Sustainable Remediation Forum (SuRF)
May 10, 2007
Washington, DC

This meeting marked the third time that various stakeholders in remediation—industry, government agencies, environmental groups, consultants, and academia—came together to develop the ability to use sustainability concepts in remedial decision-making. Those individuals that participated in the meeting are listed below (teleconference attendees are noted by asterisks and appear at the end of the listing). Participant contact information is provided in Attachment 1.

Dave Ellis (meeting host), DuPont
Mike Rominger (meeting facilitator), DuPont
Kathy Adams (meeting recorder), Writing Unlimited

Catherine Allen, U.S. Environmental Protection Agency (USEPA)
Dick Brownell, Malcolm Pirnie
Brandt Butler, URS Corporation
Ed Chu, USEPA
Chris Collet, ERM
Tom Ei, DuPont
Stephanie Fiorenza, British Petroleum (BP)
Kristeen Gaffney, USEPA
Frank Gavas, Delaware Department of Natural Resources and Environmental Control (DNREC)
Deborah Goldblum, USEPA
Mike Houlihan, GeoSyntec Consultants
Beth Hyde, Roux Associates
David Major, GeoSyntec Consultants
Ralph Nichols, Savannah River National Laboratory (SRNL)
Carlos Pachon, USEPA
Erik Petrovskis, GeoSyntec Consultants
Dick Raymond, Terra Systems
Tom Rinehart, USEPA
Steve Rock, USEPA
Philippa Scott, Shell Global Solutions
Curt Stanley, Shell Global Solutions
Dan Watts, New Jersey Institute of Technology (NJIT)

Janice Barber*, Dow Chemical Company
Frank Evans*, National Grid Property, Ltd.
Jane Forshaw*, Contaminated Land: Applications in Real Environments (CL:AIRE)
Paul Hadley*, California EPA
Stella Karnis*, Canadian National Rail
Janine MacGregor*, New Jersey Department of Environmental Protection
Tim Metcalf*, Honeywell
Izzy Zanikos*, DuPont

Meeting Opening

The meeting began with Mike Rominger (DuPont meeting facilitator) welcoming all participants, reading an anti-trust statement, and discussing meeting logistics. Prior to the meeting, export control compliance was verified. Introductions were made, with each meeting participant giving their name. The agenda, notes from prior meetings (November 13, 2006 and February 8, 2007), and one-page description of SuRF were available in hard copy for those participants attending the meeting in person. All of these items were distributed to SuRF members via e-mail previously and/or prior to the meeting.

The draft mission statement from the February 2007 meeting was read. Participants were reminded that this mission statement was a starting point and, if time allowed, would be revisited at the end of the meeting.

Presentations

As noted on the agenda, the meeting was designed to answer the following question: "How might we better understand how organizations are evaluating sustainability in their remediation projects?" The following presentations were made to address this question:

- USEPA Land Cleanup and Waste Programs (Ed Chu, USEPA Headquarters)
- International Presentations (Jane Forshaw, CL:AIRE and Philippa Scott, Shell Global Solutions)
- Denver Federal Center Case Study (Eric Petrovskis, GeoSyntec Consultants)
- DuPont Chambers Works Case Study (Brandt Butler, URS Diamond)
- BP Service Station Case Study (Stephanie Fiorenza, BP and Dick Raymond, Terra Systems)
- Savannah River Site Case Study (Ralph Nichols, SRNL)
- Research in Remediation Sustainability (Dan Watts, NJIT)
- USEPA Region III Pilot Project (Deb Goldblum, USEPA Region III and Dave Ellis, DuPont)

Each presentation is summarized briefly in the subsections below.

USEPA Land Cleanup and Waste Programs

Ed Chu (Director, Land Revitalization) brought an economist's perspective to the table, noting three items to consider when developing sustainable cleanup practices that promote clean energy and reduce greenhouse gases: (1) energy generation, (2) renewable energy sources, and (3) offsets. Ed noted that as long as fuel is inexpensive, there is little incentive to consider less fuel-intensive remediation options. He also noted an example of a site in Utah where a developer's plans for a site added sufficient environmental improvements to allow the developer an exemption from future liability actions.

International Presentations

Jane Forshaw (Chief Executive, CL:AIRE) and Philippa Scott (Senior Consultant, Shell Global Solutions) shared their international experiences in evaluating sustainability in remediation. Complete international presentations are provided in Attachments 2 and 3, respectively. A brief summary of each presentation and the discussions that followed are below.

- CL:AIRE
  The U.K. government set ambitious targets of reducing carbon dioxide (CO_2) emissions by 60% by 2050 and launched initiatives to support these targets. CL:AIRE was asked to bring together stakeholders in the remediation industry to develop the concepts of sustainable remediation decision making. CL:AIRE has performed four large-scale demonstrations of remediation technologies. Based on the experiences gained during these demonstrations, key issues emerged. Some of these key issues have been the topic of SuRF meetings in the past (e.g., metrics, economic incentives). It was mentioned that the emerging issues associated with sustainability in remediation based on U.S. and U.K. experiences were not so different and that future open communication would help identify potential links and collaboration opportunities. A question was asked as to whether it is necessary to evaluate the need to build infrastructure when there is no supportive community or potential environmental impacts perceived. Jane responded that CL:AIRE tends to focus on urban areas where the infrastructure to support remediation activity already exists.

- Shell Global Solutions
  Shell approaches sustainability by building on what already exists—otherwise known as a "benefits approach." This approach and the thought process associated with it come from traditional economic thinking and attempts to answer the question, "what are the benefits to society?" Shell is currently working on example sites, one of which is a contaminated soil project in Africa. Developing and implementing the project has revealed the challenge of developing a framework for sustainability that is applicable for both first- and third-world use. Discussions focused on the economic elements of this approach in relation to Ed Chu's earlier presentation and the idea of expanding the cost-benefit methodology to determine which parameters (e.g., CO_2 emissions) are significant as reductions are quantified. The idea of looking at options associated with offsets to society was also discussed (e.g., the importance of contaminated groundwater in an area of Africa with people suffering from AIDS).

Case Studies

Case studies were presented for three sites: Denver Federal Center, DuPont Chambers Works, and a BP service station. The Denver Federal Center case study focused on the development of an integrated environmental management system, whereas the other two case studies tested the DuPont sustainability assessment tool that was discussed in prior SuRF meetings. (The tools are Microsoft Excel spreadsheets that are used to estimate and break down sustainability impacts of implementing specific remedies at a specific site.) The sustainability case studies are summarized below.

- Denver Federal Center
  Erik Petrovskis (Associate, GeoSyntec Consultants) presented a case study of the Denver Federal Center environmental management system. The Denver Federal

Center is the largest federal campus outside of Washington, DC. At this site, an environmental management system was established to meet sustainability goals set by Executive Orders. The Executive Orders outlined the required actions needed to achieve sustainability (e.g., energy reductions of 3% per year, reduction of fuel usage by agency fleets, 2% annual reduction of water). The solution integrated all aspects of an energy and water conservation program with an environmental remediation program. Specifically, the team increased the use of renewable energy for remediation systems, reduced storm water releases that were occurring because of old breaking pipes, reduced hazardous chemical use and the transfer of chemicals to other media, and re-developed portions of the site as a medical facility and a light rail station. Additional details about these activities, complete with metrics, are provided in Attachment 4. Discussion after the presentation focused on the enormous benefits and advantage of upper management establishing a vision that, in turn, allowed the integration of various aspects into the environmental management system.

- ❑ DuPont Chambers Works
  Brandt Butler (Principal Engineer, URS Diamond) presented a sustainability assessment of a 140-acre solid waste management unit (SWMU) at a site in New Jersey. The SWMU was previously used for liquid and solid waste management, and numerous environmental investigations have been performed in the area. Human health and the environment are protected; therefore, the corrective measures study for this SWMU focused on source treatment. All areas within the SWMU were evaluated for excavation, stabilization in place, and bioremediation. Using the sustainability assessment tool, different energy requirements for each remedy were considered and combined. Global, regional, and local issues were considered when measuring sustainability and reduction. The sustainability assessment spreadsheets were discussed for this SWMU. The presentation for this case study is provided in Attachment 5.

- ❑ BP Service Station
  Stephanie Fiorenza (Regional Technology Coordinator, U.S. South and Latin America, BP) and Dick Raymond (President, Terra Systems) used the sustainability assessment tool to evaluate soil vapor extraction and pump and treat at an urban service station. The presenters emphasized that although the sustainability assessment tool is a good start, it should not be used in a “cookbook” fashion. The data input into the spreadsheet is highly site-specific and should be reevaluated during each assessment. Both presenters found the spreadsheet somewhat difficult to work with as first-time users, but agreed that the next assessment would probably be easier because they had gone through the process once. Stephanie mentioned that she will apply the assessment tool to other sites to compare the results. The presentation for this case study is provided in Attachment 6.

