Assessment Approach and Cleanup	The former retail (UST) sites are located throughout an urban environment with limited space available to expand. In general, contaminants of concern include BTEX at levels above MCLs but low enough to be no risk to the surrounding community. Native plantings are used to remediate soil and groundwater while at the same time converting a brown space into a park open to the community. Corrective Action at the three parks consisted primarily of limited soil excavation and disposal. Residual hydrocarbon impacts were allowed to remain in the subsurface. No Further Remediation (NFR) letters were received under TACO through the application of Institutional Controls including Highway Agreements with the City of Chicago, the application of Chicago's Groundwater Ordinance prohibiting the use of groundwater and proper handling of soils in the event that they are disturbed in the future. All three sites met closure terms for residential use in 2000-01.
Reuse	The community is getting park space on land that was formerly a small brownfield.
Obstacles	BP, the City of Chicago and local communities worked together to ensure that the three properties could be developed into parks. However, in some cases local politics presented a challenge to the proposed property use that resulted in numerous debates regarding redevelopment as community parks versus some form of commercial use. Many meetings were held over a 1-1/2 year period with various community groups to achieve consensus.
Costs and Funding	BP donated the three pocket park properties to the City of Chicago. In addition, BP provided $145,000 per location to the City to aid in the development of the parks. The application of TACO and the use of Institutional Controls reduced the potential corrective action cost by $100,000's per location.
Economic and Other Incentives	BP supports Chicago's "green space" initiatives and was able to donate three generally unmarketable surplus properties to the City for the development of pocket parks.
Time	3-4 years. One site is complete, the other two will be completed during the summer, 2003.
Other	Close communication between BP and the City of Chicago was critical to the success of this project. Community involvement and participation in the design of the parks, maintenance and upkeep will ensure the future viability of these projects.
Contact Information	Dave Piotrowski, (630) 434-6183

Case Study 5

Phytoscapes Case Study	
Name and Location	**Site Name:** Phytoscapes **Site Location:** United States, China
Ecological Enhancement	Enhanced landscape design.
Site Description	Phytoscapes is a concept where phytotechnologies are combined with landscape design at retail facilities. It is a process where a remediation system is "grown" into a site. The phytoscape acts as a prevention tool where small spills and leaks can be handled by the landscape materials before they are possibly even detected by sophisticated equipment. Phytoscapes can include "canary" species which can signal a problem before leak detection equipment in some cases. Phytoscape species are typical landscape quality plants that have shown phytoremediation capabilities. These species are already used by landscape architects. A phytoscape will substitute known phytoremediation capable species for other landscape plants.
Site Reuse Description	Any site can use phytoscapes to promote remediation while at the same time provide ecological enhancement.
Stakeholder Involvement	BP Retail business units, Bovis Lend Lease (Global Alliance design and construction partner), local communities / zoning boards
Site Assessment Approach and Cleanup	Phytoscapes are typically done under the authority of EPA OUST. Phytoscapes generally require less maintenance than current landscape designs. Because phytoscape species tend to be deep-rooted, they can access groundwater as their irrigation source after establishment. Retail site owners can lower water usage. Additionally, several phytoscape species include "no mow" lawn grasses. Maintenance with the phytoscapes will be less onerous.
Reuse	The community will get the same high level of aesthetic landscaping at service station sites. Ecologically can attract birds / butterflies to the region.
Obstacles	Community requirements for specific landscaping.
Costs and Funding	Typical landscaping costs cover the cost of the phytoscapes (simply substituting species)
Economic and Other Incentives	Phytoscapes can typically save money when compared to a traditional landscape design. Irrigation and maintenance costs are lower for phytoscapes. Phytoscapes are very forward thinking. They can be used to show the public that a remediation system can be "grown" into a site to handle or at least minimize potential impacts to soil and groundwater before they even become an issue for a regulatory body. They can help prevent environmental liabilities from forming in the future.
Time	
Other	This is a lesson-learned case study. Information was gathered from several other phytotechnology projects. Additional experiments were conducted, and regional-specific lists of landscape species, capable of remediating gasoline in the event of a release, were compiled.
Contact Information	Dr. David T. Tsao, (630) 420-4321.

Case Study 6

Former Ford Michigan Casting Center Landfill	
Name and Location	**Site Name:** Former Ford Michigan Casting Center Landfill **Site Location:** Flat Rock, MI
Ecological Enhancement	Wooded phytoremediation area providing increased biodiversity via creation of wildlife habitat for various birds and small mammals.
Site Description	The Site consists of approximately 90 acres of land located in the outskirts of the City of Flat Rock in southeast Michigan. Adjacent properties are a mix of manufacturing and commercial uses in a rural setting. The site was historically used as a permitted landfill for the disposal of foundry sand and cupola dust generated at the adjacent Ford Michigan Casting Center (MCC). Landfill operations terminated in 1981, after the MCC was closed, and a two-foot clay cap was used as a final cover system resulting in a wide expanse of grass covered fields. Following closure, no ongoing activities were maintained at the site.
Site Reuse Description	In addition to performing its intended function, the use of the Ecolotree® cap system provides an increased level of biodiversity and habitat that did not exist prior. By providing additional woodlands, the pervasive grassy fields are now complemented by additional protective structure for various birds and small mammals. Where the traditional grassy fields still exist, a rotational mowing schedule has been implemented to minimize disruption to ground-nesting birds on the landfill cap. Implementing phytoremediation at this site was intended to incorporate sustainable and wildlife habitat as a component of environmental remediation where specific circumstances allow for such an approach.
Stakeholder Involvement	In addition to Ford Motor Company, the Michigan Department of Environmental Quality, and Wayne County Department of Environment also had a vested interest in the performance of the new cap system as responsible regulatory authorities. Because the proposed approach was not consistent with currently accepted theory regarding cap design, a one-day training and dialogue session was scheduled by Ford Motor Company with interested regulatory groups during which the concept in general, and the application at the landfill specifically, was discussed. No dissenting positions were expressed on the part of any agencies and Ford Motor Company proceeded independently, and at Ford Motor Company expense, with the installation of the new cap system.
Site Assessment Approach and Cleanup	Evaluation of existing conditions in the landfill in the mid 1990s indicated a need to reduce existing levels of perched leachate in the landfill to preclude the potential for off-site migration. The existence of high levels of perched leachate was attributable to the unique geology of the area (i.e., thick, homogenous clay deposits and artesian groundwater conditions) that resulted in effective containment of leachate (generated through artesian and rainfall infiltration) and the absence of a leachate collection system. In 1995 a traditional active leachate collection/management system was installed in a high priority portion of the landfill measuring 45 acres. Active management of leachate in this area continues today. In 1998, an innovative passive leachate management system (by Ecolotree®, Inc.) was installed in a five-acre disposal cell on the same site. The system consists of a combination of hybrid poplar and willow trees selected to provide leachate mound reduction and infiltration control. The system was chosen so as to provide a more sustainable and natural phytoremediation approach to the needs of the site. All work performed at the sight was performed without oversight of any regulatory authority since the closed landfill had satisfied it's post-closure care obligations and the applicable state required restrictive covenant had expired. In the spirit of cooperation, and with an interest in expanding acceptance of this phytoremediation technique, Ford Motor Company maintained dialogue with both state and county authorities during the implementation of this remedy.
Reuse	Although there is currently no identified reuse for the site, as an industrial zoned property

	it is potentially available for limited brownfield redevelopment based on industrial land use with engineering controls. The property remains a restricted access area and public use is not anticipated. The use of the Ecolotree® cap has negated the ongoing O&M costs of a traditional leachate collection/management system as well as the one time investment in infrastructure.
Obstacles	The project received little resistance from local or state agencies. The proactive dialogue initiated by Ford Motor Company prior to implementation of the project allowed concerns and issues to be raised early and dealt with in an appropriate manner
Costs and Funding	The project was funded entirely by Ford Motor Company at a cost of approximately $200,000.
Economic and Other Incentives	In addition to long term cost reductions verses a traditional leachate collection/management system, use of phytoremediation to promote increased biodiversity on corporate properties is consistent with the company's corporate citizenship objectives.
Time	The project was completed during the 1998 construction season. Inspections are occurring on a regular basis to document the continued performance of the Ecolotree® cap system.
Other	The success of the Ecolotree® cap application at this site provides a demonstration that, given an appropriate set of circumstances, this type of cap systems may prove to be just as effective as a traditional clay and/or FML liner but have the added benefit of promoting increased biodiversity and habitat improvements.
Contact Information	Jeff Hartlund Ford Land (313)322-0700

Case Study 7

Joliet Case Study	
Name and Location	**Site Name:** Joliet, IL **Site Location:** Joliet, IL
Ecological Enhancement	Vegetative cover of deep-rooted prairie grasses and flowers.
Site Description	The Joliet Chemicals facility is an operating plant owned by BP. The landfill leachate needs to be managed. Precipitation falling onto the landfill would run-off or infiltrate into the landfill creating leachate that potentially migrated downgradient towards the Kankakee River
Site Reuse Description	This site is part of an operating facility. The landfill itself is closed. A vegetative cover of deep-rooted prairie grasses and flowers was planted in 2001 to manage landfill leachate. It will continue to exist as a landfill.
Stakeholder Involvement	Stakeholders include BP and Illinois EPA. This project was funded by BP.
Site Assessment Approach and Cleanup	This site is under the authority of RCRA. The site is undergoing recontouring to further promote run-off versus infiltration. Revegetation was also planned. Reselected vegetation to maximize rain interception (and subsequent evaporation) to reduce run-off and infiltration. Deep-rooted prairie species were selected due to their substantial rain interception capacities and high ET rates. Standard operation, maintenance, and monitoring of the landfill. Annual mowing plus irrigation/fertilization as needed.
Reuse	Site will continue as a closed landfill; no further developments planned. Native prairie restoration and ecological services created through plant re-selection.
Obstacles	
Costs and Funding	
Economic and Other Incentives	Reduced infiltration = reduce leachate production = reduced leachate management (currently extracted through a downgradient interceptor trench and pumped to the WWTP
Time	Planting was completed after reconstruction of the landfill cover (within 1 year).
Other	List any other information that may be of value for this case study. This can be used to insert a “lessons learned” section, or highlight other information of interest. Also, you may add additional sections as needed, if additional information does not fit in the categories above.
Contact Information	Dr. David T. Tsao, (630) 420-4321.

