Air Force Center for Engineering and the Environment

Integrity - Service - Excellence

SRT: Sustainable Remediation Tool

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Global Perspectives in Green Remediation Symposium

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EARTH TECH | 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…

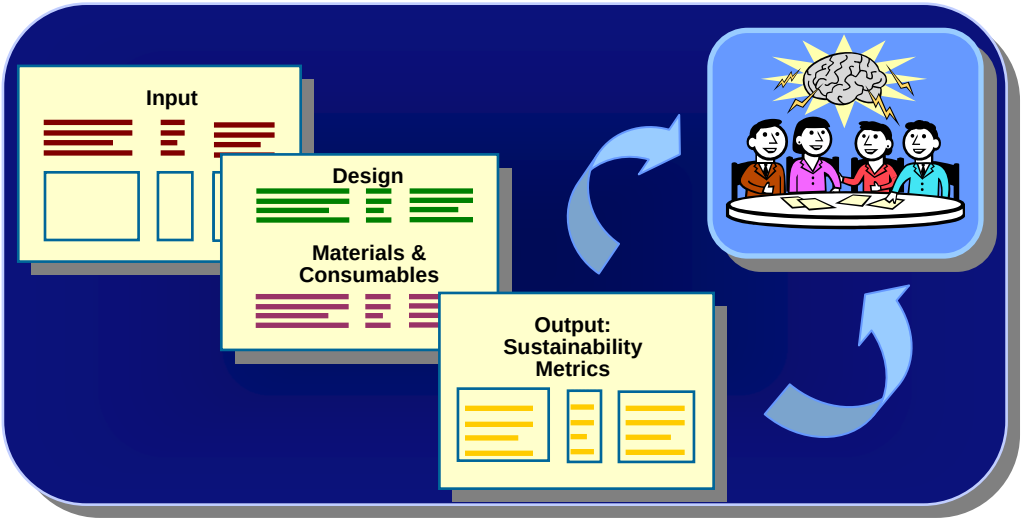
Develop tool to help AFCEE environmental professionals incorporate sustainability concepts into their remediation decision making process (e.g., PBM, RRM, ERP-O) for

i) planning future remediation implementation

ii) optimizing operating remediation sites

Tool Distribution

The tool will be available as freeware from the US Air Force to all interested parties.



What the Tool Does

Estimates sustainability metrics for specific technologies:

1. **Excavation**
2. **Soil Vapor Extraction**
3. **Pump and Treat**
4. **Enhanced Bioremediation**

The Air Force Center for Engineering and the Environment (AFCEE) intends to add additional technology modules in the future.

