Sustainable Remediation Assessment with the BalancE3™ Tool

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October 19, 2011

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Outline

Introduction to Green and Sustainable Remediation (GSR) Assessment

The BalancE3™ Tool

Case Study

Summary

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Green vs. Sustainable Remediation

Sustainable Remediation

"A remedy or combination of remedies whose net benefit on human health and the environment is maximized through judicious use of limited resources" (SuRF, 2011)

Green Remediation

"Considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup" (USEPA, 2010)

Green Remediation Elements identified by USEPA

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Examples of GSR Assessment

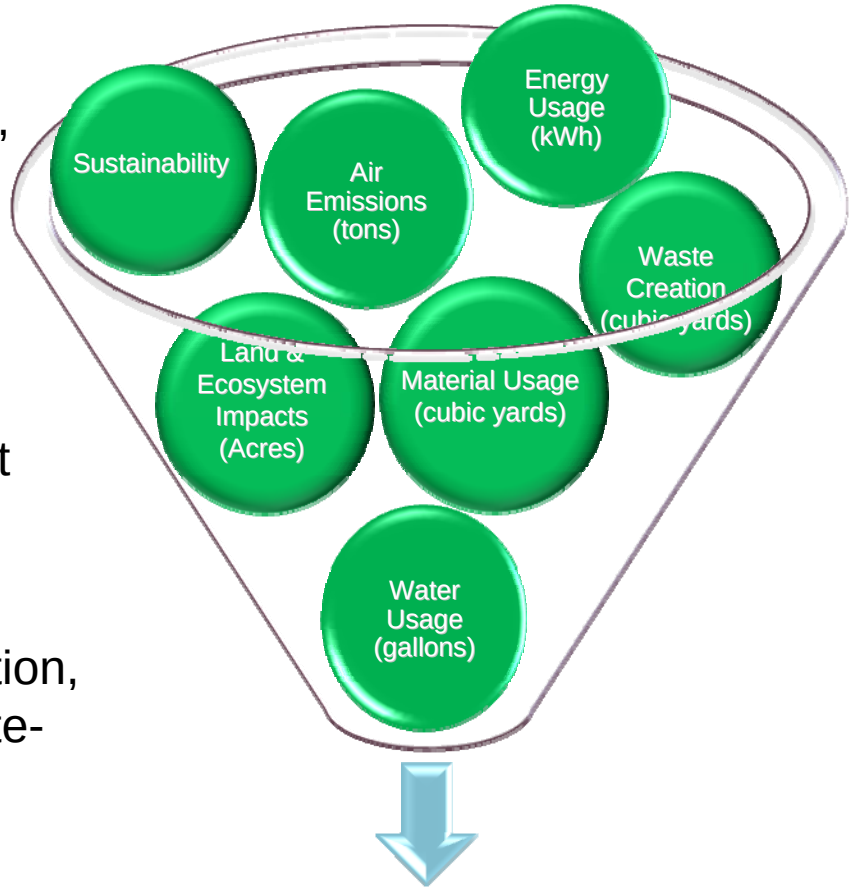
- Remedy Selection
  - Incorporate GSR into feasibility study; use as differentiator for remedy selection
  - Integrate GSR into remedy evaluation process
- Remedy Design and Implementation
  - Use FS level evaluation to guide a more sustainable design
  - Optimize or reduce environmental footprint
- Remedy Optimization
  - Continual optimization using GSR to reduce environmental footprint and H&S risks
  - Focus on key metrics and values (energy, carbon, etc.)
- Portfolio Management
  - Aggregates effect of multiple projects including greener practices and design

Overall GSR Assessment Process

- Decide on objectives (requires stakeholder engagement)
- Choose metrics
- Decide on “boundaries” for the assessment
- Select tools
  - Vary in approach and level of detail: qualitative, quantitative or semi-quantitative
- Inventory relevant project data
- Determine assessment outcome:
  - Many results by category: lbs CO2, NPV, energy, water usage
  - Normalize to a common denominator
- Perform sensitivity analysis
- Incorporate stakeholder perspectives (metric weighting)

Key Challenges with GSR Metrics

- Multiple approaches to quantification
  - Site conditions and possible remedial actions, implemented remedial solutions, compiled field activity information
  - Each has different degree of certainty
- Aggregation challenges
  - Diverse units, interdependent variables, different relative magnitudes, not straight forward calculations
- Weighing importance
  - May vary based on site geographic location, state of industry, stakeholder interest, site-specificity



