Green & Sustainable Remediation

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Agenda

– Introduction

– Frameworks and Tools

– Case Study

– Conclusions/Questions

Introduction

– Remediation of contaminated sites inherently requires the expenditure of finite resources and contributes to humankind's environmental footprint.

– Some remedies, however well engineered and well intentioned, are energy intensive and may not ever achieve cleanup goals.

– Looking at remediation with an eye towards sustainable can help evaluate decisions on a holistic level with these factors in mind.

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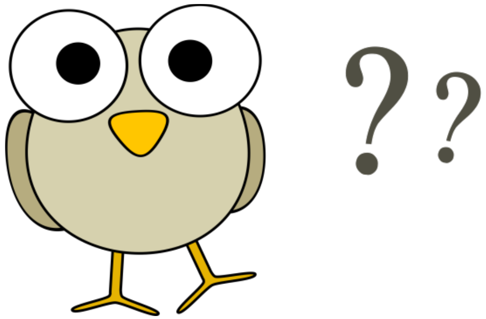
Survey

-Who has heard of Green and/or Sustainable Remediation?

-Who has worked on a project where GSR was incorporated?



-Who would be interested in seeing the environmental footprint of one of their remediation projects?

GSR Overview

– Green Remediation (GR)

- "practice of considering all **environmental** effects of cleanup actions & incorporating strategies to maximize net environmental benefit." (United States Environmental Protection Agency)

– Sustainable Remediation (SR)

- "Sustainable remediation is defined as site assessment and remediation that protects human health and the environment while maximizing the **environmental**, **social**, and **economic** benefits throughout the project life cycle." (Sustainable Remediation Forum, 2013)

– **"Green & Sustainable Remediation" (GSR)** includes both concepts

GSR Drivers

– Increasing focus on corporate and agency sustainability goals

– State/Federal policies, requirements and guidance

– Climate change and recognition that impacts and decisions may be bigger than just the site and surrounding area

– Increasing energy costs

– Proliferation of regulatory and industry guidance and frameworks

Who Is SURF?

– Founded in 2006

– Mission: to maximize the overall environment, societal, and economic benefits from the site cleanup process by:

- Advancing the science and application of sustainable remediation
- Developing best practices
- Exchanging professional knowledge
- Providing education and outreach

Thought leadership group that collaborates with environmental professionals from all disciplines to develop and advance sustainable remediation principles and practices.

http://www.sustainableremediation.org

Sustainable Remediation Semantics

SR should be:

- Holistic, process based, site specific
- Used to evaluate equivalently protective remedies
- Used to support stakeholder participation and understanding

SR should NOT be:

- Used to define a type of remediation technology
- Used as an excuse to do nothing (or less)

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Regulatory Updates

– State Programs and Policies

- New York State DEC – DER 31 Green Remediation Policy
- Massachusetts DEP – WSC #14-150 Greener Cleanups Guidance
- Minnesota Pollution Control Agency – GSR Guidance
- Illinois EPA – Greener Cleanups Matrix
- California DTSC – Interim Advisory & GREM
- Wisconsin Department of Natural Resources – WISRR

– NYSDEC DER-31

- Sustainability evaluated as part of 9 remedy selection criteria.
- Concept of Green Remediation cannot be used to justify a “no action” alternative or implementation of a lesser remedy.

DEPARTMENT OF ENVIRONMENTAL CONSERVATION • NEW YORK STATE •

- USEPA – Greener Cleanups concepts

International Activities

- SuRF International Network & Partners
  - United Kingdom, United States, Canada, Australia-New Zealand, Netherlands, Italy, Brazil, Taiwan, Colombia, Japan, China
- International Organization Standardization
  - ISO 18504:2017 Soil Quality-Sustainable Remediation
- NICOLE: Network for Industrially Co-ordinated Sustainable Land Management in Europe
- CL:AIRE: Contaminated Land: Applications in Real Environments, leadership group for sustainable land reuse
- International Sustainable Remediation Alliance (ISRA)
  - Demonstrating a united purpose
  - Promoting the message of SR globally
  - Exhibiting our collaboration especially to large global bodies such as the United Nations

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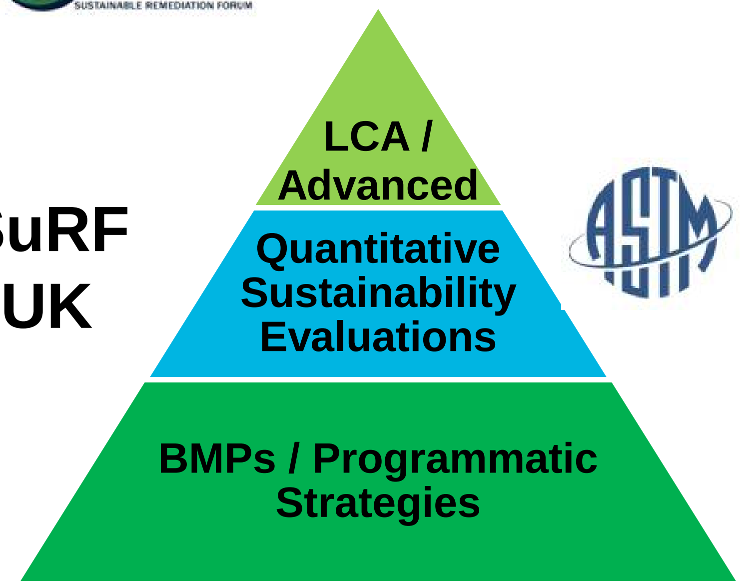
Frameworks & Tools

SURF
SUSTAINABLE REMEDIATION FORUM

SuRF UK



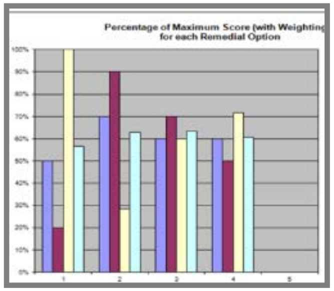
ASTM

EPA SEFA

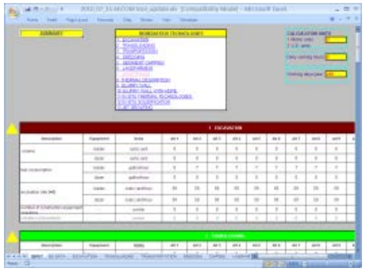
INTERSTATE TECHNOLOGY REGULATORY COUNCIL
ITRC

