INTERSOL 2011

Environmental Forensics March 28th 2011

SOIL POLLUTION AND ENVIRONEMENTAL FORENSICS

SCOPE OF LITIGATIONS, EVIDENCE MANAGEMENT, DAMAGE AND REMEDIATION

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INTERSOL – LYON March 28th 2011

SUMMARY

- SCOPE OF LITIGATIONS
  - What are soil pollutions issues
  - Where Environment Forensics has to apply
- PROVIDING AND MANAGING EVIDENCE
- DAMAGE ASSESSMENT AND REMEDIATION

What is a polluted site

- A polluted site is a site which, because of former deposits of waste or infiltration of polluting substances presents a nuisance or a long-lasting risk for people or the environment (French ministry of Environment)

- A polluted site, although after remediation schem has been conducted remains a polluted site
  - Monitoring must be driven on the long range
  - Future brekthrough in environmental (and other) sciences may lead to additonal interventions

FIELD AND SCOPE OF LITIGATION

- As the Environmental Liability Directive (ELD) deals with the "pure ecological damage", it is based on the powers and duties of public authorities ("administrative approach") as distinct from a civil liability system which is more appropriate for "traditional damage" (damage to property, economic loss, personal injury).
- Civil liability system will encompass “traditional damages” pending front of civil courts
- Anyway an administrative court can be seized in a indirect way by a request concerning private damage
- So litigation may appear ont both grounds
  - Of environmental liability and environmentally specific issues
  - Of civil liability on common grounds (loss of amenity, value…)

FIELD AND SCOPE OF ENVIRONMENTAL FORENSICS - LITIGATION

- Technical advice to courts and tribunals
- Technical advice to plaintiffs
  - Before filing a lawsuit
  - During the process of a law suit

- Technical advice to stake holders / public agencies, before or during a public procedure (hearing, public inquiry)
  - Helping to reach a sound decision
  - Preventing further environmental damages

INTERVENTION DRIVERS SCHEME OF RELATIONS

Stake holders / **Damages**	Labour force	Customer	Media Relay of opinion	Third parties	Government Public agencies
Labour force	⊕	X	↔		↔
Private property	○ ↔	○ ↔	↔	○	
Public property	↔	X ↔	□	□	⧖ ◇
Physical media, air, water, soil		⧖ ↔	□	□	⧖ ◇

Compulsory insurance ⊕

Mitigation, remediation ⧖

Communication ↔

Civil liability ○

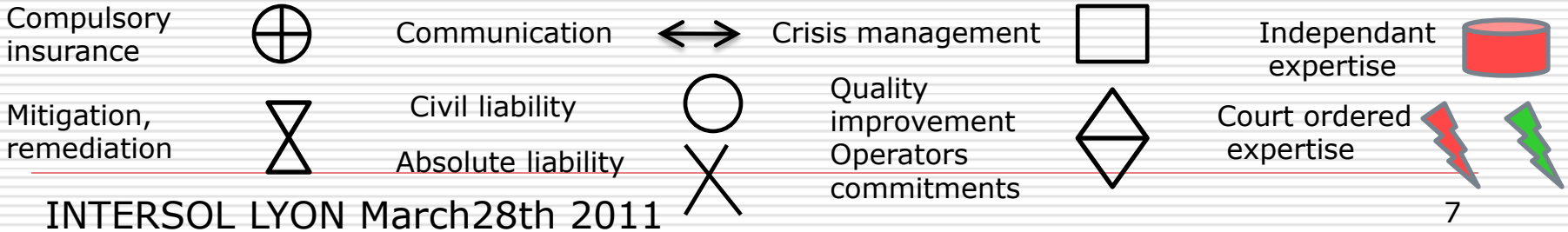
Absolute liability X

Crisis management □

Quality improvement Operators commitments ◇

INTERVENTION DRIVERS WHERE ENVIRONMENTAL FORENSICS APPEARS

Stake holders / **Damages**	Labour force	Customer	Media Relay of opinion	Third parties	Government Public agencies
Labour force					
Private property					
Public property					
Physical media, air, water, soil					



ENVIRONMENTAL FORENSICS

- Related first to litigation
- Litigation occurs mainly
  - When prevention has failed
  - When a consent, a contract has been flawed by lack or improper information, lack of transparency
  - When damages occured and were left without proper remediation

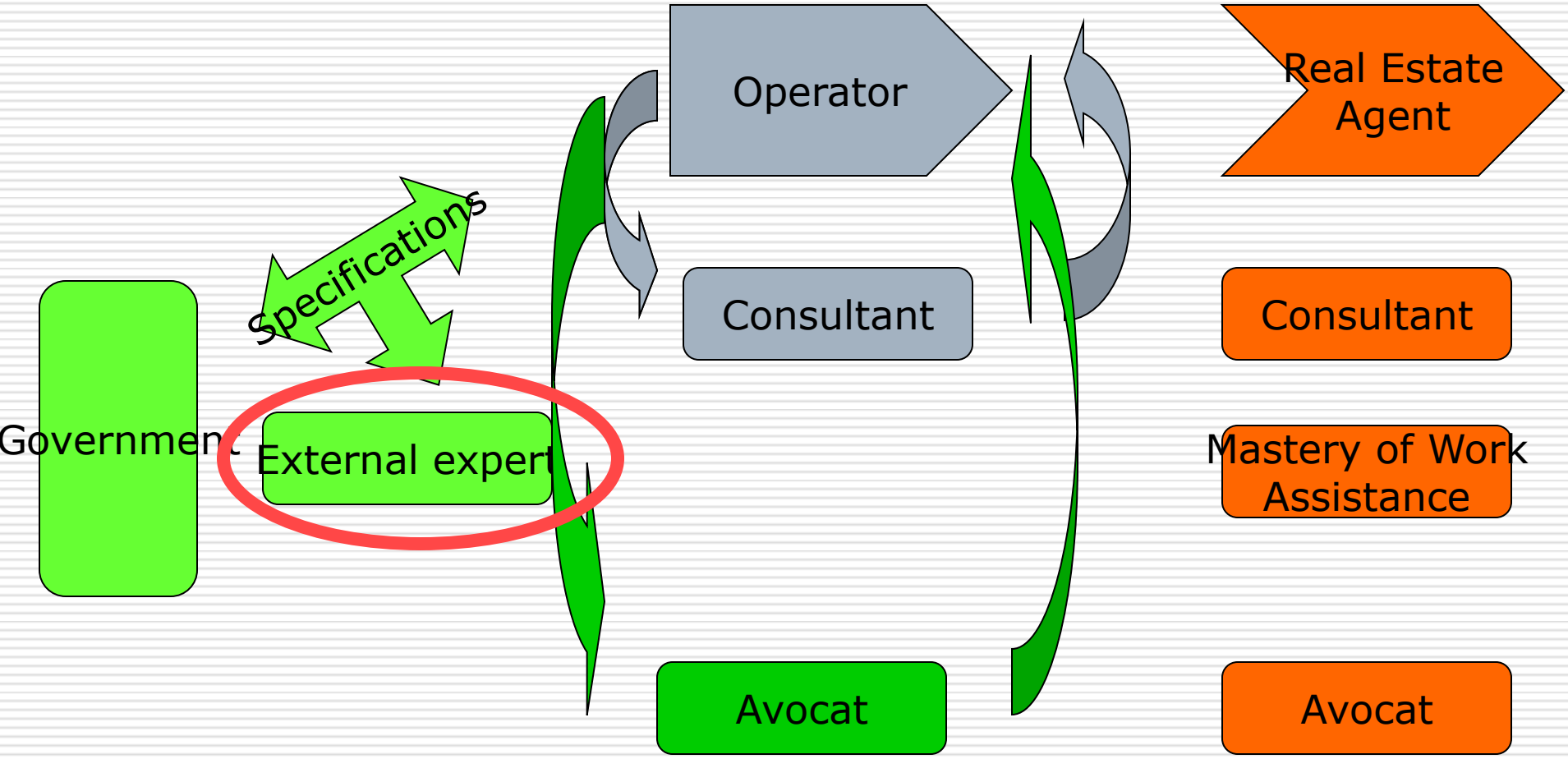
INDEPENDANT EXPERTISE

- Prevention process :
  - Environment Impact Statement
  - End of operation Application
  - Intervention during public hearing or public inquiry
- Litigation
  - Independant expert – expert of the Court (Latin system)
  - Expert witness (Anglo saxon system)

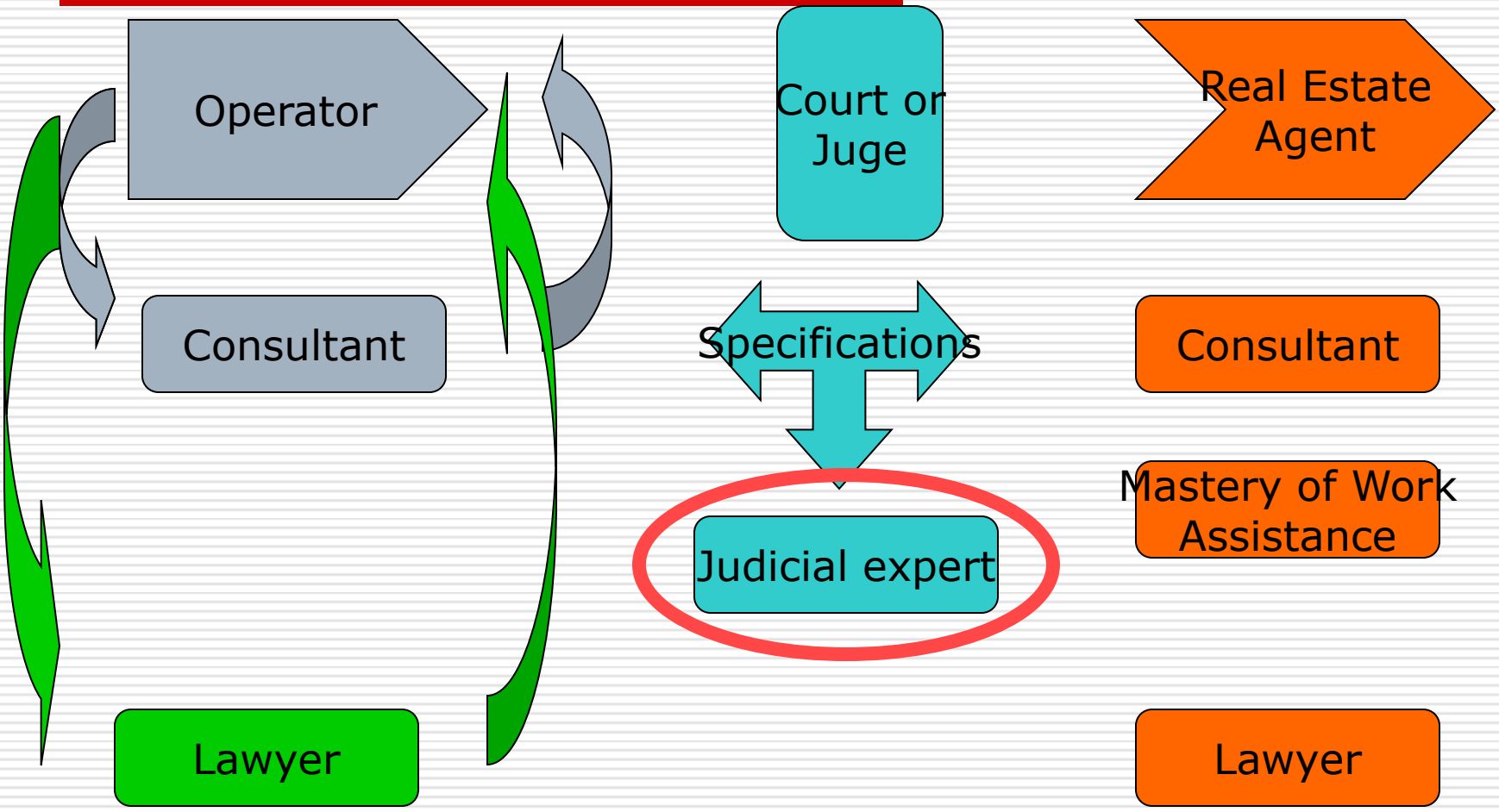
TYPOLOGY OF LITIGATIONS

- Buy and sell, real estate
- Remediate or mitigate
  - An existing pollution
  - A damage occured (to public or private property)
- Challenge administrative decisions
  - Lack of enforcement, lack of prevention
  - Improper or excessive enforcement

Environmental Forensics in the process : between Government agency and former operator



Environmental Forensics in the process : between Operator an Real Estate agent



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PROVIDING AND MANAGING EVIDENCE : What is environmental expertise

- Environmental expertise is
  - A Multidisciplinary approach
  - A project by itself with various contributors, inputs, objectives and results
  - An intervention led on a project management basis with
    - Costs
    - Time span
    - Results (answers to provide)
  - Answering two fold issues, both social, technical

PROVIDING AND MANAGING EVIDENCE Conducting environmental expertise : « an independant project »

- Environmental expertise, when needed, is a project inside a more complex operation
- Environmental expertise considered as environmental forensics must
  - Be conducted in an independant way (granting stakeholders both independance and appearances of independance)
  - So be separated from consulting or engineering tasks

PROVIDING AND MANAGING EVIDENCE :

- Checking inputs
- Issuing specifications for further investigations or technical results
- Assessing as is situation :
  - Compliance with regulations
  - Compliance with standarts and best practices when results are at stake or challenged

PROVIDING AND MANAGING EVIDENCE :

- Adding a valuable insight in a generally complex process, helping to overcome discrepancies
- Understanding the general values and constraints of environmental litigation, assessment, remediation, the concept of sustainability

