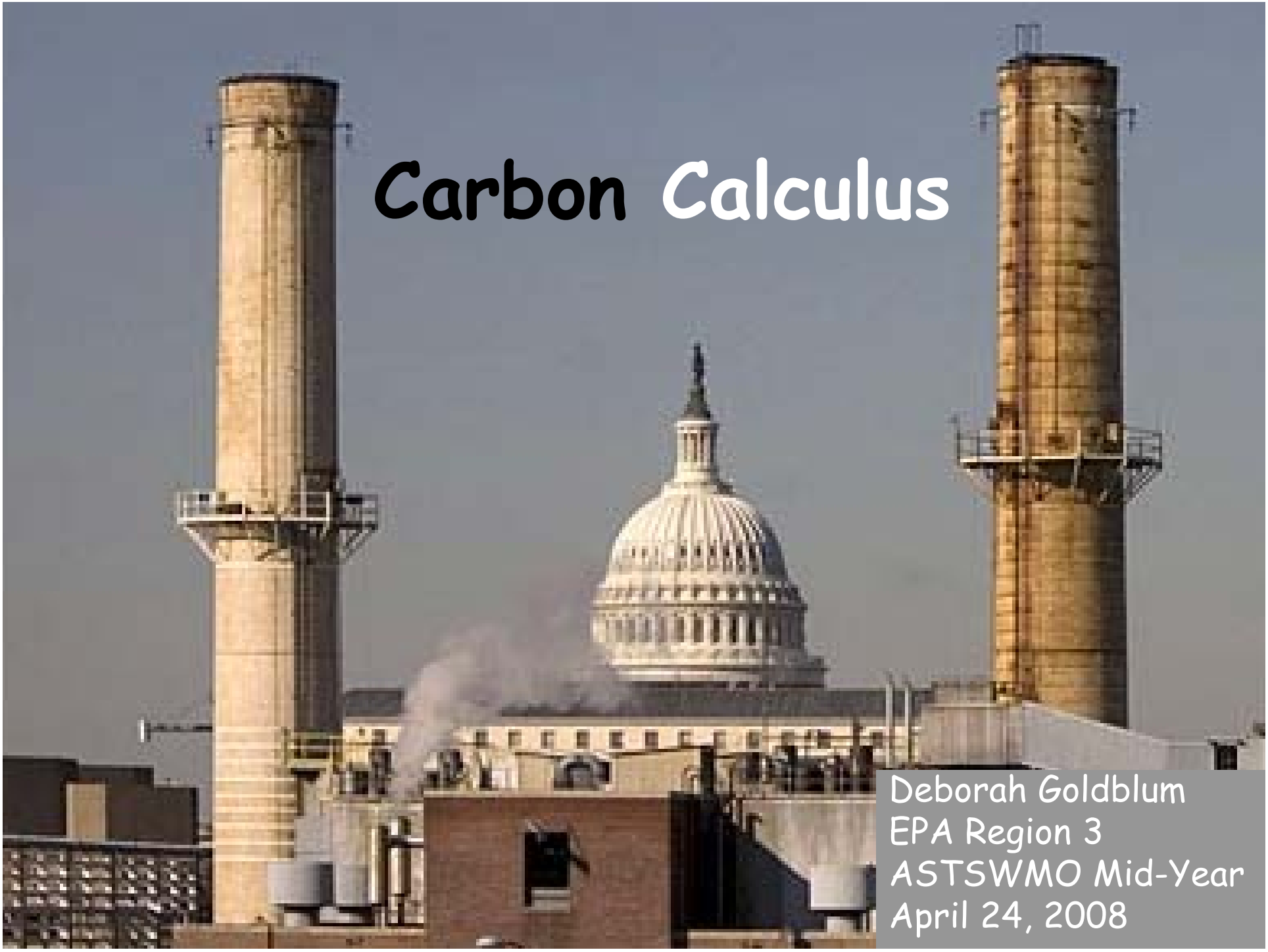

Carbon Calculus

Deborah Goldblum
EPA Region 3
ASTSWMO Mid-Year
April 24, 2008

Background

- May 1998 - Region 3 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 at semi-annual meeting
- February 2007 –
  - 2nd Sustainable Remediation Forum (SuRF) meeting
  - 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