- ❑ Savannah River Site
  By request, Ralph Nichols (Fellow Engineer, SRNL) presented a case study of a sustainable remedial alternative that was implemented at the Department of Energy Savannah River site in South Carolina. An existing pump-and-treat shallow tray air stripper was operating 90% of the time to treat trichloroethylene (TCE) in groundwater. By leveraging the site conditions with existing natural processes, a

GeoSiphon groundwater treatment system was implemented. The system siphoned the contaminated water into an 8-foot diameter well and used zero valent iron in the well to treat the TCE. The site proved that a simple design, natural analogs, and naturally occurring processes can help integrate sustainable concepts into remediation. The presentation for this case study is provided in Attachment 7.

Research in Remediation Sustainability

Dan Watts (Executive Director - Otto H. York Center for Environmental Engineering and Science, NJIT) researched how sustainability concepts could be integrated into an existing regulatory framework. New Jersey and the UN Millennium Project were used as examples because both have sustainability indicators. The research indicated that the sustainability goals and indicators of both New Jersey and the UN Millennium Project did not differ significantly from each other. Although both examples were discussed, the research for New Jersey is summarized below. Additional details (including lists of the goals, indicators, and factors) of the New Jersey research and the UN Millennium Project are provided in Attachment 8.

New Jersey has established 11 goals and 41 indicators to track the state's progress toward sustainable development. Some of the goals are as follows: economic vitality, healthy people, efficient transportation and land use, natural and ecological integrity, protected natural resources, and minimal pollution and waste. This research focused on determining which sustainability indicators applied to remediation activities and narrowed the long list of indicators. Then, factors were identified to allow sustainable options to be measured and compared. Discussion after the presentation focused on determining how much weight to apply to each factor when comparing the sustainability of technologies (i.e., should all have equal weight or should some be "counted" more than once?). Policy challenges related to weighting issues were also discussed. Similar to the weighting issue, questions about how to consider the time differences associated with different technologies were discussed (i.e., some technologies are quick, but energy intensive).

USEPA Region III Pilot Project

Deb Goldblum (Project Manager, USEPA Region III) and Dave Ellis (Principal Consultant, DuPont) presented information about a pilot project that is testing how to use sustainability as one of the balancing criteria in the Resource Conservation and Recovery Act (RCRA) Corrective Action framework. The pilot is being conducted to evaluate potential remedial measures at a RCRA site in Martinsville, Virginia, with the goal of selecting a measure that maximizes the use of renewable resources. Potential remedial measures for soil and groundwater have been identified and are currently being evaluated using the sustainability assessment tool. As a starting point, the team is trying to apply debits (e.g., emits carbon dioxide) and credits (e.g., reduces carbon dioxide emissions) to the technologies based on their operation. Although simplistic, the debits and credits could be tallied and allow a basis for the team to retain or eliminate specific technologies. The work is ongoing. Work thus far has been iterative, involving project team discussions and peer review, which result in more robust sustainability assessments. In addition, the assessment tool has proven to be fragile at times and only accurate to one to two significant figures. Both presentations about this pilot project are provided in Attachment 9.

Discussion after the presentation focused on the perception that industry would use sustainability as a method to justify monitored natural attenuation. All agreed that before sustainability concepts are considered, human health and the environment must be protected. Weighting issues were discussed again, with the idea that the most sustainable outcome for a site is unrestricted land use.

Feedback

Before the Savannah River National Laboratory presentation, participants were asked to write their answers to two questions. Answers were collected and are listed below after the question.

- What is the most important task for SURF to address?
  - Foster discussion on sustainability of remedial options among regulators, site owners, etc.
  - Institutionalize sustainability as a balancing factor in remediation and <u>then</u> for all environmental projects, then all projects.
  - Develop sustainability criteria/metric/baseline database.
  - Determine how to use sustainability in remedy selection.
  - Determine factors to be considered in sustainable remediation with perspective of "do no harm" (CO_2 is only one factor).
  - Develop methodology for assessing sustainability (peer reviewed, quantifiable, simple, open source, repeatable, published).
  - Obtain nongovernmental organization (NGO) and stakeholder inputs and participation.
  - Conduct outreach to other groups (especially regulators) on sustainability methods, evaluations, and outcomes.
  - Identify the boundaries in the decision-making process (e.g., risk reduction/management/elimination) and common terms/criteria.
  - Identify key factors that create negative impact on people, planet, and profit (related to contaminated soil and groundwater).
  - Identify boundaries.
  - Develop a broad and consistent framework for evaluating sustainability.
  - Outline agreed upon sustainability goals, including social issues.
  - Develop and agree on common meaning for "sustainable remediation."
  - Reach out to nonprofit environmental organizations <u>now</u> to provide independent review of remedial technologies for sustainability (build trust with the public).
- What is the best use of our next face-to-face meeting?
  - Establish a scope, measures, and how they are valued.
  - Have a challenge session with NGOs and other stakeholders.

- Develop sustainability criteria/metric/baseline database.
- Develop a conceptual model.
- Define criteria/method for comparing and ranking alternatives and quantitatively selecting an outcome.
- Use moderated decision analysis for establishing how key factors are considered.
- Determine under what circumstances to apply the tool (e.g., qualitative factors?).
- Present pilot metrics on more case studies.
- Identify roadblocks to implementation (i.e., regulatory, financial, institutional).
- Present pilot studies of how sustainability fits into other decision factors.
- Identify what features need to be in a decision tool.
- Develop a plan for outreach activities and determine next steps.

Path Forward

The following path forward items were identified at the meeting:

1. Meeting participants agreed that a Meeting Design Team would plan the next meeting. Based on feedback at the meeting, volunteers for the design team are as follows: Dave Ellis (DuPont), Frank Gavas (DNREC), Mike Houlihan (GeoSyntec Consultants), Ralph Nichols (SRNL), Dick Brownell (Malcolm Pirnie), and Mike Rominger (DuPont). Additional members are welcome. The feedback results presented above may prove helpful in designing the focus of the next meeting.
2. Meeting participants were polled about the appropriate length of the next meeting. Based on discussions, there is energy for at least a 1½-day meeting.
3. The next meeting will be held at the NJIT in mid-August 2007. A draft agenda will be developed by the Meeting Design Team and will be circulated via e-mail. Active feedback and suggestions are encouraged.

Attachment 1
May 10, 2007
Participant Contact Information

Attachment 1
February 8, 2007 Meeting
Participant Contact Information

Name	Organization
Dave Ellis	DuPont
Mike Rominger	DuPont
Kathy Adams	Writing Unlimited
Bryan Ashby	Delaware Dept. of Natural Resources and Environmental Control
Brandt Butler	URS Corporation
Stephanie Fiorenza	British Petroleum
Rich Galloway	Honeywell
Frank Gavas	Delaware Dept. of Natural Resources and Environmental Control
Deborah Goldblum	U.S. Environmental Protection Agency
Bob Greaves	U.S. Environmental Protection Agency
Mike Houlihan	GeoSyntec Consultants
Stella Karnis	Canadian National Rail
Dick Raymond	Terra Systems
David Reinke	Shell Global Systems
Sheryl Telford	DuPont
Dan Watts	New Jersey Institute of Technology
Izzy Zanikos	DuPont
Peter Zeeb	GeoSyntec Consultants
Janice Barber	Dow Chemical Company
Bob Boughton	California Environmental Protection Agency
Frank Evans	National Grid Property, Ltd.
Jon Greaves	UK Environment Agency
Paul Hadley	California Environmental Protection Agency
Mark Harkness	General Electric
Nicola Harries	CL:AIRE
Jo Jolly	ESI Limited
Mike Kavanaugh	Malcolm Pirnie
Janine MacGregor	New Jersey Dept. of Environmental Protection
Dave Major	GeoSyntec Consultants
Gary Wealthall	British Geological Survey

Attachment 2
CL:AIRE Presentation

INAUGRAL SUSTAINABLE REMEDIATION MEETING UK 18TH JUNE 2007

Jane Forshaw – Chief Executive
CL:AIRE
10th May 2007

HELLO

Background

The English Government through its Departments – Department of Communities and Local Government (CLG) and Department for Environment, Food and Rural Affairs (DEFRA) and English Partnerships (EP) who are the National Regeneration Agency for England have asked CL:AIRE to take forward this initiative to bring together stakeholders in the remediation industry to develop the concepts of sustainable remediation decision making.

Background cont.

The UK government has set ambitious targets of reducing CO_2 emissions by 60% by 2050 and therefore have launched a number of initiatives to support these targets.

EP help the government to delivery on a wide number of policies which include policies on high quality sustainable urban regeneration.

Through policy initiatives they are currently looking at:

Sustainable approaches to living through developments.

Background cont.

They are looking at developing innovation in design and construction of the built environment and have recently launched the “Carbon Challenge”. Here they are challenging the house builders to build zero carbon/near zero carbon houses.

This will act as a testing ground for the Government’s Code for Sustainable Homes and the new Planning Policy Statement on climate change and they see sustainable remediation of sites as a starting point.

Participant Organisations

- Government
- Regulator
- Industry
- Environmental Consultants
- Technology Vendors
- Contractors
- Other European Organisations
- NGO

Discussion Points

What is sustainability in remediation? – need to be speaking the same language.

What are views on sustainability aspects of soil and groundwater management? Is it a valid concept?

Has anyone done any work yet in this area? (what? and what are the learning points?)

What are seen as the key issues/obstacles?