GaBi Software
PRODUCT SUSTAINABILITY

SimaPro:
LCA your way



SRT™



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Sustainable Remediation Frameworks (USA)

– SURF (2009)
- White Paper- Remediation Journal 2009
- Guidance Documents- Remediation Journal 2011
  - o Framework, Metrics, Footprint and LCA

– ITRC (2011)
- GSR-1 Green and Sustainable Remediation: State of the Science and Practice
- GSR-2 Green and Sustainable Remediation: A Practical Framework

– ASTM (2013)
- ASTM E2893-13 Standard Guide for Greener Cleanups
- ASTM E2876-13 Standard Guide for Integrating Sustainable Objectives into Cleanup

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GSR Is Flexible and Scalable

Example Project Type		Tools
Extremely Large, Costly, Complex	Quantitative	Lifecycle Analysis (LCA)
Complex Diesel Fuel or CVOC Release	Semi-Quantitative	Spreadsheet Calculators or Multi-Criteria Analysis (MCA)
Simple UST Release Site	Qualitative	Narrative or Simple Spreadsheets
All	Best Management Practices	Checklists

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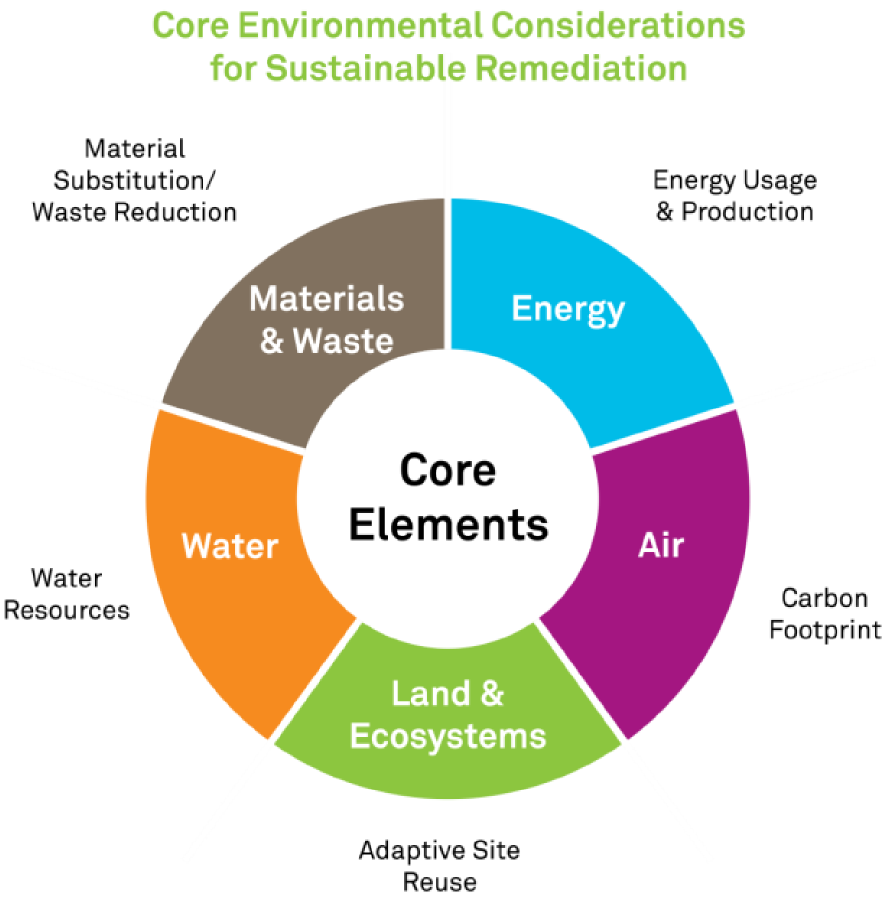
What are Best Management Practices?

– BMP: An action or practice that improves an environmental, social and/or economic aspect of a site.

– Resources for BMPs
  - SURF
  - USEPA
  - US State Agencies
  - US Department of Defense
  - ASTM Guidelines

– BMPs may be qualitative or quantitative



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BMP Categories
(adapted from SuRF-UK 2010 & EPA 2011)

Environmental

1. Energy use
2. Impacts on air (including climate change)
3. Impacts on water
4. Impacts on land and ecosystems
5. Use of natural resources and generation of wastes

Social

1. Impacts on human health and safety
2. Ethical and equity considerations
3. Impacts on neighborhoods or regions
4. Community involvement and satisfaction

Economic

1. Project economic costs or benefits
2. Employment and capital gain
3. Other benefits (tax base, infrastructure development