Case Study 8

Closed Refinery in Hooven, Ohio Case Study	
Name and Location	**Site Name:** Former Gulf Refinery Site **Site Location:** Hooven, Ohio. About 20 miles west of Cincinnati.
Site Description	The site is on the Great Miami River, along with several other former and active refineries. The Great Miami River joins the Ohio River a few miles downstream of the site. Besides the industrial development along the river, the area is rural, with suburban development moving closer in the last few years. (Insert a picture, aerial photograph, If sending this via e-mail you may want to send the picture separately.) 1931 to 1985 Gulf Oil Corporation constructed and operated a fuels and asphalt petroleum refinery on the site. Chevron acquired the facility in 1985. Refining at the site stopped in 1986. 1986 to present ChevronTexaco has dismantled the refinery and is cleaning the site for return and use by the local community. Tank bottoms and soil from spill sites were trucked to a bermed area near the refinery. This Land Treatment Unit (LTU) was fertilized and tilled from the end of receiving waste in 1988 until the phytoremediation planting in 1999. The former refinery area is 250 acres. The LTU/ phytoremediation area is 5.5 acres; the constructed wetland is 8 acres.
Site Reuse Description	**CS-8A: LTU** The LTU has been planted with trees and grasses. The vegetation serves as cover to prevent dust, erosion and physical contact as well as continuing to degrade organic materials in the soil. **CS-8B: Wetlands** BTEX contaminated groundwater is pumped and biologically treated in a fluidized bed reactor (FBR). The treated groundwater from the FBR goes to a small settling lagoon to remove suspended solids, prior to discharge to the Great Miami River. Construction of a Corrective Action Management Unit (CAMU) required the settling lagoon be removed. A surface flow wetland consisting of a small flow equalization lagoon and two wetland cells was constructed to replace the lagoon. The wetland was designed to provide removal of suspended solids, effluent polishing to remove any residual organics, and to provide wetland habitat. The community is involved in the end use decision making process. ChevronTexaco has held numerous public forums on the possible future use of the land.
Stakeholder Involvement	ChevronTexaco, the University of Cincinnati, and USEPA Office of Research and Development partnered to assess the efficacy of plants to enhance the degradation of the organics in the soil at the LTU. The US EPA Region 5 and Ohio EPA share regulatory jurisdiction over the site. Neighbors were slightly concerned about contamination at the site, though many of them had worked on the site during operations and felt it was mostly safe. There is a community desire to see the land returned to some function that provides employment or community benefit. The regulatory agencies want to ensure that water supplies are not impacted, and that applicable regulations are followed.

Closed Refinery in Hooven, Ohio Case Study	
	Chevron Research and USEPA ORD funded the research project at the LTU, including assessing the site, planting, and monitoring. ChevronTexaco funded the construction of the wetland.
Site Assessment Approach and Cleanup	The site cleanup is managed under RCRA. As part of the Consent Order, ChevronTexaco has identified the contamination on site in the Description of Current Conditions report, which consists primarily of refinery wastes deposited in several Solid Waste Management Units and Areas of Concern. **LTU** Under what specific legal authority(ies) is the cleanup being performed (CERCLA/RCRA/OUST or other)? The US EPA Region 5, Ohio EPA, and US EPA Research Technology Development Forum (RTDF). The LTU contains a mixture of highly weathered petroleum hydrocarbons, including polyaromatic hydrocarbons (PAHs). In 1999 the site was sampled for hydrocarbon analysis then planted with grasses and trees as part of the RTDF Phytoremediation project. The project is in its final year of sampling and it will continue to act as a "green" vegetative cap, providing control of rain water run off and downward migration of water. Implementing the RTDF Phytoremediation project required a complex of meetings, letters, and negotiation between ChevronTexaco, University of Cincinnati, USEPA Office of Research and Development, USEPA Region 5, and OHIO EPA. Once the project goals and work plan were agreed to by all parties and the CRADA was finally signed the work proceeded fairly smoothly, **Wetland** Describe any long term controls (e.g., institutional controls) associated with the site. What problems did you encounter during the corrective action? What was the nature of the problems encountered (e.g., regulatory, community perception, etc.) and how did you overcome these problems? Was a closure letter obtained for the site? If so what was issued and when? If not, are you currently seeking a closure letter?
Reuse	Describe the end use of the site. What are the benefits of the end use of the site (for the community, regulatory agency, etc.)? **LTU:** The end use of the former land treatment unit is to provide upgrade the site to usable habitat, consistent with the overall plan to restore the old refinery site useable land for multiple land uses by the community as park, recreational area, and natural habitat for local wildlife. The green vegetative cap and trees control erosion, rain water migration, and natural vegetation cover to the formerly bare land. **Wetland:** The end use of the wetland is to provide habitat with birds and wildlife and to extend the park planned for the adjacent area by providing community access to the wetland. The wetland has upgraded the land from a former industrial site to natural wetlands.

Closed Refinery in Hooven, Ohio Case Study	
Costs and Funding	How was this project funded, i.e., were there any redevelopment funds or other resources used? What was the total cost of the project? LTU ~ $50,000 in cash and work in kind Wetland ~ $500,000 If an ecological enhancement was used in the remediation, were there cost savings associated with the selection of this remedy. **LTU –** The purpose of the phytoremediation was to provide a vegetative cap and provide biodegradation of remaining degradable hydrocarbons of the old LTU. There is the cost savings of not having to construct a tradition RCRA cap to close the site. **Wetlands –** The primary purpose of the wetland was to provide polishing of the FBR effluent. The ecological enhancement was a positive selection factor for doing wetlands over a tradition lagoon or clarifier for solids removal.
Time	It is estimated that both the LTU and the wetland are long term features of the site.
Other	List any other information that may be of value for this case study. This can be used to insert a "lessons learned" section, or highlight other information of interest.
Contact Information	LTU – Lucinda Jackson, 510-242-1047 and John Tiffany, 513-353-1323 Wetland - Jim Myers, 713-432-6689 and John Tiffany

Case Study 9

Cleveland Case Study	
Name and Location	**Site Name:** Cleveland **Site Location:** Cleveland, OH
Ecological Enhancement	Dense prairie plantings.
Site Description	Prairie plantings were used at a former retail (UST) site in Cleveland, OH.
Site Reuse Description	Redeveloped into a commercial strip mall
Stakeholder Involvement	BP, current site occupants, commercial real estate owner (site owner)
Site Assessment Approach and Cleanup	This cleanup is being performed under the authority of Ohio EPA BUSTR. Former retail site redeveloped (USTs removed, tank pit excavated and backfilled. Residual hydrocarbon impacted soils and dissolved GW plume remained after initial site decommissioning. Phyto was selected due to suitable site conditions for the technology, limited area, and aesthetics compared to physical/mechanical treatment systems.
Reuse	Redeveloped as a strip mall.
Obstacles	The dense prairie plantings were not maintained properly to ensure the necessary aesthetic development (too infrequent of site visits, maintenance, no scheduled irrigation, pruning, etc). Resulted in adverse public perception (not related to effectiveness).
Costs and Funding	Less costly than the previous alternative of groundwater interceptor trench combined with sparging.
Economic and Other Incentives	Phyto was a more cost-effective solution with less disruption of operations of the strip mall. This was an innovative approach; it was green and sustainable.
Time	Not completed.
Other	This is a failure case study. The prairie plantings were not properly maintained to ensure aesthetic development. Due to the public nature of the area, the unkempt appearance of the prairie plantings garnered complaints. Theft of certain species was also an issue (lack of security). A different remediation remedy was required.
Contact Information	Dr. David T. Tsao, (630) 420-4321.

Case Study 10

West Page Swamp Case Study	
Name and Location	**Site Name:** West Page Swamp **Site Location:** Bunker Hill CERCLA site, Shoshone County, ID
Site Description	West Page Swamp is a naturally occurring 15 acre wetland that is part of the Coeur d'Alene River system in Northern Idaho. It is next to the community of Pinehurst, ID and is directly south of I-90. It was used as a tailings repository in the 1920s for a mill that processed zinc and lead ore. The soil material in the swamp consists of highly contaminated (up to 3% Pb and 1.5% Zn tailings. These materials were sufficiently toxic that the swamp showed no evidence of ecosystem function It is an extreme example of the contamination that characterizes the lateral lakes wetland area that is part of the 100 square mile NPL site. Waterfowl feeding and nesting in these areas have routinely developed acute Pb toxicity from ingesting the contaminated sediment. A description of the site with photos can be found at: http://faculty.washington.edu/clh/wet.html
Site Reuse Description	To restore wetland function to the site, a cap consisting of biosolids compost and wood ash was spread over the surface of the tailings. This cap was sufficient to reduce both accessibility and bioavailability of the underlying tailings and restore ecosystem function, characteristic of a naturally occurring wetland to the site. This wetland is part of an extensive area of naturally occurring wetlands and lakes that is used primarily for recreation and as habitat. While mining and smelting of metal ores were an important part of the economy in this county, there is no longer an industrial base in this area. Remediation activities are the primary industry.
Stakeholder Involvement	Stakeholders at the site were US EPA Region 10, the Coeur d'Alene Indian Tribe, mining companies listed as PRPs (potentially responsible parties) in the remedial process, Idaho Department of Environmental Quality, and US Fish and Wildlife. All stakeholders took part in approving the remedial action and their concerns were incorporated into the remedial design for the site. What were the concerns of these stakeholders and how were these resolved? Stakeholder concerns were primarily related to the ability of the surface amendment to reduce the bioavailability of the underlying metals at the site. There was concern that the site would become an attractive nuisance for wildlife. In addition, there were some concerns on the final appearance of the site with regard to site contouring. Did any of these stakeholders/partners make a financial contribution to the project? No Were any local, state, federal funding sources used? Funding for the project was provided by US EPA Environmental Response Team, a division of CERCLA.

