Portland Harbor Sustainability Project

Executive Summary
Sustainability Evaluation of EPA Portland Harbor Superfund Site Remedial Alternatives

Prepared for the Portland Harbor Sustainability Project, including but not limited to the following companies: Atlantic Richfield Company and BP West Coast Products LLC, Crawford Street Corporation, Evraz Inc. NA, Exxon Mobil Corporation, Schnitzer Steel Industries Inc., and Toyota Motor Sales, U.S.A Inc.

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Study Team and Acknowledgments

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The Team appreciates the contributions of all the organizations and individuals that participated in the Study.

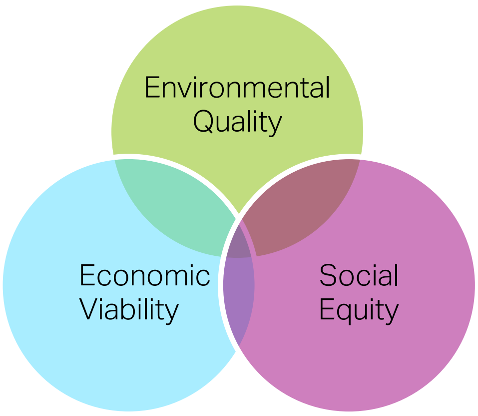
Note that the individual reports represent the views of the authors of each report and do not necessarily represent the views of any organization.

1. Introduction & Background

The Portland Harbor Superfund Site is designated by the United States (US) Environmental Protection Agency (EPA) as one of the "mega-sediment sites" in the United States. The EPA published a Proposed Plan (PP) based upon the 2016 Feasibility Study (FS) which includes eight alternatives, labeled A through I. Alternative A is the "no further action" case and is considered the baseline alternative for this analysis. The EPA-preferred remedial option in the PP is Alternative I. EPA developed detailed expenditure, construction, and other information on the alternatives in the FS, but EPA has not provided a comprehensive sustainability analysis of the alternatives that integrates environmental, economic and social considerations. In the context of remediation, sustainability has been defined as "*the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact, and that the optimum remediation solution is selected through the use of a balanced decision-making process*" (Sustainable Remediation Forum – United Kingdom).

The Portland Harbor Sustainability Project (PHSP) fills this gap by evaluating the sustainability of six remedial alternatives in terms of environmental, economic and social pillars (see Figure ES-1 for a visual summary of this approach). The PHSP evaluated 2016 EPA Alternatives A (no further action), B, D, I, E, and F (in order of increasing cost); the two largest alternatives, G and H, were not included in this study. Each pillar is composed of various quantitative metrics and the results for the three pillars are integrated into a framework that aggregates metrics weighted by their relative value to local stakeholders. This aggregation method provides a great deal of flexibility in summarizing the results and determining the robustness of sustainability conclusions to differences in stakeholder priorities. The need to consider sustainability is underscored by several publications prepared for EPA by the National Research Council (NRC), including a 2011 report that calls for EPA to include environmental, economic and social considerations in Superfund decision making.

Figure ES-1. Three Pillars of Sustainability



The PHSP team includes experts in the disciplines of environmental, economic and social analysis. State-of-the-art tools are used to develop individual assessments and metrics as well as the overall aggregation framework. Detailed technical reports have been prepared for each of the individual studies. This Executive Summary summarizes the results of the individual assessments and provides the aggregated results. We rely upon these assessments to provide overall conclusions regarding the relative sustainability of the EPA remedial alternatives. The final section provides some broader implications of the sustainability framework developed in this study.

2. Environmental Sustainability

The environmental sustainability analysis consisted of three major components:

1. Cost and Time Analysis. Clean-up costs and construction times from the 2016 EPA FS for Alternatives B, D, I, E, and F were evaluated in a an Excel-based cost tool adapted by AECOM from the Lower Duwamish Waterway (LDW) Final FS and verified by comparison with recent project experience in the Pacific Northwest (PNW).
2. Net Environmental Benefit Analysis (NEBA). Environmental scores were determined for each remedial alternative in the context of six of the nine remedy evaluation criteria defined in the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), each weighted according to their relative importance in the remedy selection.[1]
3. Human health risks. Post-construction risks were estimated using EPA's conservative deterministic assumptions regarding fish/shellfish consumption.

The results of these environmental studies were compared to remediation costs in order to assess the cost-effectiveness of the EPA remediation alternatives. These analyses are detailed in Enclosure A, Environmental Sustainability Analysis Report.

2.1 Cost and Time Analysis

As described in the 2016 EPA FS, the remedial technologies potentially applied to the remedial alternatives include a combination of removal (mechanical dredging and dry excavation), partial removal and capping, isolation capping, enhanced natural recovery, monitored natural recovery, off-site dredge material disposal in Subtitle C and D landfills, and off-site thermal treatment for sediment that exceeds acceptable landfill criteria.

Clean-up costs and construction times from the 2016 EPA FS for Alternatives B, D, I, E, and F were evaluated in a an Excel-based cost tool adapted by AECOM from the LDW Final FS and verified with recent project experience in the PNW (the most expensive Alternatives H and G were not evaluated). Net present value (NPV) estimates of costs were developed based on discount rates of 7%, 2.3%, and 0%. Our review of the EPA cost assumptions—one part of the detailed sustainability analyses conducted by the PHSP—is contained as an Appendix to Enclosure A, Environmental Sustainability Analysis Report.

EPA costs for the five alternatives in this study range from about $642 million to almost $2.2 billion assuming 2016 dollars and a 0% discount rate (2016 EPA FS). AECOM FS-level cost estimates were 36 to 64% higher than EPA's cost estimates for the same alternatives. AECOM cost estimates range from $1.1 billion to over $2.9 billion using the same 2016 dollar year and 0% discount rate.

EPA's construction periods (excluding activities such as long-term monitoring and five year reviews) ranged from 4 to 13 years. However, these construction periods are underestimated based on recent sediment remediation experience in the PNW at Boeing Plant 2, Port of Seattle Terminal-117, City of Seattle Slip 4 in the LDW, and PGE RM 13.5 in the Willamette River. AECOM construction times are estimated to be approximately 1.3 to 2 times longer than EPA estimates (5 to 26 years, with 11 years, specifically, for Alternative I).

Our analysis indicates that the EPA construction times are unrealistic based on recent PNW project experience. For example, EPA estimates Alternative I construction time will be 7 years for three dredges operating at 80 to 100% efficiency. The AECOM estimate is closer to 11 years at 64% seasonal efficiency (and up to 14 years if non-current dredged/cap construction is assumed). US Army Corps of Engineers guidance (2008) states that a seasonal efficiency of about 60% is

[1] Among the remaining three CERCLA evaluation criteria, "Cost" was evaluated but not included in the overall net benefit score because scores were compared to costs. "State Acceptance" and "Compliance with ARARs" were not included because they were difficult to quantify.

reasonable and adequately accounts for issues such as equipment downtime, clean-up passes, water quality exceedances, and best management practice (BMP) adjustments.

Separate cost analyses conducted by other firms confirm the AECOM conclusion that EPA's costs are understated. EPA's PP and 2016 FS estimate for the preferred clean-up alternative (Alternative I) estimates a $1.17 billion remedy (0% discount rate) compared to AECOM total cost estimate of $1.62 billion for the same alternative. We believe EPA costs are underestimated by about 40 to 50%. EPA's preferred remedy (Alternative I) will likely cost from $1.6 billion to $1.8 billion, based on various cost assumptions. Three other independent cost estimates similarly estimated greater costs than EPA estimates, with these studies within +/- 20% of each other (see Table ES-1).

Table ES-1. Alternative I Cost Estimate Comparison (0% NPV)

Source	Total Remedy Cost ($ billions 0%NPV)	% Higher than EPA Estimate
2016 EPA FS	$1.17	n/a
PHSP / AECOM	$1.62	38%
de Maximis	$1.72	47%
Geosyntec	$1.79	53%
Integral	$1.80	54%

Note: These are FS-level cost estimates in the range of +50 to -30% accuracy (range of $1.2 to $2.6 billion among the average of the 4 estimates).

2.2 Net Environmental Benefit Analysis (NEBA)

Environmental metrics were quantified for Alternatives A, B, D, E, I and F and linked to CERCLA remedy evaluation criteria. To aggregate metric results and scores across the various criteria, AECOM developed quantitative net environmental benefit analysis (NEBA) scores for each CERCLA criteria, scaled from 0 to 10. These benefit scores are aggregations of the scores of more than 30 individual environmental metrics that reflect the various criteria and were quantified in one of three ways:

- Feasibility Study (FS). Data were extracted from information presented in the 2016 EPA FS, including the spatial extent technology assignments, reduction in sediment concentrations, and residual risk immediately post-construction.
- SiteWise™. The greenhouse gas (GHG) and air pollutant emissions and worker safety risks were estimated using SiteWise™, a series of publicly available Excel spreadsheets used to calculate the environmental footprint of remediation activities in terms of sustainability metrics, developed in a joint effort by Battelle Memorial Institute, the US Navy, and the US Army Corps of Engineers.
- GIS mapping. Disturbances to businesses, recreational access, and ecological habitats were estimated using geographic information system (GIS) mapping to calculate the amount of overlap between the active remediation footprint (i.e., dredging and capping) of each alternative and various shoreline uses and over-water structures.

Figure ES-2 depicts the overall CERCLA-linked environmental benefit score for each alternative with an overlay of their remediation costs. The CERLCA criteria were weighted according to their relative importance in the remedy selection process.[2] The benefit scores for the remedial alternatives across alternatives range from 3.8 for Alternative A (no further action) to 6.4 for Alternative F.

The major result from the NEBA analysis is that the least expensive alternative, Alternative B, has the highest benefit score. Although this result may seem surprising, it reflects important negative effects of the more costly alternatives—alternatives with larger remedial footprints and longer construction

[2] Weights in this analysis were based on understanding of the remedial goals, best professional judgment, stakeholder values expressed at public meetings, and precedent established at the LDW Superfund Site. A sensitivity analysis indicated that different weightings did not affect the relative ranking of the overall benefit scores.

times have much higher air emissions, construction worker risk, and upland landfill disposal than the lower footprint alternatives. Air emissions associated with construction and waste transportation include GHG and criteria air pollutant emissions.

One important aspect of the "Overall Protectiveness" criterion is exposure at the end of construction, expressed in Figure ES-3 in terms of cumulative reduction in surface-weighted average concentration (SWAC). Figure ES-3 illustrates that Alternative B provides the most SWAC reduction per dollar spent.

Figure ES-2. Comparison of NEBA Results and Costs for Remedial Alternatives

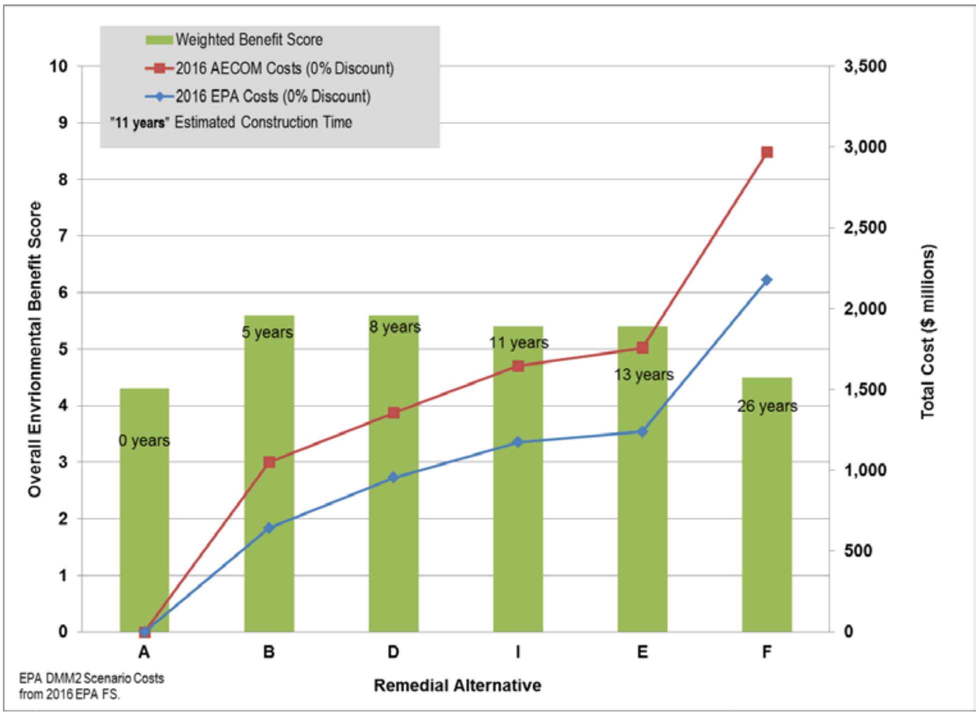
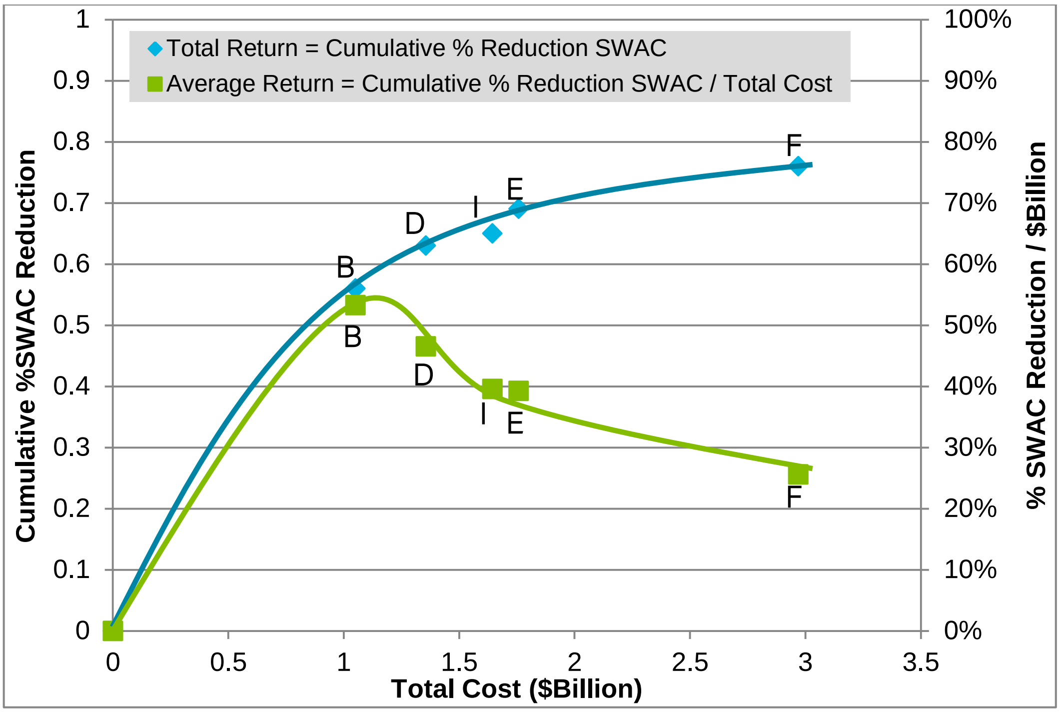


Figure ES-3. Total Cost vs. Cumulative SWAC Reductions



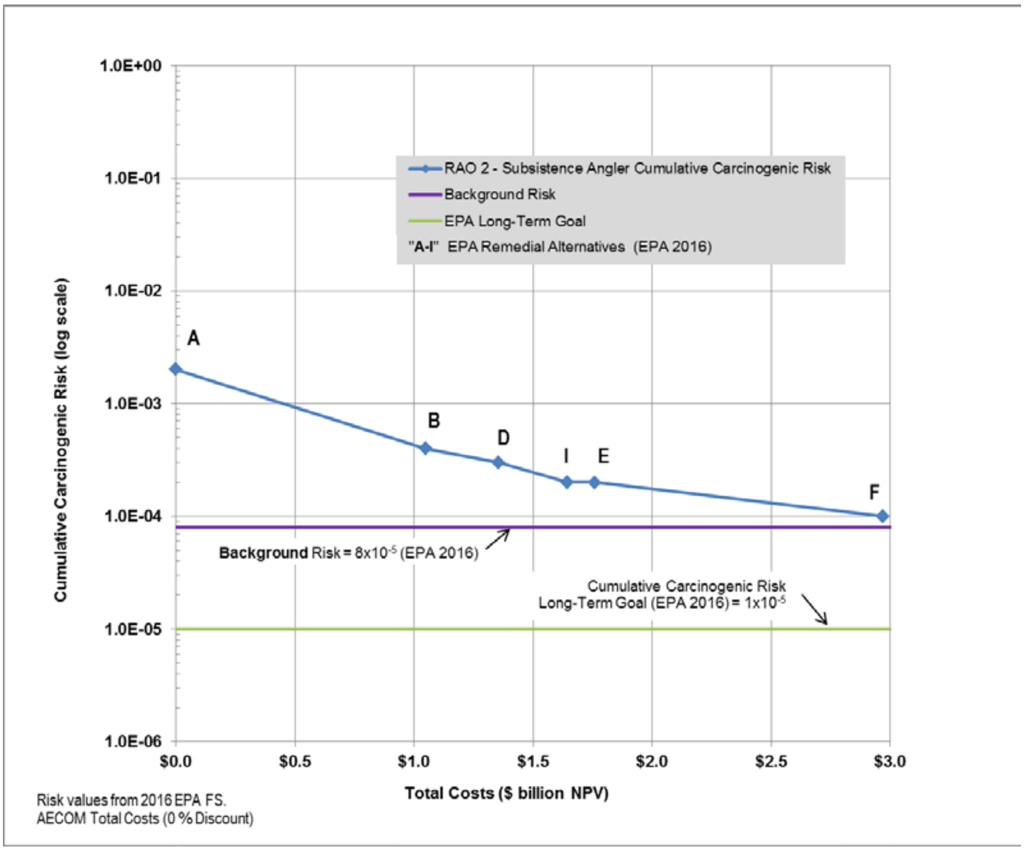
2.3 Post-Construction Human Health Risks

Figure ES-4 illustrates post-construction risks for human consumption of fish and shellfish for the alternatives based upon EPA assumptions regarding fish consumption and other risk parameters, along with the various standards of comparison for the risks. The following are the key results:

- Post-construction risks do not meet the upper end of target risk levels for Alternatives B, D, E, and I, nor the background risk levels for any of the remedial alternatives.
- For the subsistence angler who is assumed to consume 142 grams/day of resident fish (228 Study Area fish meals per year), risk reduction is limited by background. Background concentrations[3] pose risks that exceed the long-term risk management target goals of 10^{-5} and hazard index of 1 (PCBs, PCDDs/DFs).

As stated in the US Navy guidance[4], when a remedial technology is not effective in meeting the remedial goals and achieving the required level of protectiveness, the technology is simply not sustainable. In terms of risk reduction, a sustainable remedy should have clean up goals that are risk-based, that are achievable in a reasonable restoration time, and that consider the ongoing contributions of background concentrations. Residual risks (the risk remaining over time once the preliminary remediation goals (PRGs) are achieved at some point in the future) were not evaluated by EPA in the 2016 FS, but all alternatives will likely reach similar residual risk levels over time.