BMP Process

Examples from ASTM Standard Guides

– E2893-13 Standard Guide for Greener Cleanups

– E2876-13 Standard Guide for Integrating Sustainable Objectives into Cleanup

BMP Process

1. BMP Opportunity Assessment
2. BMP Prioritization
3. BMP Selection
4. BMP Implementation
5. BMP Documentation

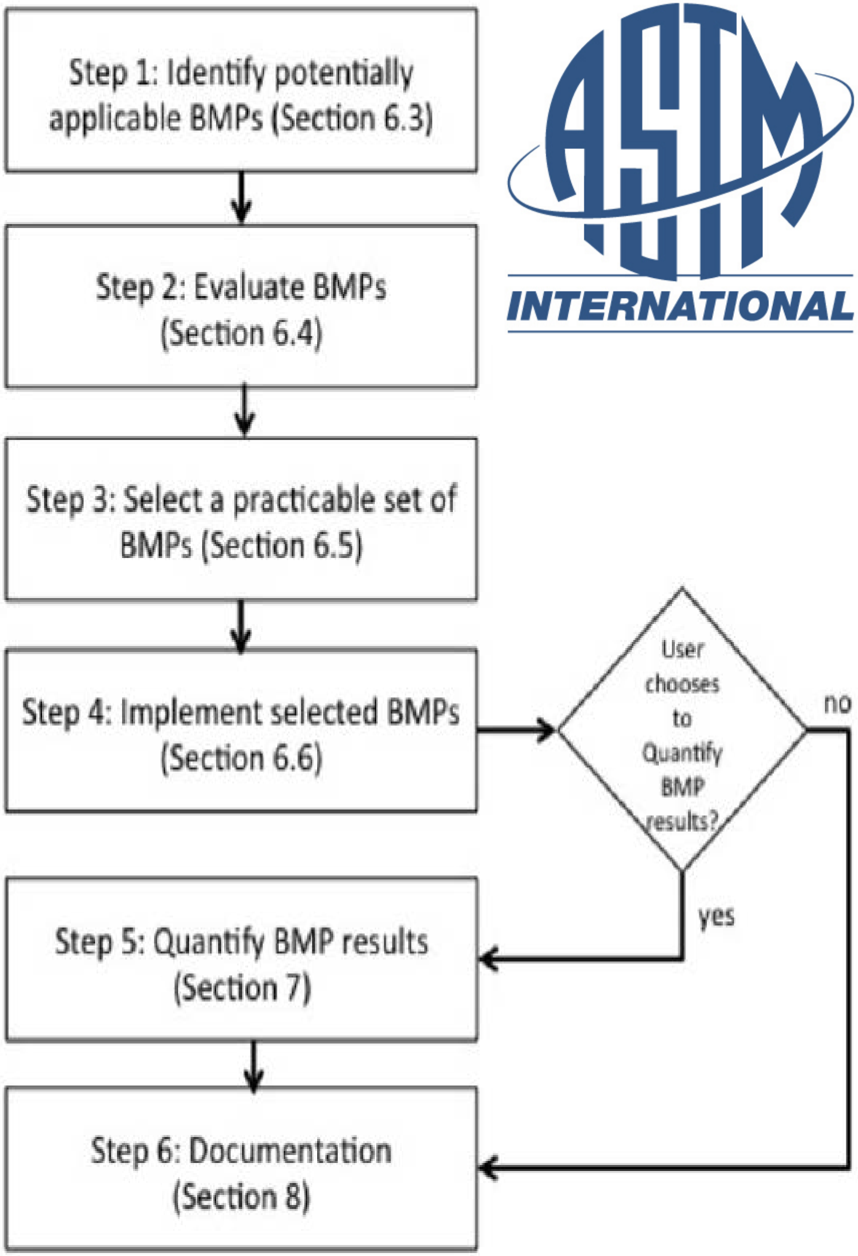

FIG. 3 BMP Selection and Implementation Process

Source: ASTM E2876-13

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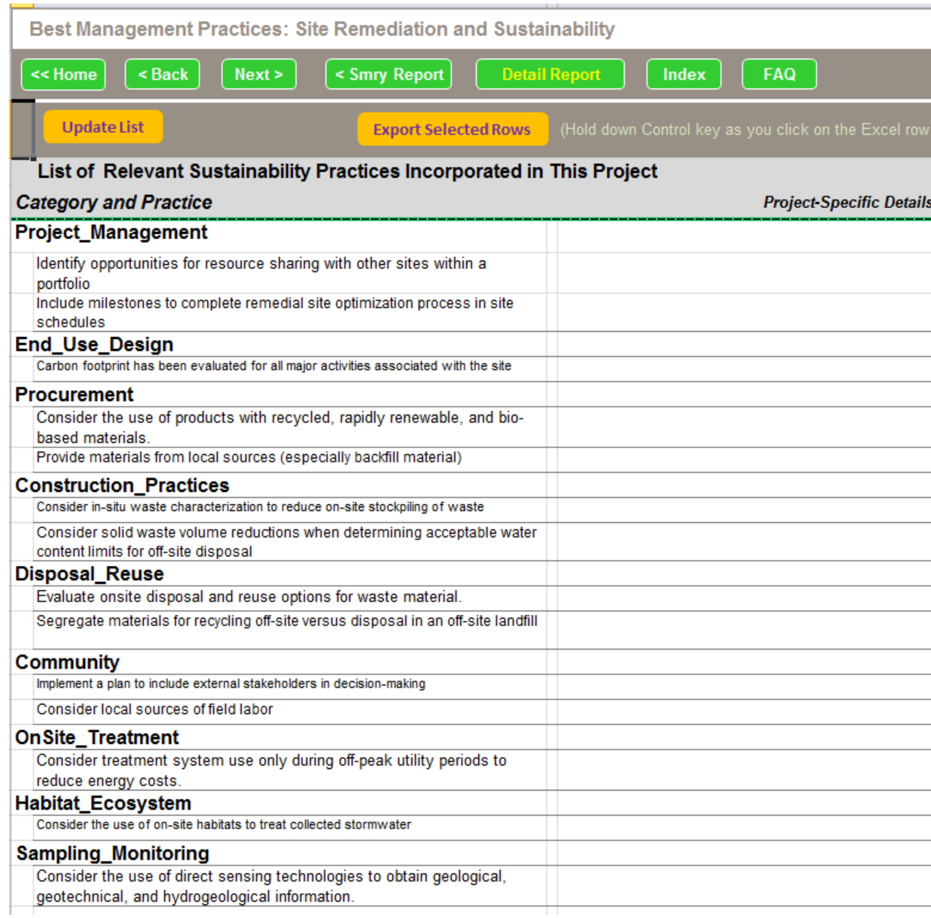
BMP Tool - GSRx™

– Excel-based proprietary BMP tool developed by AECOM that offers consistent and cost effective application of sustainable best management practices

– Includes 133 BMPs that the user selects as appropriate for the project

– A detail report is provided and lists all BMPs selected in each remediation phase



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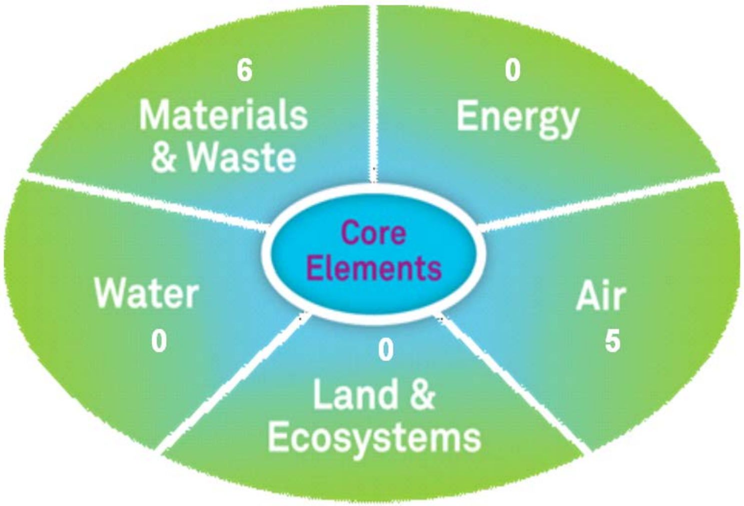
GSRx™

– After BMP screening, GSRx provides graphical and tabular output

– The graphical summary provides the number of BMPs incorporated into your project displayed on a spectrum

– The tabular printout provides a table for ease of use during field implementation and documentation