The BalancE3™ Tool

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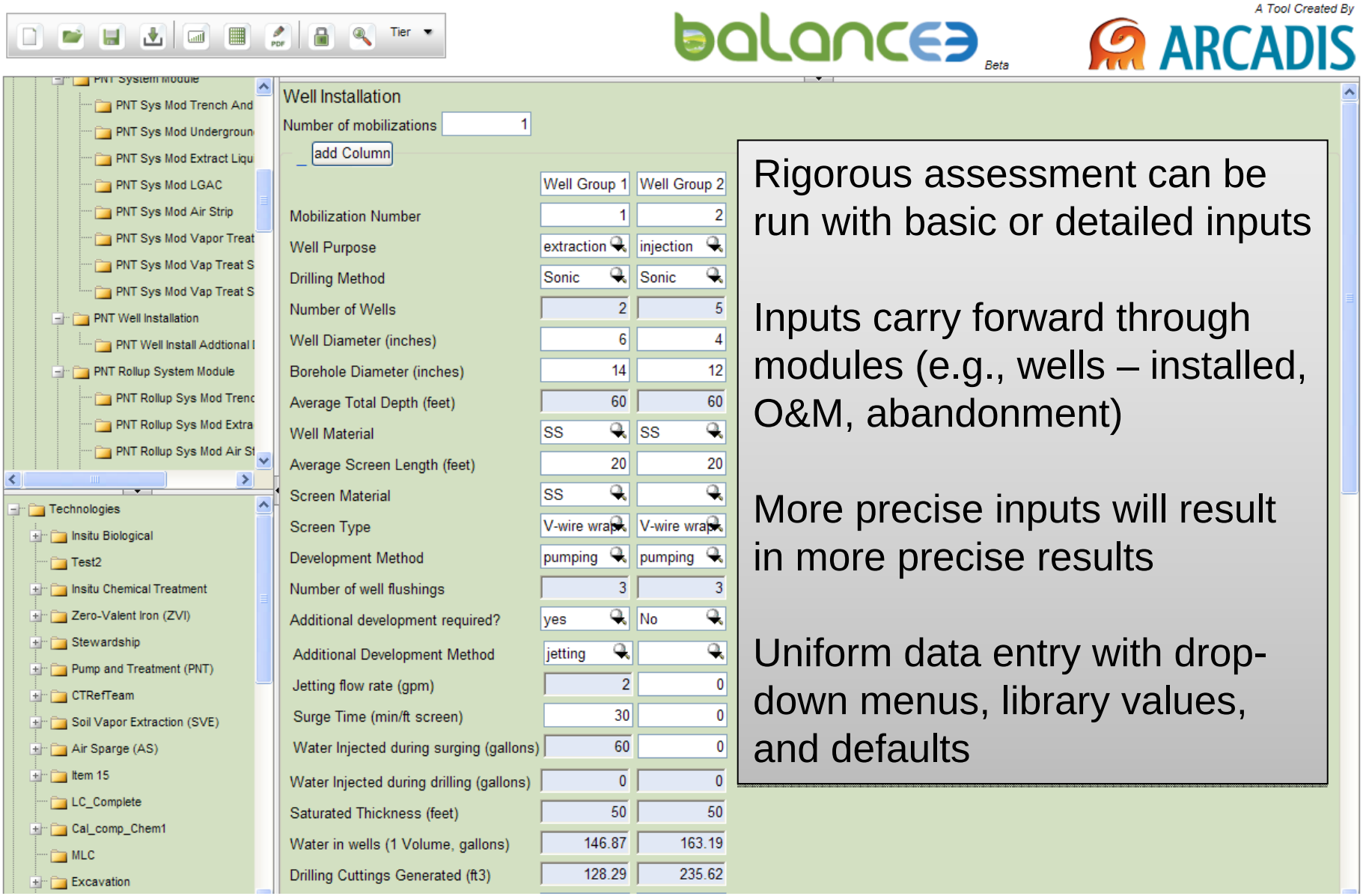
Description

- Provides a quantitative means for evaluating sustainability and green remediation concepts in remedial projects
- Offers essential information for the selection, design, evaluation and optimization of a remedy
- Technology-based modular inputs:
  - Pump & treat
  - Enhanced in-situ biological degradation
  - In-situ thermal treatment
  - Soil vapor extraction
  - In-situ chemical oxidation
  - Monitored natural attenuation
  - Capping/Covers
  - Excavation
  - Airsparge/Biosparge
  - In-situ soil mixing
  - Soil stabilization and solidification
  - Ex-situ soil treatment
  - Permeable reactive barrier
- Normalizes results to statistical z-scores and aggregates to "Balance Score"

Modular Inputs



Rigorous assessment can be run with basic or detailed inputs

Inputs carry forward through modules (e.g., wells – installed, O&M, abandonment)

