Integration of Resiliency and Sustainability into Remedy Evaluation, Design, and O&M

A Compilation of Case Study Findings

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Acknowledgements
Santa Susana Field Laboratory – Area IV:
BoRit Asbestos Superfund Site: Timothy Gallagher, PE, EPA
Portland Harbor Superfund Site: Josie Clark, Hunter Young and Sean Sheldrake, EPA
Formosa Mine Superfund Site: Chris Cora, EPA and Amy Baker, USACE

Meet the Presenters

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Outline

- Sustainable resilient remediation framework overview
- Recent guidance updates and initiatives
- Case-study compilation findings

Case Study 1 Combining GSR evaluations with cost/ risk analysis as effective communication tools to drive cleanup decisions

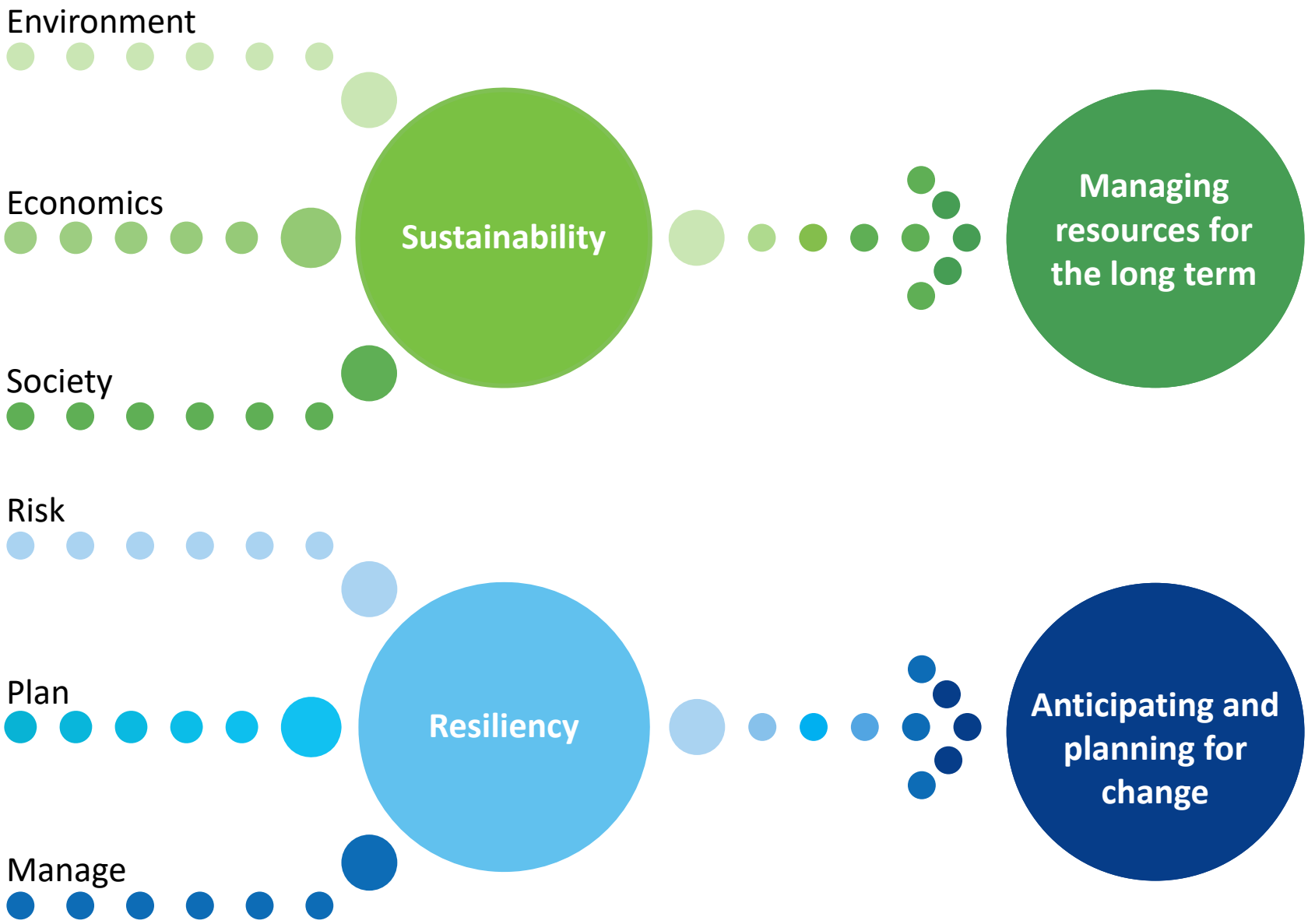
Case Study 2 Using GSR to inform technology feasibility assessment and incorporating climate change into remedial design and performance monitoring

Case Study 3 Developing resiliency remedial design guides for a sediment site informed by stakeholder engagement at remedial action workshops

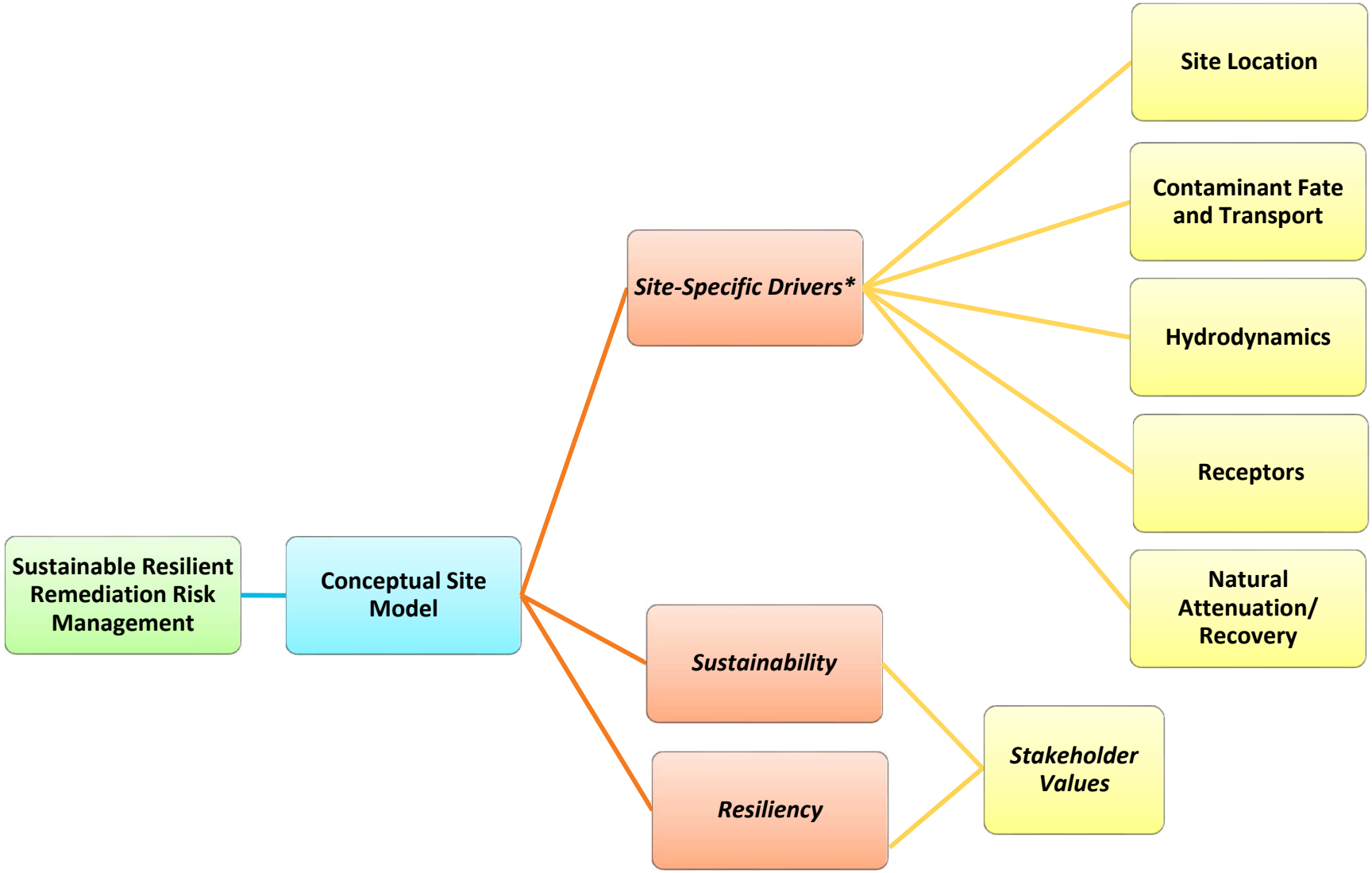
Case Study 4 Conducting Hydrodynamic modeling to support remedial design using EPA's SWMM Climate Adjustment tool

Sustainable Resilient Remediation Overview and Updates

Sustainability vs. Resiliency

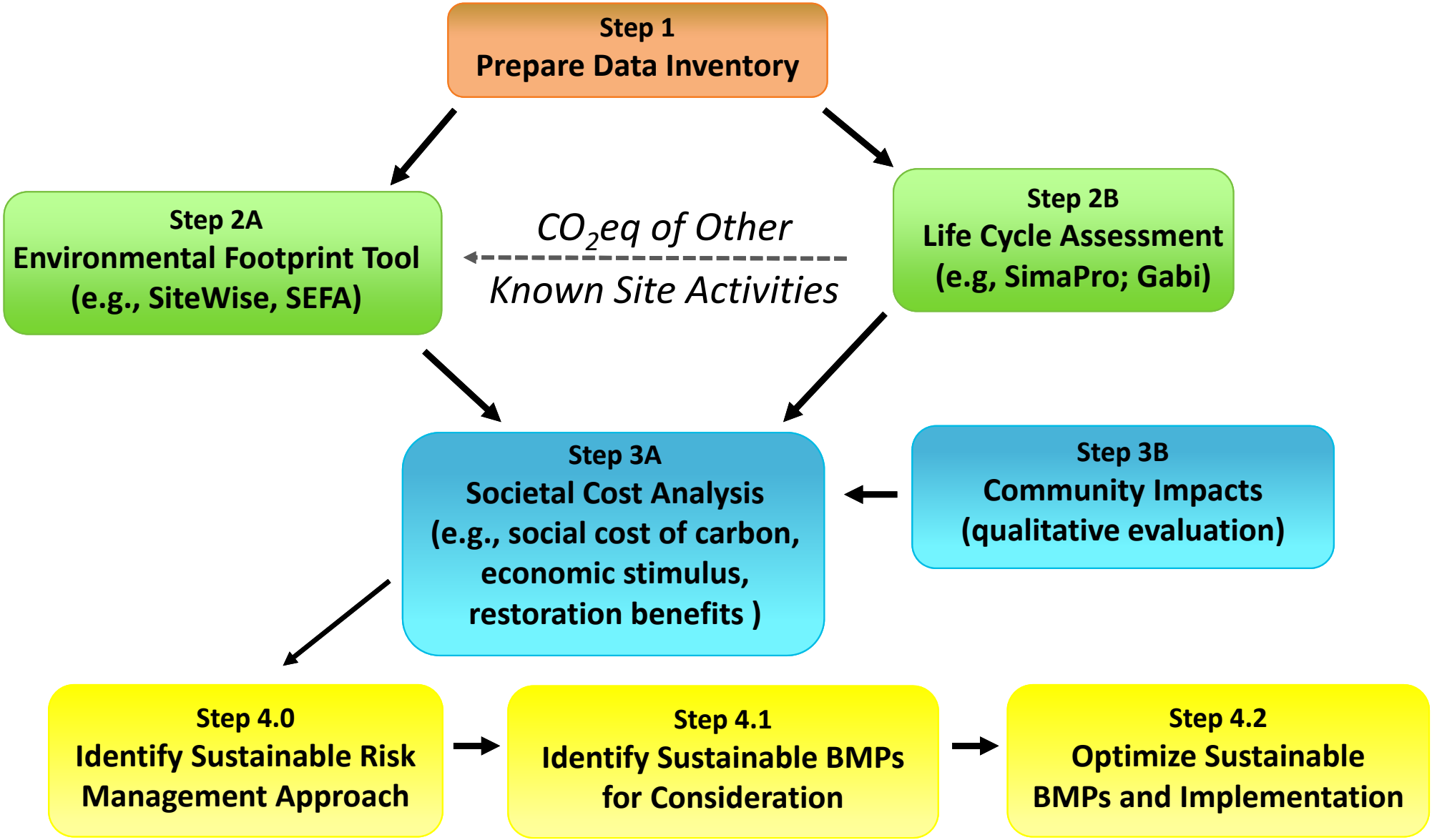


Sustainable Resilient Remediation Framework



**Not a complete list of applicable site-specific drivers*

Sustainability Assessment Process



EPA Superfund Climate Resilience: Vulnerability Assessment

- Evaluates the remedy's exposure to climate or weather hazards of concern
  - High floodwater
  - Soil subsidence
- Evaluates the remedy's sensitivity to the hazards of concern
  - The likelihood for the hazards to reduce remedy effectiveness
- https://www.epa.gov/superfund/superfund-climate-resilience-vulnerability-assessment
  - Includes information resources and what type of information is available for applicable climate change effects

Potential Hazards

A climate change-related hazard potentially affecting a remediation system may involve:

- An event, such as a hurricane
- A sustained change, such as drought
- An unanticipated project parameter, such as increased stormwater
- A technological problem arising in the system or site infrastructure, such as a power loss.