West Page Swamp Case Study	
Site Assessment Approach and Cleanup	Briefly state the results of the site assessment. Did the site assessment approach take into account end use? The site assessment showed no ecosystem function at the site and high potential for damage to wildlife due to the high concentrations of Cd,Pb, Zn and As in the tailings. It was the goal of the project to restore a functional wetland to the site. What is/were the sources of contamination? What are/were the contaminants of concern? As stated above, the contamination was from a historical milling operation. The primary contaminants were Pb, Zn, Cd, and As with Pb toxicity to waterfowl as one of the drivers for the site. Under what specific legal authority(ies) is the cleanup being performed (CERCLA/RCRA/OUST or other)? CERCLA Briefly summarize the corrective action taken on site. If corrective action/remedy still in place please describe. Why was the particular remedy selected? Please describe any barriers encountered in employing remedy selected. The tailings were amended with a surface application of biosolids compost and wood ash. The mixture was applied with a rear cast thrower that drove through the swamp on a road built from log yard debris from a local lumber yard. For areas that were not accessible using the thrower, a blower truck was brought in the following year and the same mixture was blown onto the tailings surface. The material is still in place and works like a normal wetland soil. Describe any long term controls (e.g., institutional controls) associated with the site. Monitoring of the site over time has been conducted by the University of Washington, US EPA ERT and ID DEQ Was a closure letter obtained for the site? If so, what was issued and when? If not, are you currently seeking a closure letter? No, not to my knowledge
Reuse	Describe the end use of the site. What are the benefits of the end use of the site (for the community, regulatory agency, etc.)? The site is currently a wetland. It is in a highly visible area and is lovely to look at. It provides wildlife habitat and helps a community that was known for undisturbed natural beauty recapture that image after mining and smelting operations have ceased. What has been the added value to the site?
Obstacles	What problems did you encounter during the corrective action? What was the nature of the problems encountered (e.g., regulatory, community perception, etc.) and how did you overcome these problems? This was done as a research site. It remains to be seen if this type of remedy will be used for a portion of the wetlands to be restored under the NPL Record of Decision. Describe any other obstacles related with this project (funding, etc.). There are concerns with leaving a contaminant in place, that the remedy will only be temporary. It is important to include monitoring in a remedial plan when the remedy does not completely remove contaminants from the site.
Costs and Funding	How was this project funded, i.e., were there any redevelopment funds or other resources used? This was a research project, funded by the US EPA ERT. What was the total cost of the project? Total cost of the project was about $150K. These costs were elevated as it was done as a research site. For full scale use of this type of

West Page Swamp Case Study	
	technology, costs are expected to be lower. If an ecological enhancement was used in the remediation, were there cost savings associated with the selection of this remedy? This type of remedial action was much less expensive than conventional remedial approaches and also did not result in any negative impacts to clean areas. Sourcing clean fill material in this area has resulted in destruction of river bank soils and ecosystems.
Economic and Other Incentives	What were the economic incentives (e.g., conservation easements) associated with this project? This type of remedial action, leaving contaminants in place and reducing their bioavailability through a surface amendment that simultaneously restored ecosystem function to the site is a cost effective and environmentally friendly alternative to conventional remedial options including excavating the tailings or using an artificial capping material. Were there any other incentives (e.g., public relations) associated with this project? The end result, a beautiful wetland that is highly visible (alongside an interstate) helps to restore the image of this area as an area of natural beauty rather than a Superfund site.
Time	Amendments were applied during two two-week periods over the course of two summers
Other	List any other information that may be of value for this case study. This can be used to insert a "lessons learned" section, or highlight other information of interest. Also, you may add additional sections as needed, if additional information does not fit in the categories above.
Contact Information	Sally Brown Research Assistant Professor Ecosystem Sciences University of Washington slb@u.washington.edu Harry Compton Environmental Engineer US EPA ERT Compton.harry@epa.org

Case Study 11

Upper Arkansas River Tailings Restoration	
Name and Location	**Site Name:** Upper Arkansas River **Site Location:** Leadville, CO
Site Description	Leadville Colorado has had a long history of precious and base metals mining. As a result of approximately 100 yrs. of mining at California Gulch, there were numerous uncontrolled releases of metals laden tailings. Tailings were deposited as discrete parcels along an eleven mile stretch of the Upper Arkansas. The 150, one to two acre deposits were characterized by lack of vegetation, low pH, high metals (Pb, Cd, Zn), pyritic soils and no soil structure. The tailings deposits had become a blight on the land use potential. The U. Ak. River portion of the site had largely been used as agricultural, pasturing cattle and recreational, fishing. The area is in a valley surrounded by the highest mountains of Colorado, subsequently because of the mining history and scenery, the location is a popular tourist haunt.
Site Reuse Description	The ecological enhancements involved incorporating locally available organic residuals into tailings deposits to create a fertile functioning soil. Biosolids from the Denver Metro Wastewater Treatment Authority were mixed with agricultural lime and tilled into the mine tailings. Approximately forty acres of the barren and toxic soils were converted to pasture and recreational lands. The toxic metals were immobilized and rendered significantly less bioavailable by this treatment. One landowner commented that it was the first time in eighty years he could pasture cattle on his land. Fly fishing enthusiasts now enjoy a scenic panorama of native grasslands in the floodplain rather than moonscape. The community and stakeholders were heavily involved in the end use decision making process! There were "core group" meetings on a monthly basis to address any concerns or issues.
Stakeholder Involvement	The stakeholders/partners in this site were landowners, Fish & Wildlife Service, mining companies, local government authorities, USDA, Bureau of Reclamation, and, EPA. Their roles/contributions were as follows; the landowners wanted the use of land returned by the mining companies, USDA developed the concept of biosolids & lime land application for metals immobilization and soils remediation, EPA implemented the large pilot project, local government authorities wanted control of the land use to ensure in met their master plan. The two main concerns of the stakeholders were establishing measures for success/failure and scientific assurance the project was technically sound. Both concerns were addressed through chemical extraction tests, ecological evaluation and modeling. US EPA was the only funding source.

Upper Arkansas River Tailings Restoration	
Site Assessment Approach and Cleanup	The primary sources of contamination were fluvial deposits of tailings from the California Gulch Mining area. The contaminants of concern were high levels of lead, zinc and cadmium in low pH soils. The specific legal authority was CERCLA for the cleanup performed. In summary, Biosolids from the Denver Metro Wastewater Treatment Authority were mixed with agricultural lime and tilled into the mine tailings. USDA and University of Washington had shown that this mixture can immobilize metals and render them less bioavailable. The corrective action/remedy is still in place. This was in-situ remedy. The barren and denuded landscape from the tailings has been converted to fertile habitat for recreation and agriculture. The remedy was selected because of its cost-effective common sense approach. The remedy was attractive to site managers, stakeholders, and EPA management because it essentially recycles two waste materials to generate a revitalized landscape. Barriers encountered in employing remedy selected, there were quite a few. None were insurmountable. The first was mobilizing resources to such remote areas along the Upper Arkansas. The biosolids were free but the cost of transportation was not. Water for irrigation is a valuable commodity in the West. Given the low rainfall and high altitude, irrigation water was critical to the success of the project not just to get vegetation to grow but to retard the capillary rise of metal salts. There are no long term controls associated with the remedy, and, because the site is not complete, there is no closure letter.
Reuse	The land use had historically been agriculture, specifically pasturing horses and cattle. With changes in economic drivers for the community there was new demand for recreational outlets, mountain biking and fishing access to the Upper Arkansas River. With the collapse of the mining industry, the town of Leadville has evolved into a community relying on tourism. With tremendous mining history, the location offers miles of scenic bike trails, large areas of hiking and fishing access, and, resumed agriculture practices. The community and stakeholders have benefited from reclaimed mine lands. Largely for recreation and agriculture.
Obstacles	High altitude, Leadville is the highest elevation incorporated town in North America at 10,200 ft. The growing season is somewhere between 60-70 days, rainfall is approximately 17 in. Subsequently growing anything is difficult even under healthy environmental conditions, and, the site having acutely toxic soils made the effort that much more problematic. Another issue that drove the cost of remediation up significantly was the multiple layers of scientific evaluation of the remedy to placate natural resource trustees.
Costs and Funding	This project was funded through CERCLA. There was a redevelopment grant for the community. The total cost of the project was approximately two million dollars for forty plus acres. An in-situ ecological enhancement was used in the remediation. The cost savings associated with the selection of this remedy were tremendous. The only other option put forward for remediation at this site was “dig and haul”. A huge new repository for tailings would have had to be constructed, new roads constructed to access the 150 tailings deposits along the eleven miles of the Upper Arkansas R., fill material for backfill would be needed.

Upper Arkansas River Tailings Restoration	
Economic and Other Incentives	There were economic incentives such as a conservation easements associated with this project but do not have the details. There were public relations incentives associated with this project. Early on, EPA did not recognize the importance of the community's close historical relationship to mining. EPA overcame missteps to garner a more positive relationship with the town fathers by keeping the mining aesthetic in the remediation efforts.
Time	The project has not yet been completed because of funding shortfalls and "re-prioritization" to higher human health threat sites. Other non-trivial funding issues are related to the economy in general and mining companies inability to cost share.
Other	
Contact Information	Mike Zimmerman, OSC, EPA Region VIII, Denver, CO. Mike Holmes, RPM, , EPA Region VIII, Denver, CO.