More precise inputs will result in more precise results

Uniform data entry with drop-down menus, library values, and defaults

Measuring Sustainability

Environment

5 USEPA Elements

Climate

Carbon Offsets

Alternative Fuels

Material Reuse

Social Equity

Stakeholder Engagement and Consideration

Community Quality of Life

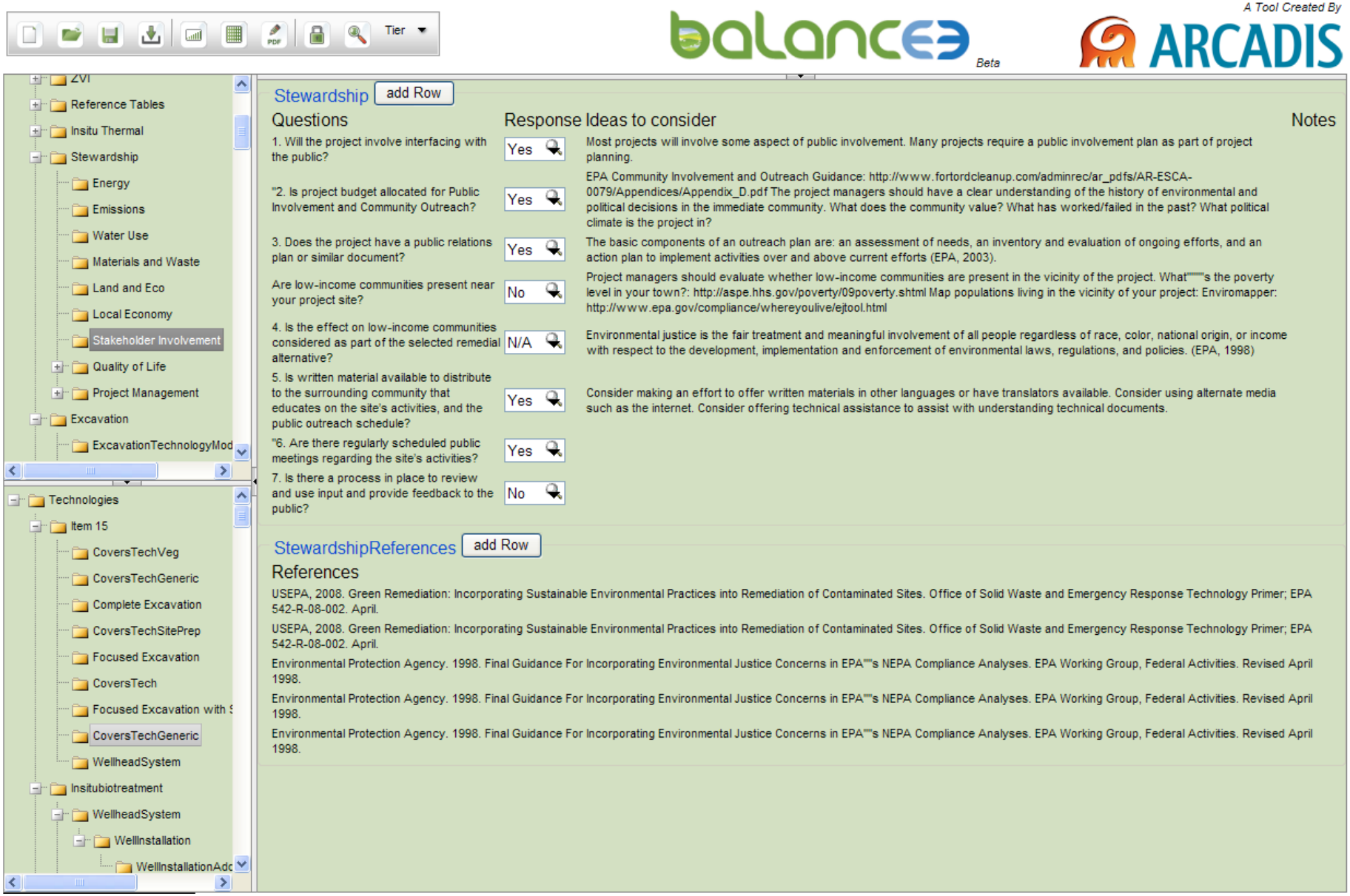
Health and Safety

Economics

Remedial Project Life-Cycle Costs

Local Economy Impacts

Stewardship



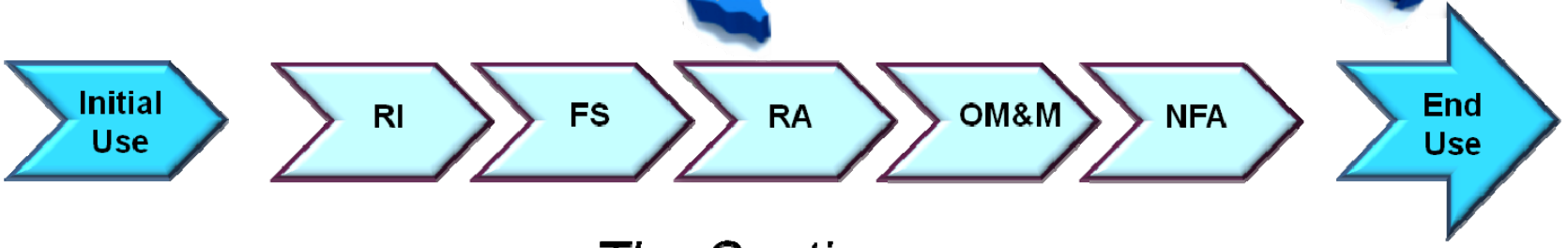
Health and Safety

- Inherent Risks
  - Motor Vehicle Accident Risk
  - Injection Reagents
  - Construction Activities
  - Sampling Preservatives
- Site-related Risks
  - Site Setting
  - Climate
  - Topography
- Technology-related Risks
  - Chemical Exposure
  - Physical Hazards
    - Noise
    - Tool/Equipment Injury

Hazard Assessment and Risk Control (HARC) Process for ARCADIS H&S Program

Hazard Type+	Hazard and Hazardous Activities	Overall Risk (Comments attached to cells explain Medium and High Risk rankings)
PS	Personal - stress - working long hours	Low
PS	Violence in the workplace	Medium
PS	Working alone	Medium
TR	Motor vehicle operation - driving in unfamiliar locations	High
TR	Motor vehicle operation - fatigue or lack of alertness from driving early or late in the day	High
TR	Motor vehicle operation - roadway and traffice hazards of driving motor vehicles	Medium
BLD	Entering and exiting hallways and running into others	Low
BLD	Furniture failure	Medium
PS	Travel - personal safety	Low
PH	Uneven or slippery terrain - slips, trips and falls	Low
PH	Ionizing radiation - gamma, beta, x-ray, etc.	Low
PH	Non-ionizing radiation - ultraviolet, microwave, laser, infrared, etc. - exposre to	Low
BIO	Insects - ticks, bees, wasps, spiders, black flies, mosquitos - bites or stings	Medium