EPA Superfund Resiliency Evaluation Process

Figure 1. Climate Change Adaptation Management

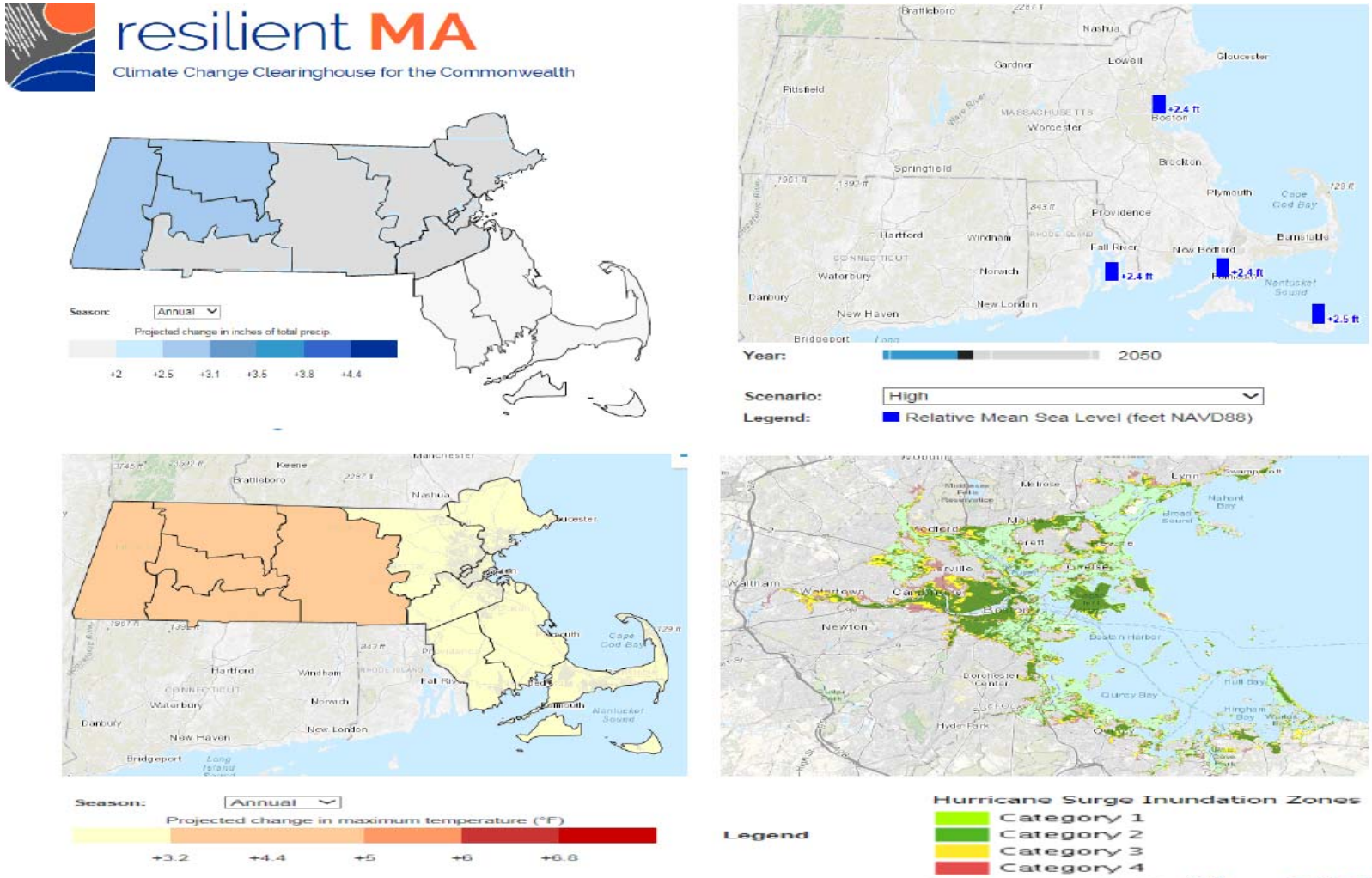
USEPA 2019 Climate Resilience Technical Fact Sheet:
https://www.epa.gov/sites/production/files/2019-12/documents/cr_containment_fact_sheet_2019_update.pdf

Available Resources: Vulnerability Assessment and Adaptation Measure Identification

- State and federal technical guidance and fact sheets
  - Example: *USEPA Climate Resilience Technical Fact Sheets*, recently updated in Fall/Winter 2019
    - *Contaminated Waste Containment Systems*
    - *Contaminated Sediment Sites*
    - *Groundwater Remediation Systems*
  - *Superfund Climate Resilience Website*
    https://www.epa.gov/superfund/superfund-climate-resilience
  - Municipal, county, and state-wide master plans

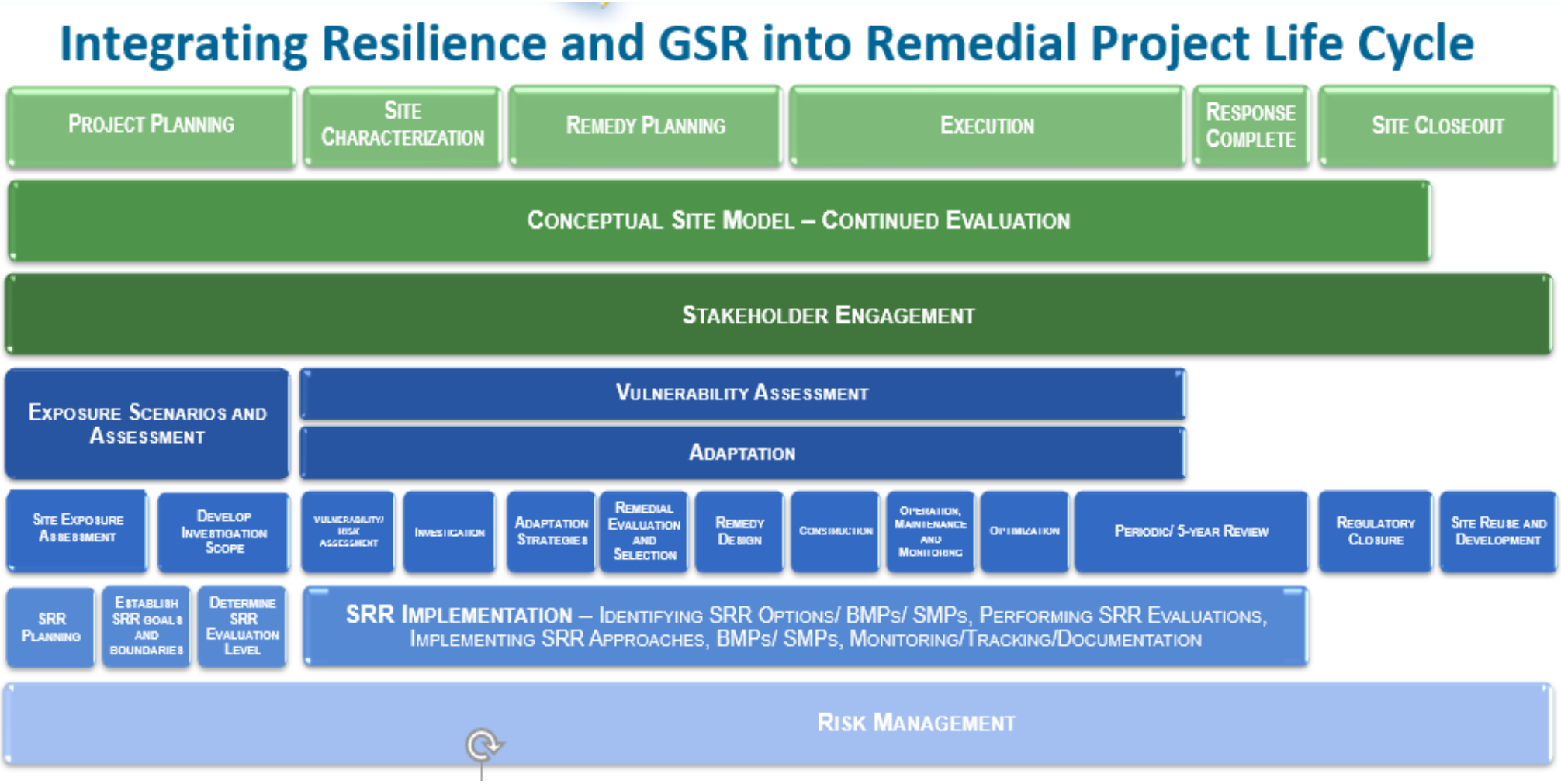
Available Resources: Exposure Assessment

- State and federal centralized repositories and GIS analysis tools
  - Massachusetts example: http://resilientma.org/map/



Mass DEP AEHS 2019 Platform Presentation Source:
https://www.mass.gov/files/documents/2018/10/04/2018-09-27%20BWSCAC%2002%20-%20Climate.pdf

ITRC Sustainable Resilient Remediation Team



Draft "working" graphic currently in team development
Additional information can be found at: https://itrcweb.org/Team/Public?teamID=84

Case Studies 1 and 2

Case Study 1

Combining GSR evaluations with cost/ risk analysis as effective communication tools to drive cleanup decisions

DOE Santa Susana Field Laboratory – Area IV

Case Study 2

Using GSR to inform technology feasibility assessment and incorporating climate change into remedial design and performance monitoring

EPA Region 3 BoRit Asbestos Superfund Site

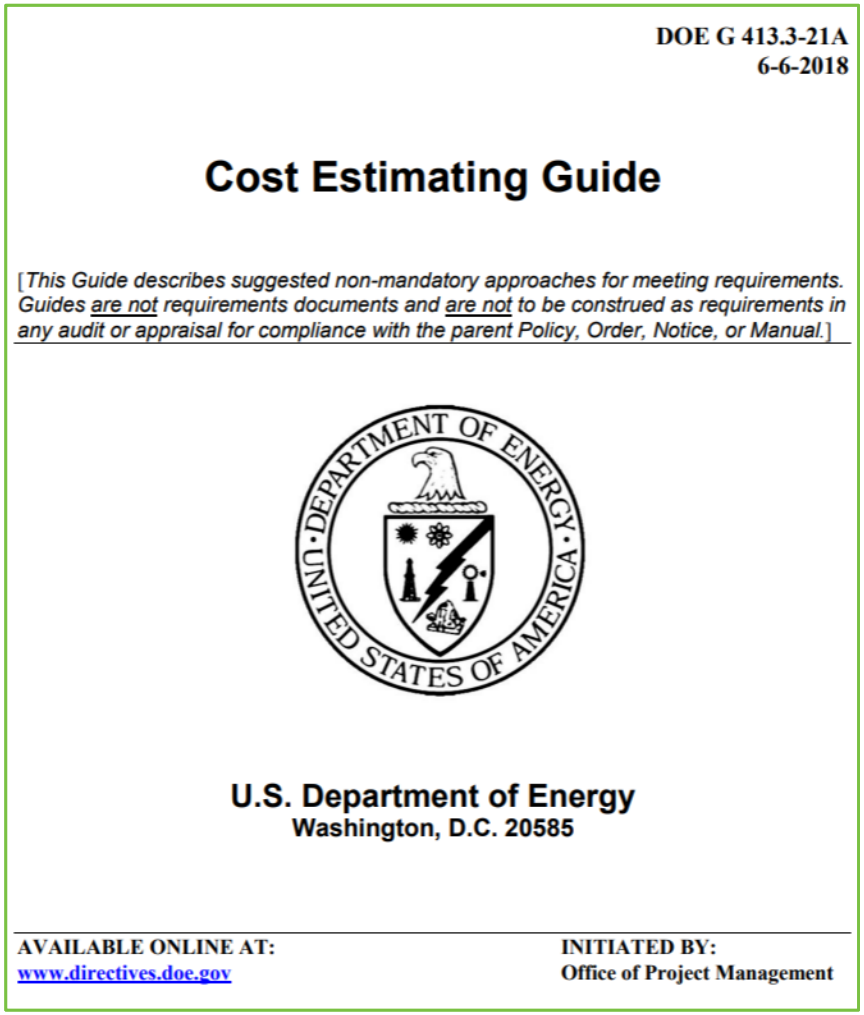
Case Study 1: Santa Susana Field Laboratory – Area IV