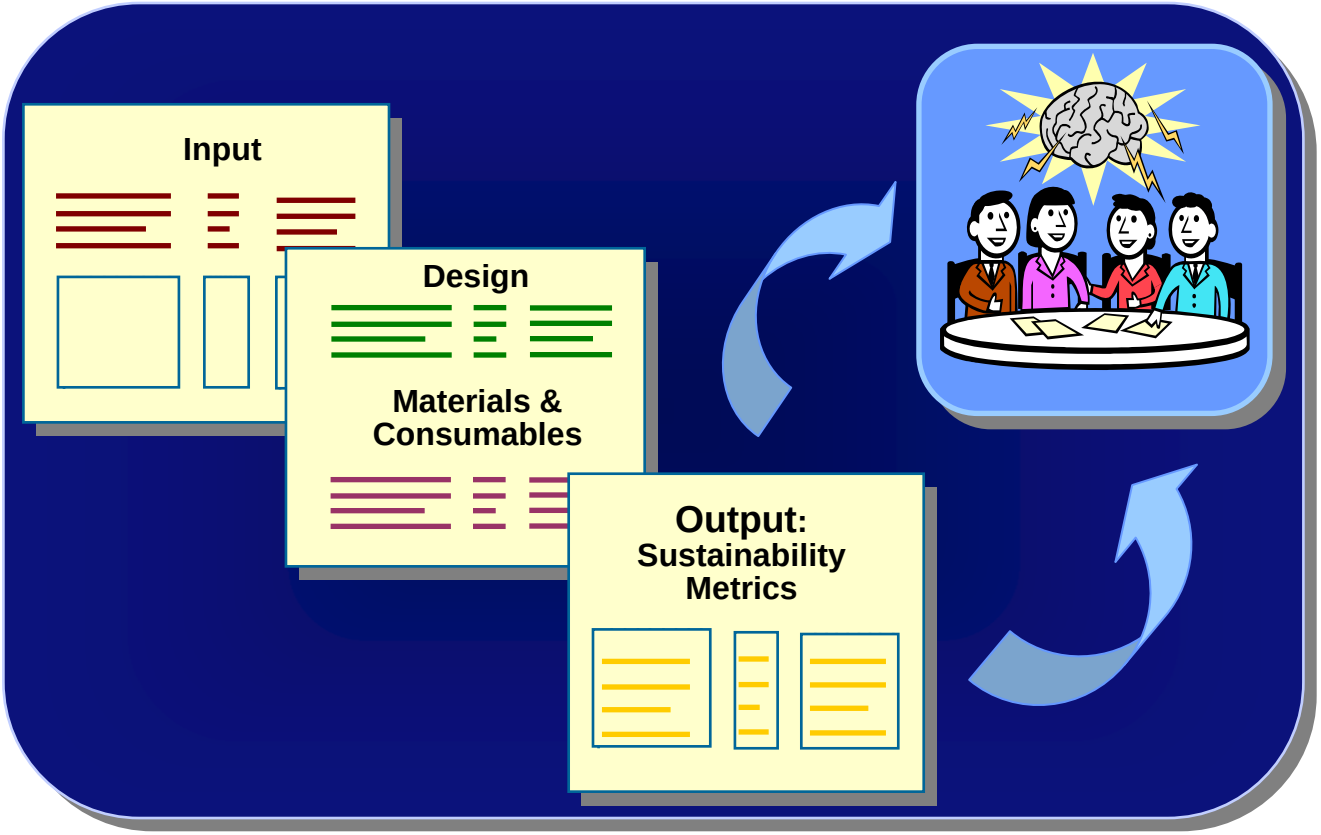
What the Tool Does

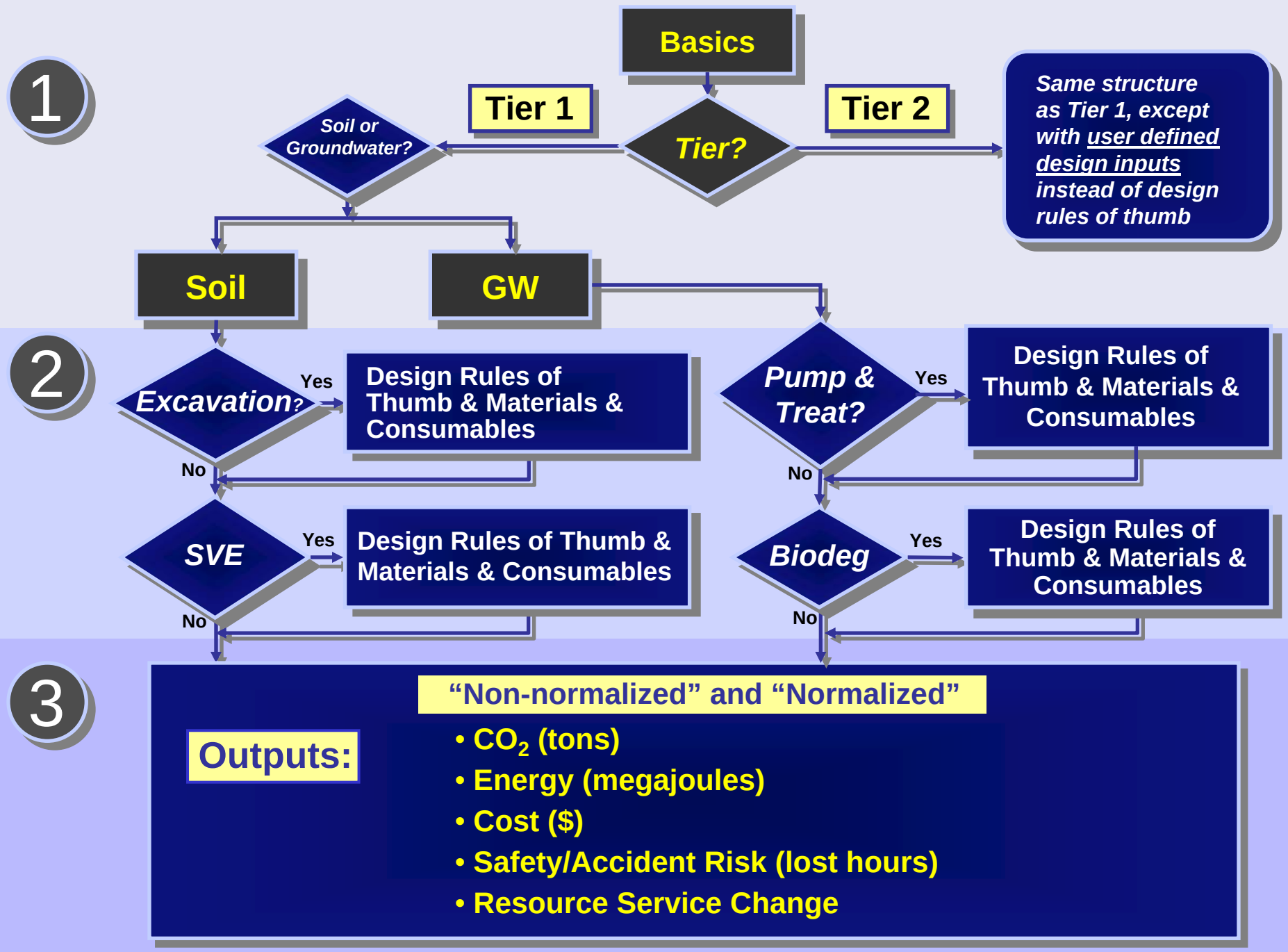
Sustainability metrics developed:

- **Carbon dioxide emissions to atmosphere**
- **Total energy consumed**
- **Change in resource service**
- **Technology cost**
- **Safety / Accident risk**

AFCEE intends to add additional metrics in the future.

Tool Structure




1
Basics
Tier 1
Tier 2
Tier?
Same structure as Tier 1, except with user defined design inputs instead of design rules of thumb
Soil or Groundwater?
Soil
GW
2
Excavation?
Yes
Design Rules of Thumb & Materials & Consumables
No
SVE
Yes
Design Rules of Thumb & Materials & Consumables
No
Pump & Treat?
Yes
Design Rules of Thumb & Materials & Consumables
No
Biodeg
Yes
Design Rules of Thumb & Materials & Consumables
No
3
Outputs:
"Non-normalized" and "Normalized"
• CO_2 (tons)
• Energy (megajoules)
• Cost ($)
• Safety/Accident Risk (lost hours)
• Resource Service Change

Levels of Complexity for Calculation Tools

GW Modeling

- Hand calculations
- Analytical models
- Numerical models

LOW

Increasing Complexity

HIGH

Sustainability (?)

- Hand calculations
- Spreadsheets
- F.B. Life Cycle Analysis

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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

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 metric tons CO_2 emitted** **"Non-normalized" natural units**

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

"Normalized" $ units

How Does It Work?