Evaluation Scope and Scale

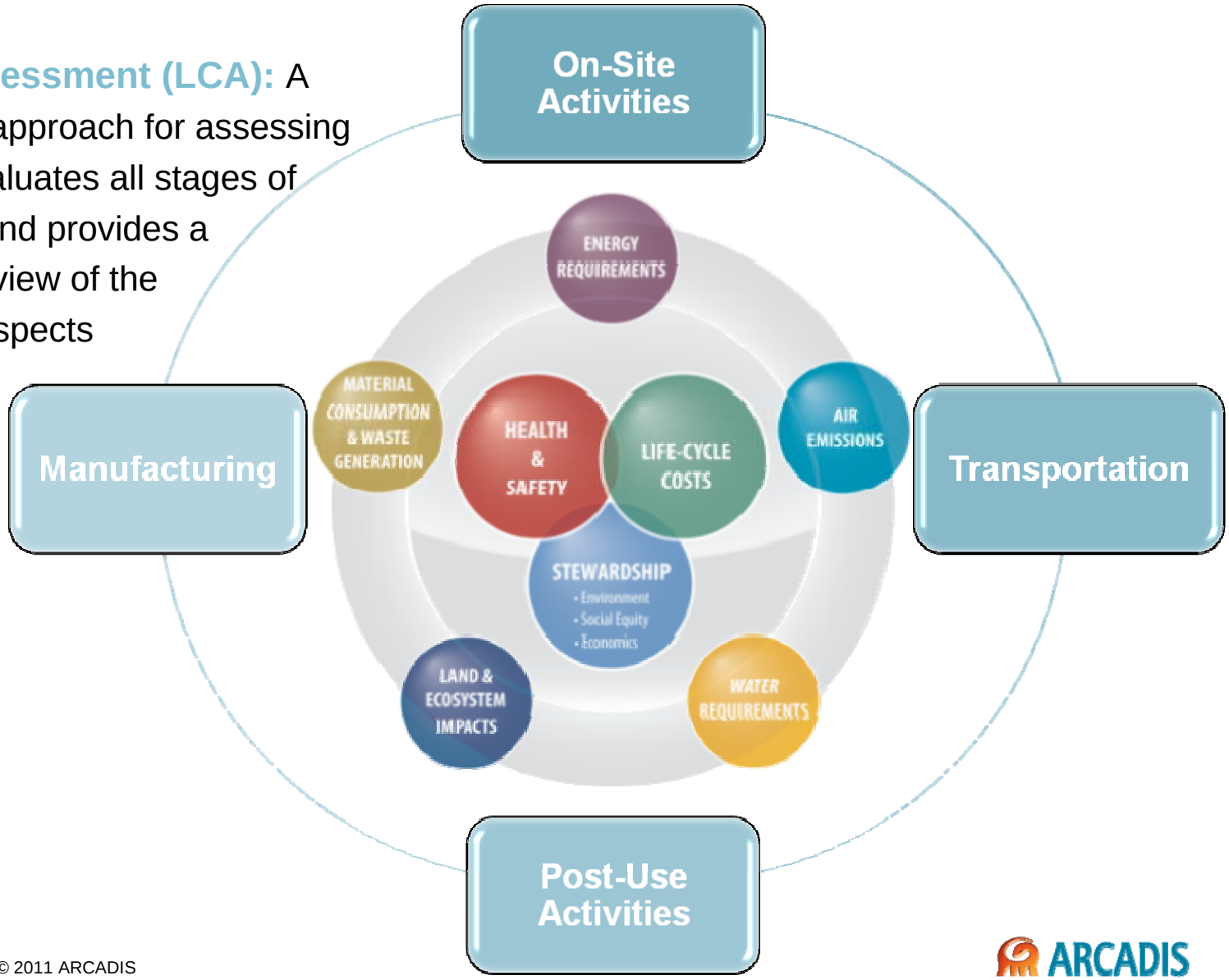


The Continuum

Evaluation Boundaries

Life-Cycle Assessment (LCA): A cradle-to-grave approach for assessing systems that evaluates all stages of a product's life and provides a comprehensive view of the environmental aspects of the product or process.

(USEPA National Risk Management Research Laboratory (NRMRL) LCA Definition)



Case Study

Using The BalancE3™ Tool

Overview

Site setting

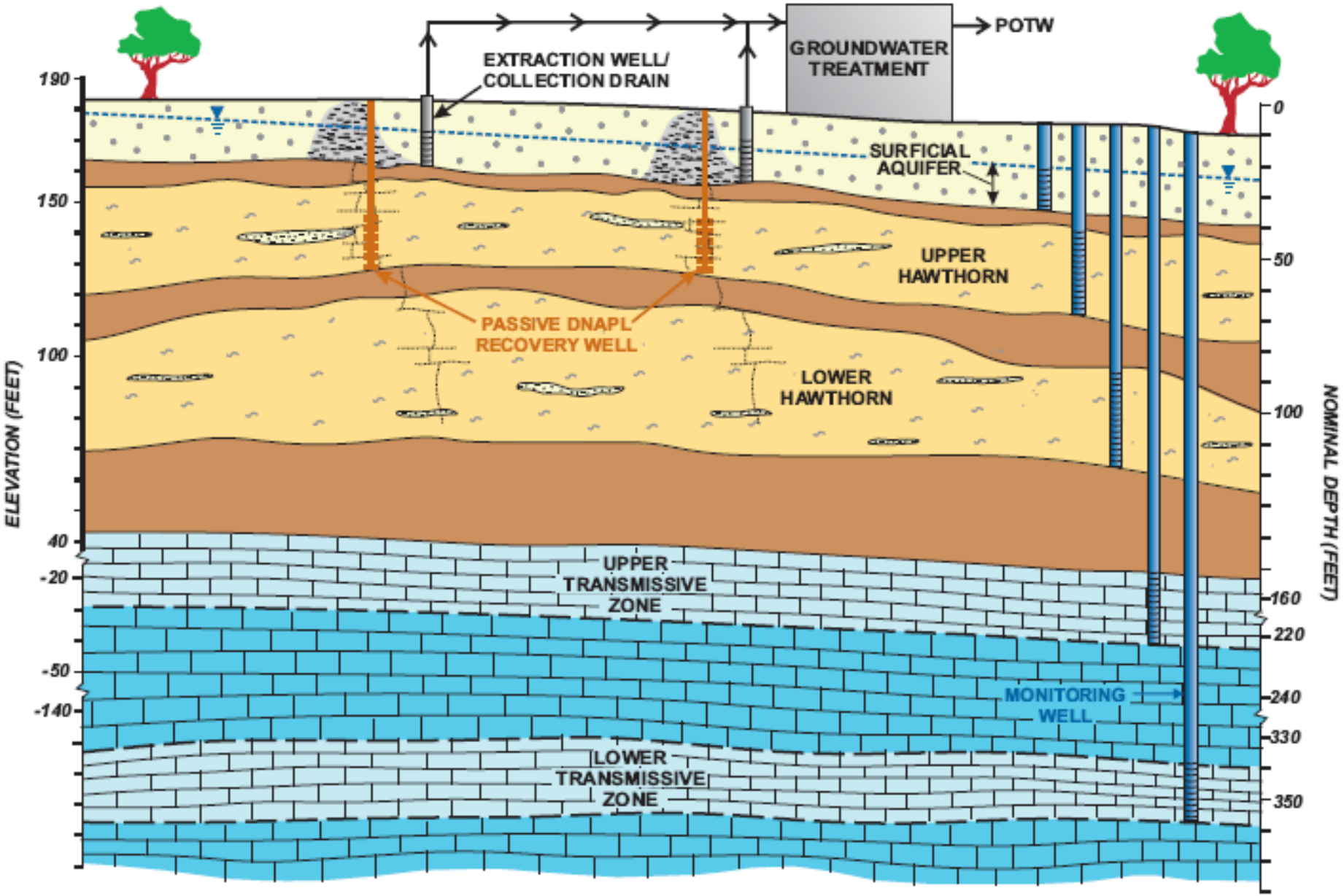
- Superfund site in Florida (EPA Region 4)
- Former wood treating facility, creosote
- Groundwater impacts: DNAPL PAHs
- Soil impacts: dioxins/furans