- Environmental Impact Statement (EIS) issued in January 2017 for public comments
- Three cleanup alternatives identified for soil (all involve excavation):
  - Alternative A - Conservation of Natural Resources (148,000 CY)
  - Alternative B - Cleanup to Revised LUT Values (192,000 CY)
  - Alternative C - Cleanup to AOC Look-Up Table Values (933,000 CY)

Photo taken from cover of EIS (DOE 2017)

Cost Risk Analysis

- Selected four historical operation areas to represent the site
- Determined cancer and non-cancer risks under the four cleanup scenarios (three alternatives plus no action)
- Performed cost estimates per DOE cost-estimating guidance



DOE G 413.3-21A
6-6-2018

Cost Estimating Guide

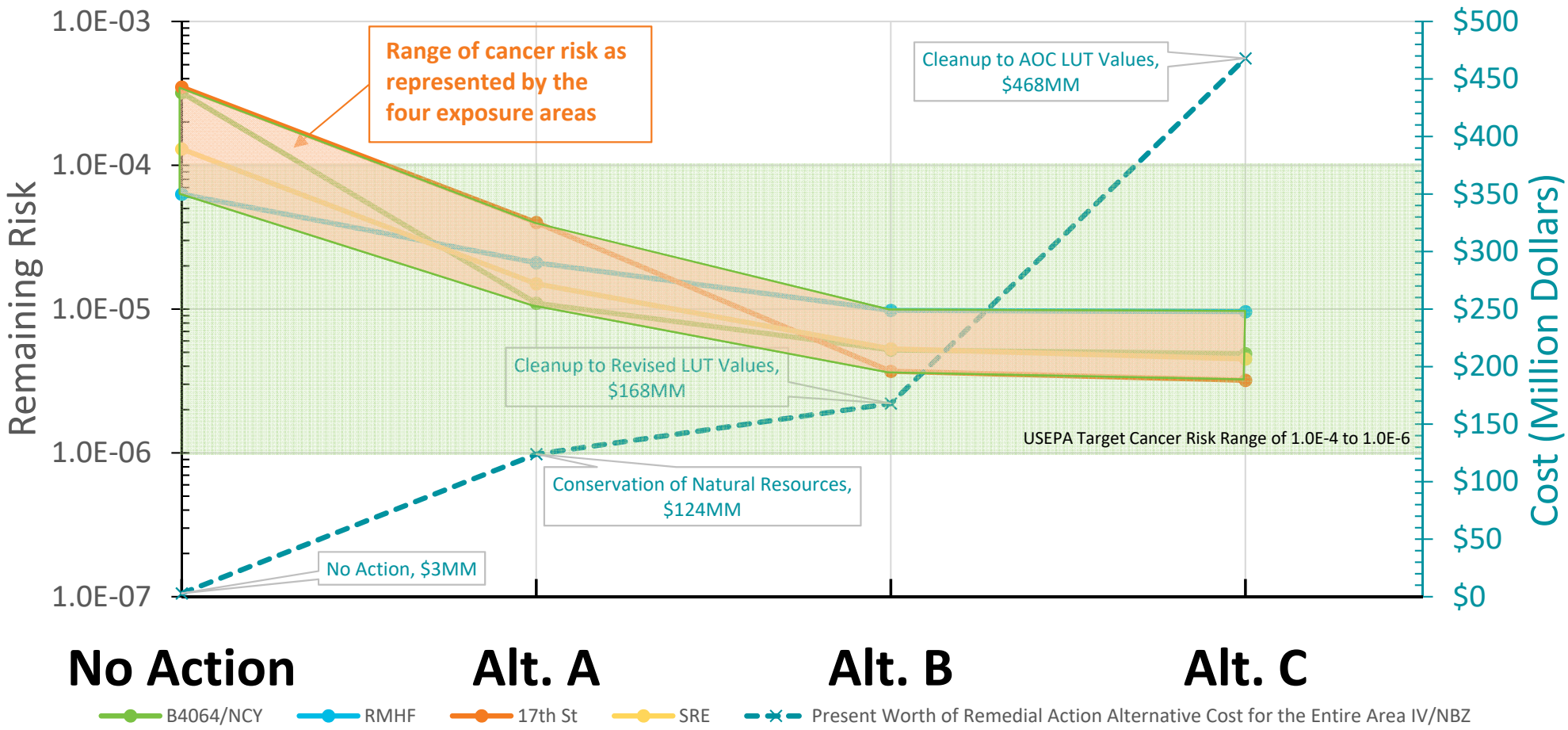
[*This Guide describes suggested non-mandatory approaches for meeting requirements. Guides are not requirements documents and are not to be construed as requirements in any audit or appraisal for compliance with the parent Policy, Order, Notice, or Manual.*]

U.S. Department of Energy
Washington, D.C. 20585

AVAILABLE ONLINE AT:
www.directives.doe.gov

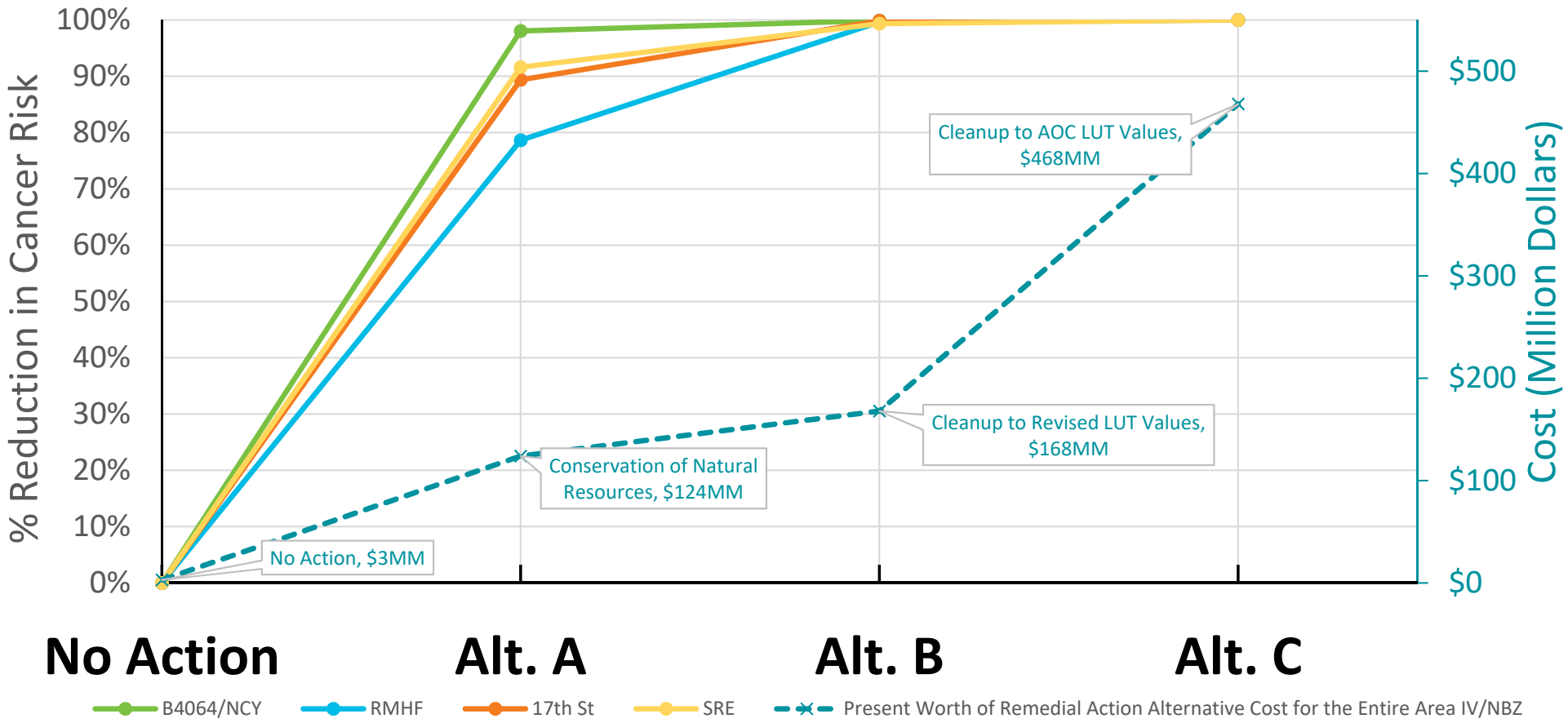
INITIATED BY:
Office of Project Management

Cost Risk Analysis – Cancer Risk



**Similar findings in cost risk analysis – non-cancer risk*

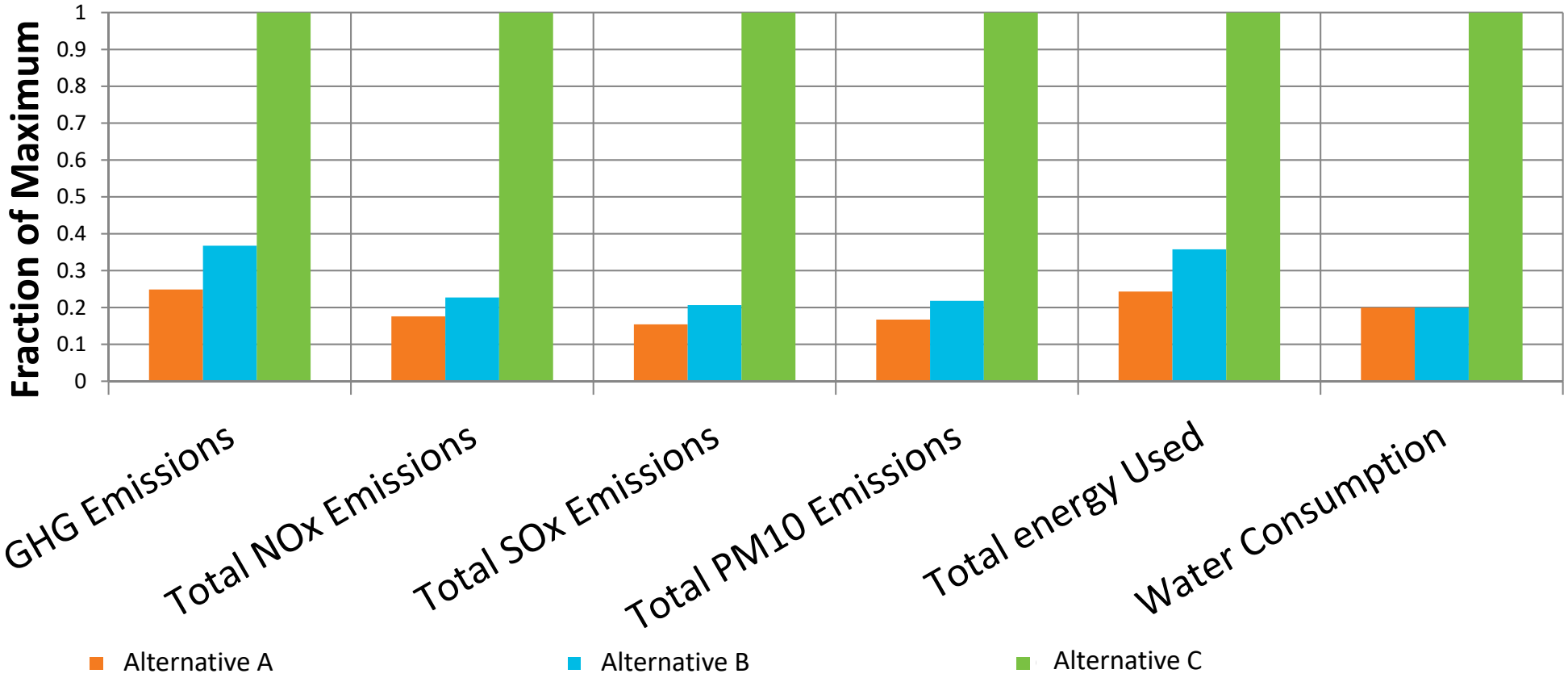
Cost Risk Analysis – Cancer Risk Reduction



**Similar findings in cost risk analysis – non-cancer risk, reduction of hazard index*

Environmental Footprint Analysis

Results from NAVFAC SiteWise™ footprint evaluation tool:



Monetization of Environmental Metrics

Remedial Alternatives	GHG Emissions	Total NO_x Emissions	Total SO_x Emissions	Total PM_{10} Emissions	Total Energy Used
	metric ton	metric ton	metric ton	metric ton	MMBTU
Environmental Impact Metrics under Each Alternative					
ALTERNATIVE A	24,000	38	10	45	320,000
ALTERNATIVE B	35,000	50	14	60	480,000
ALTERNATIVE C	96,000	220	66	270	1,300,000
Unit Social Cost for Environmental Impact Metrics					
Social Cost in 2016 US$	$ 183	$ 329	$ 1,278	$ 224	$ 14

