

How Sustainable Companies Make Decisions; Freshwater

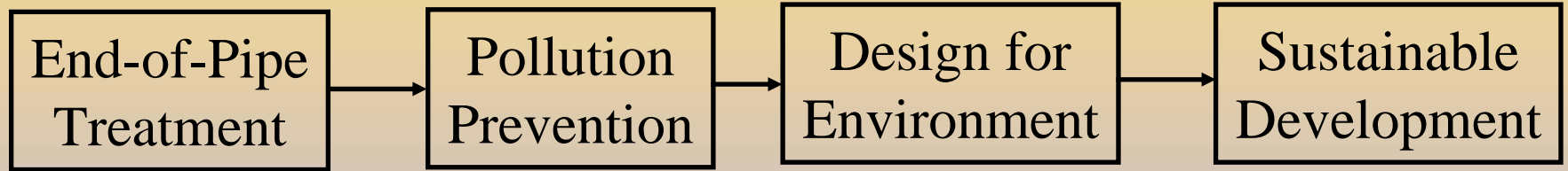
Earl R. Beaver

Institute for Sustainability

Summary

- Sustainability is truly coming of age
- We have marvelous tools
- We need specific data about water and interactions with other issues
- The tools must be integrated into the decision-making process
- Industry is getting message; how about government and academia?

Taxonomy of Environmental Issues

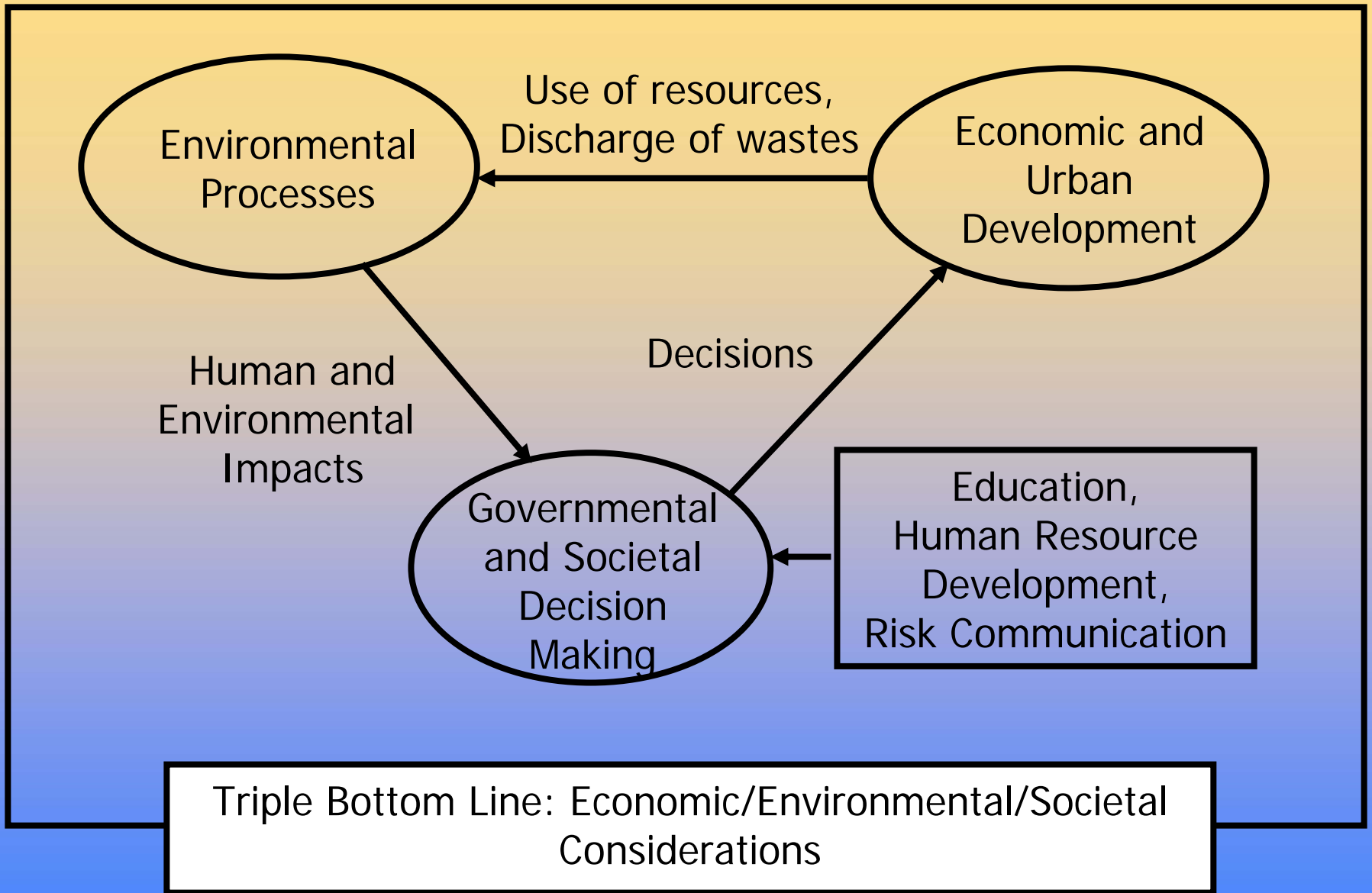


- Reactive
- Reliance on abatement
- Driven by regulations
 - Manufacture
 - Product use
 - Disposal
- No regard for resource consumption
- Limited accountability

- Reduce
- Reuse
- Recycle

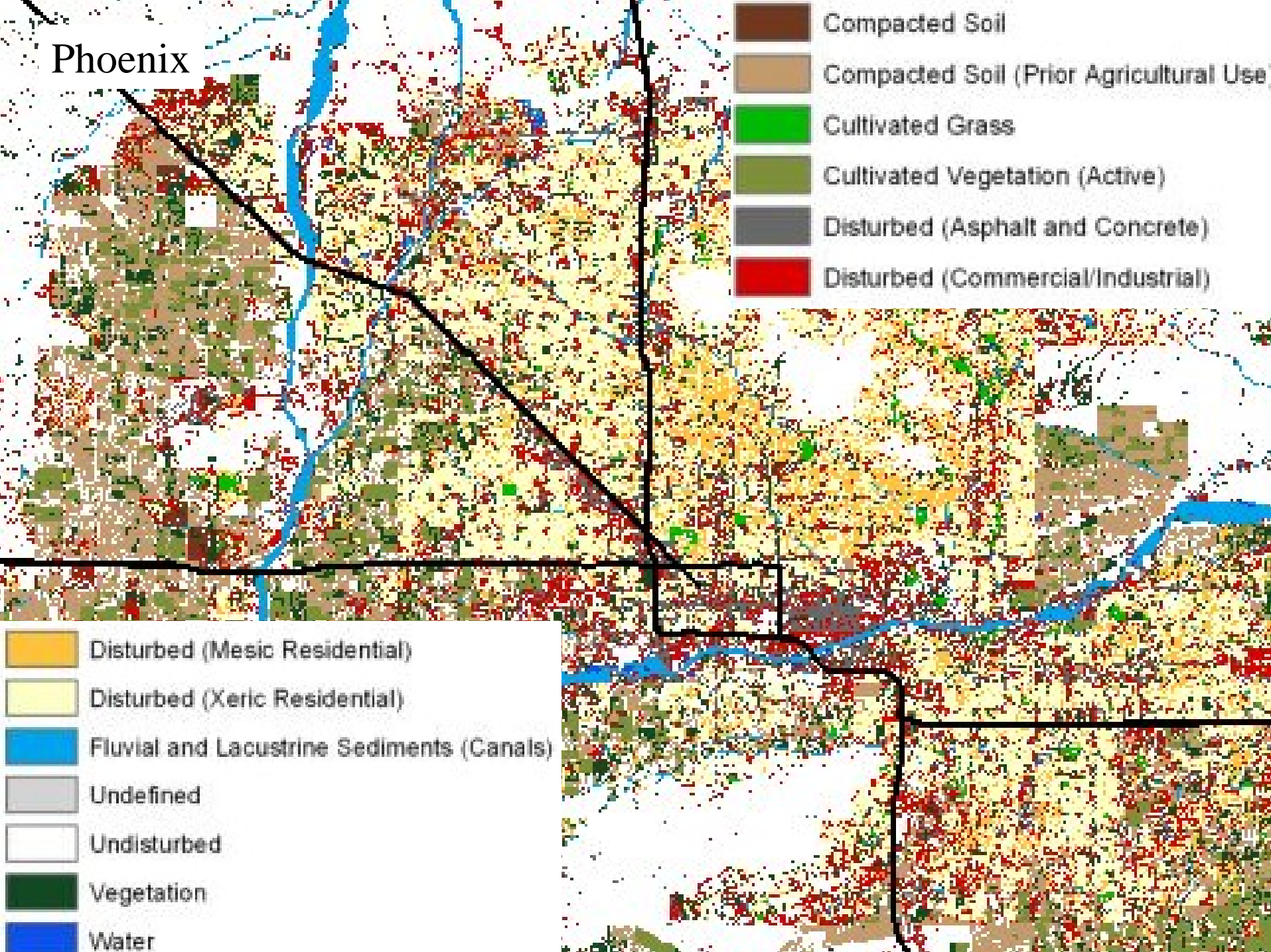
- Proactive
- Beyond compliance
- Life cycle analyses
- ISO 14000
- Extended product responsibility
- Full cost accounting
- Benchmarking

- Eco-efficiency
- Triple bottom line
 - Economic
 - Environmental
 - Societal
- Good individual and corporate citizens and Government
- Accountability in both Public and Private Sectors



Proactive Decision Making: Information Flow in Sustainable Systems

Phoenix



New Technological Development will Complicate Decisions Further

- Info - Transportation substitutes for local and long distance travel (e.g., teleworking, telecommerce infrastructure versus surface transport). Reduced travel time, improve traffic flow, make roads safer.
- Nano - Nano-photosynthesis produces sugar, starch for food; synthesis of cellulose for paper and wood avoids clear-cutting forests. Fewer farm animals and associated pollution. (Mark Weisner on Sunday)
- Cogno - New sustainable society concept and better social decision-making. Engage retired community; transfer their knowledge to create a more sustainable environment.
- Bio - Greater use of renewable resources without depletion, degrading the environment and negative impact on quality of life. Biotechnology can be used for infectious diseases, making residents more healthy.

Sustainability Metrics: Basic

Materials

Mass of Raw Materials - Mass of Product

Output

Water Consumption

Volume of Fresh Water Used

Output

Output:

Energy

Net Energy Used

Output

Mass of Product

or

Sales Revenue

or

Value-added

Pollutant Dispersion

Total Mass of Pollutants Released

Output

Toxics Dispersion

Total Mass of Recognized Toxics Released

Output

Land Use

Land covered, paved, in buildings

Output

Other Metrics

- Global Warming
- Acid Deposition
- Ozone Depletion
- Smog Formation
- Fish Toxicity
- Green Algae
- Human Acute and Chronic Disease - Carcinogenic Potential
- Need societal dimension and regional view: equity, societal justice, informed decision-making
- Difficult to compare – multi-criteria decision-making will be needed.

