Air Force Center for Engineering and the Environment

Integrity - Service - Excellence

SRT™: Sustainable Remediation Tool

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Incorporating Sustainable Approaches in Site Remediation International Conference

November 10, 2009

AECOM GSI ENVIRONMENTAL CH2MHILL

Project Team

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The Problem…

Historical approach to contaminated sites does not fully consider sustainability concepts.

A Solution…

Develop tool to help AFCEE environmental professionals incorporate sustainability concepts into their remediation decision making process (e.g., PBM, RRM, ERP-O) for

i) planning future remediation implementation

ii) optimizing operating remediation sites

AFCEE SRT:
The Basics

What the Tool Does

Sustainability metrics developed:

1. Carbon dioxide emissions to atmosphere
2. No_x emissions to atmosphere
3. SO_x emissions to atmosphere
4. PM_{10} emissions to atmosphere
5. Total energy consumed
6. Change in resource service
7. Technology cost
8. Safety / Accident risk

What the Tool Does

Estimates sustainability metrics for specific technologies:

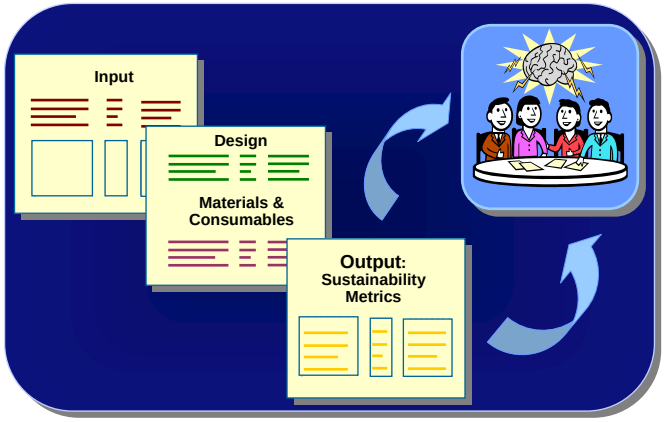
Soil

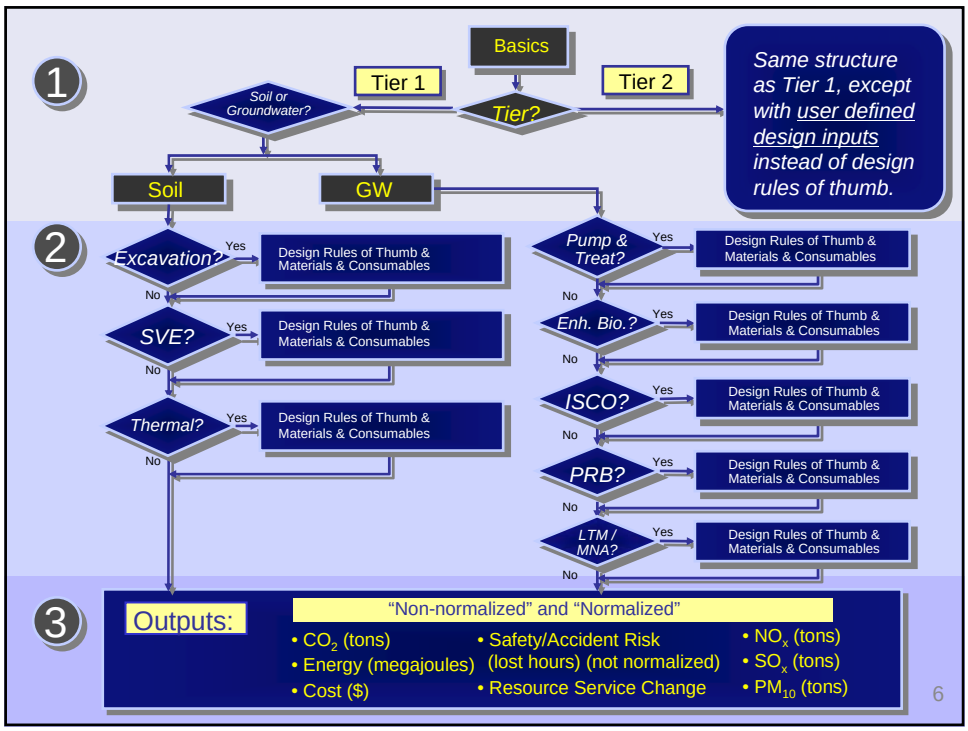
- Excavation
- Soil Vapor Extraction
- Thermal Treatment