Case Study 12

Low Impact Development Techniques on Residential Subdivision	
Name and Location	**Site Name:** SEA Streets Pilot **Site Location:** Seattle, Washington
Site Description	The community is a suburban housing development, with roof gutters and downspouts, to an open ditch drainage system. The community is in a suburban area. The development consists of 1 residential block with 18 houses.
Ecological Enhancement	This project provided areas of plantings attractive to habitat whereas a standard storm sewer system would have provided more paved and impermeable areas.
Site Reuse Description	SEA Streets is an alternative street design that uses grading, soil science, plant selection, and non-linear layout to function more like an undeveloped landscape. The ecological restorations include mixed plantings of over 100 deciduous and evergreen trees, 1100 shrubs, and native wetland and upland plant species. Ecological enhancements were chosen for this development to remove contaminants from runoff, to recharge groundwater, and to provide habitat. The community was an integral part of the project. The community had input on types and layout of hardscape, as well as types and locations of plantings.
Stakeholder Involvement	The stakeholders/partners for this development included the City of Seattle, State environmental officials, and the community. The State officials played a major role in embracing the technologies and providing permits and approvals, while the City showed great leadership in using unconventional techniques. The City of Seattle was concerned about removing contaminants from storm water runoff before it entered the surface water system, and also about recharging groundwater, as well as containing costs. Use of LID methods addressed all these concerns. The City of Seattle funded the project.
Site Assessment Approach and Cleanup	There were no previous environmental impacts to contend with. The concern was with the post development condition, when storm water runoff could potentially add contaminants to the local surface water system and lack of groundwater recharge could adversely affect subsurface hydrology. The LID practices used on this project included rain gardens, and planted roadside ditches. A rain garden is a shallow surface depression in the ground beneath a home's downspout, which is planted with various plants to accept roof drainage and encourage infiltration. Planted roadside ditches accept roadway runoff to filter contaminants and encourage infiltration. These techniques were chosen at this site to enhance groundwater recharge, remove storm water contaminants, and provide habitat and aesthetic enhancements. The plantings require long-term maintenance to optimize performance.

Reuse	The end use of the site as a residential development serves the community as housing, and as an attractive neighborhood for visitors. The LID practices met regulatory concerns to control storm water. The site enhancements provided the owners with very popular and attractive homes with enhanced resale value. The added landscaping has made the neighborhood more attractive to home-buyers, who enjoy the beauty and recreational opportunities.
Obstacles	None
Costs and Funding	The City of Seattle funded the project. The total cost of the project was $850,000. It is estimated the ecological enhancements at this location saved approximately $150,000 over the cost of a traditional curb and gutter system (or approximately 18%).
Economic and Other Incentives	The economic incentives to the City of Seattle included the potential cost savings due to reduced contaminant loadings to surface water; reduced cost of installing traditional curb/gutter systems; and increased property values. In addition, this pilot project was a public relations success, as well as an educational demonstration project.
Time	It took less than a year to complete this project.
Other	
Contact Information	Tracy Tackett, PE Seattle Public Utilities Seattle, WA (206) 386-0052 Tracy.Tackett@Seattle.gov

Case Study 13

Fernald Case Study	
Name and Location	**Site Name:** Fernald **Site Location:** Southwest Ohio
Site Description	Formerly produced uranium metal for the USDOE Nuclear weapons complex. It is currently listed on the National Priorities list (NPL) and is undergoing CERCLA remediation. The site covers 1000 acres and the entire site will undergo natural resource restoration following remediation
Site Reuse Description	The end use is designated as an educational Park focusing on site history and ecology. Restoration is well integrated with remediation by taking advantage of post-excavation topography to determine the habitat type. Deep excavation and storm water retention basins are readily converted to ponds and wetlands. Excavations into subsoil are being converted to native grasslands due to their ability to compete well on low nutrient soils. The federally listed endangered Indiana Bat has been documented on-site and restorations are intended to improve that habitat. Infiltration basins are being developed adjacent to wetlands to aid in groundwater remediation (i.e. natural injection wells) The decision to implement restoration on the site was and combination of public participation and the state of Ohio NRD claim
Stakeholder Involvement	A 30 day public comment period will be held on two separate documents. One of the documents is the NRRP. The second document for public comment is DOE's *Environmental Assessment for Proposed Final Land Use* (EA). This NEPA document presented DOE's preferred final land use for the Fernald site. The preferred alternative is natural resource restoration for the majority of the site with the exception of 115 acres occupied by the On-Site Disposal Facility and 23 acres for potential commercial development. The public comment period on both the NRRP and the EA ended October 20, 1998.
Site Assessment Approach and Cleanup	The cleanup is being performed under CERCLA Examples of past impacts include releases of contaminants to Paddy's Run and the Great Miami Aquifer. Future impacts are based upon planned remedial actions. An example of a future impact is the removal of trees and habitat associated with the Southern Waste Unit excavation. The information contained in the impact assessment was used in a model (Habitat Equivalency Analysis) to provide an estimate of the required restoration actions. The estimate was then used in conjunction with planned remedial actions to develop the restoration plan.
Reuse	The end use of the site is an educational park focusing on site history and ecology. The NRRP provides conceptual restoration plans for the post remediation landscape at Fernald. It maximizes the benefits of existing natural features such as the Paddy's Run stream corridor and forested wetlands. Additionally, the plan accounts for the post-excavation surface which includes many deep holes and large areas stripped of topsoil. The NRRP focuses on the use of native plants to develop habitats representative of those historically expected in southwestern Ohio. The plan also includes a ground water education component yet to be determined. **Restoration Plan** • expand Paddy's Run corridor • re-forestation and enhancements • open water habitat with connecting wetland systems • native prairie grasslands and savannas • aesthetic barriers • ground water project
Obstacles	

Fernald Case Study	
Costs and Funding	
Economic and Other Incentives	
Time	
Other	Further information http://offo2.epa.state.oh.us/FERNALD/Restoration/restoration.htm
Contact Information	Thomas A. Schneider Office of Federal Facility Oversight Ohio EPA T 937-285-6466 F 937-285-6404 http://offo2,epa.state.oh.us tom.scheider@epa.state.oh.us

Case Study 14

College Park Landfill Compost and Vegetative Cap Pilot Study	
Name and Location	**Site Name:** College Park Landfill **Site Location:** Beltsville, Maryland
Site Description	This site was used as a municipal landfill from approximately 1955 until 1978. It accepted household trash, as well as commercial, industrial and some agricultural/research waste. The site is located just outside the Washington, DC beltway in a suburban area. However, the immediate vicinity of the site is agricultural, with some nearby housing. A wetland of special state concern containing some threatened and endangered species bounds the southern edge of the landfill. The landfill is approximately 30 acres in areal extent, and ranging from 20 to 30 feet deep.
Ecological Enhancement	This project intends to provide 30 acres of diverse plantings which will be highly attractive as habitat, whereas the standard landfill cap would provide 30 acres of mowed grass, providing little habitat.
Site Reuse Description	The ecological enhancements intended for the site are mixed plantings for ecological habitat and educational demonstration. The ecological restoration will consist of trees, shrubs, grasses and groundcovers, both evergreen and deciduous, with an emphasis on native species where possible. Ecological enhancements are being actively pursued for this site because of its proximity to sensitive wetlands; because of habitat creation; because of greenhouse gas reduction; because of cost savings; because of sustainability concerns; because of research opportunities; and to provide educational opportunities. The community will be involved in the end use decision through the CERCLA process, which requires a public hearing and regular outreach activities.
Stakeholder Involvement	The partners in the pilot study are USDA/ARS Beltsville Safety Office, USDA/ARS Beltsville researchers, EPA/OSWER, and private consultants. The stakeholders include USDA/ARS; EPA Region III; Maryland Department of the Environment; and the Prince George's County Health Department. The stakeholders were concerned about whether or not the vegetation would be killed by methane from the landfill, and if the vegetation would be able to adequately prevent leachate generation. The intent of the pilot study is to show that the compost layer will sequester the methane, and the mix of evergreen and deciduous plants plus the storage capacity of the compost will adequately prevent leachate generation. USDA/ARS Safety Office is primarily funding the study, while USDA/ARS researchers are providing expertise and manpower. EPA Region III is providing a summer intern for the project, and EPA/OSWER (as well as EPA ACAP) is providing consultation and advice. All funding to date has been federal.

Site Assessment Approach and Cleanup	The site assessment found a 30-acre landfill, which required closure to RCRA standards, groundwater and surface water impacts, and methane gas emissions. The presumptive remedy for the landfill is a clay and/or membrane cap with gas venting. The site was never capped or closed in accordance with RCRA, so rainwater was able to enter the waste and create leachate, which contaminated groundwater. The groundwater there exhibits vinyl chloride, benzene, arsenic, cadmium, iron, lead, manganese, and nickel at levels above maximum contaminant levels (MCLs). The cleanup will be performed under CERCLA to RCRA standards. The corrective action planned for the site is a 4-foot deep layer of compost/soil over the surface of the cap to utilize methane, and a mixed planting of trees, shrubs, grasses, and groundcovers to utilize precipitation and prevent erosion. Assuming the pilot study shows this system to be as environmentally protective as a standard cap, the remedy will be selected because of environmental benefits, community benefits, and cost effectiveness. It is expected that the site will have to be maintained in its vegetated state, with controls to prevent future development. Once the remedy is implemented, a closure letter will be sought.
Reuse	The end use of the site will be maintained habitat, with possible harvesting of potential resources as part of the maintenance program. The end use of the site will prevent the use of nonrenewable (clay and plastic) resources; use renewable compost and vegetation; recycle waste materials by using fly ash, animal waste and plant waste for the compost; reduce greenhouse gas emissions both by preventing methane emissions and by using atmospheric carbon dioxide; provide habitat; prevent erosion; further the study of sustainable capping technologies; prevent further groundwater degradation; and provide an educational opportunity. This end use will transform this site from an underutilized area of scrub and weeds to a thriving sustainable remedial system.
Obstacles	The main problem thus far has been the reluctance of the regulatory community to embrace vegetative capping, despite demonstrated successes elsewhere.
Costs and Funding	This action is being funded by federal Hazardous Waste Cleanup funds and Beltsville Agricultural Research Center facility funds. Research grants are also being sought. The pilot study is expected to cost approximately $650,000. The entire cap system is expected to cost $3-4M. A standard landfill cap is estimated to cost approximately $10M for the 30-acre landfill. The ecologically enhanced remedy is expected to show a cost savings of over $5M.
Economic and Other Incentives	The major direct economic incentive is the implementation cost savings of the ecologically enhanced remedy over the presumptive remedy. There are other, less quantifiable, economic benefits of improved air quality, reuse of waste products, conservation of resources, and protection of threatened/endangered species. There are numerous public relations incentives to be gained from this effort. Furthering the science of sustainable landfill capping has far-reaching implications to municipalities around the world. The vegetative cap proposed for this landfill is expected to provide a net environmental benefit greater than a standard landfill cap, given the air quality, habitat, groundwater quality, and surface water quality improvements to be gained.
Time	It is estimated the pilot study will have a 3-year duration, with design and implementation requiring an additional 2 years, for an estimated completion date of 2008.