http://protectgainesville.org

GSR Assessment Goals

- Perform a quantitative sustainability assessment
- Evaluate the overall environmental footprint and stakeholder/social aspects of each alternative
- Serve as a differentiator in the evaluation of the proposed remedial alternatives during the feasibility study phase

Current Actions



Remedial Options in FS

Main Remediation System	Proposed Lifetime (Years)	Additional Remedial Actions: Slurry Wall	Cover	Hydraulic Containment	Passive DNAPL Extraction
1: No action	---				
2: Current actions	> 30			X	X
3A: Surficial aquifer excavation	5	X	X		
3B: Excavation to Hawthorn middle clay unit	5	X	X		
4A: ISS/S to Hawthorn middle clay unit	5		X		
4B: ISS/S to Hawthorn upper clay unit and ISBS in Upper Hawthorn	5		X		
5A: Vertical flow barrier	30				X
5B: Vertical flow barrier with ISBS in Upper Hawthorn	30	X	X	X	X
5C: Vertical flow barrier with ISBS in Surficial Aquifer	30	X	X	X	X
5D: Vertical flow barrier with ISS/S in Surficial Aquifer	30	X	X	X	X

Results in Metrics' Units

balanceB Beta

A Tool Created By ARCADIS

Sustainability Assessment Tool

Weight		Evaluation Criteria	Unit	Option 3A	Option 3B	Option 4B	Option 5C	Option 5D
	50	Energy Usage	kWh	2,199,561	5,567,924	4,120,623	1,828,391	4,839,977
	50	Air Emissions	Metric Tons C	452	1,264	230	334	349
	50	Water Usage	Gallons	5,669,460	40,805,345	2,599,527	610	6,754,801
	50	Land Impacts	Acres	13	11	1.2	11	12
	50	Materials & Waste	Cubic Feet	117,416,117	8,906,688	2,960,303	105,716,740	142,615,184
	50	Stewardship	Scale	1.4	2.7	1.3	2.6	2.7
	50	Health & Safety	Scale	2.6	5.5	3	2	2
	50	Life-Cycle Costs	MM$	66.1	172.55	57.6	25.5	46.42
Use Weighting ☐		Balance Score	Unit					

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Results in Unitless Z-scores

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Sustainability Assessment Tool

Weight			Evaluation Criteria	Unit	Option 3A	Option 3B	Option 4B	Option 5C	Option 5D
	50	100.0%	Energy Usage	Unitless	-0.92	1.1	0.25	-1.2	0.69
	50	100.0%	Air Emissions	Unitless	-0.18	1.8	-0.7	-0.46	-0.42
	50	100.0%	Water Usage	Unitless	-0.33	1.8	-0.51	-0.67	-0.26
	50	100.0%	Land Impacts	Unitless	0.7	0.28	-1.8	0.28	0.49
	50	100.0%	Materials & Waste	Unitless	0.65	-1	-1.1	0.46	1
	50	100.0%	Stewardship	Unitless	-1	0.77	-1.2	0.64	0.77
	50	100.0%	Health & Safety	Unitless	-0.29	1.7	-0.014	-0.7	-0.7
	50	100.0%	Life-Cycle Costs	Unitless	-0.13	1.7	-0.28	-0.84	-0.47
Use Weighting			Balance Score	Unitless	-0.3	1.6	-1.1	-0.49	0.23

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Balance Score Output

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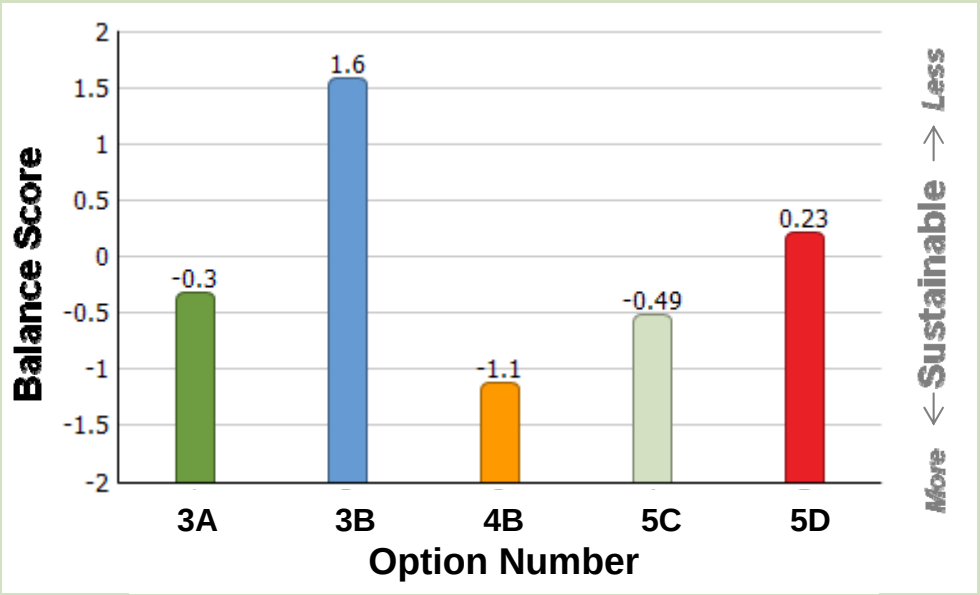