Management Practices Selected, by EPA Core Element



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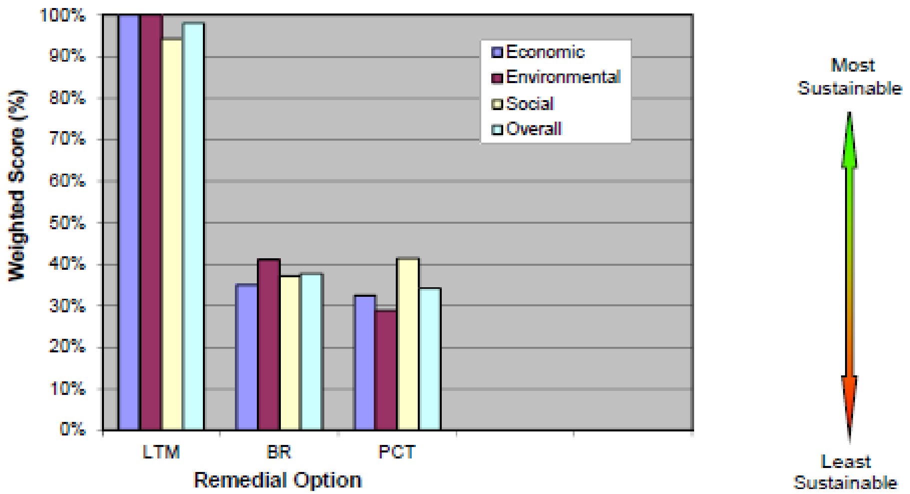
Qualitative Analysis- AECOM Qualitative Sustainable Remediation Tool (AqSRT)

- Excel based proprietary tool built by AECOM based on SuRF-UK sustainable remediation indicators
- Can be customized to look at site specific themes or sustainability indicators
- Provides qualitative analysis based on weighted stakeholder values
  - Environmental
  - Social
  - Economic

Example AST Results



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Quantitative Analysis – USEPA Footprint Methodology and SEFA

- EPA's Footprint Methodology
  - 7 step quantification process
  - Evaluation of 21 metrics aligned with core elements for a greener cleanup
- SEFA: Set of 3 Excel workbooks used to assist user with metric estimation
- Incorporates data on materials, waste, water, energy, and air
- Structured for inputting data, running calculations, and organizing outputs
- Tool and tutorials available on CLU-IN website: https://clu-in.org/greenremediation/methodology/#SEFA

Quantitative Analysis - Sustainable Remediation Tool (SRT)™

– Spreadsheet based model

– Use for remedy selection & optimization of an existing remedy

– Metrics:
  - Air emissions, GHG emissions, energy, cost, accident risk, change in resource use

– Includes stakeholder scoring matrix

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

Quantitative Analysis - SiteWise™

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– Series of Excel spreadsheets to calculate the environmental footprint of each stage of remedial action

– Widely used for environmental footprint calculation and sustainability analysis of remedial alternatives

– Includes inputs for various remediation activities including:
  - Transportation
  - Equipment use
  - Waste handling
  - Raw materials
  - Well installation

– Considers life-cycle impacts from remedial actions including emissions due to manufacturing of materials consumed during remedial action

Version 3.1 includes sediment remediation inputs

https://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/erb/gsr.html

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SiteWise™ - Metrics

Metrics calculated with tool:

– Energy Consumption
  - Expressed as British Thermal Units (BTUs)

– Greenhouse Gases Emitted
  - Metric tons CO_2e
    - o Includes CO_2, CH_4, and N_2O

– Criteria Air Pollutants Emitted
  - NOx, SOx, PM in metric tons

– Water Consumption
  - Expressed as gallons

– Worker Safety
  - Accidental injury and death and lost hours

– Resource Consumption
  - – Landfill space, top soil

- Cost of Footprint Reduction
  - – Wind, solar, microturbines

Metrics qualitatively evaluated for comparison table within tool:

– Ecological Impacts
  - – For example land, surface water and aquifer impacts

– Community Impacts
  - For example noise, traffic, odors

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SiteWise^{TM} Input Sheet Example– Material Production

WELL MATERIALS	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5
Input number of wells					
Input depth of wells (ft)					
Choose well diameter (in) from drop down menu	1/2	1/2	1/2	1/2	1/2
Choose material type from drop down menu	Steel	Steel	PVC	PVC	PVC
Choose specific material schedule from drop down menu	Schedule 40 Steel	Schedule 40 Steel	Schedule 40 PVC	Schedule 40 PVC	Schedule 40 PVC

TREATMENT CHEMICALS	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Input number of injection points					
Choose material type from drop down menu	ISCO Chemical	Sodium Hypochlorite	Urea	EZVI	Sodium Hypochlorite
Input amount of material injected at each point (lbs)					
Input number of injections per injection point					

GAC	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Input weight of GAC used (lbs)					
Choose material type from drop down menu	GAC	GAC	GAC	GAC	GAC

CONSTRUCTION MATERIALS	Material 1	Material 2	Material 3	Material 4	Material 5
Choose material type from drop down menu	HDPE	HDPE	HDPE	HDPE	HDPE
Input area of material (ft^2)					
Input depth of material (ft)					

WELL DECOMMISSIONING	Well Type 1	Well Type 2	Well Type 3	Well Type 4	Well Type 5
Input number of wells					
Input depth of wells (ft)					
Choose well diameter (in) from drop down menu	1/2	1/2	1/2	1/2	1/2
Choose material from drop down menu	Soil	Soil	Soil	Soil	Soil