Metrics Comparison of USA to Other Countries

Metric	Efficient	Current Status			Source
		Least	Europe/World	USA	
O ₃ Concentration ug/m ³ (8 hour mean)	120	40~70			WHO (1999)
SO ₂ Emissions kg per capita per yr	10.0	4.9 Switzerland	4.9~119.1	63.1	OECD (1997)
Water (Potable) L/day per capita	150	25 Uganda	159 Amsterdam	466 New York	UNCHS (1997)
Solid Waste kg/day per capita	1.0	0.3 Madagascar	1.1 Amsterdam	1.7 New York	UNCHS (1997)
Urban Population Per ha	100~170		100 152 Amsterdam	72 New York	UNCHS (1997)
Energy tons oil equiv/cap/yr	2.5		2.74 (Fr.); 2.85 (Switz.); 6.02 Can.	5.33	OECD (1997)
Ecological Footprint ha/person	2.3		4.3 Canada	10.3	Wackernagel (1996)

Many Data Sources are Available – Some with Values Judgement

Metric	High (environmentally efficient)	Medium (environmentally responsible)	Low (needs work)
<i>Air</i>			
O ₃ ambient average annual air concentration ($\mu\text{g}/\text{m}^3$)	120	121–170	> 170
<i>Water</i>			
Water use per capita (l/day)	< 150	151–300	> 301
<i>Solids</i>			
Waste generated per capita (kg/day)	1.0	1.1–1.5	> 1.5
<i>Transportation</i>			
Percentage of housing units within 350 m of public transit	100	80–99	< 80
<i>Energy</i>			
Energy use per capita (toe/year)	≤ 2.50	2.51–3.50	> 3.50
<i>Resource use</i>			
Resource use per capita (kg/day)	2.5	2.6–3.6	> 3.6
<i>Population</i>			
Population density (people/ha)	100–170	80–100 or 170–200	< 80 or > 200
<i>Urban ecology</i>			
Open space per capita (ha)	> 2.75	1.75–2.75	< 1.75
<i>Liveability</i>			
UNDP's Human Development Index	> 0.911	0.750–0.911	< 0.750
<i>General environmental management</i>			
Does the city/region have an overall environmental management plan?	Yes, and it works	No, but in progress	No, and not in progress

Note: toe, Tons of oil equivalent; UNDP, United Nations Development Programme.

Many Data Sources are Available – Some with Values Judgement

Metric	High (environmentally efficient)	Medium (environmentally responsible)	Low (needs work)
<i>Air</i>			
O ₃ ambient average annual air concentration ($\mu\text{g}/\text{m}^3$)	< 120	121–170	> 170
<i>Water</i>			
Water use per capita (l/day)	< 150	151–300	> 301
<i>Solids</i>			
Waste generated per capita (kg/day)	1.0	1.1–1.5	> 1.5
<i>Transportation</i>			
Percentage of housing units within 350 m of public transit	100	80–99	< 80
<i>Energy</i>			
Energy use per capita (toe/year)	≤ 2.50	2.51–3.50	> 3.50
<i>Resource use</i>			
Resource use per capita (kg/day)	2.5	2.6–3.6	> 3.6
<i>Population</i>			
Population density (people/ha)	100–170	80–100 or 170–200	< 80 or > 200
<i>Urban ecology</i>			
Open space per capita (ha)	> 2.75	1.75–2.75	< 1.75
<i>Liveability</i>			
UNDP's Human Development Index	> 0.911	0.750–0.911	< 0.750
<i>General environmental management</i>			
Does the city/region have an overall environmental management plan?	Yes, and it works	No, but in progress	No, and not in progress

Let's not go too far!

Note: toe, Tons of oil equivalent; UNDP, United Nations Development Programme.

Strange Things in Treated Wastewater

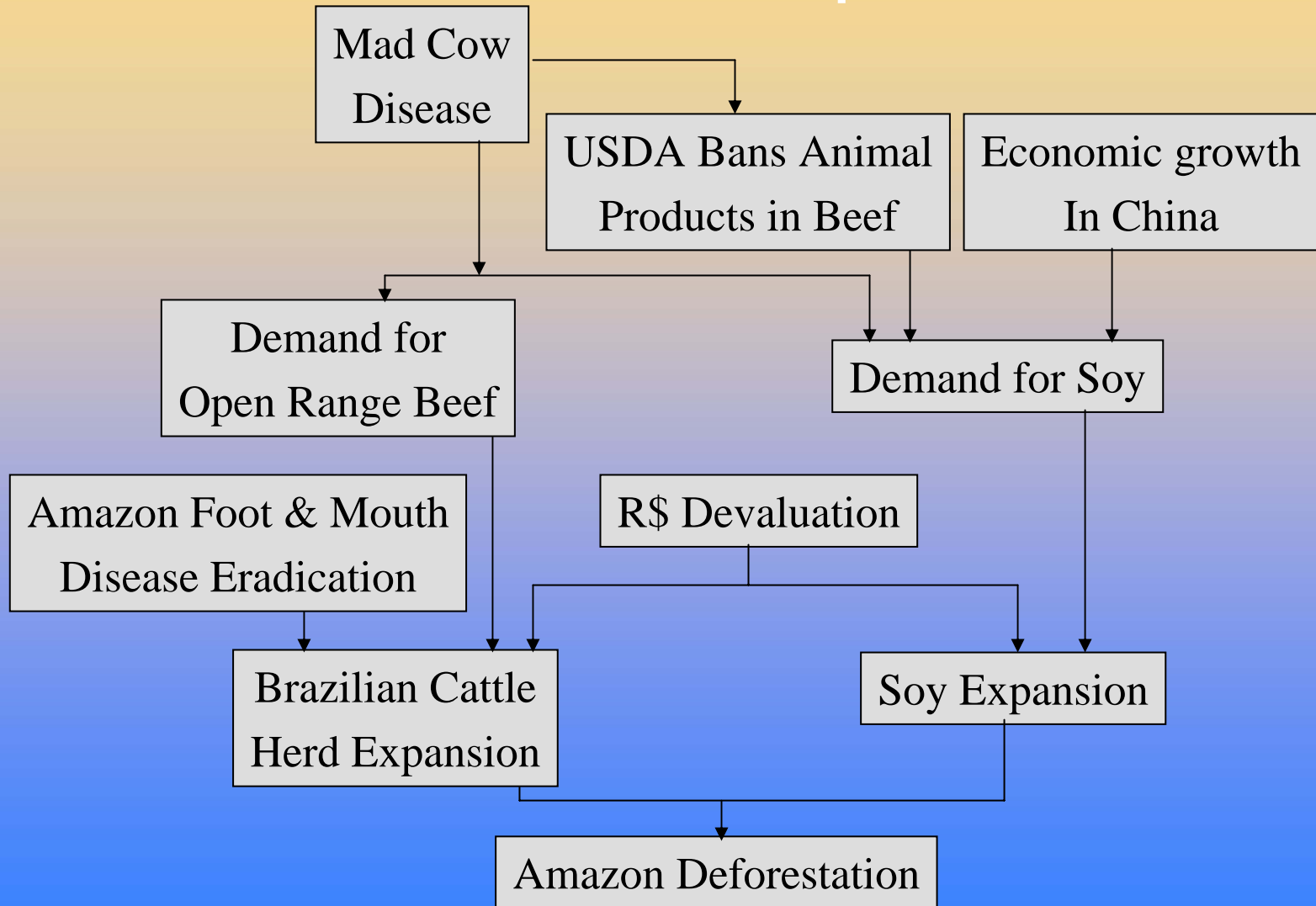
COMPOUND

- AHTN
- Anthraquinone
- Benzophenone
- Bisphenol A
- Bromoform
- Caffeine
- Carbamazepine
- Cotinine
- DEET
- Dehydronifedipine
- Fluoxetine
- HHCB
- Prometon
- Synthetic Musk
- Tetrachloroethylene
- Tri(2-butoxyethyl) phosphate
- Tri(2-chloroethyl) phosphate
- Tri(dichlorisopropyl) phosphate
- Tributyl phosphate
- Triethyl citrate

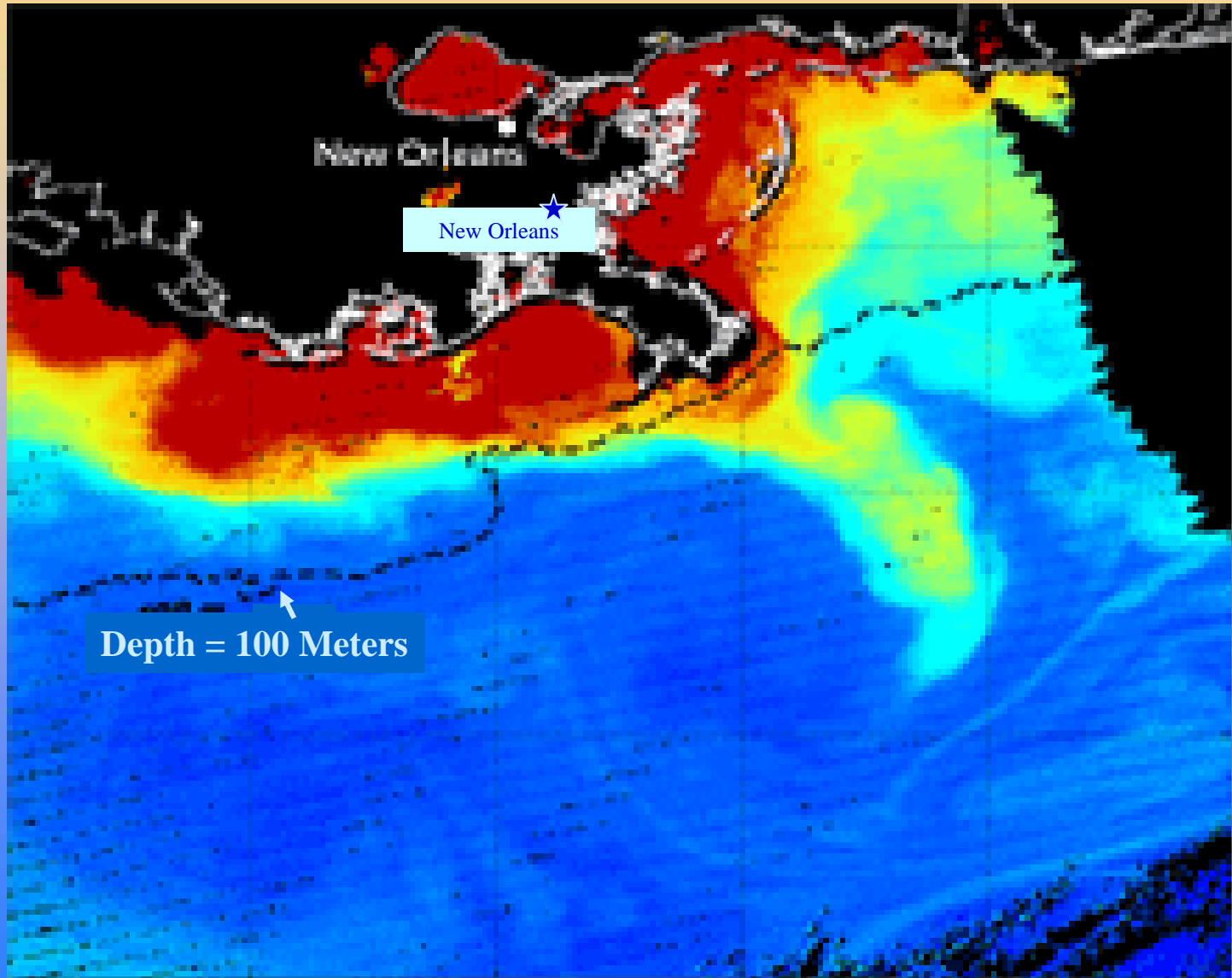
USE OR SOURCE

- Fragrance
- Manufacturing
- Fixative
- Plasticizer
- Trihalomethane
- Stimulant
- Anticonvulsant
- Nicotine metabolite
- Insect repellent
- Nifedipine metabolite
- Anti-depressant (Prozac)
- Fragrance
- Herbicide
- Fragrance
- Solvent
- Plasticizer
- Flame retardant
- Flame retardant
- Flame retardant
- Cosmetics

Unintended Consequences



Fertilizer Effects



And What about Katrina & Rita?