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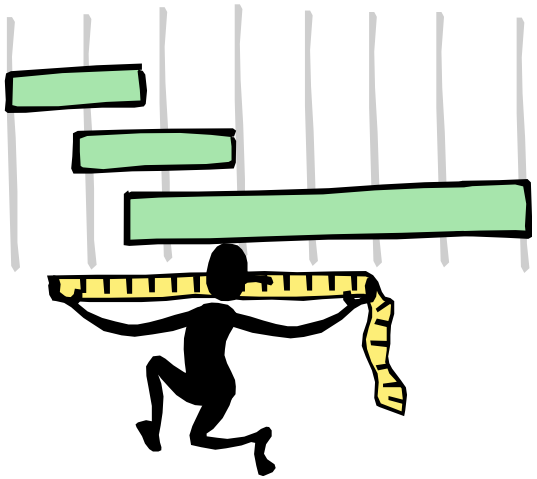
Objectives

- Develop sustainability framework
  - Factors (common language)
  - Measures
- Process for implementation



Sustainability Framework

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

Sustainability Measurement Factors

- Greenhouse Gases & Energy
  - CO_2
  - Energy
- Resources Consumed/Recycled
  - Soil & Solid Material
  - Land
  - Water

RCRA Remedy Selection Criteria

Threshold Criteria

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

Balancing Factors

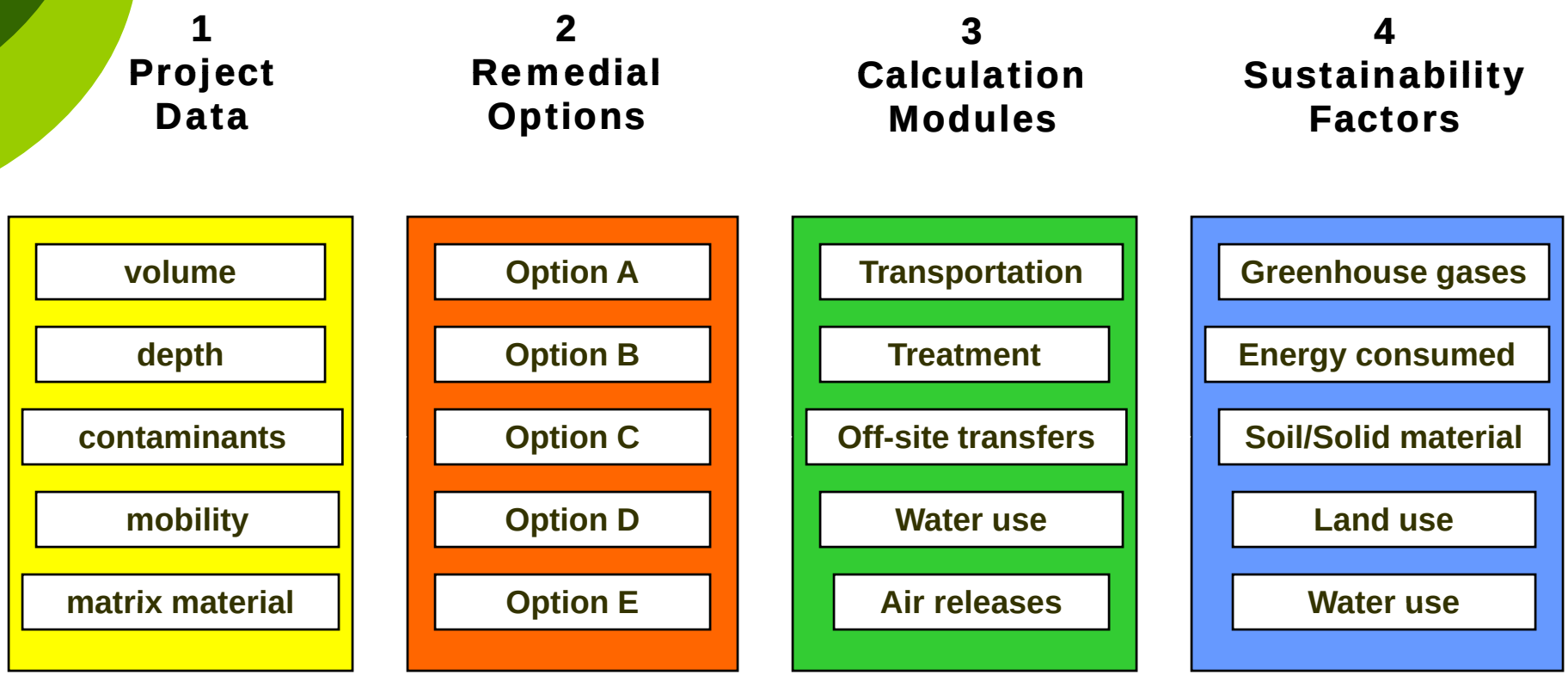
- Long-term reliability
- Reduction of toxicity, mobility or volume
- Short-term effectiveness
- Ease of implementation
- Cost
- Community acceptance
- State acceptance
- Sustainability