To understand the scale of this, is this about CO_2 accounting for site work and remediation or a cradle to grave approach Life Cycle Analysis for site management involving a holistic "life cycle" approach?

CL:AIRE

Discussion Points cont.

What are we trying to achieve and why, now and into the future?

How could the outputs be used?

Who will benefit from this (society, business, environment, intergenerational issue)?

How to incorporate regulator and public perspective and gain acceptance?

Economic Incentives?

Metrics? – What to measure, how to obtain measurements that can be standardised.

CL:AIRE

Workshop

- Series of presentations
- Break into Groups to discuss several key points per group.
- Decide a way forward
- Get defined outputs
- Ultimately a National Standard/Code of Practice
- Decision Support Tool
- Funding

CL:AIRE

QUESTIONS

CL:AIRE

Attachment 3
Shell Global Solutions Presentation

CONFIDENTIAL

Shell Global Solutions

SURF Presentation Washington DC
Shell Approach

10 May 2007

CONFIDENTIAL

Preliminary thoughts

- Need to tie in with sustainability principles
  - People, Planet, Profit
- Build on existing tools RBCA, BATNEEC, ALARP
- Pursuing the “Benefits Approach” (to society)
  - EU acceptance growing
  - Environment Agency Methodology expanded if necessary
- Currently working on example sites
  - Soil
  - Groundwater

Shell Global Solutions

Way Forward

- Open to all possibilities because currently end point unclear
- Collaboration essential
- Need a framework that is:
  - fit for global use (first and third world issues)
  - flexible, relevant and of benefit
- Rapid return on R & D investment

Shell Global Solutions

Attachment 4
Denver Federal Center Case Study

The Denver Federal Center EMS - Framework for a Sustainable Campus

Erik Petrovskis
Geosyntec Consultants
May 10, 2007

Vision for DFC

The DFC is becoming **sustainable**, integrating…
- Environmental protection
- Business performance
- Community involvement

…within the framework of an Environmental Management System (**EMS**)

Sustainability Drivers – Executive Orders

EO 13148 – Greening the Government Through Leadership in Environmental Management

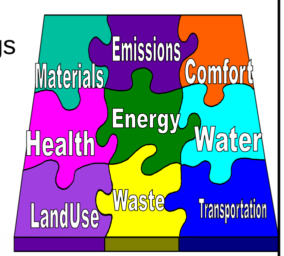
EO 13423 – Strengthening Federal Environmental, Energy, and Transportation Management

DFC Sustainability – The Goal

- Beyond Green Buildings

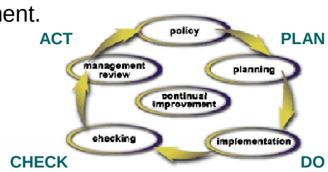
LEED

- Integrated approach
  - Energy and water conservation program
  - Environmental program
    - Remediation



EMS – The Framework to Sustainability

- An organized and logical approach on how to identify, document, understand, and manage day-to-day business operations that may impact the environment.
- EMS: a continual improvement cycle



U. S. General Services Administration

Site Remediation Team

- **Objectives**
  - Remediate surface and subsurface at DFC
  - Comply with CDPHE Consent Order
  - Integrated with other Action Teams
    - Energy
    - Stormwater
    - Waste
    - “Greening” buildings
    - Site acquisition/development

Geosyntec consultants

Denver Ordnance Plant (1945)

Western View along Alameda

30 & 50 Caliber Munitions (1940-45)

Geosyntec consultants

Site Activities

Created: August 2002
Partial Update: February 2007

DOP ERA (1940-1945)

- Munitions manufacturing

Post WWII (1945-present)

- Dumping/landfills
- Leaking UST
- Animal research
- Firing ranges
- Chemical Laboratories/storage

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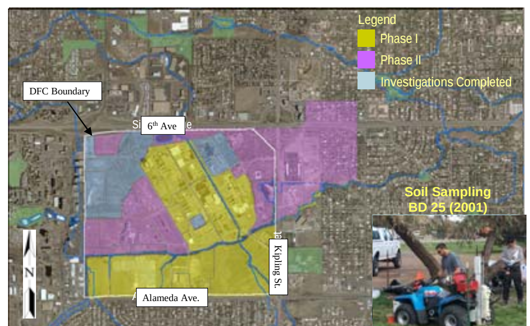
Environmental Program Status



Program Status as of Fall 2004

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Findings at the DFC Site

- **Downing Drainage Ditch:** The state health department determined in 2002 that Downing Reservoir is not a source of contamination in the ditch.
- **Offsite Indoor Air:** The state health department determined in 2004 that there was no unacceptable risk to the public at the Fletcher Miller School.
- **Onsite Indoor Air:** No unacceptable risk to public health identified based on 1997–2003 data for DFC buildings.
- **Offsite Groundwater:** Neighborhood wells tested and evaluated in 1995 and public water supply provided in 1997 for those wells in the Bonvue neighborhood.
- **Offsite Groundwater:** Contaminated with only solvents at low levels
- **Surface Water East of Kipling:** The state health department in 2004 identified no unacceptable risk to public health associated with the sediments, water, or air in the gulch.

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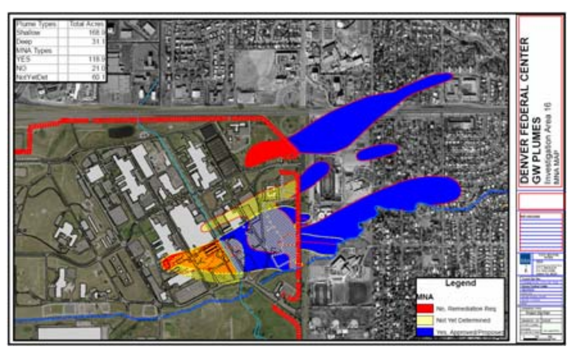

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Energy Use

- Increase use of renewable energy for remediation systems
  - install 1 megawatt photovoltaic system for DFC
- Metrics
  - 233,000 kWh/yr used
  - 198 metric tons CO_2E

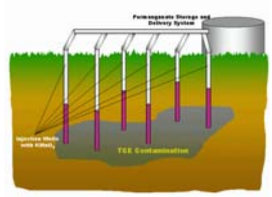
Stormwater

- Reduce releases to storm water
  - implement dig permits
  - provide awareness training
  - monitor contractor activities
- Metrics
  - 65 yds sediment retained
  - Reduced investigation costs
  - Reduced contractor costs

Geosyntec consultants

"Greening" Material Use

- Reduce hazardous chemical use and transfer of chemicals to other media
  - implement monitored natural attenuation
- Metrics
  - eliminated use of chemicals and energy for active remediation:
    119 acres MNA
    60 acres TBD



Site Acquisition & Development

- Redevelop portions of the DFC as a medical facility and a light rail station
- Metrics
  - 65 acres remediated to commercial cleanup criteria

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Site Remediation Team

- **Key operational controls**
- ❖ Excavation Permit
- ❖ 90-Day Storage Area(s) & Spill Response
- ❖ RCRA Facility Investigation Process
- ❖ Environmental Divestiture Audit
- ❖ Fugitive Dust Management
- ❖ Spill Response

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Future Work

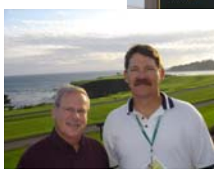
- Continue corrective actions and redevelop Site
- Identify opportunities for integration with other Action Teams
- Expand EMS to Region 8

Geosyntec consultants

GSA U. S. General Services Administration

DFC Environmental Programs Group

John Kleinschmidt
Carl Eriksson
William Fieselman
Michael Gasser
Robert Melvin
Robert Kipper
Robert Collins



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Attachment 5
DuPont Chambers Works Case Study

SWMU 8 Sustainability Assessment
Interim Corrective Measures Study

DuPont Chambers Works Facility

Brandt Butler URS Diamond

The miracles of science

Overview

Largest solid waste management unit on site ~140 acres

- Used for solid and liquid waste management over decades
- Numerous historic and ongoing disposal and waste management activities

Remedial Investigation

- Multiple phases of investigation
- Targeted to specific issues/requests
- Data for many key elements and areas is not complete

SWMU is contained

- Groundwater impacts contained by Interceptor Well System
- Soil impacts mitigated by soil and stone cover

Corrective Measures Study

CMS RAOs - Focused on source treatment

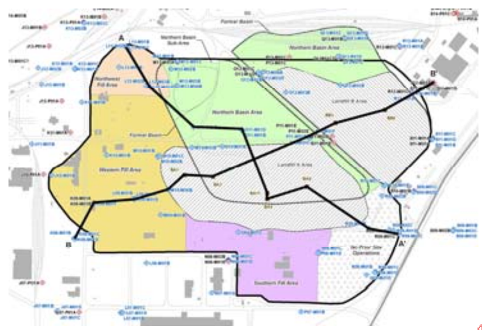
- Areas significantly contributing to groundwater impacts
- Groundwater impacted by SWMU 8

Identify source areas potentially impacting groundwater

Assess appropriate technologies for significant source areas

- Effectiveness
- Implementability
- Reduction of mobility, toxicity, and volume
- Sustainability
- Cost

