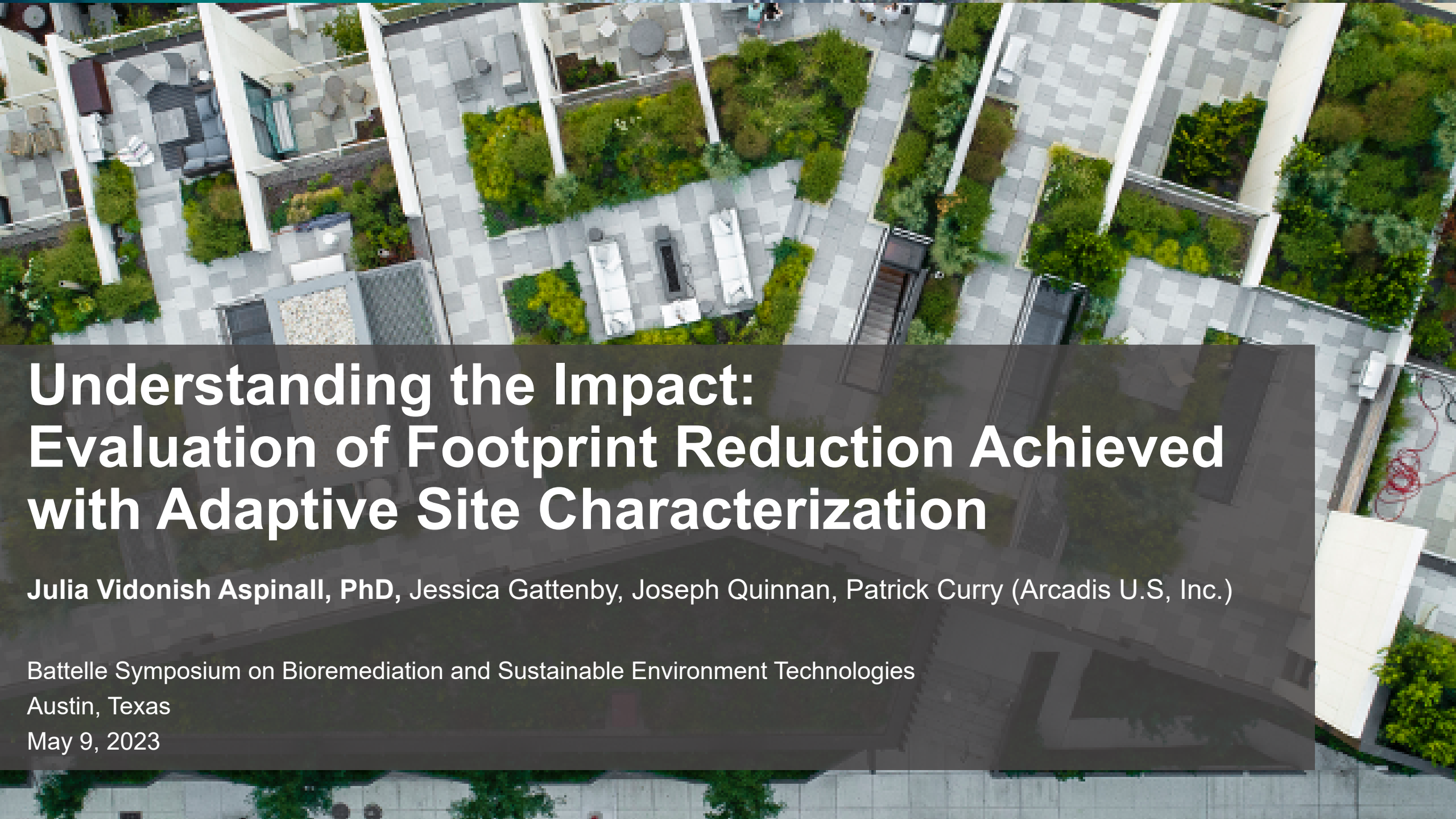

Understanding the Impact: Evaluation of Footprint Reduction Achieved with Adaptive Site Characterization

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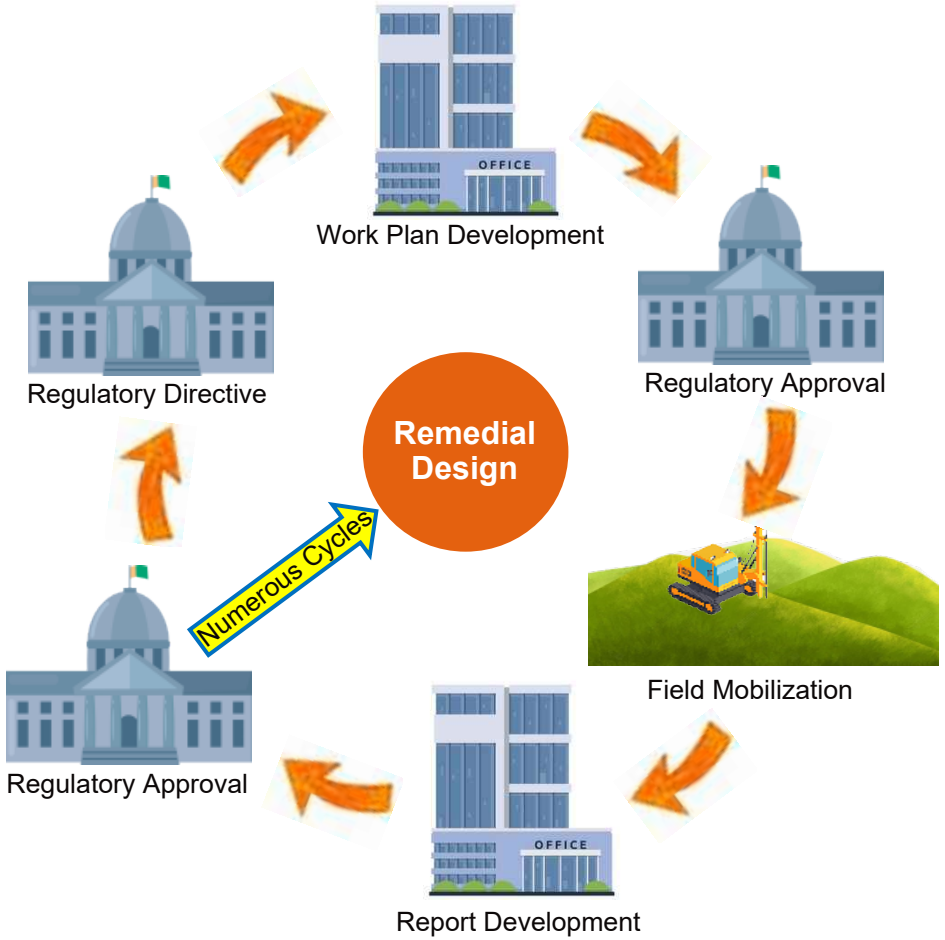
Agenda

1. What is an adaptive remedial investigation (RI)?
2. What is the footprint of an adaptive RI?
3. What are the social and ecosystem impacts of an adaptive RI?
4. What was challenging? Where can we grow?