DuPont Martinsville, VA
Unit H1
North
Fire Training Area
DuPont Precision Concepts (DPC) Building
Smith River
1980's-1990's
Minneapolis
Detroit
Chicago
New York
Martinsville
Memphis
Charlotte
New Orleans
Jacksonville

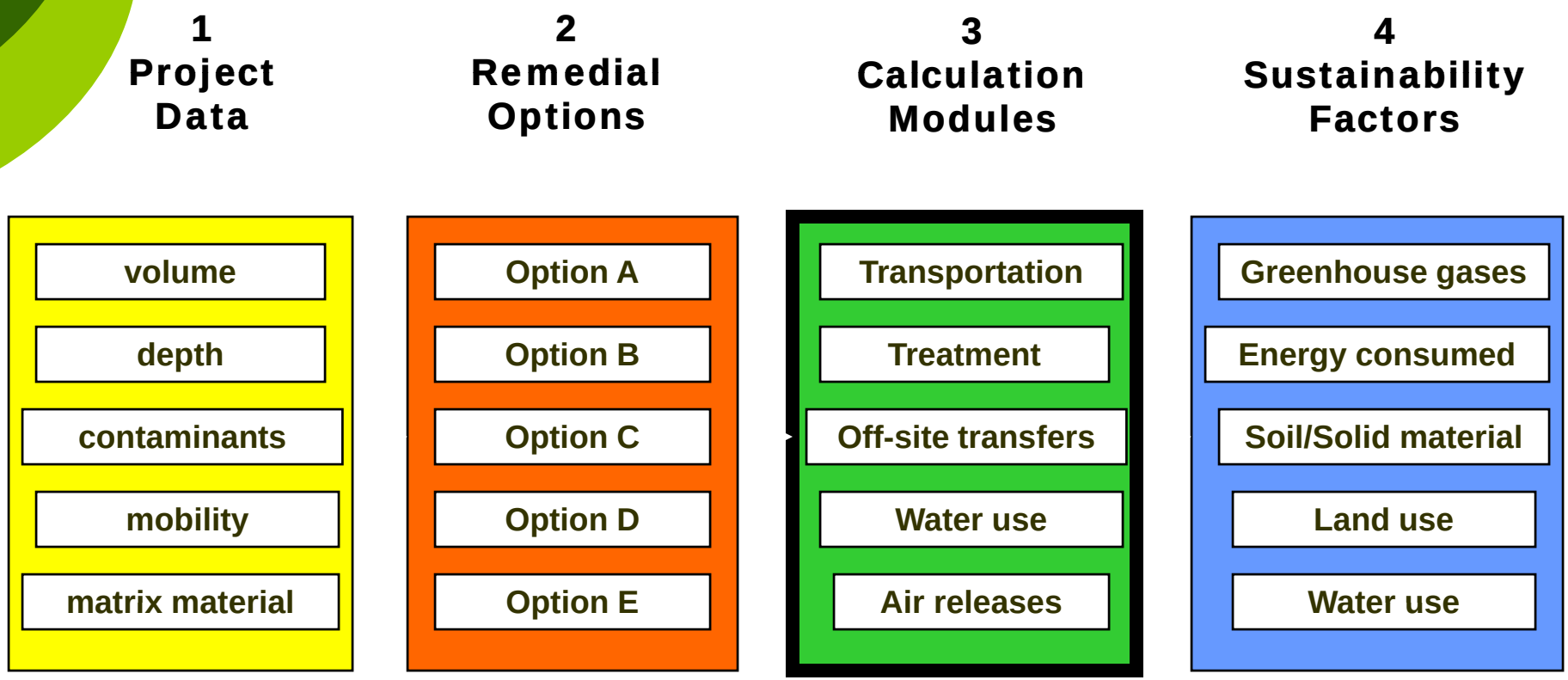
Credit & Debit Approach

Media or Impact	Credit (+)	Debit[1] (-)
Greenhouse Gases & Energy		
• **Carbon Dioxide** (CO_2 equivalents)	❑ Sequestered by plants ❑ Sequestered in-situ ❑ Destroyed GWP equivalents	❑ generated by fuel used during remediation ❑ generated by manufacturing of consumables
• **Energy** (kWh)	❑ Renewable energy generated on-site	❑ Required by remediation ❑ Required for manufacturing of consumables
Resources		