Unique Source Areas



Primary Organic Constituents

Benzene	Vinyl chloride
N-Nitrosodiphenylamine	Chloroform
Bis(2-ethylhexyl)phthalate	Aldrin
Tetrachloroethylene	1,2-Dichlorobenzene
Bromodichloromethane	1,4-Dichlorobenzene
Trichloroethene	cis-1,2-Dichloroethene
Chlorobenzene	2,4-Dinitrotoluene
1,2,4-Trichlorobenzene	2,6-Dinitrotoluene
Chlorodibromomethane	Nitrobenzene

Virtually all constituents biodegrade aerobically

Area-Specific Technologies

Area	Technology
Landfill A (28 acres)	Excavation
	Stabilization
	Bioreactor
	Capping
DNAPL Area (6 Acres)	Excavation
	Stabilization
	Biosparging
	Pump and Treat
	Steam Enhanced Recovery
	Surfactant Enhanced Recovery
Northern Basin Sub-Area (5 acres)	Excavation
	Stabilization
	Bioventing
	Biosparging
	Pump and Treat
GW Containment (200 gpm)	Leachate Control and B Aquifer Capture

Sustainability – Environmental Footprint

Green house gas (CO_2 equivalents)
- Implement remedy
- Consumables

Resources
- Land
- Water
- Landfill space

Energy
- Implement remedy
- Consumables

Occupational Risk
- Exposure hours
- Highway miles

Sustainability Assessment

Based on quantities from conceptual design and cost estimate

Calculate for each task
- Fuel
- Consumables
- Resources
- Occupational risk

Calculate remaining measures
- Energy equivalents
- GHG equivalents

Greenhouse Gas Contributions

Parameter	SWMU 8 Focus Areas		
	Excavation	Stabilization	Bioremediation
Carbon Dioxide Production (tons)			
Gasoline	11,040	2,378	1,162
Diesel	1,206,892	43,609	603
Consumables	1,509,266	867,188	604
Contaminant Degradation	0	0	156,645
TOTAL	**2,727,000**	**913,000**	**159,000**

Spreadsheet Calculations

See: DuPont_SWMU 8_Sustainability.xls

Comparison of SWMU-wide Technologies

Metric	Units	Excavation	Stabilization	Bioremediation
Greenhouse Gas - CO_2 Equivalents				
	ton	2,727,000	913,000	159,000
Resource Consumption				
Water	acre-ft	0	0	0
Soil	acre-ft	5,940	0	0
Energy				
	kwh	6,634,000,000	1,177,000,000	1,238
Occupational Risk				
Exposure	hours	4,909,000	538,000	80,796
Highway Miles	miles	56,070,000	7,959,000	27,000
Particulate PM-10				
	ton	50,500	7,200	24

Measures of Sustainability and Reduction

	Excavation	Stabilization	Bioremediation
Destruction	No	No	Yes
In-situ	No	Yes	Yes
Mobility	↓↓	↓↓	↔
Toxicity	↔	↔	↓
Volume	↑	↑	↓
Tons CO_2	2,700,000	910,000	159,000
Exposure Hours	4,900,000	540,000	81,000
Highway Miles	56,000,000	8,000,000	27,000
Odor	High	Moderate	None
Light	High	Moderate	None
PM10, tons	50,500	7,200	24

Attachment 7
Savannah River Site Case Study

Savannah River National Laboratory (SRNL) researchers are developing tools to evaluate the need to power new or existing remediation systems with renewable energy sources. The tools employ sustainability metrics for assessing energy demand and storage along with characteristics of the site and contaminants. Early evaluation of these parameters can reduce the footprints of many aggressive cleanup technologies, which are now recognized increasingly as secondary impacts of environmental contamination. It can also help identify risk transfer across environmental media and associated regulatory programs.

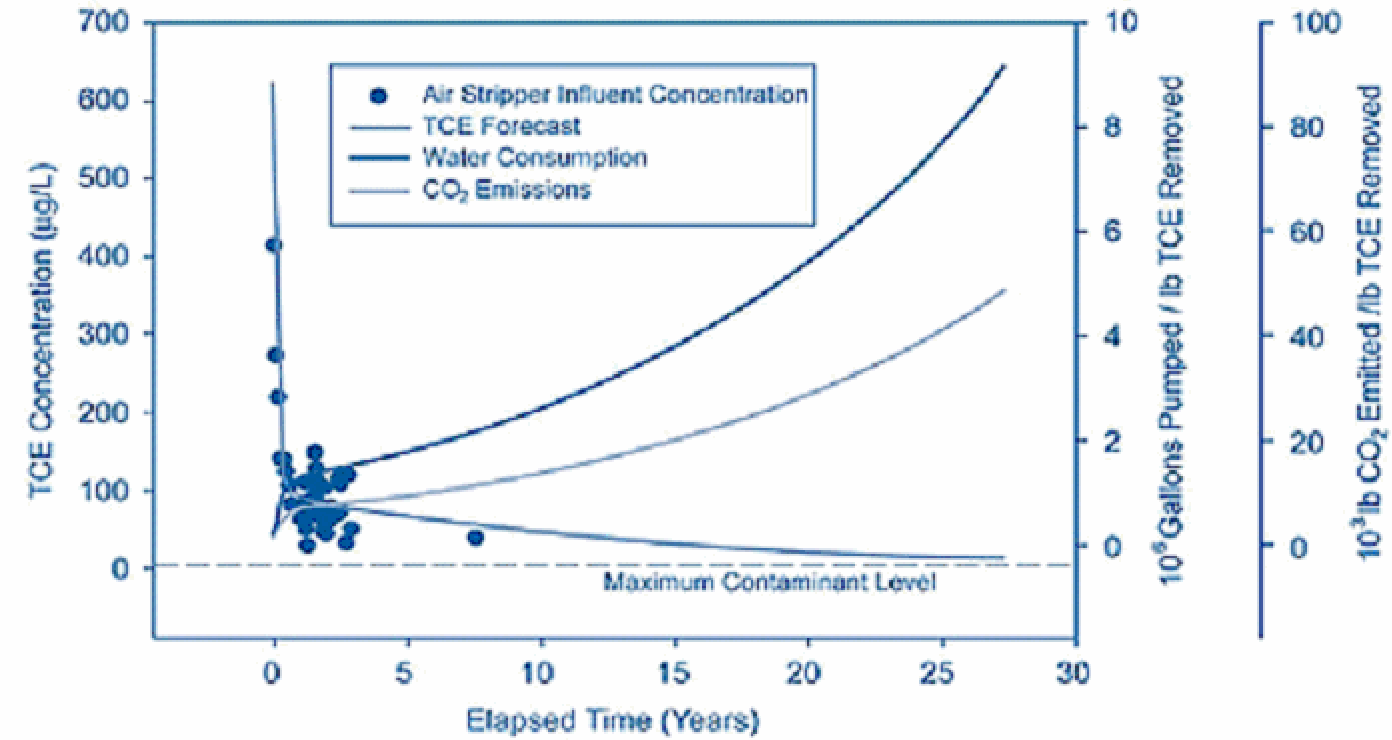
This strategy was demonstrated last year for a Savannah River Site (SRS) P&T system operating since 1996 to treat TCE-contaminated ground water. Following extraction, ground water is treated by a 70-gpm air stripping system and ultimately discharged to the Savannah River. Average TCE concentrations in treatment influent decreased from 600 µg/L to 40 µg/L after eight years of P&T operation. These dissolved CVOC concentrations (<50 µg/L or <0.0045 % solubility) mark the point at which media-specific benefits of baseline technologies such as P&T and in-situ chemical oxidation typically begin to be outweighed by increased burdens transferred to other environmental media, otherwise known as the onset of collateral environmental damage.

Common ground-water remediation goals such as hydraulic containment of contaminants, attainment of maximum contaminant levels, contaminant mass removal, risk reduction, and contaminant flux reduction do not reflect environmental burdens posed by cleanup technologies. Typical goals also do not reflect the value of in-situ environmental resource services such as drought buffering, prevention of land surface subsidence, protection against salt-water intrusion, and maintenance of ecological diversity. Accordingly, the SRNL study evaluated sustainability goals considered only minimally at the time of remedy selection:

> **Resource conservation** measured by "water intensity," or the amount of water necessary to remove one pound of contaminant,
>
> **Energy efficiency** measured by the amount of energy needed to remove one pound of contaminant, and
>
> "**Carbon intensity**" estimating the amount of CO_2 emitted for each pound of contaminant treated, based on power industry standards.

During the first six months of air stripping operations, 100,000-500,000 gallons of ground water were removed for every pound of TCE removed. Influent contaminant concentrations over the following seven years were more moderate, decreasing from 100 µg/L to 40 µg/L. Water intensity during that period increased to 3,000,000 gallons per pound of contaminant removed. As of early 2006, TCE concentrations persisted at levels eight-fold higher than the 5 µg/L cleanup target.

Forecasts estimate that influent concentrations of TCE after 20 more years of P&T operation would still be 15 µg/L (three times the cleanup goal) and water intensity would increase to 9,000,000 gal/lb. The remediation system's carbon intensity also would increase exponentially to an estimated 50,000 lbs of CO_2 for each pound of contaminant removed, significantly increasing the rate of risk transfer from ground water to the atmosphere (Figure 4).