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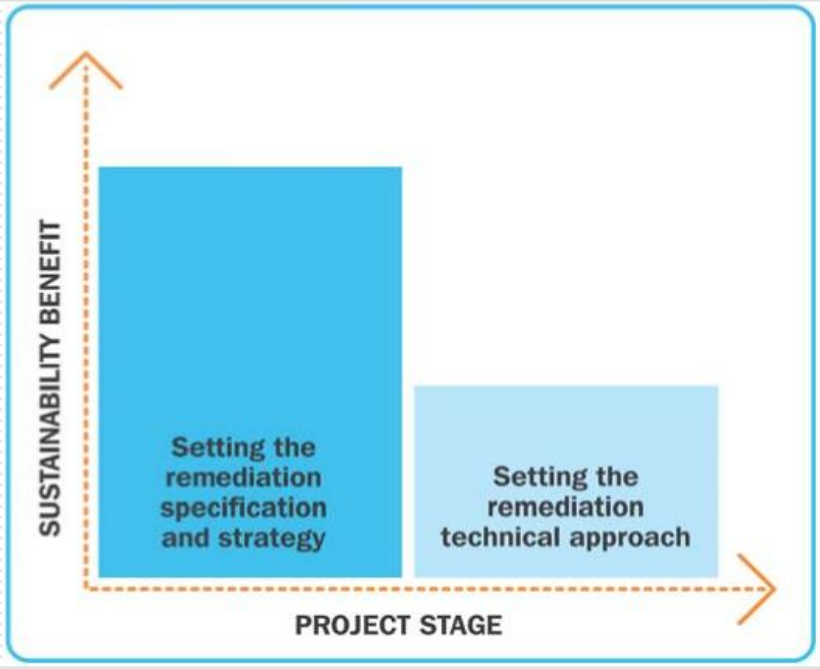
DAMAGE AND REMEDIATION : Two examples on the ground of sustainability

- EUROPEAN EXAMPLE : NICOLE (Network for Industrially Contaminated Soils in Europe) WORKSHOP www.Nicole.org road map for sustainable Remediation
- US EXAMPLE : AFCEE (Air Force Center for Engineering and Environment) http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/srt/index.asp afcee
  - Performance tracking tool
  - Sustainable remediation tool

EUROPEAN EXAMPLE : ROAD MAP FOR SUSTAINABLE REMEDIATION



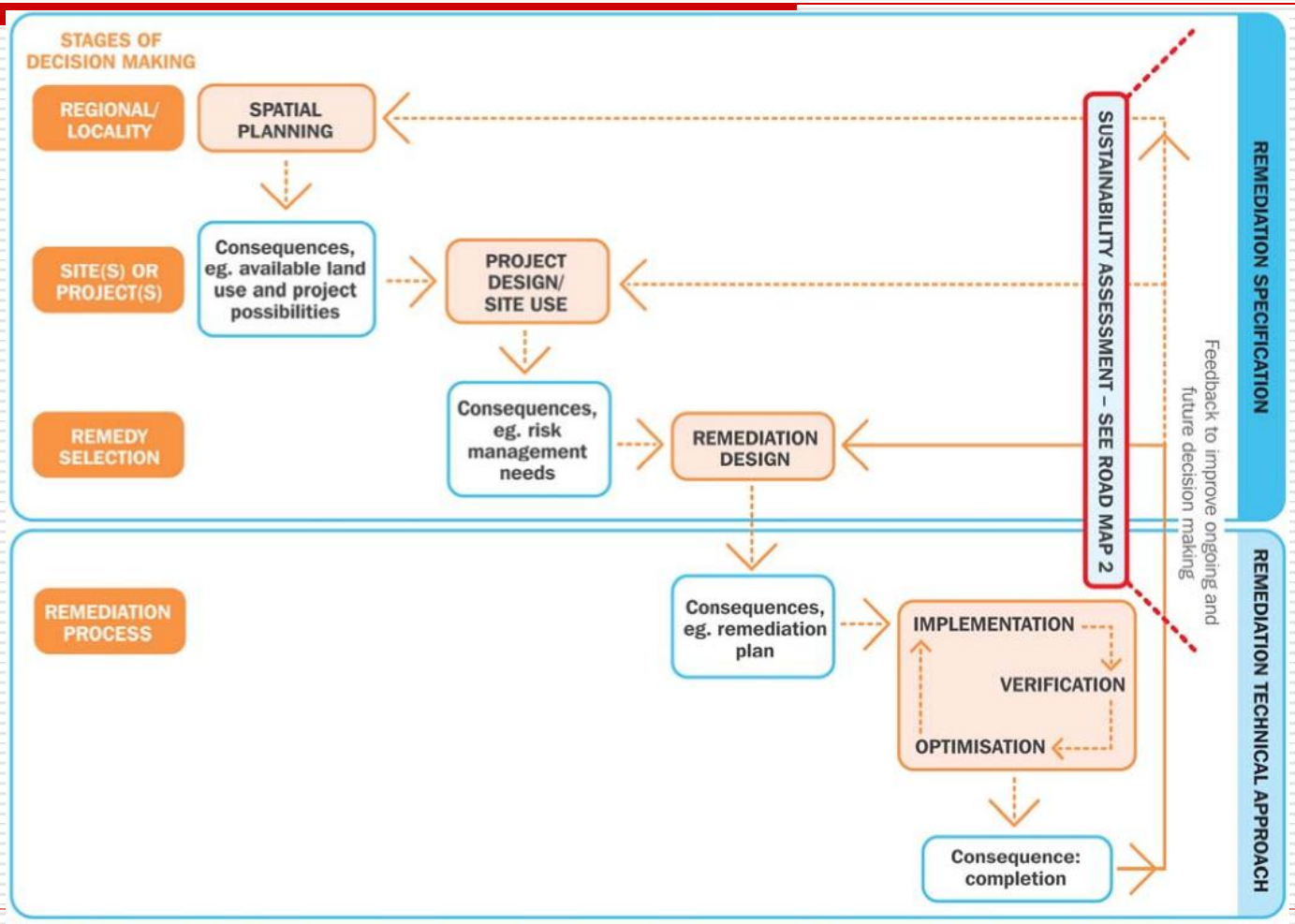
Sustainability gain dependent on the stage of the project at which it is introduced

Similar to the concept of risk management and risk assessment, sustainable remediation can be divided into two inter-related components:

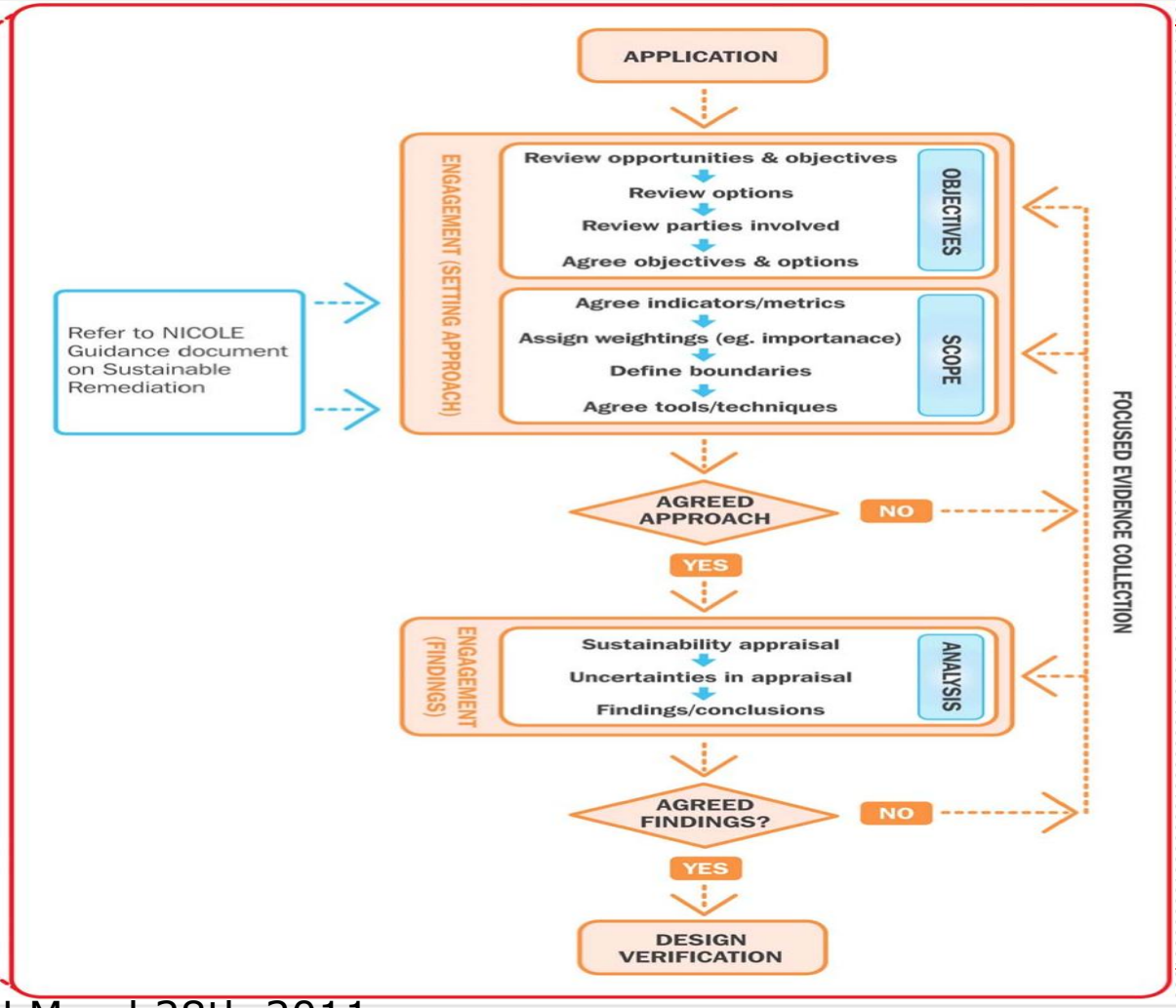
a. *Sustainability management:* the discipline of integrating sustainability assessment into contaminated land management decision making

b. *Sustainability assessment:* the process of gaining an understanding of possible outcomes across all three elements (environmental, social and economic) of sustainable development.

ROADMAP FOR SUSTAINABILITY MANAGEMENT



DAMAGE ASSESSMENT & REMEDIATION Sustainability assessment



DAMAGE ASSESSMENT & REMEDIATION **Sustainability assessment**

- Demonstrating a sustainability gain builds trust and therefore support from stakeholders.
- Sustainability assessment is a tool used for understanding sustainability impacts and benefits. As sustainability assessment is essentially a *subjective* process, transparency in the sustainability assessment approach greatly improves the chances of agreement between all stakeholders, and an acceptable and durable decision.
- The sustainability assessment component of NICOLE's Road Map recommends a simple process to help establish an agreed view between the different project stakeholders. It includes two broad stages.

DAMAGE ASSESSMENT & REMEDIATION **Sustainability assessment**

- First stage :
  - the stakeholders are identified
  - the objectives and the scope of the sustainability assessment are agreed with these parties.
- Objective setting includes:

i. making sure that everyone who should be, is involved;

ii. agreeing the sustainable development opportunities and objectives for the project;

iii. agreeing the range of possible options that are going to be compared, for example remediation methods;

iv. setting out a common understanding of purpose (objectives and options).

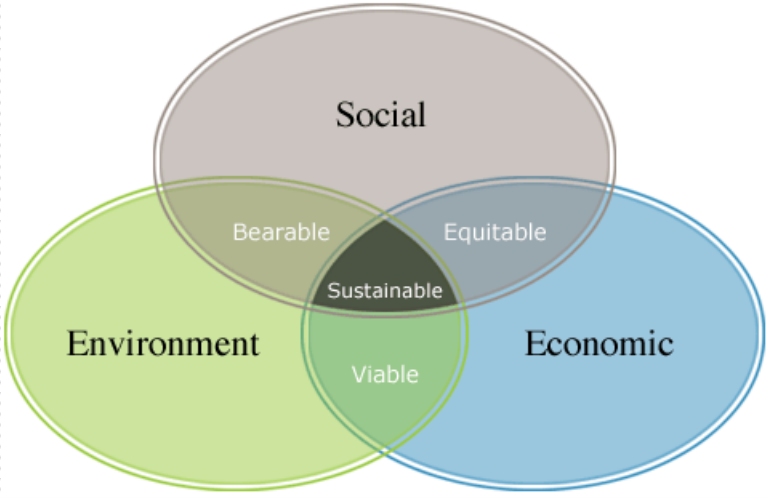
DAMAGE ASSESSMENT & REMEDIATION **Sustainability assessment**

- Second stage : the sustainability analysis. This consists of three activities:
  - i. a sustainability appraisal based on the agreed scope and objectives;
  - ii. a review of the uncertainties within the appraisal;
  - iii. ultimately drawing the conclusions or sustainability findings, together with the stakeholders.
- Finally, a monitoring and verification process should be developed and applied during project execution to demonstrate sustainability, achievement of project objectives and satisfaction of stakeholders.
- Acknowledgement to be made to NICOLE's Guidance on Sustainable Remediation, where further details are available.

US EXAMPLE : ROAD MAP FOR SUSTAINABLE REMEDIATION Motivation and Purpose

Sustainability Language

- UN Bruntland Commission (1987)
  - Defines sustainable development: that which meets present needs without compromising future needs



- UN World Summit (2005) Environmental, social, and economic pillars of sustainability

Motivation and Purpose
Definition for Sustainable Remediation

"A remedy or combination of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources." (Sustainable Remediation White Paper, *Remediation Journal*, Summer 2009)

More specifically:

1. Minimize or eliminate consumption of energy & other natural resources;
2. Reduce or eliminate releases to the environment, especially to the air;
3. Harness or mimic a natural process;
4. Result in the reuse or recycling of land or otherwise undesirable materials;
5. Encourage the use of remedial technologies that permanently destroy contaminants.

Key Point:
How can we easily **apply these principles to real-world situation**s?