• **Soil/Solid Material** (tons)	❑ Reused-recycled soil or soil-substitute (crushed concrete)	❑ Off-site soil required ❑ Off-site disposal
• **Land** (acres)	❑ No limitations to anticipated use ❑ Wetlands created or upgraded ❑ Conservations easement	❑ Permanent limited use
• **Water** (gallons)	❑ Reused-recycled ❑	❑ public or surface water used ❑ groundwater for remedy – where resource is critical

Conceptual Framework for Sustainability Analysis

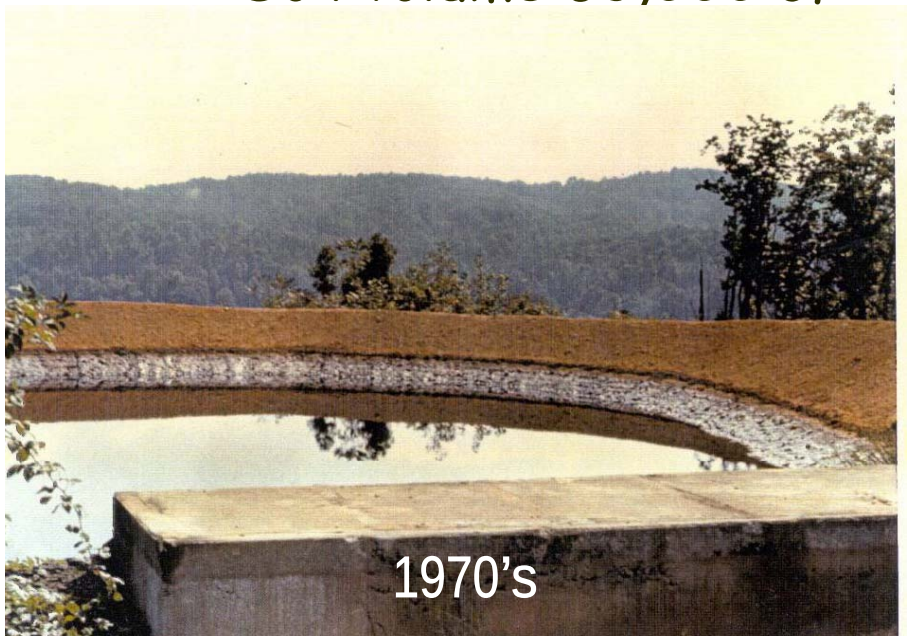


Conceptual Framework for Sustainability Analysis



Project Data - Unit H1

- Former finish oil disposal pond
- Chlorinated VOCs in soil & groundwater
- PCBs, arsenic (coal ash) in soil
- About 100' diameter; impacts 3.5 to 8 feet bgs
- Groundwater about 90' bgs
- Soil volume 63,000 cf