Recent studies by the Interstate Technology and Regulatory Council, the National Research Council, and other government organizations recommend addressing the diminishing environmental returns of aggressive remediation technologies by:

> **Evaluating collateral damages** such as energy use and loss of environmental resources early in remediation planning,
>
> **Establishing alternative metrics** for tracking collateral impacts during active remediation, and
>
> **Developing new economic models** using sustainability metrics to balance natural resource damages with resource restoration.

SRNL will continue developing innovative strategies for minimizing collateral damage during remediation polishing. Potential methods involve harnessing new forms of renewable energy and leveraging prevalent site conditions with natural processes.

Contributed by Ralph Nichols, SRNL (ralph.nichols@srnl.doe.gov or 803-725-5228)

First, Do No Harm

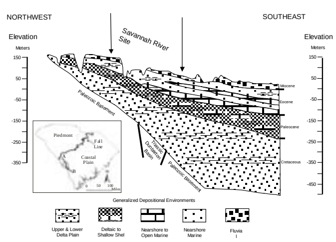
Helping the Earth Heal Itself

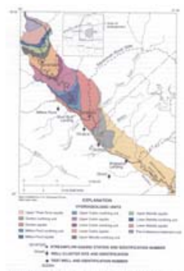
Ralph L. Nichols, Brian B. Looney
Georgia Water Resources Conference
March 27 – 29, 2007
Athens, GA

Savannah River Site

- Located in Aiken, South Carolina
- Savannah River Site produced weapons grade nuclear material
  - Fabrication facilities
  - Reactors
  - Separations facilities
- Savannah River National Laboratory
  - Applied research laboratory

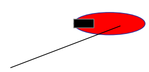
Hydrogeology





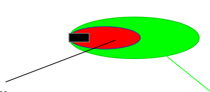
Anatomy of a Plume

- Spatial variation



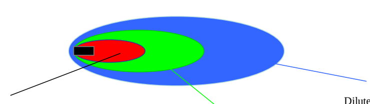
Anatomy of a Plume

- Spatial variation

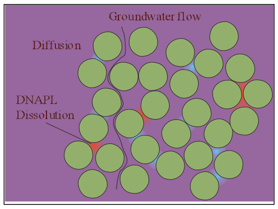


Anatomy of a Plume

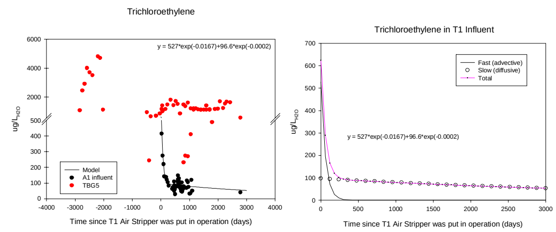
- Spatial variation



Rate Limitations



Rate Limitations



Sustainable

Sustainable development "Reconciliation of society's developmental goals with the planet's environmental limits over the long term".

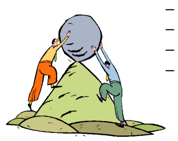
(National Academy of Sciences, 2003. Our Common Journey: A Transition Toward Sustainability)

Remediation vs Sustainability

- Remediation Goals
  - Drinking Water Standards
  - Containment
  - Mass removal
  - Reduce flux
  - Reduce risk
- Remediation Metrics
  - Concentrations
  - $ / lb
  - $ / cubic yd
  - $ / 1000 gal
  - $ / yr

Remediation vs Sustainability

- Remediation Goals
  - Drinking Water Standards
  - Containment
  - Mass removal
  - Reduce flux
  - Reduce risk
- Remediation Metrics
  - Concentrations
  - $ / lb
  - $ / cubic yd
  - $ / 1000 gal
  - $ / yr
- Sustainability Goals
  - Preserve natural resources
  - Minimize energy use
  - Minimize CO2 emissions
  - Maximize recycle / reuse
  - Minimize footprint
- Sustainability Metrics
  - lb / Kwhr
  - lb / lb CO2
  - lb / 1000 gallon
  - lb / cubic yard



Groundwater Example

- Pump and treat shallow tray air stripper w/ 3 wells, 70 gpm
  - 3 pumps @ 5 hp each
  - 1 pump @ 15 hp
  - 50 ug/L TCE
  - Operating 90% of the time

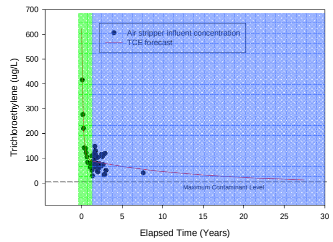
1 Hp = 0.745 Kw

1.34 lb CO2 emitted / Kwhr

Density CO2 @ 1.03 bar and 59F = 1.87 Kg/m3

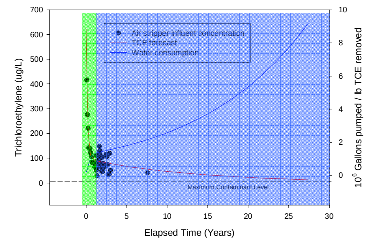
MW TCE131.39 gm

Measures of Sustainability



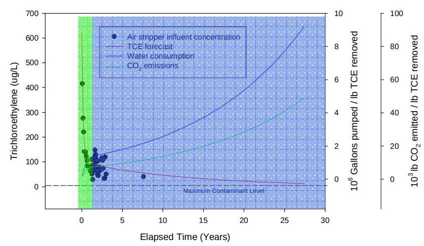
SRNL

Measures of Sustainability



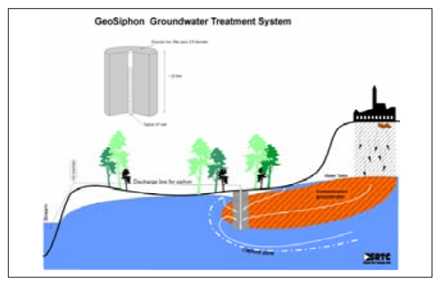
SRNL

Measures of Sustainability



SRNL

GeoSiphon



SRNL

GeoSiphon

SRNL

Sustainable Remediation Technologies

- Horizontal wells, patented 1989, licensed
- PHOSter™, patented 1996, licensed
- Cone Sipper™, patented 1998, licensed
- StrataSampler™, patented 1998, licensed
- BaroBall™, patented 1997, licensed
- GeoSiphon™, patented 2001, licensed
- MicroBlower™, patented 2005, licensed

SRNL

Summary and Conclusions

- Remediation goals and sustainability goals can be difficult to blend
- Determining sustainability is somewhat arbitrary, guides and standards are needed
  - Leadership in Energy and Environmental Design (LEED)
  - Energy Star
- Good conceptual model is important
- Identify naturally occurring opportunities
  - Chemical properties
  - Site conditions
- Keep design simple to minimize wasted energy
- Look for natural analogs

SRNL

Attachment 8
Research in Remediation Sustainability

Sustainability Issues Related to Choices of Remediation Approaches

Daniel Watts
Harnoor Dhaliwal
New Jersey Institute of Technology

Fast Background: Concept of Sustainability

- Sustainability is related to the idea of Sustainable Development:
- For all intents and purposes, the concept of sustainable development has its origins in a report called Our Common Future which was published by the United Nation's Brundtland Commission in 1987.

Fast Background: Concept of Sustainability

The Brundtland Commission famously defined sustainable development as…

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainability is the state where these conditions are met, most often assumed to require a balance of three components:

- Protective and Protected Environment
- Vibrant Economy
- Supportive Quality of Life

Fast Background: Determinants of Sustainability

- Many places have engaged processes to characterize sustainability for them
- These processes have lead to development of "Indicators of Sustainability" for those places
- To classify a human activity as "sustainable" it must not cause an overall reversal of progress of the indicators toward the goal
- To choose among alternatives, the most sustainable alternative will be the one that overall shows the greatest positive effect on the "indicators of sustainability".

Which Sustainability Indicators Apply?

- Some Companies are Developing Their Own—For Example Bristol-Myers Squibb
  - Environmental, health, and safety (EHS) effects analysis
  - Safety performance targets to drive down reportable incidents and days lost from work.
  - Environmental performance targets and goals (normalized by sales) to reduce water use, greenhouse gas emissions, energy use, wastewater, air emissions, hazardous waste, nonhazardous waste, and off-site releases of chemicals of high concern.
  - Sustainable products promotion through packaging reductions, green chemistry, and inherent product and process safety.
  - Supply chain partnership to promote EHS performance improvements among key suppliers.
  - EHS research addressing business issues.
  - Sustainability awards initiated.

Which Sustainability Indicators Apply?

- Some Companies are Developing Their Own—For Example Bristol-Myers Squibb (Continued)
  - Leadership development program established.
  - Biotechnology development.
  - Community outreach
  - Social policies and metrics
  - EHS research contributions
  - Endangered species sponsorship to encourage each facility and business to help protect local endangered species and habitats.
  - Land preservation of biologically diverse land to offset the property used by Bristol-Myers Squibb's total operations worldwide and to promote employee participation in protecting critical land areas.

Which Sustainability Indicators Apply?