Groundwater

- Pump and Treat
- Enhanced Bioremediation
- In Situ Chemical Oxidation
- Permeable Reactive Barrier
- Monitored Natural Attenuation / Long-term Monitoring

Tool Structure





AFCEE SRT:

How Does It Work?

Example Carbon Emission Calculation

$$2{,}500 \text{ lb PVC} \times \frac{2 \text{ lb } CO_2}{1 \text{ lb PVC}} \times \frac{0.453 \text{ kg}}{1 \text{ lb}} \times \frac{0.001 \text{ metric ton}}{1 \text{ kg}} = 2 \text{ metric tons } CO_2 \text{ emitted}$$

"Non-normalized" natural units

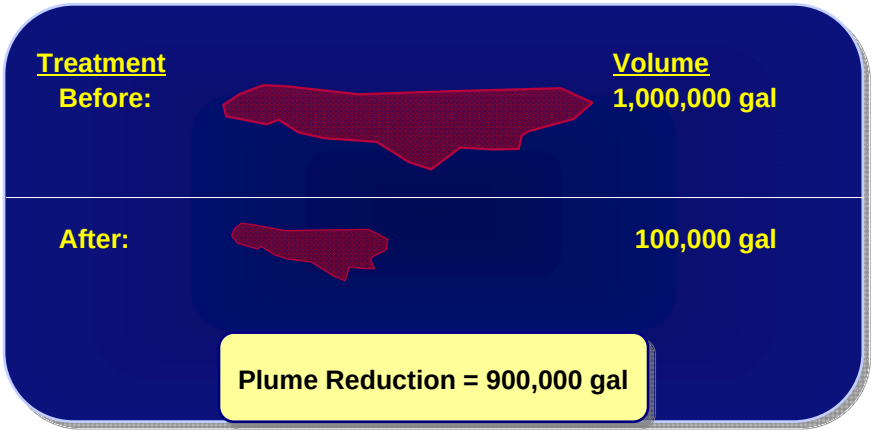
$$\times \frac{\$6}{1 \text{ ton } CO_2} = \$12 \ CO_2 \text{ offset}$$

"Normalized" $ units

AFCEE SRT:

How Does It Work?

Example Resource Service Metric



AFCEE SRT:

The Basics

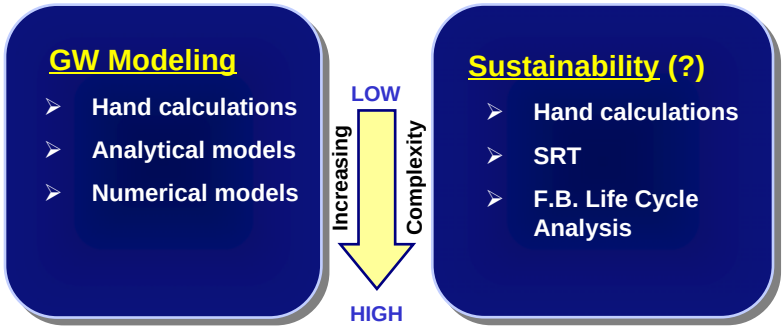
Like RBCA Toolkit!