Remedial Options – Unit H1

Source remediation to meet MCLs throughout the plume

- Excavate (source material removal) and landfill + MNA
- Excavate & ex-situ thermal treatment + MNA
- Cap + MNA
- Soil vacuum extraction (SVE) + MNA
- Zero valent iron (ZVI) in-situ treatment + MNA

Calculation Module - ZVI + MNA

Media or Impact	Credit (+)	Debit (-)
Greenhouse Gases & Energy		
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Calculation Module - ZVI + MNA
Identify Components

Task	Item	Quantities
Mobilization and Site Prep	Time Staff Equipment	10 days 11 - 1 Super, 1 Eng'r, 9 Operators & Laborers Man lift, forklifts (2), crane, mix head, others
Crane and Mix Head Assembly	Time	5 day
Shallow Soil Mixing	Time Staff Equipment Materials	17 days 11 - 1 Super, 1 Eng'r, 9 Operators & Laborers Mix head/crane, fork lifts, excavator 70 ton ZVI, 50 ton bentonite, 200 ton kiln dust 130,000 gal water
Demob, including grading	Time Staff Equipment	4 days 11 - 1 Super, 1 Eng'r, 9 Operators & Laborers Excavator, man lift, forklifts (2), crane, mix head
Asphalt Paving	Time Staff Equipment Materials	4 days 8 - 1 Super, 1 Eng'r, 6 Operators & Laborers Asphalt spreader, backhoe and roller 6" subbase, 3" base coarse, 2" top coarse

Calculation Module – ZVI + MNA Quantify Components

Fuel from remedy

- Mobilization/demobe
- Soil mixing
- Regrading
- Sub-base installation
- Delivery of ZVI
- Delivery of kaolinite
- Delivery of flyash
- Sampling events

Gasoline (gallons)

Diesel (gallons)

CO_2 from consumables

- ZVI
- bentonite
- kiln dust

Process Model Examples - CO_2 Emissions

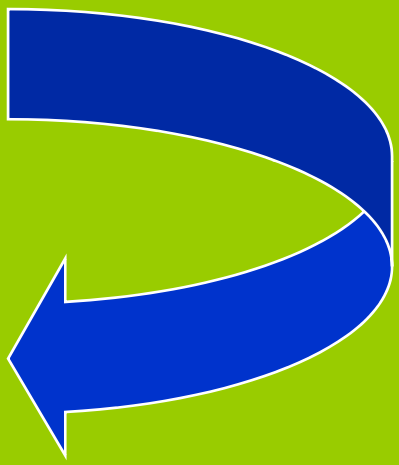
Combustion of Fuels			CO2 emissions				
Fuel	**Quantity**	**Unit**	**Pre-Combustion**	**Combustion**	**Total**	**Data Source**	Total GWP kg CO2 eq
			lb CO2	lb CO2	lb CO2		
Diesel	1000	Gal	3258	22543	25801	nrel.gov/lci	
Gasoline	1000	Gal	2776	17403	20179	nrel.gov/lci	
	Quantity	**Unit**	kg CO2	kg CO2	kg CO2		
Diesel	1	kg	0.46	3.18	3.64	nrel.gov/lci	
Gasoline	1	kg	0.46	2.86	3.31	nrel.gov/lci	
Propane	1	kg	0.48	3.00	3.48	ecoinvent	3.59
Consumables	**Quantity**	**Unit**	kg CO2	kg CO2	kg CO2		Total GWP kg CO2 eq
Electricity, US Average	1	kWh			0.85	nrel.gov/lci	0.861
Electricity, US Average	1	kWh			0.73	MSU data	0.77
Cement	1	kg			0.74	Ecoinvent	0.77
Concrete	1	cubic yard			195.47	Ecoinvent	202.53
HDPE Sheet	1	kg			2.41	Plastics Europe	2.47
High Alloy Steel Pipe	1	kg			4.99	Ecoinvent	5.31
Carbon Steel Pipe	1	kg			1.85	Ecoinvent	2.02
PVC pipe	1	kg			2.35	Industry data	2.58
Activated Carbon	1	kg			6.45	Kirk-Othmer,nrel.gov/lci	
Asphalt	1	USD			2.00	US Input-Output DB	2.49
Zero Valent Iron	1	kg			1.21	Ecoinvent	1.32
Kiln Dust	1	kg			0.74	Co-product of Cemer	0.77
Bentonite	1	kg			0.44	Ecoinvent	0.47
Transportation - Use the table below from NREL, then the combustion data above to get to energy and CO2							
	Quantity	**Unit**	lb CO2	lb CO2	lb CO2		
Xport - Tractor trailor	1000	ton-miles	34.2	236.7	270.9	nrel.gov/lci	
	10.5	Gal Diesel					
	Quantity	**Unit**	kg CO2	kg CO2	kg CO2		
Xport - Tractor trailor	1000	tonne-kg	0.009	0.059	0.068	nrel.gov/lci	
	18.67	Gal Diesel					
	Quantity	**Unit**	kg CO2	kg CO2	kg CO2		
Earthwork	1000	kg earth	0.244	1.688	1.932	Ecoinvent	
	0.53	kg Diesel					