- For Remediation Activities—
  - Action Often Takes Place within Companies and Should be Guided by Corporate Sustainability Measures
  - Action Also Takes Place outside of Companies and Should be Guided by the Place-Based Sustainability Indicators as Well

New Jersey Sustainability Indicators

welcome
to the New Jersey Sustainable State Institute

What kind of New Jersey are we leaving to future generations? The New Jersey Sustainable State Institute is dedicated to helping New Jerseyans "Live With the Future In Mind." Our mission is to create a healthy, just, and efficient New Jersey for us, and for future generations.

Where are we, and where do we need to be, in order to preserve our quality of life and become a sustainable state?

These 11 goals & 41 indicators track NJ's progress toward sustainable development

- Economic Vitality
  - 1. Per capita income
  - 2. Unemployment
  - 3. Productivity of labor
  - 4. Share of New Jersey households below the poverty line
  - 5. Gross State Product
  - 6. Energy efficiency in the economy
- Equity
  - 7. Pay equity
  - 8. Legislature's reflection of the composition of the population
  - 9. Racial disparities in infant mortality
- Strong Community, Culture & Recreation
  - 10. Newspaper circulation
  - 11. Crime rate
  - 12. Open space
- Quality Education
  - 13. High school graduation rate
  - 14. Student/teacher ratio
  - 15. Standardized test scores
  - 16. Higher education

These 11 goals & 41 indicators track NJ's progress toward sustainable development

- Good Government
  - 17. Awareness of state government
  - 18. Voter turnout
- Decent Housing
  - 19. Affordability of rental housing
  - 20. Home prices vs. income
  - 21. Trends in new housing
- Healthy People
  - 22. Life expectancy
  - 23. Infectious diseases
  - 24. Asthma
  - 25. Occupational safety and health
- Efficient Transportation and Land Use
  - 26. Need for road and bridge repairs
  - 27. Vehicle miles traveled per capita
  - 28. Workplace transportation options
  - 29. Traffic fatalities

These 11 goals & 41 indicators track NJ's progress toward sustainable development

- Natural and Ecological Integrity
  - 30. Loss of freshwater wetlands
  - 31. Nesting water bird populations
  - 32. River health
  - 33. Marine water quality
- Protected Natural Resources
  - 34. Total energy consumption
  - 35. Farmland
  - 36. Ocean and bay beach closings
  - 37. Preserved and developed land
- Minimal Pollution and Waste
  - 38. Greenhouse gas emissions
  - 39. Drinking water quality
  - 40. Solid waste
  - 41. Air pollution

Which NJ Indicators are Not or Only Remotely Connected with Remediation Activity

- 4. Share of New Jersey households below the poverty line
- 8. Legislature's reflection of the composition of the population
- 9. Racial disparities in infant mortality
- 10. Newspaper circulation
- 11. Crime rate
- 13. High school graduation rate
- 14. Student/teacher ratio
- 15. Standardized test scores
- 16. Higher education
- 17. Awareness of state government
- 18. Voter turnout
- 19. Affordability of rental housing
- 20. Home prices vs. income
- 21. Trends in new housing
- 23. Infectious diseases

Among Remaining NJ Indicators What Factors Need to Be Measured and Compared in Making Choices for Sustainability?

- Economic Vitality:
  - Differences in Pay Levels for Workers (Goal is Higher Pay)
  - Number of Jobs Created (Goal is More Jobs)
  - Value Added per Worker (Goal is High Productivity)
  - Contribution of Total Value Produced (Goal is High State Product Value)
  - Differences in Total Energy Used (Goal is Most Value for the Least Energy Investment)
- Issues to Be Decided:
  - What is the Value of the Remediation?
  - For Example, Natural Resources Value.

Among Remaining NJ Indicators What Factors Need to Be Measured and Compared in Making Choices for Sustainability?

- Equity:
  - Differences in Pay Earned by Gender, Ethnic Background or other Demographic Issue (Goal is equal pay for equal work)
- Strong Community, Culture, and Recreation
  - Differences in the Amount of Open Space When Remediation is Completed (Goal is maximum amount of open space)
- Issues to be Decided:
  - What is the relative difference in amount of open space when remediation is complete?
  - Is it on-site or off-site? In state or out of state?

Among Remaining NJ Indicators What Factors Need to Be Measured and Compared in Making Choices for Sustainability?

- Healthy People:
  - Differences in risk factors that may lead to changes in life expectancy (Goal is longer life expectancy)
  - Differences in risk factors that may lead to asthma—particularly childhood asthma (Goal is fewer cases of reported asthma)
  - Differences in Occupational Safety and Health Factors (Goal is fewer occupational accidents and injuries)
- Issues to be Decided:
  - What are the risk factors? Air emissions? Contaminated water? Increased traffic accidents? Issues at disposal sites?

Among Remaining NJ Indicators What Factors Need to Be Measured and Compared in Making Choices for Sustainability?

- Efficient Transportation and Land Use:
  - Differences in Road Transportation the May Necessitate Repairs to Roads and Bridges—Length of Trips, Tonnage Hauled, Number of Trips (Goal is to cause as little road damage as possible)
  - Differences in Worker to Site transportation options (Goal is to encourage public transportation use or high occupancy vehicles)
  - Differences in Predicted Number of Traffic Fatalities (Goal is reduced number of traffic fatalities)
- Issues to be Decided:
  - Need to consider transportation of goods to and from the site. Is there a difference in the number of worker trips required? Are there differences in length of trips or trips on dangerous roads that increase risk of traffic fatalities?

Among Remaining NJ Indicators What Factors Need to Be Measured and Compared in Making Choices for Sustainability?

- Natural and Ecological Integrity:
  - **Differences in Area and Quality of Freshwater Wetlands at End of Remediation (Goal is to Retain or Increase Size and Productivity).**
  - **Differences in Size of Nesting Water Bird Populations (Goal is to increase population size up to the point of carrying capacity of the bird's territory)**
  - **Differences of impact on water quality and productivity of any river involved (Goal is to maintain or improve water quality and to protect and promote balanced populations depending on the river)**
  - **Differences of impact on water quality and productivity of any marine waters involved (Goal is to maintain or improve water quality and to promote and sustain marine life)**
- Issues to be Decided:
  - **Need to consider fate and transport of any water-borne discharges or air discharges that may impact nearby waters. Need to determine the factors that may impact the size of water nesting bird populations.**

Among Remaining NJ Indicators What Factors Need to Be Measured and Compared in Making Choices for Sustainability?

- Protected Natural Resources:
  - **Differences in consumption of non-renewable energy resources (Goal is to reduce the total amount of energy resources used)**
  - **Differences in Area of Farm Land Remaining at End of Remediation Activity (Goal is to increase or at least maintain the acreage of Farm in New Jersey)**
  - **Differences of impact on water quality at the shore that results in beach closings (Goal is to minimize or eliminate the number of beach closings)**
  - **Differences in the area of developed land resulting from remediation activity (Goal is to decrease the area of developed land in New Jersey)**
- Issues to be Decided:
  - **Need to determine factors that are responsible for beach closing—often due to bacterial concentration**

Among Remaining NJ Indicators What Factors Need to Be Measured and Compared in Making Choices for Sustainability?

- Minimal Pollution and Waste:
  - **Differences in emissions of greenhouse gasses—including methane from landfills (Goal is to reduce greenhouse gas emissions to the smallest level possible)**
  - **Differences in impact on drinking water quality, including both level and type of contamination and duration of contamination (Goal is to cause as little drinking water contamination as possible)**
  - **Differences in quantity of solid waste--should include level of toxicity as well (Goal is to the smallest quantity with the lowest level of toxicity possible)**
  - **Differences in the amount of pollutants emitted to air (Goal is to minimize the quantity of pollution in the air)**
- Issues to be Decided:
  - **Need to determine how all of these factors have impact throughout the entire lifecycle of the process.**

Other Sustainability Indicators UN Millennium Project

1. Improve small-scale agricultural production systems

- Increase the use of sustainable agriculture techniques
- Restore and manage desertified lands
- Protect surrounding natural habitat

2. Promote forest management for protection and sustainable production

- Increase real income in informal forest sector activities by at least 200 percent
- Integrate ecosystem management of 90 percent of river basin systems
- Protect and restore representative areas of all major ecosystems

3. Combat threats to freshwater resources and ecosystems

- Reduce demand for freshwater, especially in cropping systems
- Minimize pollution levels in surface water and groundwater sources

Other Sustainability Indicators UN Millennium Project

4. Address the threats to fisheries and marine ecosystems

- Implement an ecosystem-based approach to fisheries management
- Restore depleted fish population levels to at least target biomass levels
- Establish a network of representative, fully protected marine reserves

5. Address the drivers of air and water pollution

- Reduce exposure to toxic chemicals in vulnerable groups
- Significantly reduce the under-five mortality and morbidity rates caused by pneumonia and acute respiratory infection
- Significantly reduce the under-five mortality and morbidity rate caused by waterborne diseases
- Reduce the atmospheric levels of the six key pollutants and methane

Other Sustainability Indicators UN Millennium Project

5. Address the drivers of air and water pollution

- Reduce exposure to toxic chemicals in vulnerable groups
- Significantly reduce the under-five mortality and morbidity rates caused by pneumonia and acute respiratory infection
- Significantly reduce the under-five mortality and morbidity rate caused by waterborne diseases
- Reduce the atmospheric levels of the six key pollutants and methane