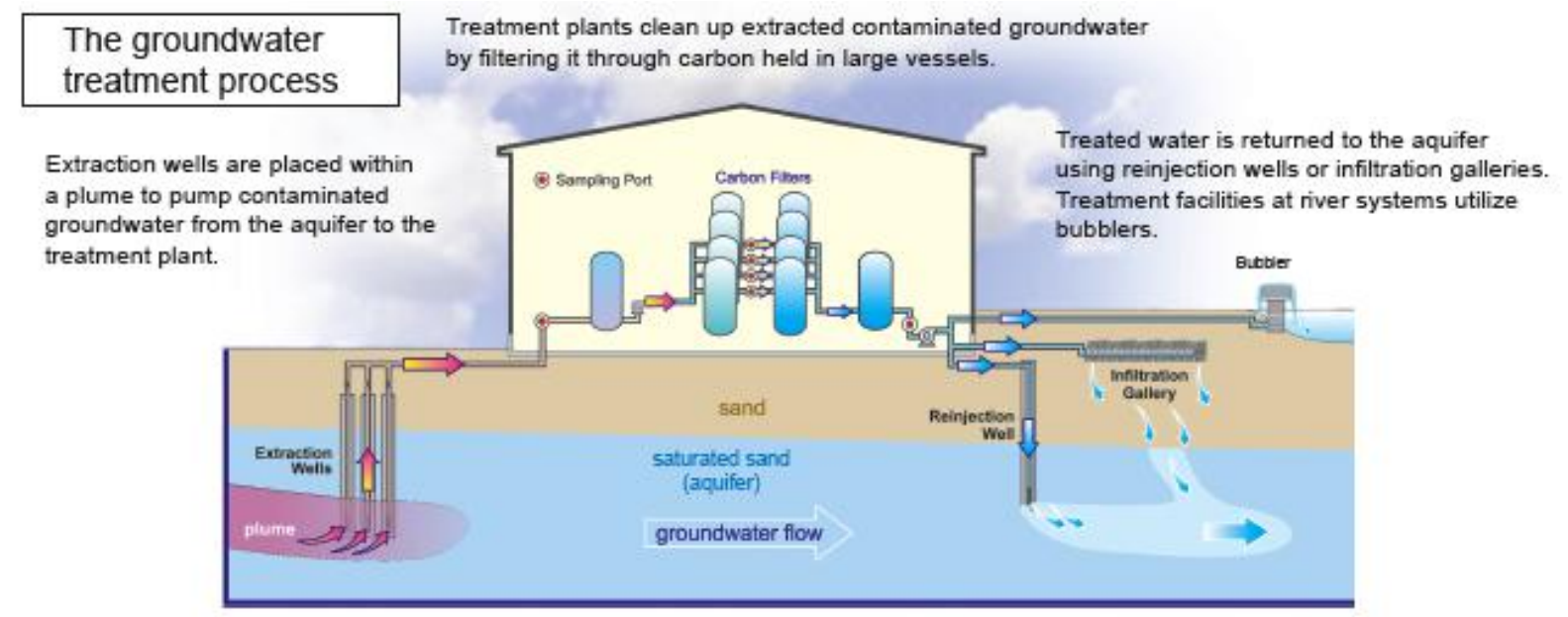
Motivation and Purpose

- New Remediation Paradigm
- Examples of Existing Metrics
  - CERCLA (Nine Criteria)
  - Risk and Economic Cost
- Potential Supplemental Metrics
  - Air Emissions
  - Energy Usage
  - Resource Service
  - Materials Consumption

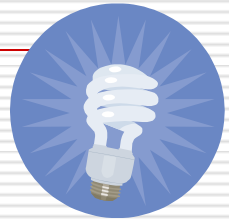
Motivation and Purpose

The Problem…

Historical approach to contaminated sites does not fully consider sustainability concepts. Plus, remediation systems performance not routinely tracked.



Motivation and Purpose



Solutions…

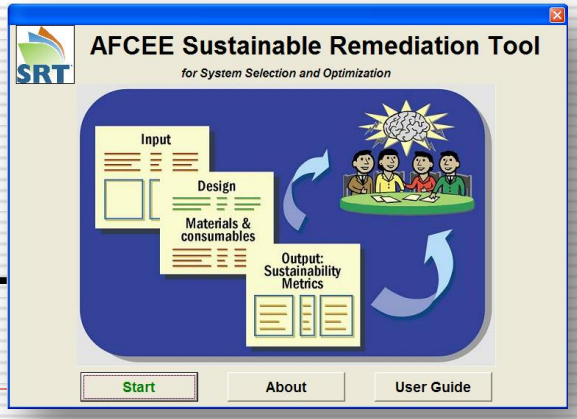
Develop tools to help AFCEE environmental professionals incorporate sustainability concepts into their remediation decision making process (e.g., PBM, RRM, ERP-O) and track performance:

i) Plan future remediation implementation

ii) Optimize operating remediation sites

Tools…

- ✓ **Performance Tracking Tool (PTT)**
- ✓ **Sustainable Remediation Tool (SRT)**
- ✓ **Alternative Energy Siting Tool**
- ✓ **Environmental Restoration Program-Optimization (ERP-O) Initiative**

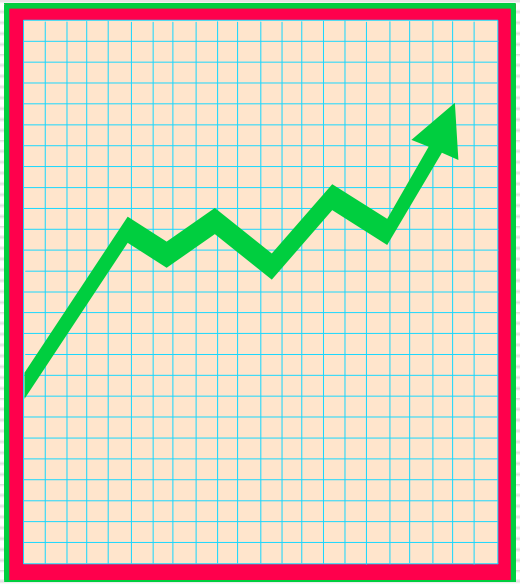


US EXAMPLE : ROAD MAP FOR SUSTAINABLE REMEDIATION

PERFORMANCE TRACKING TOOL (PTT)

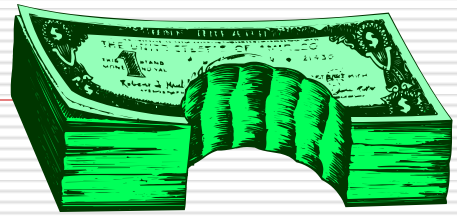
The Performance Tracking Tool – What Is It?

- The Performance Tracking Tool (PTT)
  - Very general (back of the envelope)
  - Excel 2007 based, mathematical model
  - Evaluates system operation
  - Presents data in a graphical format
- Initiated in 2004 with goal of finding a faster way of analyzing system performance during Remedial Process Optimization (RPO) reviews



The Performance Tracking Tool – What Is It For?

- Assists in answering two key questions:
  - Is contaminant mass being reduced at the appropriate rate?
  - Are costs consistent with projections?
- Provides input for either optimizing or discontinuing system
- Goes beyond simply assessing whether contaminants are being removed to evaluate removal efficiency by comparing treatment performance with cost



Systems Evaluated : until technical solutions

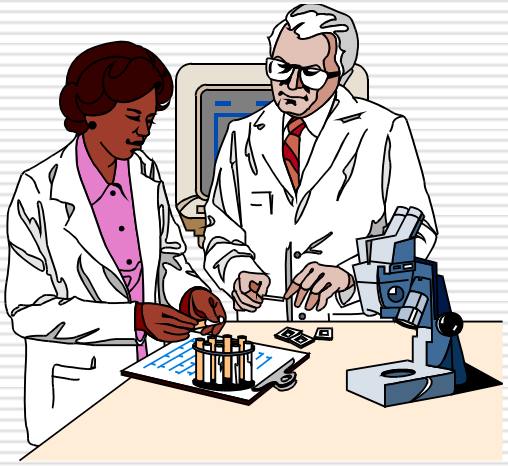
- The initial version was designed for evaluating pump and treat systems
  - Acknowlegements to Javier Santillan, Marc Gill and Mike Flinn
- The current version of the PTT adds five additional approaches
  1. Bioslurping
  2. Monitored Natural Attenuation (MNA)
  3. Surfactant Extraction (SurfactX)
  4. Soil Vapor Extraction (SVE)
  5. Dual Phase SVE-P&T Extraction

Data Population

- Data requirements
  - Preliminary (Record of Investigation –RI -, Record of Documents- ROD-)
    - ✓ Interim remedial action costs and mass removed
    - ✓ Estimated contaminant mass, completion schedule and cost
    - ✓ Establishes Performance Objectives Baseline
  - Operational (Five Year Reviews, Annual Cost and Performance Reports)
    - ✓ System capital, operation, and maintenance costs
    - ✓ Contaminant and geochemical concentrations, extraction rates, and operating time (alternative – annual mass removed or degraded)
- Data are entered into selected areas of the models and embedded algorithms return the results

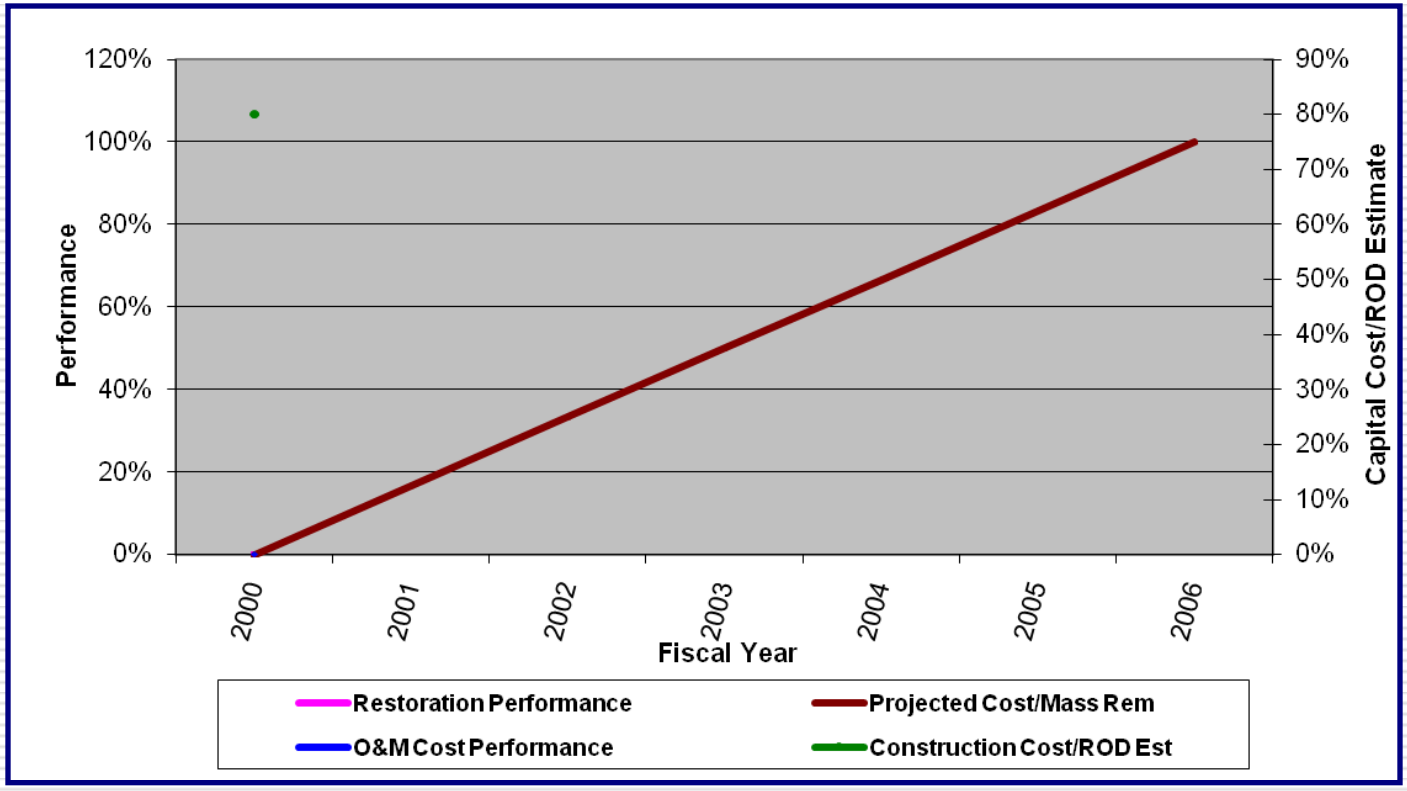
Data Results

- Data results are normalized as percentages
  - Focus on performance, not expectations
  - Not distracted by magnitude of data values (same scale)
- Graphic presentation assists in visualizing system performance
- Provides preliminary projections for future funding based on system performance