What is an Adaptive RI?

Traditional RI



Adaptive Implementation Process

Initial Preparation

- Preliminary CSM and strategy
- Sample existing wells to refine strategy

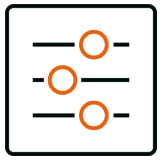
Benefits of an Adaptive Approach

Reduces duration of RI via more informed decisions.

- Delineate impacts to support risk assessment
- Flux-based CSM to map migration pathways and focus GW control actions
- Rank and prioritize sources to reduce mass flux/discharge
- Collaborative approach using screening method provides higher resolution CSM

Reveals potential threats or impacts to receptors earlier.

- Provide alternative water supply
- Mitigate potential off-site migration
- Remove/treat significant sources for best benefit



Efficient approach allows for better use of resources.

- Reduced duration, investigation-derived waste, subcontractor time
- Streamlined reporting schedule
- Adaptive project management approach

Today's technology enables near real-time data sharing, collaboration and decision making.

Significance of Green and Sustainable Remediation

White House Executive Order E.O. 13514, Federal Leadership in Environmental, Energy, and Economic Performance

"…ensure green and sustainable remediation practices by increasing **energy efficiency**; conserving and protecting **water resources**…; **eliminating waste**, **recycling, and preventing pollution**; …**foster markets for sustainable technologies**…; and **strengthening the vitality and livability of the communities** in which Federal facilities are located.

Increased interest in private sector to help companies meet environmental, social and governance goals.

Our industry is evolving as green technologies and sustainability goals develop.

What is the Footprint of an Adaptive RI?

SiteWise™ Version 3.2

BASELINE INFORMATION

COMPONENT 3 DURATION AND COST	Entire Site
Input duration of the component (unit time)	1
Input component cost per unit time ($)	

MATERIAL PRODUCTION

WELL MATERIALS	Well Type 1	Well Type 2
Input number of wells		
Input depth of wells (ft)		
Choose specific casing material schedule from drop down menu	Sch 40 PVC	Sch 40 PVC
Choose well diameter (in) from drop down menu	1/8	1/8
Input total quantity of Sand (kg)		
Input total quantity of Gravel (kg)		
Input total quantity of Bentonite (kg)		
Input total quantity of Typical Cement (kg)		
Input total quantity of General Concrete (kg)		
Input total quantity of Steel (kg)		

TREATMENT CHEMICALS & MATERIALS	Treatment 1	Treatment 2
Input number of injection points		
Choose material type from drop down menu	Hydrogen Peroxide	Hydrogen Peroxide
Input amount of material injected at each point (pounds dry mass)		
Input number of injections per injection point		

TREATMENT MEDIA	Treatment 1	Treatment 2
Input weight of media used (lbs)		
Choose media type from drop down menu	Virgin GAC	Virgin GAC

CONSTRUCTION MATERIALS	Material 1	Material 2
Choose material type from drop down menu	HDPE Liner	HDPE Liner
Input area of material (ft2)		
Input depth of material (ft)		

SiteWise™ is a tool to determine the environmental footprint of remediation scenarios.

Analyses several sustainability metrics:

- GHG Emissions
- Energy Usage
- Water Consumption
- Electricity Usage
- Air Pollution Emissions (NO_x, SO_x, PM_{10})
- Accident Risk (Injury, Fatality)

Available at SURF's Website

Traditional Approach

Mobilization 1

- 10 Soil Borings
- 5 Monitoring Wells

Mobilization 2

- 10 Soil Borings
- 10 Monitoring Wells

Mobilization 3

- 5 Soil Borings
- 9 Monitoring Wells

Mobilization 4

- 8 Monitoring Wells

Mobilization 5

- 4 Monitoring Wells

Quarterly Sampling of 36 Wells

5-Year Period of Performance (POP)

Adaptive Approach

ARCADIS

Mobilization 1

- 15 Soil Borings
- 12 VAP Borings (3 samples per boring)