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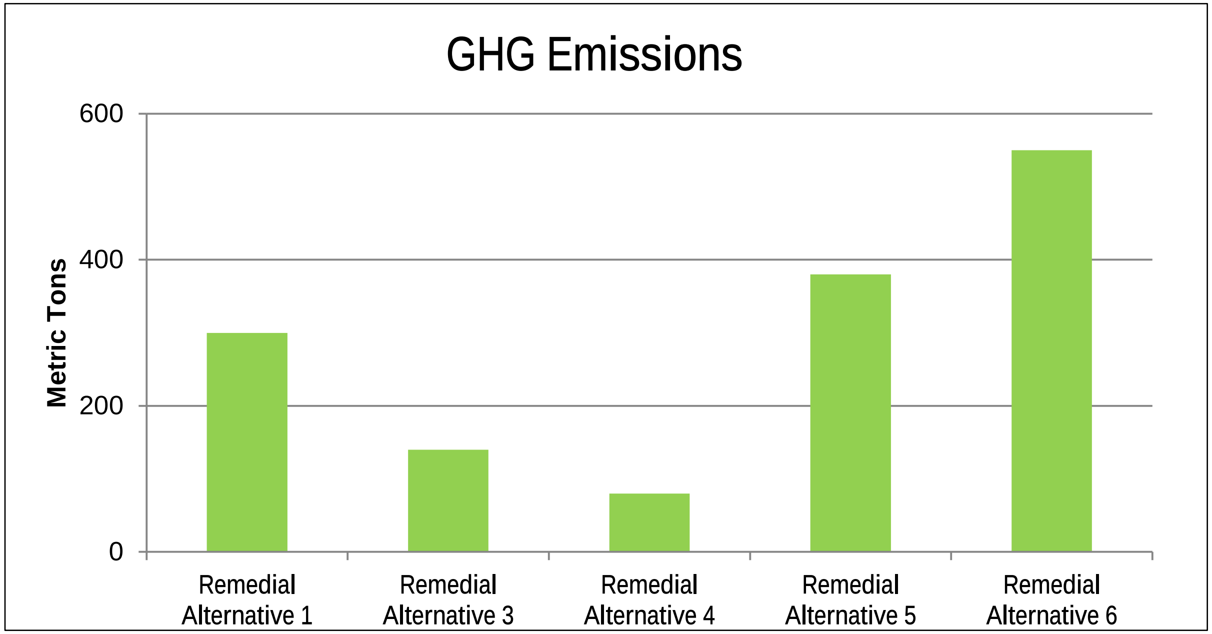
SiteWise™ Output Examples

Remedial Alternatives	GHG Emissions	Total Energy Used	Water Consumption	NO_x emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
	metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Remedial Alternative 1	300.00	3.05E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Remedial Alternative 3	140.00	3.05E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Remedial Alternative 4	80.00	3.05E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Remedial Alternative 5	380.00	2.20E-01	0.00E+00	6.00E-05	1.00E-06	1.00E-06	1.51E-08	3.14E-06
Remedial Alternative 6	550.00	2.20E-01	0.00E+00	6.00E-05	1.00E-06	1.00E-06	1.51E-08	3.14E-06



Comparative graph shown for GHG emissions

Similar graph is generated for each metric

SiteWise™ Graphical Output Examples

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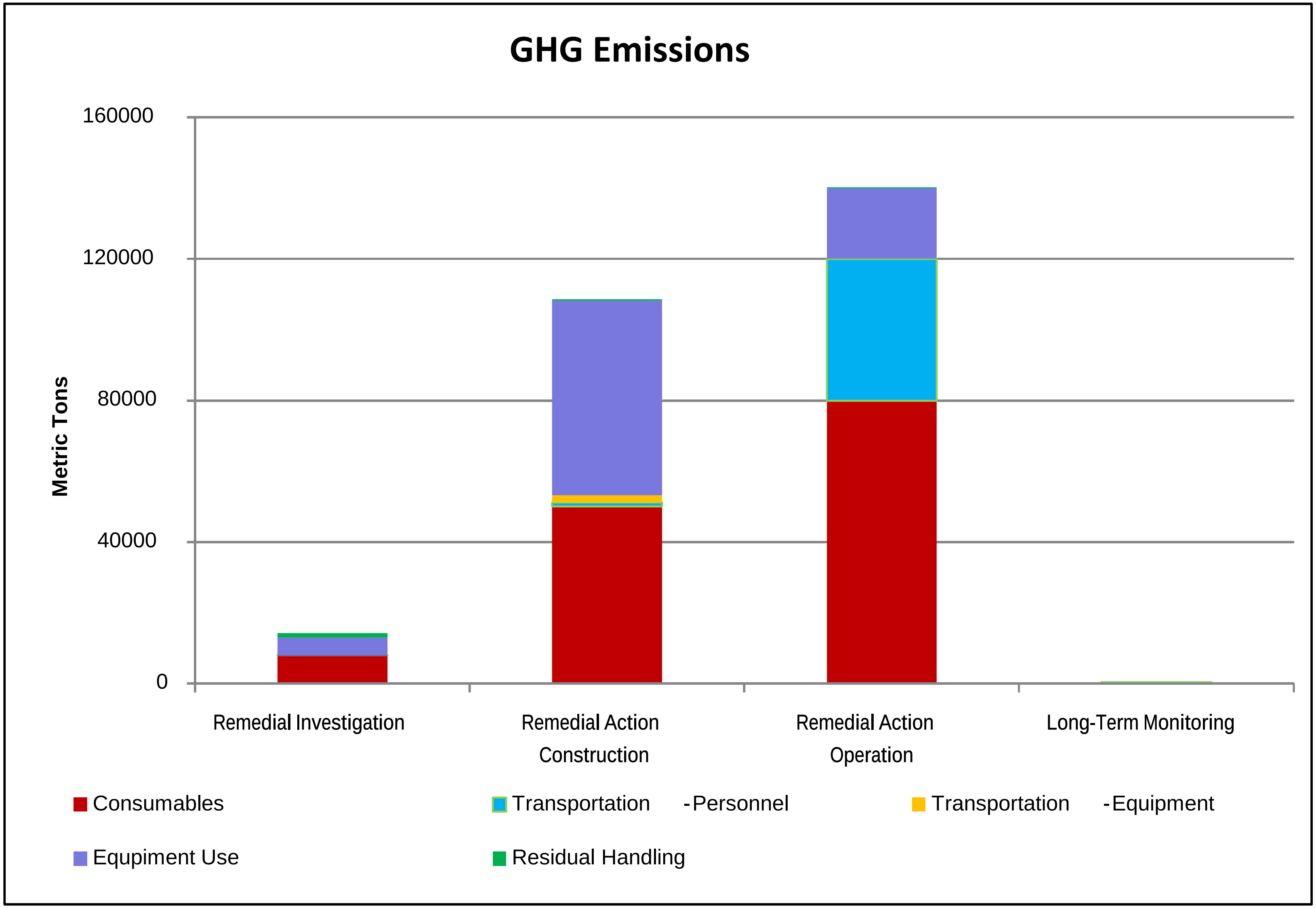
Illustrates which phases of the project have large footprints and which specific elements in each phase have large footprints



Case Study: A Retrospective Analysis of Sustainability Metrics for Remedial Alternatives at 3 Sediment Remediation Sites

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Demands of Sediment Sites Make a Case for Action