- Destruction of marshlands and buffer zones of vegetation
- Pollutants pumped into Lake Ponchartrain
- Disruption of aquatic and marine breeding areas
- Seepage into underground
- Are funds achieving the greatest benefit?

What is Green Engineering?

Design, commercialization and use of processes and products that are *feasible* and *economical* while minimizing:

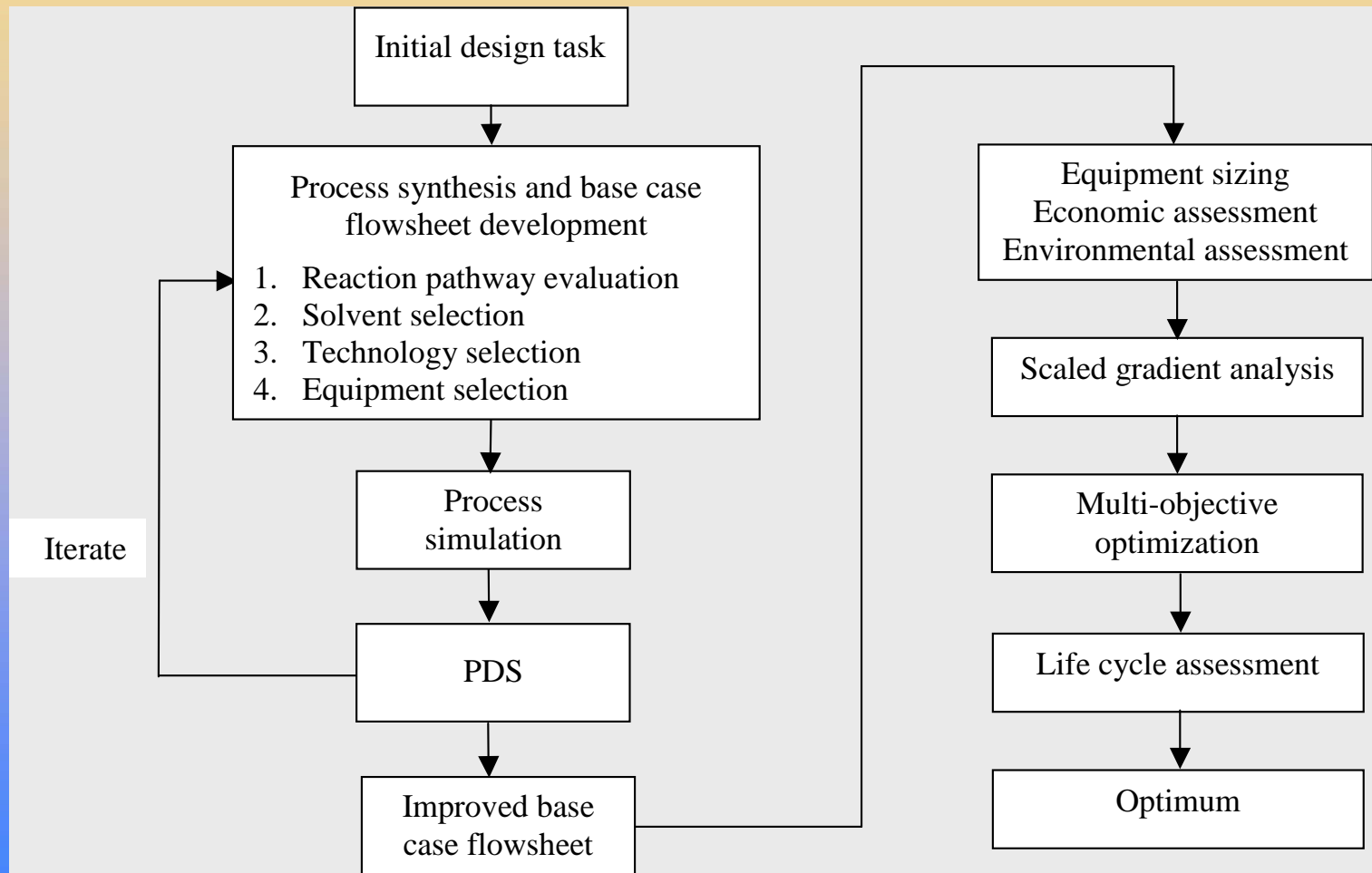
- + Risk to human health and the environment
- + Generation of pollution at the source

Green Engineering

The Sandestin Principles

1. Engineer processes and products holistically, use systems analysis, and integrate environmental impact assessment tools.
- * 2. Conserve and improve natural ecosystems while protecting human health and well-being
3. Use life-cycle thinking in all engineering activities
- * 4. Ensure that all material and energy inputs and outputs are as inherently safe and benign as possible
5. Minimize depletion of natural resources
- * 6. Strive to prevent waste
- * 7. Develop and apply engineering solutions, while being cognizant of local geography, aspirations, and cultures
8. Create engineering solutions beyond current or dominant technologies; improve, innovate and invent (technologies) to achieve sustainability
- * 9. Actively engage communities and stakeholders in development of engineering solutions

Early vs. Detailed Design Tasks

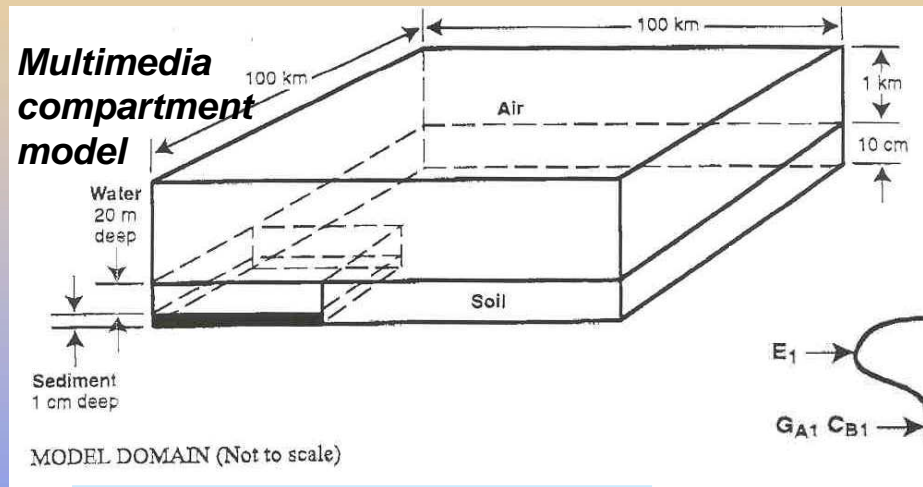


Early Design

Detailed Design

Environmental Fate Calculations

Level 1. Input / Output Information "Tier 1" Environmental Impact Analysis

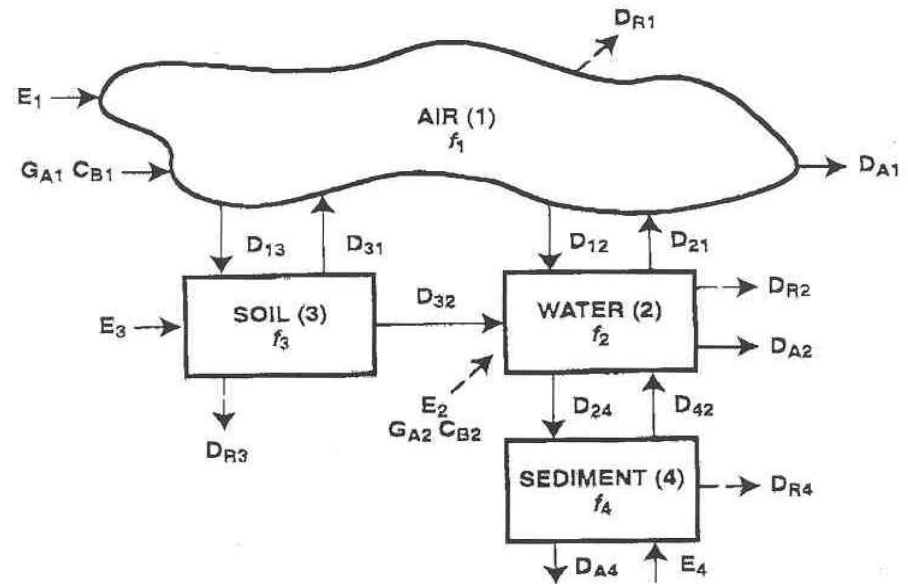


Processes modeled

- emission inputs, E
- advection in and out, D_A
- intercompartment mass transfer, $D_{i,j}$
- reaction loss, D_R

Model Domain Parameters

- surface area - $10^4 - 10^5 \text{ km}^2$
- 90% land area, 10% water
- height of atmosphere - 1 km
- soil depth - 10 cm
- depth of sediment layer - 1 cm
- multiphase compartments



Inventory of Stressors

Land Use
Chemical Emissions
Water Use
Fossil Fuel Use

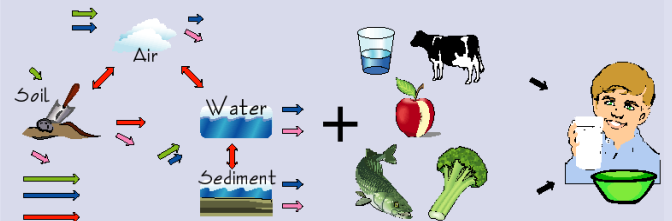


Impact Categories

Ozone Depletion
Global Warming
Acidification
Cancer
Noncancer
Criteria
Eutrophication
Smog Formation
Ecotoxicity
Fossil Fuel Use
Land Use
Water Use

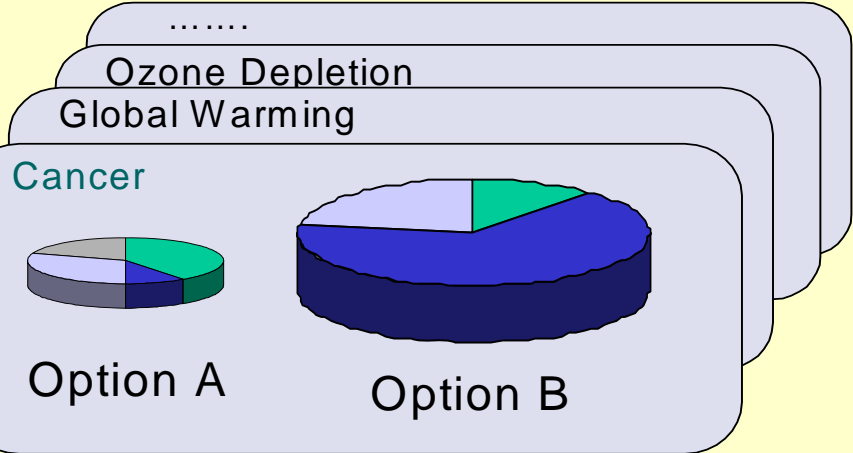


Characterization (e.g., Cancer)