Mobilization 2

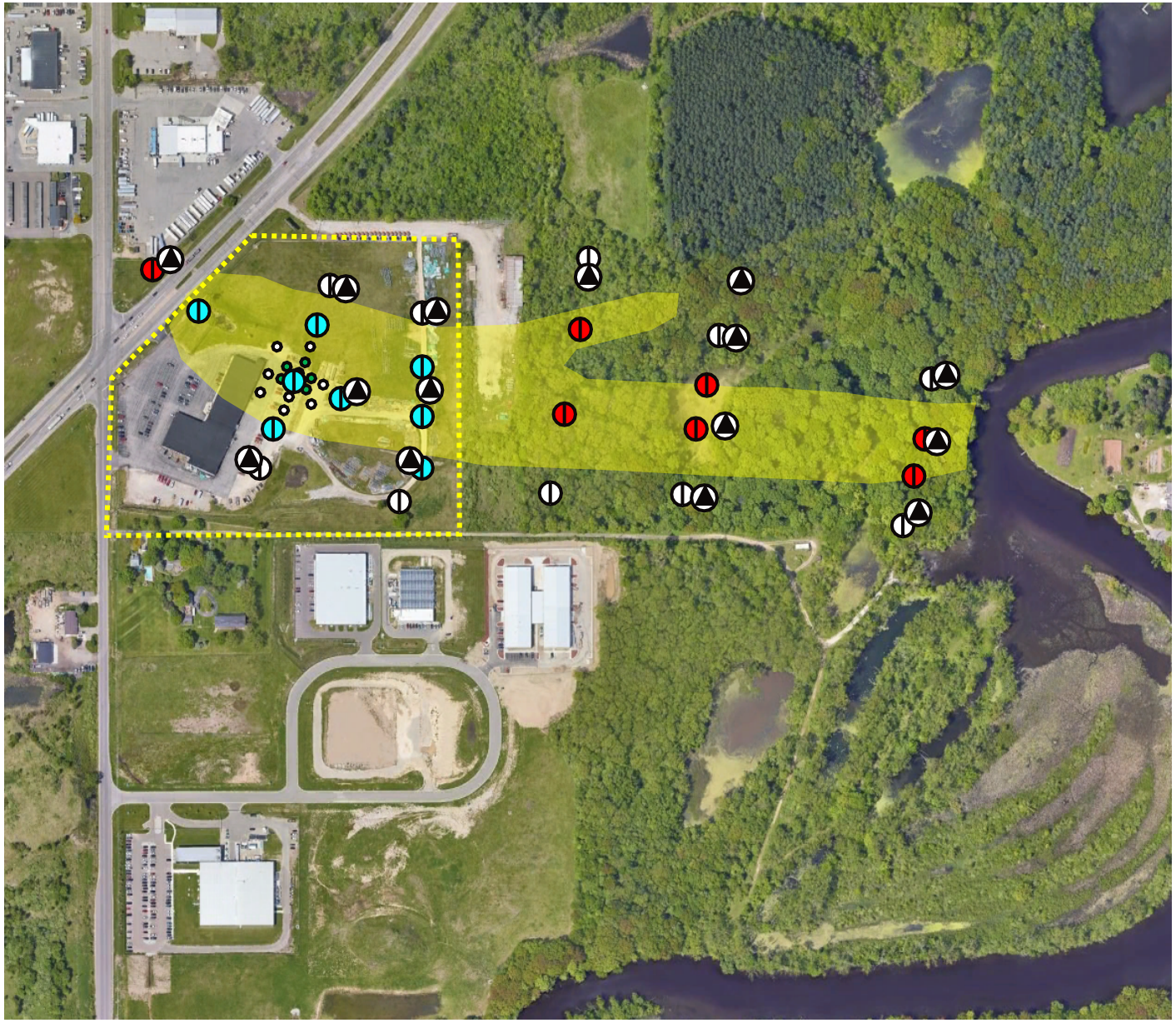
- 13 VAP Borings (3 samples per boring)