Social Cost of Environmental Impact Metrics for Each Alternative 2016 US$						Total Social Cost
ALTERNATIVE A	$ 4,392,000	$ 12,502	$ 12,780	$ 10,080	$ 4,480,000	**$8,907,000**
ALTERNATIVE B	$ 6,405,000	$ 16,450	$ 17,892	$ 13,440	$ 6,720,000	**$13,173,000**
ALTERNATIVE C	$ 17,568,000	$ 72,380	$ 84,348	$ 60,480	$ 18,200,000	**$35,985,000**

Community Impact Analysis

		Alternative A	Alternative B	Alternative C
Short Term Impact	Traffic Congestion	Lowest	Intermediate	Highest
	Noise and Dust Generation	Lowest	Intermediate	Highest
Resources Lost	Water	Least	Intermediate	Most
	Clean Soil	Least	Intermediate	Most
	Landfill Space	Least	Intermediate	Most
Timeframe for Benefits from Remedial Activities		2-3 Years	2-3 Year	10 Years

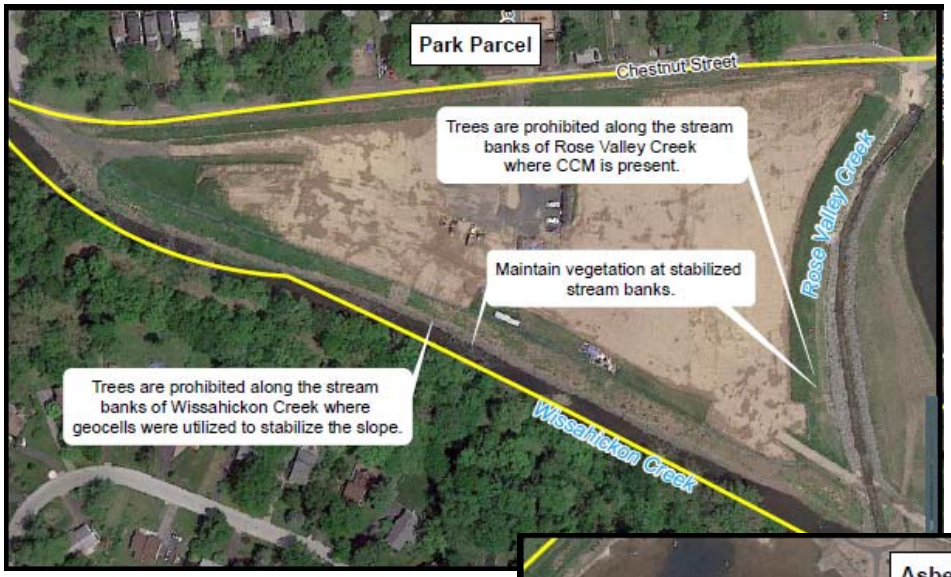
Overall Results

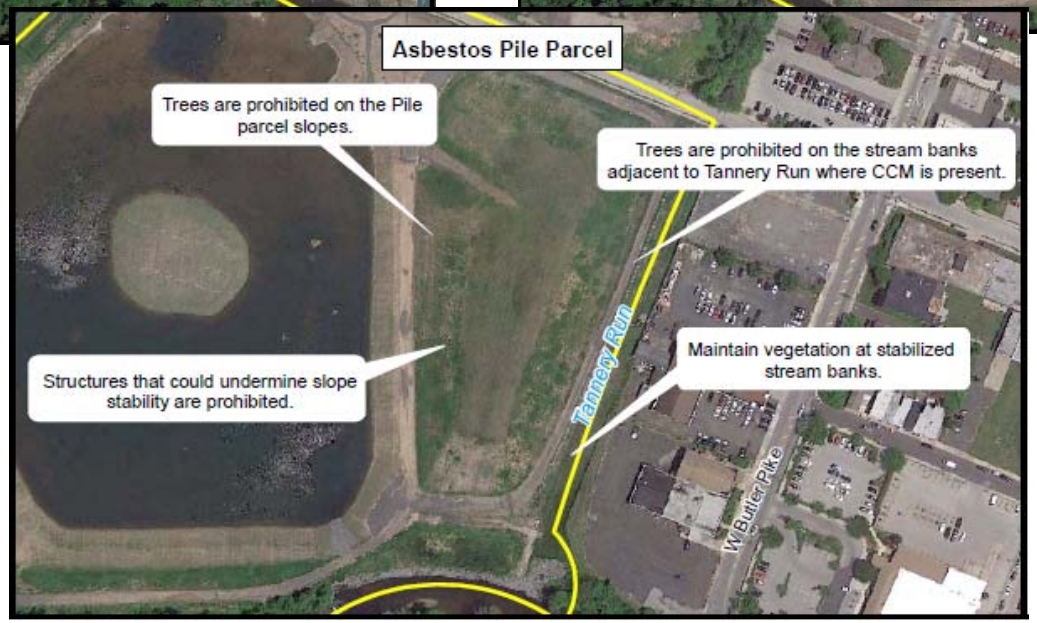
	Alternative A	Alternative B	Alternative C
Cancer Risk Reduction (all within EPA target risk range 10^{-4} to 10^{-6})	79% to 98%	>99%	100%
Hazard Index Reduction (all below HI of 1)	0% to 98%	93% to >99%	100%
Cost	$124MM	$168MM	$468MM
Environmental Footprint	Smallest	Intermediate	Highest
Social Cost	$9MM	$13MM	$36MM
Short-Term Impact	Lowest	Intermediate	Highest
Resources Lost	Least	Intermediate	Most
Timeframe for Benefits from Remedial Activities	2-3 Years	2-3 Years	10 Years

Conclusions

- Cleanup to more stringent cleanup levels ≠ better solution for human health or for the environment
- By combining risk/cost analysis and GSR assessment, decision makers see a more complete picture and can make an informed remedial alternative selection
- These tools can be effective communication tools for the public and other interested parties

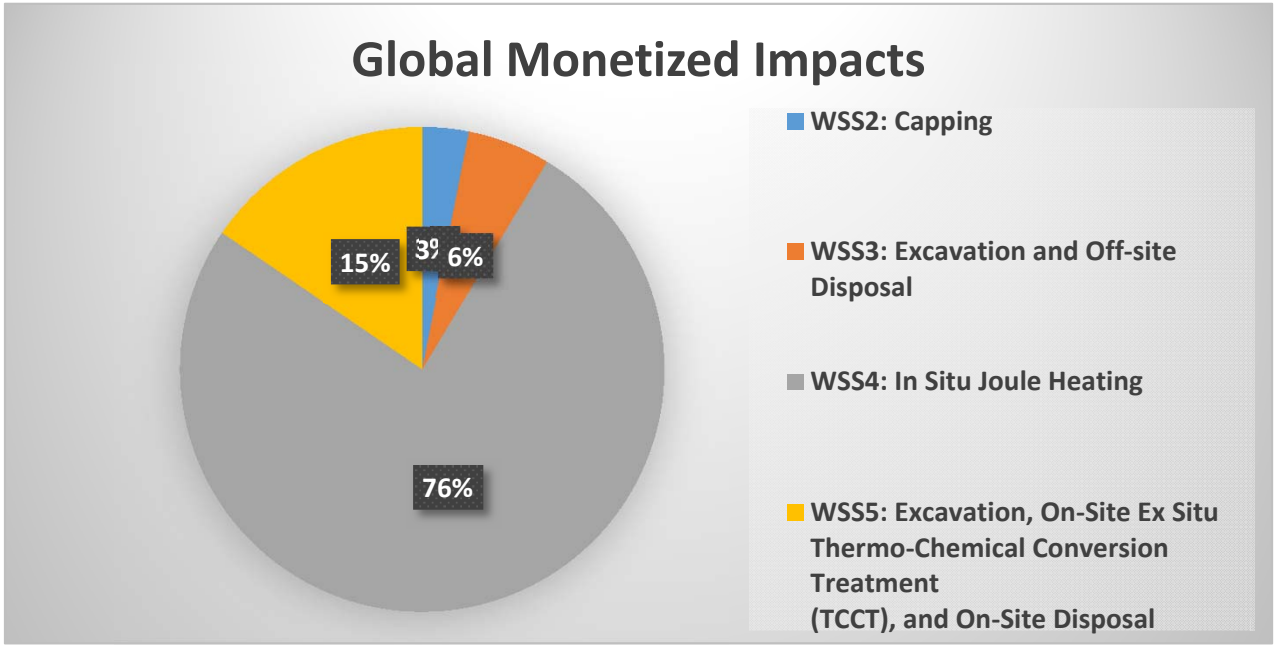
Case Study 2: EPA Region 3 BoRit Asbestos Superfund Site





Feasibility Study GSR Assessment

- Based on environmental footprints metrics, using:
  - EPA's Spreadsheets for Environmental Footprint Analysis (SEFA) tool
  - Social cost of emissions and energy metrics



- A qualitative evaluation of potential detrimental and beneficial impacts to the surrounding community, such as:
  - Increased truck traffic
  - Short-term risks to workers and the community

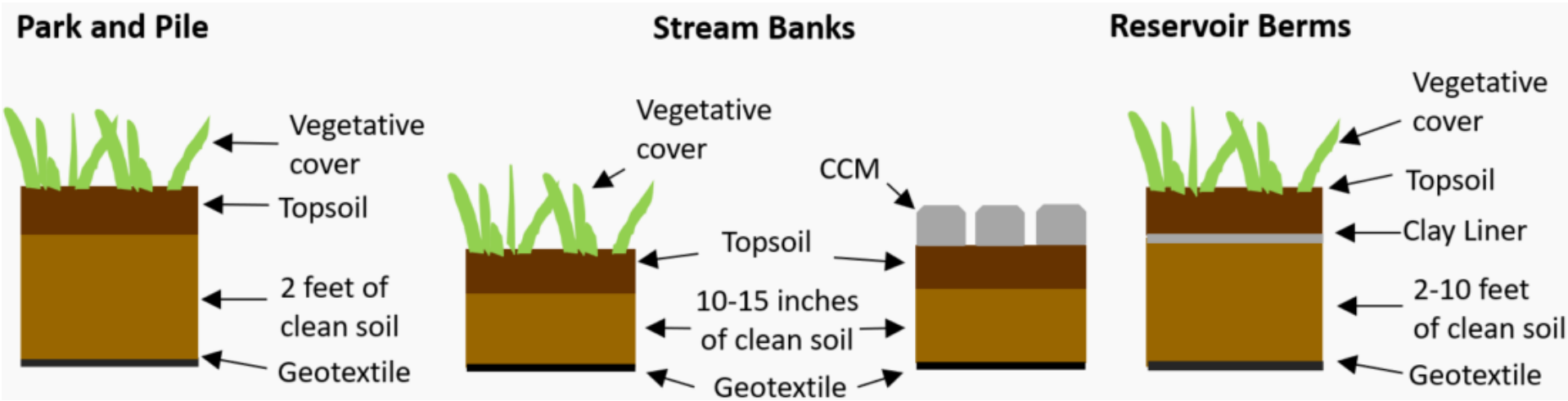
Secondary Assumptions Affecting Remedial Alternatives Refinement and Detailed Analysis

Secondary Assumption Category	Secondary Assumption Description	Rationale	Impact if Assumption Not Met
Site Setting	Impact on remedy implementation	• Proximity of Site to surface water bodies and located within 100-year flood zone. • Alternatives WSS4 and WSS5 convert Site waste into an inert material which could impact floodplain hydraulics and storage capacity. • Alternatives WSS3, WSS4, or WSS5 require the Reservoir to be drained.	• Limit types of treatment for consideration, the design of *in situ* treatment, and monitoring components of a remedial action. • The potential or increased possibility of flooding due to climate change and urbanization may impact long-term effectiveness of the remedy and increase remedy costs.
Climate Change	Climate Change Alternatives would incorporate relevant elements of EPA's Climate Change Adaption Plan where protectiveness is vulnerable to a changing climate	• Climate change impacts include increased occurrence of extreme temperatures, sustained changes in average temperatures, increased heavy precipitation events, increased flood risk, and increased intensity of hurricanes and tornados. • When warranted, climate change adaptation measures serve to eliminate or minimize the impact of climate change-related hazards potentially affecting a remediation system.	• Neglecting to consider climate change adaptation measures when warranted could result in adverse impacts to the remedy. • Flooding and hurricanes could cause cover material erosion, side slope failure, or contaminated material washout for WSS2 and WSS3 remedies. • Above ground treatment components could be vulnerable to extreme temperatures and increased wind intensity. • Electrical power needs are susceptible to delays if power supply is impacted and a backup power supply was not properly identified.