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Metrics Output

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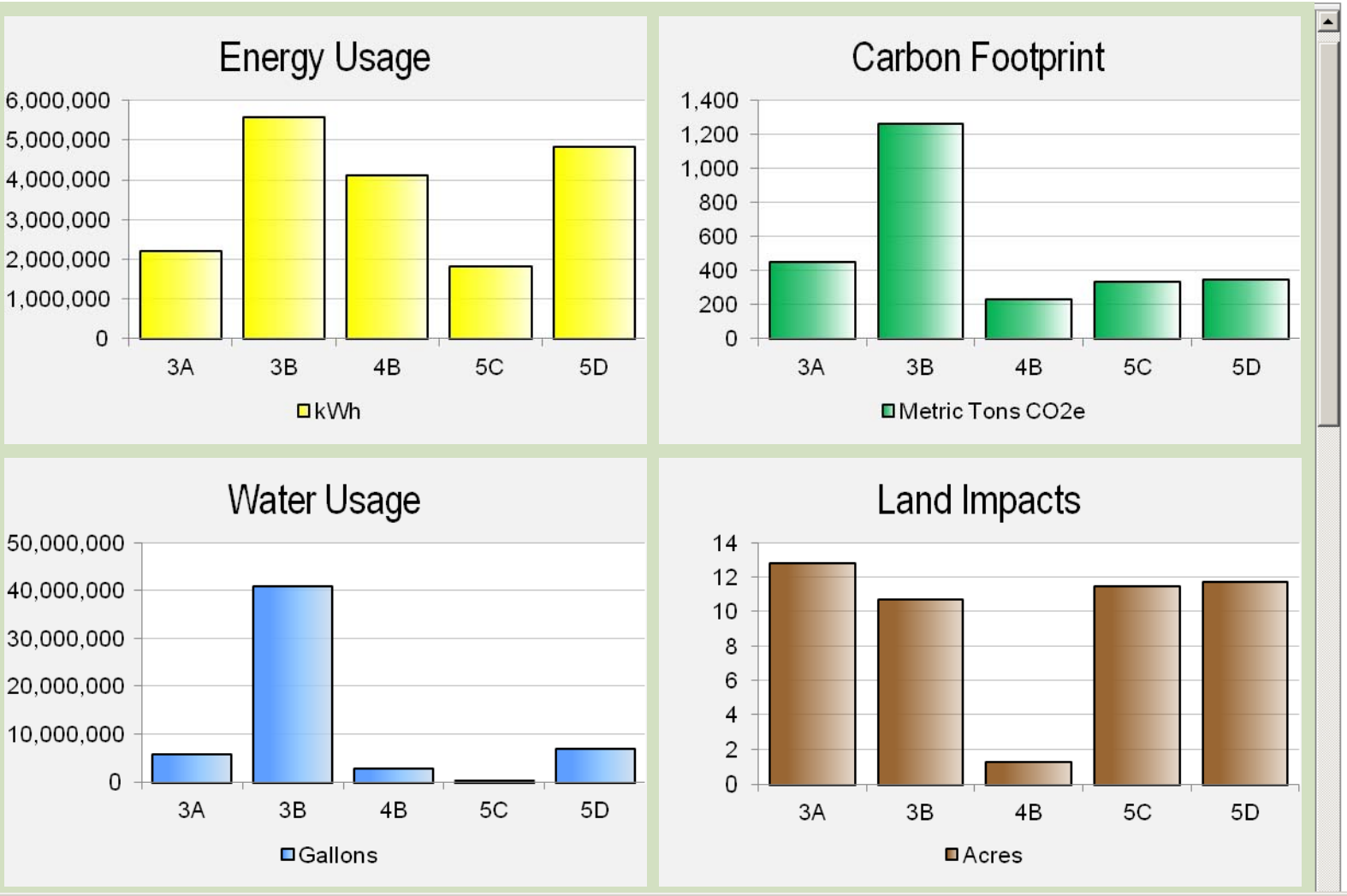