Other	
Contact Information	Lori P. Miller, PE USDA/ARS/BA/FMOD/SOHES 10300 Baltimore Avenue, Bldg. 003, Rm. 117 Beltsville, Maryland 20705 (301) 504-6025

Case Study 15

FORD Rouge Center Case Study	
Name and Location	**Site Name:** Ford Rouge Center **Site Location:** Dearborn, Michigan
Ecological Enhancement	Ecological enhancements are focused on minimizing impact to Rouge River water quality via improved storm water management and restoring wildlife habitat including: vegetated roof, pervious pavement, phytoremediation, vegetated drainage swales, hedgerow wildlife corridors, wetland restoration, sunflower plantings and grassland restoration. Honey bee hives have been added to enhance pollination for the new plantings.
Site Description	The Ford Rouge Center is an automobile-manufacturing complex with adjacent primary steel making operations along the Rouge River (constructed circa 1917) consisting of approximately 1100 acres. Formerly farmland and marsh, the area is now a highly urbanized area zoned Heavy Industrial. A residential area is about ½ mile from the Center.
Site Reuse Description	Sustainable ecological enhancements were utilized to reduce maintenance and to demonstrate Ford commitment to environmental protection and restoration. Students participated in various components of the restoration including research, growing of native plants and planting on site
Stakeholder Involvement	Partners included: McDonough/Braungart, Walbridge Aldinger, WH Canon, Harley Ellis, Cahill & Associates, Don Tilton and Associates, Arcadis Giffels, Michigan DOT, Michigan DEQ, Dearborn Public Schools, Hortect Inc., Conestoga Rovers and Associates, Golder Associates, DecisionQuest, Friends of the Rouge River, ACCESS (Arab community group), Southwest Detroit Environmental Vision, University of Michigan Dearborn, Michigan State University. Local stakeholders (residents near the property) seem to be taking a wait and see attitude about the land management initiatives as their concerns are more operations related. Watershed stakeholders such as the Rouge RAP Advisory Council and Friends of the Rouge are very pleased with the direction for land management. Communications with the local community are maintained via company newsletters, a Dearborn Public Information Repository, and community meetings. State of Michigan provided an enhancement grant for the reconstruction of Miller Road including the storm water swale and the USEPA (5 star program) provided grant funding.
Site Assessment Approach and Cleanup	In April 2000, Ford Motor Company and Rouge Steel Company entered into a Consent Order with the Michigan Department of Environmental Quality for the purpose of performing RCRA Corrective Action at the 1100-acre site. Site assessment efforts to date have identified pervasive impacts to surficial soils due to historic steel making operations (SVOCs and metals) and localized areas of impact associated with historic manufacturing operations (PCBs, metals, and organics). The Site has a 2005 deadline, in accordance with the Government Performance Results Act, to demonstrate mitigation of any off-site migration issues or human exposure pathways. Remediation objectives are taking into account the proposed end use (industrial) while incorporating aspects of habitat improvement such as natural bio-attenuation storm water management techniques and phytoremediation to reduce the soil concentrations of SVOCs remaining in the soil and additionally improving bio-diversity. Corrective action to date has taken the form of phytoremediation in a controlled environment for evaluation purposes as well as removal and disposal of heavily impacted or source material. Future engineering controls may include various containment strategies and water management techniques to address relevant exposure pathways for remaining constituents.

Reuse	The site continues to manufacture automobiles and light trucks as well as engines, frames, and metal stampings. The grounds are also now being used for environmental benefits that include improved storm water management/runoff control to the river, increased wildlife habitat for use in environmental education for the community as well as employees. If the phytoremediation project is successful, it may be expanded throughout the site to provide improvements to soils beyond that required by applicable federal, state, or local regulations. The value added includes more wildlife habitat, improved employee morale, significantly improved aesthetics and a variety of demonstration projects that can be emulated. Additional demonstrations at the Site include the use of photovoltaics, fuel cells, and geo-thermal applications.
Obstacles	This is a highly complex site with a long history. Information on historic operations is limited which increases level of effort needed to identify and define the presence of impacts caused by those operations. Existing information on underground structures, utilities, etc. has also been shown to be incomplete. Safety issues demand significant planning, and sometimes-inefficient procedures, during invasive investigation activities. Another complicating factor was the need to coordinate the investigation and remediation efforts with the ongoing plant expansion and modernization activities. Frequent discoveries of unknown Waste Management Units (as defined in the Consent Order) threatened the construction schedule associated with new plant construction and existing plant upgrades. Recognizing this issue in the early negotiations with the Michigan Department of Environmental Quality, the parties were able to agree on a process that, when necessary, would allow remedial activities to proceed unburdened by a lengthy review and approval process.
Costs and Funding	Except as described above, all costs have been funded by Ford Motor Company.
Economic and Other Incentives	The primary tangible economic incentives, long term, are reduction of maintenance through sustainable landscaping, longer life for the vegetated roof, and potentially reduced regulatory burden costs associated with remediation. Intangible benefits are also anticipated.
Time	The project started in 1999 and is ongoing, expanding pilot projects to other areas of the site. The restoration process is expected to last at least 10 years due to funding and other constraints.
Other	Perceptions that sustainable land management also needs to be aesthetically pleasing has led to less than sustainable practices, such as formal landscaping and the use of non-native plants that may require more maintenance over time. However, several areas will include the strictly native plant components, which provide for side-by-side comparisons of sustainability throughout the development of this project. Union issues have also shaped some of the projects, considering both the cost and capabilities of the work force in dealing with innovative approaches to landscaping.
Contact Information	Dan Ballnik Ford Motor Company 313.248.8606 dballni1@ford.com

Case Study 16

Tibbetts Road Superfund Site Case Study	
Name and Location	**Site Name:** Tibbetts Road Superfund Site **Site Location:** Barrington, New Hampshire
Ecological Enhancement	Wooded phytoremediation area providing increased biodiversity via creation of wildlife habitat for various birds and small mammals.
Site Description	Rural area, formerly farmland, now rural residential. Site soils and groundwater were impacted by chlorinated and non chlorinated solvents via historical waste disposal practices of prior site owner.
Site Reuse Description	Ecological and greenspace enhancements should help facilitate exit strategy by Potentially Responsible Party to bring finality to the project and return the site to the community. Reversion of property ownership to the Swains Lake Water Authority assures that appropriate institutional controls preclude future site development.
Stakeholder Involvement	Field visits with local residents, Town of Barrington, and Swains Lake Water District. Prepared June 29, 2001 WHC Opportunities Report. Regular periodic site meetings are conducted at the site with representatives of ARCADIS, USEPA and the State of New Hampshire.
Site Assessment Approach and Cleanup	Remediation included source removal, building demolition, water supply extension, vacuum enhanced recovery, monitoring, phytoremediation, institutional controls, and monitored natural attenuation. Approximately 90% of the active remediation is now completed and passive phytoremediation component of the remedy is beginning to phase in.
Reuse	Swains Lake Water Authority to acquire the site from the Town of Barrington. New Hampshire DEQ coordinating liability protection issues.
Obstacles	Superfund NPL Site, Consent Decree dated 11/8/1994. An amended EPA Region 1 Record of Decision was needed.
Costs and Funding	Entire remedy approximately $8 million, funded by the Potentially Responsible Party.
Economic and Other Incentives	None.
Time	Work began in 1994 and should be concluding shortly. Some monitoring may continue.
Other	Positive example for regulators and others demonstrating win-win-win team effort public-private partnership among stakeholders (regulators, regulated community, local community interests).
Contact Information	Jerome S. Amber, P.E. Ford Motor Company, retired 248/765-1044 jamber@comcast.net

Case Study 17

Tall Grass Prairie Case Study	
Name and Location	**Site Name:** Tall Grass Prairie, OK **Site Location:** Pawhuska, OK
Ecological Enhancement	Changed brine scared land with no vegetation into a native prairie area over 15,000 hectares. Buffalo population re-stimulation.
Site Description	The Tall Grass Prairie housed a chemicals facility and a petroleum well field. The land is located on Osage Indian Land. Accidental releases of brine have occurred resulting in high saline/sodic conditions and hence, loss of soil fertility. Several brine scars exist throughout the Prairie. Historical photographs of the scars date back to the 1930s. At the chemicals plant site, the groundwater is also impacted by heavy metals.
Site Reuse Description	The Nature Conservancy is revegetating over 15,000 hectares and stimulating buffalo re-population.
Stakeholder Involvement	BP, Nature Conservancy, Bureau of Indian Affairs, Oklahoma Energy Resource Board (OERB).
Site Assessment Approach and Cleanup	In late 1999, Eucalyptus trees were planted to accumulate and stabilize the inorganics. Certain inorganics will be phytosequestered versus others that will be phytoextracted. The "scars" have high salinity and sodic conditions down to 3 feet of depth. In 2000-2002 several test plots were planted with a variety of seed containing Canadian Wild Rye and Indian Grass among others. These plants enhance soil remediation and stabilization.
Reuse	While the growth has been slow, the site had been devoid of vegetation for 70+ years.
Obstacles	July in Oklahoma is a bad time to plant.
Costs and Funding	
Economic and Other Incentives	Public perception of this site will increase substantially. Going from scars to vegetated property is a major change.
Time	This project is on-going.
Other	
Contact Information	Dr. David T. Tsao, (630) 420-4321.