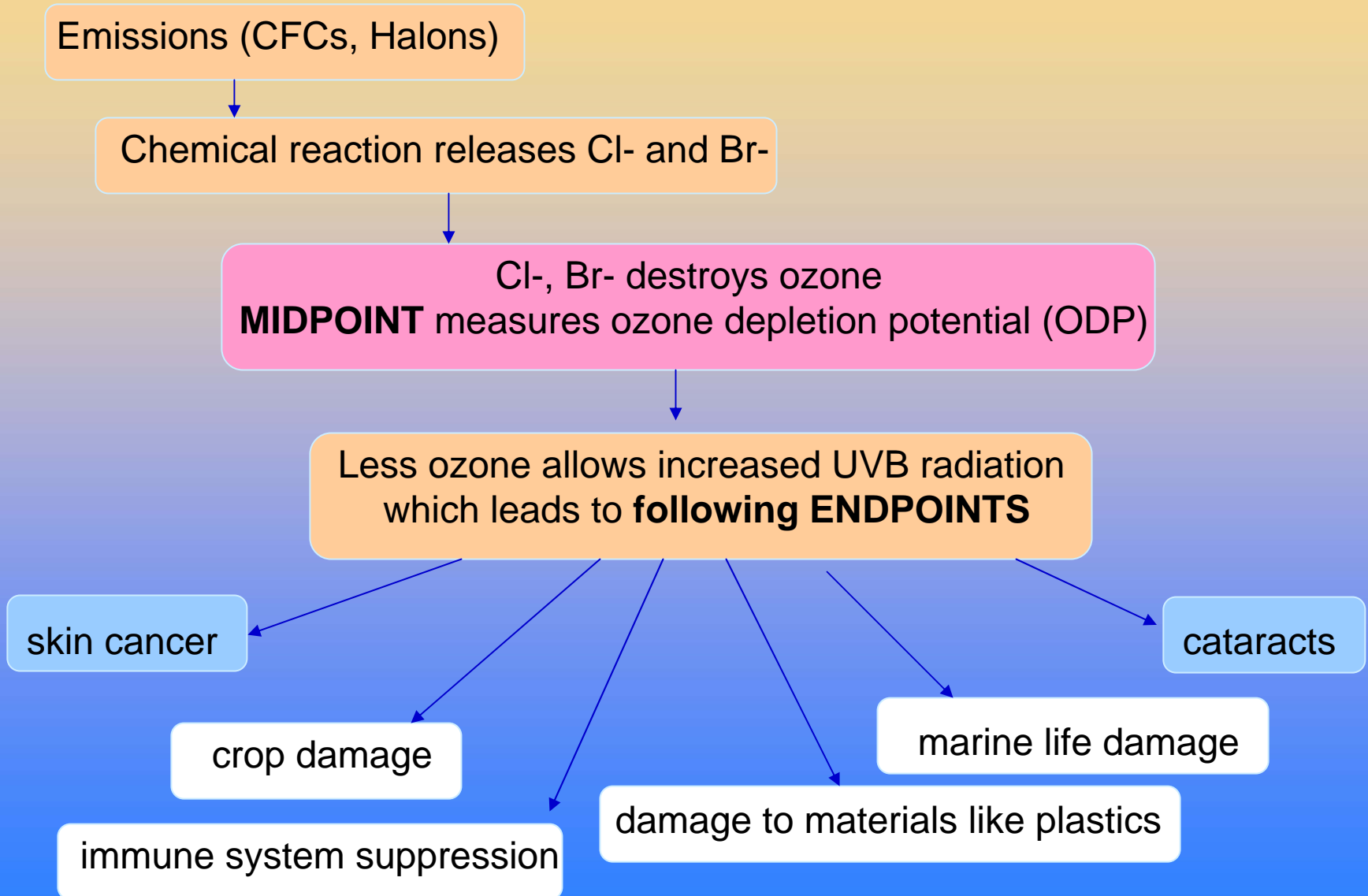


TRACI

Tool for the Reduction and Assessment Of Chemical and Other Environmental Impacts



Endpoint Approach May Reduce Comprehensiveness



Hazard Toxics Potential - CalTOX

- Follows Risk Assessment Guidelines and Exposure Factors Handbook.
- Multimedia modeling approach allows appropriate media transfer.
- Persistence is integral part of LCIA equation.
- Developed for U.S. - incorporates data for every state.
- USEPA Science Advisory Board said that CalTOX was the "most sophisticated."

Microsoft Excel - Sen1

File Edit View Insert Format Tools Data Window Help Acrobat

Geneva 10

A1 = Local Sensitivity Results

1	Local Sensitivity Results					
2	Chemical name	chem-name				
3	Landscape Name	Site name				
4						
5	Parameter name	Symbol	Base value	CV	Local sensitivity	Sensitivity Score
6	Inhalation cancer potency	q1*(inh)	1	0	0.1000	0.00
7	Ingestion cancer potency	q1*(ing)	1	0	0.1000	0.00
8	Dermal cancer potency	q1*(drm)	1	0	0.1000	0.00
9	Inhalation cancer potency	ADI(inh)	1	0	0.1000	0.00
10	Ingestion non-cancer ADI	ADI(ing)	1	0	0.1000	0.00
11	Dermal non-cancer ADI	ADI(drm)	1	0	0.1000	0.00
12	Total dose non-cancer ADI	ADI(ttt)	1	0	0.1000	0.00
13	Time after measured concentrations	Time1	1	0.1	0.1000	0.01
14						
15						
16						
17	Source term to air (mol/d)	Sa	0	0.1	0.1000	0.01
18	Source term to ground-surface soil (mol/d)	Sg	0	0.1	0.1000	0.01
19	Source term to root-zone soil (mol/d)	Ss	0	0.1	0.1000	0.01
20	Source term to surface water(mol/d)	Sw	0	0.1	0.1000	0.01
21						
22						
23						
24						
25	Molecular weight (g/mol)	MW	1	0.1	0.1000	0.01
26	Octanol-water partition coefficient	Kow	1	0.1	0.1000	0.01
27	Melting point (K)	Tm	1	0.1	0.1000	0.01
28	Vapor Pressure in (Pa)	VP	1	0.1	0.1000	0.01
29	Solubility in mol/m3	S	1	0.1	0.1000	0.01
30	Henry's law constant (Pa-m ³ /mol)	H -	1	0.1	0.1000	0.01
31	Diffusion coefficient in pure air (m2/d)	Dair	1	0.1	0.1000	0.01
32	Diffusion coefficient; pure water (m2/d)	Dwater	1	0.1	0.1000	0.01
33	Organic carbon partition coefficient	Koc -	1	0.1	0.1000	0.01
34	Partition coefficient in ground/root soil layer	Kd_s -	1	0.1	0.1000	0.01
35	Partition coefficient in vadose-zone soil layer	Kd_v -	1	0.1	0.1000	0.01
36	Partition coefficient in aquifer layer	Kd_q -	1	0.1	0.1000	0.01
37	Partition coeffic. in surface wtr sediments	Kd_d -	1	0.1	0.1000	0.01

Typical
CalTOX
Screen

Indicators of Toxicity

Level 1. Input / Output Information “Tier 1” Environmental Impact Analysis

The TRACI method and software contains a comprehensive listing of impact categories and indicators.

Relative Risk Index	Equation
Human Toxicity Ingestion Route	$I_{ING}^* = \frac{C_{W,i} LD_{50,Toluene}}{C_{W,Toluene} LD_{50,i}}$
Human Toxicity Inhalation Route	$I_{INH}^* = \frac{C_{A,i} LC_{50,Toluene}}{C_{A,Toluene} LC_{50,i}}$
Human Carcinogenicity Ingestion Route	$I_{CING}^* = \frac{C_{W,i} HV_i}{C_{W,Benzene} HV_{Benzene}}$
Human Carcinogenicity Inhalation Route	$I_{CINH}^* = \frac{C_{A,i} HV_i}{C_{A,Benzene} HV_{Benzene}}$
Fish Toxicity	$I_{FT}^* = \frac{C_{W,i} LC_{50f,PCP}}{C_{W,PCP} LC_{50f,i}}$

LD₅₀ = lethal dose 50% mortality, **LC**₅₀ = lethal concentration 50% mortality and **HV** = hazard value for carcinogenic health effects.

Total Cost Assessment—What does it do?

Evaluate a decision on a financial basis

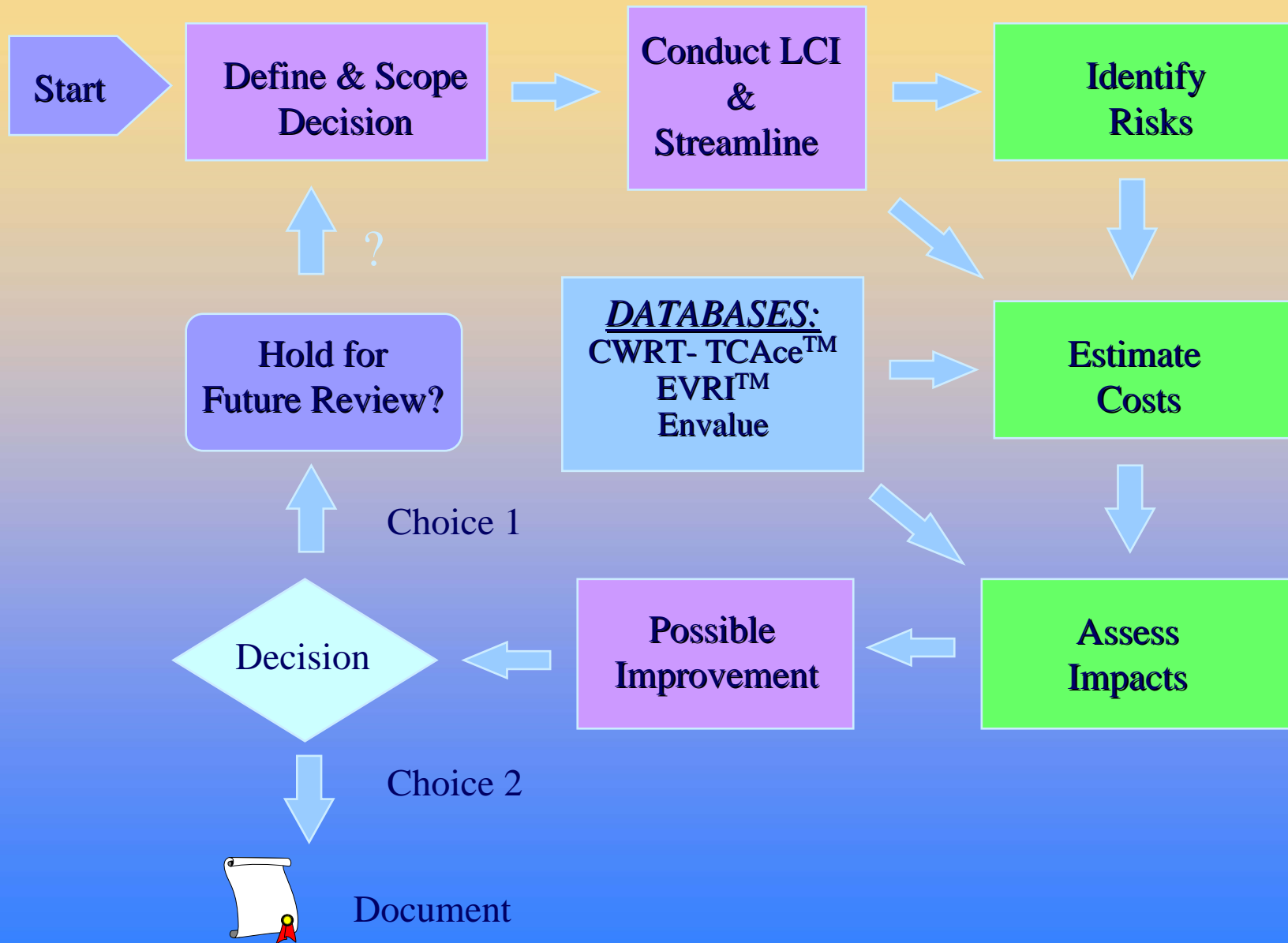
Takes into consideration contingent liabilities and intangibles