Figure ES-4. Fish/Shellfish Consumption Risk (Subsistence Angler Cumulative Carcinogenic Risk) vs. Cost for Remedial Alternatives



[3] For PCBs, residual risk is defined as background which EPA identifies as 9 µg/kg in sediment; the risk-based PRGs are below background and therefore not achievable.
[4] NAVFAC (Naval Facilities Engineering Command) 2012. *Department of the Navy Guidance on Green and Sustainable Remediation. User's Guide. UG-2093-ENV-Rev. 1.* Prepared by Battelle Memorial Institute for NAVFAC, Engineering Service Center, Port Hueneme CA. April 2012.

3. Economic Sustainability

Economic sustainability can be evaluated using three major methodologies:

1. Cost-effectiveness comparisons. Comparisons of the incremental gains in effectiveness (as measured by one or more metrics) with the incremental costs of increasingly expensive alternatives.
2. Benefit-cost comparisons. Comparisons of the net benefits (i.e., monetary benefits minus monetary costs) of alternatives, including assessments of the likely relative significance of benefits and costs that are not monetized.
3. Economic impact comparisons. Comparisons of the impacts on the regional economy of alternatives, taking into account both the positive impacts of expenditures and the negative impacts due to financing of expenditures by local governments (e.g. increased taxes) and local businesses (e.g., higher costs and thus less-competitive positions relative to similar businesses in other regions).

3.1 Cost-Effectiveness and Cost-Benefit Considerations

Results from the environmental assessments provide evidence that the more costly alternatives are less cost effective than Alternative B, with effectiveness measured by NEBA scores, SWAC values, or human health risk reduction. Indeed, NEBA scores indicate that Alternative B "dominates" the other alternatives—Alternative B has a higher NEBA score and lower costs than the other alternatives. Cost-effectiveness results for the other metrics show a marked "knee of the curve" at Alternative B, as the more extensive alternatives would lead to much greater increases in cost relative to their added SWAC or human health risk reduction.

Although a formal benefit-cost analysis was not performed—in which risks and other benefits would be put in monetary terms to the extent feasible— these environmental results suggest that the more costly alternatives also would not pass a benefit-cost test, i.e., that the monetary value of the additional environmental benefits relative to Alternative B would be less than the additional costs for all of the other alternatives.

3.2 Economic Impact Assessment

The economic study undertaken by the PHSP concentrated on assessing the impacts of EPA's remedial alternatives on the Portland regional economy. The details of this analysis are provided in Enclosure B, Economic Impact Analysis Report. This focus was particularly important because the two prior economic impact assessments of Portland Harbor remediation—both done in 2012 before EPA had identified its remedial alternatives in the FS—came to opposite conclusions, one finding positive impacts and the other negative impacts.[5] [6] These seemingly contradictory results arose because one study estimated only the positive effects of expenditures and the other study estimated only the negative effects if all of the expenditures were paid for by local businesses and governments.

NERA used the Regional Economic Models, Inc. (REMI) Policy Insight Plus Model (PI+) to develop estimates of the net economic impacts of the EPA alternatives, taking into account both of these effects. REMI PI+ is a state-of-the-art regional economic model that is used by public agencies in most states as well as numerous governments abroad. Using the REMI PI+ model, the total regional impacts were estimated for both (a) increased spending associated with remediation activities and (b) local financing burdens, including the direct as well as the indirect and induced (often referred to as "multiplier") effects. The REMI PI+ model also incorporates various important market effects, including effects on local wage rates, prices, and other economic variables. Impacts on the seven-county

[5] Brattle Group. 2012. *Economic Impacts of Remediating the Portland Harbor Superfund Site*. January.
[6] ECONorthwest. 2012. *Economic Impacts of the Portland Harbor Superfund Site Cleanup*. June.

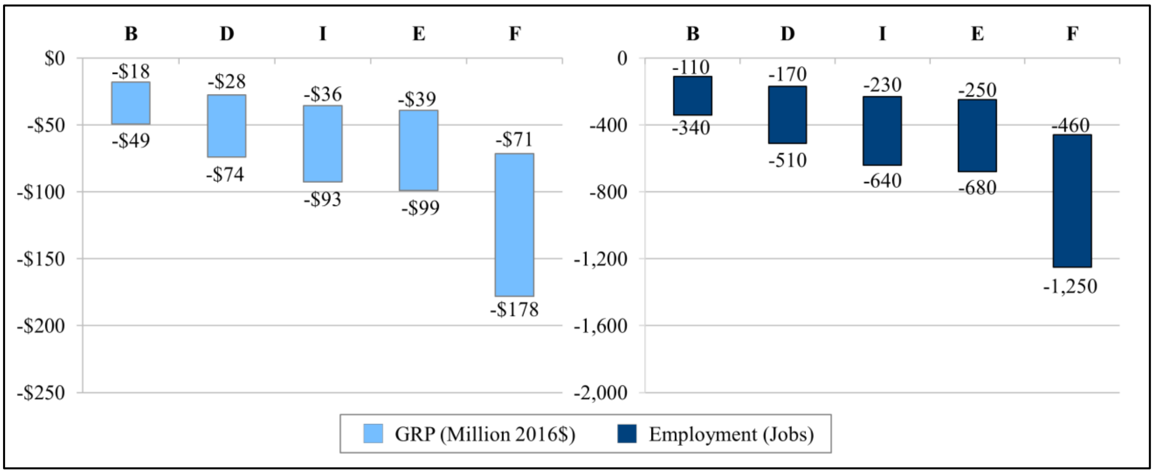
Portland Metropolitan Statistical Area (MSA) were estimated over the 31-year period from 2020, when it is assumed remediation activities would begin, through 2050.

Table ES-2 summarizes the estimated average annual impacts to the Portland regional economy as well as cumulative impacts over the 31-year period from 2020–2050. The impacts are measured in terms of changes in: (1) jobs; (2) Portland gross regional product (GRP), a regional measure equivalent to gross national product (GNP, which is calculated for the US as a whole); (3) personal income; and (4) population. Figure ES-5 summarizes the ranges of average annual job and GRP impacts for the five EPA alternatives. The ranges for a given EPA alternative reflect uncertainties in how the local government and local business costs might be financed. The results assume that local governments, local businesses, and national/international businesses share equally—i.e., one-third each—in the financing of remediation expenses.

Table ES-2. Economic Impacts of Combined Expenditures and Financing of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Gross Regional Product (Million 2016$)										
Average Annual	-$18	-$49	-$28	-$74	-$36	-$93	-$39	-$99	-$71	-$178
Cumulative (3% DR)	-$381	-$815	-$575	-$1,233	-$747	-$1,544	-$821	-$1,648	-$1,432	-$3,030
Personal Income (Million 2016$)										
Average Annual	-$13	-$39	-$20	-$59	-$26	-$73	-$29	-$78	-$53	-$142
Cumulative (3% DR)	-$261	-$632	-$401	-$962	-$528	-$1,206	-$585	-$1,289	-$1,027	-$2,388
Total Employment (Jobs/Job-Years)										
Average Annual	-110	-340	-170	-510	-230	-640	-250	-680	-460	-1,250
Cumulative	-3,430	-10,430	-5,290	-15,780	-7,020	-19,810	-7,800	-21,180	-14,150	-38,860
Population (Persons/Person-Years)										
Average Annual	-290	-470	-440	-710	-570	-890	-620	-950	-1,100	-1,750
Cumulative	-9,010	-14,540	-13,770	-22,150	-17,690	-27,690	-19,270	-29,530	-34,160	-54,220

Figure ES-5. Economic Impacts of Combined Expenditures and Financing of EPA Alternatives on Portland MSA



The following are the major results of the REMI analysis.

- Net impacts are negative for each alternative, meaning that the negative economic impacts of local government/business financing outweigh the positive impacts of expenditures. These net negative impacts are reflected in net losses in jobs, GRP, personal income and population in the Portland MSA.
- The more expensive alternatives result in substantially larger negative impacts than the less expensive alternatives. Based on the maximum value financing assumptions, the average annual job loss ranges from about 340 jobs under Alternative B to 1,250 jobs for Alternative F. With regard to the equivalent GRP values, the range is from -$49 million (GRP loss) under Alternative B to -$178 million (GRP loss) for Alternative F.

- Potential losses to the Portland regional economy could differ substantially based upon uncertainties in how the expenditures will be financed. For example, with regard to Alternative I, the estimated range of average annual job losses over the 31-year period ranges from 230 to 640.
- Most sectors of the Portland regional economy are affected. Multiplier effects lead to negative impacts on nearly every sector of the Portland regional economy.
- Socioeconomic losses are concentrated in relatively high-wage sectors. Approximately forty percent of the estimated job losses due to the remedial alternatives under consideration are projected to be in relatively high-wage sectors.

3.3 Business Disruption and "Stigma" Effects

The EPA alternatives could have additional impacts on the regional economy through effects on riverfront activities, which were not included in the REMI modelling. NERA prepared a business questionnaire that was administered to riverfront businesses (on conditions of anonymity) to assess these potential impacts.

The questionnaire responses generally identified two impact categories as potentially significant:

1. Negative impacts related to business disruption; and
2. Positive impacts related to stigma removal.

Questionnaire respondents did not consider increased noise a concern but did indicate potential increased truck traffic is of some concern.

Virtually all respondents indicated that changes in their river operations were "very likely" if access were disrupted during the EPA's in-water work window. Changes depended on the nature of the available options.

- Participants with nearby alternative facilities with port access (e.g., on the Columbia River in Washington) would likely consider relocating operations.
- Participants without nearby facilities—particularly those with highly specialized and stationary equipment—would consider shipping by other higher-cost means in the near term (e.g., relying more on rail or trucks); eventually, this group might eliminate local production all together.

Most participants responded that remedial alternatives with longer durations would lead to greater disruption and more severe reactions (i.e., relocation or permanent shutdown of riverfront facilities).

Most respondents believed there was a stigma associated with the listing as a Superfund site and that this stigma affected business. A majority believes that remediation *might* remove this stigma; however, participants cautioned that stigma removal would require two major changes.

1. Legal certainty for new entrants fearing liability; and
2. Long-term perception of remediation success.

In summary the questionnaire results suggest that the net effect of Superfund remediation on businesses on the river is ambiguous (i.e., one positive, one negative). We suspect that the net effect is likely small relative to the direct effects quantified from the remedial expenditures and financing.

4. Social Sustainability

Social equity is one of the three pillars of sustainability and provides one platform for stakeholder trade-off evaluation and remedy decision making. This part of the sustainability assessment evaluates the social sustainability of five remedial alternatives presented in the 2016 EPA FS, relative to baseline, or Alternative A (no further action). This assessment is detailed in Enclosure C, Social Analysis Report.

4.1 Metrics and Stakeholder Values

The metrics quantified in other pillar assessments (environmental and economic) were adapted and integrated into a stakeholder values-based assessment that was supplemented to include social equity metrics. Metrics were aggregated into one of four Stakeholder Group (SG) Values (identified in a broad-based review of sustainability projects and regional stakeholder documents) for each pillar. Then, the sorted metrics were scored in the Excel-based Sustainable Value Assessment (SVA) tool, which was developed for this project.

A six month exploratory effort was conducted to identify Portland Harbor SGs and their values. Over 280 separate SGs, including many which are potentially underrepresented in the decision process, were identified and placed in a project-specific stakeholder mapping database. These include regional businesses and industries adjacent to or dependent on the river (including potentially responsible parties to the clean-up); neighborhood, community, and Tribal groups; recreational clubs and other associations; environmental, social justice, and other non-governmental organizations; and local, regional, state, and federal government entities. In parallel with the stakeholder mapping effort, a documentation review was conducted to collect information on inferred and elicited stakeholder values and priorities in terms of Portland Harbor remediation, restoration, planning and development issues. This review included publications, websites, newsletters, journals, brochures, meeting minutes, interviews, and written comments.

SG Values were linked to specific indicators or metrics that could be used to score each remedial alternative in terms of the SG Value. A total of 49 metrics were grouped into the following 12 SG Values (sorted by sustainability pillar) and scored for each of five alternatives (B, D, E, I, and F). The 12 SG Values are listed in Table ES-3.

Table ES-3. Stakeholder Group Values

Environmental Quality	Economic Viability	Social Equity
Fish & Wildlife	Economic Vitality	Quality of Life & Recreation
Habitat	Jobs	Community Values
Resilience	Infrastructure	Acceptable Remedy
Low Impact Remedy	Cost Effectiveness	Health & Safety

Impact (negative) and/or benefit (positive) scores were determined for each metric and each remedial alternative on a scale of -10 to +10. The metric scores were then aggregated according to their respective SG Values to generate SG Value scores (See Enclosure C, Social Analysis Report, for detailed discussion).

4.2 Social Tool Developed to Evaluate Trade-Offs

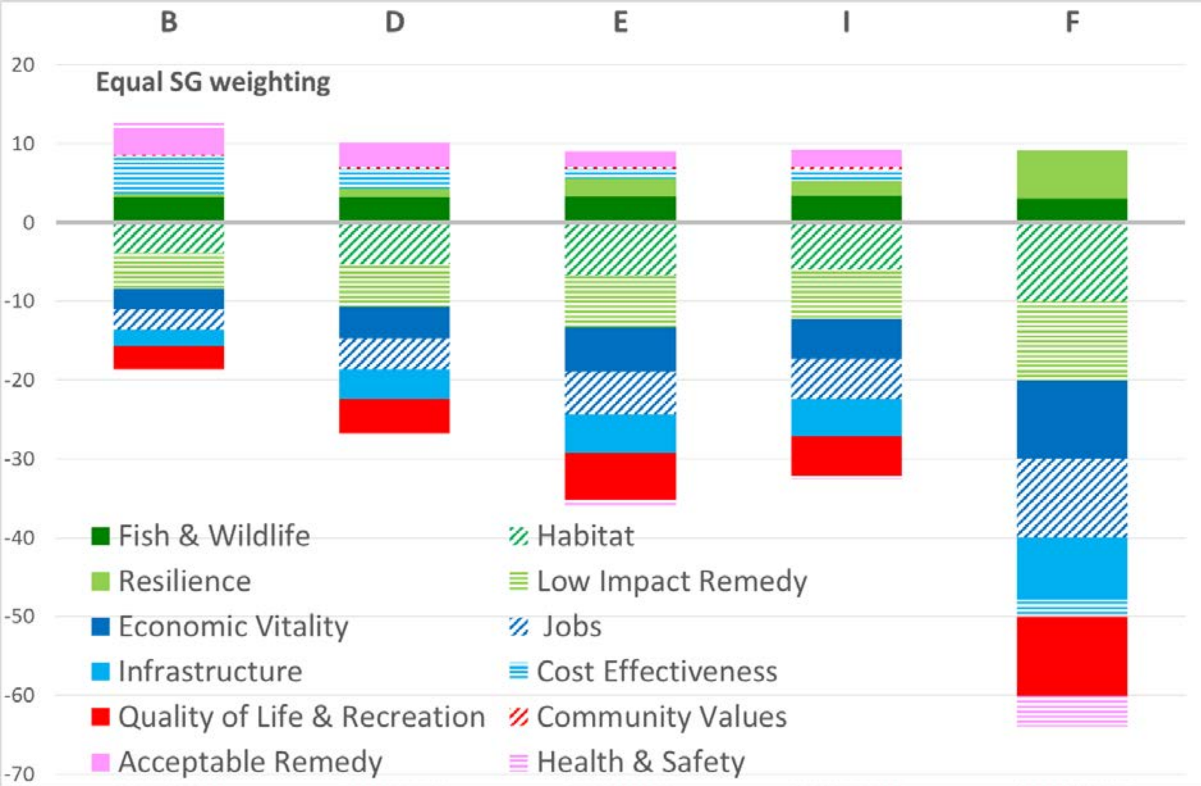
The SVA tool was developed as a sediment remediation-specific multi-criteria assessment tool and used to evaluate trade-offs between environmental, economic, and social costs and benefits in terms of SG Values for remedial alternatives and to compare the overall SG Values-based sustainability of each remedial alternative. Comparing each remedial alternative in terms of disparate SG Values provides a platform for dialogue and communication on trade-offs, and supplements more established evaluation of incremental environmental benefits versus costs, such as those evaluated in the CERCLA-linked NEBA. When the diverse impacts of remedial options are considered, stakeholders can better understand the full range of potential consequences of such a substantial undertaking, supporting better-informed decisions, and ideally, avoiding single-issue decision making.

4.3 Values-Based Sustainability Results

Figure ES-6 shows the aggregated scores for each SG Value, weighted equally and summed for each of the remedial alternatives. The following are the major results of the comparative social assessment.

- The net sustainability scores (i.e., the sum of the negative and positive scores) show a clear pattern, with progressively lower net scores for the larger alternatives.
- A closer look shows that the difference between remedial alternatives is driven not by increased benefits for the higher-scoring alternatives, but by increasing negative impacts for the more extensive alternatives.
- The positive benefit scores (the bars above the zero line) decrease slightly from Alternative B to the larger and more extensive alternatives. Most of the SG Values with positive scores (Fish & Wildlife, Acceptable Remedy, Cost Effectiveness, and Community Values) are among those that are frequently reflected in SG priority differences, and result in trade-offs that produce slightly decreasing net benefits scores across most alternatives (they are scored with both positive and negative values). The higher Resilience score for Alternative F reflects the more extensive removal-based remediation for that alternative.
- In contrast, for the SG Values that have net negative scores, the environmental, economic, and social impacts of a large remediation increase as the remedial alternatives become more extensive.
- For the EPA remedial alternatives under consideration, the small incremental decrease in risk for more aggressive alternatives is outweighed by the increased environmental, economic, and social costs and impacts.

Figure ES-6. Stakeholder Group Values-Based Sustainability Scores



Notes:
1. SG Values weighted equally; metrics weighted according to relevance to values.
2. Bars for some SG Values (e.g., Community Values) are not visible on the graph, as their aggregate scores are small relative to other SG Values.

4.4 Sensitivity Analysis

A sensitivity analysis was completed using different weightings to represent differing priorities among stakeholder groups, and comparing SG Value scores using AECOM vs EPA cost and time estimates. The following are results from this analysis.

- The SVA tool is sensitive to various stakeholder inputs—the relative value and pillar scores change in response to different SG priorities, identifying trade-offs, opportunities for optimization, and sources of potential disagreement.
- There were also some differences observed in time-sensitive metrics when EPA versus AECOM costs and construction times were used.
- However, the conclusions are robust—when a broad range of positive and negative impacts of large-scale remediation is considered, regardless of the weighting approach used, the overall relative sustainability rankings of the remedial alternatives remained the same.

4.5 Summary of Relative Sustainability Scores

In summary, the overall values-based sustainability scores of the Portland Harbor remedial alternatives can be ranked as: Alternative B ≥ Alternative D > Alternative I > Alternative E >> Alternative F.

5. Conclusions

This section provides conclusions regarding EPA's cost and timing information and on the relative sustainability of the EPA's Portland Harbor remediation alternatives in terms of the three major pillars of environmental, economic and social sustainability.