Mobilization 3

- Install 15 Monitoring Wells

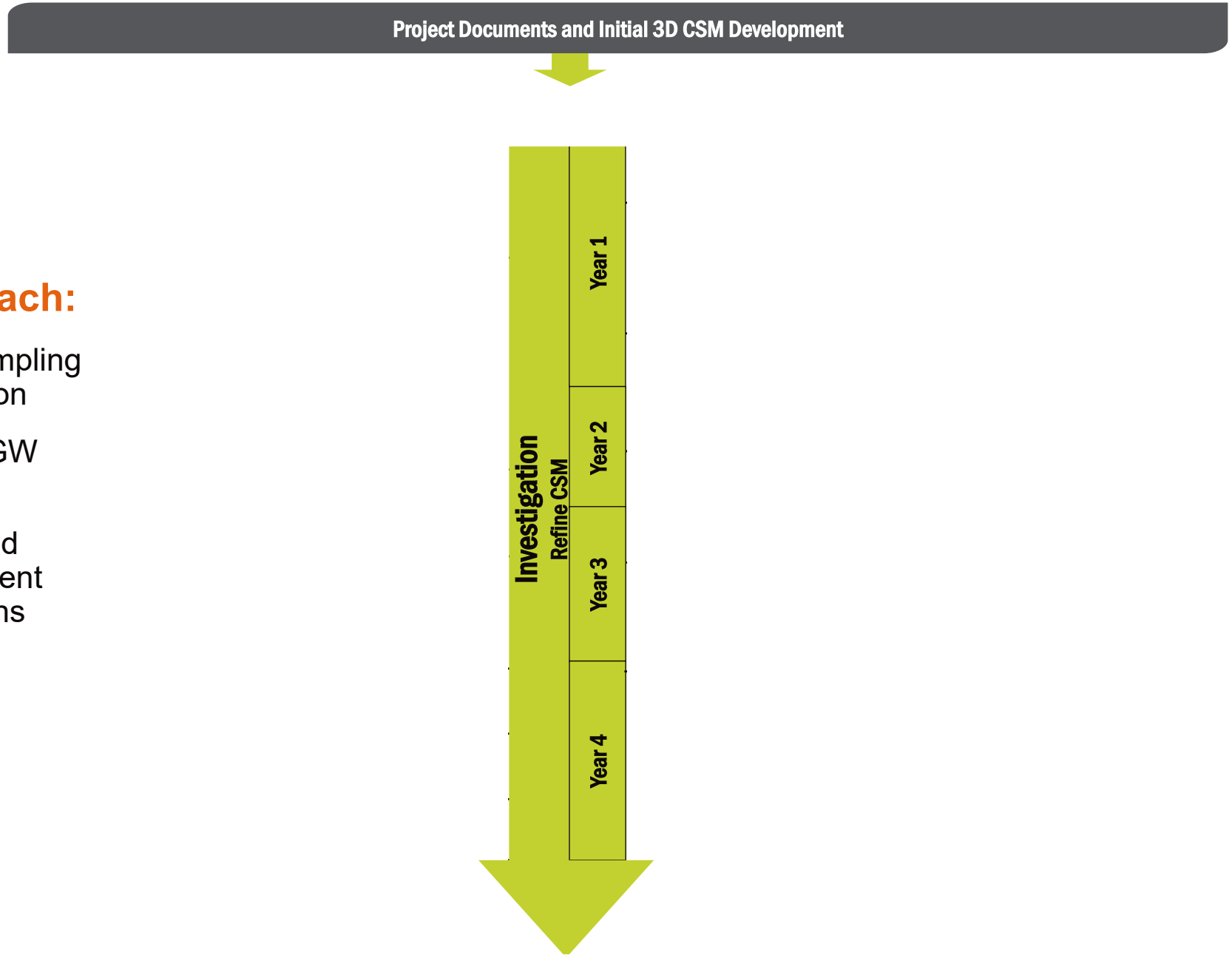
Quarterly Sampling of 15 Wells

3- to 4-year POP



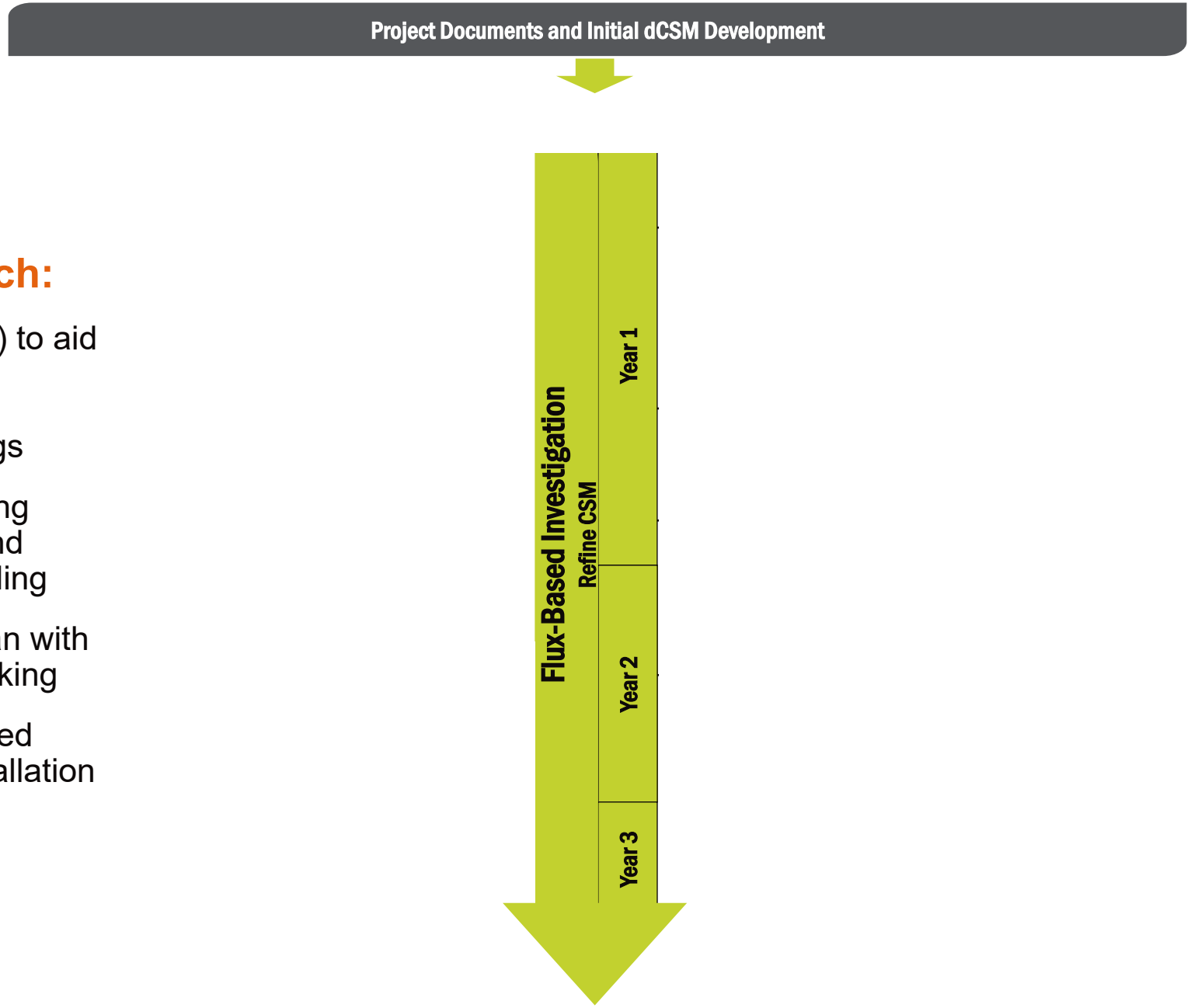
Traditional Approach:

- Prescriptive Soil Sampling for Source Delineation
- MW installation for GW Characterization
- Interim Reporting and Workplan Development between mobilizations



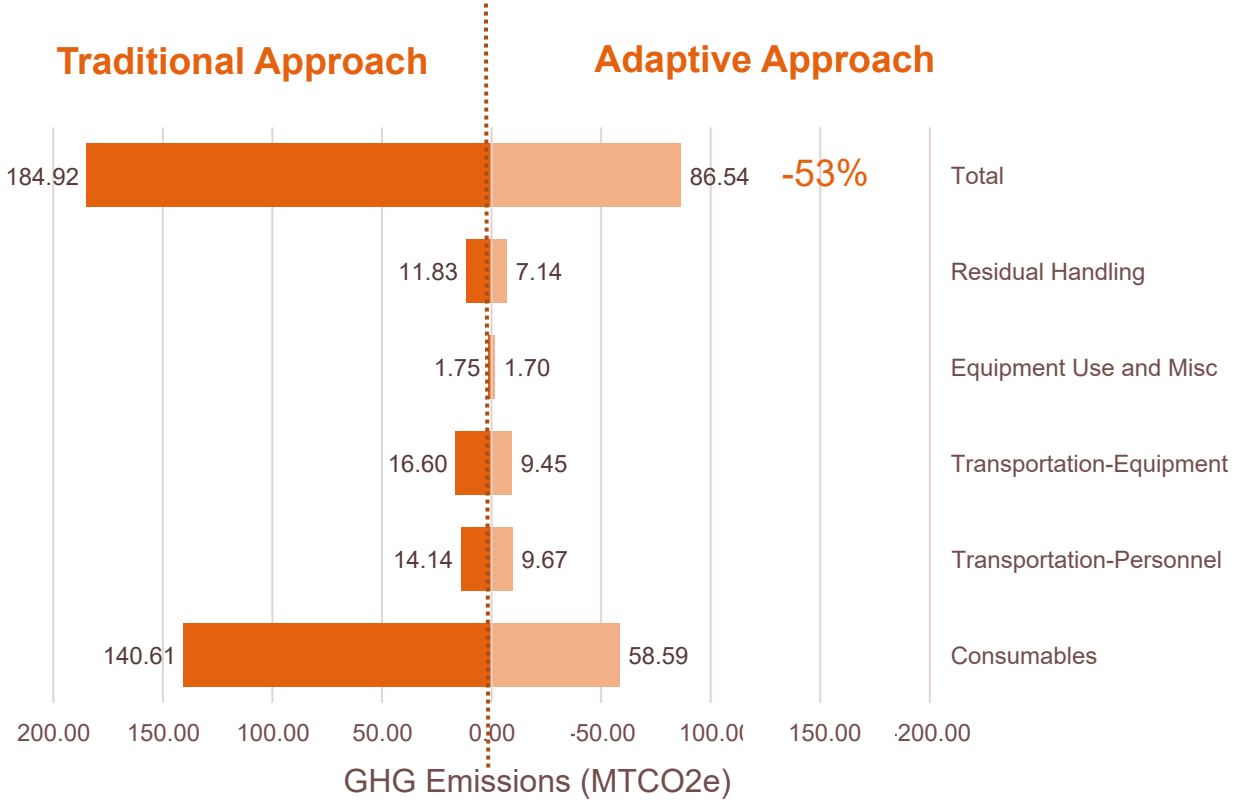
Adaptive Approach:

- Digital CSM (dCSM) to aid decision making, visualization and stakeholder meetings
- Rapid Turn/Screening Methods For Soil and Groundwater Sampling
  - Dynamic workplan with field decision making
- Flux-based, optimized monitoring well installation



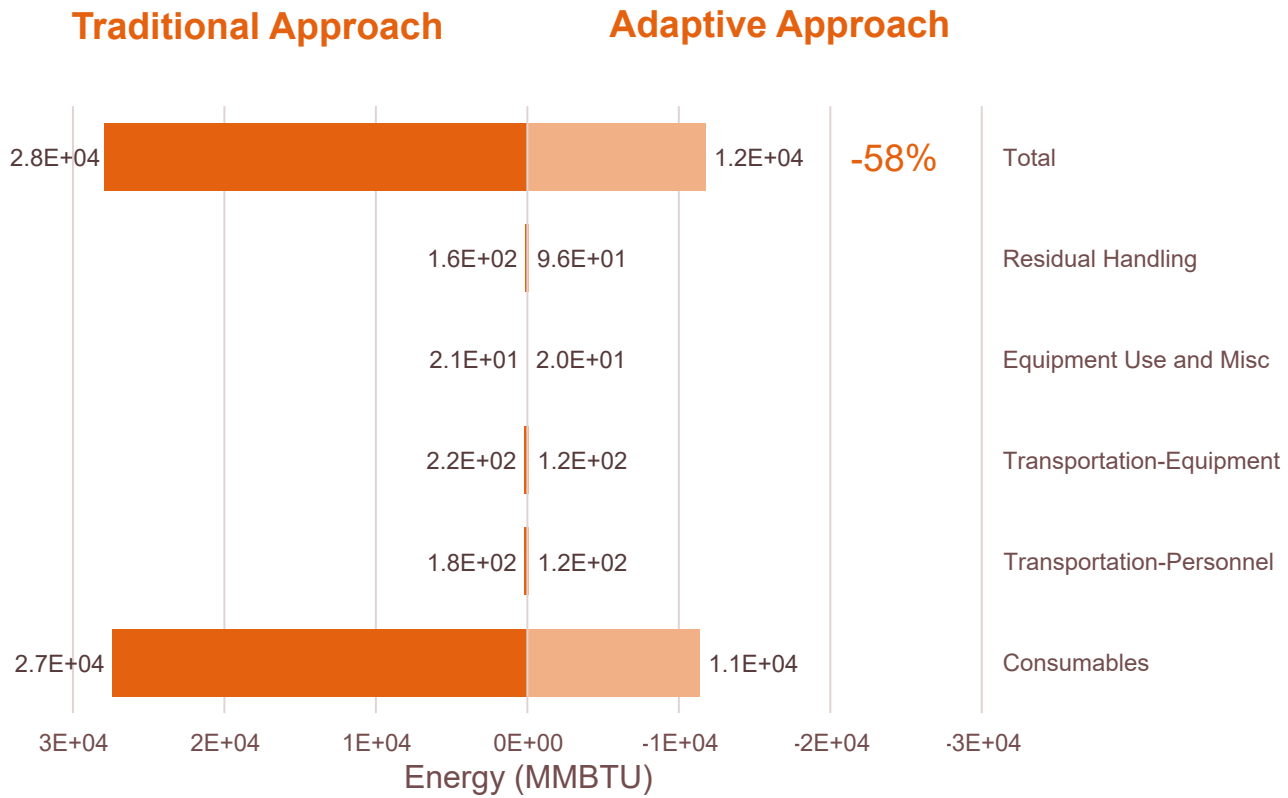
Greenhouse Gas (GHG) Emissions

- 53% decrease in overall emissions with an adaptive approach.
- “Consumables” category includes complete footprint of materials that cannot be reused, (e.g. well construction materials).
- Reduction in monitoring wells significantly reduced materials production emissions.
- Drilling footprint was nearly identical.