Graphical Display

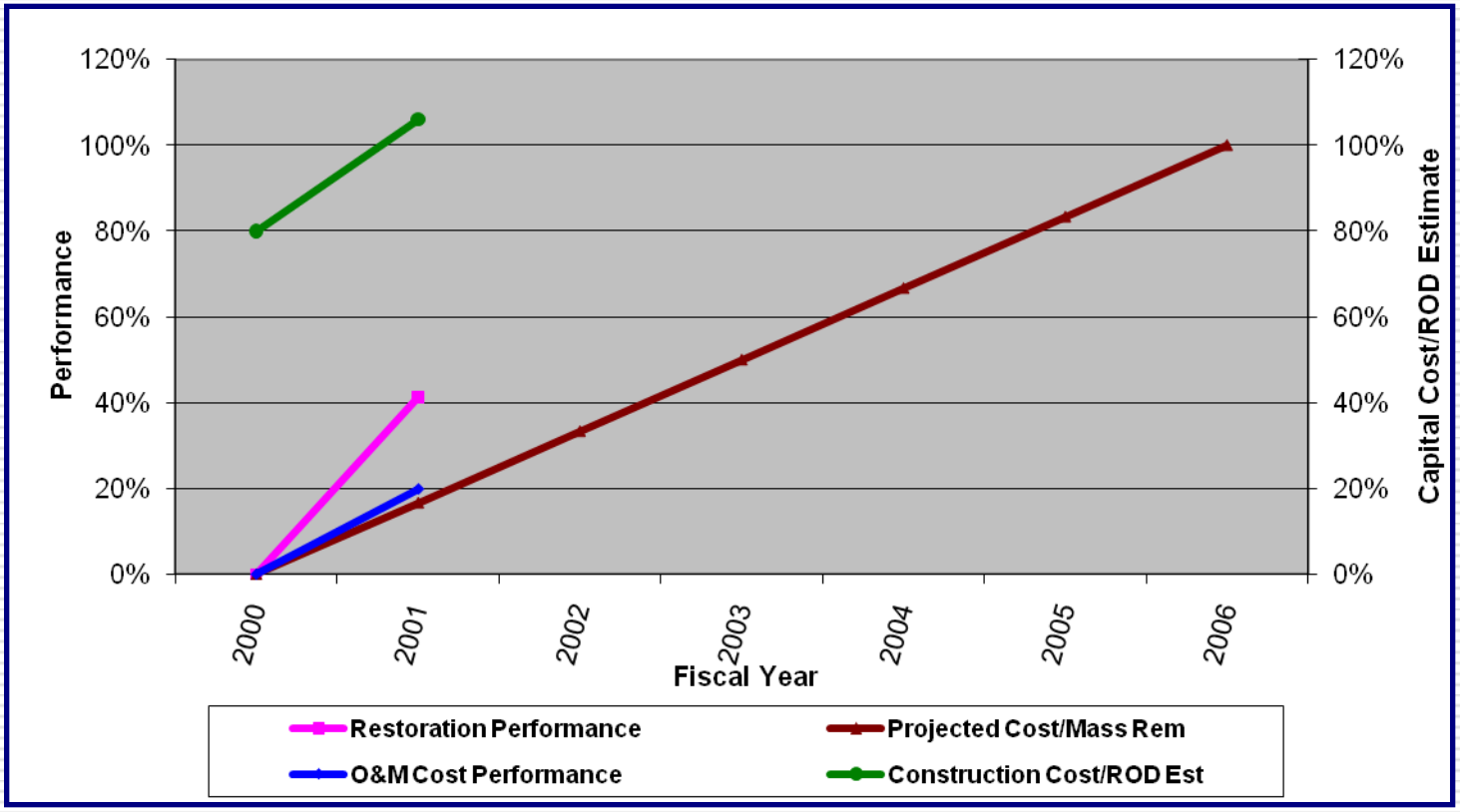
- Cost and treatment correlated on



- Need several years of data to see trends develop

Graphical Display
(continued)

- Cost and treatment correlated on



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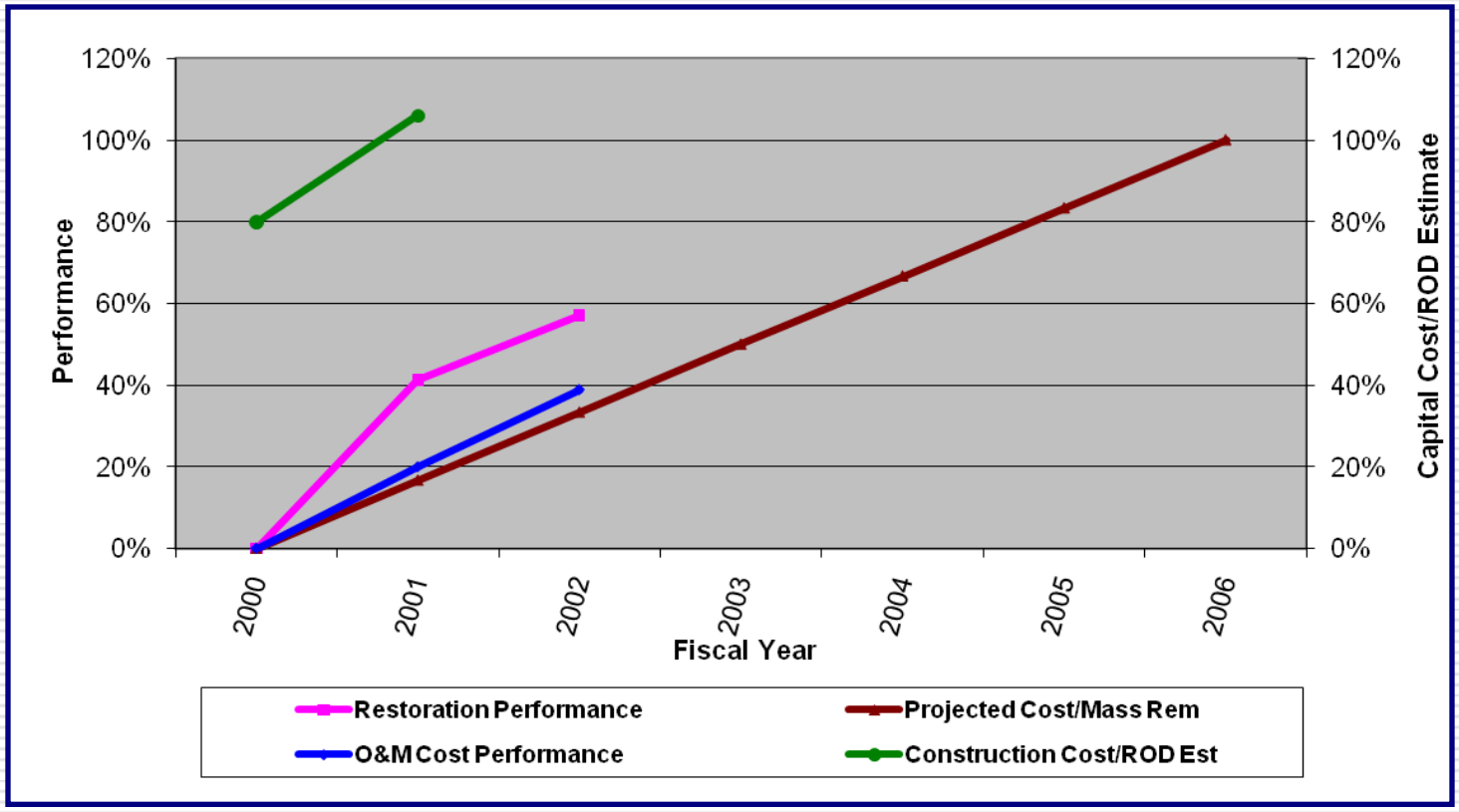
Graphical Display
(continued)

- Cost and treatment correlated on



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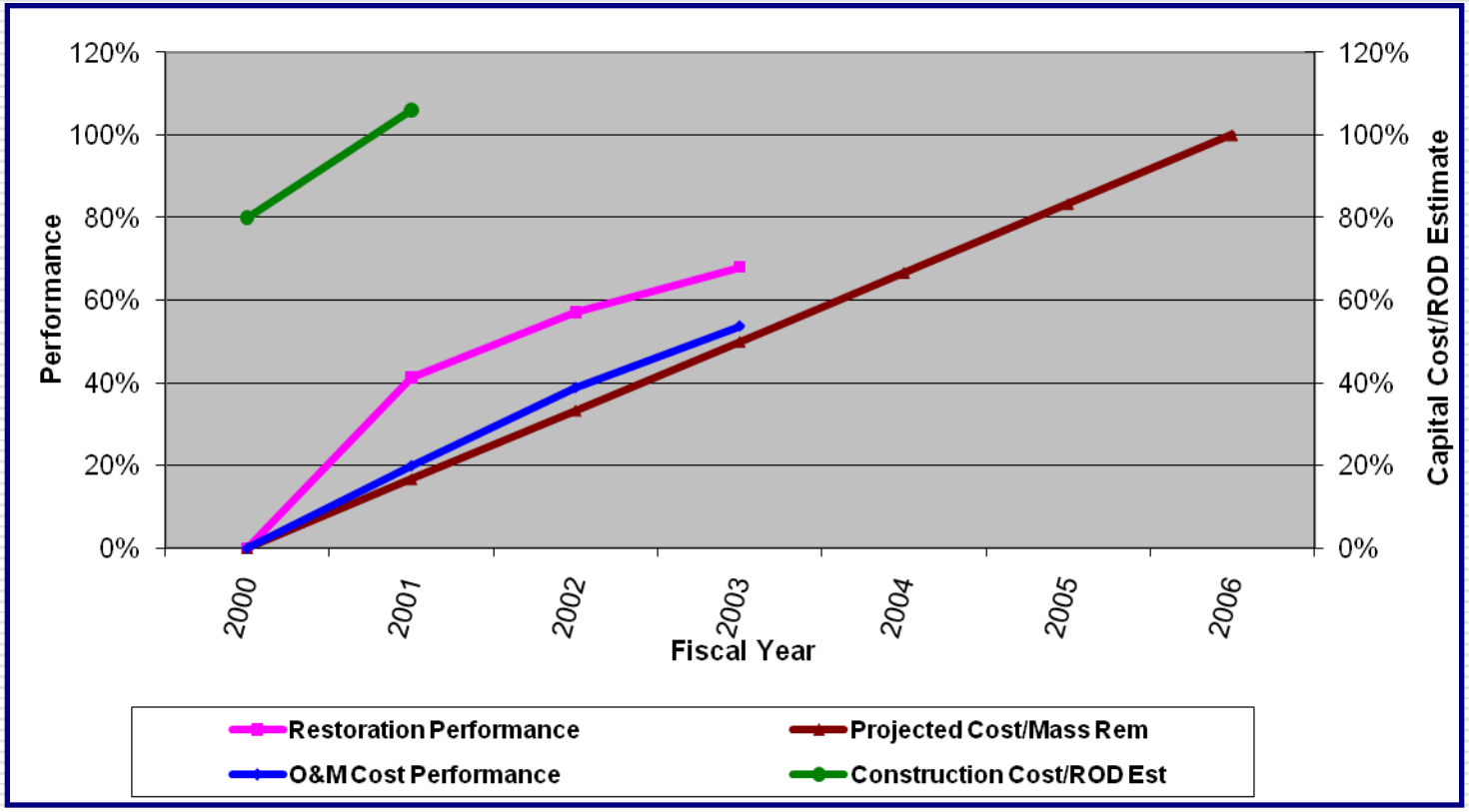
Graphical Display
(continued)

- Cost and treatment correlated on



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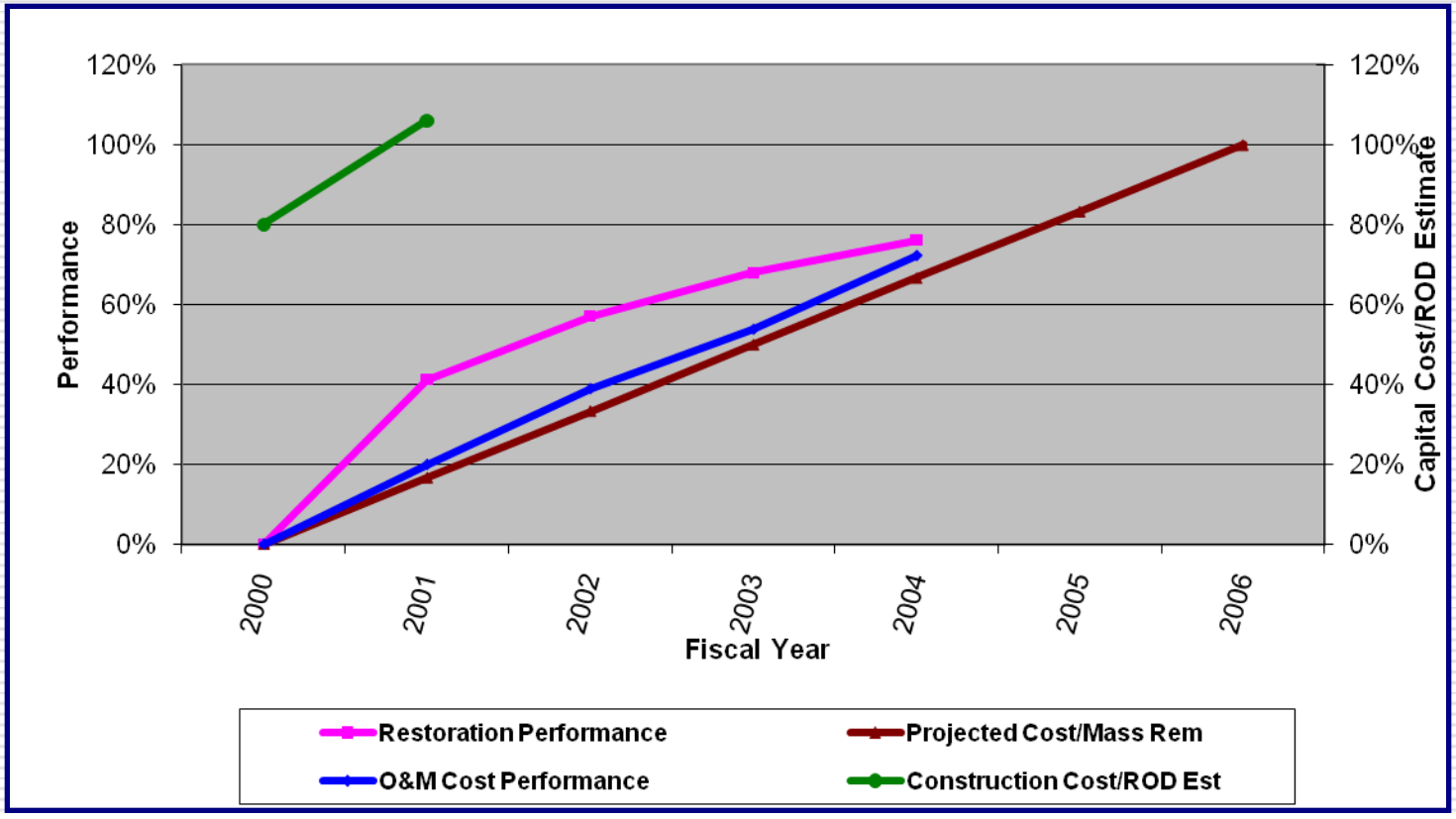
Graphical Display
(continued)