Case Study – EPA Region 3 BoRit

Selected Remedy WSS 2: Capping

- Stream banks and reservoir capping approach were different to account for erosion



CCM = concrete cable mats

Case Study – EPA Region 3 BoRit

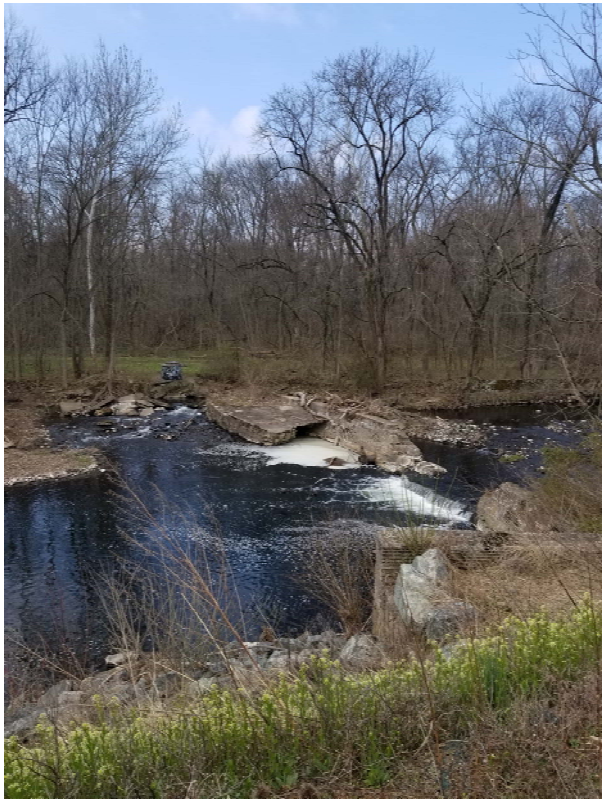
Before

After

- Photos of Wissahickon Creek slope stabilization

Case Study – EPA Region 3 BoRit

- Severe weather events undermined the remedy during the removal action

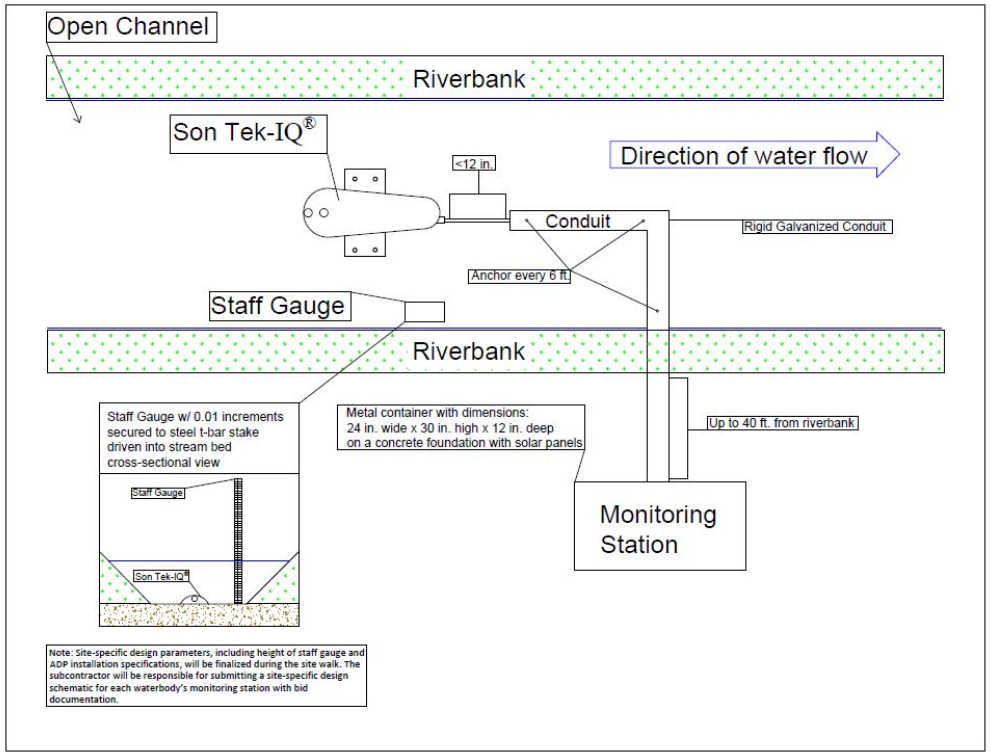


Case Study – EPA Region 3 BoRit

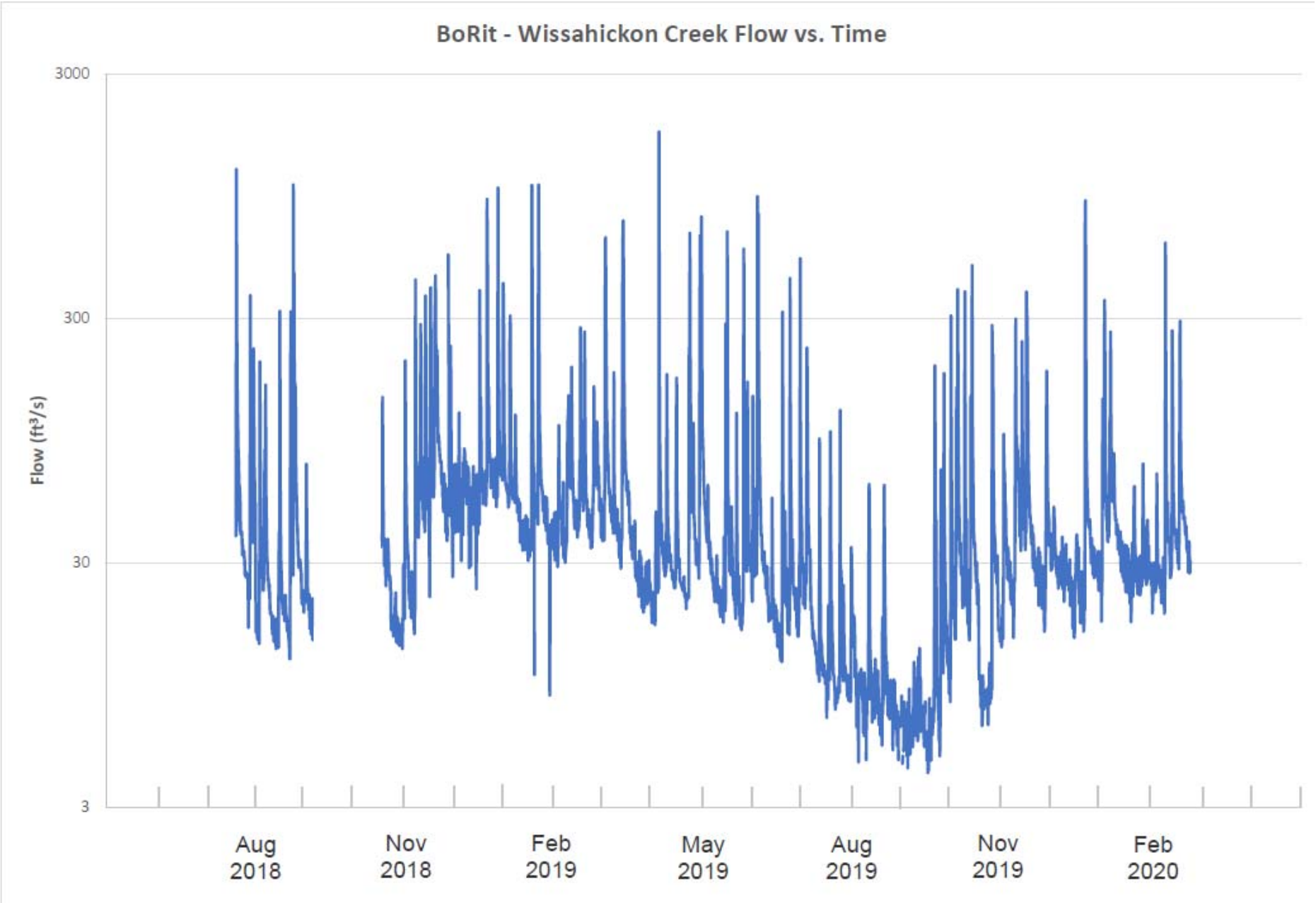
- O&M climate change vulnerability monitoring objectives
  - Determine onsite flooding events frequency and location
  - Evaluate trends in surface water flow velocity and water levels over time
  - Define storm conditions that may impact cap integrity and shoreline stabilization
  - Use vulnerability data during the Five-Year Review to determine if adaptation measures need to be reconsidered

Case Study – EPA Region 3 BoRit

- Developed Technical Standard Operating Procedure (TSOP)
- Installed acoustic doppler profilers and staff gauges to monitor creek velocity and water levels over time
- Used telemetry to evaluate the data in real time