Helpful for environmental and health related decisions

Total Cost Assessment

<i>Cost Type</i>	<i>Description</i>	<i>Examples</i>
I. Direct costs	Manufacturing site costs	Capital investment, operating, labor, materials, and waste disposal costs
II. Indirect costs	Corporate and manufacturing overhead	Reporting costs, regulatory costs, and monitoring costs
III. Future and contingent liability costs	Potential fines, penalties and future liabilities	Clean-up, personal injury, and property damage lawsuits; industrial accident costs.
IV. Intangible internal costs (Company-paid)	Difficult-to-measure but real costs borne by the company	Cost to maintain customer loyalty, worker morale, union relations, and community relations.
V. External costs (Not currently paid by the company)	Costs borne by society	Effect of operations on housing costs, degradation of habitat, effect of pollution on human health

Total Benefit & Cost Assessment



New Work in Sustainability



File Edit View Insert Format Tools Data Window Help Acrobat

C:\Program Files\TCAce\QTips\compliance.xls

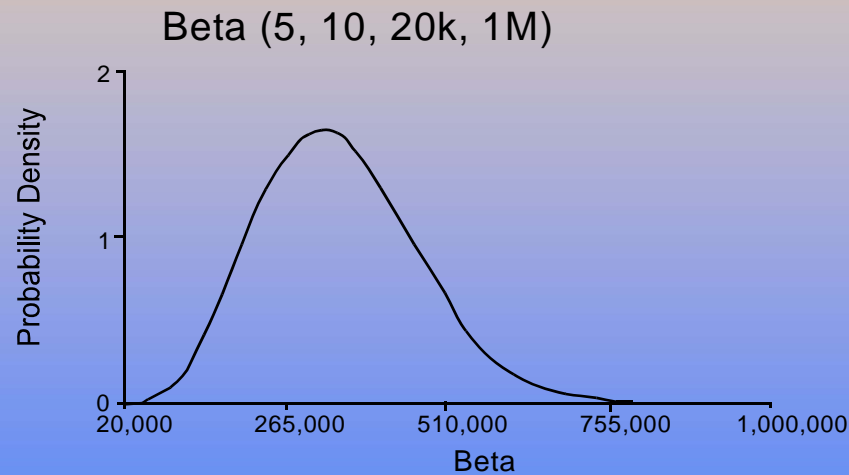
	A	B	C	D	E	F	G	H	I	J	K	L
1	Inflation and Discount Factor Tables	Inflation and	Inflation and D	Inflation and	Inflation and	Inflation and	Inflation and	Inflation and	Inflation and	Inflation and	Inflation and	Inflation and
2												
3	Inflation Factor	2%										
4	Discount Factor	7%										
5												
6	Inflated Cash Flows											
7												
8	Industry	Nominal Cost	Inflated Cost	NPV to 1998*	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
9												
10												
11	Inflation Factor				1.02	1.04	1.06	1.08	1.10	1.13	1.15	1.17
12												
13	Aerospace											
14	- Annualized Cost	(80,476)	(1,419,539)		(82,085)	(83,727)	(85,402)	(87,110)	(88,852)	(90,629)	(92,442)	(94,290)
15	Amino and Phenolic Resins											
16	-O&M	2,013,778	35,521,611	21,041,538	2,054,054	2,095,135	2,137,038	2,179,778	2,223,374	2,267,841	2,313,198	2,359,462
17	-Capital	2,719,067	2,773,448	2,592,008	2,773,448							
18	Pesticides											
19	-O&M	524,498	9,251,768	5,480,366	534,988	545,688	556,601	567,733	579,088	590,670	602,483	614,533
20	-Capital	944,076	962,958	899,960	962,958							
21	Pharmaceuticals											
22	-Annualized Cost	13,732,397	242,229,668		14,007,045	14,287,186	14,572,930	14,864,388	*****	*****	*****	*****
23	Polymers and Resins I											
24	-O&M	2,011,101	35,474,390	21,013,567	2,051,323	2,092,350	2,134,197	2,176,881	2,220,418	2,264,827	2,310,123	2,356,326
25	-Capital	2,529,089	2,579,670	2,410,907	2,579,670							
26	Polymers and Resins IV											
27	-Annualized Cost	(1,558,744)	(24,283,488)		(1,589,918)	(1,621,717)	(1,654,151)	(1,687,234)	(1,720,979)	*****	*****	(1,826,317)
28	Polyurethane Foam											
29	-O&M	42,290	745,973	363,139	43,136	43,999	44,879	45,777	46,692	47,626	48,578	49,550
30	-Capital	367,068	374,409	349,915	374,409							
31	Pulp & Paper											
32	-O&M	1,505,058	26,548,142	12,923,613	1,535,159	1,565,862	1,597,179	1,629,123	1,661,705	1,694,939	1,728,838	1,763,415
33	-Capital	11,357,581	11,584,733	10,826,853	11,584,733							
34	Synthetic Organic Chemicals											
35	-O&M	231,668	4,086,453	1,989,282	236,301	241,027	245,848	250,765	255,780	260,895	266,113	271,436
36	-Capital	599,916	611,915	571,883	611,915							
37												
38	Notes:											
39	* - Each one of the cash flows in future years is inflated, then discounted. The values in the "NPV to 1998" column are the sum of the discounted future cash flows.											
40	The discounted values are shown in Table 2.											
41												
42	Discounted Cash Flows											

Compliance Costs Background Data Inflation Table

Financial inventory

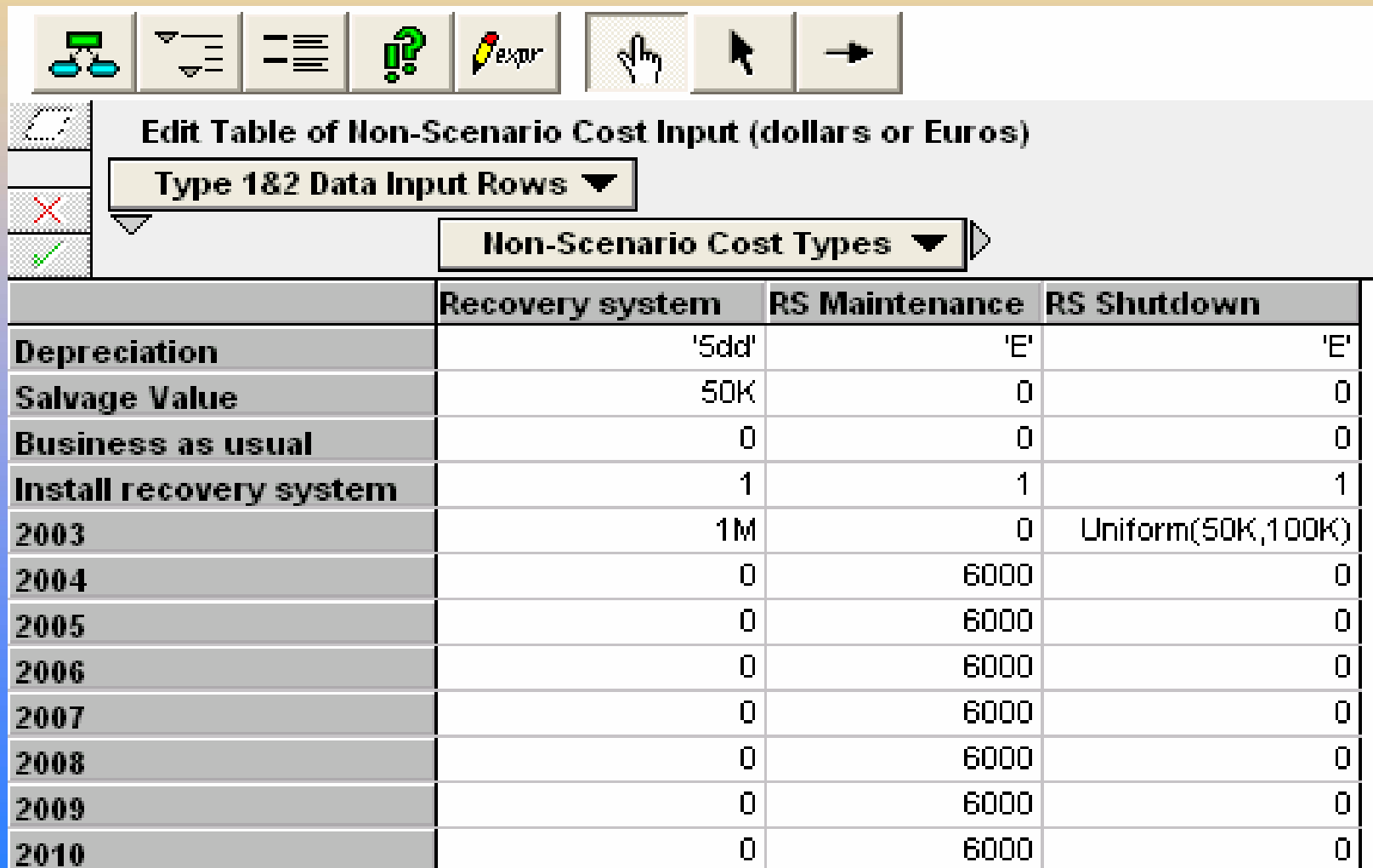
Major non-compliance

Loss of some customers, at least temporarily : 50% probability of losing at least one customer. Costs from \$20K/yr to \$1M/yr. Most likely result is annual losses of \$200-\$400K/yr.



Conduct Assessment

Data is entered into tables in a tool such as TCAce™



The screenshot displays the TCAce software interface. At the top, there is a toolbar with icons for various functions. Below the toolbar, a title bar reads "Edit Table of Non-Scenario Cost Input (dollars or Euros)". A dropdown menu is set to "Type 1&2 Data Input Rows". Another dropdown menu is set to "Non-Scenario Cost Types". The main table has four columns: "Recovery system", "RS Maintenance", and "RS Shutdown". The rows represent different cost categories and years from 2003 to 2010.