Calculation Module – ZVI + MNA Greenhouse Gases

Fuel (gal) X CO_2 Conversion

Consumables (lbs) X CO_2 Conversion

CO_2 Released (ton equivalents)



ZVI Treatment → **170 CO_2 ton equivalents**

MNA → **5 CO_2 ton equivalents**

175 CO_2 ton equivalents

Calculation Module - ZVI + MNA

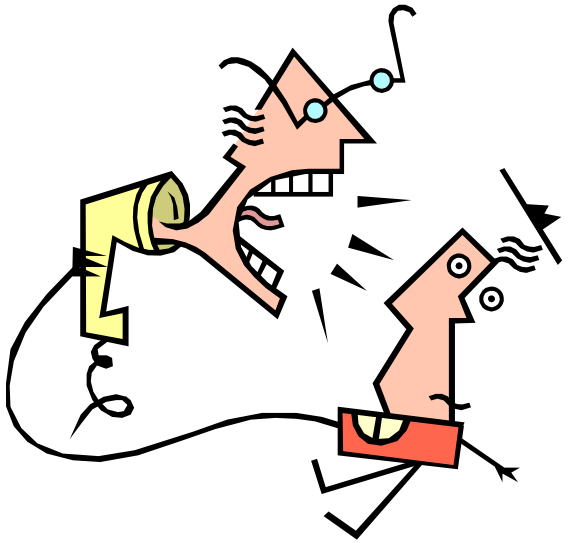
Media or Impact	Credit (+)	Debit (-)
Greenhouse Gases & Energy		
Carbon Dioxide (CO_2 equivalents)	0 CO_2 ton equivalents from contaminant destruction	175 CO_2 ton equivalents from remedy & consumables
Energy (kWh)	0 kWh of renewable energy generated	791,000 kWh of energy used by remedy & consumables
Resources		
Soil/Solid Material (tons)	0	200 tons of soil required to cap area
Land (acres)	<1 acre available for use	0 acres with permanent limited use
Water (gallons)	0 gallons reused/recycled	130,000 gallons of water used

Greenhouse Gases

	ZVI-Clay In Situ Treatment +MNA	Excavation & Off-Site Disposal +MNA	Ex-Situ Thermal Treatment + MNA	Soil Vapor Extraction + MNA	Capping + MNA
CO_2 Equivalents (tons)	175	255	595	165	29

Feedback

- Leads to more innovation
- Fosters collaborative process



- Dangerous – too much opportunity for monkey business
- Remedy at every site will be natural attenuation
- Slow down cleanup due to review time

Green Cleanup Goals

- minimize or eliminate use of non-renewable 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
- maximize the recycling of material
- encourage the use of remediation technologies that permanently destroy contamination

We Can Do Better