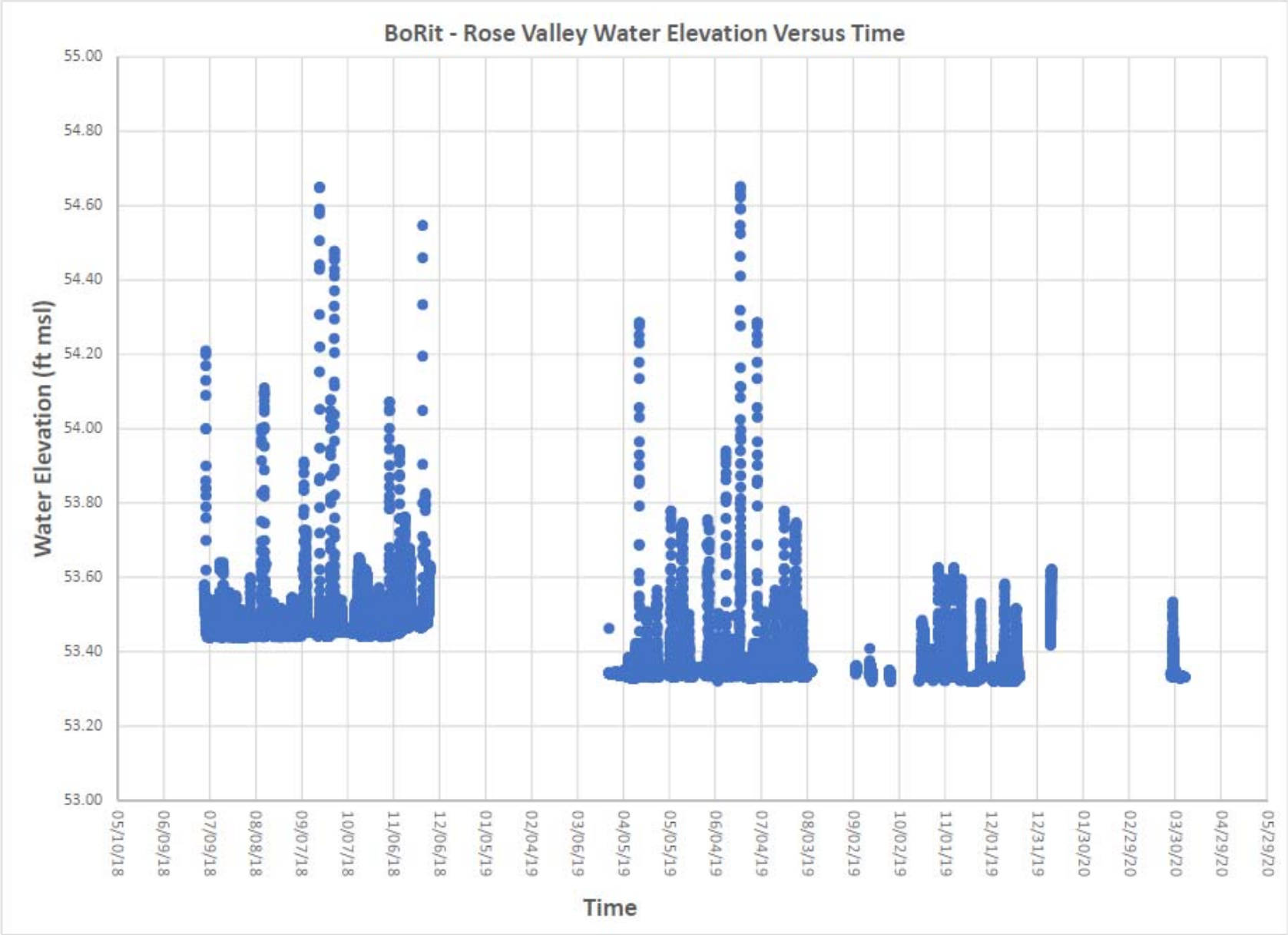


2018 to 2020 Wissahickon Creek Flow Data



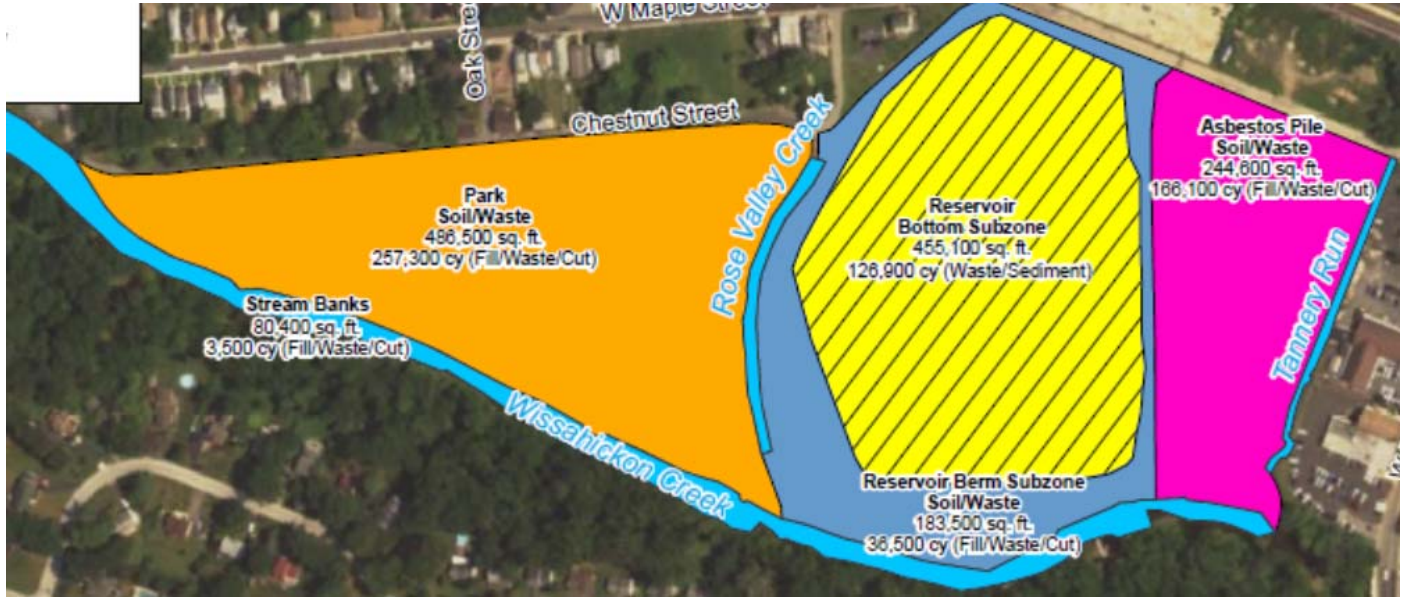
Average Flow = 1.53 m^3/sec

2018 to 2020 Rose Valley Water Elevation Data



O&M Site Inspections

- When
  - Quarterly
  - After significant weather events
- O&M Documentation
  - Remedy integrity including cap, stabilized stream banks, vegetation, and institutional controls
  - Monitoring station maintenance and calibration



Case Studies 1 and 2 Question and Answers

Case Study 1

Combining GSR evaluations with cost/ risk analysis as effective communication tools to drive cleanup decisions

DOE Santa Susana Field Laboratory – Area IV

Case Study 2

Using GSR to inform technology feasibility assessment and incorporating climate change into remedial design and performance monitoring

EPA Region 3 BoRit Asbestos Superfund Site

Case Studies 3 and 4

Case Study 3

Developing resiliency remedial design guides for a sediment site informed by stakeholder engagement at remedial action workshops

EPA Region 10 Portland Harbor Remediation

Case Study 4

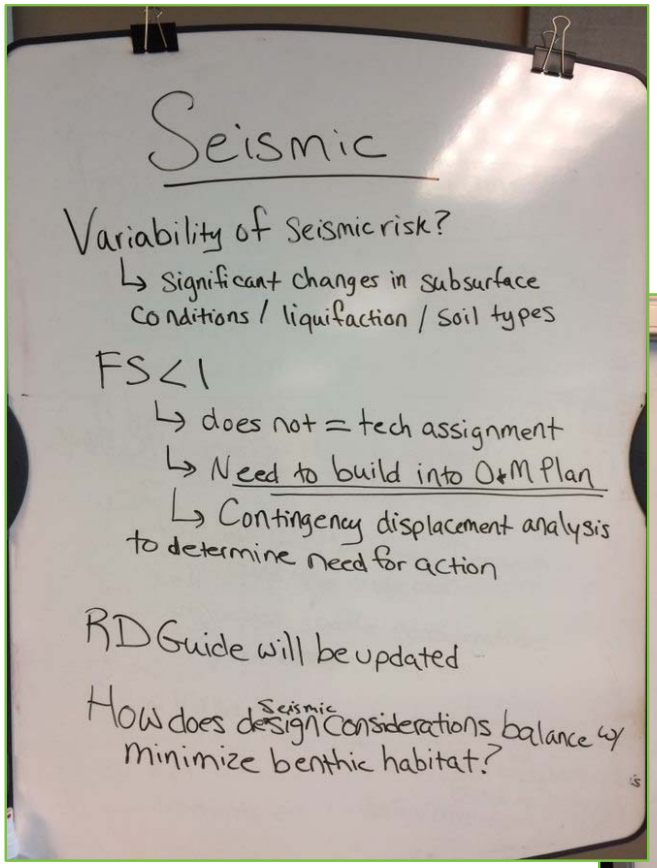
Conducting Hydrodynamic modeling to support remedial design using EPA's SWMM Climate Adjustment tool

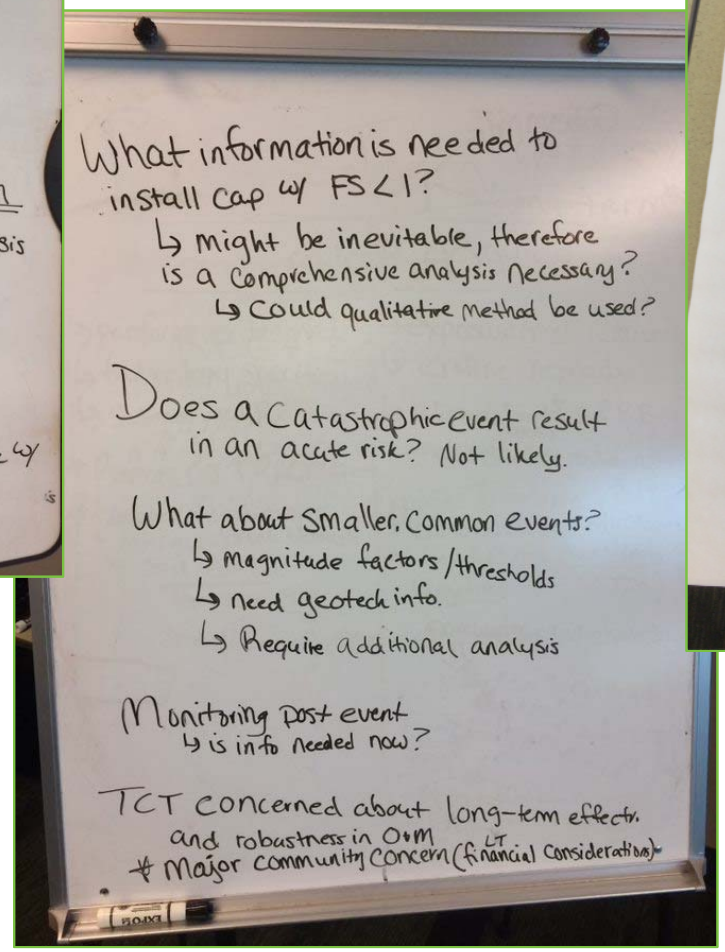
EPA Region 10 Formosa Mine Site

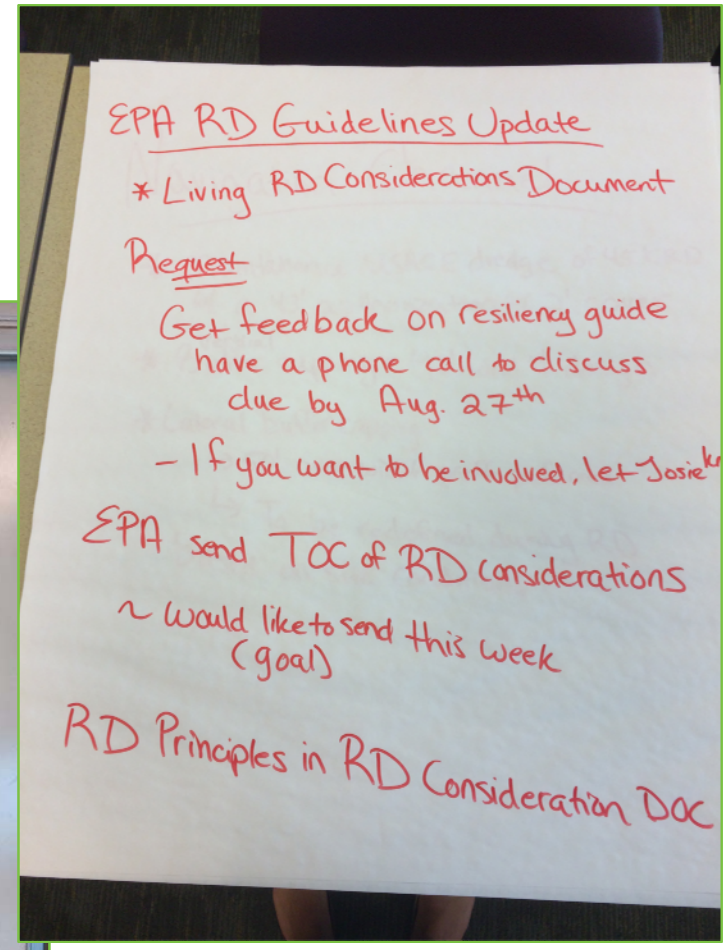
Case Study 3: EPA Region 10 Portland Harbor Superfund Site

- Developed design guidelines and considerations to support integrating resiliency best management practices into the sediment remedial design
  - Seismic design evaluation
  - Climate change resiliency evaluation
  - Community impacts
  - Used green remediation practices
- Two remedial design (RD) workshops to solicit stakeholder feedback
  - Stakeholders included: responsible parties, regulatory agencies, the City of Portland, and tribal communities
  - Format: technical presentation followed by open forum, and stakeholder breakout sessions with EPA

2020 RD Workshop White Boarding







Seismic Design Guidelines and Workshop Presentation Contents

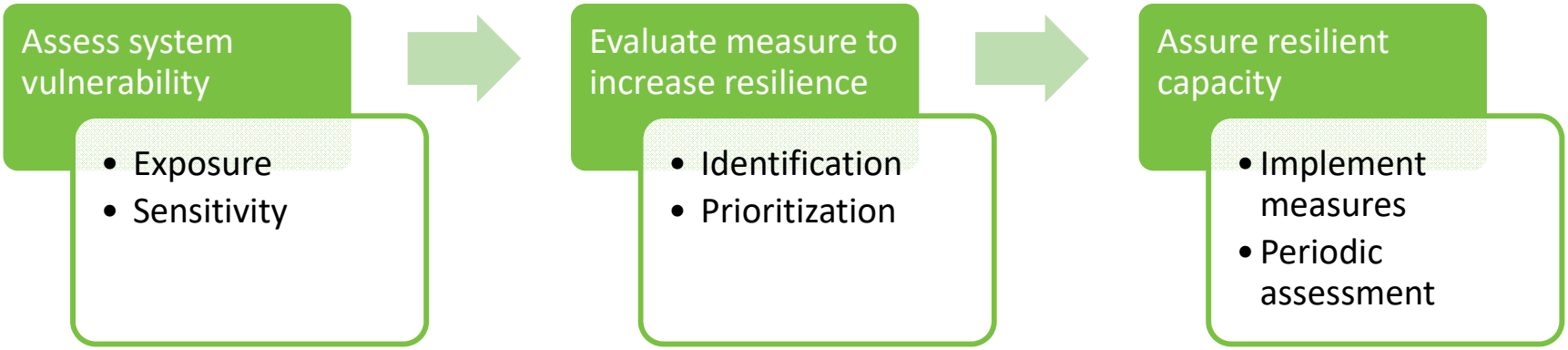
- History of seismic activity*
- Key findings of a literature review and experience at other sites*
- Design recommendations*^
  - ROD Section 14.2.9 – "Caps will also factor in appropriate earthquake design elements for contingency level events (CLE)."
  - Seismic cap design should include analysis of the likelihood that the cap will be damaged to the extent that underlying contaminated sediment is exposed during the CLE hazard level.
    - Conduct liquefaction evaluations under pre- and post-remedy conditions; and consideration of the CLE
    - Assess stability of capped sediment slopes for the CLE
- Resources^
  - Oregon Department of Transportation Geotechnical Design Manual
  - Washington State Department of Transportation Geotechnical Design Manual