– Sediment remediation is complex; costs and benefits not always balanced; remedies take too long and are focused on mass removal

– Sustainability already has a place in the remedy selection process
  - Consistent with CERCLA and state regulations (e.g., NY, others)
  - Net Environmental Benefits Analysis (NEBA) is one of many proven tools that should be part of a Sustainability Assessment

– Sustainability should be part of the weight-of-evidence approach for selecting remedial actions
  - Most effective when considered early, as part of the selection process
  - May easily be incorporated into remedial design and implementation
  - Provides a platform for stakeholders to evaluate trade-offs (costs, risks, benefits) and make informed decisions

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Retrospective Analysis Demonstrates Value of Sustainability Assessments in Remedy Selection

– **Objective**: Conduct sustainability assessment for several large sediment remediation projects with remedies selected over 10 years ago (pre-SURF) to demonstrate that sustainability should be considered in remedy selection process

– **Why**: Selected remedies for complex sediment sites often focus on mass removal, take years to implement, and require expenditures well beyond the point of diminishing return

– **Benefit:** Newly established sustainability tools provide a structured platform for stakeholders to evaluate trade-offs (costs, risks, benefits) and make informed decisions within the CERCLA framework

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Sediment Sites In Analysis

Hudson River Polychlorinated Biphenlys (PCBs) (Phase 1) Site, NY

- **Alternative 1:** "Cap-3/10/Select" limited hot spot dredging and 207 acre cap
- **Alternative 2:** "Rem-3/10/Select" limited hot spot dredging
- **Alternative 3:** "Rem 0/0/3" more extensive sediment dredging

Lower Fox River PCBs Site (OU 3), WI

- **Alternative 1:** "C2B-500" dredging of sediments with PCBs >500ppb
- **Alternative 2:** "C2B-1,000" dredging of sediments with PCBs >1,000ppb
- **Alternative 3:** "F-1,000" combination of dredging or capping sediments with PBCs>1,000ppb

Bremerton Naval Complex (OU B, Sinclair Inlet), WA

- **Alternative 1:** "SD2" dredging of sediments with upland disposal in landfill
- **Alternative 2:** "SD4" dredging of sediments with disposal in built confined aquatic disposal (CAD) facility
- **Alternative 2:** "SD7" dredging of sediments with disposal in excavated CAD facility

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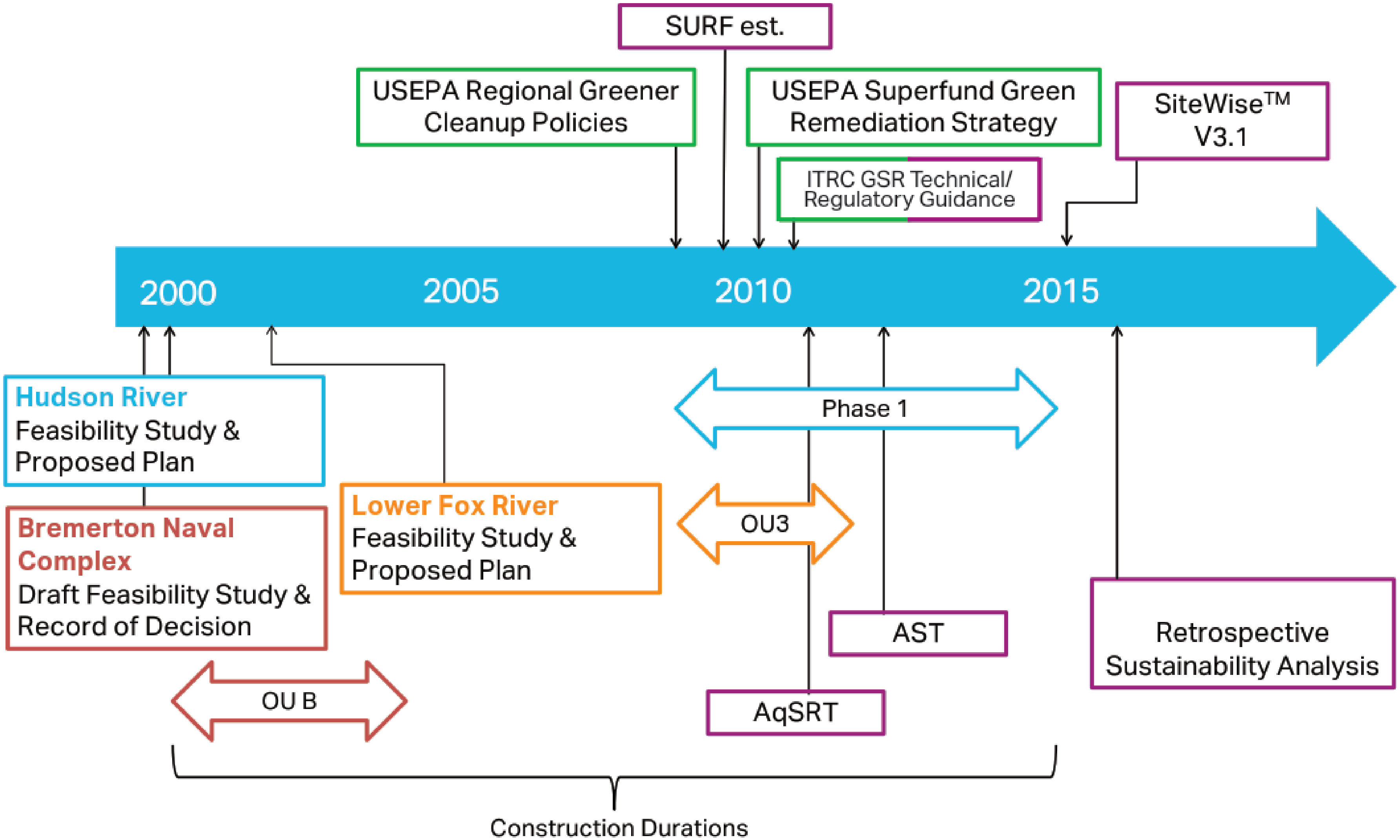
Site Timelines



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Selected Tools

Tool	Developer	Type	Sustainability Pillars Evaluated	Inputs
SiteWise™	Battelle, 2015 (Version 3.1)	Publically Available Quantitative Footprint Tool	Environmental (Energy, Air Emissions, Waste) Social (Safety)	FS Cost Estimate Quantities
AECOM Sustainability Tool (AST)	AECOM, 2012	Proprietary Quantitative Footprint Tool	Environmental (Energy, Air Emissions, Waste) Social (Safety)	FS Cost Estimate Quantities
AECOM qualitative Sustainable Remediation Tool (AqSRT)	AECOM, 2011	Semi-Quantitative/ Qualitative Evaluation Tool	Environmental, Social, & Economic (based on SuRF-UK Indicator Set for Sustainable Remediation)	SiteWise™/AST Output, Inferred Stakeholder Values, Professional Judgment