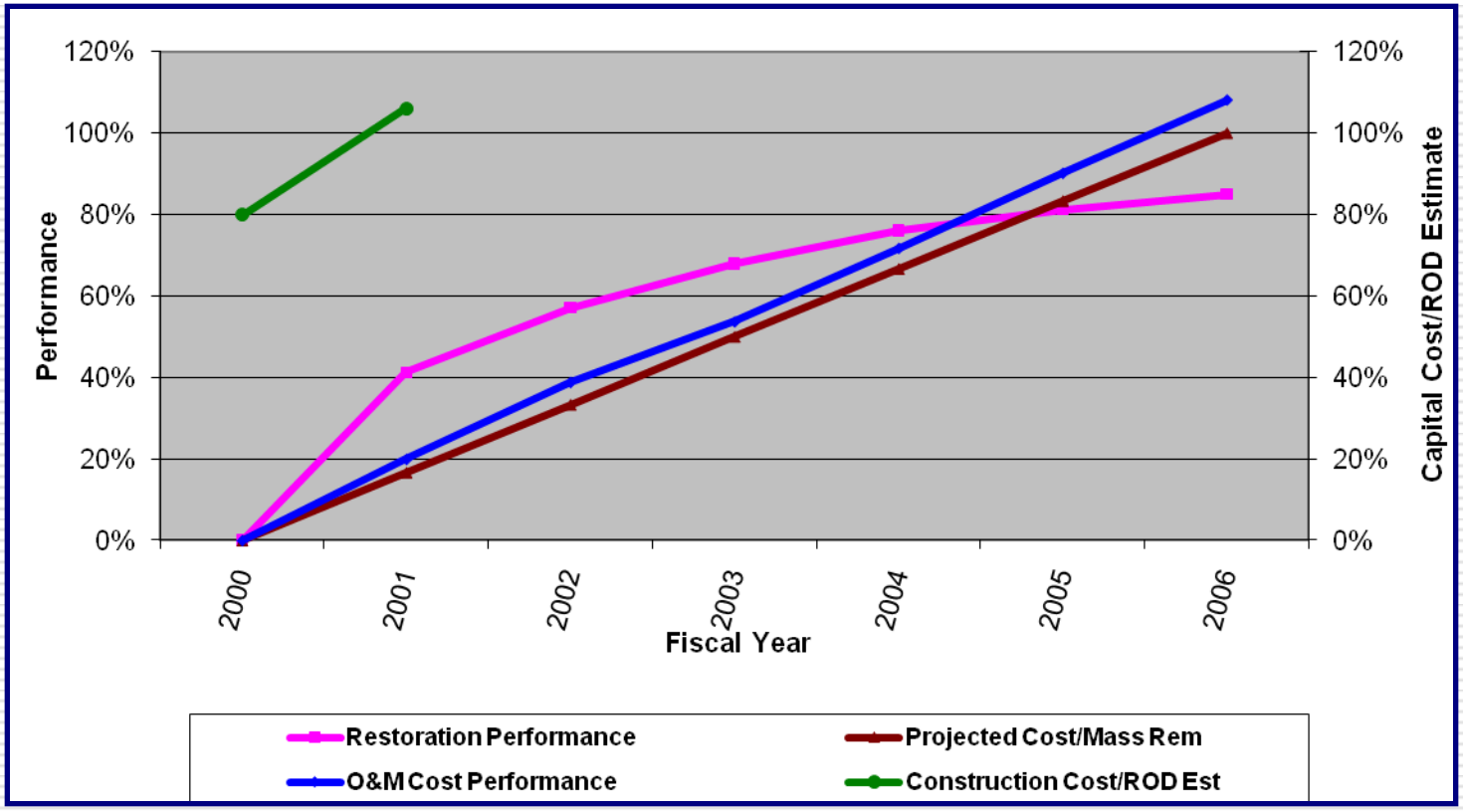
- Cost and treatment correlated on



- Need several years of data to see trends develop

Graphical Display
(concluded)

- Cost and treatment correlated on



- Need several years of data to see trends develop

Example 1: P&T – Step 1

- Chlorinated Solvents Release
- Decision Document Expectations

Mass Data Entry Directions: Enter mass data in Mass Calculations worksheet	
Interim Action Start Year	**N/A**
Interim Action Cost	N/A
Interim Action Mass Removed	N/A
Remedy Start Year (from DD)	**1981**
Estimated Mass at Remedy Start (lbs.)	10,000
Estimated Acreage Impacted	200
Acre-ft of Groundwater Impacted	1,200
Remedy Completion Year	**2010**
DD Cost-To-Complete (CTC)	$ 5,887,000
DD Estimated Capital Costs	$ 887,000
DD Estimated O&M Costs	$ 5,000,000
Total Capital Costs	$ 500,000
Total O&M Costs	$ 3,930,917

Example 1: P&T – Step 2

- Raw data entered and calculated

Fiscal Year	Avg. Volume Pumped (gpm)	Percent Operational Uptime	Average Annual Concentration ug/l (influent)								Total Annual Mass Removed (lb/yr)
			VOCs	Chloro-benzene	12DCB	14DCB	cDCE	PCE	TCE	VC	
1981	-	96	0	0	0	0	0	0	-	0	
1982	400	96	0	0	0	0	0	0	1,000	0	1,687
1983	1,155	96	0	0	0	0	0	0	231	0	1,125
1984	568	96	0	0	0	0	0	0	251	0	601
1985	800	96	0	0	0	0	0	0	201	0	678
1986	685	96	0	0	0	0	0	0	180	0	520
1987	685	96	0	0	0	0	0	0	159	0	459
1988	685	96	0	0	0	0	0	0	138	0	399
1989	685	96	0	0	0	0	0	0	117	0	338
1990	685	96	0	0	0	0	0	0	96	0	277
1991	809	100	0	0	0	0	0	0	76	0	270
1992	877	100	0	0	0	0	0	0	55	0	212
1993	649	92	0	0	0	0	0	0	35	0	92
1994	693	100	0	0	0	0	0	0	32	0	97
1995	613	100	0	0	0	0	0	0	32	0	86
1996	626	100	0	0	0	0	0	0	29	0	80
1997	600	97	0	0	0	0	0	0	25	0	64
1998	588	98	0	0	0	0	0	0	21	0	53
1999	565	100	0	0	0	0	0	0	15	0	37
2000	673	100	0	0	0	0	0	0	12	0	36
2001	630	100	0	0	0	0	0	0	13	0	37
2002	597	100	0	0	0	0	0	0	12	0	31
2003	570	100	0	0	0	0	0	0	11	0	27
2004	596	100	0	0	0	0	0	0	11	0	29
2005	471	100	0	0	0	0	0	0	12	0	25
2006											
2007											
2008											
2009											
2010											

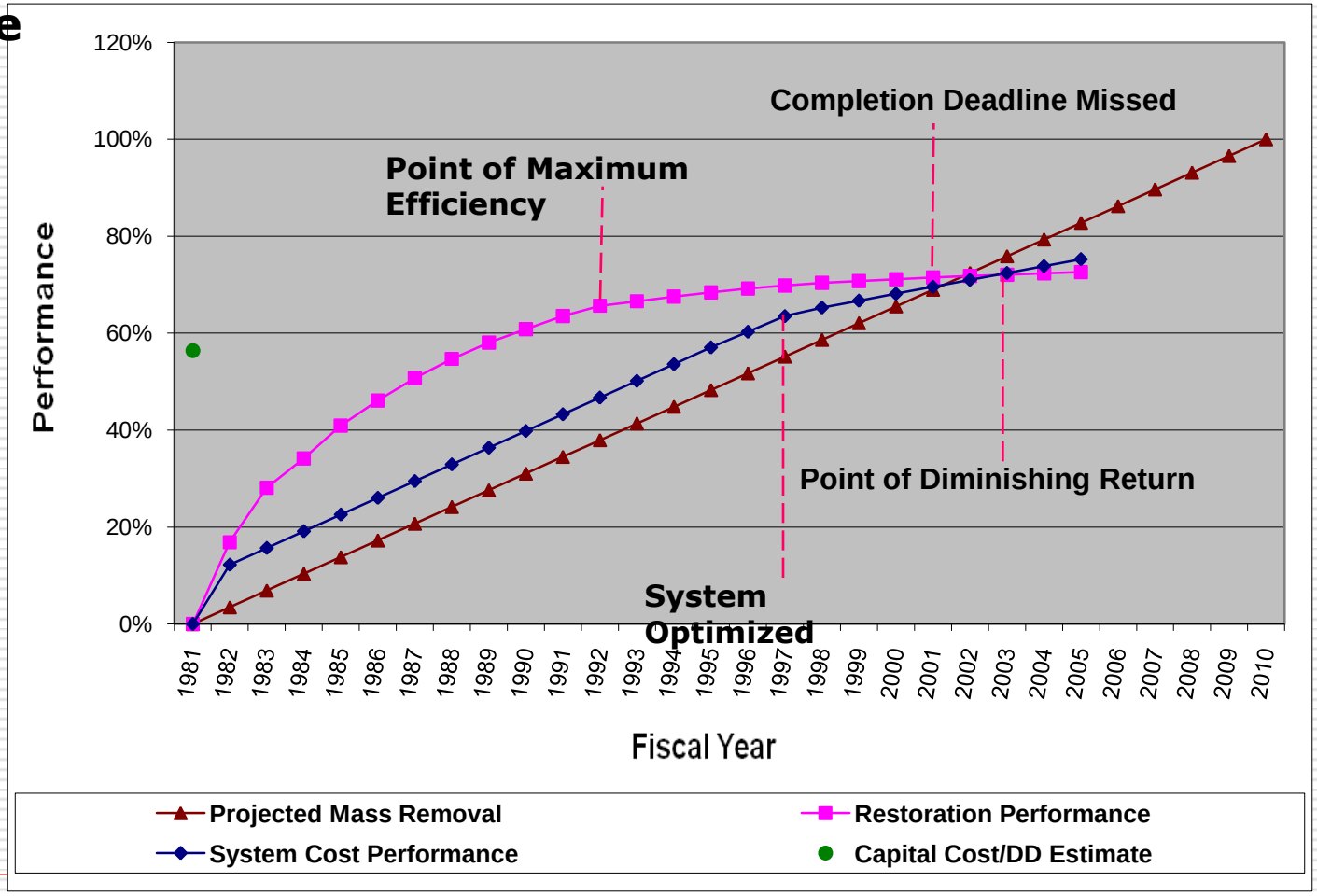
Example 1: P&T – Step 3

- **Capital and O&M costs entered**
- **Results tabulated**

Fiscal Year	Total Mass Removed per Year (lbs.)	Capital Cost per Year	O&M Cost per Year	Capital Cost as Percent of DD Estimate	O&M as Percent of CTC	Projected System Cost as Percent of CTC	Actual System Cost as Percent of CTC	Projected Mass Removed	Actual Mass Removed
1981		$ 500,000	$ 16,917	56%	0%	0%	0%	0%	0%
1982	1,687		$ 203,000		4%	15%	12%	3%	17%
1983	1,125		$ 203,000		7%	18%	16%	7%	28%
1984	601		$ 203,000		11%	21%	19%	10%	34%
1985	678		$ 203,000		14%	24%	23%	14%	41%
1986	520		$ 203,000		18%	27%	26%	17%	46%
1987	459		$ 203,000		21%	30%	29%	21%	51%
1988	399		$ 203,000		24%	33%	33%	24%	55%
1989	338		$ 203,000		28%	36%	36%	28%	58%
1990	277		$ 203,000		31%	39%	40%	31%	61%
1991	270		$ 203,000		35%	42%	43%	34%	64%
1992	212		$ 203,000		38%	45%	47%	38%	66%
1993	92		$ 203,000		42%	48%	50%	41%	67%
1994	97		$ 203,000		45%	51%	54%	45%	68%
1995	86		$ 203,000		49%	55%	57%	48%	68%
1996	80		$ 190,000		52%	58%	60%	52%	69%
1997	64		$ 190,000		55%	61%	64%	55%	70%
1998	53		$ 104,000		57%	64%	65%	59%	70%
1999	37		$ 84,000		58%	67%	67%	62%	71%
2000	36		$ 84,000		60%	70%	68%	66%	71%
2001	37		$ 84,000		61%	73%	70%	69%	71%
2002	31		$ 84,000		62%	76%	71%	72%	72%
2003	27		$ 84,000		64%	79%	72%	76%	72%
2004	29		$ 84,000		65%	82%	74%	79%	72%
2005	25		$ 84,000		67%	85%	75%	83%	73%
2006						88%		86%	
2007						91%		90%	
2008						94%		93%	
2009						97%		97%	
2010						100%		100%	

Example 1: P&T – Step 4

- **Performance Graphed**



Example 1: P&T – Step 5

- **Future Expenditures Projected**

	To Date	Projected Total Cost	Estimated Total Cost
System Cost/Acre	$ 19,654.59	$ 27,077.48	$ 29,435.00
System Cost/Acre Foot	$ 3,275.76	$ 4,512.91	$ 4,905.83
Cost/lb Removed by System	$ 541.55	$ 746.08	$ 588.70
System Costs	$ 3,930,917.00	$ 5,415,496.44	$ 5,887,000.00
Mass Removed by System	7,259 lbs		
Percent of DD Mass Removed	73%		
Total Mass Removed	7,259 lbs		
Total Remediation Costs	$ 3,930,917		

Example 2: Dual Phase – Step 1

- JP Fuel Leak
- Decision Document Expectations

Mass Data Entry Directions: Enter mass data in Mass Calculations worksheet		
Interim Action Start Year		**N/A**
Interim Action Cost		N/A
Interim Action Mass Removed		N/A
Remedy Start Year (from DD)		**1991**
Estimated Mass at Remedy Start (lbs.)		250,000
Estimated Acreage Impacted		10
Acre-ft of groundwater impacted		50
Remedy Completion Year		**2015**
DD Cost-To-Complete (CTC)	$	6,250,000
DD Estimated Capital Costs	$	250,000
DD Estimated O&M Costs	$	6,000,000
Total Capital Costs	$	250,000
Total O&M Costs	$	3,250,000