5.1 Conclusions for the Three Sustainability Pillars

5.1.1 Environmental Sustainability

AECOM's analysis indicates that Alternative B provides greater environmental benefits as determined by the NEBA. The negative impacts of the more aggressive alternatives far outweigh the small incremental improvements in risk reduction for the more aggressive remedies. Furthermore, alternatives with longer construction times have higher GHG and air pollutant emissions than alternatives with shorter construction times. Construction activities associated with the larger alternatives will disturb up to 45% (for Alternative F) of shoreline businesses and recreational access to the river. As with air emissions, shoreline disturbance increases with construction times for larger alternatives.

While BMPs may be implemented to reduce some of the short-term impacts of the more costly alternatives, the relatively small improvements in environmental metrics do not affect NEBA ranking of the alternatives. More benefits can be achieved through selection of a lower-impact remedy.

The human health risk analysis indicates some gains for the more extensive alternatives, but these gains have a relatively low impact on human health. All of the alternatives are limited by background concentrations of contaminants that pose risks in excess of the long-term risk management targets set by EPA for the Site of 10^{-5} (cancer) and a hazard index of 1 (non-cancer). Even the most extensive remediation options considered by EPA (Alternatives F, G, and H) do not achieve fish consumption goals for subsistence anglers or remove fish consumption advisories. Furthermore, Alternatives B and D may achieve similar background levels over time because of ongoing natural recovery processes and source control.

5.1.2 Economic Sustainability

The environmental analysis suggests that the more extensive alternatives are inferior to Alternative B based on economic cost-effectiveness and benefit-cost metrics. Indeed, using NEBA as a metric, Alternative B dominates the other alternatives, resulting in the highest NEBA score and the lowest cost. Using SWAC and human health risk as effectiveness metrics, Alternative B is much more cost-effective, with the more expensive alternatives providing small additional gains for large additional costs. These various metrics all suggest that Alternative B would be superior based on economic benefit-cost comparisons.

The regional economic modeling indicates that all remedial alternatives would result in net job losses and other negative impacts to the Portland regional economy, a result that reconciles the two prior apparently contradictory economic impact studies done for Portland Harbor. The regional modeling results also indicate that Alternative B is superior to the other alternatives, since it results in the smallest negative impacts, as measured in terms of declines in employment, GRP, regional income and population in the Portland region.

5.1.3 Social Sustainability

The social sustainability analysis suggests that all remedial options have environmental, economic and social impacts, and that these impacts increase in proportion to the magnitude of the remedial alternative. The relatively small incremental increase in permanence and risk reduction for the more extensive options is more than offset by the increased impacts. The net SG Values-based sustainability scores (i.e., the sum of the negative and positive scores) show a clear pattern, with progressively lower net scores for the larger and more expensive alternatives. These conclusions are robust—when a broad range of positive and negative impacts of large-scale remediation is considered, regardless of the weighting approach used, the overall relative sustainability rankings of the remedial alternatives remained the same.

5.1.4 Sensitivity Analyses

Various sensitivity analyses were developed for all three pillars—environmental (CERCLA criteria weighting factors, dredge production rates, and waste transportation and disposal scenarios), economic (financing and by whom), and social (weighting factors for diverse stakeholder groups, comparison to EPA vs AECOM cost and time estimates). Each of these analyses concluded that while the results are sensitive (notable differences between the results) the sustainability rankings of the EPA remediation alternatives are robust with respect to these parameters. The overall rankings did not change.

5.2 Overall Conclusion

We conclude that Alternative B is the most sustainable Portland Harbor Superfund Site remedy among those evaluated by EPA—with Alternative D close behind—when environmental, economic, and social benefits and impacts are considered. With regard to EPA's preferred alternative (Alternative I), we conclude that actual costs and construction times will likely be 40 to 50% higher than EPA estimates and that the net negative environmental, economic, and social impacts of Alternative I relative to both Alternative B and Alternative D substantially outweigh the small incremental improvements in post-construction health risk.

6. Broader Implications

The PHSP is a significant step forward in developing a sustainability framework that can be used as an aid to environmental decision making for complex sediment remedies. A comprehensive analysis of the environmental, economic and social impacts (all three pillars of sustainability) associated with remedial alternatives provides a broader basis for decision-making rather than focusing on a narrow set of criteria. Moreover, integrating all of these factors into a common framework allows one to develop robust conclusions of potential trade-offs among the remediation alternatives.

Our quantitative assessment of stakeholder values is extensive, new, and robust. It advances the incorporation of sustainability considerations, and we strongly believe it is a worthwhile effort that should be considered by EPA as it decides on a final remediation plan for the Portland Harbor Superfund Site. Indeed, the framework should be used for decision-making at other environmental sites, within the existing CERCLA evaluation process. Further, the application of a sustainability framework to complex environmental decisions is consistent with recommendations from the NRC and recent US executive directives, requiring that federal decision making should consider community needs and how they are affected.

For Portland Harbor, as with other contaminated sites, risks, benefits and costs are not borne equally, in terms of time, space, stakeholders, or demographics. These issues should be kept in mind when the trade-offs described in this report are considered – it is important to consider the needs of a diverse population. It is primarily for this reason that the equal SG Value weighting scheme was developed – although some SGs are very active and vocal, there is evidence of diverse values and priorities throughout the region, and these disparate priorities should be considered, even if not all stakeholders are fully engaged in the decision making. Adverse spatial and demographic equity issues can, to some extent, be minimized using best management practices, considering community needs in design, and minimizing footprints.

For this tool to be most useful in optimizing sustainable options, a wide range of remedial options with a broad range of potential risk reductions should be evaluated, to identify the point where additional impacts overwhelm the additional gains. Identification of the risks and benefits of most interest to stakeholders can allow for negotiation and optimization of alternatives under consideration, and for collaborative design of more sustainable options.

The application of sustainability tools for complex environmental issues should, ideally, be considered earlier in the remedial process with a high level of stakeholder engagement, in order to develop more realistic and effective options. Because this study was conducted after completion of the Portland Harbor FS, the broad range of sustainability considerations were not incorporated into the development of remedial alternatives. The goal for large, complex projects should be to envision a sustainable approach from the beginning of a project with collaborative input from a large group of stakeholders. In addition, the use of a dynamic multi-year regional economic impact model that considers both the positive impacts of expenditures and the negative impacts of their financing is important to clarify potential economic impacts to stakeholders, especially for remedies like Portland Harbor that may cost close to $1 billion. An informed, transparent, and balanced decision making process will enable selection of a remedy that more stakeholders can support earlier in the process.

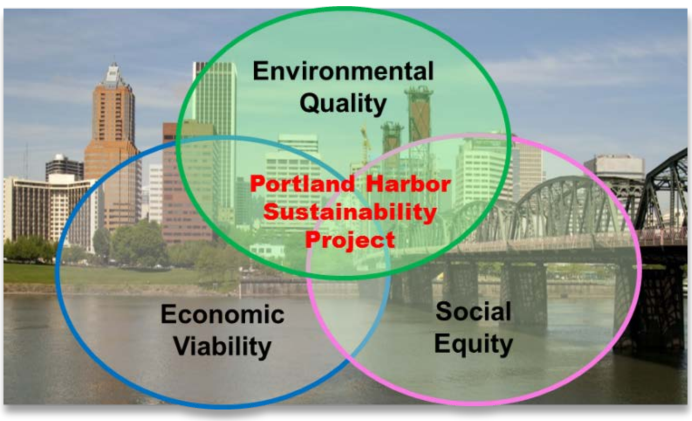
Portland Harbor Sustainability Project

Evaluation of EPA Portland Harbor Superfund Site Remedial Alternatives

Environmental Sustainability Analysis Report

Prepared for:

The Portland Harbor Superfund Site Sustainability Project



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List of Acronyms

ARAR	Applicable or Relevant and Appropriate Requirement
BMP	best management practice
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH_4	methane
CM	construction management
CO_2	carbon dioxide
CO_2e	CO_2 equivalents
COC	contaminant of concern
CY	cubic yard(s)
DMM	disposed material management
DOE	US Department of Energy
DSL	Oregon Department of State Lands
ENR	enhanced natural recovery
ENV	Environmental pillar abbreviation, this report
EPA	United States Environmental Protection Agency
FS	Feasibility Study
GAC	granular activated carbon
GHG	greenhouse gas
GIS	geographic information system
HI	hazard index
IC	institutional control
kg	kilogram
LDW	Lower Duwamish Waterway
LF	linear feet
LTM	long-term monitoring
MNR	monitored natural recovery
N_2O	nitrous oxide
NAVD88	North American Vertical Datum 1988
NEBA	Net Environmental Benefit Analysis
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NPV	net present value
NRC	National Research Council
ODEQ	Oregon Department of Environmental Quality
O&M	operations and maintenance
OMB	Office of Management and Budget
PAH	polyaromatic hydrocarbon
PCB	polychlorinated biphenyl
PGE	Portland General Electric
PHSP	Portland Harbor Sustainability Project
PM	project management
PM10	airborne particulate matter
PRP	potentially responsible party
QA/QC	quality assurance and quality control
RD	remedial design
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act

Contents (Continued)

RM	River Mile
SF	square feet
SMA	sediment management area
SO_X	sulfur oxides
SURF	Sustainable Remediation Forum
SWAC	surface weighted average concentration
US	United States
USACE	US Army Corps of Engineers

1. Introduction

The Portland Harbor Sustainability Project (PHSP) developed a sustainability framework to evaluate remedial alternatives proposed for the Portland Harbor Superfund Site. This study comprises three reports that evaluate the sustainability of Alternatives B, D, E, I, F, and A (baseline, no-action) as presented in the 2016 United States (US) Environmental Protection Agency (EPA) *Portland Harbor Feasibility Study* (herein called the 2016 EPA FS) (EPA 2016). These reports present evaluation of the following components:

A. Environmental Sustainability Analysis Report;
B. Economic Impact Analysis Report; and
C. Social Analysis Report.

This Environmental Sustainability Analysis Report is the first component of the PHSP and evaluates the environmental pillar of sustainability, including an assessment of environmental benefits and impacts using a net environmental benefit analysis (NEBA) and a cost-benefit analysis.

Environmental sustainability is one of the three pillars of a sustainability assessment and provides a platform for evaluating stakeholder trade-offs when making remedy decisions. In the context of environmental remediation projects, a key objective of sustainability is to "*demonstrat[e], in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact, and that the optimum remediation solution is selected through the use of a balanced decision-making process*" (Sustainable Remediation Forum [SURF] – United Kingdom). In other words, sustainable remediation is defined as *"a remedy or combination of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources*" (Ellis and Hadley 2009).

Sustainability should be considered during all phases of a project, including remedy selection (Ellis and Hadley 2009). Sustainability can be defined as the process by which four questions are answered: what to sustain? For whom to sustain it? For how long to sustain it? And, what are the costs to sustain it? (Stahl et al. 2011). The purpose of this report is to determine the condition of the environment and stakeholder values in the Portland Harbor area to holistically answer these four questions, and to evaluate the environmental sustainability of several remedial alternatives presented in the 2016 EPA FS (EPA 2016). The alternatives considered for comparison are Alternatives B, D, E, F, I, and Alternative A (no action) as a baseline.

1.1 Regulatory Background

To date, EPA has encouraged the implementation of green remediation, defined as considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions (EPA 2010a). This narrow approach, however, fails to consider sustainability implications of the remedy selection process and entirely excludes the economic and social aspects of sustainability. Oregon Department of Environmental Quality (ODEQ) published a Green Remediation Policy in 2011, which is applicable to state actions, to parties responsible for investigating or cleaning up contaminated sites, and to those hired to perform such work. Under this policy, ODEQ encourages responsible parties to implement green remediation technologies voluntarily (ODEQ 2011). However, it does not provide specific guidance or requirement for consideration of sustainability during evaluation of remedial alternatives. The EPA Region 10 Clean and Green Policy (EPA 2009) and the EPA Superfund Green Remediation Strategy (EPA 2010a) documents encourage the implementation of strategic actions to reduce environmental impacts of cleanup actions and conserve natural resources.

Numerous federal and state guidance documents developed over the last 10 years describe frameworks for and approaches to sustainable remediation, including those by EPA Region 10 (EPA 2009), US Navy (NAVFAC 2012), ODEQ (ODEQ 2011), SURF (Ellis and Hadley 2009; Holland et al. 2011; Butler et al. 2011; Favara et al. 2011), Interstate Technology and Regulatory Council (ITRC 2011a, 2011b), and ASTM International (ASTM 2013a, 2013b); but few of these have been implemented for managing contaminated sediments.

The exclusion of sustainability concepts from the 2016 EPA FS is underscored by several publications prepared for EPA by the National Research Council (NRC) reinforcing the value of including sustainability considerations in decision-making processes. The 2011 NRC *Sustainability and the US EPA*, also known as the Green Book (NRC 2011), presents a sustainability framework that calls for EPA to consider the three sustainability pillars (environmental, economic, and social domains) in decision-making. In 2014, at the request of the EPA and as a follow-up to the Green Book, the NRC published *Sustainability Concepts in Decision Making: Tools and Approaches for the US Environmental Protection Agency* (NRC 2014) to examine application of scientific tools and approaches for incorporation into sustainability assessments. Specifically, the NRC recommended that "[f]or every major decision, EPA should incorporate a strategy with the goal of assessing the three dimensions of sustainability (economic, social, and environmental) in an integrated manner" and "apply tools and approaches in a manner best suited to the type of problem being addressed." In the context of Superfund, the NRC recommended inclusion of the broad consideration of possible effects of remediation alternatives and the potential for natural systems to advance remediation. In light of these recommendations, further evaluation of the EPA alternatives presented in the 2016 EPA FS is required to fully consider sustainability impacts of the remediation of Portland Harbor.

1.2 Scope of Work

To evaluate sustainability in terms of environmental impacts and benefits, a NEBA was completed. NEBA quantifies and compares remedial alternatives' environmental benefits as a result of remedial actions (relative to no action) with their implementation costs, identifying those alternatives for which the implementation costs are either proportionate or disproportionate to the environmental benefits achieved. Implementation costs are considered disproportionate to benefits when the incremental costs of the alternative exceed the incremental benefits achieved by the alternative compared to benefits achieved by other lower-cost alternatives. The results of a NEBA can generally be used to identify approaches or remedies that provide protection of human health and the environment and optimize environmental trade-offs, all in the context of cost.

The metrics used for the NEBA were grouped into categories that align with six[1] of nine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) evaluation criteria (EPA 1988). Benefits achieved by each remedial alternative were determined by calculating the weighted average of CERCLA evaluation criteria benefit scores: overall protectiveness of human health and the environment, permanence, long-term effectiveness, management of short-term risks, technical and

[1] *Two CERCLA criteria (Compliance with ARARs and State Acceptance) were not evaluated because they were difficult to quantify with available information or insensitive. The CERCLA cost criterion was used as a comparison for the net environmental benefit scores.*

administrative implementability, and consideration of public concerns. The CERCLA evaluation criteria scores were quantified by aggregating the scores of individual environmental metrics that reasonably reflected each criterion. Over 30 environmental metrics were included in the analysis and quantified in one of three ways:

- Data, including the spatial extent of technology assignments, reduction in risk driver sediment concentrations, and risk immediately post-construction, were extracted from information presented in the 2016 EPA FS when possible.
- The greenhouse gas (GHG) and air pollutant emissions and worker safety risks were evaluated using SiteWise™, a series of publicly available Microsoft Excel spreadsheets used to calculate the environmental footprint of remediation activities in terms of sustainability metrics (developed in a joint effort by Battelle Memorial Institute, the US Navy, and the US Army Corps of Engineers).
- Disturbances to businesses, recreational access, and high-value habitats were evaluated using geographic information system (GIS) mapping to calculate the amount of overlap between the active remediation footprint (i.e., dredging and capping) of each alternative and various shoreline uses and overwater structures.

Section 11 of the EPA-approved Lower Duwamish Waterway Final FS (AECOM 2012) was used as a guide for the NEBA.

Sustainability assessments, which address the analysis of the interconnectedness of the environment and ecosystems, must be carried out at appropriate, and clearly specified, spatial and temporal scales for decision-making. Remediation project phases are not stand-alone entities but rather are interconnected components of wider environmental systems, and these interconnected components interact with each other as the project progresses (Holland et al. 2011). The boundary conditions (spatial and temporal) established for this analysis included:

- Two domains – human and ecological. These domains included upland, riverbank/shallow habitat, and subtidal footprints used by humans (for recreational, business, or subsistence purposes) and by ecological receptors (benthic, fish, and higher trophic-level animals).
- Four remedial alternatives (B, D, E, F, and I) from the 2016 EPA FS; with Alternative A, the no-action alternative, being the baseline condition (Table 1).
- Three spatial scales – Local (Portland Harbor Superfund Site and adjacent land use from River Mile (RM) 1.9 to RM 11.8), City of Portland (nearby businesses, infrastructure), and Regional (transport to the disposal sites).
- One temporal scale – short term during construction (0 to 26 years) ending immediately after construction completion. Monitored natural recovery (MNR) processes were not included.

Longer time scales were considered in the economic analysis (31 years) and the social analysis (years to generations), but these pillars used data and metrics beyond the information available in the 2016 EPA FS. Source control efforts and early action remediation efforts completed prior to 2015 were not included in this analysis, nor were subsequent restoration and/or re-use of the sites.

Table 1. FS Remedial Alternatives Summary

Remedial Alternative	Construction Duration		Dredge Volume	Dredge and Dredge/Cap	Capping	ENR	*In-Situ* Treatment	MNR	Costs (0% Discount)
#	EPA (years)	AECOM (years)	(cy)	(acres)	(acres)	(acres)	(acres)	(acres)	$millions
B	4	5	576,883	72	23	100	7	1,966	$1,051
D	6	8	1,108,046	132	45	87	3	1,900	$1,355
E	7	13	1,928,136	204	66	60	0	1,838	$1,758
F	13	26	4,462,574	387	118	28	0	1,634	$2,969
I	7	11	1,649,750	167	64	60	0	1,876	$1,644

Table 1 notes: All data extracted from the 2016 EPA FS, except AECOM construction length estimates and costs. Total study area is 2167 acres. cy = cubic yards; ENR = enhanced natural recovery; MNR = monitored natural recovery

1.3 Report Organization

- Section 1 presents the scope of work, boundary conditions, and environmental metrics included in this report.
- Section 2 discusses the environmental footprint of the remedial alternatives, which was evaluated by AECOM using the sediment module of the publicly available SiteWise™ calculation tool (version 3.1). SiteWise™ was used to quantify environmental footprint metrics to evaluate impacts (e.g., energy consumptions, GHGs, worker injury, etc.) during remedy construction.
- Section 3 discusses the GIS analysis conducted by AECOM to determine land use and habitat disturbances that would occur during active construction. Aerial photographs and GIS layers obtained from the City of Portland and the 2012 AnchorQEA Draft FS were used to evaluate disturbances to shoreline infrastructure, water-dependent businesses, recreational areas, and high-value habitat during construction.
- Section 4 provides a summary of the post-construction risks of each remedy, as presented in the 2016 EPA FS.
- Section 5 contains a detailed explanation of the NEBA, which compares the environmental benefit of each remedial alternative to the implementation cost.
- Section 6 discusses a sensitivity analyses associated with metrics and rankings used within the NEBA.
- Section 7 presents the conclusions and recommendations for the most sustainable alternative.
- Section 8 includes the references cited in the document.