** - workshop presentation contents*

^ - seismic design guideline considerations

Climate Change Resiliency Evaluation Design Guidelines

- Climate change drivers
  - Changes to hydrology (both in seasonal patterns of river flow and peak storm event flows) in the Willamette and Columbia Rivers
  - Sea level rise
- Vulnerable remedy components
  - Erosion protection measures used in caps
  - Various engineering measures used for shoreline stabilization

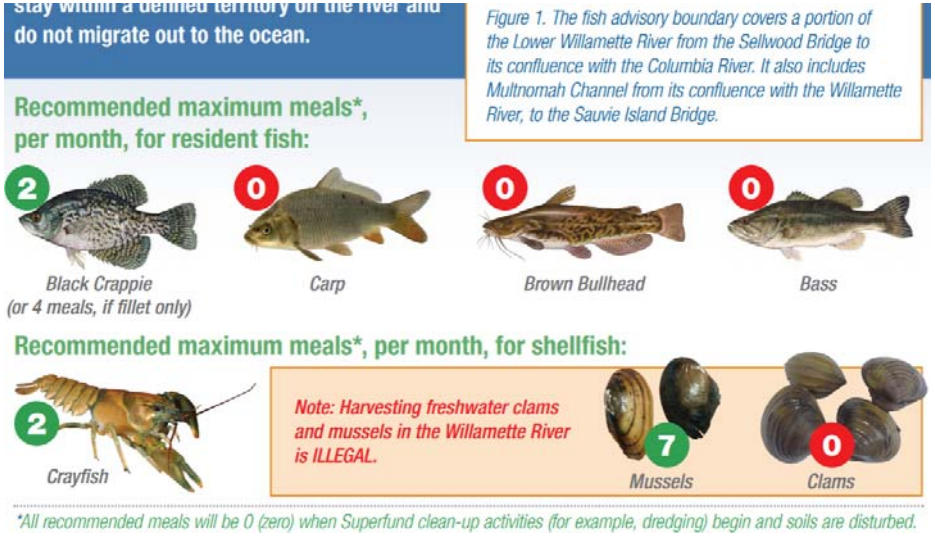


Resilient Remedy Design Recommendations

- Most-recent climate change projections and emission scenarios
  - Develop river flow rate corresponding to 100-year storm
  - Sea level rise projections using same emission scenario from USACE or NOAA
- 2100 planning horizon
  - Maximize design life given most current data available
  - Backwater effect from Columbia River, current and future
- Modeling framework
  - USGS regional scale hydrodynamic model considered climate change impacts for 2040 planning horizon
  - Model validation and grid resolution factors

Remedial Design Considerations
Community Impacts

- Mitigation measures and best management practices to protect the community, worker, and the environment during remedial action construction
  - Access, dust/emissions control
  - Mitigate increased river traffic via coordination with USACE, U.S. Coast Guard, and other stakeholders during design
  - Buffer zone between site work areas and pleasure craft and commercial shipping
- Fish consumption advisories
  - Continue until RAOs achieved

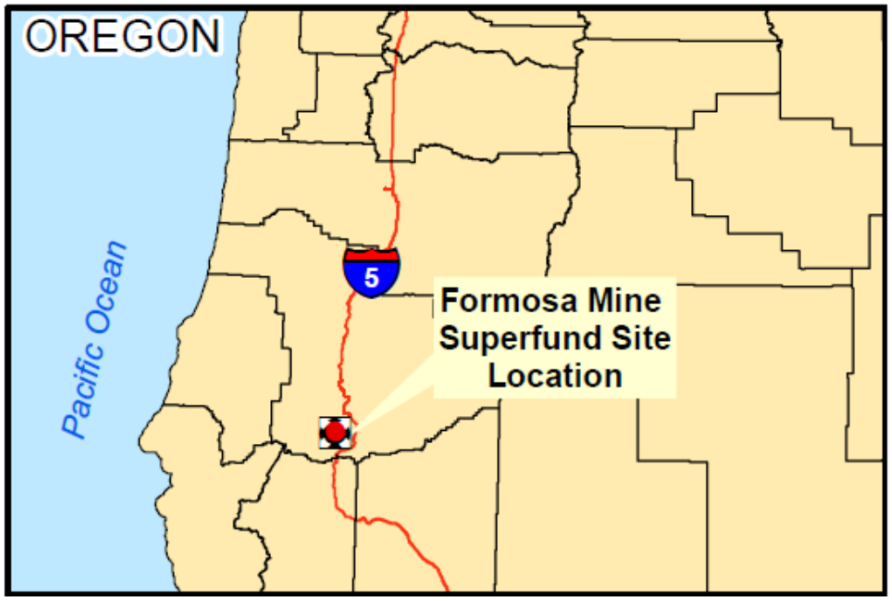


Remedial Design Considerations Using Green Remediation Practices

- Consistent with EPA Region 10 Clean and Green policy (2009) and Superfund Green Remediation Strategy (2010)
- Considers best management practices that limit overall environmental footprint
  - Local materials
  - Truck route
  - Clean fuel and emission control retrofit incentives
- Measures to reduce impacts of habitat
  - Compensatory mitigation loss
  - Increase opportunity for healthy recreation activities
- Green Remediation Plan requirement
  - Include discussions how resource impacts will be mitigated to the extent possible

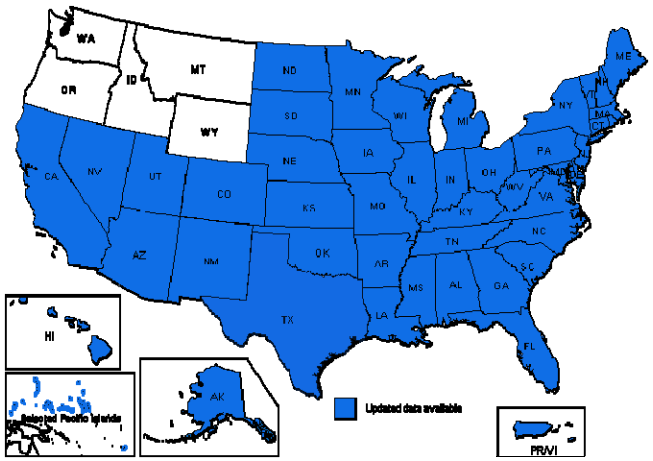
Case Study 4: EPA Region 10 Formosa Mine Superfund Site

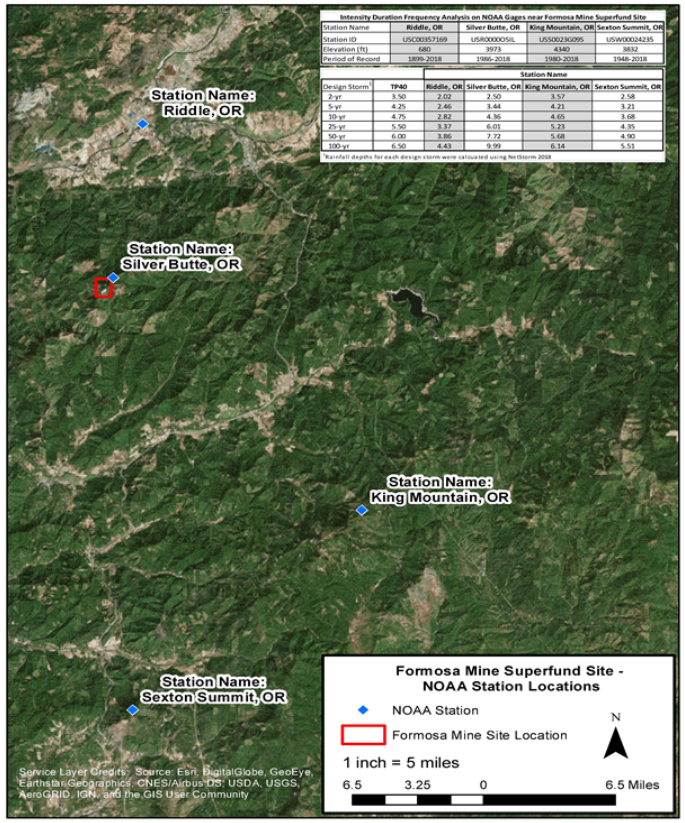
- Former copper mine in southwestern Oregon characterized by steep slopes with mine impacted materials
- Design considerations for viability of remedy and reduction in long-term O&M requirements
- Used combination of rainfall analysis and climate variability analysis to determine 100-year 24-hour design storm event



Rainfall Analysis

- Method 1: NOAA Atlas 2 Technical Paper
  - NOAA Atlas 14 not published for Oregon
  - Rainfall depths for different design storms calculated from NOAA Atlas 2 (1973)
- Method 2: Frequency Analysis of Rainfall Gages
  - Seven rain gages located near project site
  - Statistical analysis performed using methods comparable with NOAA Atlas 14





Intensity Duration Frequency Analysis on NOAA Gages near Formosa Mine Superfund Site

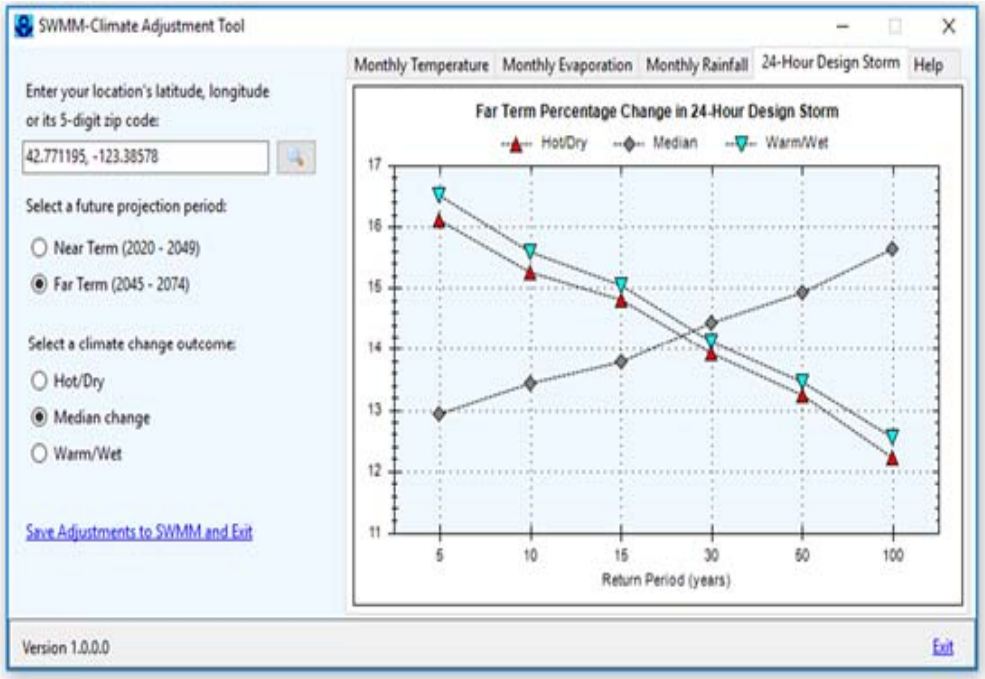
Station Name	Riddle, OR	Silver Butte, OR	King Mountain, OR	Sexton Summit, OR
Station ID	USC00357169	USR0000OSIL	USS0023G095	USW00024235
Elevation (ft)	680	3973	4340	9832
Period of Record	1899-2018	1986-2018	1980-2018	1948-2018

	Station Name				
Design Storm*	TP40	Riddle, OR	Silver Butte, OR	King Mountain, OR	Sexton Summit, OR
2-yr	3.50	2.02	2.50	3.57	2.58
5-yr	4.25	2.46	3.44	4.21	3.21
10-yr	4.75	2.82	4.36	4.65	3.68
25-yr	5.50	3.37	6.01	5.23	4.35
50-yr	6.00	3.86	7.72	5.68	4.90
100-yr	6.50	4.43	9.99	6.14	5.51