Example Energy Consumed Metric

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

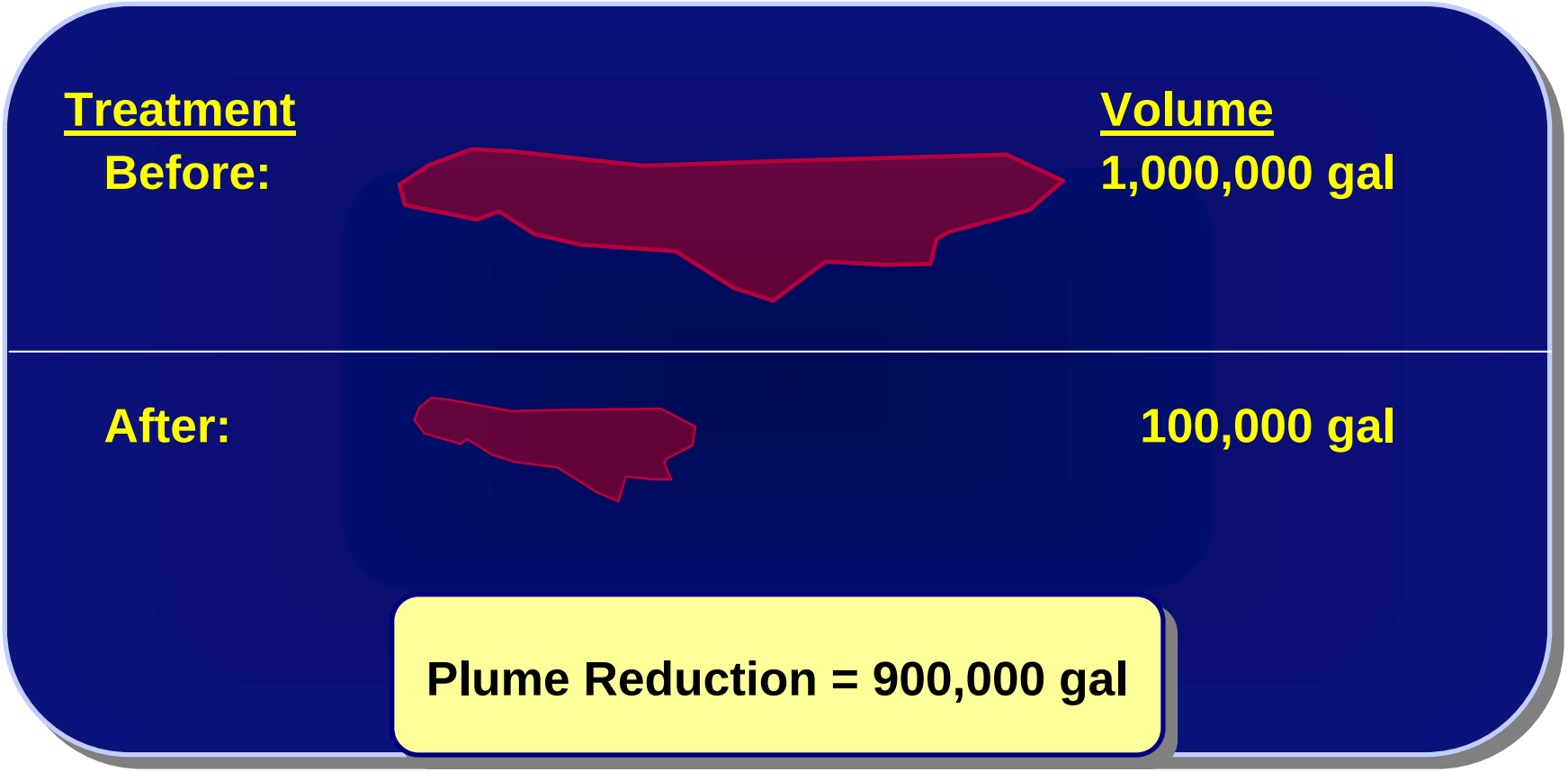
"Non-normalized" natural units

$$32 \text{ gal gas} \times \frac{\$4.00}{1 \text{ gal gas}} = \$128$$

"Normalized" $ units

How Does It Work?