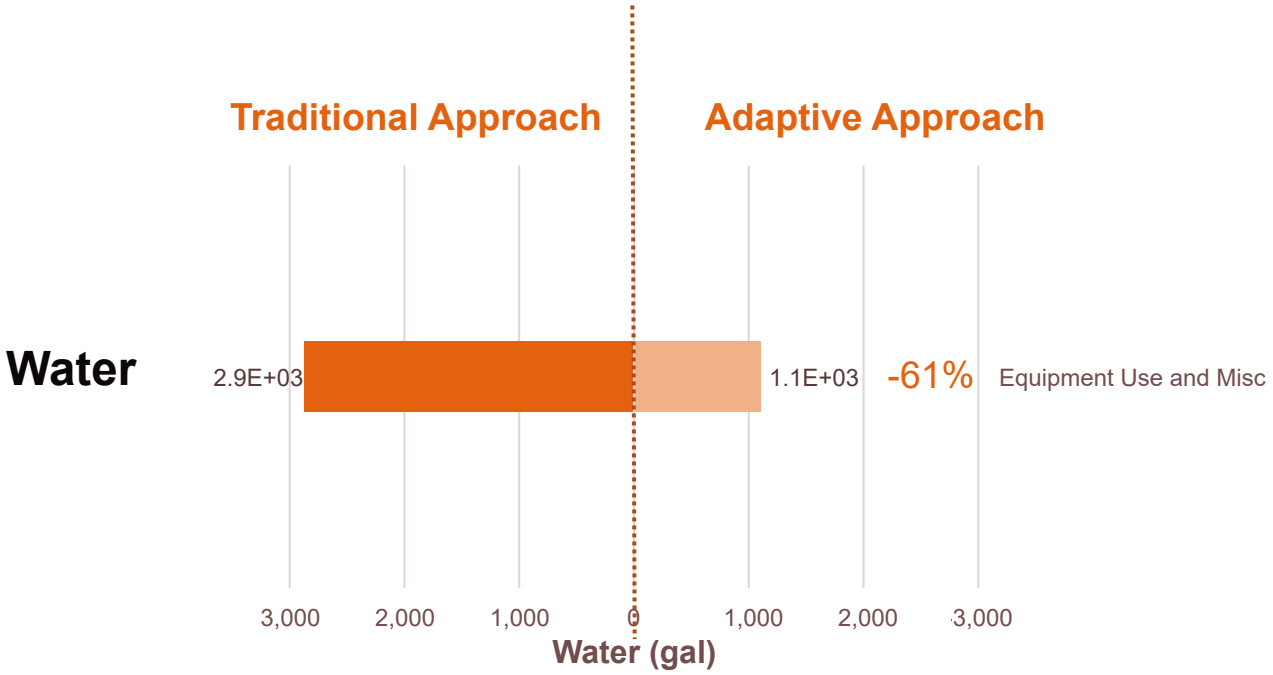
Total Energy Use

- 58% less energy used by adaptive approach.
- Similar to GHG emissions, the reduction in monitoring wells was the predominant difference.
  - ❖ Shows magnitude of scale for full lifecycle costs (sand, concrete, cement, bentonite)
  - ❖ 97 to 98% of energy in both approaches stems from materials production.



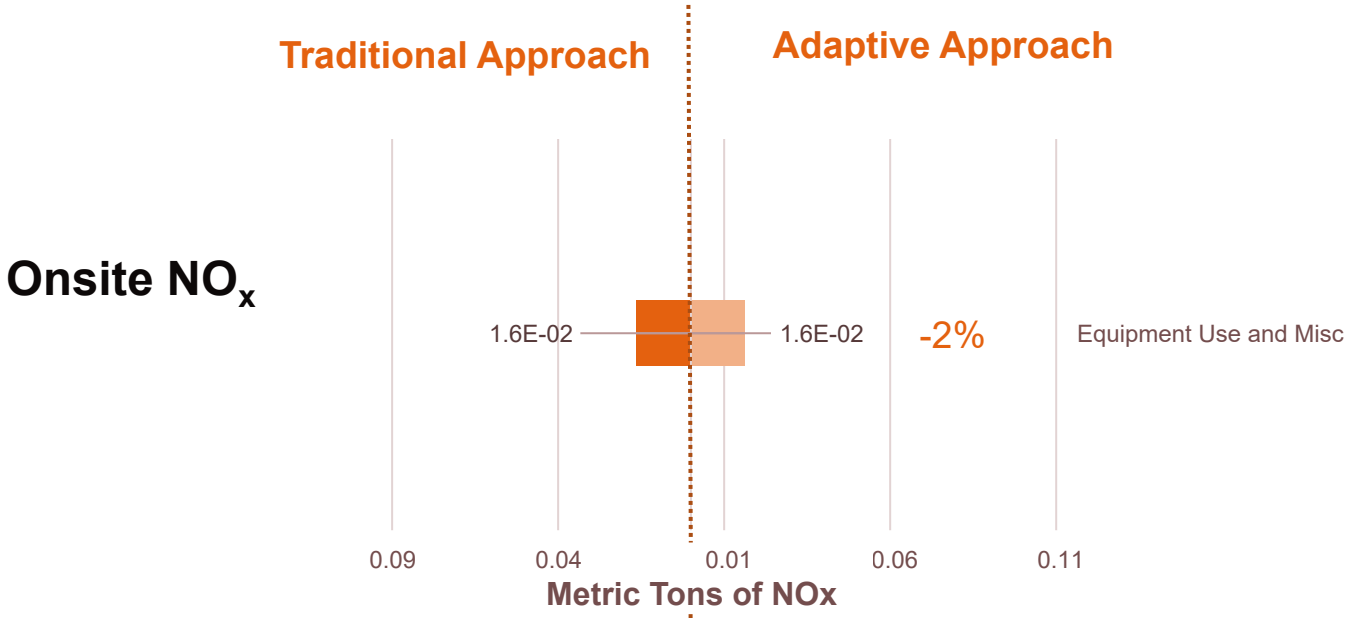
Electricity and Water

- 61% reduction in water use with adaptive approach from reduced purge water generation.