Example 2: Dual Phase – Step 2

- **Raw data entered and calculated**

Fiscal Year	Avg. Volume Pumped (gpm)	Percent Operational Uptime	Average Annual Concentration ug/l (influent)					NAPL Recovered (lb/yr)	Total Annual Mass Removed (lb/yr)
			TCE	DCE	VCl	BTEX	Other VOC		
1991									
1992	10	95	0	0	0	0	0	160	160
1993	10	95	0	0	0	0	0	125	125
1994	10	95	0	0	0	0	0	240	240
1995	10	95	0	0	0	0	0	360	360
1996	10	95	0	0	0	0	0	395	395
1997	10	95	0	0	0	0	0	150	150
1998	10	95	0	0	0	0	0	100	100
1999	10	95	0	0	0	90	65	360	366
2000	10	95	0	0	0	30	40	150	153
2001	10	95	0	0	0	15	40	138	140
2002	10	95	0	0	0	15	40	266	268
2003	10	95	0	0	0	15	40	214	216
2004	10	95	0	0	0	25	40	239	242
2005									
2006									
2007									
2008									
2009									
2010									
2011									
2012									
2013									
2014									
2015									

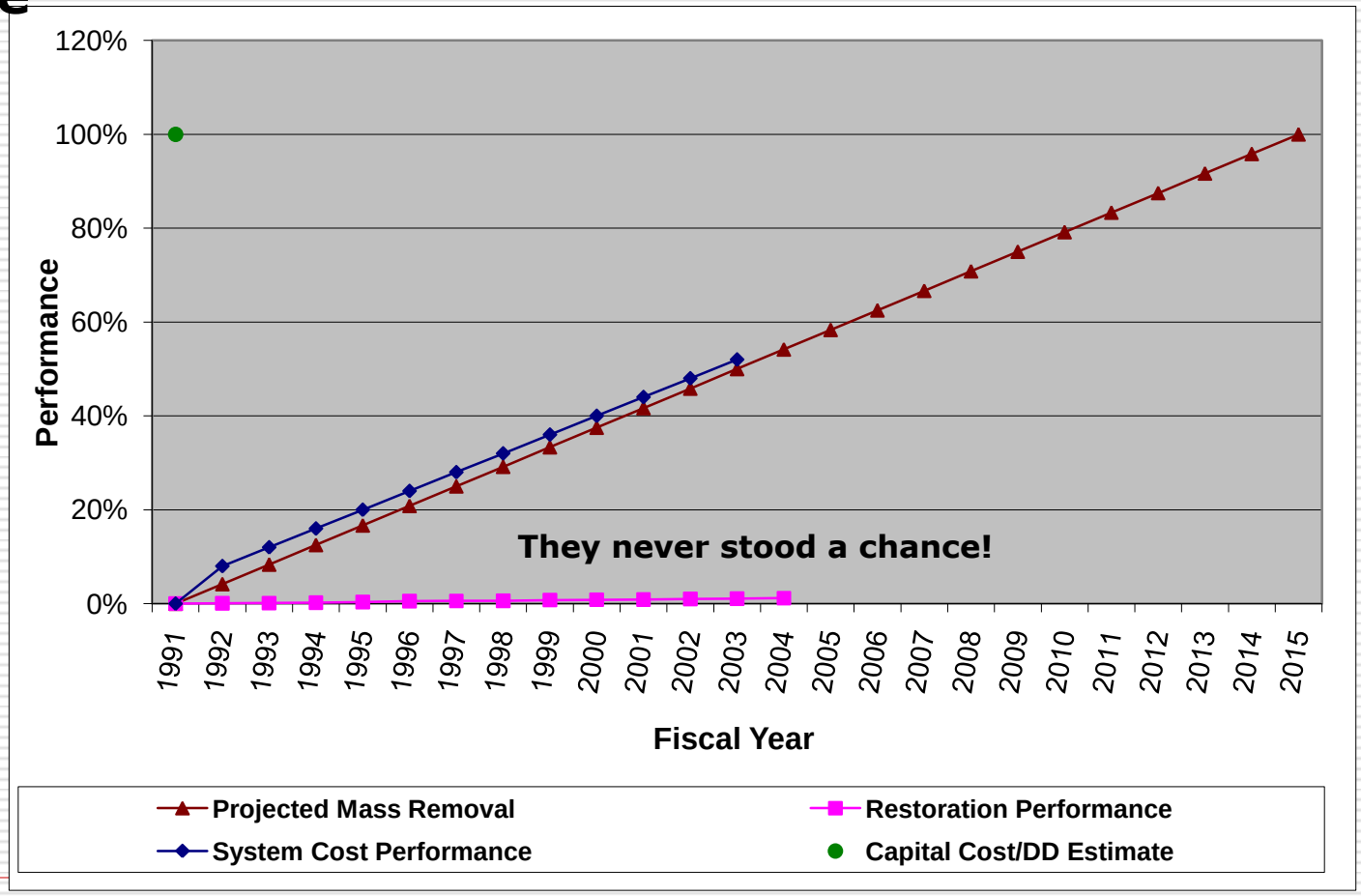
Example 2: Dual Phase – Step 3

- **Capital and O&M costs entered**
- **Results tabulated**

Fiscal Year	Total Mass Removed per Year (lbs.)	Capital Cost per Year	O&M Cost per Year	Capital Cost as Percent of DD Estimate	O&M as Percent of CTC	Projected System Cost as Percent of CTC	Actual System Cost as Percent of CTC	Projected Mass Removed	Actual Mass Removed
1991		$ 250,000		100%		0%		0%	0%
1992	160		$ 250,000		4%	4%	8%	4%	0%
1993	125		$ 250,000		8%	8%	12%	8%	0%
1994	240		$ 250,000		12%	12%	16%	13%	0%
1995	360		$ 250,000		16%	17%	20%	17%	0%
1996	395		$ 250,000		20%	21%	24%	21%	1%
1997	150		$ 250,000		24%	25%	28%	25%	1%
1998	100		$ 250,000		28%	29%	32%	29%	1%
1999	366		$ 250,000		32%	33%	36%	33%	1%
2000	153		$ 250,000		36%	37%	40%	38%	1%
2001	140		$ 250,000		40%	42%	44%	42%	1%
2002	268		$ 250,000		44%	46%	48%	46%	1%
2003	216		$ 250,000		48%	50%	52%	50%	1%
2004	242		$ 250,000		52%	54%	56%	54%	1%
2005						58%		58%	
2006						62%		63%	
2007						67%		67%	
2008						71%		71%	
2009						75%		75%	
2010						79%		79%	
2011						83%		83%	
2012						87%		88%	
2013						92%		92%	
2014						96%		96%	
2015						100%		100%	

Example 2: Dual Phase – Step 4

- **Performance Graphed**



Example 2: Dual Phase – Step 5

- **Future Expenditures Projected**

	To Date	Projected Total Cost	Estimated Total Cost
System Cost/Acre	$ 325,000.00	$ 27,864,293.68	$ 625,000.00
System Cost/Acre Foot	$ 65,000.00	$ 5,572,858.74	$ 125,000.00
Cost/lb Removed by System	$ 1,114.57	$ 95,559.24	$ 25.00
System Costs	$ 3,250,000.00	$ 278,642,936.83	$ 6,250,000.00
Mass Removed by System	2,916		
Percent of DD Mass Removed	1%		
Total Mass Removed	2,916		
Total Remediation Costs	$ 3,250,000		

INTERSOL LYON March28th 2011

Potential Applications

- The PTT can enhance your understanding of system operations and environmental conditions
  - Data from an existing system may be useful when considering whether to install a similar system at a different location
- The PTT can assist in decision making
  - Designate system endpoints in ROD
  - System optimization – apply to individual system components
    - ✓ Rehabilitate or abandon less productive extraction points
    - ✓ Increase rates on more productive extraction points
  - Use subsequent results to evaluate the effect of your decisions and adjust accordingly

Summary

- Focus of PTT is on system operation, not site remediation
- "Back of the envelope" general assessment (Reality Check)
  - Professional judgment or assumptions often required
    - ✓ Cost to complete estimates
    - ✓ Original mass estimates
    - ✓ Area/volume of contamination
  - Results are only as good as the data used
    - ✓ Original (raw) O&M data are best
    - ✓ Summary data are okay
    - ✓ Averaged data are not so hot (loss of data resolution)

Future Developments

- Develop and validate additional technologies
  1. *In Situ* Thermal Treatment
  2. Enhanced *In Situ* Bioremediation
  3. *In Situ* Chemical Oxidation
  4. Permeable Reactive Barriers (ZVI and biowall)

- Create Site System Summary

- Develop multiple system graphing capability

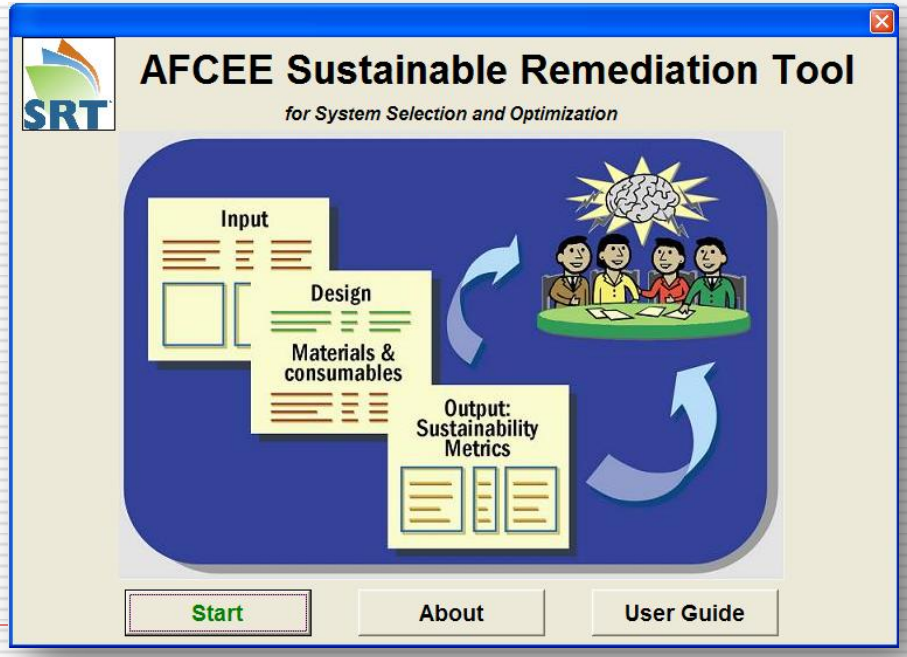
US EXAMPLE : ROAD MAP FOR SUSTAINABLE REMEDIATION

SUSTAINABLE REMEDIATION TOOL

SRT Overview

Project Team

- SRT Design and Functionality
- SRT Workflow
- Hands On Practice



Acknowledgements : SRT Project Team

- **Air Force Center for Engineering and the Environment**
  - **Erica Becvar**
- **AECOM**
  - **Doug Ruppel, John Claypool, Dave Woodward**
- **GSI Environmental Inc.**
  - **Chuck Newell, Tiffany Swann, Lila Beckley, Ata Rahman**
- **CH2M HILL**
  - **Doug Downey, Paul Favara, Brad Woodard**

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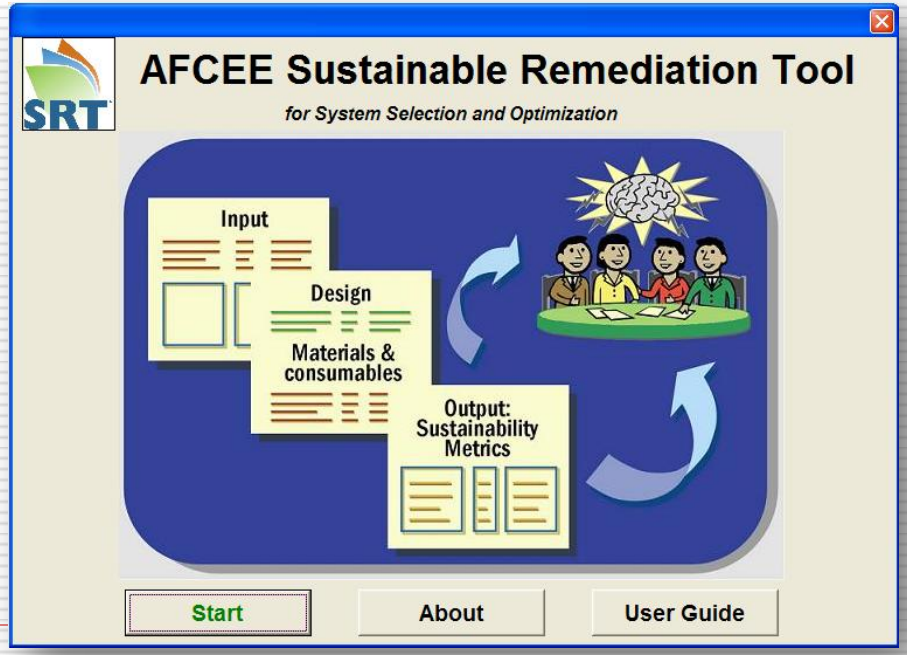


SRT Design Principles

- **No replication of design tools (simply calculate metrics)**
- **Develop with tiered approach for parameter inputs**
  - **Easy Tier 1 with Rules of Thumb for technology estimates**
  - **Tier 2 can estimate but not intended to replace design tools**
  - **Allow user override of estimated values at any time to accommodate real design parameters**
- **Include cost as a sustainability metric**