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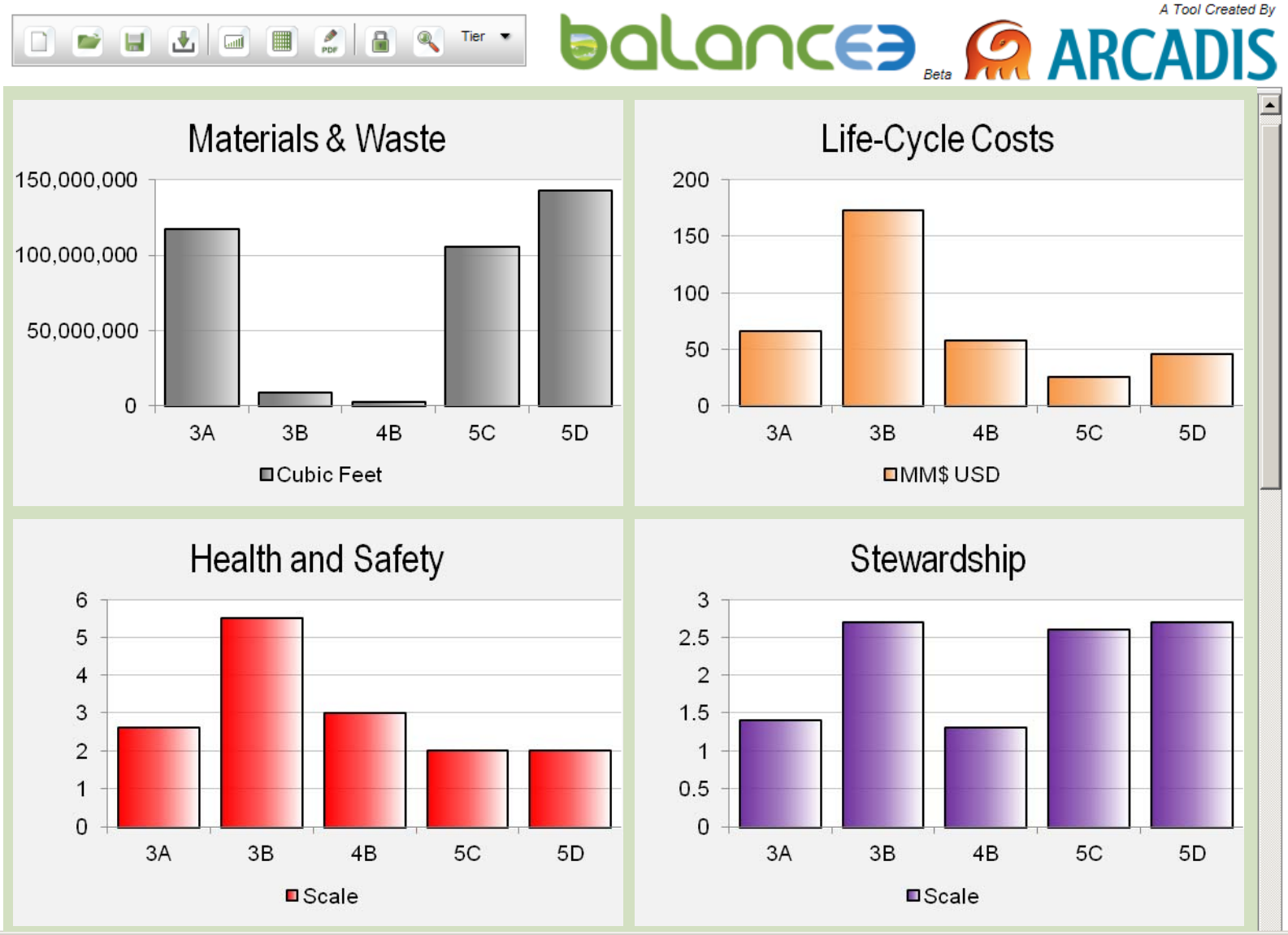
Metrics Output



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Balance Score per Metric

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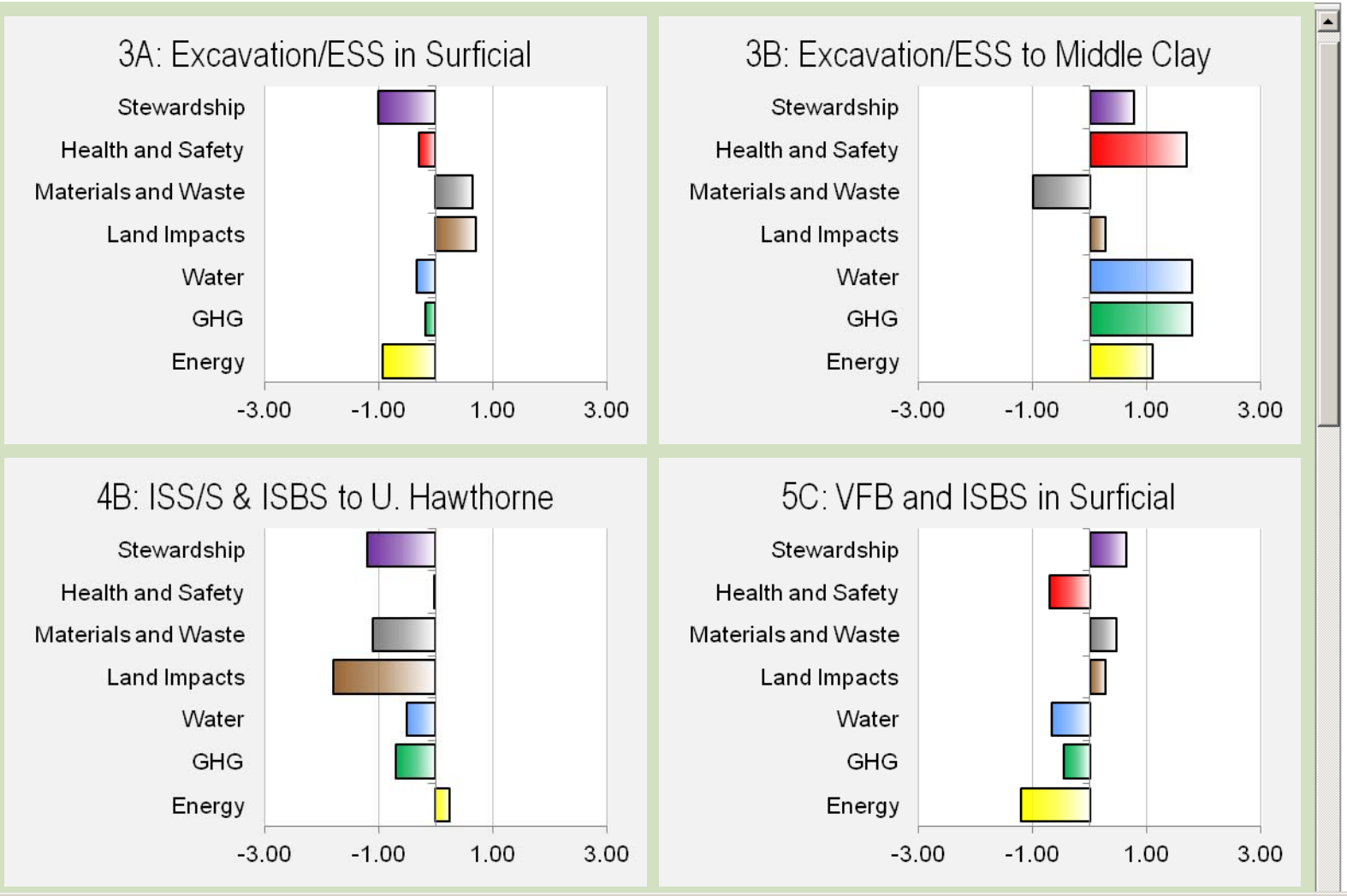