Example Resource Service Metric

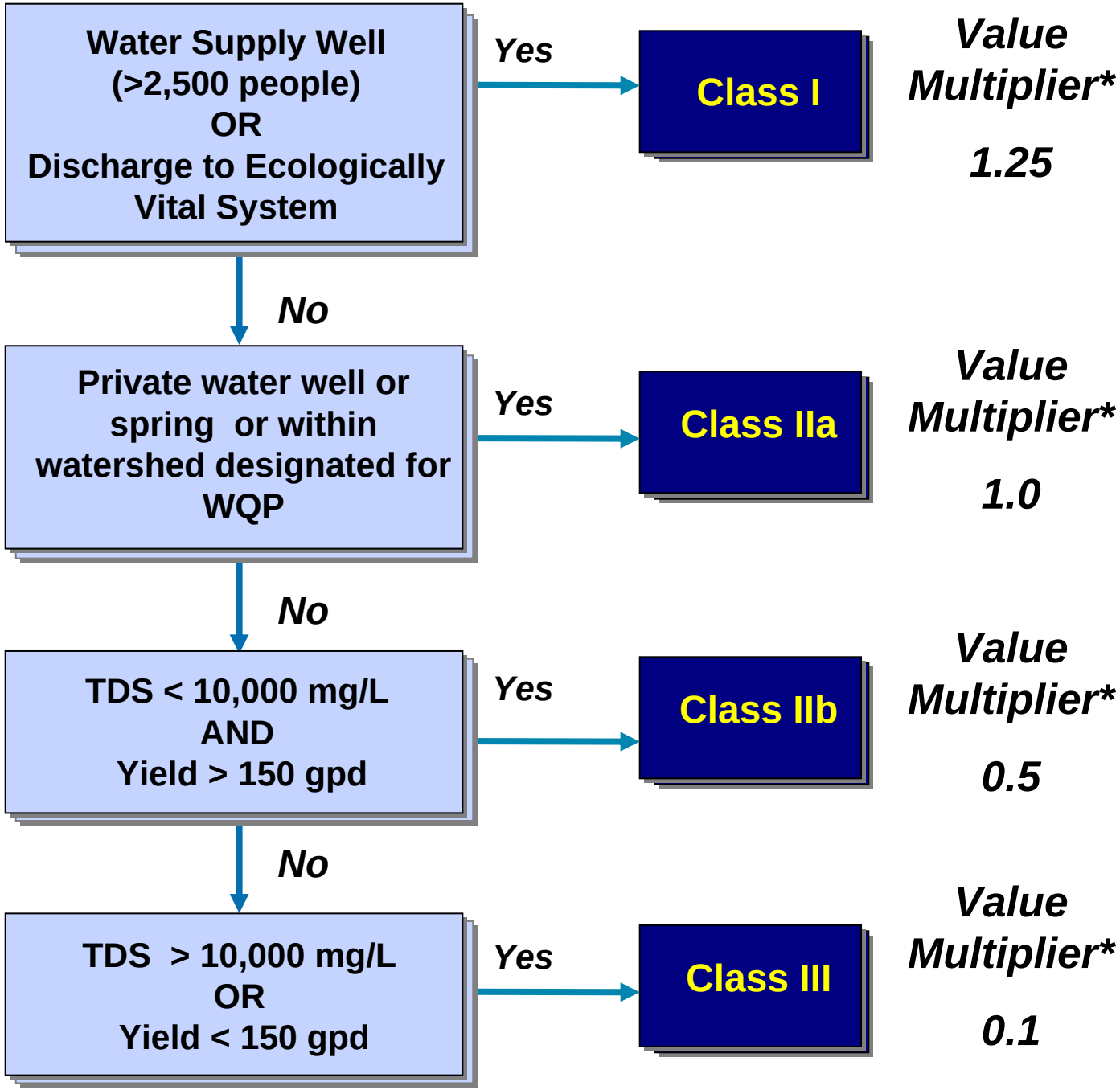


AFCEE SRT:

How Does It Work?

GW Resource Value Calc

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



* If Used

Safety / Accident Risk Example

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

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

$$= 9.5 \times 10^{-5} \text{ injuries}$$

"Non-normalized" natural units

"Normalized" natural units: ***not calculated***

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

Tier 2 Case Study Site

Site Stats:

- Existing large-scale groundwater extraction and treatment system
- Operating since 1999
- Pumping over 3,500 gpm, through 17 wells
- Approximately 300 lbs TCE removed / year using activated carbon
- System optimized on a regular basis

Plume Stats:

- Sandy aquifer
- Low concentrations of trichloroethene (TCE)
- Average contaminated aquifer thickness: < 100 ft
- Models predict pumping for additional 47 years to reach MCLs

Five Metrics for GW Remediation: "Non-normalized"

Pump & Treat over 47-year projected lifetime

CO_2 Emissions……57,000 tons
lb CO2 / lb dissolved mass……..160,000 lb / lb

Energy Consumed……920,000,000 Megajoules

Cost……$58,000,000
Cost / lb dissolved mass……$80,000 / lb

Safety / Accident Risk……...1.7 injury risk
Lost work-time……..83 lost hours

Change in Resource Service
Plume reduction……..1,700 million gallons

Five Metrics for GW Remediation: "Normalized"

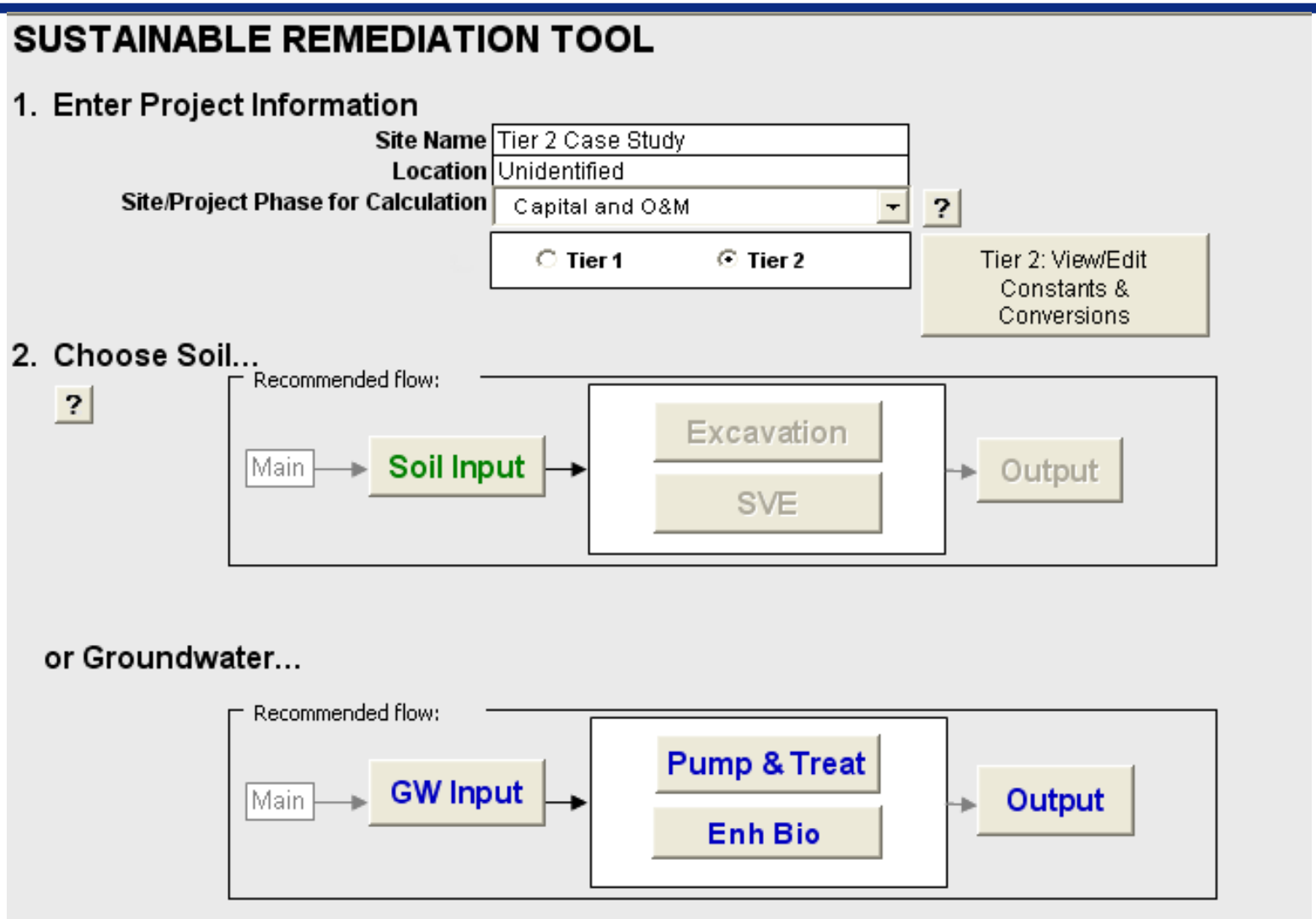
Pump & Treat over 47-year projected lifetime