Figures and tables are presented throughout the document, and appendices are included at the end of the document.

1.4 Environmental Metrics Included in This Evaluation

Metrics are measurable values that correlate with a parameter of interest and are used as an indicator value of that parameter. Measurable environmental metrics developed and quantified for this sustainability analysis are listed in Table 2, along with the sources of metric data. As a starting point, relevant metrics described in the EPA sustainability guidance (EPA 2011) and the US Navy guidance (NAVFAC 2012) and those accepted by EPA Region 10 as part of the Lower Duwamish Final FS (AECOM 2012) were included in the analysis. Additional metrics available for Portland Harbor and deemed important to stakeholders were added. A total of 25 metrics were included in the analysis (Table 2) and all were mapped to one of the CERCLA criteria for evaluation. It is important to determine what the chosen indicators represent and the context for the analysis, including stakeholder values and the context for making regulatory decisions. With that in mind, the environmental metrics were aggregated into one of the CERCLA criteria for protection of human health and the environment, scored, and used in the NEBA for environmental benefit ranking of the remedial alternatives (Section 5).

1.4.1 Source of Information

Information used to quantify metrics was extracted from one of four sources: the 2016 EPA FS (when available) (EPA 2016), the 2015 Draft Final EPA FS (herein called the 2015 EPA FS) (EPA 2015), the 2012 AnchorQEA Draft FS (AnchorQEA 2012), or one of the AECOM tools (costs, construction times, or SiteWise™). Data and GIS layers used from the 2015 and 2016 FS documents included the remedy footprint, post-construction surface weighted average concentrations (SWACs), and post-construction risks. Data and GIS layers used from the 2012 Draft FS included many of the physical site features, including berthing areas, navigation channels, and bathymetry. Although EPA included cost and construction time estimates in their 2016 FS, AECOM's cost and time estimates were used because they have been field-validated on other Pacific Northwest projects and AECOM believes they represent realistic estimates.

In some cases, an "indicator" metric (e.g., air emissions, construction time, or cumulative risks) was selected to represent a group of metrics and/or values, especially if the group of metrics all had similar responses. Alternatively, results were aggregated into a single result in the NEBA to minimize dilution of the result with too many quantified metrics. The use of more metrics does not necessarily translate to a site being better assessed. In other words, accumulation of more measured site data in a single point in time or multiple metrics with similar values can lead to a false sense of certainty around those similar responses, without characterization of the spatial and/or temporal variability of the data. Some investigators have observed that too many indicators can lead to complexity and confusion (Cimorelli and Stahl 2014; Stahl et al. 2011). Therefore, this analysis was limited to approximately 30 metrics (see Table 2).

1.4.2 Environmental Metrics Considered but Not Included in This Evaluation

Some metrics could not be quantified due to lack of data, lack of sensitivity, or no information/analysis presented in the EPA 2016 FS. These metrics included the following: temporal residual risks several years after construction, MNR processes, water quality during construction, sediment transport/net erosion, utilities overlap with remedial areas, archaeological site overlap with remedial areas, and transloading site availability. These additional metrics were not included in the NEBA analysis, but some were included in the social analysis if they were deemed of particular importance to stakeholders based on inferred or elicited value statements. To ensure that qualitative or uncertain metrics do not play an undue role in the overall scoring of values, the relative uncertainty of these metrics is addressed explicitly in the social analysis (SEA Environmental Decisions, Ltd. & AECOM 2016)

Table 2. Environmental Metrics

Metrics	Method of Quantification or Source	Used in NEBA?	Mapped to CERCLA Criterion
Air emissions: GHG, nitrogen oxides (NO_X), sulfur oxides (SO_X), and particulate matter (PM10)	SiteWise ™	Yes	Short-term Risks
Total energy use	SiteWise ™	No	NA, but included in social analysis
Accident risk: Injury risk and fatality risk	SiteWise ™	Yes	Short-term Risks
Landfill disposal volumes: hazardous and non-hazardous waste quantities	SiteWise ™	No	NA, evaluated separately
Vessel traffic	GIS Disturbance Analysis	No[a]	NA
Truck trips	SiteWise ™	No[a]	NA
Bridge openings	GIS Disturbance Analysis	No[a]	NA
Reduction of site-wide surface weighted area concentration of risk driver chemicals	2016 EPA FS	Yes	Overall Protectiveness
Implementation risks: Release of contamination into water column, air, and direct contact during construction	AECOM-calculated Construction Years	Yes	Overall Protectiveness
Contaminated surface sediment left on-site	2016 EPA FS	Yes	Permanence
Reduction in the mobility of hazardous substances	2016 EPA FS	Yes	Permanence
Human health risks (Post-construction T=0): Direct contact (Tribal) and fish/shellfish consumption (subsistence)	2016 EPA FS	Yes	Long-term Effectiveness
Ecological risks (Post-construction)	2016 EPA FS	Yes	Long-term Effectiveness
Remedial alternative success certainty	2016 EPA FS	Yes	Long-term Effectiveness
Reliability of institutional and engineering controls	2016 EPA FS	Yes	Long-term Effectiveness
Volume of material handled or removed	2016 EPA FS	Yes	Short-term Risks
Disturbances during construction: Infrastructure access, overwater businesses, recreational access, nearshore high-value habitat	GIS Disturbance Analysis	Yes	Short-term Risks
Effectiveness of protective measures to manage short-term construction-related risks	2016 EPA FS	Yes	Short-term Risks
Total Cost (0% discount rate, 2015 dollars)	AECOM-calculated	Yes	Benefit/Cost
Downstream transport	2012 Draft FS	No	NA, but included in social analysis
Navigational channel disturbance from construction	GIS Disturbance Analysis	No	NA, but included in social analysis

Table 2. Environmental Metrics (Continued)

Metrics	Method of Quantification or Source	Used in NEBA?	Mapped to CERCLA Criterion
Time to achieve remedial action objectives	2012 Draft FS	No	NA, but included in Social Analysis
Stakeholder/community values	Social Analysis	Yes	Consideration of Public Concerns
Public acceptance	Social Analysis	Yes	Consideration of Public Concerns
Ability to construct and operate	2016 EPA FS	Yes	Implementability
Ability to monitor effectiveness	2016 EPA FS	Yes	Implementability
Availability of specialists, equipment, and materials	2016 EPA FS	Yes	Implementability

Table 2 notes: (a) See Section 3.3 for a detailed explanation of why metric was excluded from the analyses. NA = not applicable

2. Environmental Footprint – Using SiteWise™

The environmental footprints of Portland Harbor Remedial Alternatives B, D, E, F, and I were quantified in SiteWise™. SiteWise™ is a series of publicly available Microsoft Excel spreadsheets used to calculate the environmental footprint of remediation activities in terms of sustainability metrics. This tool is based on life cycle equivalents used to quantify common environmental metrics, as well as worker safety metrics. SiteWise™ was developed in a joint effort by Battelle Memorial Institute, the US Navy, and the US Army Corps of Engineers (NAVFAC 2015). SiteWise™ can be used to compare any number of remedial alternatives and evaluate up to four discrete stages of a project life cycle, beginning at the earliest remedial investigation phases and continuing through the FS, remedial action operation, and long-term management project phases. The latest version of SiteWise™, Version 3.1 (NAVFAC 2015) was used on this project because it includes input parameters applicable to sediment remediation sites. This analysis focused on the quantitative metrics available for the remedial action and associated monitoring during construction.

2.1 Methods

The SiteWise™ tool was used to calculate the following metrics using life cycle equivalents (i.e., published emission factors, consumption rates, and accident statistics):

- Air emissions, including:
  - GHGs, reported as the combined total of carbon dioxide (CO_2) methane (CH_4), and nitrous oxide (N_2O)
  - On-site and total nitrogen oxides (NO_X)
  - On-site and total sulfur oxides (SO_X)
  - On-site and total airborne particulate matter (PM10)
- Total energy use
- Accident risk (injury and fatality)
- Hazardous and non-hazardous waste quantities

Life cycle equivalents used in the tool for calculation of the metrics listed above were sourced from published data, including EPA, US Department of Energy (DOE), and Occupational Safety and Health Administration, among others (NAVFAC 2015). SiteWise™ includes various modules related to specific aspects of remediation and construction activities. These include production of construction and treatment materials; transportation of personnel, equipment, and materials; equipment use, including earthwork, drilling, trenching, dredging, capping, sediment management, watercraft operation, water treatment, and other fuel-based operations; labor; and residual handling.

In addition to the metrics evaluated in SiteWise™, the ecological footprint was calculated for each remedial alternative in terms of the acreage of Douglas-fir forest (i.e., a species native to the Pacific Northwest US) required to sequester an equivalent amount of carbon from the atmosphere in one year. This metric is discussed in Section 2.3.1.

2.2 Inputs and Assumptions

Inputs for the SiteWise™ tool were developed from the 2016 EPA FS cost estimates (EPA 2016, Appendix G). Inputs to the tool included bulk material quantities, sediment volumes for capping and dredging operations, production rates for activities without dedicated modules in SiteWise™ (e.g., geotextile installation, sheet pile wall installation, and pile removal and replacement), crew size and duration for each activity (to estimate total labor hours), and landfill disposal quantities.

The environmental footprint evaluation included primary on-site construction activities (dredging, capping, sand placement, transloading, and construction equipment operation), transport of materials to the site, waste disposal, and materials production (e.g., geomembranes, granular activated carbon, steel, etc.). Waste transportation assumptions included 70 miles of transport by barge from the construction site up the Columbia River to a former pulp mill plant in Bingen, Washington (EPA 2016), transloading from barge to truck, and then travelling an additional 70 miles by truck to landfills in Roosevelt, Washington (Subtitle D) or Arlington, Oregon (Subtitle C). Both landfills are located an approximately equal distance from the transloading facility. Material quantities were determined based upon the cost estimates in the 2016 EPA FS (EPA 2016, Appendix G). The tool does not quantify impacts from construction nor long-term maintenance of the upland landfill.

The 2016 EPA FS evaluated two disposed material management (DMM) scenarios:

- DMM Scenario 1: Confined disposal facility (CDF) and off-site disposal, applied only to Alternatives E through I because the estimated dredge volumes under these alternatives meet the minimum quantity for placement in a CDF.

- DMM Scenario 2: Off-site upland disposal, applied to all alternatives.

The environmental footprint evaluation evaluated DMM Scenario 2 as a baseline assumption for comparison across all alternatives. However, a sensitivity analysis of the DMM Scenario 1 for Alternatives E, F, and I was completed and discussed in Section 6.4.

SiteWise™ calculates metrics using production rates for each activity (e.g., dredging, capping, transloading, etc.) based on the volume inputs and selected equipment size. In this analysis, equipment sizes were selected based on the corresponding production rates used in the tool that most closely matched the average production rates estimated by AECOM based on relevant Pacific Northwest project experience (see Appendix E). Two dredging production rates were selected in SiteWise™ for this analysis: 26 cubic yards per hour (for confined dredging with a 25-ton, 1-cubic yard crawler crane) and 124 cubic yards per hour (for open water dredging with a 100-ton, 4-cubic yard crawler crane). Emissions metrics in SiteWise™ were calculated based on production rates, volumes, and emissions factors developed for each type of equipment.

These production rates equate to daily production rates of about 312 to 1,488 cubic yards per day per dredge (Table 3). These rates are much lower than those assumed in the 2016 EPA FS (EPA 2016), but consistent with those assumed in the Lower Duwamish Final FS (AECOM 2012), and recent Pacific Northwest project experience (see Appendix E). AECOM estimates range from about 300 to 1,000 cubic yards per day per dredge (see Appendix E).The sensitivity of the environmental footprint metrics to these dredge rates is discussed in Section 6.

Table 3. Comparison of Average Dredge Production Rates (per Dredge)

Dredge Type	SiteWise™ Tool	EPA 2016 Final FS Portland Harbor	Lower Duwamish Waterway Final FS (AECOM 2012)	Portland Harbor Sustainability Project (Appendix E)
Open-Water	1,488 cy/day	2,382 cy/day	1,000 cy/day	2,000 cy/day
Confined/Near-shore	312 cy/day	713 – 2,821 cy/day	300 cy/day	920 cy/day

Table 3 notes: cy/day = cubic yards per day. AECOM assumes a blended rate for daily production rates.

This environmental footprint evaluation did not include impacts associated with second-tier activities such as site characterization activities; long-term monitoring; construction of dewatering, treatment, or transloading facilities; management of landfills; or site closure activities. While inclusion of these activities in the environmental footprint analysis would increase the size of the footprint, the activities are not expected to vary between alternatives (i.e., they are insensitive inputs). Thus, the relative comparison between alternatives is considered reasonable for this analysis.

2.3 Environmental Footprint Results

Figures 1 and 2 illustrate that environmental impacts are proportional to the size of the active remedial footprint. Alternative F has the greatest environmental footprint, and Alternative B has the lowest among the alternatives evaluated (B, D, E, F, and I). Environmental footprint results in Figure 1 are normalized to the largest alternative for each metric quantified in SiteWise™. Alternatives B, D, E, and I have impacts ranging from approximately 20 percent to 60 percent of Alternative F. Alternative F also has the greatest total dredge volume among the alternatives evaluated—twice that of Alternative E and nearly seven times that of Alternative B. As expected, larger volumes, longer construction periods, and greater quantities of waste requiring transportation lead to larger environmental footprint/impacts. Figure 2 compares the GHG emissions to the total dredge volume for each remedial alternative.

Similarly, the risks to worker safety and total energy consumption increase proportionally to the footprint and activity of each remedial alternative. The following sections describe the SiteWise™ model results for several key metrics. Detailed SiteWise™ results are presented in Appendix A.

Figure 1. Environmental Footprint Normalized Impacts

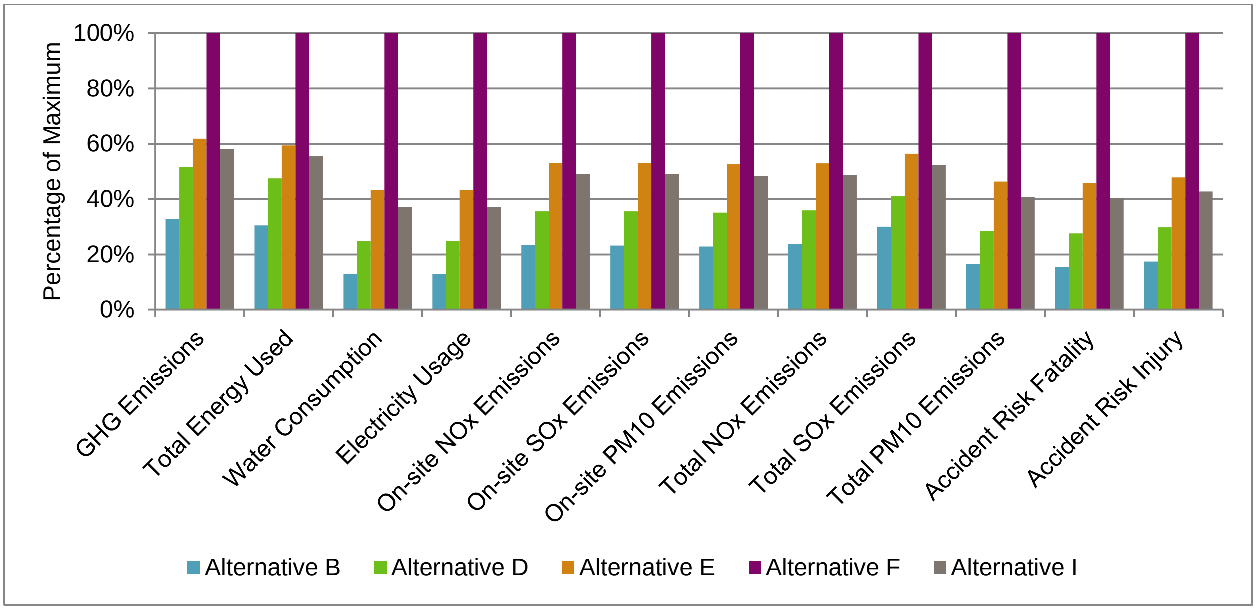

Figure 1 notes: The results for each metric quantified in SiteWise™, normalized to the largest alterative footprint (Alternative F).

Figure 2. GHG Emissions vs. Dredge Volume

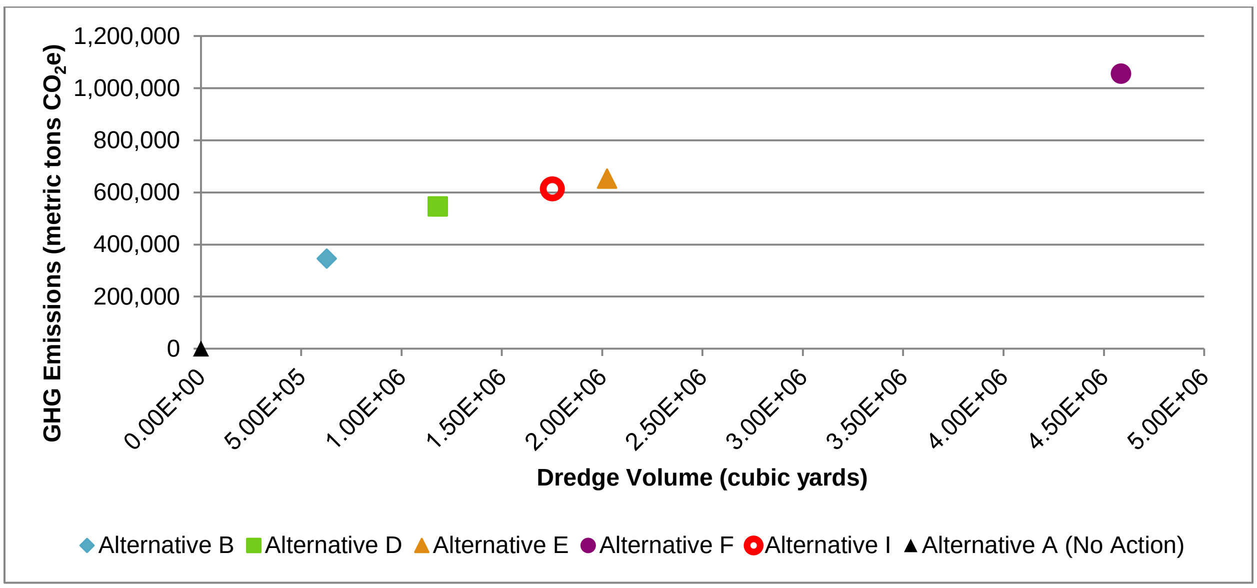

Figure 2 notes: For each remedial alterative evaluated, the total GHG emissions, expressed in tons of CO_2 equivalents (CO_2e), is plotted against the total sediment dredge volume, expressed in cubic yards.

After each metric is quantified, SiteWise™ assigns an impact category (i.e., high, medium, or low) to each alternative relative to the others based on the quantified values for all alternatives. For each metric, the tool assigns "high" to the highest alternative, then adjusts the rating for the other alternatives to "medium" or "low" based on a 30 percent relative percent difference in the values between alternatives (NAVFAC 2015). The tool does not currently assign relative impact ratings for the two accident risk metrics; these were assigned manually using the same 30 percent relative percent difference methodology. Table 4 provides a summary of the relative impacts for each metric. Quantified results are presented in Appendix A.