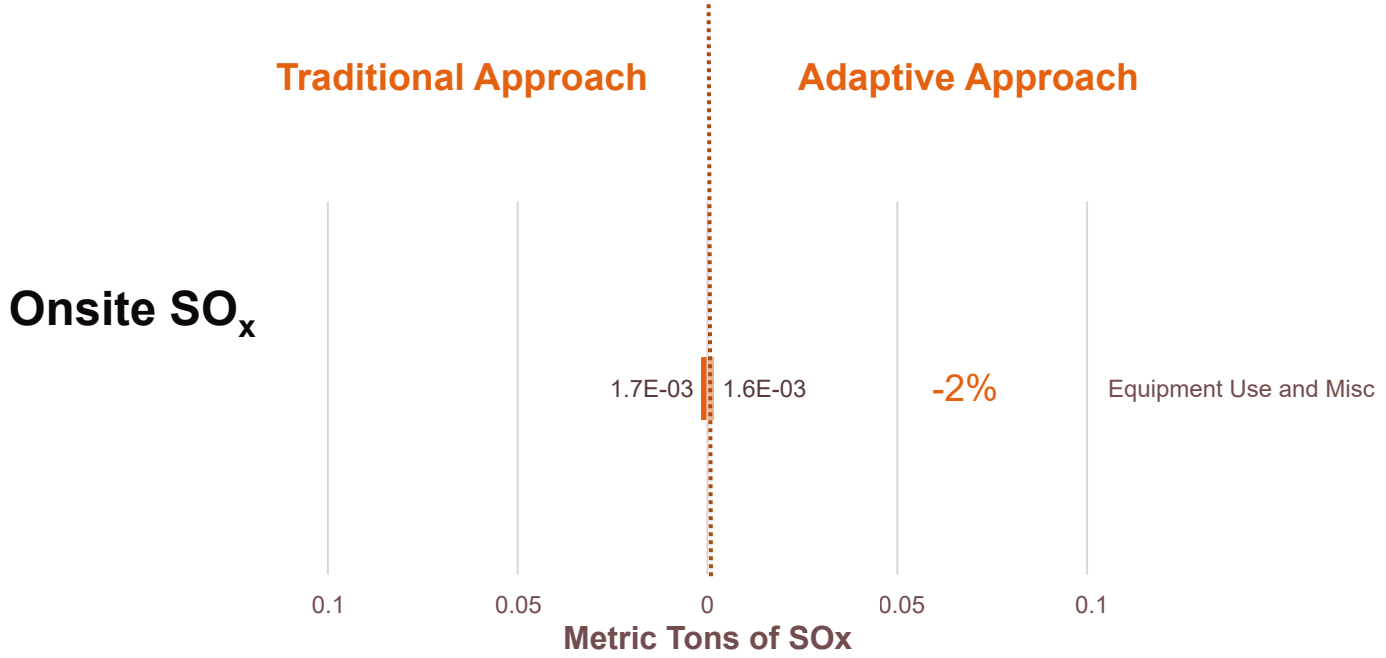
Air Pollution Results: NO_x

- Onsite NO_x emissions are nearly identical due to similar drilling time.



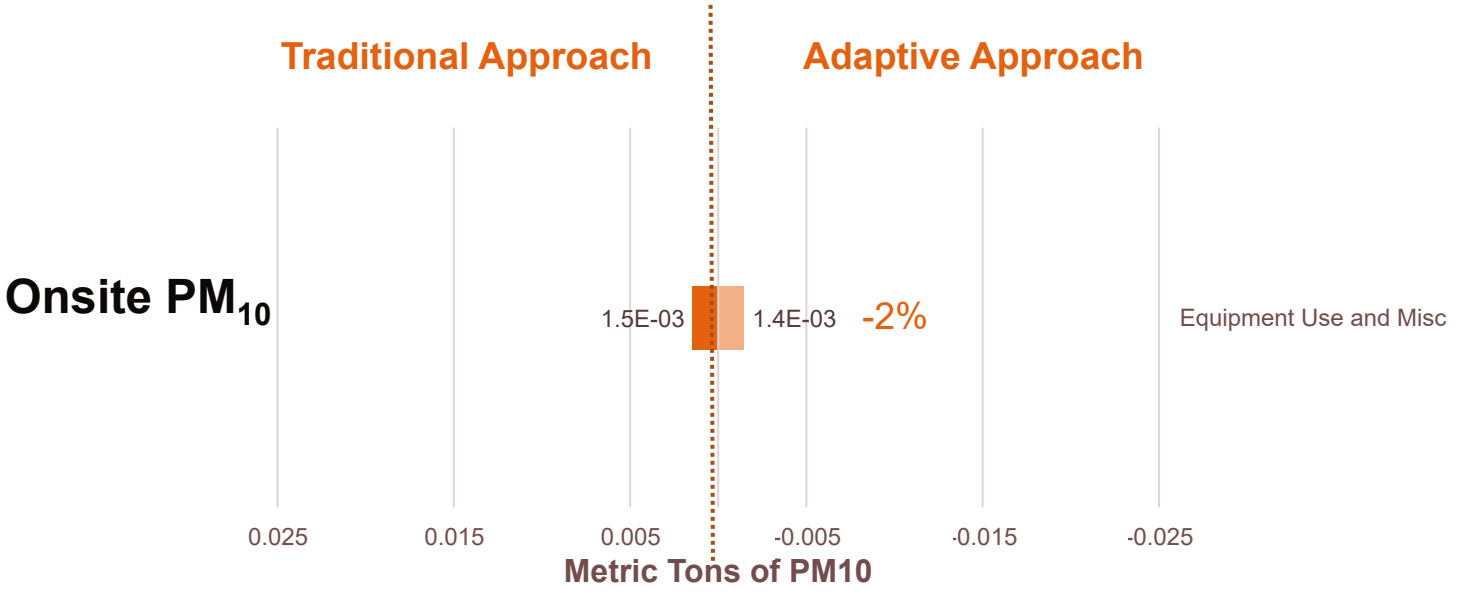
Air Pollution Results: SO_x

- Onsite SO_x emissions are nearly identical due to similar drilling time. Proportional to onsite NO_x.



Air Pollution Results: PM_{10}

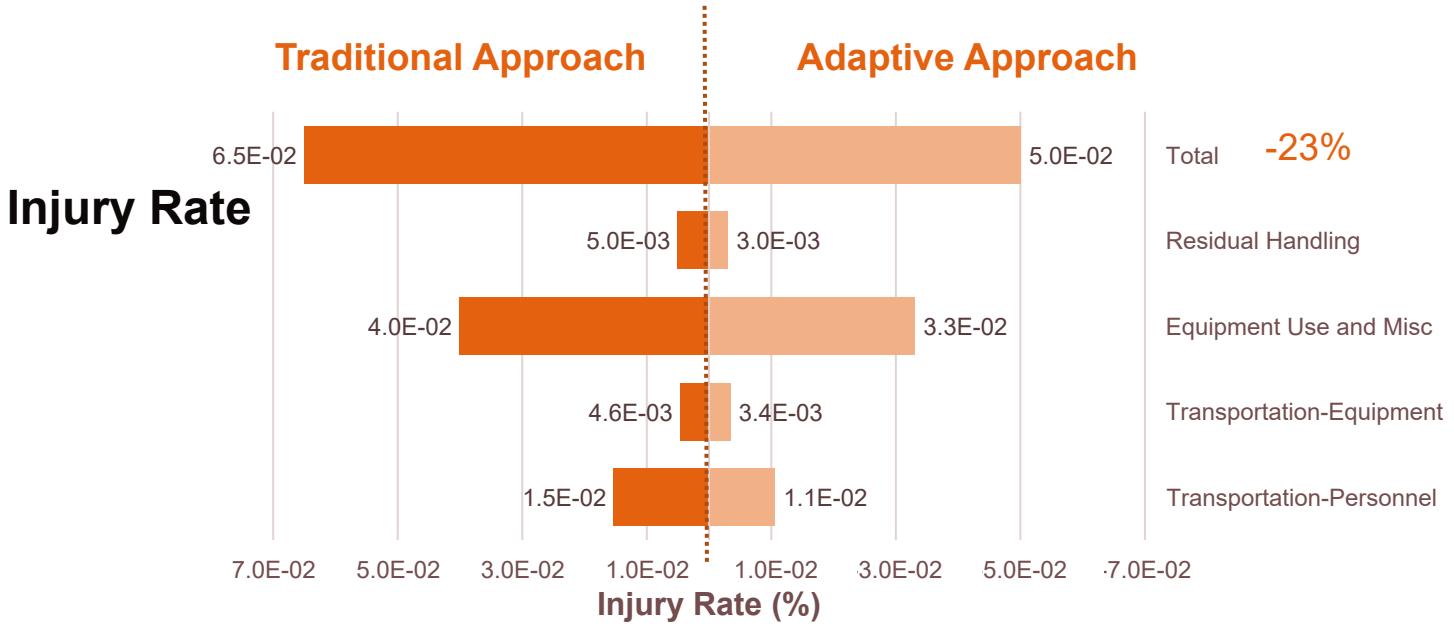
- Onsite PM_{10} emissions are nearly identical due to similar drilling time. Proportional to onsite No_x and SO_x.