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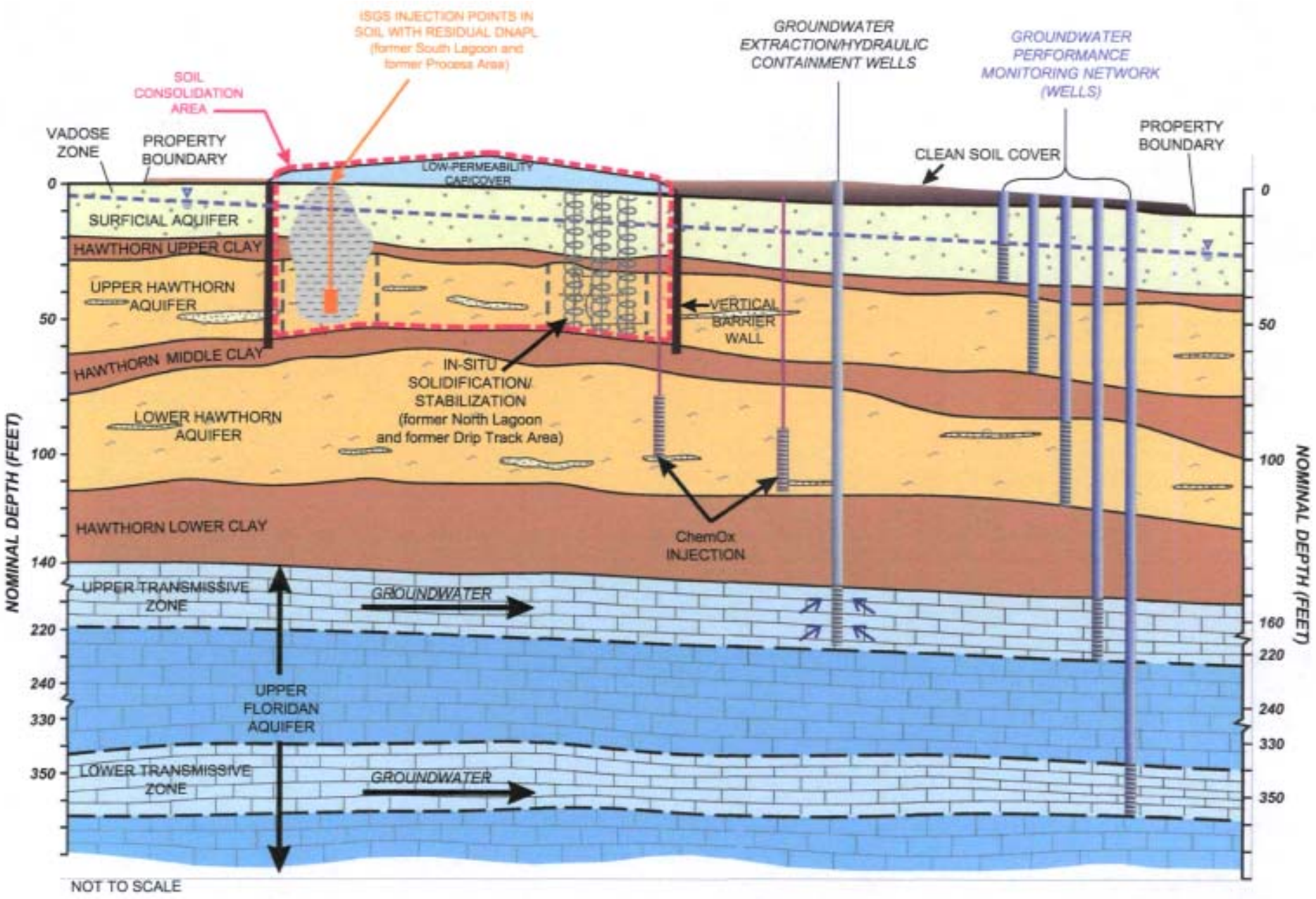
Selected Remedy



GSR Assessment Outcome

Selected Remedy

- GSR assessment results were reviewed by EPA Region 4 and taken into consideration when selecting the final remedy.
- A remedy most similar to Remedial Alternative #4B was selected for implementation.
- This remedy is now in place through a Record of Decision.

Significant GSR elements

- Chose remedy with less environmental impacts (reduced energy, CO2 emissions)
- Chose remedy with lower health and safety risk to workers
- Analysis demonstrated that the project as a whole scored well for Stewardship - project coordinators' attention to Stewardship topics were heightened
- Difficult to differentiate stewardship benefits of different remedial options

Summary

- New topic and continually evolving
- GSR assessment is a fundamental component of remedial decision-making
- Quantification makes success measurable and establishes validity of greener and more sustainable solutions

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Imagine the result
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