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Example Results

SiteWise™

AST™

AqSRT

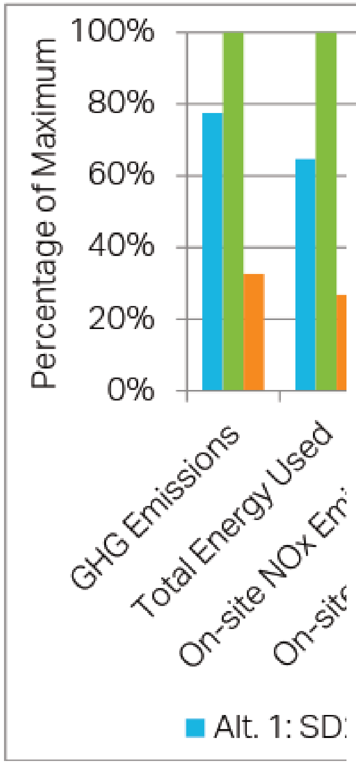

Figure 1: SiteWise™ Re

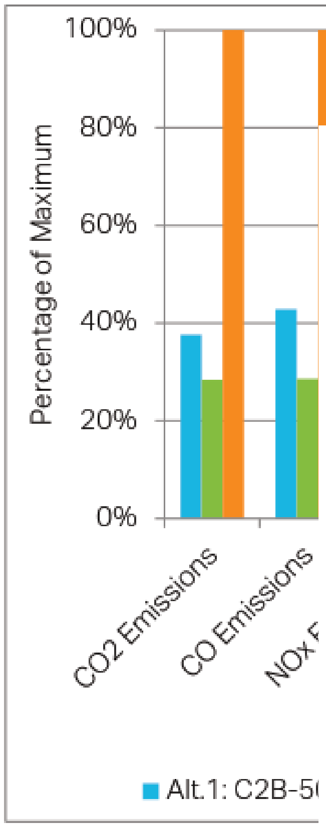

Figure 2: AST Result

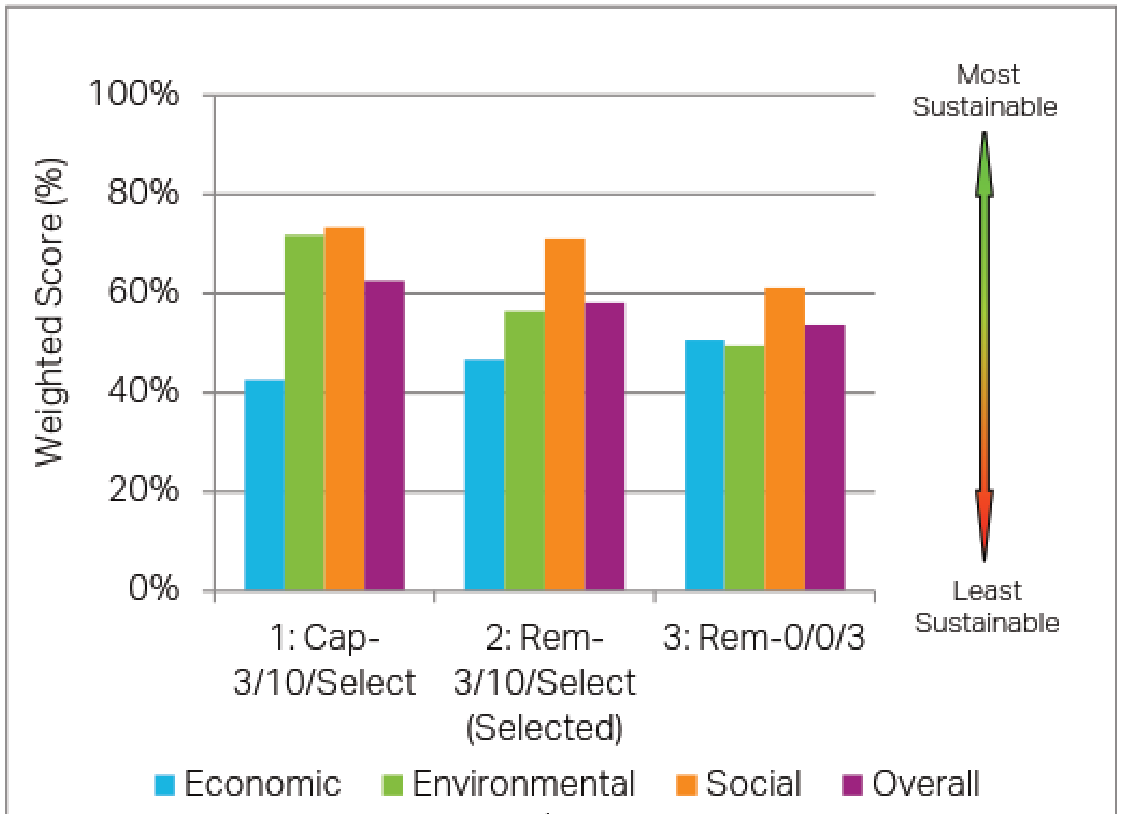

Figure 3: AqSRT Results Hudson River Phase 1

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Sustainability Analysis Conclusions

Site	Selected Alternative	Sustainable Alternative	Discussion Points
Hudson River Phase 1	Alternative 2: Rem-3/10/Select	Alternative 1: Cap-3/10/Select	On-site disposal of waste considered but not evaluated in FS BMPs Implemented to mitigate impacts
Lower Fox River Operable Unit 3	Alternative 2: C2B-1,000 (Dredge, 1,000 ppb)	Alternative 2: C2B-1,000 (Dredge, 1,000 ppb)	Waste pumped to landfill via pipeline as sustainable trucking alternative
Bremerton Naval Complex Operable Unit B	Alternative 3: SD7, Dredge w/ Excavated CAD	Alternative 3: SD7, Dredge w/ Excavated CAD	Optimized alternative not originally considered in FS Reuse of clean material from CAD construction for ENR

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Case Study Conclusions & Lessons Learned