Framework: Tiers of Varying Detail

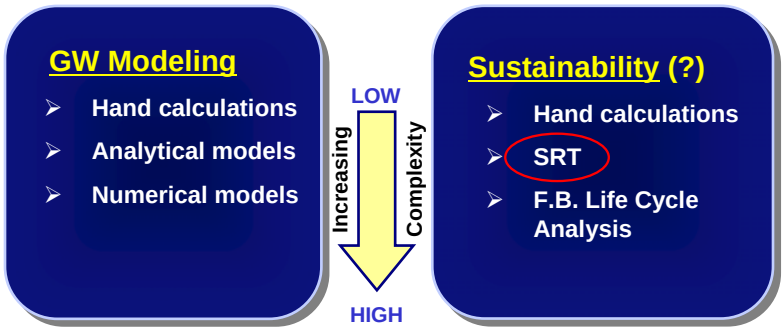
	Tier 1	Tier 2
Calculation Basis:	"Rules of Thumb"	User-entered detailed design
Time Required:	1 - 2 hrs	1 - 2 days

Tier 1 Advantages	Tier 2 Advantages
✓ Shorter execution than Tier 2 ✓ Extensive built-in defaults ✓ Simpler user inputs ✓ Most appropriate before a Feasibility Study	✓ More site-specific results ✓ More default user-overrides ✓ Most appropriate after a Feasibility Study ✓ More appropriate for optimization of existing systems

Levels of Complexity for Calculation Tools



Levels of Complexity for Calculation Tools



AFCEE SRT:

Case Study

Tier 2 Case Study – Groundwater Only

Inputs:

- Primary contaminant: trichloroethene (TCE)
- 2,300 m^3 source zone
- Typical concentration: 100 mg/kg
- Well-graded sand
- Average contaminated thickness: 6 meters
- Groundwater plume: 100 $x10^6$ liters and shrinking
- 1 hectare wetland is impacted by discharge

Evaluation:

- Thermal Treatment (1 year)
  compared with
- Monitored Natural Attenuation (30 years)
  - Monitoring twice per year

Key Question: What are the effects of a short, intensive treatment versus MNA?

AFCEE SRT:

Case Study

Thermal Treatment: "Non-normalized" Metrics

CO_2 Emissions……1,300 tons
kg CO2 /kg dissolved mass……..3,400 kg / kg

NO_x Emissions……7.4 tons
SO_x Emissions……14 tons
PM_{10} Emissions……2.6 tons
Energy Consumed……..20,000,000 Megajoules

Cost……$560,000
Cost / lb contaminant……$1520 / kg

Safety / Accident Risk……1 x 10^{-4} injury risk
Lost work-time……..0.005 lost hours

Change in Resource Service
Plume volume reduction……..90% reduction
Wetland……Restored 1 hectare

AFCEE SRT:

Case Study

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AFCEE SRT:

Case Study

Thermal Treatment: "Normalized" Metrics

CO_2 Emissions……..$2,600
Energy Consumed……..$180,000
Cost (minus energy costs)……..$380,000
Change in Resource Service
Economic gain…….. -$16,000
Ecologic gain…….. -$55,000

Gains reduce the total cost

TOTAL $492,000

Converting metrics to dollars gives a common baseline.

AFCEE SRT:

Case Study

Monitored Natural Attenuation: "Non-normalized" Metrics

CO_2 Emissions……2.6 tons
kg CO2 / kg dissolved mass……3 kg / kg

Energy Consumed……30,000 Megajoules

Cost……$370,000

Safety / Accident Risk……2.7 x 10^{-3} injury risk
Lost work-time……0.13 lost hours

Change in Resource Service
Plume volume reduction……90% reduction
Wetland……Restored 1 hectare

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AFCEE SRT:

Case Study

Monitored Natural Attenuation vs. Thermal: "Normalized" Metrics

	MNA	*Thermal*
CO_2 Emissions	**$5**	***$2600***
Energy Consumed	***$370***	***$180,000***
Cost (minus energy costs)	**$370,000**	***$380,000***
Change in Resource Service		
Economic gain	**-$1,600***	***-$1600***
Ecologic gain	**-$55,000***	***-$55,000***
TOTAL	**$341,000**	***$492,000***

***However, this benefit occurs 30 years from now….**

Stakeholders can then decide whether varm rengør or naturlig rengør is better for the given site!