	Recovery system	RS Maintenance	RS Shutdown
Depreciation	'Sdd'	'E'	'E'
Salvage Value	50K	0	0
Business as usual	0	0	0
Install recovery system	1	1	1
2003	1M	0	Uniform(50K,100K)
2004	0	6000	0
2005	0	6000	0
2006	0	6000	0
2007	0	6000	0
2008	0	6000	0
2009	0	6000	0
2010	0	6000	0

Conduct Assessment

Calculate Net Present Value with Respect to Baseline (Business as Usual) or Conventional Treatment

Double Click to Begin Model Documentation

TCA Options List Select Baseline **Business as usual** Select Cost Tax Basis **After-tax basis**

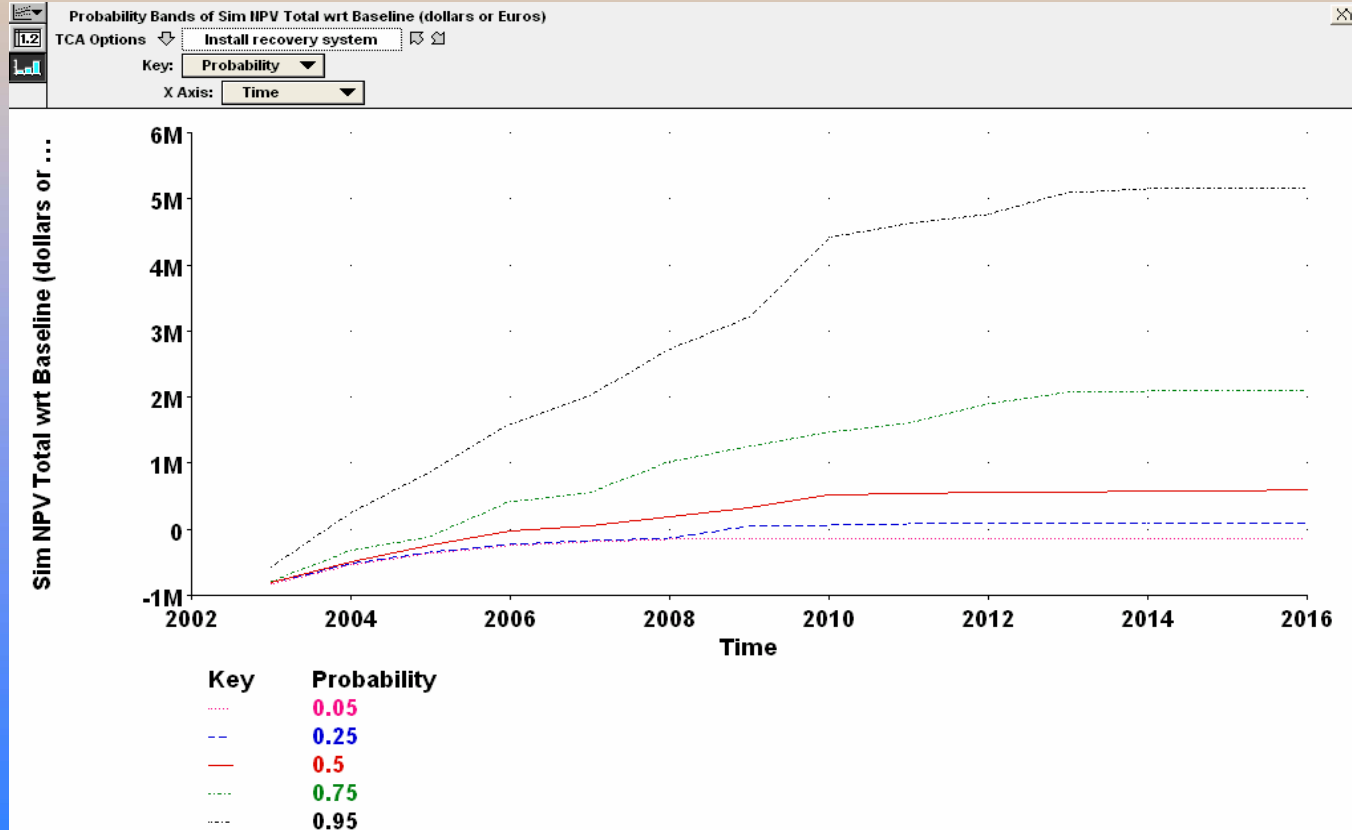
Discount Rate **0** Scenario Horizon Years (Year) List (Marginal) Tax Rate **0.25**

Define Non-Scenario Costs **Define Scenarios and Their Cost Consequences** **Define External Pollution Costs** **Model details**

Results		Expected	Probabilistic
Scenarios	Scenario probabilities / occurrence	Calc <small>mid</small>	Calc <small>📊</small>
	Scenario costs	Calc <small>μ</small>	Calc <small>μ±</small>
Costs	Costs, by cost	Calc <small>μ</small>	Calc <small>📊</small>
	Costs, by cost type	Calc <small>μ</small>	Calc <small>μ</small>
Option Evaluations	After-tax Net Cash Flow wrt Baseline	Calc <small>μ</small>	Calc <small>μ</small>
	Net Present Value wrt Baseline, by cost	Calc <small>μ</small>	Calc <small>μ</small>
	Net Present Value Total wrt Baseline	Calc <small>μ</small>	Calc <small>📊</small>
External Costs	External Cost Results	Calc <small>mid</small>	Calc <small>mid</small>

Conduct Assessment

Simulation shows < 25% chance “Business as Usual” will be the more cost-effective solution.







CONSTRUCTED TREATMENT WETLANDS

Is this a Sustainable
Choice?



What Is a Constructed Wetland?

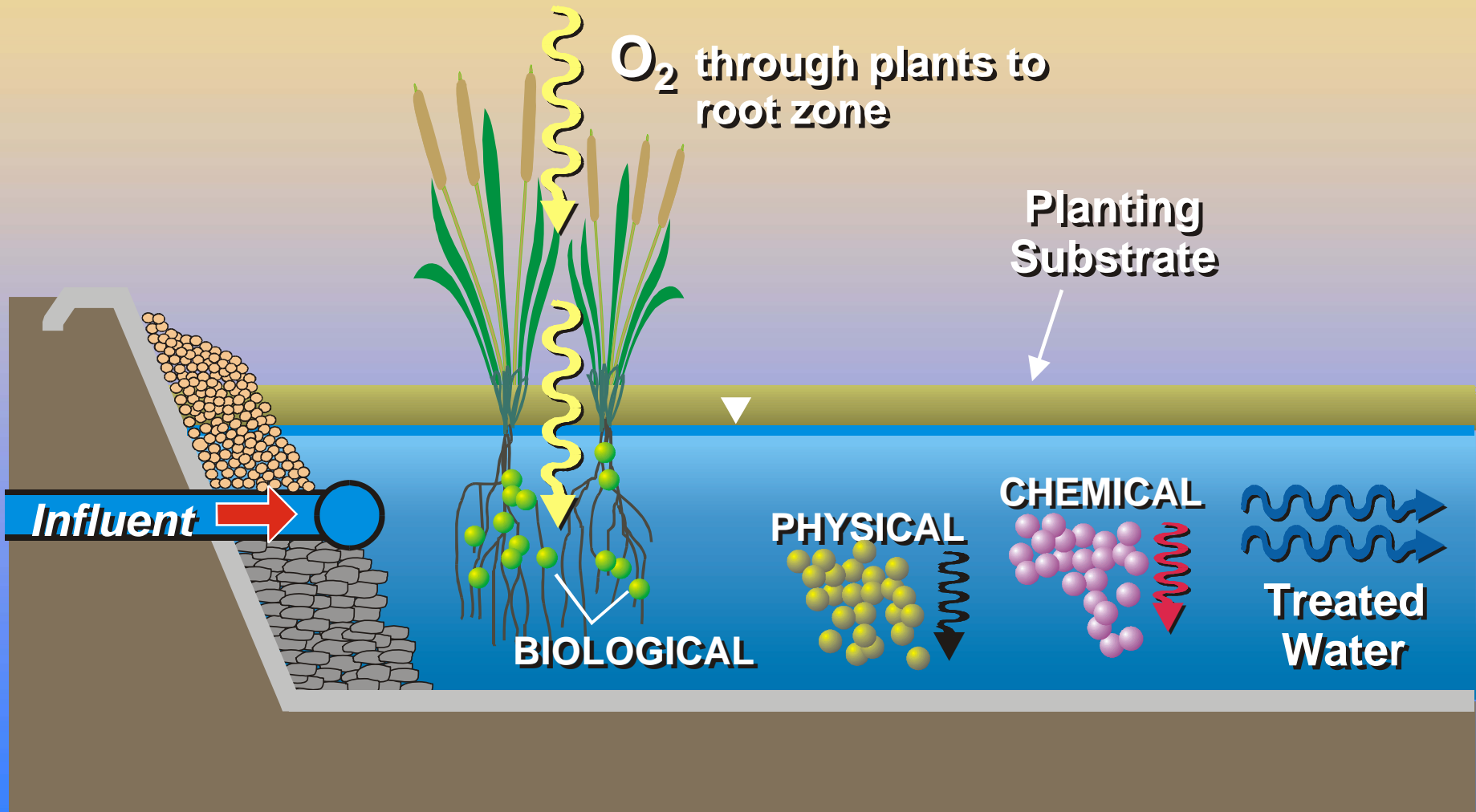
A designed man-made complex of:

-  **Saturated Substrates**
-  **Emergent and Submergent Vegetation**
-  **Animal Life**
-  **Water That Simulates Natural Wetlands**

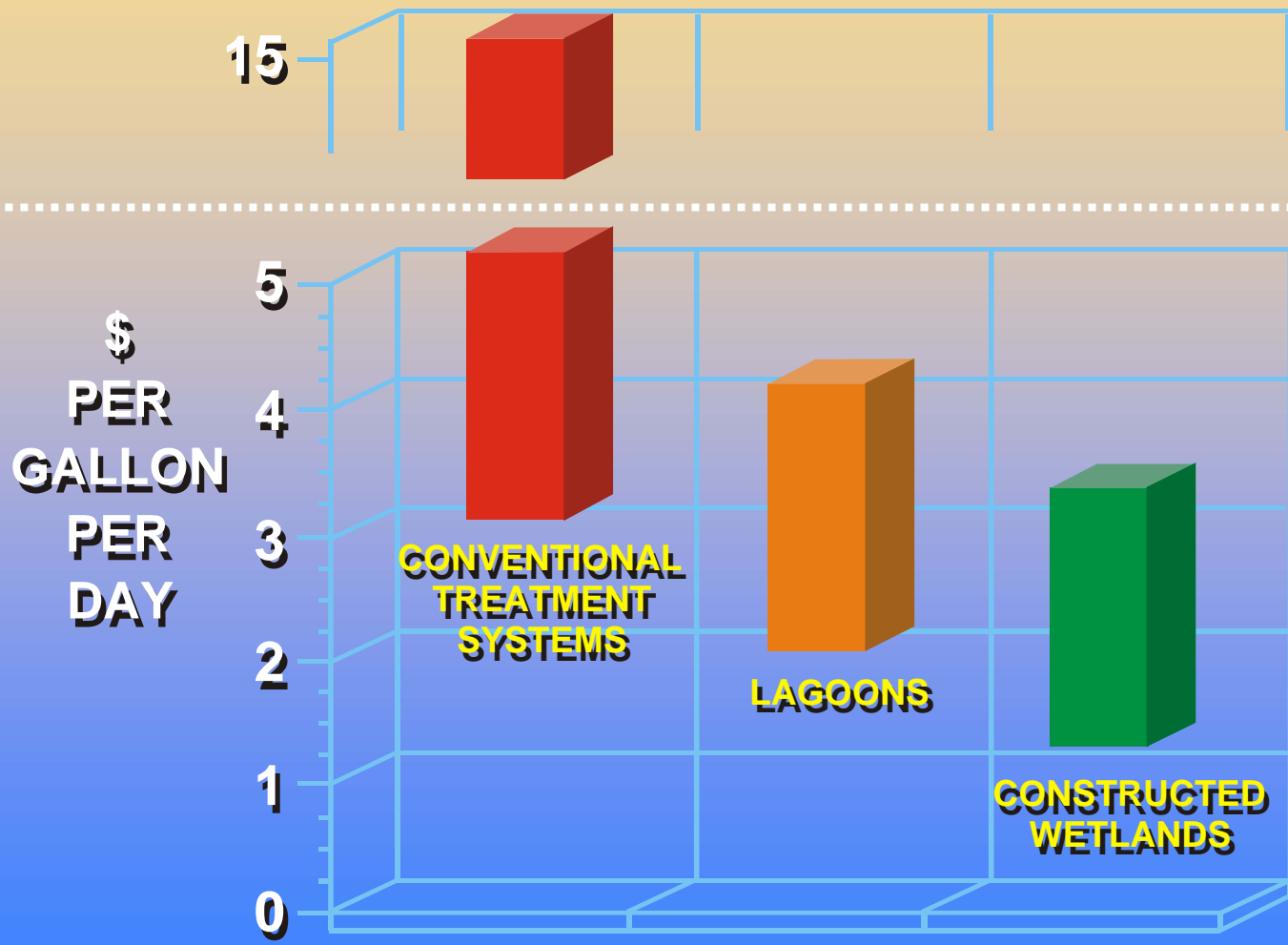
Present Treatment Applications

- ➔ **Municipal and Industrial Wastewaters**
- ➔ **Acid Mine Drainage**
- ➔ **Landfill Leachates**
- ➔ **Agricultural Runoff**
- ➔ **Urban Stormwater**