Table 4. Environmental Footprint Relative Impacts

Remedial Alternatives	GHG Emissions	Energy Usage	Water Usage	Electricity Usage	On-site NOx Emissions	On-site SOx Emissions	On-site PM10 Emissions	Total NOx Emissions	Total SOx Emissions	Total PM10 Emissions	Accident Risk Fatality	Accident Risk Injury
B	M	M	L	L	L	L	L	L	M	L	L	L
D	M	M	L	L	M	M	M	M	M	L	L	L
E	M	M	M	M	M	M	M	M	M	M	M	M
F	H	H	H	H	H	H	H	H	H	H	H	H
I	M	M	M	M	M	M	M	M	M	M	L	M

Table 4 notes**:** Numeric results for environmental footprint relative impacts are presented in Appendix A. GHG = greenhouse gas; NO_X = nitrogen oxides; SO_X = sulfur oxides; PM10 = airborne particulate matter; L = Low Impact (green shading); M = Medium Impact (yellow shading); H = High Impact (red shading). The H, M, and L categories were assigned based on 30 percent relative percent difference in the values between alternatives.

2.3.1 Impacts on Air

GHG emissions, as calculated by SiteWise™, include the contributions of CO_2, CH_4, and N_2O in units of metric tons of CO_2 equivalents (CO_2e). Figure 3 summarizes the GHG emissions for each remedial alternative, indicating contributions from major categories of remedial construction activities defined in SiteWise™. These categories include materials production (generation of capping and construction materials); transportation of equipment to the site, including materials transport; construction equipment operation; and residual handling, which includes off-site waste transportation. Alternative F has the greatest quantity of GHG emissions associated with remedial activities (over 1,000,000 metric tons CO_2e), with the most significant contributions from materials production (73 percent) and equipment use (18 percent), with a smaller proportion attributed to waste transportation, dewatering and disposal (i.e., residual handling), and transportation of equipment to the site.

For comparison, the carbon emissions of Multnomah County in 2013 totaled 7,695,000 metric tons CO_2e (City of Portland 2015). The total GHG emissions from the Portland Harbor alternatives ranged from 4.5 percent (Alternative B) to 13.6 percent (Alternative F) of the total emissions for all of Multnomah County. However, the emissions from the Portland Harbor remedial alternatives would be released over the duration of construction.

Figure 3. GHG Emissions by Construction Activity

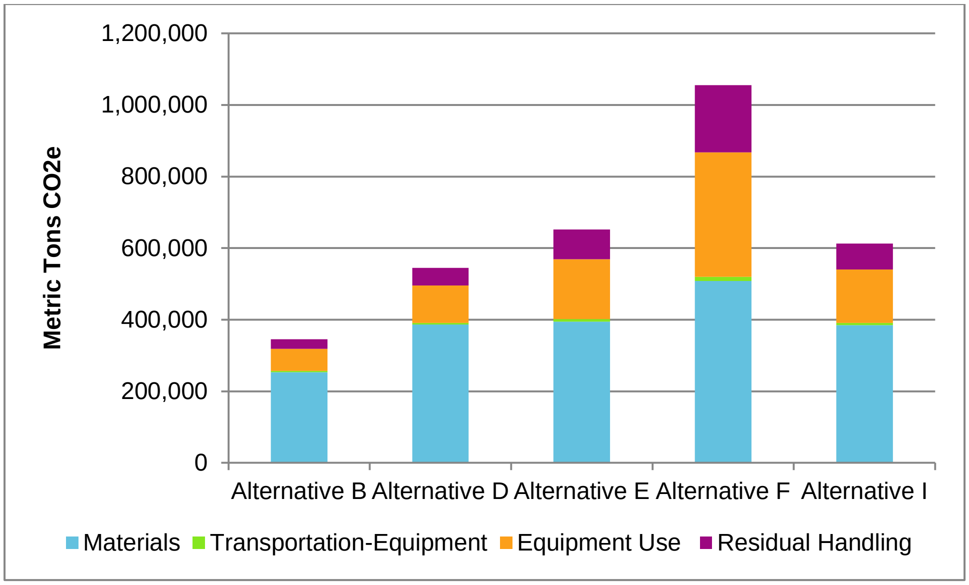

Figure 3 Notes**:** The total GHG emissions, expressed in tons of carbon dioxide equivalents (CO_2e), for each remedial alternative evaluated are presented with contributions from materials, equipment transportation, equipment use, and residual handling.

To help quantify the air impacts, a supplemental analysis was conducted outside of SiteWise™ in terms of ecological GHG offsets. The ecological footprint of each remedial alternative was equated to the acreage of Douglas-fir forest required to sequester the total amount of carbon (as CO_2e) generated by each alternative from the atmosphere in one year. This ecological footprint required for GHG sequestration ranged from approximately 37 acres for Alternative B to over 112 acres for Alternative F.

Figure 4 summarizes the quantities of total NO_X, SO_X, and PM10 emissions for each remedial alternative. The total quantities include those from on-site (equipment use), and off-site (material production and transportation of equipment and waste) activities. As with GHG emissions, Alternative F has the highest emissions of air pollutants among the four alternatives. The most significant contributions are from transportation and the disposal of waste (off-site). As such, the quantity of waste transported to landfills via trucks is a sensitive contributor to the overall environmental footprint of the selected remedy.

Figure 4. Air Pollutant Emissions

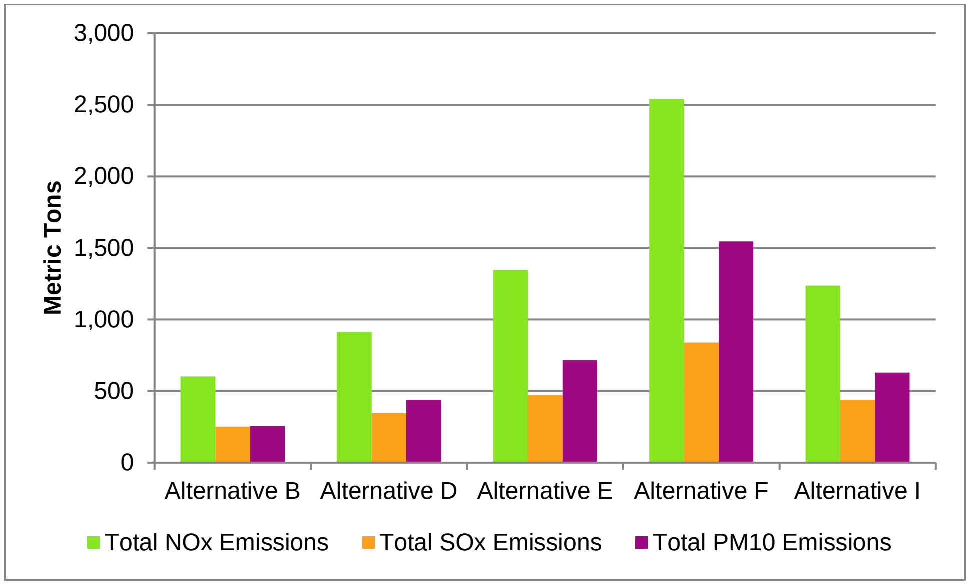

Figure 4 notes**:** The emissions of nitrogen oxides (NO_X), sulfur oxides (SO_X), and airborne particulate matter (PM10), expressed in metric tons, are presented for each remedial alternative evaluated.

Roosevelt Landfill, the facility designated for disposal of Subtitle D (non-hazardous) waste, is also accessible via rail. Using rail to transport non-hazardous waste would reduce GHG emissions for Alternative I by 20,228 metric tons, representing a 32 percent reduction in GHG emissions for waste transportation and 3.3 percent for the entire project. Using rail to transport non-hazardous waste also reduces worker accident risk for Alternative I by more than 11 recordable injuries (see Section 2.3.2 and Appendix B).

2.3.2 Worker Safety

SiteWise™ calculates accident risk for remediation construction activities in terms of numbers of worker injuries and fatalities expected to occur during remedial construction based on national average injury and fatality rates from the Bureau of Labor Statistics, Air Transportation Association, National Highway Transportation Safety Administration, and Federal Railroad Administration. Worker risks are calculated based on the types of construction equipment specified, distance traveled, number of personnel labor hours, and the category of labor specified (i.e., construction laborer, operating engineer, waste management services, and scientific and technical services). Figure 5 summarizes the estimated number of injuries and the number of lost work hours associated with those injuries for the duration of each remedial alternative. The largest contributors to the injury risks are construction equipment operation and waste transportation. Increased accident risks for each alternative are associated with increased dredging and capping equipment operation and increased truck miles driven associated with waste transportation and disposal. The worker risk metrics in SiteWise™ do not include risks to the public from construction activities, vehicle accidents, or exposure to contaminants.

Referenced injury and fatality rates in SiteWise™ were used for the calculation of injuries and fatalities for each remedial alternative. However, local conditions in an urban area and high traffic transportation corridor could increase the risks associated with road transportation (i.e., transportation of waste via trucks for the Portland Harbor alternatives).

Figure 5. Accident Risk – Injuries

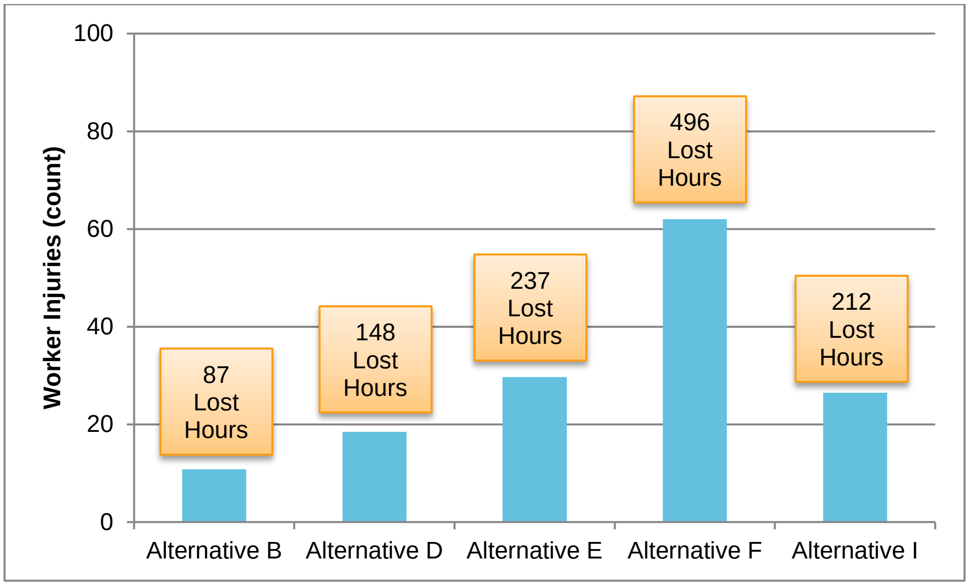

Figure 5 notes:
1. The estimated quantity of worker injuries is displayed for each remedial alternative evaluated.
2. The number of lost labor hours due to those injuries is also reported in the text box above each bar.
3. Lost hours metric is based on the Bureau of Labor Statistics median number of days away from work for non-fatal injuries (NAVFAC 2015).

2.3.3 Waste Generation

Waste transportation and disposal are addressed in the residual handling module of SiteWise™ and include an evaluation of the total quantity of waste disposed of as hazardous (i.e., Subtitle C under the Resource Conservation and Recovery Act [RCRA]) and non-hazardous (i.e., Subtitle D under RCRA), the distance traveled to each disposal facility, and the number of trucks required to transport the waste. Figure 6 summarizes the total quantities of Subtitle C and Subtitle D waste generated by each remedial alternative, representing the total quantities of debris and dredged material specified in the detailed cost estimates for each alternative (EPA 2016, Appendix G). Alternative F, which has the largest footprint among the alternatives evaluated in SiteWise™, would generate over 7,500,000 tons of waste (including dredged material and debris), equivalent to a volume that would overflow Portland's Moda Center (Portland's indoor sports arena) by nearly 25 percent (see Appendix B for calculations and references).

Figure 6. Waste to Landfill Disposal

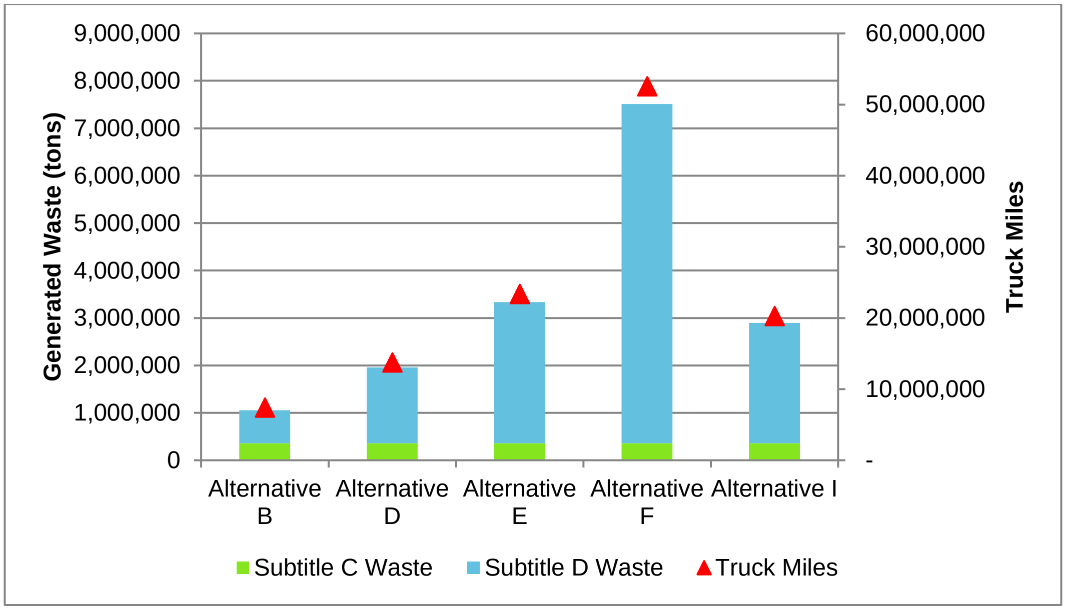

Figure 6 notes: The total quantity of waste, expressed in tons as a total of Subtitle D (non-hazardous) and Subtitle C (hazardous) waste, and total truck miles traveled for disposal are presented for each remedial alternative evaluated.

As shown in Figure 6, the total quantity of Subtitle C (i.e., hazardous) waste is 359,000 tons for each remedial alternative. The significant increases in total waste generation between alternatives is attributable entirely to increased disposal of Subtitle D (i.e., non-hazardous) waste (694,000 tons for Alternative B to over 7,000,000 tons for Alternative F. This disproportionate increase in waste quantities suggests that smaller alternatives provide similar levels of protectiveness while generating significantly smaller quantities of waste.

The 2016 EPA FS indicates that dredged sediment will be barged 70 miles to a planned transloading facility on the Columbia River near Bingen, Washington, and then transported 70 miles (one way) via trucks to either Arlington, Oregon (Subtitle C) or Roosevelt, Washington (Subtitle D). The number of truck trips required to transport waste to the two designated landfills ranges from 52,637 round trips (over 7 million truck miles) for Alternative B to 375,402 truck trips (over 52 million truck miles) for Alternative F. Each truck round trip to the landfill from the transloading facility is approximately 2.5 hours, not including standby, transloading, or off-loading time. With each increase in physical footprint between remedial alternatives (i.e., dredge volume and capping area), there are associated increases in waste generation, truck miles, and worker labor hours, thereby contributing increased environmental footprint and increased worker safety risks.

SiteWise™ results and supplemental calculations are included in Appendices A and B, respectively.

2.4 Best Management Practices

Air emissions, waste, energy, and particulate matter can be reduced during implementation by optimizing the equipment, staging, and sequencing of remedial activities (e.g., lower sulfur fuels, electric equipment), and setting clear expectations of the contractor regarding best management practices (BMPs) and equipment use (e.g., car-pooling, re-use of construction materials, idling restrictions). Many of these BMPs are described in EPA's Region 10 Clean and Green Policy (EPA 2009). These BMPs are expected to result in some incremental reduction of environmental impacts, but these benefits are small (i.e., 5 to 10 percent reduction) compared to the total environmental footprint of different remedial alternatives and technologies selected during decision-making.

This concept is illustrated in Figure 7 (presented at SURF 18 Meeting in Seattle, Washington by Seattle Public Utilities [Schuchardt 2011]), in which the CO_2 emissions for several sediment remediation technologies are estimated for a unitized site. For each technology, it is assumed that the site is 10 acres in size with contamination in sediment to a depth of 5 feet; waste (if generated) is transported via truck between Seattle and Roosevelt, Washington, with 50 percent volume creep and 50 percent beneficial re-use of dredged sediments. The stacked bars on the graph represent the total CO_2 emissions from remediation completed using each technology (total height of the bar) and the potential reductions in CO_2 emissions that could be achieved by implementing BMPs. For this example, BMPs included finer site characterization (i.e., to limit dredge and cap construction areas), maximization of rail use, and use of biofuels in trucks.

Figure 7 shows that the most effective way to reduce construction-related impacts that adversely affect air quality, such as CO_2 emissions, is by selecting a remedy that favors on-site remediation (e.g., capping, enhanced natural recovery [ENR]) and reducing the amount of dredge material transported long distances to a disposal site. Remedy selection will have a greater effect on short-term construction-related sustainability metrics than optimizing the use of BMPs during construction.

Figure 7. Carbon Dioxide Emissions Reductions Achieved by BMPs

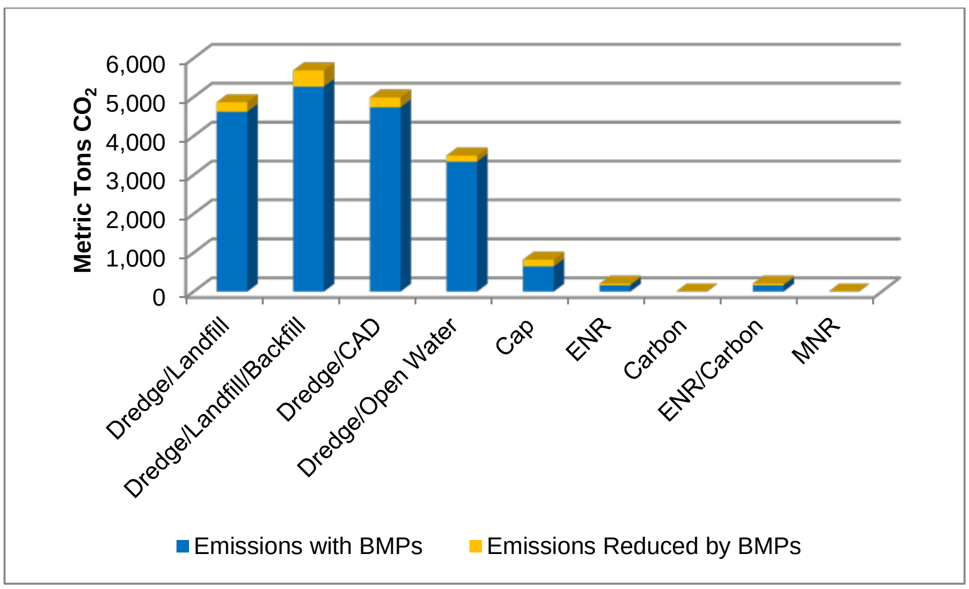

Figure 7 notes:

1. Quantities are normalized to a 10-acre site with 5 feet of sediment contamination. Dredge material is transported by truck from Seattle to Roosevelt Landfill, Washington.
2. The quantity of carbon dioxide (CO_2) emissions associated with various remedial technologies is shown in the blue stacked bar, with the portion of CO_2 emissions that could be reduced through implementation of best management practices (BMPs) shown in the yellow stacked bar. The quantity of CO_2 emissions, expressed in metric tons, is unitized for a 10-acre site with contamination depth of 5 feet, 50 percent volume creep, and waste transportation from Seattle to Roosevelt, Washington. CAD = confined aquatic disposal; ENR = enhanced natural recovery; MNR = monitored natural recovery.