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AFCEE SRT:

Case Study

Monitored Natural Attenuation vs. Thermal: "Normalized" Metrics

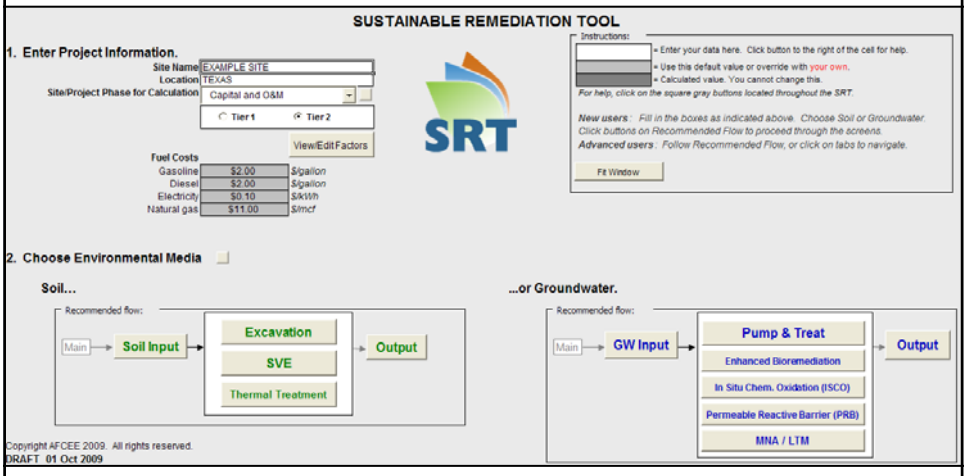
	MNA	Thermal
CO_2 Emissions	[illegible]	$2600
Energy Consumed	[illegible]	$180,000
Cost (minus energy c[illegible]	[illegible]0,000	$380,000
Change in Resource Serv[illegible]		
Economic gain	-$6,500	-$1600
Ecologic gain	-$22,000	-$55,000
TOTAL	$34[illegible]00	$492,000

Con[illegible]g metrics to dollars gives a common [illegible]line.

Stakeholders can then decide whether varm rengør [illegible] naturlig rengør is better for the given site!

AFCEE SRT:

Case Study



AFCEE SRT:
Case Study

SOIL/SOURCE INPUT

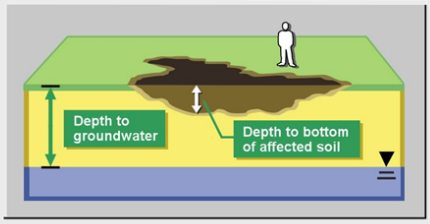
EXAMPLE SITE
TEXAS

Area of Affected Soil	4050	ft^2
Depth to Top of Affected Soil	5	ft
Depth to Bottom of Affected Soil	25	ft
Depth to Groundwater	20	ft
Soil Type	Sand (well graded)	
Contaminant Class	CVOCs	
Max Concentration	200	mg/kg
Typical Concentration	100	mg/kg
Contaminant mass	810.	lbs
Calculate natural resource service?	Yes / No	
Land Value (in current state)	$10,000	$/acre
Increase in economic value due to project	Medium	
Benefit to ecological service value due to project	Medium	
Current ecosystem setting	Cropland	
Future ecosystem setting	Cropland	

Instructions:
= Enter your data here. Click button to the right of the cell for help.
= Use this default value or override with your own.
= Calculated value. You cannot change this.