Case Study 18

Texas City Prairie Case Study	
Name and Location	**Site Name:** Texas City Prairie Planting **Site Location:** Texas City, TX
Ecological Enhancement	Brown space converted to vegetated space with Eucalyptus and switchgrass.
Site Description	Texas City Refinery is an operating facility owned by BP. The active landfarm at this site encompasses 170 acres of the property. The contaminants of concern include TPH, PAHs, oil and gasoline down to a depth of 5 feet. Eucalyptus and switchgrass were planted and natural revegetation was stimulated in 1999 and 2002 to enhance soil remediation. The site is fertilized and irrigated with biosludge.
Site Reuse Description	This area will continue to be a landfarm.
Stakeholder Involvement	Stakeholders include BP, Texas Department of Natural Resources, RCRA, ITRC, Wildlife Habitat Council. This project was fully funded by BP.
Site Assessment Approach and Cleanup	The refinery soils are impacted with TPH, PAHs, oil and gasoline down to 5 ft. This site is under the authority of RCRA.
Reuse	The landfarm was a biosludge plot that was turned over mechanically. Now, it has trees and natural revegetation.
Obstacles	
Costs and Funding	
Economic and Other Incentives	
Time	
Other	
Contact Information	Dr. David T. Tsao, (630) 420-4321.

Case Study 19

Whiting Alkaline Fen Case Study	
Name and Location	**Site Name:** Whiting alkaline fen **Site Location:** Whiting, IN
Ecological Enhancement	A brown space was converted to an alkaline fen wetland area.
Site Description	The Whiting Refinery in Whiting, IN is an operating refinery owned by BP. It has been in operation since 1890. The alkaline fen wetland was planted near the J&L outfall. Alkaline fens are rare, making this site quite interesting. 22 facultative and obligate wetland species were planted in 2000 to deal with impacted groundwater and surface water. Contaminants of concern include phenols and alkalinity. The depth of impact is 1-10 feet.
Site Reuse Description	This area is of interest to the local government bodies as a potential recreational reuse.
Stakeholder Involvement	Stakeholders include BP, IN Department of Natural Resources, community of Hammond and local government. This project was funded by BP.
Site Assessment Approach and Cleanup	The soils in this area are impacted by TPH down to a depth of 1-10 feet. 22 facultative and obligate wetland species were planted in 2000 to provide surface and groundwater remediation. Annual plant maintenance and monitoring continues. This project works under the authority of US ACE and EPA.
Reuse	Ultimately, this land may be given back to the community for recreational reuse.
Obstacles	Infiltration by invasive weed species.
Costs and Funding	Project funded by BP. $15,000 for installation, $5,000 per year plant maintenance, $5,000 per year monitoring.
Economic and Other Incentives	
Time	
Other	Difficulties with phragmites invasion.
Contact Information	Dr. David T. Tsao, (630) 420-4321.

Case Study 20

Whiting Case Study	
Name and Location	**Site Name:** Whiting prairie planting **Site Location:** Whiting, IN
Ecological Enhancement	Space with just grass was replaced with native prairie plantings forming several islands. Donated bird houses were installed.
Site Description	The Whiting Refinery in Whiting, IN is an operating refinery owned by BP. It has been in operation since 1890. The area around 1st and 126th Streets was converted to a deep-rooted prairie planting.
Site Reuse Description	This site improves the aesthetic value of the neighborhood while maintaining hydraulic control and soil & groundwater remediation.
Stakeholder Involvement	Stakeholders include BP, IN Department of Natural Resources, community of Whiting and local government. The community is heavily involved in this effort with aesthetic suggestions, donated bird houses, and involvement by local scouting groups. This project was funded by BP with donations from the community (birdhouses).
Site Assessment Approach and Cleanup	The soils in this area are impacted by TPH down to a depth of 3-7 feet over an approximately 2 acre size site. Deep-rooted prairie grasses and flowers, black alder, cottonwood, willow, Norway spruce and Austrian pines were planted between 1999 and 200 to maintain hydraulic control and provide soil & groundwater remediation.
Reuse	This area is an aesthetic prairie planting near a residential area. It benefits the community through its improved visual effect and remediation efforts.
Obstacles	
Costs and Funding	
Economic and Other Incentives	
Time	
Other	
Contact Information	Dr. David T. Tsao, (630) 420-4321.

Case Study 21

Wood River Case Study	
Name and Location	**Site Name:** **CS-21A:** Wood River Refinery PRS **CS-21B:** Wood River Chemicals CDF **CS-21C:** Wood River Terminal **Site Location:** Wood River, Illinois
Ecological Enhancement	Brown spaces were converted to native prairie grass and flower areas. Several trees were planted and the area will be used by the community.
Site Description	Wood River is a former refinery that was operated from 19?? To 19??. Currently, the majority of the site is not being used. A small portion of the site remains an operating terminal. The area is suburban residential. Community members are very active and would like to see a site re-use plan implemented. The refinery PRS site is 52 acres, the chemical CDF site is 27 acres and the terminal site is less than 1 acre.
Site Reuse Description	Deep rooted prairie grasses and flowers have been planted at the refinery site in 2001 for weed control/aesthetics. At the Chemicals CDF site, Willows, Cottonwoods, Black Alder, River Birch , Bald Cypress, Crown Vetch, Bluestem Grasses, Perennial Rye, and Birdsfoot Trefoil were planted in 1998-99 as a vegetative cover to control landfill leachate. At the terminal, deep-rooted prairie grasses and flowers were planted in 2002 for hydraulic control and soil remediation. The ecological enhancements were chosen to facilitate property re-use by the Wood River community. The community is heavily involved in the end use decision making process.
Stakeholder Involvement	Stakeholders include BP, IEPA, Wood River. The community wishes to see a light industrial or recreational re-use at this site. This project was fully funded by BP.
Site Assessment Approach and Cleanup	The refinery soils are impacted with TPH and PAHs down to 10 ft. The chemicals site source of contamination is landfill leachate between 2 and 20 ft below ground surface. The terminal site has impacted soils and groundwater containing BTEX and MtBE up to 3 ft below ground surface.
Reuse	
Obstacles	
Costs and Funding	The project was fully funded by BP.
Economic and Other Incentives	
Time	
Other	
Contact Information	Dr. David T. Tsao, (630) 420-4321.

Case Study 22

Constructing Tidal Wetlands in an Overall Remediation Strategy for a Landfill	
Name and Location	**Site Name:** Operable Unit 3 (Jamaica Island Landfill) **Site Location:** Portsmouth Naval Shipyard, Kittery, Maine
Ecological Enhancement	Removal and consolidation of approximately 2.6 acres of landfill and construction of a tidal wetland comprised of tidal salt marsh and mudflat.
Site Description	The Portsmouth Naval Shipyard (PNS) is a highly industrialized 278-acre island located in the Piscataqua River. The Piscataqua River is a tidal estuary that forms the southern boundary between Maine and New Hampshire. In March 1989 the USEPA issued a Corrective Action Permit under the RCRA Hazardous and Solid Waste Amendments of 1984 (HSWA Permit) (USEPA, 1989) that required PNS to investigate 13 solid waste management units (SWMUs) and take appropriate corrective action. However, effective May 31, 1994, PNS was included on the National Priorities List (NPL). The subsequent studies have been conducted under the authority of CERCLA, commonly known as Superfund. Operable Unit 3 (OU3) consists of Site 8 (Jamaica Island Landfill) and two additional sites (Site 9 – Mercury Burial Sites I and II and Site 11 – Former Waste Oil Tanks 6 and 7) within the boundaries of the Jamaica Island Landfill (JILF). The JILF, which is approximately 25 acres of PNS, was a tidal mudflat that the Navy used as a disposal area from 1945 to 1978 for general refuse, trash, construction rubble, and various industrial wastes. Prior to the initiation of the remedy for OU3, the JILF was covered with topsoil/vegetation, pavement, and gravel and was used for limited recreational activities, vehicle parking, and equipment storage. Sampling of the sites within OU3 was conducted as part of the RCRA Facility Investigation (RFI) for PNS, the RFI Data Gap for PNS, and the 1996/1997 groundwater monitoring for OU3 (under CERCLA) to determine the nature and extent of contamination at the site and the potential risks associated with the contamination. After the revised risk assessment for OU3 was complete (in 2000), the Navy prepared a Feasibility Study (FS) for OU3 in 2000. A Proposed Plan for OU3 was issued January 2001 and the Record of Decision (ROD) for the site was signed in August 2001. Remedial action at OU3 will consist of a cover over the landfill, institutional controls to limit use of and exposure to the area, shoreline erosion controls, and long-term monitoring of the effectiveness of the remedy. The design for Phase I was completed in June 2002. The first phase of the design included movement of the waste in the portion of the landfill near Jamaica Cove to the remaining portion of the landfill to consolidate the waste in a smaller area. After the consolidation, wetlands were constructed in Jamaica Cove. The consolidation activities were completed in September 2002. The wetland planting was completed in June 2003. The second phase of the design, completed in January 2003, includes construction of the cover over the remaining larger portion of the JILF and shoreline erosion controls. Construction activities for the second phase began in the Spring 2003.