3. GIS Disturbance Analysis

At many recent Portland Harbor neighborhood association meetings, local businesses expressed concern about the cost of cleanup, who will bear the cost burden of cleanup, and disturbance to their daily operations during construction (SEA Environmental Decisions, Ltd. & AECOM 2016). Other attendees expressed concern about river uses and public access. To address the latter concerns, this section quantifies different kinds of disturbance. Aerial photographs, maps, figures, and GIS layers from the City of Portland, 2016 EPA FS, 2015 EPA FS, or 2012 AnchorQEA Draft FS were used to evaluate and quantify various land use disturbances during remedy implementation. These included disturbance of shoreline infrastructure for businesses, water-dependent businesses, recreational area access, and high-value habitat areas during construction. Disturbances were quantified using GIS “overlap” mapping techniques as described below. To AECOM’s knowledge, this is the first FS evaluation to quantify business disturbance metrics, in particular, for a sediment site.

3.1 Methods

To quantify construction-related disturbances, the area of overlap between alternative-specific active remedial footprints (Alternatives B, D, E, and F, from the 2015 EPA FS and Alternative I from the 2016 FS) and water-related infrastructure, business, recreational, and habitat areas or shorelines were calculated. The “active” remedial footprint was defined as the sum of dredging, capping, treatment, and ENR areas plus a 25-foot buffer surrounding the active remedial areas to account for equipment needs, in-water staging, and cut-back slopes. The additional buffer also accounts for nearshore connectivity with the remedy. The GIS layers included in the disturbance analysis are as follows:

- Remedial Areas: Active remedial footprints of Alternatives B, D, E, and F from the 2015 EPA FS and Alternative I from the 2016 EPA FS.[2]

- Shoreline Infrastructure for Businesses: Infrastructure areas including primary, secondary, and tertiary infrastructure from the City of Portland Planning Department’s North Reach Specialized Infrastructure Access Map (City of Portland 2007). Upland parcels identified as primary and secondary are marine/rail infrastructure users. The report does not provide criteria for the primary and secondary marine/rail infrastructure users, but these areas appear to link with transloading from barge/ship to rail and truck (based on review of aerial photos). Remaining shoreline areas are designated as “rest of river,” much of which is undeveloped and vegetated. The primary and secondary upland parcels were used in this analysis. Results were calculated as linear feet (LF) of overlap with shoreline.

- Water-Dependent Businesses: Overwater structures including docks, pilings, marinas, and piers from the 2012 FS. A private berthing area layer was not developed in GIS for the 2012 AnchorQEA Draft FS, so the overwater structure layer included a 100-foot buffer distance

[2] Active remedial footprint for Alternative I was hand-digitized in GIS using Figures 3.8-9B through 3.8-9F from the 2016 EPA FS. AECOM does not have GIS layers for the 2016 EPA FS.

intended to account for berthing and mooring areas.[3] Results were calculated as the area of overlap in square feet (SF).

- Recreational Access (beach, bike, public park, and boat access to the shoreline): GIS layers included beach areas identified in the human health risk assessment for human health direct contact scenarios, and bike, public park, and boat access shoreline identified by the City of Portland (Kennedy/Jenks 2013; City of Portland 2014). Results were calculated as LF of overlap with shoreline.

- Nearshore high-value habitat: The high-value nearshore habitat area is defined by National Oceanic and Atmospheric Administration (NOAA) designation as the area extending from +13 feet North American Vertical Datum 1988 (NAVD88; top of bank, vertical boundary of the active channel margin) down to -15 feet NAVD88 elevation (bottom of the main channel shallow water zone). These areas are defined only by bathymetry elevations, and not by visual field surveys to confirm that habitat is present. The 2009 bathymetry survey (AnchorQEA 2012) was used for this analysis and was converted to NAVD88. Results were calculated as the area of overlap in SF.

Other disturbance indicators evaluated but not included as metrics in the NEBA cost-benefit analysis are detailed in Section 3.3.

3.2 Disturbance Results

The extent[4] of construction-related disturbances was estimated by the amount of overlap between the alternative-specific active remedial footprint and four separate land use features: (1) upland shoreline perimeter of infrastructure marine/rail business users to quantify business disturbance, (2) overwater structures to quantify business disturbance, (3) human recreational access, and (4) high-value nearshore habitat areas to quantify ecological disturbance. Alternative-specific disturbances to these land- and water-use features are summarized in Figure 8. Results for Alternatives B, D, E, F, and I are described below. Tabulated results and GIS overlap figures are provided in Appendix C.

3.2.1 Impacts on Business Activities

There is approximately 137,537 LF of shoreline in the study area (both sides of river), and 106,835 LF (78 percent) of the shoreline is designated for primary and secondary business activities (City of Portland 2007). Up to 54 percent of the infrastructure along the river would be impacted by the active remedies (Alternative F); the larger alternatives would have over two times more impact on water-dependent shoreline infrastructure sometime during the construction period compared to the smaller alternatives (Alternative B, 22 percent disturbance). The active remedial footprint perimeter overlap with adjacent upland infrastructure parcels is provided in Table C-1 (Appendix C). Infrastructure overlap areas for Alternatives B and I are shown in Figures C-1a and C-1b.

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[3] The overwater structures layer does not include vessels that may berth directly along a bulkhead (dock-side berthing); therefore, the overwater structure layer may underestimate the vessel traffic and mooring activities in the Lower Willamette River. The "Shoreline Infrastructure Mapping" should account for dock-side berthing and may be more representative.

[4] The extent of a construction-related disturbance indicates the amount of area that will be disturbed at any point during the construction timeframe. There is no temporal component in the disturbance analysis. However, it is likely that the length of the disturbance will be proportional to the size of the site.

The active remedial footprint overlap with overwater structures is provided in Table C-2 (Appendix C). The size of the cleanup area is approximately 95.5 million SF and 31.4 million SF (33 percent) have overwater structures present (including buffer for berthing areas). GIS maps of the overlap with these structures are shown in Figures C-2a and C-2b. Up to 22 percent of overwater businesses would be impacted by the remedies (Alternative F); the larger alternatives would have over two times more impact on water-dependent business operations compared to the smaller alternatives (Alternative B would impact only 9 percent of overwater structures). The extent of business disturbance is likely underrepresented by this metric because only those structures extending into the river were included; dock-side operations were not included in the footprint. Therefore, the in-water disturbance is considered a subset of the infrastructure impacts described above.

3.2.2 Recreational Disturbance

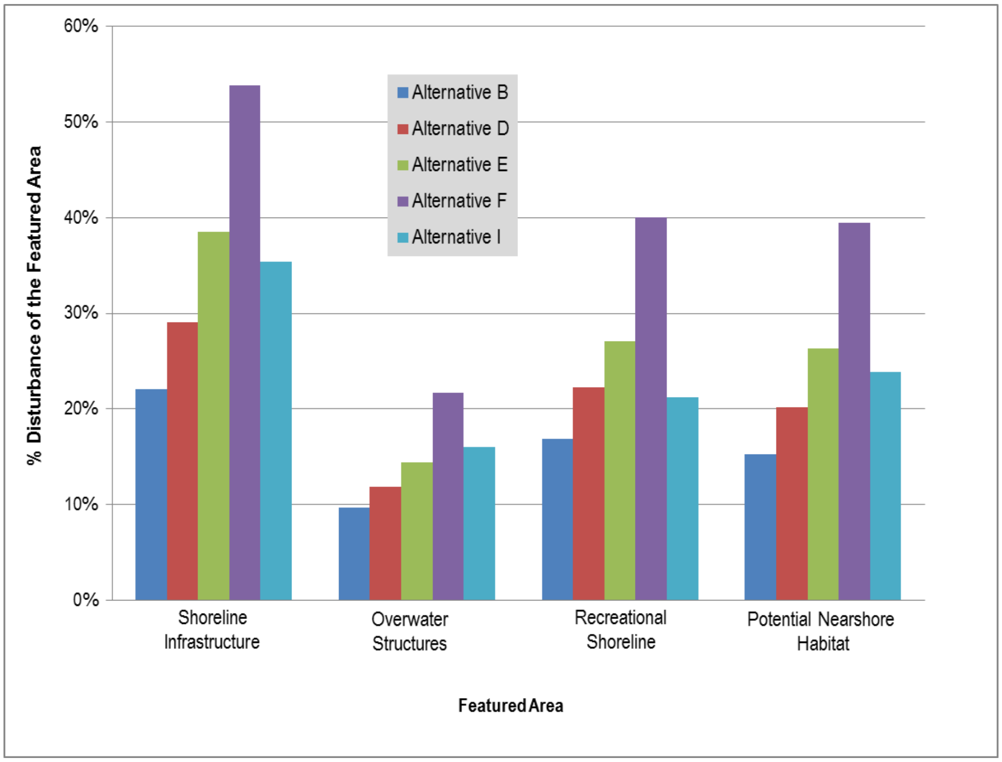
Recreational areas and access to river for humans represent approximately 17 percent of the shoreline. Only two boat ramp access points were identified in the 2015 EPA FS. Up to 40 percent of recreational access areas would be impacted by the remedies (Alternative F); the larger alternative (Alternative F) would have over two times more impact on recreational shoreline compared to the smaller alternative (Alternative B, 16 percent disturbance). The remedial footprint overlap with recreational shoreline is provided in Table C-3 and shown in Figures C-3a and C-3b (Appendix C).

3.2.3 Ecological Disturbance

Approximately 20.6 million SF of this nearshore habitat area are above -15 feet NAVD88 elevation, or approximately 22 percent of the study area. The active remedial footprint area overlap with nearshore habitat area is provided in Table C-4 (Appendix C). Up to 39 percent of the habitat area, as defined above, would be impacted by the largest alternative analyzed (Alternative F); Alternative F would have over two times more impact on potential habitat areas compared to the smallest alternative (Alternative B, 15 percent disturbance). The nearshore high-value habitat area and the overlap with the Alternative I remedial footprint are shown in Figure C-4.

It is important to note that ecological disturbance is expected throughout the construction duration, so remedies with longer construction times will have greater ecological impacts. However, not all spatial areas are expected to be impacted to the same degree year-after-year depending on where the dredge and capping operations are being staged each season.

Figure 8. Disturbances to Featured Areas



3.3 Other Types of Disturbance

Other types of disturbance evaluated in this report include truck traffic, bridge openings, barge traffic, utility crossings, and archaeological sites.

Truck traffic, quantified in Section 2, is a sensitive metric and important to stakeholders, as expressed by stakeholders at numerous public meetings (SEA Environmental Decisions, Ltd. & AECOM 2016). However, most of the truck traffic related to remedy implementation will occur outside of the urban footprint of Portland based on preliminary EPA transloading plans. Most of the dredge material and the backfill source material will come to the Portland Harbor Superfund Site by barge. Therefore, barge traffic was analyzed as a local disturbance to recreational boaters and commercial transport. Currently, approximately 1,000 self-propelled dry cargo one-way trips per year occur on the Lower Willamette River (USACE 2016). During construction, barge traffic (for dry cargo transport of dredge material and cap/backfill import material) will increase by approximately 260 to 460 one-way trips annually.[5] Therefore, construction would increase the amount of barge traffic by a factor of 2.5. However, traffic for all types of vessels is approximately 14,000 trips per year; therefore, construction-related barge traffic would not have a substantial effect on the total vessel traffic (~10 percent increase during construction).

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[5] *The approximate barge trips are calculated assuming a 3,000-ton barge and a sediment density of 1.5 tons/cy. Barge trips are based on volumes used for cost estimates (i.e., 1.75 x volume multiplier).*

Bridge openings were also explored to quantify disturbance to the Portland urban area and traffic patterns as a result of increased barge traffic. However, all three bridges located between RM 1.9 and 11.8 are tall (55 to 205 feet) and do not require opening to allow passage of material barges and other on-water construction-related equipment. The steel bridge (for railroad and light rail) has a lower clearance (26 feet above the water line when closed) but is located upstream of the Superfund Site at RM 12.1.

Disturbance of buried utilities by the remedial alternatives' active footprints was also explored. There are utility crossings at RM 2.8 and RM 11.5 based on limited review of NOAA electronic navigational charts (US1WC01M) and Portland General Electric cable crossing data; however, all remedial alternatives are affected equally by these utility crossings (Appendix C, Figure C-5). Utility overlap is not a sensitive indicator among remedial alternatives. Additional utilities may exist but were not identified in the 2012, 2015, or 2016 FS documents.

An archaeological records search was conducted by AECOM using the State Historic Preservation Office Oregon Archaeological Records Remote Access database to determine the extent of previously recorded archaeological resources within the study area. Eight archaeological resources are located in-water or along the riverbank of the study area, and all remedial footprints have similar overlaps with these sites. The archaeological overlap is therefore not a sensitive indicator.

The additional disturbance metrics described above were not sensitive endpoints and therefore were not included as environmental metrics in the NEBA cost-benefit analysis (Section 5).

4. Risk Reduction

At many of the recent Portland Harbor stakeholder outreach meetings,[6] attendees have asked, "*What I am going to get for this cleanup? Will it be safe to eat fish?*" (SEA Environmental Decisions, Ltd. & AECOM 2016). This section summarizes Time 0 post-remediation human and ecological risks presented in the 2016 EPA FS to address these concerns.

- **Post-construction (Time 0)** risk represents conditions immediately following completion of active remedial construction. Because each remedial alternative has a different construction length, Time 0 will refer to a different date for each alternative.

- **Residual risk** is defined as the risk that will remain on-site 45 years after completion of remediation or once PRGs have been achieved. Residual risks include risks to humans, wildlife, and the benthic community from surface sediment contaminant concentrations remaining on-site at the completion of remediation.

The 2016 FS did not present residual risks over time (e.g., 45 years after construction completion, or Time 45). This site may have additional incremental changes in risk over time as a result of additional natural recovery and/or subsequent inputs from the watershed, but these incremental changes in risk have not been predicted by EPA.

4.1 Risk Calculation Methods

Evaluation of human health background risks used the methodology and assumptions presented in the baseline human health risk assessment (Kennedy/Jenks 2013). Human health post-construction risks for the remedial alternatives were calculated using predicted contaminant concentrations in surface sediment at the completion of construction (EPA 2016). Risks were calculated for human health direct contact (Tribal fisher) [Remedial Action Objective (RAO) 1] and consumption of contaminated fish and shellfish (subsistence adult, subsistence child, nursing infant) [RAO 2] for risk driver chemicals.[7] Risk driver chemicals for the human health exposure pathways include polychlorinated biphenyls (PCBs), dioxins and furans, arsenic, polyaromatic hydrocarbons (PAHs), DDx, and other chemicals.

For the evaluation of ecological endpoints, risks to the most sensitive receptor were evaluated for direct contact [RAO 5] and ingestion [RAO 6] pathways for the risk-driver chemicals in the sediment. Risk driver chemicals for ecological receptors via direct contact include PCBs, total PAHs, DDx, BEHP, chlordanes, lead, and mercury and for ecological receptors via fish/shellfish ingestion include 4,4-DDE, PCBs, HxCDF, PeCDF, TCDD, and TCDF. Direct contact ecological risks are presented as acres where unacceptable benthic risk remains immediately after construction. Ecological risk calculations used processes consistent with the baseline ecological risk assessment (Windward Environmental LLC 2013). However, one key limitation of this analysis is that risks were only quantified at Time 0 based on

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[6] 1/26/16 Community Action Group/EPA public meeting; 1/27/16 Northeast Coalition of Neighborhoods Land Use/Transportation Committee meeting; 2/8/16 Audubon Society meeting; 2/9/16 League of Women Voters meeting, 2/23/16 CAG/EPA Linton public meeting.

[7] The 2015 EPA FS quantified risks for both the recreational and Tribal receptors; this was changed to subsistence level consumers in the 2016 EPA FS. See the Baseline Human Health Risk Assessment for an evaluation of background and post-construction risk using a probabilistic risk assessment approach.

estimated SWACs, and not from 5 years to 45 years after construction completion, because a predictive model has yet to be approved by EPA.

For the purposes of developing sediment management areas (SMAs) in the FS, EPA identified a short list of "focused COCs" that includes PCBs, total PAHs, 1,2,3,7,8-PeCDD, 2,3,4,7,8-PeCDF, 2,3,7,8-TCDD, and DDx.

4.2 Post-Construction Risks (Time 0)

The Time 0 post-construction risks for Alternatives A (baseline, no action), B, D, E, F, and I are presented in Table 5. The post-construction risks are compared to the long-term target risk levels established for the Portland Harbor Superfund Site (EPA 2016), which include (under Oregon Administrative Rules 340-122-0040(2)(a)): 1 in 1,000,000 (1×10^{-6}) lifetime excess cancer risk for individual carcinogens; 1 in 100,000 (1×10^{-5}) cumulative lifetime excess cancer risk for multiple carcinogens; and a hazard index[8] (HI) of 1 for non-carcinogens. Some incremental benefits are predicted with sequentially larger alternatives (e.g., the post-construction risk is lower for Alterative F than for Alternative D); however, none of the alternatives are predicted to achieve all of the risk-based goals for the project. Further, the direct contact and fish consumption carcinogenic risks and child non-cancer HIs are within the same order of magnitude for all active remedial alternatives (and well within the uncertainty for such a calculation; e.g., tenfold uncertainty in the toxicity factors), indicating that additional remediation acreage will achieve only marginal additional risk reduction.

Predicted risk outcomes for RAOs 1, 2, 5, and 6 immediately post-remediation (Table 5) are described below[9]:

- Alternatives E, F, and I achieve RAO 1 (human health – direct contact with sediment) immediately post-construction. Some of the other alternatives may also reach RAO 1 over time if natural recovery processes are considered in the passive remedial footprints.

- None of the alternatives achieve RAO 2 (human health – consumption of fish/shellfish). RAO 2 includes the human fish and shellfish consumption carcinogenic risk, child non-cancer HI, and nursing infant non-cancer HI. Post-construction risks for all alternatives are in the 10^{-4} range (range from 1×10^{-4} to 4×10^{-4}) and approximately one order of magnitude above the long-term cumulative risk goal (1×10^{-5}) and EPA's residual risk which is driven by background (8×10^{-5})[10].

- None of the alternatives achieve RAO 5 (ecological – direct contact), which has a goal of zero acres remaining with unacceptable benthic risk (HI = 1). Areas with unacceptable benthic risk immediately after construction range from 168 acres for Alternative F to 670 acres for Alternative B.