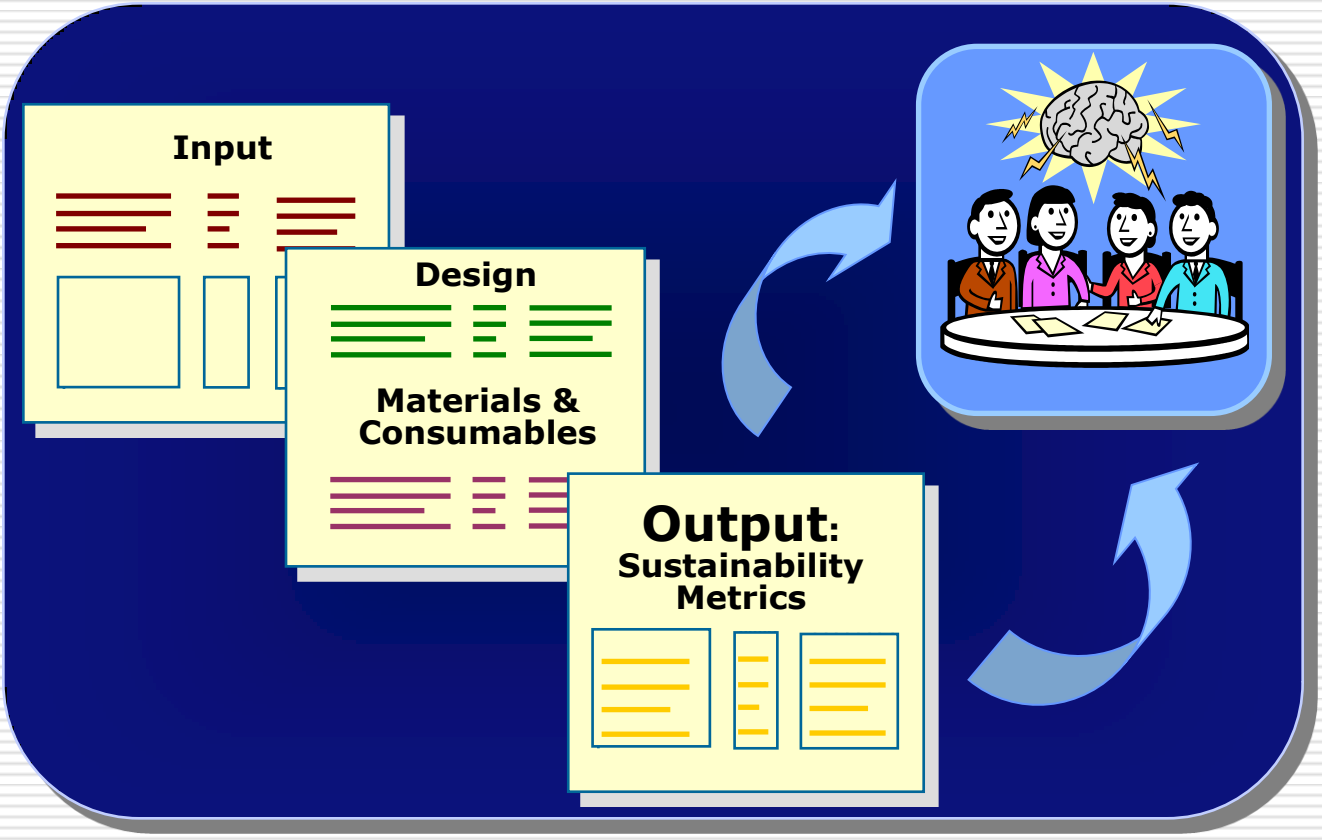
Technologies in the SRT

- **Excavation**
- **Soil Vapor Extraction (SVE)**
- **Pump and Treat (P&T)**
- **Enhanced Bioremediation**
- **In Situ Chemical Oxidation (ISCO)**
- **Permeable Reactive Barrier (PRB)**
- **Long-term Monitoring (LTM) / Monitored Natural Attenuation (MNA)**
- **Thermal Treatment**

Metrics Estimated by the SRT

- **Emissions to atmosphere**
  - **CO_2**
  - **NO_x**
  - **SO_x**
  - **PM_{10}**
- **Total energy consumed**
- **Change in resource service**
- **Technology cost**
- **Safety / Accident risk**

SRT Structure



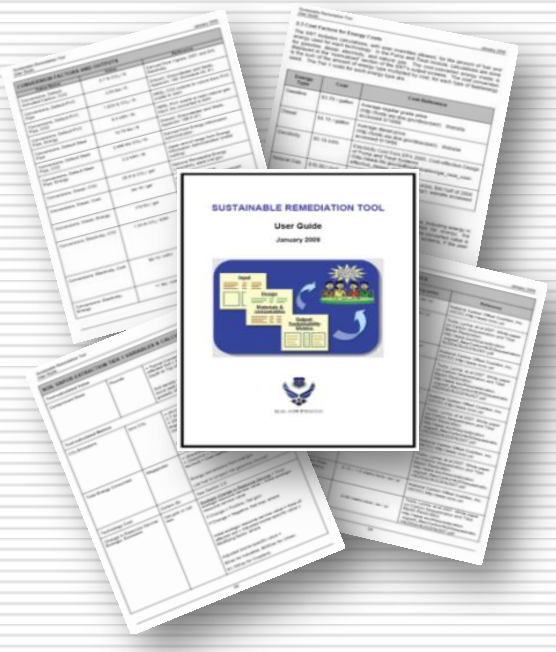
2-Tier Framework

	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 (FS)	✓ More site-specific results ✓ More default user-override ✓ Most appropriate after an F ✓ More appropriate for optimizing existing system

SRT Strengths

- Evaluates sustainability metrics
- Screens / Compares technologies side-by-side
  - Up to 8 different technologies at once
- Two tier options for user
- Scenarios feature
- Stakeholder roundtable feature
- Capable of using inputs from design tools
- Will have validated costing model (RACER™ - sold on line-) interaction in next release



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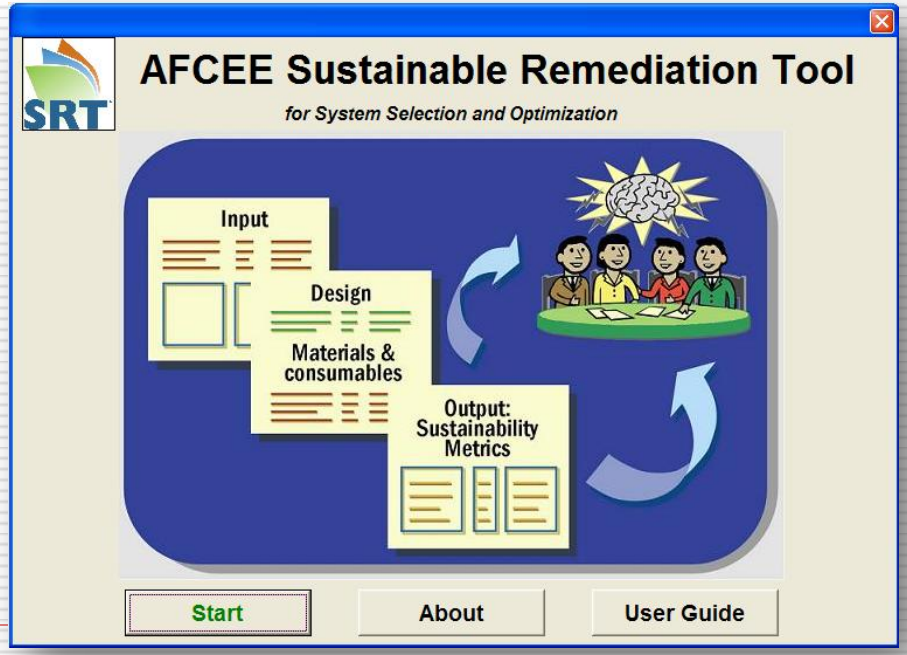
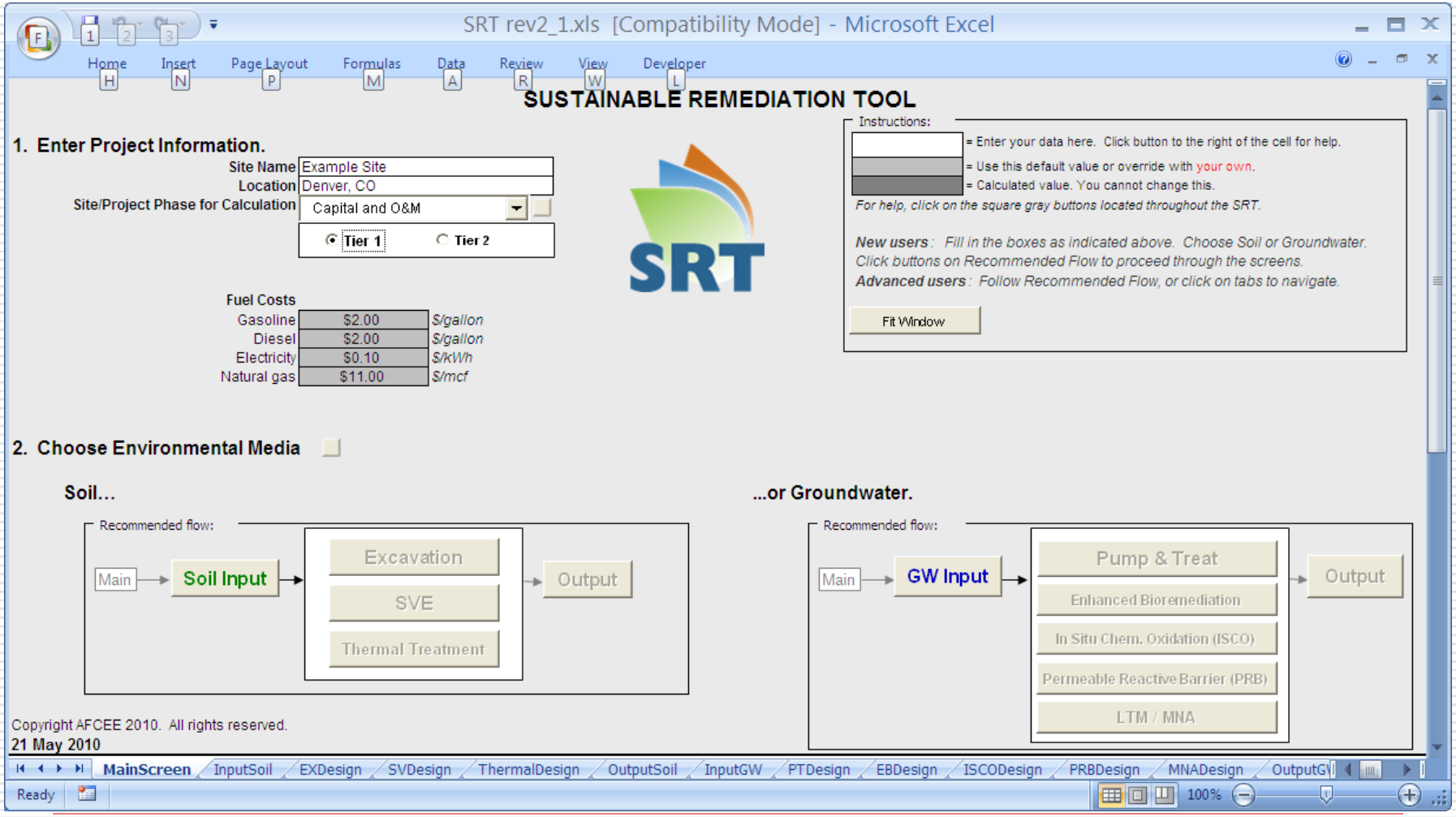
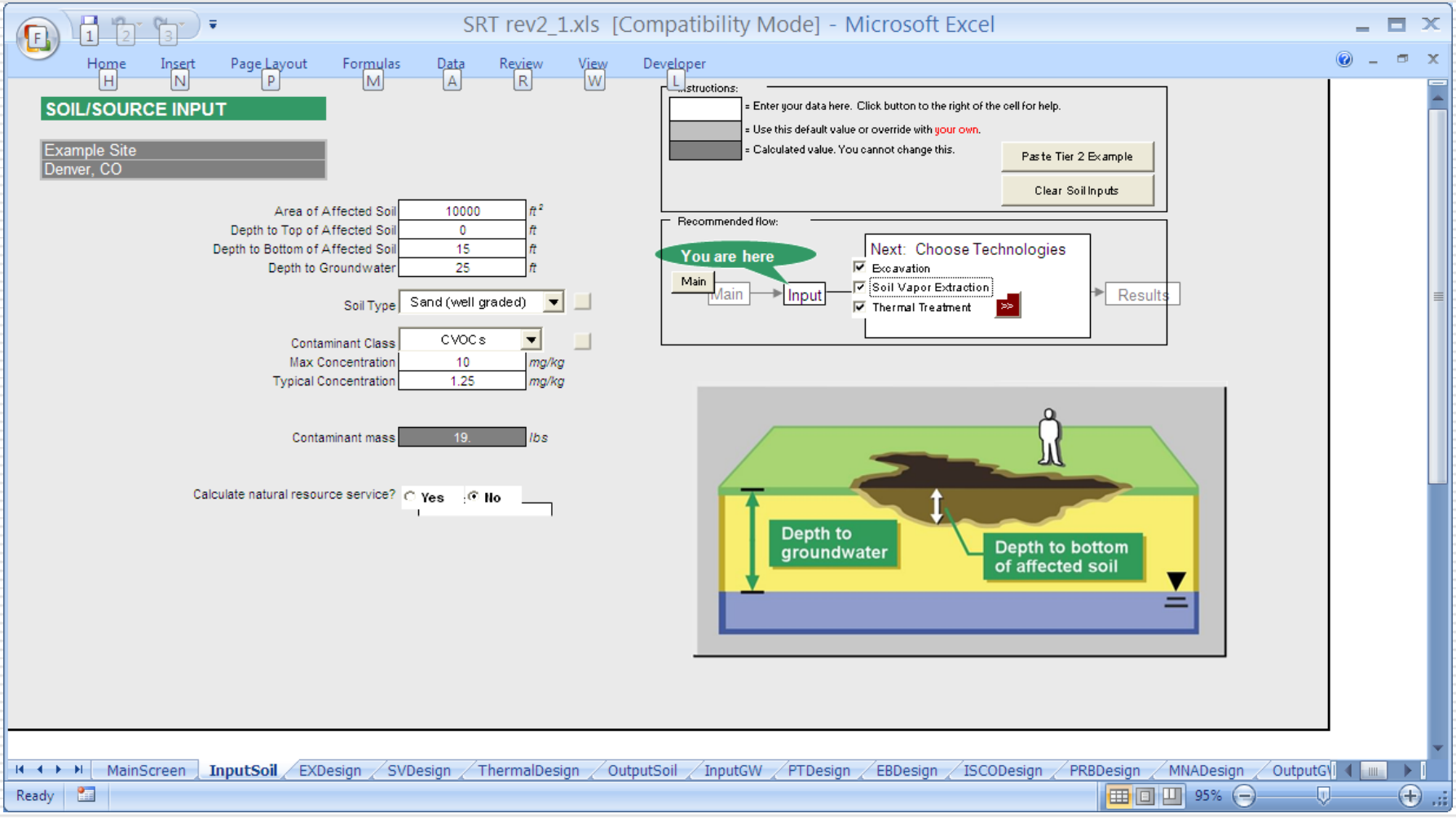