CO_2 Emissions	$340,000
Energy Consumed	$8,700,000
Cost (minus energy costs)	$49,000,000
Change in Resource Service	
Economic gain	-$430,000
Ecologic gain	-$50,000
TOTAL	$58,000,000

Gains reduce the total cost

Converting metrics to dollars gives a common baseline.

Case Study


SUSTAINABLE REMEDIATION TOOL
1. Enter Project Information
Site Name
Tier 2 Case Study
Location
Unidentified
Site/Project Phase for Calculation
Capital and O&M
?
Tier 1
Tier 2
Tier 2: View/Edit Constants & Conversions
2. Choose Soil...
?
Recommended flow:
Main
Soil Input
Excavation
SVE
Output
or Groundwater...
Recommended flow:
Main
GW Input
Pump & Treat
Enh Bio
Output

Case Study

PUMP AND TREAT - TIER 2

Tier 2 Case Study
Unidentified
CAPITAL and O&M

Design for Managing Groundwater

Airline miles flown by project team (total miles for all travelers)	140000	*miles over proj lifetime*
Average Distance Traveled by Site Workers per one-way trip	30	*miles*
Trips by Site Workers during construction	1200	*# over project lifetime*
Trips by Site Workers after construction	12220	*# over project lifetime*
Remediation Design (Purpose)	Remediation	
Duration (must be <100 years)	47	*years*

Tier 2: Change Calculated Values (dark gray boxes)

Total pumping rate	3,500.	*gpm*
Per well pumping rate	210.	*gpm*
Number of wells	17.	#
Length of manifold	25,000.	*ft*
Treatment Method	Activated Carbon	
Beginning Plume Mass	330.	*kg*
Ending Plume Mass	0.	*kg*

	Original Plume		After Project	
Plume Area	880.	*acres*	0.	*acres*
Plume Length	13,000.	*feet*	0.	*feet*
Plume Volume	1,700.	*million gallons*	0.	*mil gals*
Dissolved Mass	330.	*kg*	0.	*kg*

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.

Restore Defaults

Show Inputs

Recommended flow:

Main → Input → Technology Design (You are here) → Results

Technology Design: Pump & Treat; Enhanced Bioremediation

<<Last Screen Next>>

Materials and Consumable Amounts Used for Metrics

PVC	57,000.	*lbs*
Steel	83,000.	*lbs*
Activated carbon	76.	*lbs*
Electricity	82,000,000.	*kWh*
Diesel (Capital)	700.	*gal*
Diesel (O&M)	80,600.	*gal*
Gasoline (Capital)	4,936.	*gal*
Gasoline (O&M)	48,803.	*gal*
Natural gas	0.52	*mcf*