6. Mitigate the anticipated effects of global climate change

- Invest in cost-effective and environmentally sustainable energy
- Promote and engage climate-friendly carbon and technology markets
- Mainstream responses to climate change and variability

Other Sustainability Indicators UN Millennium Project

7. Strengthen institutions and governance

- Train, recruit, and retain environment experts
- Secure sufficient funding for environmental institutions
- Reform governmental institutions and improve interagency coordination
- Improve governance and gender equality

8. Correct market failures and distortions

- Account for the cost of environmental degradation in national accounts
- Introduce payments for ecosystem services
- Reform tax structures
- Phase out environmentally harmful subsidies
- Develop trade regulations to promote legal, sustainable harvesting of natural resource products
- Strengthen property and land-tenure rights
- Improve national and international regulatory frameworks

Other Sustainability Indicators UN Millennium Project

9. Improve access to and use of scientific and indigenous knowledge

- Mobilize science and technology on a national scale
- Establish mechanisms for science and technology advice to policymakers
- Train civil servants and political decision makers in environmental management
- Provide public access to information
- Improve extension training and services so that they are based on locally-derived solutions
- Strengthen global scientific assessments

10. Build environmental sustainability into all development project proposals

- Ensure that all project proposals and poverty reduction strategies submitted to funding agencies include an assessment of their environmental impacts
- Establish a system of targeted incremental funding of national environmental programs
- Increase funding to countries in support of implementing existing multi-

Questions to Consider

- What is the Functional Unit of the Remediation Operation—What is the Basis of Comparison?
  - Time Issues
  - Scale Issues
- From a Sustainability Context, do we define a remediation action as one to meet some regulatory objectives,
- Or, as one that restores an area of land to contributing value with environmental, economic, and quality of life attributes

Further Questions to Consider

- In comparing impacts on Sustainability Indicators, should some receive more weight than others?
- Some indicators depend on the same measured variables—such as energy use. Should they be counted more than once?

Comparative Approach—Scenario Building

- Questions to Ask:

1. Site Location.
2. Contaminants of concern.
3. Cleanup goal for contaminants of concern
4. Clean-up program:
   - Treatment Train Information:
   - This specifies whether the project is using a combination of treatment technologies, with a brief description of the sequence and type of technologies.

Comparative Approach—Scenario Building

- Questions to Ask:

5. Media:
   - Type of media being treated by the technology
   - Contaminated Depth: Depth (below ground surface) of the media to be treated by the technology.
   - Contaminated Area: Area of the contaminated media to be treated by the technology.
   - Contaminated Quantity: Quantity of contaminated media to be treated by the technology.

Comparative Approach—Scenario Building

- Questions to Ask:

6. Approximate time required for contaminant treatment.
7. Time period to be considered for LCA
8. Approximate transportation distance involved:
   - This specifies transportation distance involved in the selected process - to and from the site to estimate emissions e.g. transport to landfill, transport of samples to laboratory, transport of clean material etc.

Comparative Approach—Scenario Building

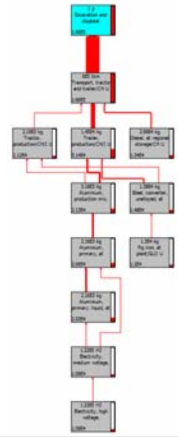
- Questions to Ask:

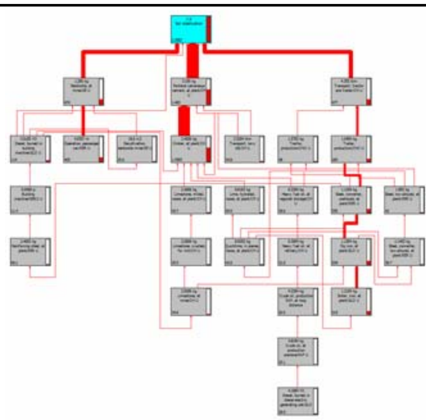
9. Contaminant discharge rate:
   - To groundwater
   - To surface water
   - Air emissions
10. Consumables:
    - This specifies amount of material (clean fill, chemicals, nutrients etc.) to be used.

Comparative Approach—Scenario Building

- Questions to Ask:
  11. Approximate waste generation
      - Type and quantity of waste
      - Waste management practice:
        - Treatment (%)
        - Recycling (%)
  12. Equipment:

      This specifies equipment requirement to calculate non-road emissions.





Attachment 9
USEPA Region III Pilot Project

Region 3 RCRA / DuPont Sustainability in Remediation Pilot

Deborah Goldblum
EPA Region 3
RCRA Corrective Action
May, 2007

Background

- May 1998 - Region 3 RCRA CA and DuPont initiate semi-annual meetings to address site-specific & global corrective action issues
- November 2006 – DuPont introduced the concept of sustainable remediation to Region 3 RCRA
- February 2007 – Region 3 RCRA attended second Sustainable Remediation Forum (SuRF) meeting
- February 2007 – Land Revitalization Office was tasked with developing clean energy and greenhouse reduction strategy for OSWER
- April 2007 – DuPont/Region 3 RCRA began to test sustainability criteria on Martinsville, VA site

Background

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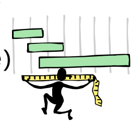
Sustainable Remediation Goals

- minimize or eliminate energy consumption
- minimize or eliminate ancillary environmental impacts from cleanups, such as CO_2 emissions to the air
- preserve natural resources
- maximize the reuse of land & the recycling of other material
- encourage the use of remediation technologies that permanently destroy contamination

Integrating Sustainability into Cleanups

- Develop framework to assess sustainability
  - Factors (common language)
  - Measures



- Potential to use sustainability as a balancing criteria for cleanups

RCRA Remedy Selection Criteria

Threshold Criteria

- Protect Human Health & the Environment
- Control Sources
- Meet Cleanup Objectives

Balancing Criteria

- Long-term reliability
- Reduction of toxicity, mobility or volume
- Short-term effectiveness
- Ease of implementation
- Cost
- Community acceptance
- State acceptance
- Sustainability

Measuring Sustainability

- land use
- water use
- air impacts
- energy
- human exposure hours
- PM-10
- NO_X
- CO_2
- local issues
- treatment vs. containment
- SO_X
- occupational risk
- recycled materials

Sustainability Measurement Factors

- Greenhouse gases (carbon dioxide equivalents)
- Resources consumed
  - Soil/solid material
  - Land
  - Water
- Energy consumed

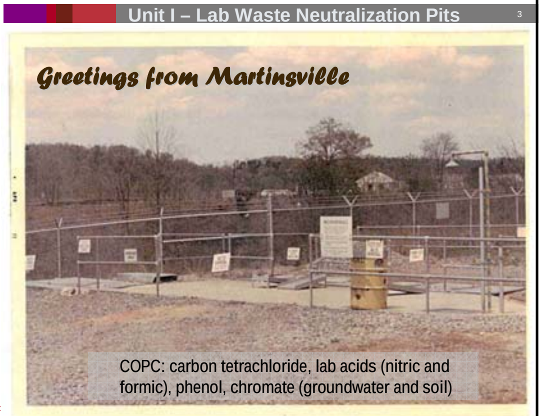
DuPont Martinsville, VA
SURF Sustainability Pilot Project

David E. Ellis Ph.D.
DuPont Engineering – CRG

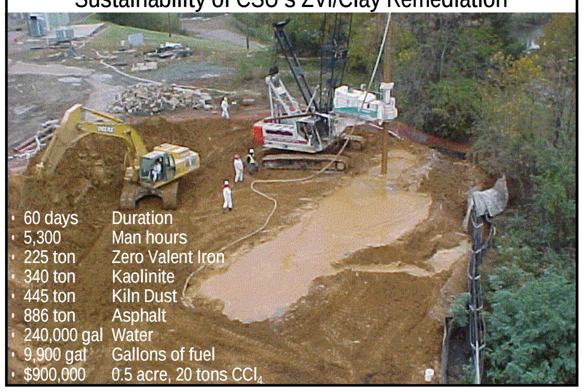
SURF 3 - May 10, 2007

The miracles of science

Unit I – Lab Waste Neutralization Pits



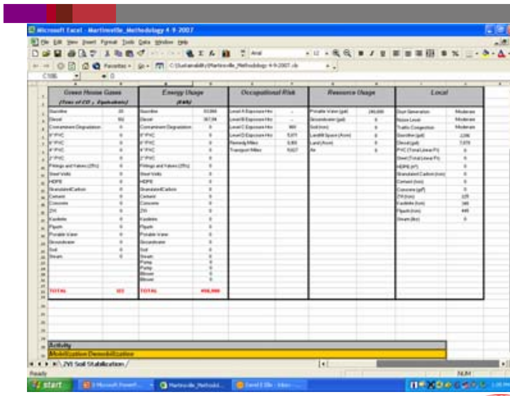
Sustainability of CSU's ZVI/Clay Remediation



- 60 days Duration
- 5,300 Man hours
- 225 ton Zero Valent Iron
- 340 ton Kaolinite
- 445 ton Kiln Dust
- 886 ton Asphalt
- 240,000 gal Water
- 9,900 gal Gallons of fuel
- $900,000 0.5 acre, 20 tons CCl_4

ZVI/Clay Remediation - Tasks and Quantities

Task	Item	Quantities
Mobilization and Site Prep	Time Staff Equipment	10 days 11 - 1 Super, 1 Eng'r, 9 Operators & Laborers Excavator, fork lifts (2), crane, mix head, others
Well Abandonment	Time	1 day – trackhoe
Crane and Mix Head Assembly	Time	5 day
Utility Abandonment	Time	3 day
Shallow Soil Mixing	Time Staff Equipment Materials	30 days 4 Level C, 7 Level D Mix head/crane, fork lifts, excavator 225 ton ZVI, 340 ton kaolinite, 445 ton kiln dust 250,000 gal water
Demob, including grading	Time Equipment	4 days Excavator
Asphalt Paving	Time Staff Equipment Materials	10 days 2 Asphalt spreader and roller 3" base coarse, 2" top coarse



Martinsville_Methodology 4-9-2007.xls

Unit H1 - Former Finish Oil Disposal Pond

COPC: Chlorinated VOCs in soil, soil vapor and groundwater; PCBs, coal ash (arsenic) in soil only.