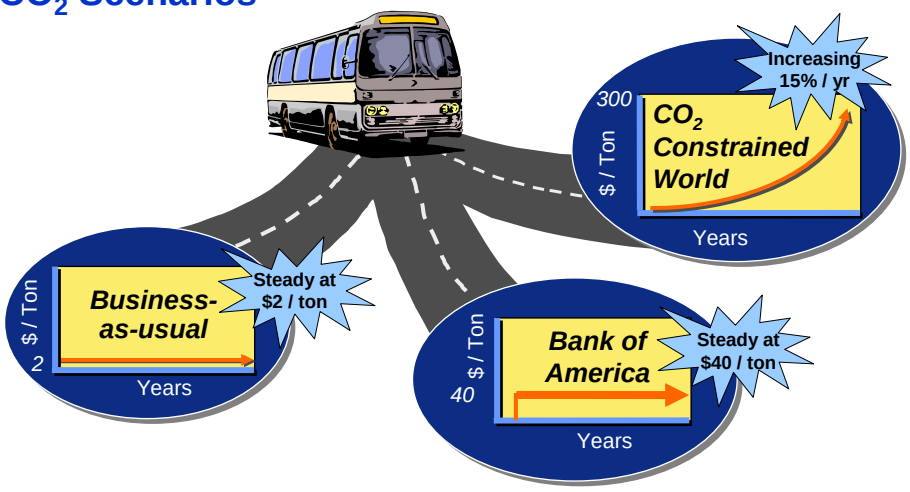
Paste Tier 2 Example
Clear Soil Inputs

Recommended flow:
You are here
Main → Input → Next: Choose Technologies (Excavation, Soil Vapor Extraction, Thermal Treatment >>) → Results



AFCEE SRT:
Features

CO_2 Scenarios



EXAMPLE:
CO_2 Scenarios and Net Present Value Calculations

Using a given capitalization rate, the tool calculates the net present value of CO_2 offset costs in three different future scenarios.

NPV CALCULATION - CARBON DIOXIDE EMISSIONS

Capitalization Rate	0.03	
Business as Usual	2	$ per ton per year (base rate)
Bank of America	40	$ per ton per year
Carbon Constrained World	0.15	increase after Year 1

PUMP AND TREAT[1]

Capital phase	230	tons CO2
O&M phase	1100	tons CO2 pe
Duration	47	years

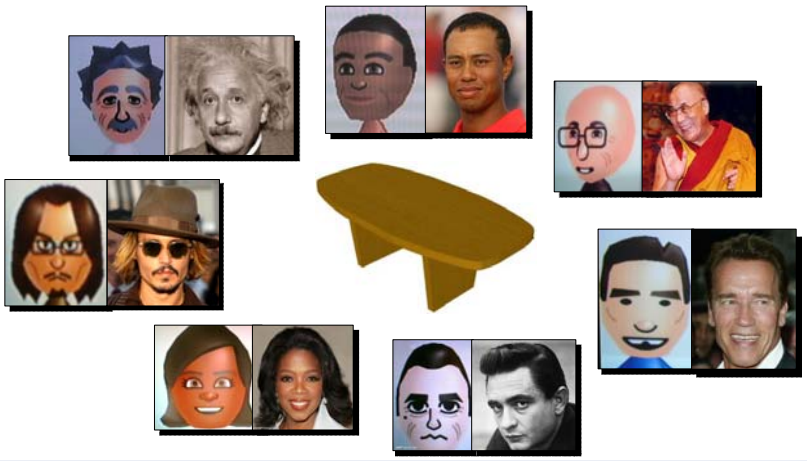
	Business as Usual	Bank of America	Carbon Constrained World
No NPV:	$100,000	$2,100,000	$10,000,000
NPV[3]:	$56,000	$1,100,000	$3,200,000

CO_2 Scenario Values

Net Present Value Calculations

[1] Pump & Treat calculations assume all PVC, Steel, Diesel, and capital-phase gasoline are used in capital phase; all other materials and fuel are used in O&M phase.