*Rainfall depths for each design storm were calculated using NetStorm 2018

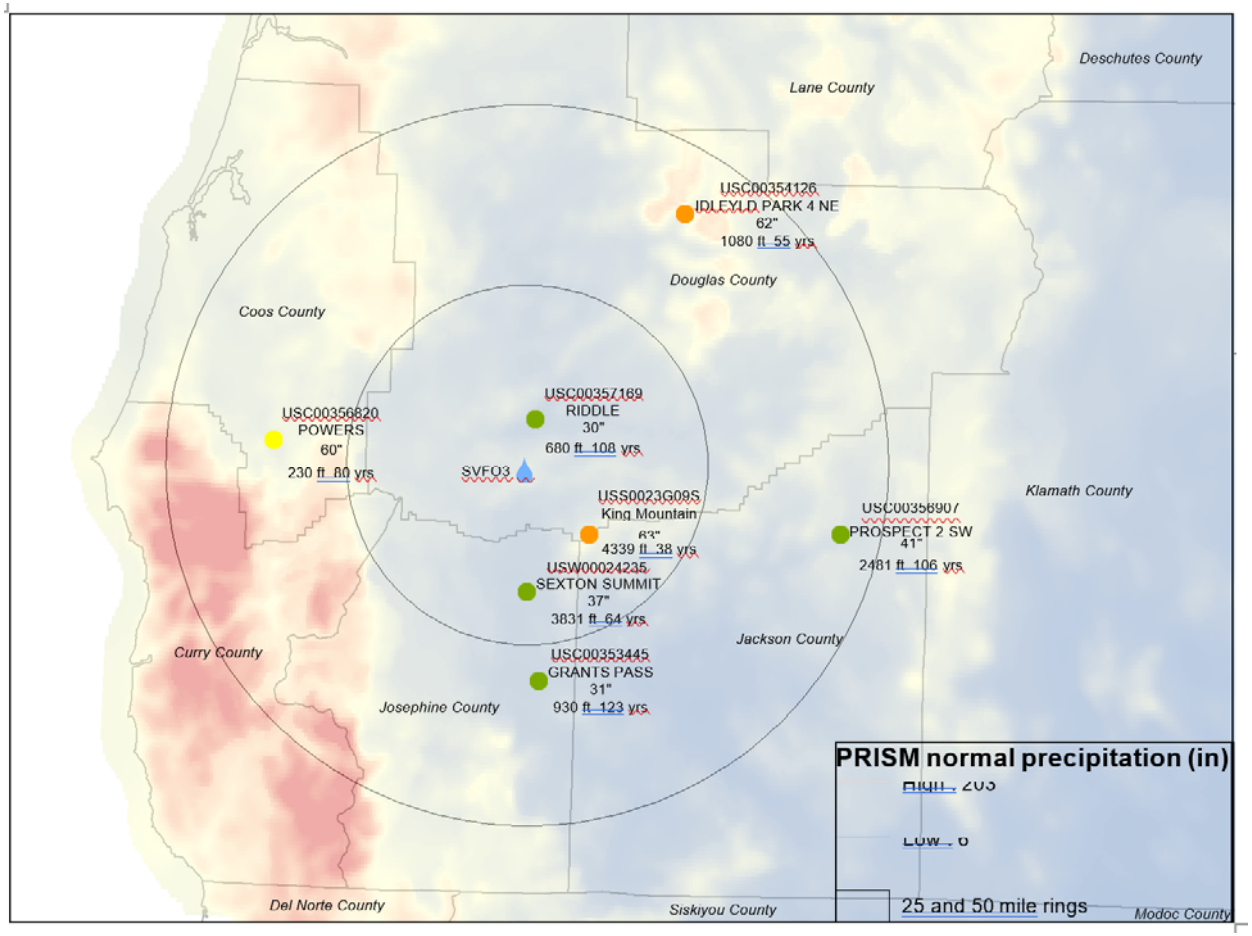
Climate Variability Analysis – Method 1: SWMM-Climate Adjustment Tool (EPA SWMM-CAT)

- Uses statistically downscaled General Circulation Model projections from the World Climate Research Programme Coupled Model Intercomparison Project Phase archive
- Location-specific results: 13-16% long-term increase in 24-hour design storm precipitation depth compared with present for period between 2045 and 2074



Climate Variability Analysis – Method 2: Long Term Precipitation Trends

- 8 rain gages analyzed
- Silver Butte removed (inadequate data)



Climate Variability Analysis – Method 2: Long Term Precipitation Trends

- Analyzed rolling 20-year moving average
- No significant long-term trend based on historic data
- Data does not include future emission scenarios

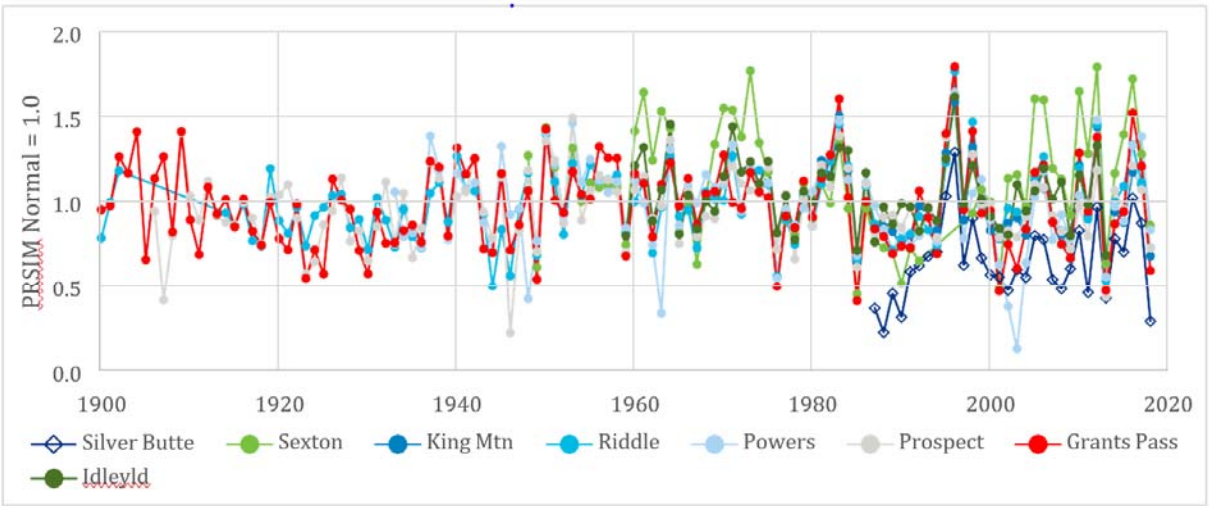


Figure 2. Normalized Annual Precipitation at Sites near Formosa Mine

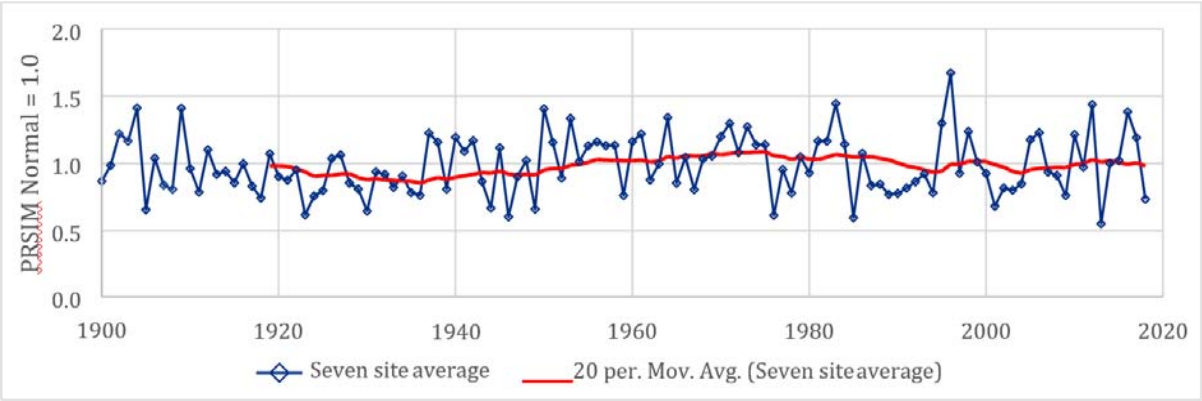
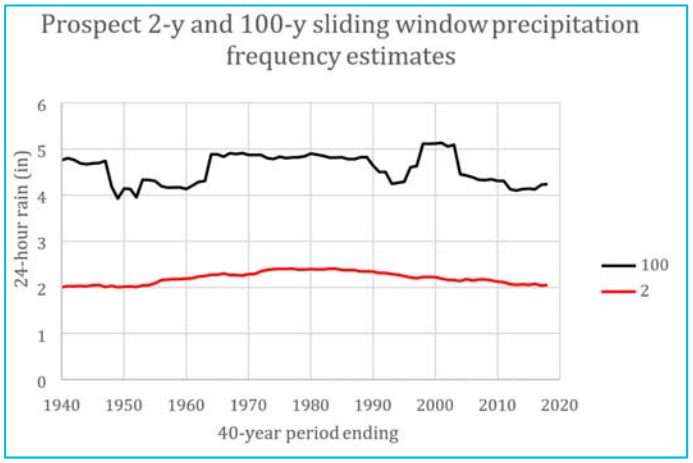
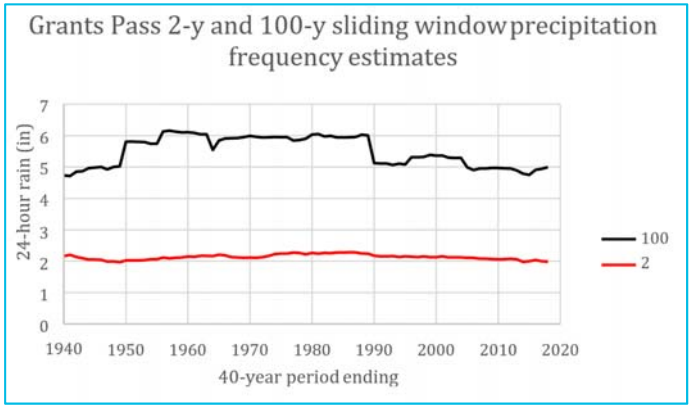


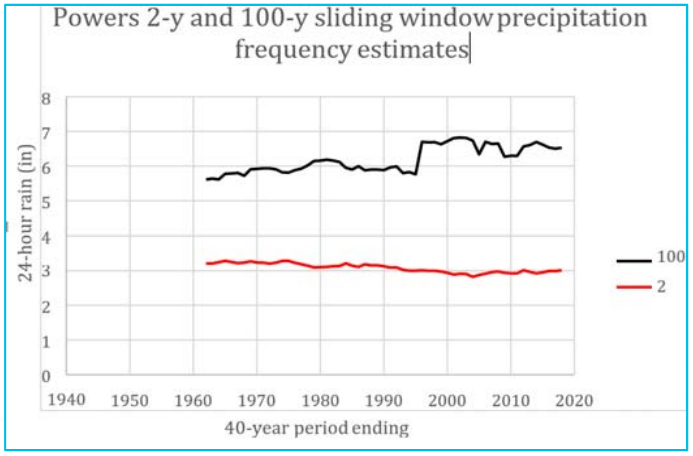
Figure 3. Seven Site Average Normalized Annual Precipitation near Formosa Mine

Climate Variability Analysis – Method 2: Frequency Analysis

- 40-year sliding scale
- 2-year and 100-year compared for three of the most representative rain gages
- Little to no significant long-term trend based on historical data
- Data does not include future emission scenarios







Climate Variability Analysis – Method 3: Oregon Climate Assessment Report 2017

- Under the high emissions pathway, the amount of precipitation falling on extreme precipitation days is projected to increase by 15-39% in the Oregon region
- No site-specific data for percentage increase for extreme events precipitation depths

OCCRI

Oregon Climate Change Research Institute

Final Recommended Design Storm Event

- 100-yr rainfall depth (7.52) includes EPA SWMM-CAT adjusted rainfall depth for conservative design

Final Precipitation Depths for Formosa Mine Site			
Design Storm (24-hour)	NOAA Atlas 2 Precipitation Depth (inches)	Climate Change Percentages from SWMM-CAT (%)	Final Recommended Rainfall Depth Projected Far-Term Climate Change from 2045 to 2074 (inches)
2-year	3.5	N/A	3.5
5-year	4.25	12.94	4.80
10-year	4.75	13.43	5.39
25-year	5.5	14.25	6.28
50-year	6.0	14.91	6.89
100-year	**6.5**	**15.63**	**7.52**

Case Studies 3 and 4 Question and Answers

Case Study 3

Developing resiliency remedial design guides for a sediment site informed by stakeholder engagement at remedial action workshops

EPA Region 10 Portland Harbor Remediation

Case Study 4

Using Hydrodynamic modeling to support remedial design using EPA's SWMM Climate Adjustment tool

EPA Region 10 Formosa Mine Site

Additional Project Findings and Lessons Learned

- More successfully implemented when considered and budgeted during project planning
  - Access your sustainable resilient remediation experts
  - Develop SMART sustainable resilient remediation objectives and goals

- Sustainable Remediation
  - Implementing best management practices can be challenging due to subcontractor equipment availability, such as clean diesel

- Resilient Remediation
  - Climate change vulnerability assessment level of effort dependent upon availability of hydraulic and hydrological (H&H) models and data sets
  - Hydrodynamic modeling may show a decrease in vulnerability to wave action and erosional forces from future storm events due to seal level rise

Thank you for your time!

Special Thanks to Case Study Project Teams:

- USDOE Santa Susanna Field Laboratory – Area IV Site
- USEPA R3 BoRit Asbestos Superfund Site
- USEPA R10 Portland Harbor Superfund Site
- EPA R10 and USACE Formosa Mine Superfund Site

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