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[8] *A hazard index (HI) represents the sum of individual contaminant hazard quotients (HQs).*

[9] *RAOs 3 and 4 (human health – surface water and groundwater, respectively) and RAOs 7 and 8 (ecological – surface water and groundwater, respectively) were not evaluated in this report.*

[10] *EPA FS Report. June 8, 2016. Appendix J.*

- None of the alternatives achieve RAO 6 (ecological – consumption of fish/shellfish) which has an HI risk goal of 1. HI for RAO 6 ranges from 15 for Alternative F to 34 for Alternative B immediately after construction completion.

Table 5. Human Health and Ecological Post-construction Risks

Post-Construction Risk (Time 0 immediately after construction))		Site-wide Remedial Alternatives						Long-Term Goal
		A **No Action**	B	D	E	F	I	
Human carcinogenic post-construction risks	RAO 1: Direct Contact to Tribal Fisher - Cumulative Carcinogenic Maximum Risk (river-mile scale)	4.0E-04	5.0E-05	2.0E-05	1.0E-05	1.0E-05	1.0E-05	1.0E-05
	RAO 2: Subsistence Angler Consumption of Fish/ Shellfish – Cumulative Carcinogenic Risk (site-wide)	2.0E-03	4.0E-04	3.0E-04	2.0E-04	1.0E-04	2.0E-04	1.0E-05
	RAO 2: Subsistence Angler Child Consumption of Fish/ Shellfish – Cumulative Non-cancer Hazard Index (site-wide)	138	38	29	21	12	21	1
	RAO 2: Nursing Infant Consumption of Fish/ Shellfish – Non-cancer Hazard Index (site-wide)	3,333	810	619	446	268	454	
Ecological post-construction risks	RAO 5: Direct Contact to Ecological Receptors: Acres where unacceptable benthic risk continues	1,289	670	464	348	168	464	0[a]
	RAO 6: Ecological Fish/ Shellfish Consumption – Maximum Hazard Quotient (river-mile)	138	34	19	15	15	19	1

Table 5 notes: Post-construction risks are from the 2016 EPA FS. Cumulative carcinogenic risk is the sum individual carcinogenic risks (EPA 2016). Post-construction risks are presented as site-wide or on a river-mile scale in river segments. (a) The RAO 5 goal is 0 acres remaining with unacceptable benthic risk. Unacceptable benthic risk is quantified by a hazard index greater than 1 (HI>1). Interim targets were included in the 2016 EPA FS. The interim target and long-term goal for RAO 1 are both $1x10^{-5}$. The interim target goal for RAO2 is $1x10^{-4}$ for cancer risk, HI=10 for non-cancer hazard, and HI=1,320 site-wide for nursing infant.

The increased costs of the larger alternatives do not correspond to large proportional increases in human health benefit and risk reduction at Time 0 (Figures 9a and 9b). Alternative B has the largest risk reduction (RAO 2) for the cost. For alternatives larger than Alternative B, there is a point of diminishing returns in the risk-benefit of larger remediation expenditures. In addition, all remedial alternatives will likely reach similar risk levels over time (see draft analysis from 2012 AnchorQEA Draft FS, and Lower Duwamish Final FS [AECOM 2012]) and none of the alternatives will achieve background risk immediately post-construction (using EPA assumptions of background). However, EPA has not yet approved a model that can predict temporal differences between the alternatives.

As stated in the US Navy guidance (NAVFAC 2012), when a remedial technology is not effective in meeting the remedial goals and achieving the required level of protectiveness, the technology is simply not sustainable. In terms of risk reduction, a sustainable remedy should have cleanup goals that are risk-based, that are achievable in a reasonable restoration time, and that consider the ongoing contributions of background concentrations (both natural and anthropogenic). Active and energy-intensive remedial options are still applicable in suitable situations, appropriate target areas, and with transparent exit strategies developed for the rest of the site. The post-construction risks have been included in the NEBA under long-term effectiveness.

Figure 9a. Fish/Shellfish Consumption Risk (Subsistence Angler Cumulative Carcinogenic Risk) vs. Cost for Remedial Alternatives

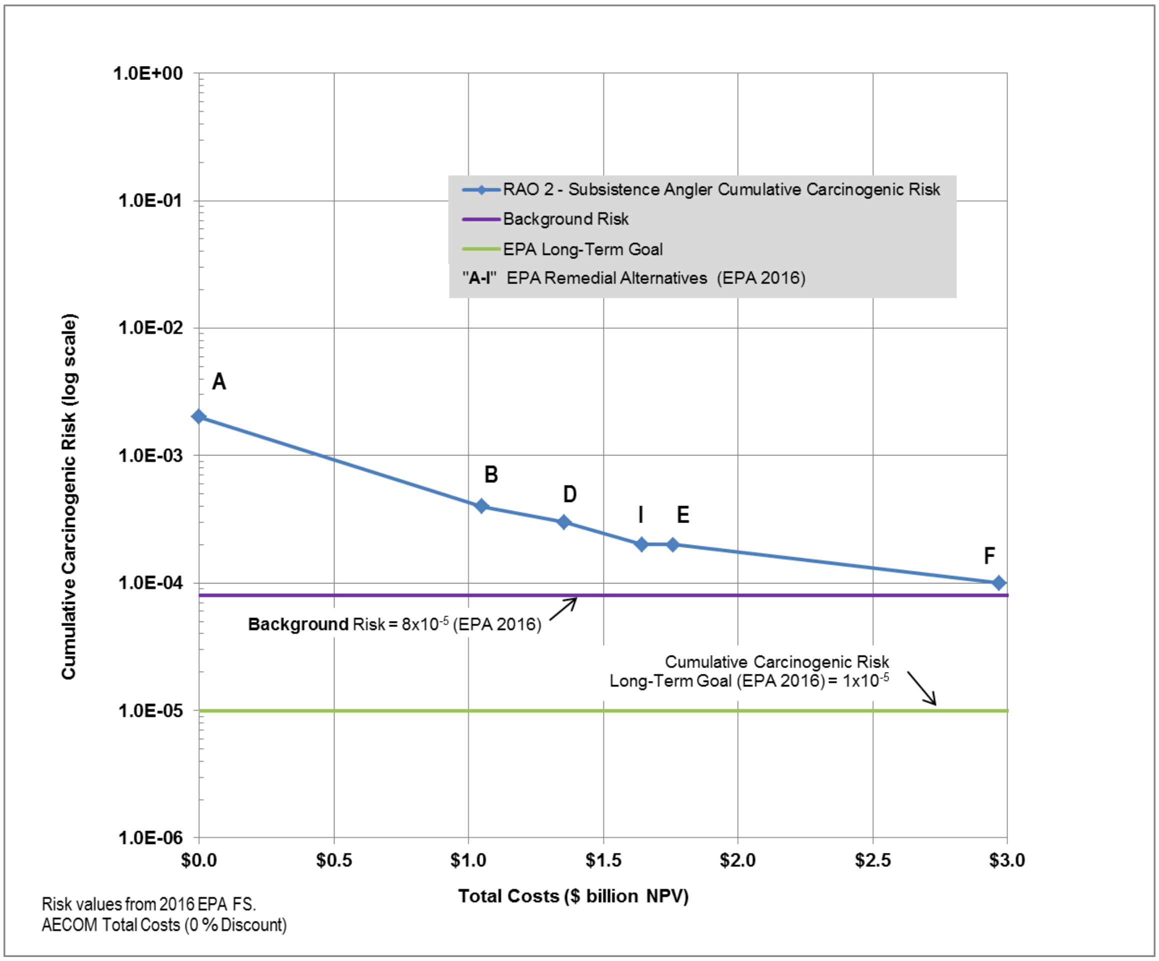


Figure 9b. Fish/Shellfish Consumption Risk (Subsistence Child Cumulative Hazard Index) vs. Cost for Remedial Alternatives

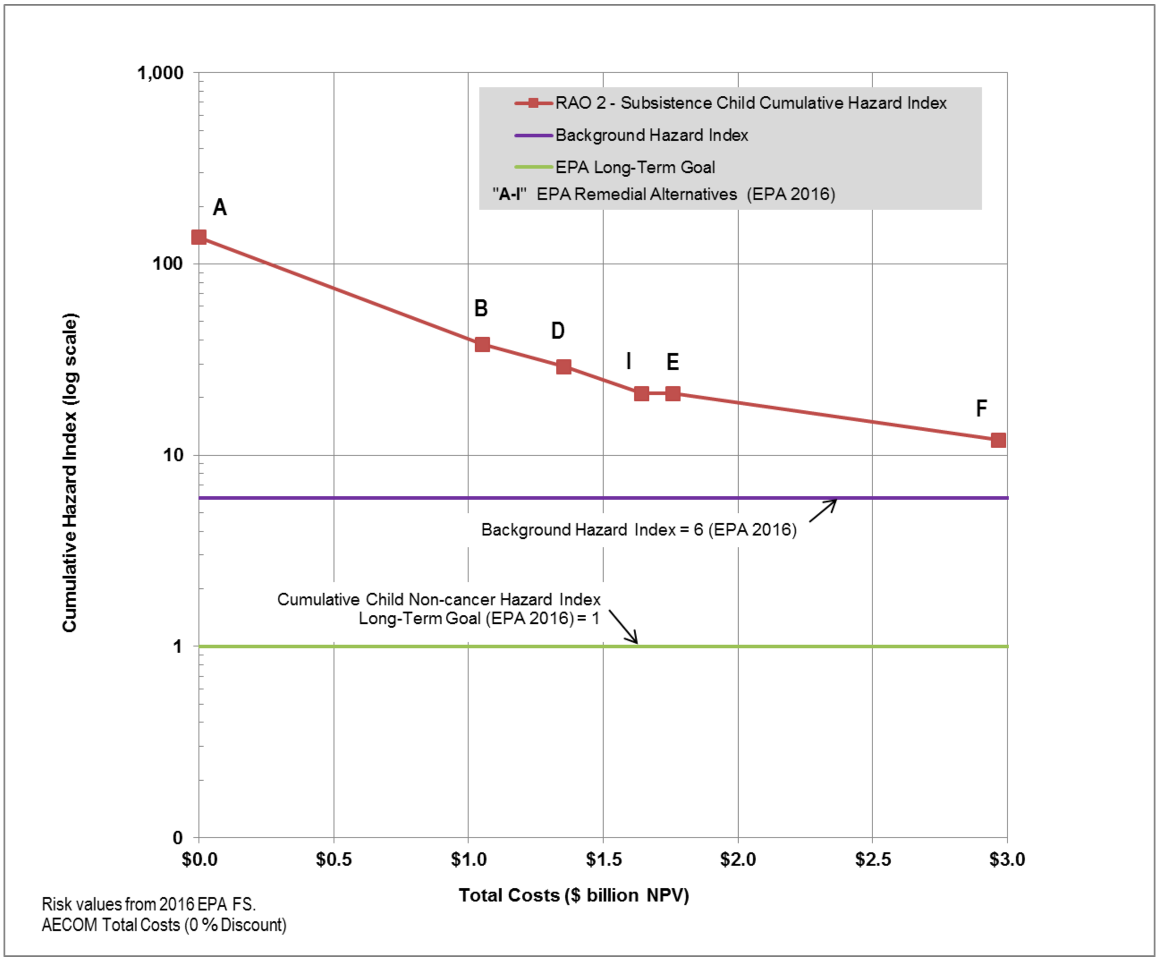


Figure 9a & 9b notes: The Tribal angler cumulative carcinogenic post-construction risk (9a) and the Tribal child cumulative hazard index (9b) as a result of consuming fish and shellfish (RAO 2) at Time 0 are plotted versus the EPA costs (0 percent discount). The increased cost of the larger-scope alternatives does not show large proportional increases in human health benefit.

5. Net Environmental Benefit and Cost-Benefit Analysis

A NEBA is a value-based analysis that quantifies and compares remedial alternatives' benefits or gains in human and ecological domains due to the remedial action (e.g., residual risk, permanence) minus the environmental impacts due to the remedial action (e.g., air impacts, disturbance, costs) (NAVFAC 2012; DOE 2003). The NEBA presented in this report evaluates trade-offs among remedial alternatives presented in the EPA 2016 FS (B, D, E, F, and I) using selected evaluation criteria to determine the overall environmental benefit compared to the costs of implementing the remedies. The NEBA calculation table is presented in Appendix D.

The NEBA can also identify those alternatives for which the implementation costs are disproportionate (or proportionate) to the environmental benefits achieved compared to a baseline of no action. Costs are considered disproportionate to benefits when the incremental costs of the alternative exceed the incremental benefits achieved by the alternative compared to benefits achieved by other lower-cost alternatives. Results can be used to identify approaches or remedies that provide for protection of human health and the environment and optimize environmental trade-offs, all in the context of cost.

Overall environmental benefit was determined for each remedial alternative by calculating an overall score based on the CERCLA remedy evaluation criteria. The CERCLA evaluation criteria scores were quantified by aggregating the scores of individual environmental metrics that reasonably reflected each criterion. The specific metrics that fall under each criterion's category are described in Section 5.3.

Scores for environmental metrics were scaled to the range of alternatives (Alternatives A, B, D, E, F, and I) or to a risk goal. The benefit scores were valued from 0 to 10, and there were no negative scores in this analysis.

The NEBA evaluation criteria used in this analysis were catalogued into six of the nine CERCLA criteria. These criteria fall under three categories: threshold, balancing, and modifying. The six CERCLA criteria used in this NEBA analysis are:

- Threshold Criteria:
  - Overall Protectiveness of Human Health and the Environment
- Balancing Criteria:
  - Permanence
  - Long-Term Effectiveness
  - Management of Short-term Risks
  - Technical and Administrative Implementability
- Modifying Criteria:
  - Consideration of Public Concerns

Cost is one of EPA's nine CERCLA evaluation criteria; however, in this analysis, the NEBA compares the benefits relative to the costs; therefore, costs were not weighted. The other two CERCLA criteria, compliance with Applicable or Relevant and Appropriate Requirements (ARARs) and state acceptance, were not quantified in this assessment. The NEBA assesses the environmental cost/benefit that can help make remedy decisions by the State of Oregon and EPA, and avoid remediation-related injuries and risks.

5.1 Methods

This section provides an overview of the NEBA steps and scoring process:

1) Select metrics for each NEBA evaluation criterion such that the metrics reasonably reflect the CERCLA criteria.

2) Quantify metrics that will be evaluated.

3) Determine metric endpoints and scale the benefit score from 0 to 10 (0 = worst; 10 = best). Negative values were not used to indicate impacts.

4) Determine the weighting of the metric.

5) Determine the weighting of the CERCLA evaluation criteria.

6) Sum the individual evaluation criteria scores into an overall benefit score.

7) Compare the overall benefit score to remedy costs.

In Step 1, individual metrics that reasonably reflected each CERCLA evaluation criterion were aggregated. Section 11 of the Lower Duwamish Waterway Final FS was used as a guide for the selection, aggregation, and measuring of each metric (AECOM 2012). The Lower Duwamish Waterway study was considered relevant because it was also done for an urban river located in the Pacific Northwest with many of the same contaminants, history, and endpoints as the Portland Harbor Superfund Site. The analysis generally followed the Washington State Department of Ecology Model Toxics Control Act guidance for developing a disproportionate cost analysis.

In Step 2, each environmental metric was quantified using several resources: the 2016 EPA FS (acres, volumes, costs, risk outcomes, and goals), the 2015 EPA FS (GIS layers), cost and construction time calculations by AECOM (Appendix E), GIS disturbance analysis, SiteWise™, and, if needed, the 2012 AnchorQEA Draft FS. Values were quantified for Alternatives A, B, D, E, F, and I based on remedial footprints presented in the 2016 EPA FS and 2015 EPA FS. The selected metrics and the source of information used to quantify reach metric are listed in Table 2. Twenty-five metrics were quantified for this analysis.

In Step 3, a benefit score was calculated for each metric from 0 to 10 ranking. The benefit score determined for each metric consisted of one or more components. For example, accident risk is the average of two components: the injury risk and the fatality risk. This allows multiple components of a metric to contribute to the benefit score. A “0” was the lowest possible score (non-negative) and a “10” was the best possible score. Each alternative was ranked between 0 and 10 relative to the endpoints selected for scaling. A score of 0 represents a poor-performing alternative for that metric, and a score of 10 represents an optimal performing alternative for that metric. In general, one endpoint for each metric scoring was Alternative A (“no action” or baseline) and the other endpoint was Alternative F (the largest-scope alternative considered in this analysis). However, for risk, the desired cleanup goal was selected for the “10” rank. Note that, depending on the basis for a metric’s scale, the alternatives may not always cover the full range (0 to 10) if they all have less-than-optimal results for that measure. The relative importance assigned to each metric was based on precedence from other studies and best professional judgment; however, scoring the “benefit” of each remedial alternative could be scored differently by different stakeholders (see SEA Environmental Decisions, Ltd. & AECOM 2016). To minimize potential bias and uncertainty, the metrics were quantitatively scaled to data available among the remedial alternatives.

In Step 4, each metric was given a metric weight that determines its contribution to the evaluation criteria benefit score. These metric weights, shown in Appendix D, were determined using the Lower Duwamish Final FS as a guide (approved by EPA Region 10), Portland Harbor stakeholder values, and best professional judgement. Once the weighted averages of the metric scores were calculated to produce the CERCLA evaluation criteria benefit scores (Step 5), an overall remedial alternative score was determined in Step 6. This overall score is the weighted average of the evaluation criteria benefit scores. The CERCLA criteria weighting is described in Section 5.2. Appendix D summarizes the metrics, evaluation criteria, weightings, and the benefits scores for all alternatives analyzed in the NEBA.

In Step 7, a total net benefit score was calculated for each remedial alternative, then this score was compared to the total remedial costs. A cost-effectiveness score was calculated as the ranking divided by the total cost.

5.2 Weighting of CERCLA Evaluation Criteria

The total benefit score is the weighted average of the CERCLA evaluation criteria benefit scores. The different weightings emphasize the core purpose of protecting human health and the environment and reflect site-specific considerations, such as the size, complexity, uncertainty, and potential restoration timeframes involved with the remedial alternatives. The weightings used in this analysis were based on AECOM’s understanding of remedial goals, best professional judgement, and precedent established at the Lower Duwamish Superfund site (AECOM 2012) and other sediment cleanup sites, as well as general stakeholder values expressed at public meetings. Evaluation criteria weightings from other sediment and non-sediment cleanup sites in Region 10 are shown in Table 6. The sum of the evaluation criteria weightings equals 100 percent. The evaluation criteria weightings are:

- Threshold Criteria:
    - “Overall protectiveness” represents the ultimate objective of implementing a remedial alternative. The overall protectiveness was weighted 25 percent, the highest amongst the criteria.
- Balancing Criteria:
    - The four balancing criteria, “permanence,” “long-term effectiveness,” “management of short-term risk,” and “technical and administrative implementability,” were weighted equally, each at 16.25 percent.
- Modifying Criteria:
    - “Consideration of public concerns” was assigned a weighting of 10 percent (increased from 5 percent in the Lower Duwamish Final FS). This weighting is based on the avid stakeholder interest in Portland Harbor expressed at public meetings, the importance of social indicators in this analysis, and precedent from other Washington State-led sites that also weighted public concerns at 10 percent (Table 6).