Stakeholder Conference Table



Stakeholder Roundtable Feature: Reaching a Consensus

GROUNDWATER ROUND TABLE - WEIGH THE RESULTS

	Person 1	Person 2	Person 3	Person 4	Person 5
Carbon Dioxide Emissions to Atmosphere	High	Medium	Low	Don't Use	Medium
Total Energy Consumed	Medium	Low	Don't Use	High	Medium
Technology Cost	Low	Don't Use	High	Medium	Low
Change in Resource Service for Land	High	Medium	Low	Don't Use	High

Stakeholder Roundtable Feature: Reaching a Consensus

Monitored Natural Attenuation / Long-term Monitoring

Normalized/Cost-based Starting Point

Carbon Dioxide Emissions to Atmosphere	$5.2	*dollars*
Total Energy Consumed	$400.	
Technology Cost	$370,000.	
Change in Resource Service	$170,040.	
	$200,000.	

Consensus (Average) Results

$4.7	dollars
$360.	
$300,000.	
$200,000.	
$100,000.	

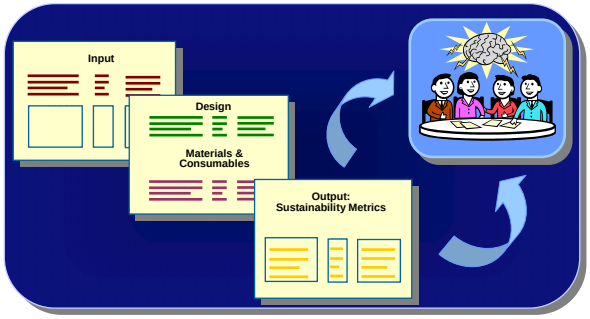
KEY POINT:

Starting cost is different than consensus cost

Is it free? - Yes!

The tool is available as a free download from the US Air Force to all interested parties.

http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/index.asp



or Google:

SRT AFCEE

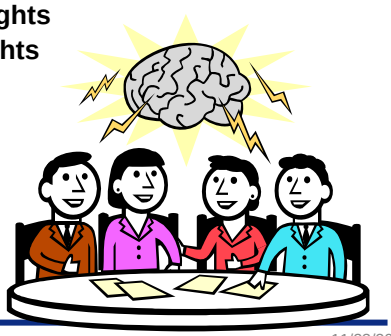
or email me
cjnewell@gsi-net.com

Questions / Discussion

Stakeholder Conference Table

- Customizable Stakeholders
  - Visual Representation
  - Metric Weights
  - Output Comparison of Weights
- Poll of Stakeholder Input Weights
  - AFCEE PPC Tool



Where We Are

Where We Are

- Release of SRT
  - Released May 2009
  - Available at http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/

Where We Are Going

- Testing of version 2
- Integration with RACER™ costing tool

Example Carbon Dioxide Emission Calculation

$$10{,}000 \text{ lb PVC} \times \frac{2 \text{ lb } CO_2}{1 \text{ lb PVC}} \times \frac{0.453 \text{ kg}}{1 \text{ lb}} \times \frac{0.001 \text{ metric ton}}{1 \text{ kg}}$$

= 9 metric tons CO_2 emitted "Non-normalized" natural units

$$\times \frac{\$2}{1 \text{ ton } CO_2} = \$18 \ CO_2 \text{ offset}$$ "Normalized" $ units

Example NO_x Emission Calculation

$$10{,}000 \text{ lb PVC} \times \frac{0.003 \text{ lb } NO_x}{1 \text{ lb PVC}} \times \frac{0.453 \text{ kg}}{1 \text{ lb}} \times \frac{0.001 \text{ metric ton}}{1 \text{ kg}}$$