	 Portion of the JILF nearest to Jamaica Cove Prior to Start of Phase I  Salt Marsh Establishment After Consolidation and Backfilling
Site Reuse Description	The 2.6 acres portion of the JILF nearest to Jamaica Cove was consolidated onto the remaining 22 acres of the landfill, which allowed for the creation of tidal wetlands (i.e., saltmarsh and mudflat) in this area. The implementation of first phase of the overall JILF remediation was initiated to enhance the estuarine habitat surrounding PNS, while at the same time providing the opportunity to consolidate JILF waste to an overall smaller area, which will be capped as part of second phase of construction.
Stakeholder Involvement	In August 2001, after more than ten years of intensive and comprehensive scientific investigation and evaluation, PNS and USEPA, with concurrence from MEDEP, signed a ROD for the remediation of the JILF. As part of the CERCLA process, the Navy received

	input from the public, including the Restoration Advisory Board (RAB) for PNS on the ROD for the JILF. The consolidation of materials from the portion of the JILF near Jamaica Cove and subsequent creation of the over two acres of tidal wetlands (i.e., salt marsh and mudflat) in the excavated area was viewed as a positive outcome of the overall remediation of the JILF by all stakeholders involved in the project. The creation of the wetlands, as well as the overall remediation of the JILF, has been funded through the Navy's Installation Restoration Program.
Site Assessment Approach and Cleanup	Operable Unit 3 (OU3) is comprised primarily of Site 8 (Jamaica Island Landfill) and two additional sites (Site 9 – Mercury Burial Sites I and II and Site 11 – Former Waste Oil Tanks 6 and 7) within the boundaries of Site 8. The Jamaica Island Landfill (JILF), which comprises approximately 25 acres of PNS, was a tidal mudflat that the Navy used as a disposal area from 1945 to 1978 for general refuse, trash, construction rubble, and various industrial wastes. Sampling of the sites within OU3 was conducted as part of the RCRA Facility Investigation (RFI) for PNS, the RFI Data Gap for PNS, and the 1996/1997 groundwater monitoring for OU3 to determine the nature and extent of contamination at the site and the potential risks associated with the contamination. After the revised risk assessment for OU3 was complete (in 2000), the Navy prepared an FS for OU3 in 2000. A Proposed Plan for OU3 was issued January 2001 and the ROD for the site was signed in August 2001. Soil and groundwater data for Sites 8, 9, and 11 show similar chemical contamination throughout the area of the landfill. A variety of organic and inorganic constituents were detected in soil and groundwater and included volatile organic compounds, semi-volatile organic compounds, polychlorinated biphenyls (PCBs), pesticides, metals, and petroleum hydrocarbons. The identified COCs in soil for Site 8/9 and Site 11 were combined to develop the list of soil COCs for OU3. The following is a list of soil COCs: • Benzo(a)anthracene • Benzo(a)pyrene • Benzo(b)fluoranthene • Dibenzo(a,h)anthracene • Indeno(1,2,3-cd)pyrene • Arsenic • Lead The following is a list of COCs in fresh groundwater for OU3: • Benzene • Antimony • Arsenic • Cadmium • Lead • Nickel • Thallium The following RAOs were provided in the Feasibility Study Report for Operable Unit 3, which addressed exposure to materials within the JILF boundary (OU3) based on risks to potential receptors (human and ecological): 1. Prevent human exposure through ingestion, dust inhalation, and dermal contact to contaminated soils and/or waste within the landfill at unacceptable levels. 2. Prevent human exposure through ingestion of contaminated groundwater at unacceptable levels. 3. Prevent erosion of contaminated soils and/or waste on the edge of the landfill to the Piscataqua River or the Back Channel. 4. Provide for JILF's current and future uses (organized and unorganized sports, equipment storage, and parking) while providing sufficient protection of human

	health and the environment. The selected remedial action for soil and groundwater within the boundary of the JILF at PNS was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The selected remedy for OU3 was a hazardous waste landfill cover, institutional controls, erosion controls, and monitoring. The following components were deemed necessary to address soil and groundwater contamination within the boundary of the JILF: • A multiple layer cover over the landfill surface that would prevent receptors on the surface from coming in contact with contaminated soil and/or waste and minimize infiltration of water through the cover to the landfill material. Portions of the JILF that have buildings and structures will not be covered under the hazardous waste landfill cover. The specific cover components will be determined as part of the cover design, based on pre-design investigation, as necessary. • Institutional controls to restrict land and fresh water groundwater uses within the JILF boundary to prevent unacceptable human exposure to site contaminants. Institutional controls will also be used to prevent unrestricted disturbance of the hazardous waste landfill cover, shoreline erosion controls, and buildings and structures within the boundary of the JILF. • Shoreline erosion controls, including rip-rap and/or wetlands placed along the shoreline, to minimize the potential for washing away of soil and/or waste materials from the edge of the JILF. • Monitoring of site media to assess the effectiveness of the remedy over the long term. The appropriate media for monitoring, frequency, testing protocol, and evaluation criteria will be determined as part of the monitoring program development and will be documented in the monitoring plan. • Routine inspections and maintenance of the cover, shoreline erosion controls, and institutional controls to ensure that the cover, erosion controls, and site controls remain effective. An operation and maintenance plan will be developed. The operation and maintenance plan will include identification of verification activities to determine whether the buildings and structures within the JILF boundary are still in place.
Reuse	The creation of two acres of tidal wetland in the former Jamaica Cove portion of the Jamaica Island Landfill was seen as an innovative way to accomplish the required landfill cleanup, maintain positive community support, and at the same time add to the thriving biodiversity of the area. The wetland creation will provide additional estuarine habitat to that already existing around PNS. Additionally, completing the consolidation to support wetland creation provided the added benefit of removing landfill from a tidally influenced area and providing additional area for construction of shoreline erosion controls.
Obstacles	Some of the following obstacles were experienced during completion of the first phase (i.e., consolidation and creation of wetlands) of the overall JILF remedy: • Designing the phase to minimize any impact to existing mudflat within Jamaica Cove. • Determining and locating the appropriate backfill to maximize the potential for successful establishment of salt marsh.
Costs and Funding	The creation of the wetlands, as well as the overall remediation of the JILF, has been funded through the Navy's Installation Restoration Program. The costs for Phase I and II are as follows: • Phase I (Consolidation and Creation of Tidal Wetlands)– $2,028,120 • Phase II (Erosion Controls and Cap of Remaining Portion of the JILF) – Estimated at $14,257,216

Economic and Other Incentives	The main incentives for this project were as follows: • The consolidation will allow less physical area of the JILF to be covered, monitored and maintained (as part of long-term operations, maintenance, and monitoring for the site). • The project allowed for the enhancement of the estuarine habitat surrounding PNS. • The public and the RAB for PNS supported the inclusion of tidal marsh creation as part of the overall JILF Remedy.
Time	Phase I – Initiated in June 2002 and completed (planting of salt marsh species) in June 2003. Phase II (Installation of Landfill Cap and Erosion Controls) – Initiated in April 2003 and scheduled to be completed Fall of 2005.
Other	Initial design and subsequent modifications to planting scheme for establishment of the tidal wetlands was aided with careful monitoring of tidal cycle after regrading occurred.
Contact Information	Mr. Fred Evans, Remedial Project Manager, Portsmouth Naval Shipyard Phone - (610) 595-0567 x-159 Fax (610) 595-0555 evansfj@efane.navfac.navy.mil

Case Study 23

Dahlgren Case Study	
Name and Location	**Site Name:** Site 46 Landfill A, Stump Dump Road **Site Location:** Dahlgren, Virginia
Ecological Enhancement	Integrated and established tidal wetlands as part of the remedial design and action in addition to contaminant removal.
Site Description	This is a 5 acre landfill that was operated from the 1940's until the 1960's that is located adjacent to Gambo Creek – a tributary to the Potomac River and ultimately Chesapeake Bay. The waste disposed of here was primarily municipal waste including scrap metal, wire, metal shavings, roofing tar, railroad ties, and empty 55 gallon drums. The site was covered with soil and successional vegetation after closure. Since closure, the site was largely unused until the cleanup investigations in the late 1990s. This project is located in a largely rural setting with mostly forests and open fields around it. The site is adjacent to Gambo Creek and therefore has tidal wetlands on one side.
Site Reuse Description	The Feasibility Study determined that based upon the contaminants present at the site and its proximity to Gambo Creek, a removal action would be conducted. As part of the restoration after the removal action, wetlands would be established in the low areas of the site. This is a wetlands restoration project. The facility has a wetlands accounting program for different types of wetland habitat on the base. Integrating wetlands into this project would enable the base to establish wetland credits for this Site as part of the larger basewide accounting. The community is able to provide comments and input to the decision process through involvement on a remedial action board (RAB).
Stakeholder Involvement	In addition to the Navy, the partners include the EPA, United States Fish and Wildlife, National Oceanic Atmospheric Administration, and the Commonwealth of Virginia. This group worked as part of a partnering team where decisions are reached through consensus. Concerns included the acreage of wetlands that would be restored, the amount of open water created, types of species to plant, and the types of wetlands that would ultimately be established. These concerns were resolved through discussions and group decisions as part of the partnering team. The project was Navy funded.
Site Assessment Approach and Cleanup	This followed the standard Installation Restoration process with the end results being a remedial action. End use was considered from both an ecological and human health risk standpoint. The sources of contamination were the waste. The contaminants of concern included the following: Cadmium, Copper, Lead, Mercury, Nickel, Zinc, DDT, total PAHs, and total PCBs. The cleanup was performed under CERCLA. The corrective action taken was removal of the contaminated waste from the site to an appropriate off-site landfill. This remedy was selected due largely to the landfills location relative to the adjacent creek. Concerns included potential contaminant transport via

	groundwater or surface water transport into the creek and ultimately the Potomac River. The initial sampling effort indicated that this was already beginning to take place. The primary barrier encountered in the remedy selection was the potential loss of existing tidal wetlands and upland habitat as part of the removal. The site was a clean closure. A wetland restoration work plan is being prepared and implemented. The wetlands will be monitored to ensure successful restoration. Final wetland plantings are currently being installed (June 03). Once complete, a Final Remedial Action Completion Report will be prepared and submitted for approval to EPA and VDEQ.
Reuse	The site has now been restored back to its pre-filled condition and cleaned up to reduce future risk to human health and the environment. There are no restrictions on the site. Approximately 1 acre of tidal emergent and scrub-shrub wetlands has been added to the site.
Obstacles	Uncovering unexploded ordnance (UXO) was a safety issue at the site and required EOD support and screening at all times. A bald eagle nest was located near the site and prevented construction between December through July, as long as eagles were still using the nest. This necessitated an additional mobe and demobe.
Costs and Funding	ER,N funded. The total cost of the project was $1,700,000.
Economic and Other Incentives	Wetland mitigation commitments from other sites (i.e. capping a wetland in exchange for enlarging an existing wetland) Creating wetlands is good public relations.
Time	1 ½ years accounting for mobe and demobing for the eagle's nest.
Other	
Contact Information	Neal Parker, Engineering Field Activity Chesapeake Phone: 202-685-3281 Email: ParkerNM@efaches.navfac.navy.mil