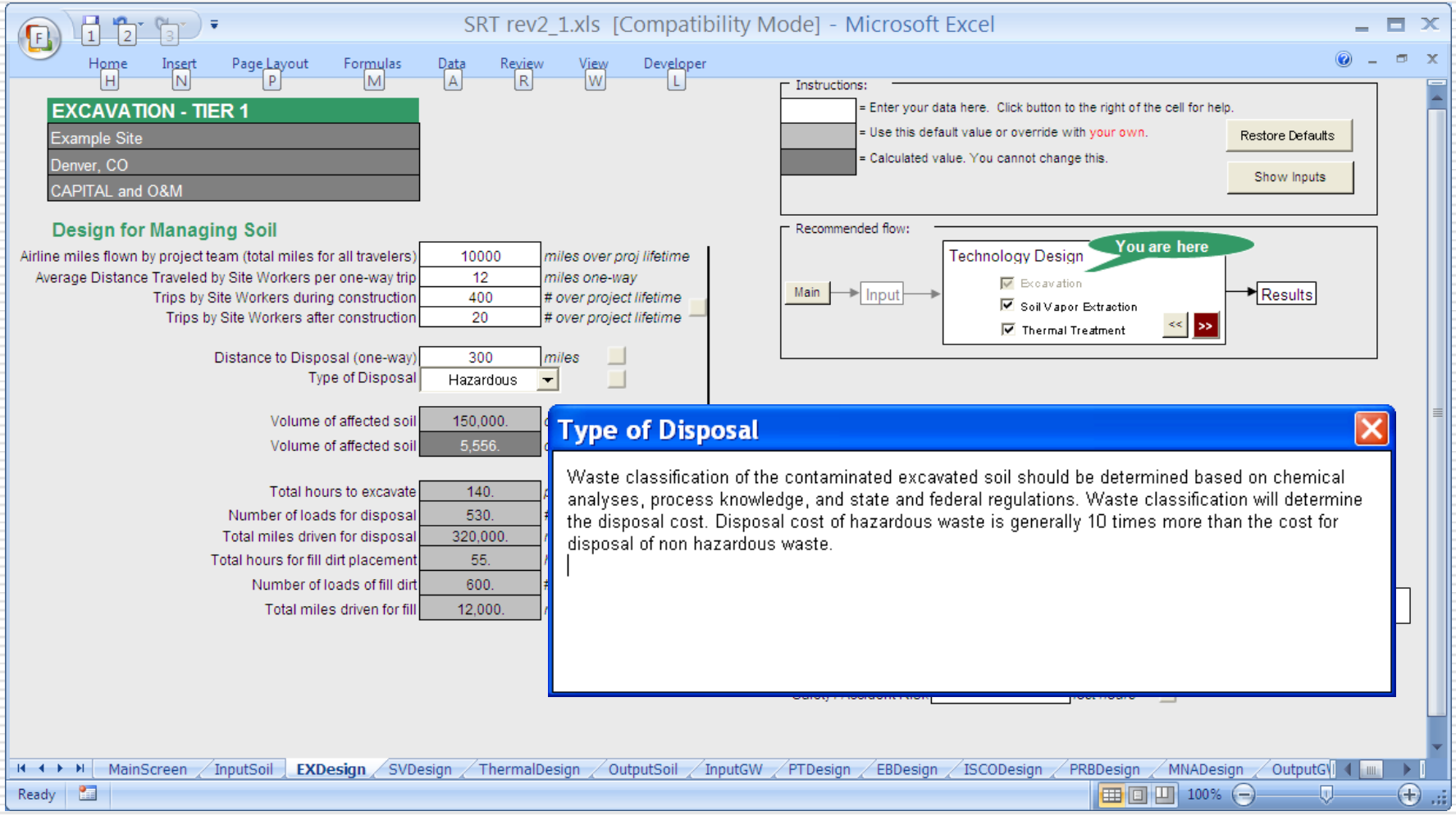
SRT General Inputs



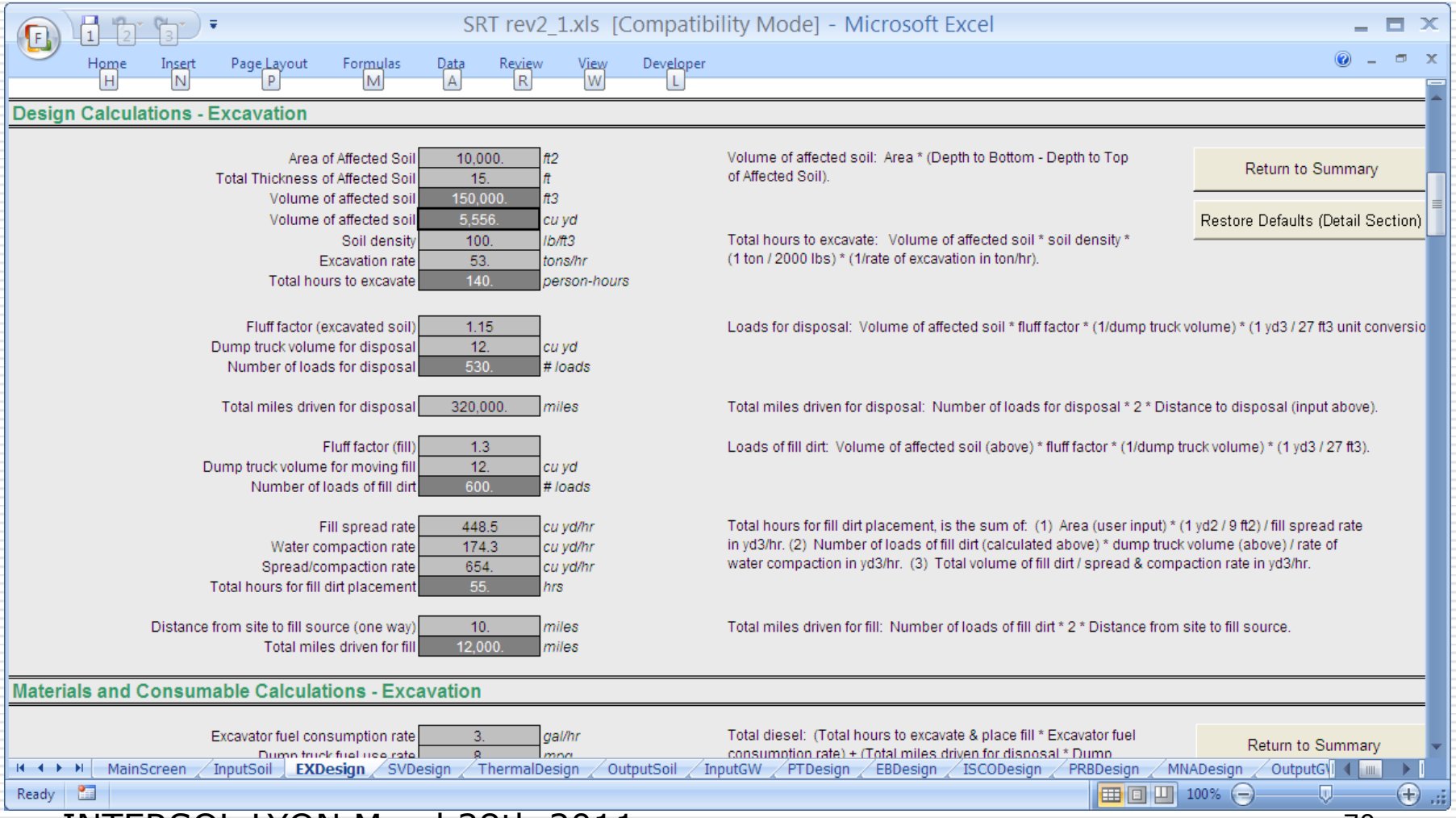
SRT Soil Inputs



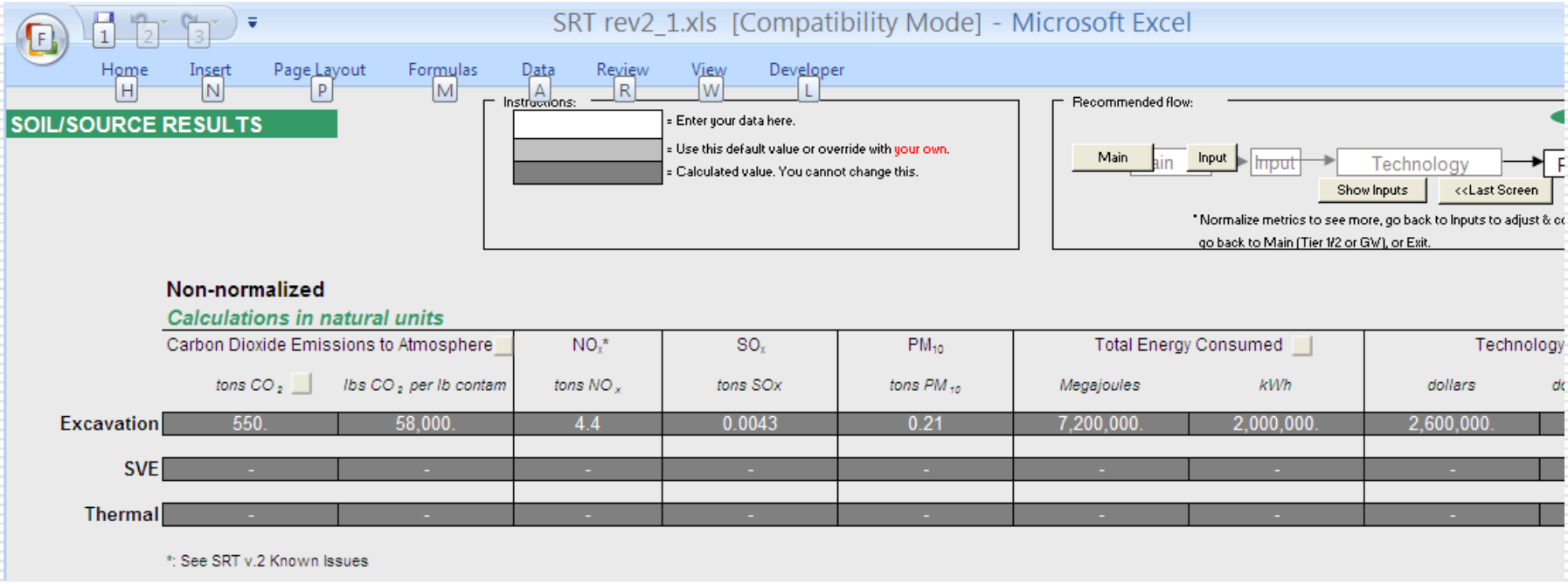
SRT Tier 1 - Excavation



SRT Tier 2 - Excavation



SRT Results Screen



Conclusions

Sustainable Remediation Tool (SRT) Distribution

Available as free download from US Air Force (AFCEE)

www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation

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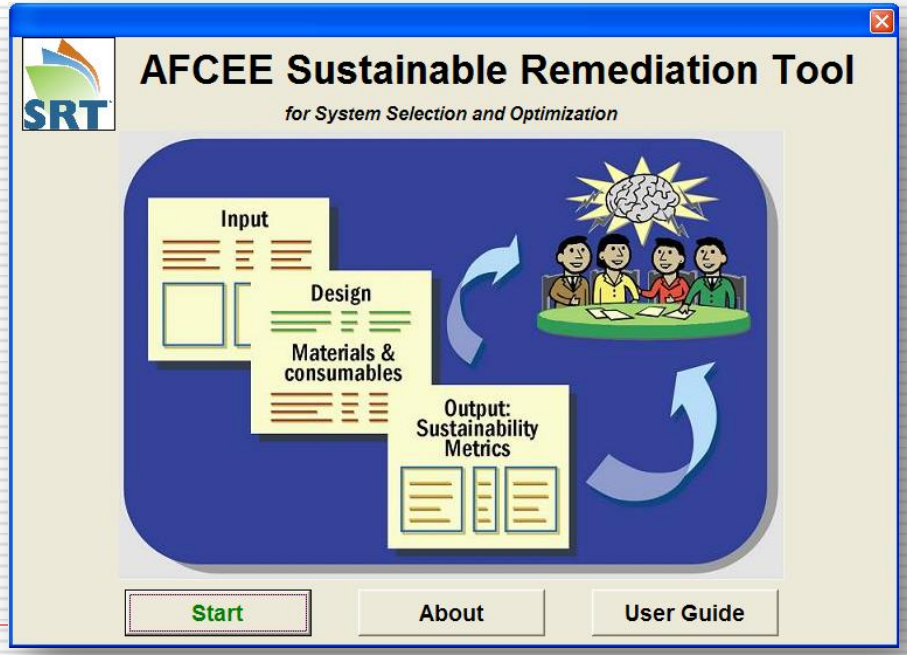

Environmental forensics

- The process
  - Legal
  - Commercial
  - Litigation Court issues
- Actors : Who does what
- Actors who owes what to whom
  - A two fold key point : independance and appearance of independance

Comparisons

- European roadmap
  - Stresses role of the three pillars and social and local (land use) decision
  - Allows a wider range of decision, leaves open technical solutions
- US tools
  - Are more related to binding regulation, although interactive process is one of the conditions
  - Are built to support a project management system and track costs, use feedback and provide outlooks so far as possible to decision makers
  - Encompass technical solutions in a detailed way, available both to Mastery of work, external expertise, stake holders

SOIL POLLUTION AND ENVIRONEMENTAL FORENSICS

- Now, time for questions