Contaminant Removal Mechanisms: *Multiple Processes At Work*



Typical Construction Costs



Advantages of Constructed Wetland Treatment Systems

- ▲ Inexpensive to construct
- ▲ Very low operation and maintenance costs
- ▲ Easy to maintain, simple to operate
- ▲ Provide proven and reliable wastewater treatment
- ▲ Tolerant of fluctuating hydraulic and contaminant loading rates
- ▲ Indirect benefits including additional green space, wildlife habitat, recreational and educational areas
- ▲ Less negative impact on freshwater

Potential Disadvantages of Constructed Wetland Treatment Systems

- ▼ Require relatively large land areas
- ▼ Lack precise design and operating criteria
- ▼ Potential vector control concerns
- ▼ Processing mechanisms not fully defined

Sustainability Model



Invest when **Business revenues** > **Business costs**
and **Total benefits** > **Total costs**

Evolution of Costs

External

Reduced Enjoyment of Property
Psychological Impacts
Physical Health Impacts

Individual Choice

System Imposed

Society

Join Citizen Groups
Take Legal Action
Contact Regulatory Agency
Relocate

Property Devalues
Tourism Declines
Development Hindered
Employment Declines

Direct

Indirect

Future

Intangible

Capital for equipment

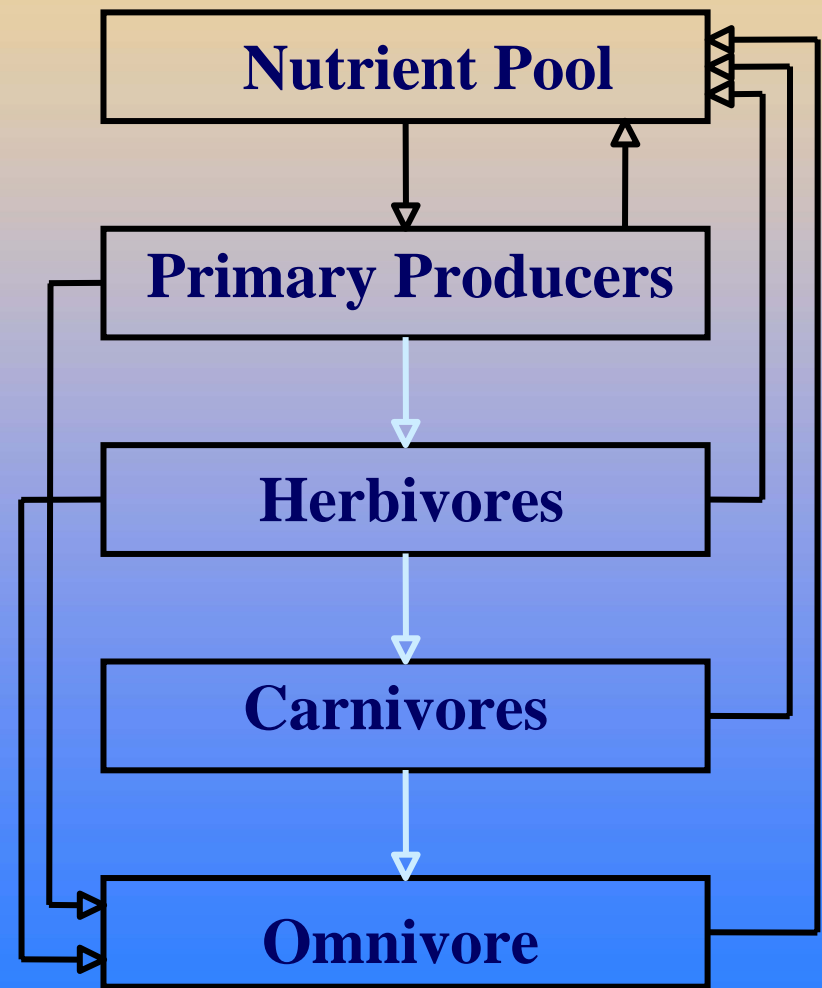
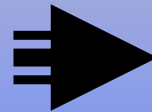
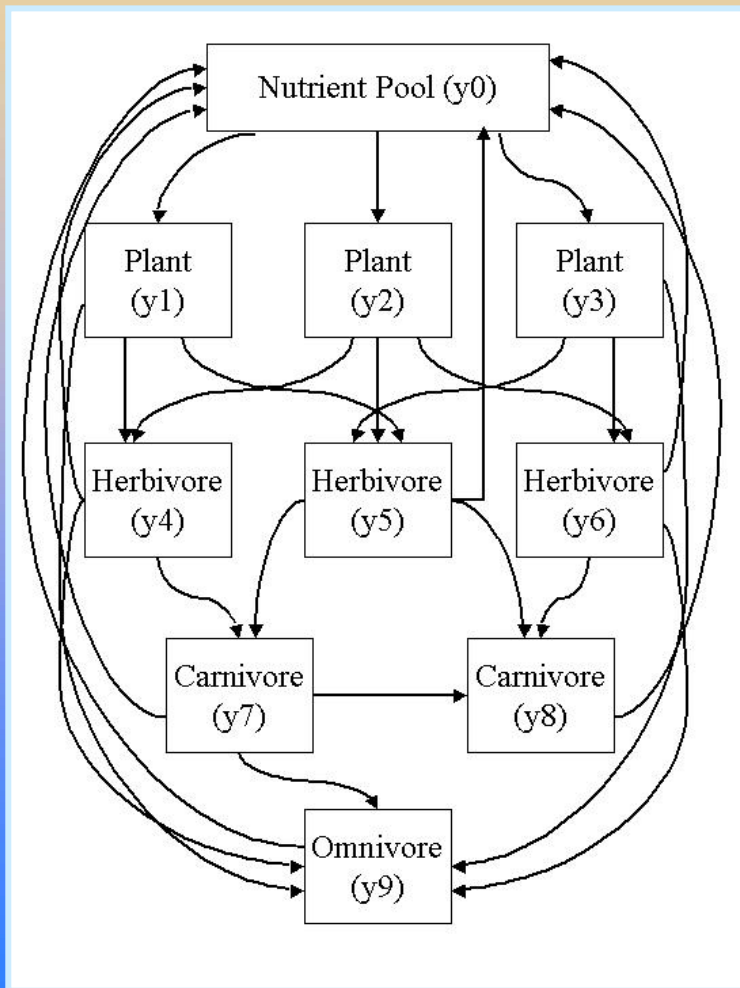
Internal legal costs
Punitive Damages
Public Relations Staff