= 0.014 metric tons NO_x emitted "Non-normalized" natural units

"Normalized" natural units: *not calculated*

Example SO_x Emission Calculation

$$10{,}000 \text{ lb PVC} \times \frac{0.011 \text{ lb } SO_x}{1 \text{ lb PVC}} \times \frac{0.453 \text{ kg}}{1 \text{ lb}} \times \frac{0.001 \text{ metric ton}}{1 \text{ kg}}$$

= 0.05 metric tons SO_x emitted "Non-normalized" natural units

"Normalized" natural units: *not calculated*

Example PM_{10} Emission Calculation

$$10{,}000 \text{ lb PVC} \times \frac{0.0002 \text{ lb } PM_{10}}{1 \text{ lb PVC}} \times \frac{0.453 \text{ kg}}{1 \text{ lb}} \times \frac{0.001 \text{ metric ton}}{1 \text{ kg}}$$

= 0.0009 metric tons PM_{10} emitted "Non-normalized" natural units

"Normalized" natural units: *not calculated*

How Does It Work?

Example Energy Consumed Metric

32 gal gas x $\frac{150\ MJ}{1\ gal\ gas}$ = 4,800 MJ energy

"Non-normalized" natural units

32 gal gas x $\frac{\$2.00}{1\ gal\ gas}$ = $64

"Normalized" $ units

How Does It Work?

Example Resource Service Metric

Treatment	Volume
Before:	1,000,000 gal
After:	100,000 gal

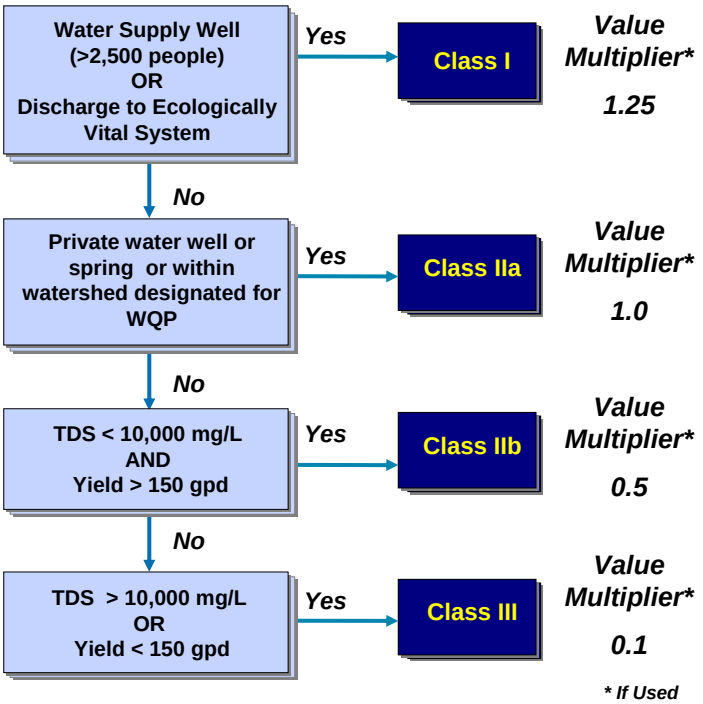
Plume Reduction = 900,000 gal

AFCEE SRT:

How Does It Work?

GW Resource Value Calc

(GW Classes from U.S. EPA, 1986)



AFCEE SRT:

How Does It Work?

Safety / Accident Risk Example

(1,000 hrs worked + 400 hrs traveled) x $\frac{2.7 \times 10^{-9} \text{ injuries}}{1 \text{ hr worked}}$

+ (100 miles traveled) x $\frac{91 \text{ injuries}}{100{,}000{,}000 \text{ VMT}}$

= 9.5×10^{-5} injuries

"Non-normalized" natural units

"Normalized" natural units: *not calculated*

Risk of non-fatal injuries derived from the US Bureau of Labor, 2006

AFCEE SRT:

Case Study

Monitored Natural Attenuation / Long-term Monitoring: "Non-normalized" Metrics

CO_2 Emissions……2.6 tons
kg CO2 /kg dissolved mass……3 kg/ kg

NO_x Emissions……0.0025 tons
SO_x Emissions……0.0032 tons
PM_{10} Emissions……0.0002 tons

Energy Consumed……30,000 Megajoules

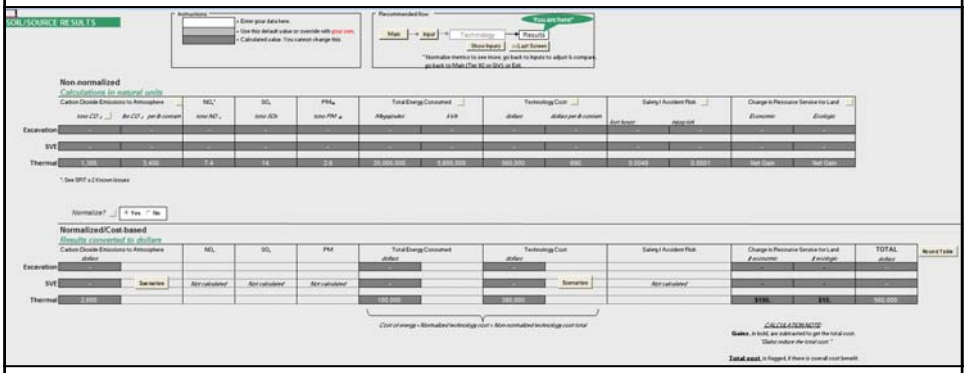
Cost……$370,000
Cost /kg contaminant……$460 / kg

Safety / Accident Risk……2.7×10^{-3} injury risk
Lost work-time……0.13 lost hours

Change in Resource Service
Plume volume reduction……90% reduction
Wetland……Restored 1 hectare

AFCEE SRT:

Case Study



Non-normalized

Calculations in natural units

	Carbon Dioxide Emissions to Atmosphere		NO_x	SO_x	PM_{10}	Total Energy Consumed	
	tons CO_2	*lbs CO_2 per lb contam*	*tons NO_x*	*tons SO_x*	*tons PM_{10}*	*Megajoules*	*kWh*
Excavation	-	-	-	-	-	-	-
SVE	-	-	-	-	-	-	-
Thermal	1,300.	3,400.	7.4	14.	2.6	20,000,000.	5,600,000.

Normalize? (•) Yes ( ) No

Normalized/Cost-based

Results converted to dollars

	Carbon Dioxide Emissions to Atmosphere		NO_x	SO_x	PM	Total Energy Consumed
	dollars					*dollars*
Excavation	-					-
SVE	-	Scenarios	*Not calculated*	*Not calculated*	*Not calculated*	-
Thermal	2,600.					180,000.

AFCEE SRT:

Case Study

Non-normalized

Calculations in natural units

	Carbon Dioxide Emissions to Atmosphere		NO_x	SO_x	PM_{10}	Total Energy Consumed	
	tons CO_2	*lb CO_2 per lb dissolved mass*	*tons NO_x*	*tons SO_x*	*tons PM_{10}*	*Megajoules*	*kWh*
Pump & Treat	-	-	-	-	-	-	-
Enhanced Bio.	-	-	-	-	-	-	-
ISCO	-	-	-	-	-	-	-
PRB	-	-	-	-	-	-	-
MNA / LTM	2.6	2.9	0.0025	0.0032	0.0002	30,000.	8,300.

Normalized/Cost-based

Results converted to dollars

	Carbon Dioxide Emissions to Atmosphere		NO_x	SO_x	PM	Total Energy Consumed	
	dollars	Scenarios				*dollars*	Scenarios
Pump & Treat	-					-	
Enhanced Bio.	-					-	
ISCO	-		*Not calculated*	*Not calculated*	*Not calculated*	-	
PRB	-					-	
MNA / LTM	$5.2					$400.	

AFCEE SRT:

Features

Energy Scenarios