Technology Cost

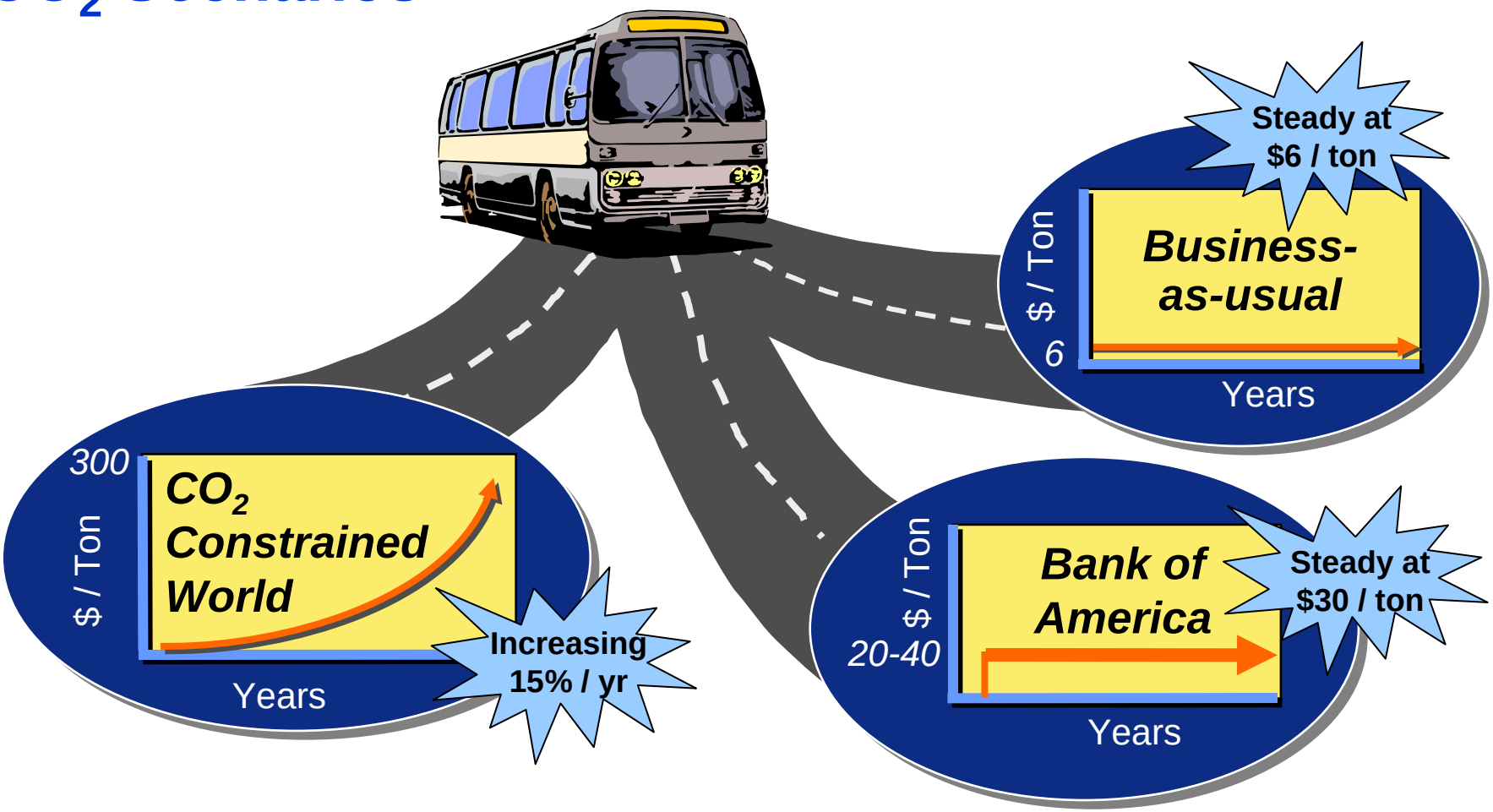
Capital	6,500,000.	*$*
O&M	51,700,000.	*$ over project*

Project-specific Metrics (Add & Subtract/Offsets)?

Yes / No

Additional Technology Cost		*$*
Total Energy Consumed		*Megajoules*
CO_2 Emissions to Atmosphere		*tons* CO2
Safety / Accident Risk	48	*lost hours*

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 (Normalized; 100 years max)

Capitalization Rate	0.03	
Business as Usual	6	$ per ton per year (base rate)
Bank of America	40	$ per ton per year
Carbon Constrained World	0.15	increase after Year 1 (Year 1 uses base rate).