What are the Social and Ecosystem Benefits of an Adaptive RI?

Injury and Fatality Rates

- Injury and fatality rates both decreased significantly with the adaptive approach.
- The adaptive approach reduced the time spent conducting the most dangerous tasks: driving and heavy equipment operation.



Social and Ecosystem Benefits of an Adaptive Approach

Biodiversity:

Less disturbance (vegetation clearance, foot and equipment traffic)

Stakeholder Communication:

Discussion with key stakeholders is built into the adaptive timeline.

Community Disturbance:

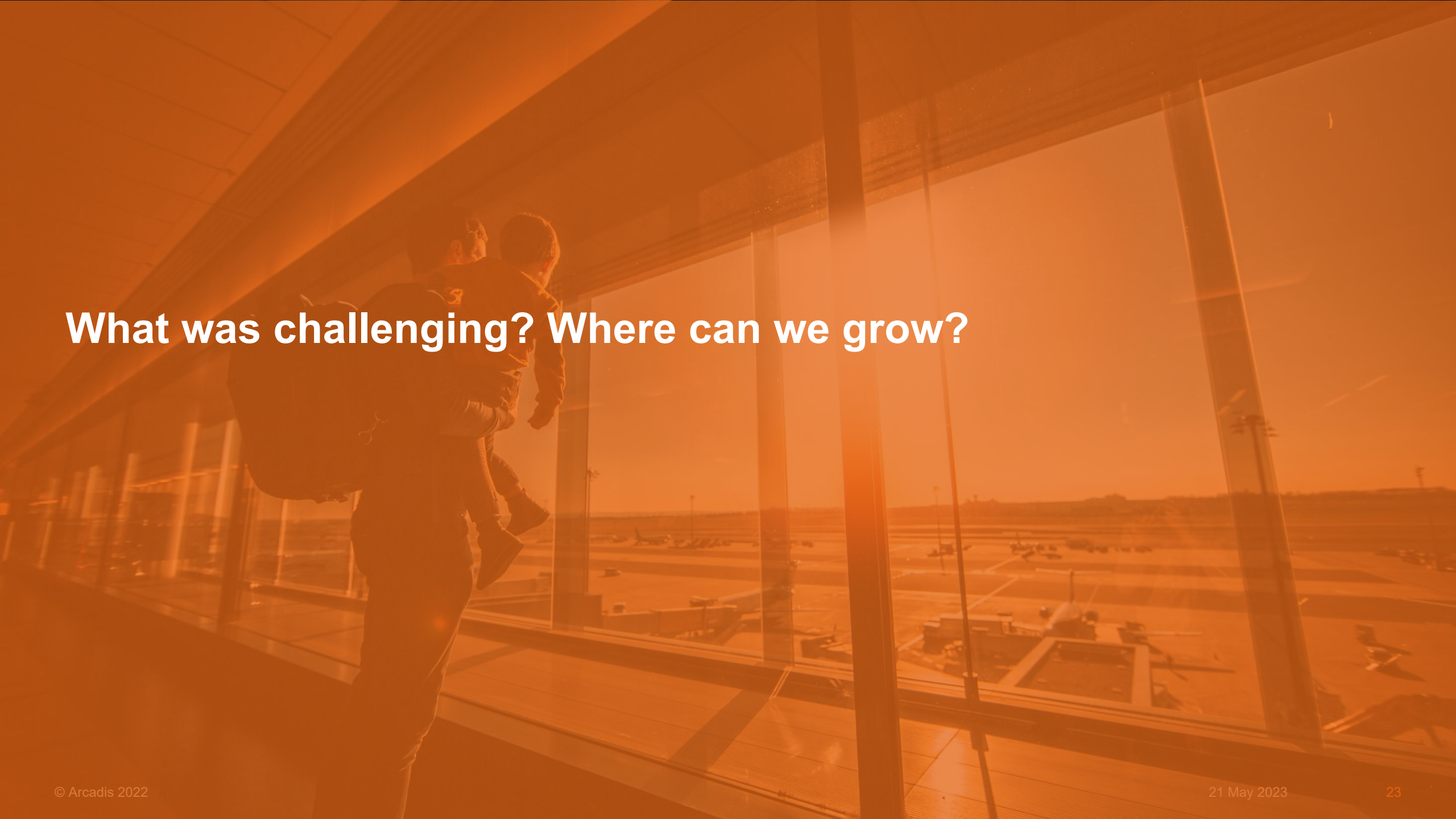
Shorter duration of noise and traffic

Site Restoration:

Remediate and restore to the community sooner.

Resilience:

Shorter duration and less permanent infrastructure



What was challenging? Where can we grow?

Overview of Findings

- The adaptive RI approach had significantly lower GHG emissions, resource use, air pollution, and injury risk.
- Reduced duration of field time and a smaller monitoring well network were the main drivers of footprint reduction.
- Shorter POP was main driver of social and ecosystem benefits.

Room for Growth and Opportunities:

Link increased understanding of CSM to more sustainable and resilient approach in remedy selection

Link increased understanding of receptors and communication across media to a more holistic approach in addressing PFAS

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