Former pond filled with coal ash and site soils

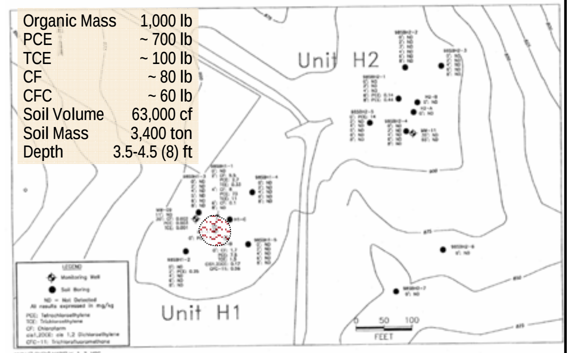
Nearly round, approximately 100' diameter

Residuals impacts 3.5 to 4.5 feet bgs

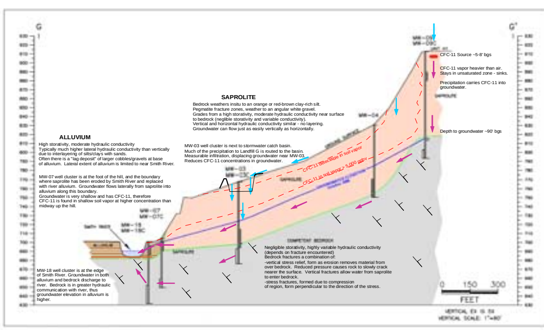
Then - 1970's

Now - 2004

Unit H1 - Soil



Conceptual Migration of VOCs



April 10 Outcome: Unit H1 Potential Remedial Measures

- **Source remediation – mitigate groundwater impacts**
- **Soil**
  - ****Excavation (source material removal) and landfill**
  - ****Cap (geomembrane)**
  - ***SVE**
  - In-situ Stabilize
  - ****Chem-reduction - ZVI/Clay optimized treatment**
  - Enhanced bio
  - In-situ thermal & vapor capture
  - **(--)Excavate & Ex-situ thermal treatment**
  - **(--)Excavate & Chem-ox (not effective chlorinated orgs & high oil demand)**
  - Excavate and soil wash
- **Groundwater – Meet MCLs (GPS) in plume and surface water standards in discharge to river**
- **Groundwater (source area or river)**
  - ***MNA**
  - **(--)PRB – Iron (river)**
  - ***Enhanced bioremediation**
  - ***Pump and treat (strip and carbon adsorption) – source and river**
  - Air sparge w/vapor capture (akin to Unit G) – option w/windmills - source
  - In-situ chem-ox (source)
  - In-well stripping

Measures of Sustainability

Carbon Dioxide Equivalents

Resources Consumed

Energy Consumed

Occupational Risk

Local Issues

Sustainability Credits and Debits

Media or Impact	Credit (+)	Debit[1] (-)
Greenhouse Gas (CO_2 equivalents)	❑ Sequestration	❑ Generated by fuel consumed during activity ❑ Generated by manufacture of consumables
Resource Use		
Soil	❑ Reused-recycled soil or soil-substitute (e.g. crushed concrete)	❑ All soil required ❑ Off-site disposal
Land	❑ Beneficially reused (brownfields, wind field, solar field) ❑ Wetlands created or upgraded	❑ Permanently deed restricted
Water	❑ Reused-recycled	❑ All water used or captured for treatment ❑ Water for dust control
Energy	❑ Renewable energy generated on-site	❑ Required by remediation activity ❑ Required for manufacture of consumables
Occupational Risk	❑ Controls or measures to reduce hazardous exposure	❑ Exposure hours on-site ❑ Exposure hours for travel and delivery ❑ Road miles traveled for personnel and consumables

Conceptual Framework for Sustainability Analysis

Remedial Options | **Calculation modules**

Remediation Project Data
- Size
- Volume
- Quantity
- Distance
- Etc.

Remedial Options
- Excavation
- Soil Treatment A
- Soil Treatment B
- Soil Treatment C
- Groundwater Treatment A
- Groundwater Treatment B
- Vapor Treatment
- Others, as Identified

Calculation modules
- Transportation
- Treatment
- Off-site transfers
- Water losses
- Exposure hours
- Air releases
- Land use
- Others, as Identified

Remediation Sustainability Parameters
- Pollutants
  - Green House Gases
  - Air
  - Water
  - Waste
- Resources
  - Energy
  - Water
  - Land
  - Air
- People

Creating Sustainability Evaluation Modules

- **Is there an existing evaluation for a similar process?**
- **Revise or create new module(s) by revisiting assumptions and calculations**
  - Different processes
  - Better understanding of actions or assessment factors
  - Data sources: EPA (AP-42), state websites, Google!
- **Peer-review with URS team and CRG support**

Sustainability Assessment Process

Scope Tasks
- Time
- Labor
- Materials
- Equipment

Quantities

Sustainability Equivalents

Example: Ex-Situ Thermal Treatment Scope

Task	Item	Quantities
Mobilization and Site Prep	Time Staff	4 days 9 - 1 Super, 1 Eng'r, 7 Operators & Laborers
Soil Excavation, Treatment and Backfilling	Time Staff Equipment	42 days 16 - 1 Super, 1 Eng'r, 14 Operators & Laborers 2 loaders, excavator, thermal desorb unit, Catox emissions control unit
Soil Cover	Time Staff Equipment Materials	2 days 8 - 1 Super, 1 Eng'r, 6 Operators & Laborers Loader and roller 400 tons clean soil
Demob	Time Staff	2 days 9 - 1 Super, 1 Eng'r, 7 Operators & Laborers

Summary of Sustainability Assessments

Parameters \ Remedies		ZVI-Clay In-Situ Treatment	Excavation & Off-Site Disposal	Ex-Situ Thermal Desorption	Soil Vapor Extraction	Capping
Tons of CO_2 Equivalents		85	252	586	306	21
Energy Usage (kWh)		308,103	911,883	2,348,094	700,999	113,287
Occupational Risk	Exposure Hours	3,562	4,364	5,482	3,952	612
	Mileage	10,942	109,815	15,662	16,742	4,645
Resource Use	Potable Water (gal)	0	0	0	0	0
	Groundwater (gal)	130,000	0	0	0	0
	Soil (ton)	200	3,400	400	170	1,200
	Landfill Space (acre-ft))	0	2	0	0	0
	Land (Acre)	0.3	0.3	0.3	0.3	0.3
	Air	0	0	0	0	0
Local	Dust Generation	Moderate	High	Moderate	Moderate	Moderate
	Noise Level	Moderate	High	High	Moderate	Moderate
	Traffic Congestion	Moderate	High	Low	Moderate	Moderate

Unit H1 Sustainability Calculations 4_25_07_c.xls

Remedy Comparisons

	ZVI/Clay	Soil-Vapor Extraction	Ex-situ Thermal Treatment	Excavation and Off-site Disposal	Capping
Treatment/ Destruction	Yes	Yes	Yes	No	No
In-situ Remedy	Yes	Yes	No	No	N/A
Mobility	↓	↔	↔	↓	↓
Toxicity	↓	↓	↓	↔	↔
Volume	↑	↓	↓	↔	↔
Carbon Dioxide, Ton	85	306	586	252	21
Exposure Hours	3,600	4,000	5,500	4,400	612
Highway Miles	11,000	17,000	16,000	110,000	4,600
Odor	Moderate	Low	Moderate	High	Low
Traffic	Moderate	Moderate	Moderate	High	Low

Learnings and Insights

Sustainability assessments iterative – project team progress and peer review discussions result in better, more robust assessments

- Better defined conceptual scope
- Labor intensive
- New/different/alternative ideas surface
- Iterative assessments improve and add insight

Assessment spreadsheets are fragile, relatively easy to break, candidate for more robust framework

Accurate to 1-2 significant figures

- +/-20% precision at best
- Best when consistent "drivers," such as fuel type or components, versus multiple types

Discussion