Case Study 24

Joliet Army Ammunition Plant	
Name and Location	**Site Name:** Joliet Army Ammunition Plant (JOAAP) **Site Location:** Joliet Illinois
Ecological Enhancement	Establishment of the Midewin National Tall Grass Prairie (MNTP)
Site Description	The JOAAP is a former U.S. Army munitions production facility located on approximately 36 square miles (23,542) acres of land in Will County, Illinois. JOAAP was constructed during World War II for the purposes of manufacturing, loading, assembling, packing, and shipping bombs, projectiles, fuses, and supplementary charges. JOAAP is divided into two main functional areas; the Load-Assemble-Pack (LAP) area and the Manufacturing Area (MFG). The LAP area is where munitions were loaded, assembled, and packaged for shipping. This area of JOAAP contains munitions filling and assembly lines, storage areas, and a demilitarization area. The MFG area is where the chemical constituents of munitions, propellants and explosives, were manufactured. The production facilities are located in the northern portion of the MFG. The southern portion of the MFG there is an extensive explosives storage facility. The MNTP will be located, primarily, on areas that were once part of the LAP facility.
Site Reuse Description	Approximately 19,100 acres of JOAAP was transferred to the U.S. Department of Agriculture (USDA) for establishing the MNTP. This transfer was mandated by Congress in the Illinois Land Conservation Act or 1995, P.L. 104-106. The Illinois Land Conservation act established MNTP to be managed for National Forest System purposes. Specifically, the purposes of MNTP include the following: 1) To manage the land and water resources of Midewin in a manner that will conserve and enhance the native populations and habitats of fish, wildlife and plants. 2) To provide opportunities for scientific, environmental, and land use education and research. 3) To allow the continuation of agricultural uses of lands within Midewin consistent with section 2916 (b). 4) To provide a variety of recreation opportunities that are not inconsistent with the preceding purposes.
Stakeholder Involvement	Stakeholders at the site are the US Army, US EPA, Illinois EPA, the Illinois Department of Natural Resources, the US Fish and Wildlife Service, the US Department of Agriculture, the US Forest Service and the public. In accordance with CERCLA, the Army began a series of field evaluation studies of JOAAP to assess the risk to human health and the environment from the past release of hazardous substances. The Army, EPA and IEPA signed a Record of Decision (ROD) in 1998, which called for the removal and treatment of soils contaminated, primarily, with explosives constituents and metals. At the time the ROD was signed, there was disagreement as to whether the Remediation Goals (RGs) specified in the ROD were protective of ecological resources of the MNTP. As a result, the RGs were designated "Interim" for the acreage that would be transferred to the USDA. Since 1998, a management group, comprised of representatives of the Army, EPA, IEPA, USDA, USFS, USFWS, and IDNR, has been working to establish RGs that are protective of the MNTP and consider the Army's fiscal responsibilities.

Site Assessment Approach and Cleanup	The contamination at JOAAP consists primarily of explosives constituents including trinitrotoluene, dinitrotoluene, trinitrobenzene, RDX and HMX and metals including lead, arsenic, cadmium, zinc, and chromium. JOAAP is an NPL site. The cleanup is, therefore, being performed under CERCLA. Remedial actions for the site include excavation of contaminated soil followed by onsite bioremediation of explosives contaminated soils and excavation and offsite disposal of soil contaminated with metals. There are not expected to be any long-term institutional controls required for the site. The interim ROD is expected to become final in FY04. Once remedial activities are complete, the site will be proposed for delisting from the NPL.
Reuse	The end use of the site will be the MNTP. The prairie is expected to provide recreational, educational, and agricultural benefits to the public and to enhance and preserve native populations and habitats of fish, wildlife and plants.
Obstacles	The primary obstacle associated with this project was a disagreement between stakeholders over appropriate cleanup goals. Debate continued for years over balancing uncertainty management and fiscal responsibility.
Costs and Funding	This project is being funded by the Defense Environmental Restoration Account. The final costs for this project are still being determined but costs are expected to be approximately $15,000,000 from investigation through remediation. There were no ecological enhancements used in the remediation.
Economic and Other Incentives	The primary incentive for this project was the Illinois Land Conservation of 1995, P.L. 104-106, Div. B, Title 2901-2932.
Time	Work has been ongoing at JOAAP since 1986. Remediation of contaminated soils is expected to last until 2010.
Other	Uncertainty about the risk posed by chemical constituents to wildlife, plants and habitat was the most difficult problem to overcome when making cleanup decisions. Uncertainty about risk tends to result in very low cleanup goals which can significantly increase the cost of remediation. Responsible parties will likely be hesitant to spend a significant amount of money to pursue stringent cleanup goals if an option is available to clean a site up to a level that would be protective of a less stringent use (i.e. an industrial use).
Contact Information	Laurie Haines US Army Environmental Center

Case Study 25

Milan Army Ammunition Plant	
Name and Location	**Site Name:** Milan Army Ammunition Plant (MAAP) **Site Location:** Milan, Tennessee
Ecological Enhancement	Phytoremediation of explosives contaminated groundwater.
Site Description	MAAP is an active U.S. Army munitions production facility located on 22,436 acres of land in Milan, Tennessee. MAAP was constructed during World War II for the purposes of loading, assembling, packing, and shipping bombs, and other conventional munitions. MAAP also maintains and renovates munitions items and, when necessary, conducts demilitarization activities. There are nine Load-Assemble-Pack (LAP) lines, a test area, storage areas, demolition and burning grounds area and various administrative, housing and recreational areas. LAP area is where munitions were loaded, assembled, and packaged for shipping.
Site Reuse Description	MAAP will remain an active Army munitions loading facility into the foreseeable future. MAAP was used as a demonstration site for an Army innovative remediation project to test the utility of phytoremediation to treat groundwater contaminated with explosives constituents including TNT, RDX, HMX, 24DNT and 26DNT.
Stakeholder Involvement	Stakeholders at the site are the US Army, US EPA, the Tennessee Department of Environmental Quality, and the public. The demonstration project was conducted by the US Army Environmental Center with the cooperation of the installation, the Tennessee Valley Authority and the US Army Waterways Experiment Station. Because this was a demonstration project there was little concern on the part of the regulatory community except to ensure the health and safety of those involved and to ensure that site conditions were not harmed as a result of the experiment.
Site Assessment Approach and Cleanup	The contamination at MAAP consists primarily of explosives constituents including trinitrotoluene, dinitrotoluene, trinitrobenzene, RDX and HMX and metals including lead, arsenic, cadmium, zinc, and chromium. MAAP is an NPL site. The cleanup is, therefore, being performed under CERCLA. The MAAP demonstration consisted of two wetland system designs – a subsurface flow gravel-bed wetland and a surface flow lagoon wetland. Overall, the gravel-bed wetland performance proved superior in degrading all explosives and their byproducts compared to limited degradation by the lagoon system. Demonstration goals were to reduce TNT to concentrations less than 2 ppb and other total nitrobodies, including RDX, HMX, and the DNTs to less than 50 ppb. Influent concentrations averaged 4,000 ppb each for TNT and RDX, with total nitrobodies averaging 9,000 ppb. The gravel-bed system met these goals, except for low-level explosives concentrations releases during the cold winter months. The lagoon system only reduced TNT to 2 ppb during the initial demonstration stages, with no RDX degradation.
Reuse	MAAP is expected to remain an active Army munitions LAP facilities into the foreseeable future.
Obstacles	The primary obstacle associated with this project was the weather. Weather proved to be a main factor in degradation efficiency for phytoremediation. Explosives compounds tended to degrade more during warmer temperatures.

Costs and Funding	Congress and the taxpayers, through the Defense Environmental Restoration Account, are funding this project. More than 6.5 million gallons of explosives-contaminated groundwater were remediated at MAAP during the demonstration. The treatment cost for constructed wetlands is approximately $1.80 per 1000 gallons compared to almost $4.00 per 1000 gallons for granular activated carbon systems.
Economic and Other Incentives	The cost of constructed wetlands phytoremediation technology appears to be less than half the cost of more traditional treatment technologies.
Time	Work has been ongoing at MAAP since the early 1980s. The treatment times/retention times in the first and second cells of the gravel-bed system were 7.5 and 1.6 days, respectively, for a total of 9.1 days.
Other	
Contact Information	Laurie Haines US Army Environmental Center

APPENDIX E

Contacts, ITRC Fact Sheet, and Product List

Contacts

Steve Hill
ITRC Program Advisor
RegTech, Inc.
HC-87, Box 371
Pine, ID 83647
P 208-653-2512 / F 208-653-2511
srhill1@mindspring.com

Bob Johnson
Executive Vice President
Wildlife Habitat Council
8737 Colesville Rd., Suite 800
Silver Spring, MD 20910
P 301-588-8994 / F 301-588-4629
whc@wildlifehc.org

Charles Johnson
ITRC Team Lead
Dept. of Public Health and Environment
4300 Cherry Creek Dr. South
Denver, CO 80246-1530
P 303-692-3348 / F 303-759-5355
charles.johnson@state.co.us

Bob Mueller
ITRC Team Lead
Dept. of Environmental Protection
401 East State St., Box 409
Trenton, NJ 08625-0409
P 609-984-3910 / F 609-292-7340
bob.mueller@dep.state.nj.us