PUMP AND TREAT[1]

Capital phase	260	tons CO2
O&M phase	1200	tons CO2 per year
Duration	47	years

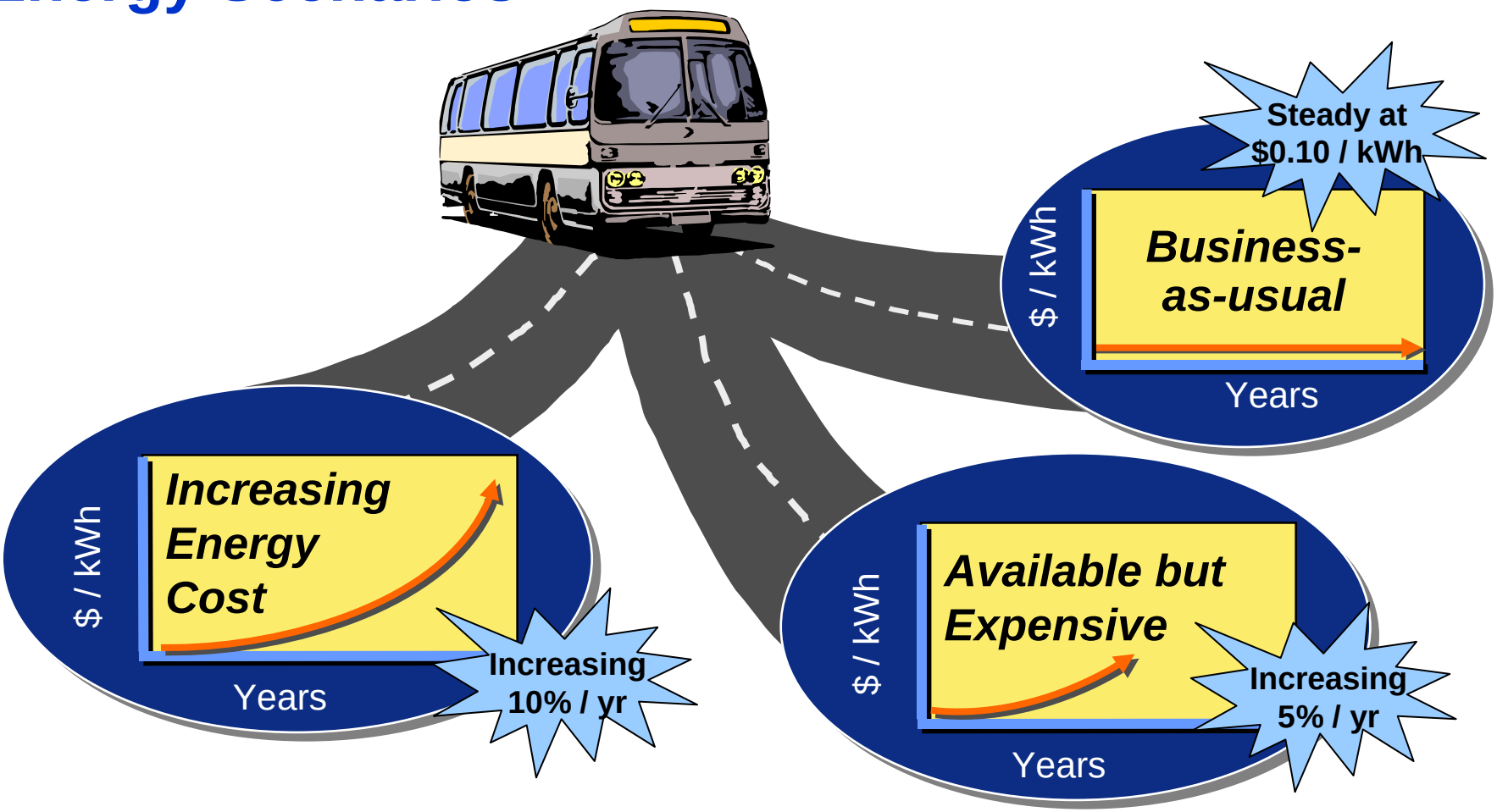
	Business as Usual	Bank of America	Carbon Constrained World
No NPV:	$340,000	$2,300,000	$34,000,000
NPV[3]:	$180,000	$1,200,000	$11,000,000

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.

Energy Scenarios



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

Pump and Treat

Normalized/Cost-based Starting Point

Carbon Dioxide Emissions to Atmosphere	$340,000.	dollars
Total Energy Consumed	$8,700,000.	
Technology Cost	$58,000,000.	
Change in Resource Service	**$550,000.**	
	$57,000,000.	

Consensus (Average) Results

$310,000.	dollars
$7,800,000.	
$46,000,000.	
$610,000.	
$54,000,000.	

KEY POINT:

Starting cost is different than consensus cost

Where We Are

Where We Are

- **Beta testing**
  - **First Round released January 16, 2009**
  - **Review comments due February 20, 2009**
  - **Release of SRT following compilation / updating**
    - **~ 4 - 6 Weeks**

Where We Are Going

- **Additional technology modules**
- **Additional metrics (?)**
- **Integration with RACER™ costing tool**

Questions / Discussion