Fines & penalties

Lost good will
Job productivity

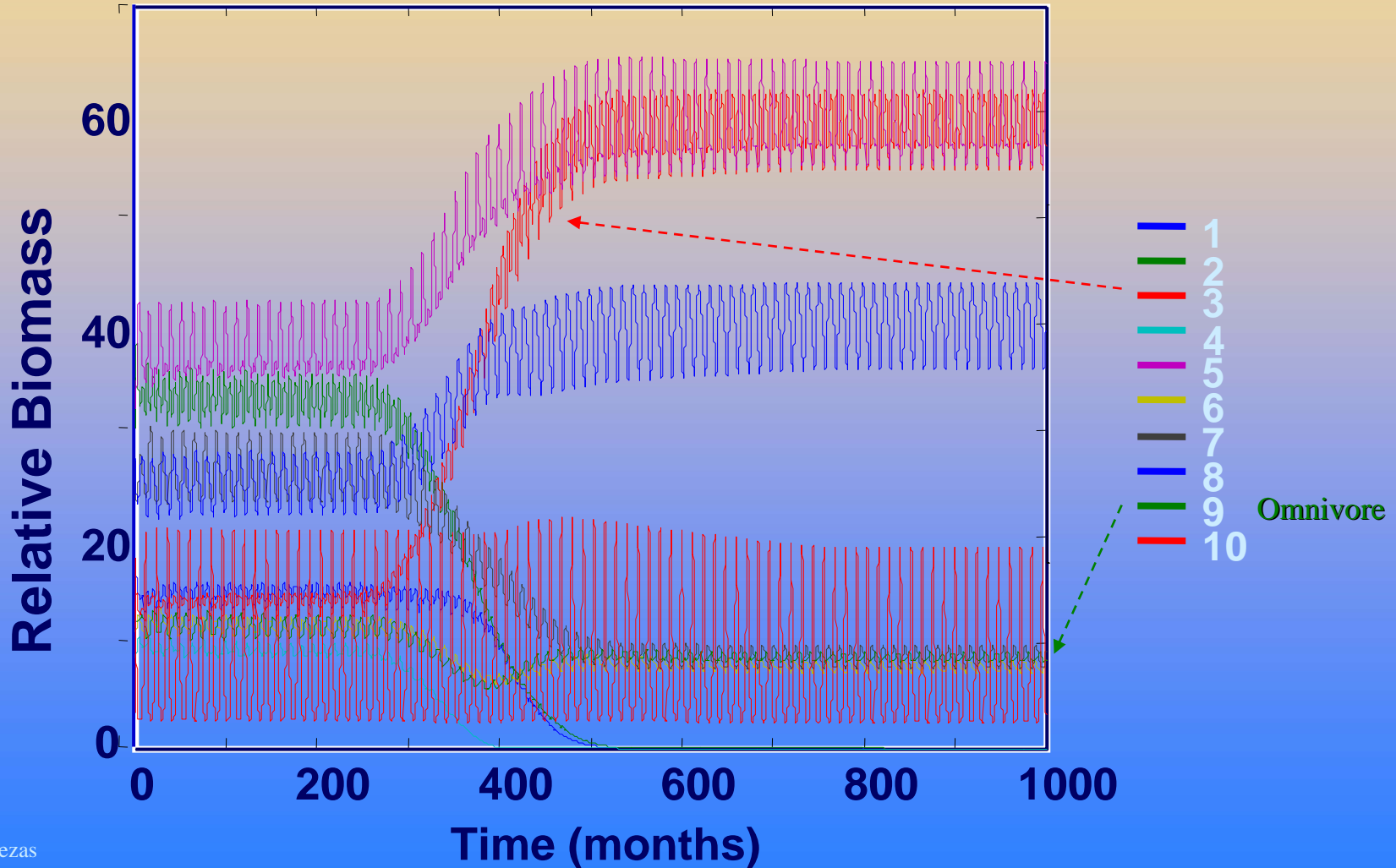
Organization

Model Ecosystem: Trophic Levels

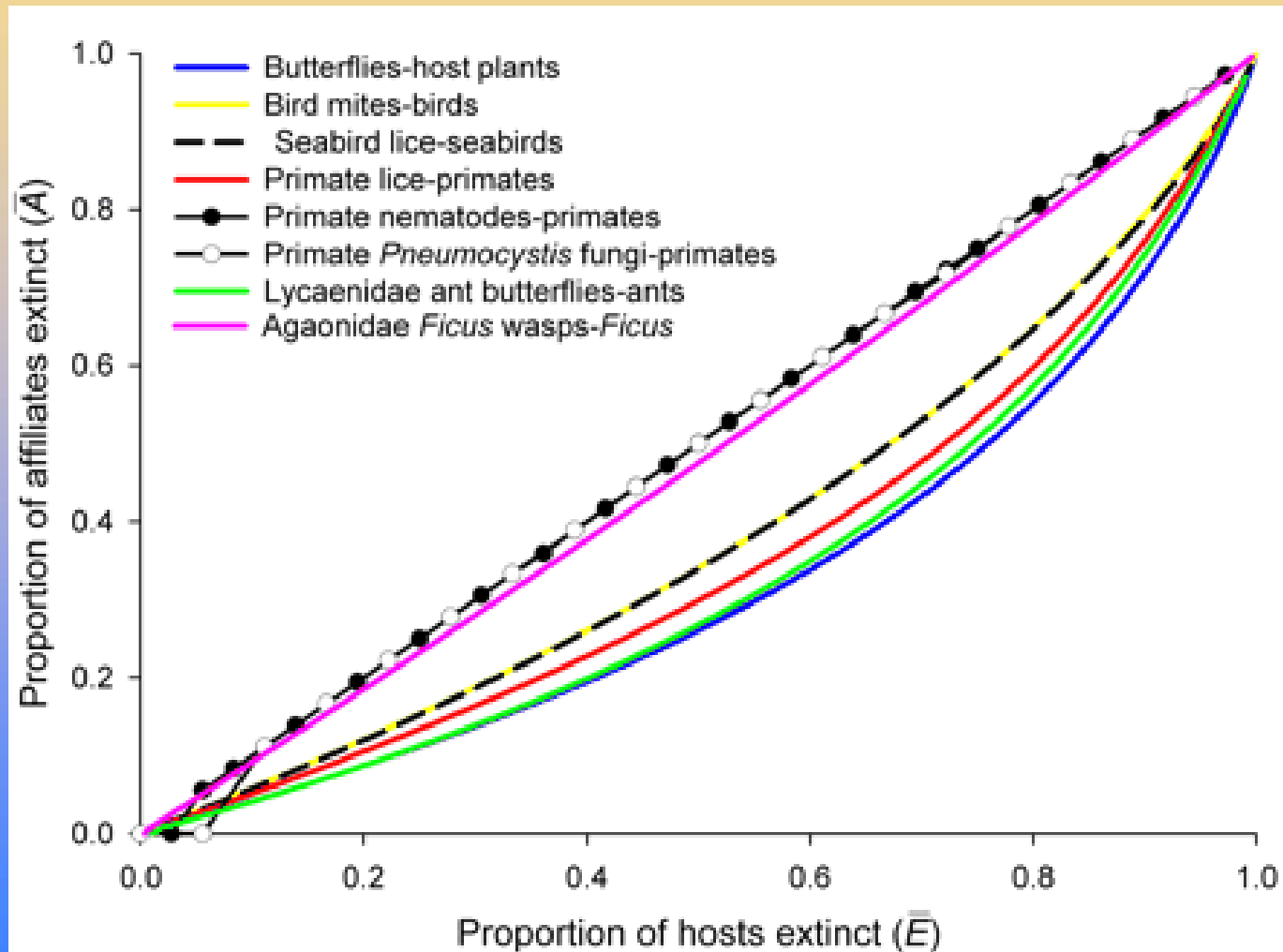


System Response

Increase Growth of Plant 3



Co-extinctions





Screening Module Environmental Valuation Reference Inventory

Navigate Records



Record Management



Search



Session



Help



Geographic

Population

Environment

Timeliness of Data

Economic Measure

Estimated Values

Abstract

Complete Study

EVRI Number: 99331-43415 Record 1 of 9

Bann, C., "*An Economic Analysis of Tropical Forest Land Use Options, Ratanakiri Province, Cambodia*", Economy and Environment Program for Southeast Asia, International Development Research Centre 1998, 1997

Table 1. Annual Value and Net Present Value (NTV) of Non-Timber Forest Products by Village:
Tapean Forest (1996 US\$)

	Kancheung	Mas	Koy	Tangaich	TOTAL
Fuelwood	5,333	2,613	4,375	2,652	14,973
Malva nuts	2,537	138	175	343	3,193
Trad. baskets	830	336	1,086	189	2,441
House construction	1,776	777	888	1,498	4,939
Mfd. goods	123	87	221	60	491
Wildlife	6,683	39,163	153,671	27,000	226,517
Fish	12,806	14,529	20,056	3,834	47,391
Medicine	60	35	92	19	206
TOTAL	30,088	57,678	180,564	35,576	303,906

Evolution of Benefits

External

Increased Enjoyment of Property
Psychological Impacts
Physical Health Impacts

Individual Choice

System Imposed

Society

Support Citizen Groups
Reduce Legal Action
Regulatory Agency Silence

Property Revalues
Tourism Increases
Development Tailored
Employment Improves

Direct

Indirect

Future

Intangible

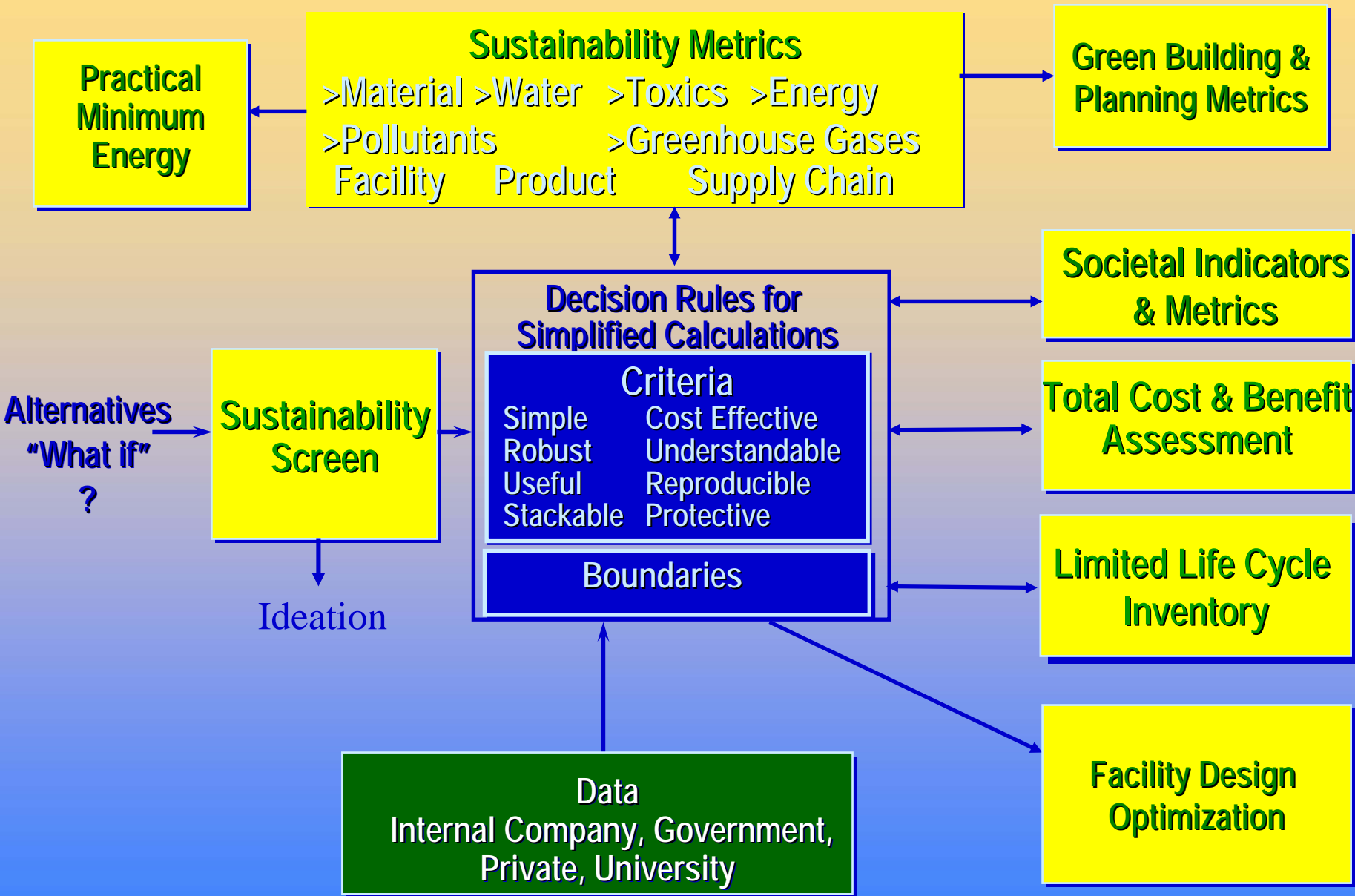
Capital for equipment

Internal legal costs
Faster Approvals
Public Relations Staff

New Options

Good will
Job productivity

Organization



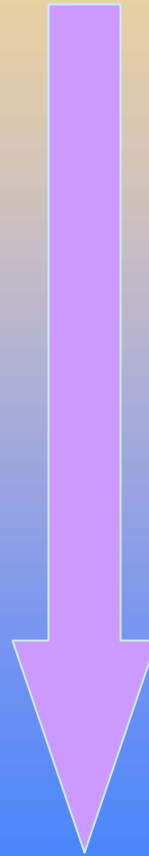
Where Do We Need More Information? (for Freshwater)

- Eutrophication
- Perchlorates
- Animal Agriculture
- Wastewater Residuals
- Disinfection Methods
 - Ozone
 - Chlorination
 - Ultraviolet
- Seawater Substitution
- Industrial treatment Systems
- Homeland Security
- Constructed Wetlands
- Desalination
- Use of Graywater
- Rainwater Collection and Use

More Information or Better Transfer?

Eutrophication

Emissions to water
Green slime
Impacts on many life forms
Property devalues
Tourism declines
Commercial activity declines
Job loss
Search for the guilty
Punishment of the innocent
Reward to the non-participant



Monetized by
BRIDGES to Sustainability

1 day at the beach = \$24



Seawater Substitution

- Ocean is pH of 8.2 to 8.4
- Specific gravity is 1.02 to 1.03
- Salinity of 36,000 ppm
- Temperature is 29 F to 104 F
- Variable Total Solids (Littoral)
- 10x more than freshwater

Summary

- Sustainability is truly coming of age
- We have marvelous tools
- We need specific data about water and interactions with other issues
- The tools must be integrated into the decision-making process
- Industry is getting message; how about government and academia?

Acknowledgements & Credits

- John Crittenden – Arizona State University
- David Shonnard – Michigan Technological University
- BRIDGES to Sustainability Institute
- Ray Merrill - Alcoa
- Greg Norris – Sylvatica
- Herb Cabezas - USEPA
- Bob Willard – *“The Sustainability Advantage”*
- Florida Aquatic Weed Management
- USDOE & USEPA for Funding

Questions?
Comments?
Harassment?

Electronic or paper copies, TCA report, Institute for Sustainability

Inst4sust@sbcglobal.net