1. Sustainability assessments are consistent with Federal and State regulations governing remediation of sediment sites

2. Sustainability tools provide a structured & transparent methodology during remedy evaluation and selection process
   - Allows stakeholder considerations of impacts and tradeoffs
   - Optimizes benefits relative to environmental, social, and economic impacts
   - Environmental metrics are more easily quantified than social and economic indicators

3. All 3 tools reached similar conclusions about the most sustainable alternative
   - AECOM qSRT requires a more robust stakeholder input to establish meaningful cumulative sustainability rankings and weights

Conclusions

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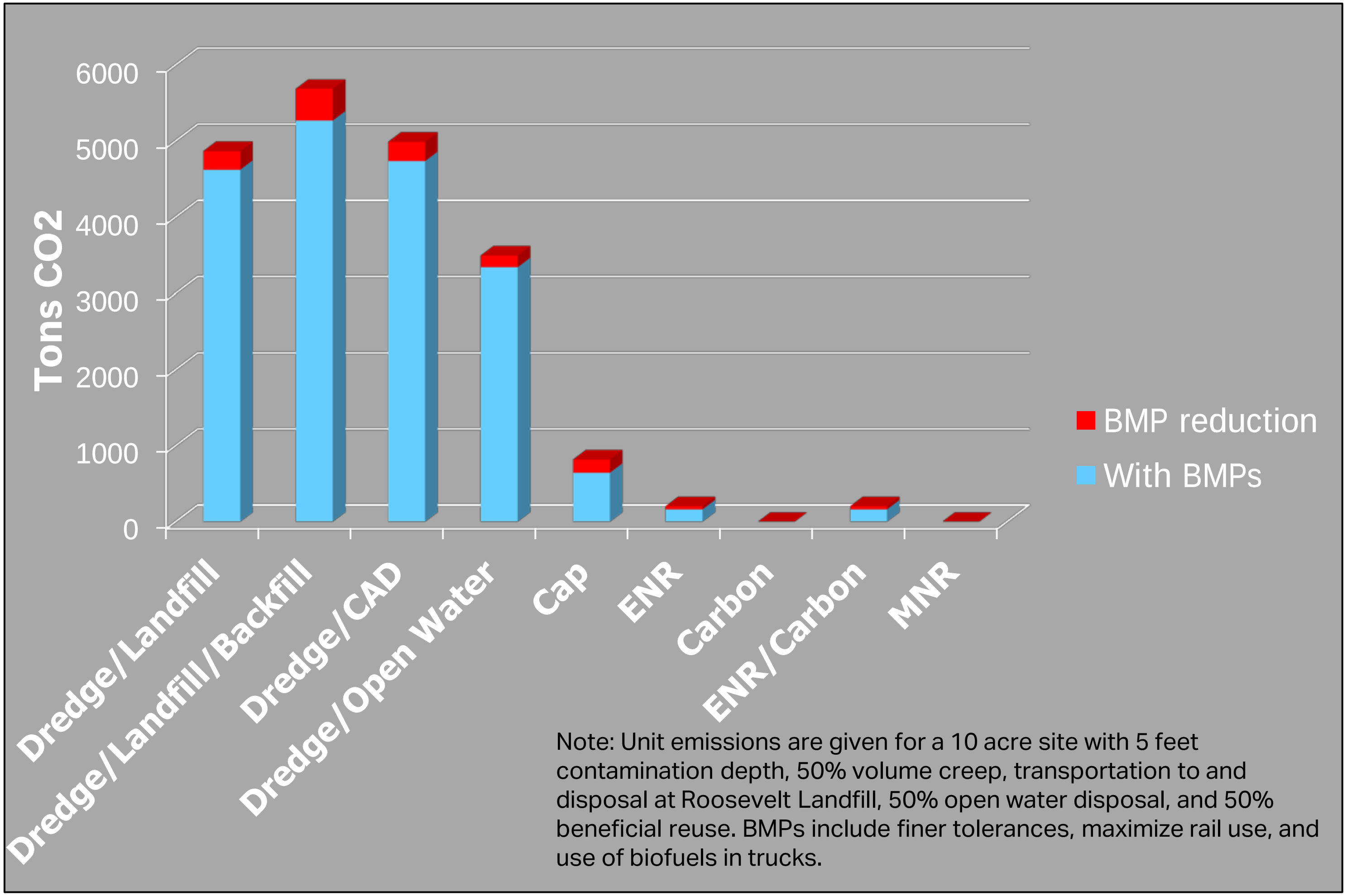
Why is This Important: Example

Effect of BMPs is Incremental Compared To Remedy Selection



Reference: Schuchardt, D. 2011. “Sustainability Considerations for Sediment Remediation in the Northwest”. Presented at 18th Meeting of the Sustainable Remediation Forum, Seattle, WA. Prepared by City of Seattle and AECOM. September 2011.

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Sustainable Remediation as a Communication Tool

- Sustainability as a stakeholder engagement mechanism
- Used as discussion topic for large scale projects
  - Time to complete remediation
  - Effect on local businesses, public recreation areas
- SR can be an effective communication tool
  - Express emissions in aces of trees
  - Relate land use to familiar size metric (i.e. football field)

Survey

Who thinks that integrating GSR into one of their existing projects could provide a direct benefit?

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Closing Thoughts

- Sustainability should be considered early in the remediation process

- Most benefit derived from incorporation at the FS level

- Challenge conventional thinking in order to produce a better remedy overall

- Many different tools and frameworks exist, all have underlying commonalities

- State and local governments provide guidance and requirements for incorporation of sustainability

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Thank You!

Questions?

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Additional Resources

SURF: http://www.sustainableremediation.org/

NICOLE: http://www.nicole.org/

CL:AIRE https://www.claire.co.uk/

IRTC Green and Sustainable Remediation:
https://www.itrcweb.org/Team/Public?teamID=7

USEPA Greener Cleanups:
https://www.epa.gov/greenercleanup

CLU-IN: https://clu-in.org/greenremediation/

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SURF Value or Sustainable Remediation Survey

– The sustainable remediation forum (SURF) is currently working on a technology initiative in order to better understand the value that sustainable remediation (SR) brings to the remediation community. If you haven't done so already please consider taking the survey. (It will only take about 5 minutes!)

– SURF Value of SR Survey

– Please be aware that respondents' name and company affiliation will remain confidential.

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Case Study Acknowledgements

- ExxonMobil (Frank Messina)
- Current and Former AECOM Staff (Amanda McNally, Anne Fitzpatrick, Matt Salmon, Maureen McBride, & Gerlinde Wolf)
- General Electric
- Wisconsin DNR