Table 6: NEBA Weighting Factor Comparisons

Evaluation Criteria	Federal or State	Year	Overall Protectiveness	Permanence	Long-term Effectiveness	Short-term Risks	Implementability	Consideration of Public Concerns	Cost
			Weighting Factors						
Sediment Projects									
Portland Harbor, NEBA from Sustainability Analysis for EPA 2016 Alternatives	CERCLA	2016	25%	16%	16%	16%	16%	10%	0%
Portland Harbor, Draft Feasibility Study	CERCLA	2012	Threshold Criteria	25%	25%	25%	25%	0%	0%
Cornwall Avenue Landfill in Bellingham, Remedial Investigation/Feasibility Study	State-WA	2013	30%	20%	20%	10%	10%	10%	0%
Lower Duwamish Waterway, Final Feasibility Study	CERCLA	2012	25%	20%	30%	15%	5%	5%	0%
Everett Shipyard, Draft Cleanup Action Plan	State-WA	2011	30%	20%	20%	10%	10%	10%	0%
Whatcom Waterway, Final Cleanup Action Plan	State-WA	2007	30%	20%	20%	10%	10%	10%	0%
Soil and/or Groundwater Projects									
Port of Longview Maintenance Facility Area, Remedial Investigation/Feasibility Study	State-WA	2015	14%	14%	14%	14%	14%	14%	14%
Former Reynolds Metals Reduction Plant in Longview, Remedial Investigation/Feasibility Study	State-WA	2015	25%	20%	20%	15%	10%	10%	0%
1440 Puyallup Avenue in Tacoma, Limited Feasibility Study/Disproportionate Cost Analysis	State-WA	2014	30%	20%	20%	10%	10%	10%	0%
Port of Seattle Terminal 30, Remedial Investigation/Feasibility Study	State-WA	2013	30%	20%	20%	10%	10%	10%	0%
General Electric 3422 1st Ave South in Seattle, Feasibility Study and Disproportionate Cost Analysis	State-WA	2013	14%	14%	14%	14%	14%	14%	14%

Table 6 notes**:** CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; TMV = Toxicity, Mobility, and Volume; State-WA = Washington State.

5.3 Evaluation Criteria and Metric Results

The following evaluations provide the basis for the numerical ratings for each metric in the NEBA. Each metric evaluation includes the unit used for each alternative (e.g., years, cubic yards, or acres), as well as the representative value that would receive a score from 0 to 10. The metrics, evaluation criteria, and aggregations are summarized in Table 7. Appendix D provides a summary of benefit rankings for each remedial alternative on a scale of 0 to 10 for each criterion.

Table 7. Evaluation Criteria and Metrics

CERCLA Evaluation Criteria	Metric Number	Metric Description
1. Overall Protectiveness of Human Health and the Environment	1a	Residual exposure at end of construction
	1b	Risks from implementation
2. Permanence	2a	Reduction in volume of contaminated sediment
	2b	Reduction in mobility of hazardous substances
3. Long-term Effectiveness	3a	Human carcinogenic and non-cancer risks
	3b	Ecological risks
	3c	Degree of certainty that the remedial alternative will be successful
	3d	Reliability of institutional controls and engineering controls used to manage risk
4. Management of Short-term Risks	4a	Implementation risks
	4b	Disturbance during construction

Table 7. Evaluation Criteria and Metrics (Continued)

CERCLA Evaluation Criteria	Metric Number	Metric Description
	4c	Accident risk during construction
	4d	Effectiveness of protective measures to manage short-term risks
5. Technical and Administrative Implementability	5a	Ability to construct and operate
	5b	Ability to monitor effectiveness based on cap and monitored natural recovery acres
	5c	Availability of specialists, equipment, and materials
6. Consideration of Public Concerns	6a	Best professional judgment based on meetings with the public. Used SOC-2 score from Social Pillar Analysis (SEA Environmental Decisions, Ltd. & AECOM 2016)

Table 7 notes**:** CERCLA-based net environmental scores were determined for each remedial alternative for six of the nine remedy evaluation criteria, each weighted according to their relative importance in the remedy selection. Among the remaining three CERCLA evaluation criteria not evaluated, “Cost” was evaluated but not included in the overall net benefit score because scores were compared to costs. “State Acceptance” and “Compliance with ARARs” were not included because they were difficult to quantify.

5.3.1 Overall Protectiveness of Human Health and the Environment

Protectiveness of human health and the environment was evaluated based on the degree to which existing site risks are reduced, the time required to reduce those risks and to achieve cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality. In summary, overall protectiveness is measured by each alternative’s ability to reduce both long- and short-term risks. For Portland Harbor, protectiveness was quantified using two metrics:

- **Exposure at the End of Construction (Metric 1a):** The first metric evaluates the average reduction in SWACs for the focused COCs[11] on a site-wide basis following construction. A low score of 0 represented 0 percent average SWAC reduction (i.e., Alternative A), and a high score of 10 represented a 76 percent average SWAC reduction (i.e., Alternative F). Average SWAC reductions are presented as individual COC SWAC reductions occurring immediately after construction has finished. Although alternative-specific average SWAC reductions occur at different times, this was not factored into the ranking. For example, a 56 percent average SWAC reduction would occur after 5 years of construction for Alternative B, and a 76 percent average SWAC reduction would occur after 26 years of construction for Alternative F. Natural recovery processes were not factored into the ranking. The alternatives with a higher percentage of average SWAC reductions score higher than the alternatives with a lower percentage of average SWAC reductions, regardless of the length of construction.

[11] Focused COCs include PCBs, Total PAHs, DDx, TCDD, PeCDD, and PeCDF. SWAC reductions from MNR are not considered. Each alternative has a different construction time.

- **Risks from Implementation (Metric 1b):** Implementing the remedial alternatives introduces construction-related environmental risks such as mobilization of contaminants during construction. Risks from implementation include a number of factors that are proportional to the total construction time. Risks to the community, construction workers, and the environment are simplified into one metric (the construction time) that represents several metrics such as impacts on workers and the community from dredging and transporting sediment and capping materials, air pollution generated, depletable resources consumed, expected short-term increases of contaminant concentrations in fish and shellfish tissue in Portland Harbor, releases of contaminants from the site, and disruptions to aquatic habitat. A score of 0 represents the longest construction time frame of the remedial alternatives (Alternative F: 26 years); a score of 10 represents no construction (Alternative A: 0 years). The alternatives with a shorter construction period score higher than the alternatives with a longer construction period.

The exposure at the end of construction (Metric 1a) is 4/5 of the overall criterion score. The risk from implementation (Metric 1b) is 1/5 of the overall criterion score. These weighting factors express the relative importance of the metrics using best professional judgment. Overall, the result is that the alternatives have similar scores because the implementation risks for long construction periods balance the long-term SWAC reduction and permanence.

5.3.2 Permanence

Permanence was evaluated based on the potential for exposure of subsurface contamination left in place following remediation, and the degree to which site media are treated to permanently reduce the toxicity, mobility, and volume of site contaminants. In general, remedial alternatives that emphasize the removal of contaminated sediments have a lower potential for subsurface sediment to be exposed than alternatives emphasizing capping, ENR, *in situ* treatment, and MNR. For this analysis, the weighted average of the following two metrics was selected to represent permanence.

- **Reduction in the Mass of Contamination (Metric 2a):** The first metric evaluated the magnitude of subsurface contamination remaining in place by assigning a benefit score related to the mass of PCB contamination removed from Portland Harbor. The average site-wide PCB SWAC (EPA 2016) and the blended volume of sediment removed (between the 2016 EPA FS low and high removal volume estimates) were used to calculate mass of PCBs removed, and therefore the benefit scores. This metric was scaled from 0 kilograms (kg) PCBs removed (score 0), for no sediment removal (i.e., Alternative A), to 289,305 kg PCBs removed (score 10),[12] based on the largest amount of contamination removed for the remedial alternatives evaluated in this analysis (i.e., Alternative F). For this metric, a higher benefit score is given to alternatives that remove a higher mass of PCBs from Portland Harbor.

- **Reduction in Mobility of Hazardous Substances (Metric 2b):** The second metric ranks the reduction in contaminant mobility based on the weighted average of the acreage for each technology used in the Portland Harbor cleanup area. For this analysis, removal

[12] *Score 10 does not indicate that all PCB contamination is removed from Portland Harbor. Score 10 indicates the maximum PCB mass removed among the alternatives evaluated in the NEBA (Alternative F).*

(dredging and dredge/cap) was assumed to reduce mobility more than the other technologies (score of 9); capping, *in situ* treatment, and ENR were assumed to reduce mobility more than a moderate amount (score 6); and MNR was assumed to reduce mobility to a lesser degree (score 1). Burial is the mechanism by which ENR and MNR reduce mobility; monitoring and adaptive management (i.e., contingency actions) ensure that contaminated sediment is sufficiently immobilized. *In situ* treatment further reduces mobility by adding amendments that bind or retard contaminants. This metric scores similarly to the previous metric; the removal-emphasis alternatives score significantly higher than the combined-technologies alternatives; and the alternatives with larger active footprints score higher than the alternatives with smaller active footprints.

The reduction in the volume of contaminated sediment (Metric 2a) is 1/3 of the overall criterion score. The reduction in the mobility of hazardous sediments (Metric 2b) is 2/3 of the overall criterion score. Metric 2b is assigned a higher weight due to the importance of risk-based remedies according to EPA guidance (EPA 2005). Overall, the result is that the removal-emphasis alternatives score higher than the combined-technologies alternatives, and the alternatives with larger active footprints score higher than the alternatives with smaller active footprints.

5.3.3 Long-Term Effectiveness

Long-term effectiveness addresses how well the remedy reduces risks; for example, whether contamination is removed or left in place to be managed over the long term after remediation is complete, and whether controls are adequate to maintain protection against exposures to contamination left in place in the long term. The long-term effectiveness evaluation criterion is evaluated by considering the following four metrics:

- The magnitude of post-construction human risks.
- The magnitude of post-construction ecological risks.
- The degree of certainty that the remedial alternative will be successful.
- The reliability of institutional controls and engineering controls used to manage risks to the extent they are necessary.

These metrics are summarized below.

- **Human Carcinogenic and Non-Cancer Risks (Metric 3a):** Post-construction risk is the risk predicted to remain on-site immediately after construction is complete based upon human exposure to surface sediment containing residual concentrations of those contaminants considered risk drivers. For Metric 3a, four carcinogenic or non-cancer risks were averaged: carcinogenic risks from direct contact (RAO 1), and carcinogenic risks, child non-cancer HIs, and nursing infant non-cancer HIs as a result of fish and shellfish consumption (fish and shellfish tissue) (RAO 2). A low score of 0 represented risks without construction (i.e., Alternative A), and a high score of 10 represented minimal adverse/acceptable human risks (i.e., EPA's target risk for human health is $1x10^{-5}$ for multiple carcinogens and EPA's target HI for non-carcinogens is 1 [EPA 2016]). Note: none of the alternatives rank a "10". These risks were estimated from Time 0 post-remedy SWACs and did not consider additional risk reduction expected over time via natural recovery processes (not quantified in the 2016 EPA FS).

- **Ecological Risks (Metric 3b):** The second metric evaluated two post-construction risks to ecological receptors: direct contact with COCs in sediment (RAO 5) and ingestion through the food chain (RAO 6). The RAO 5 risk was quantified in the 2016 EPA FS by the number of acres with unacceptable benthic risk that remain after construction. The RAO 6 risk was presented in the 2016 EPA FS as the maximum hazard quotient of the focused COCs. These two ecological risks were used to calculate scores. A low score of 0 represented risks without construction (i.e., Alternative A), and a high score of 10 represented acceptable ecological risks (i.e., RAO 5 – 0 acres with unacceptable benthic risk; RAO 6 – maximum hazard quotient of 1).

- **Degree of Certainty That the Remedial Alternatives Will Be Successful (Metric 3c):** The predicted outcomes and success of remediation for all remedial alternatives have some uncertainty, particularly those that rely more on natural recovery. Uncertainties include the effectiveness of source control, the rates of natural recovery, concentrations of incoming sediment from upstream and lateral sources, and the effectiveness of remedial technologies. Some of these uncertainties, such as the actual contaminant concentrations in upstream sediment, are the same for all remedial alternatives. However, uncertainties related to the effectiveness of specific remedial technologies will affect the alternatives to different degrees. Therefore, the remedial alternatives were scored based on the remedial technologies that would be employed. For Metric 3c, each remedial technology was weighted based on best professional judgment. This analysis assumed that the remedial technologies that depend on construction only (i.e., capping and dredging) have a higher degree of certainty of success than remedial technologies that depend on natural recovery (i.e., ENR and MNR). Dredging scored a 9.5 because, while it would remove a significant degree of contamination from Portland Harbor, removal technologies are not perfect in practice, and some contamination would be left following dredging (e.g., due to dredge residuals or losses during dredging); dredging does not score a perfect “10”. Capping and partial dredge/cap scored 9 because it would isolate contaminated sediment, but contaminated sediment would remain on-site with a chance of exposure. *In situ* treatment scored 7 because it would not provide full containment like a cap, but would reduce the possibility of contaminant breakthrough and uptake by adding a carbon amendment. ENR scored 5 because it does not ensure chemical isolation but achieves some protectiveness with a thin layer of sand. MNR as a technology scored 1 because it depends on natural recovery and time. The remedial alternatives are scored based on the weighted average of the acreage for each technology used in the Portland Harbor cleanup area.

- **Reliability of Institutional Controls and Engineering Controls Used to Manage Risk (Metric 3d):** All remedial alternatives would use similar institutional and engineering controls to manage residual risk. However, the degree to which they need to use these controls would differ. Institutional controls include fish and shellfish consumption advisories, public outreach and education programs, and environmental covenants and restricted navigation areas. Fish and shellfish consumption advisories would remain in effect for all remedial alternatives. However, the alternatives differ significantly in the degree to which environmental covenants would be relied upon. Therefore, reliability was mainly scored based upon engineering controls, which would be needed to manage and monitor contaminants remaining on-site. Alternatives with more dredging received higher scores because removal of contaminants is a more reliable technology in the long term, and because it does not rely on covenants or other devices to address potential exposure of contaminants left in place. This metric (3d) is scored as inversely proportional to the surface area for which buried contamination remains on-site for the non-dredging footprints. For this metric, the number of acres assigned with caps, ENR/*in situ* treatment, and MNR in the Portland Harbor cleanup area are summed for each alternative. This assumes that more engineering controls will be needed for alternatives that leave contamination in-place. The metric is scored from 0 for no active remediation (score 0, i.e., Alternative A) to all of the cleanup area removed (score 10).

The post-construction human and ecological risks (Metrics 3a and 3b) were each weighted as 1/3 of the overall criterion score. This equal weighting assumes that protection of human health (RAOs 1 through 4) and protection of benthic invertebrates (RAOs 5 through 8) are of equal importance. The last two metrics (3c and 3d) were each weighted as 1/6 of the criterion overall score.

5.3.4 Management of Short-term Risk

Short-term risks to human health and the environment occur during construction and implementation. This criterion is evaluated by considering the following four metrics:

- Implementation risks.
- Disturbance during construction.
- Accident risks during construction.
- Effectiveness of the protective measures used to manage those short-term risks.

These metrics are summarized below.

- **Implementation Risks (Metric 4a):** This metric addresses the release of contamination into the water column during dredging (thereby increasing contaminant concentrations in fish and shellfish tissues), landfill usage, environmental impacts due to transportation of material and mining of sand, GHG emissions, particulate emissions, and other factors. This metric was the equally weighted average of two components used to represent implementation risks: (1) the volume of material removed and handled (including dredge and disposal), and volume of material placed at the site (including cap, ENR, and backfill material); and (2) the total GHG emissions. For the volume of material removed or handled, a score of 0 represents the maximum amount of removal and handling proposed (i.e., Alternative F), and a score of 10 represents no removal or handling (i.e., Alternative A). For the total GHG emissions, described in Section 2.3.1, a score of 0 represents the maximum amount of GHG emissions that could occur (i.e., Alternative F), and a score of 10 represents no GHG emissions (i.e., Alternative A).

- **Disturbance during Construction (Metric 4b):** This metric is related to the active remedial footprint (dredge, cap, ENR/*in situ* treatment) overlap with shoreline area that would disrupt infrastructure access, water-dependent business, recreational access (beach areas, shoreline parks, and public areas), and habitat. The overlap percentages used to quantify disturbances during construction are described in Section 3.2. As expressed during a public survey of Multnomah County residents, stakeholders are very concerned about business disruption and limited access to the river during construction, especially for prolonged construction times of 9 years[13] or more. The metric score gives equal weight to the four types of disturbance. A score of 0 represents a maximum active remedial footprint overlap (i.e., Alternative F), and a score of 10 represents no disturbance (i.e., Alternative A).

- **Accident Risks during Construction (Metric 4c):** This metric is related to the accident risks as a result of construction. Accident risks, which are the equally weighted average of injury and fatality risks, are based on the transportation type, labor type, and construction duration calculated in SiteWise™, as described in Section 2.3.2. A score of 0 represents highest accident risk (i.e., Alternative F), and a score of 10 represents no construction and therefore no accident risk (i.e., Alternative A).

- **Effectiveness of the Protective Measures Used to Manage Those Short-term Risks (Metric 4d**): This metric evaluates the effectiveness of protective measures such as institutional controls and BMPs that would be used to mitigate the risks associated with the remedial alternatives during construction. For this analysis, it is assumed that the same types of protective measures would be used for all alternatives; therefore, the effectiveness of these protective measures is inversely proportional to the construction time frame of the remedial alternative. The alternatives with the shortest construction time frame ranked the highest, and those with the longest construction time frames ranked the lowest. A score of 0 represents no short-term risk (i.e., Alternative A), and a score of 10 represents the highest risk of ineffective protective measures due to a longer construction duration (i.e., Alternative F).

The metrics are equally weighted to produce the overall management of short-term risks criterion score. Overall, the alternatives with more removal and longer construction scored lower than the less active alternatives.

5.3.5 Technical and Administrative Implementability

Implementability has several components, including technical feasibility; availability of necessary off-site facilities, services, and materials; administrative and regulatory requirements; scheduling, size, and complexity of the cleanup; monitoring requirements; access for construction and operation and maintenance monitoring; and integration with existing facility operations and other remedial actions. All alternatives would require some institutional controls (administrative implementability) to manage fish consumption advisories for RAO 2 because none of the alternatives are expected to achieve protective risk levels (these levels are below background). Capping would require more deed restrictions, flood rise analysis, and long-term maintenance to ensure stability. Alternatives that rely on MNR are easier to implement because no permitting and no construction are required.

The technical and administrative implementability evaluation criterion is evaluated by considering the following three metrics:

- Ability to construct and operate.

[13] An independent third-party survey was conducted for Multnomah County residents in 2015. When asked about construction duration, over 75 percent of respondents supported construction times of 9 years of less. Very limited support was expressed for durations extending beyond 9 years.

- Ability to monitor effectiveness.
- Availability of specialists, equipment, and materials.

These metrics are summarized below.

- **Ability to Construct and Operate (Metric 5a):** This metric relates the ability to construct and operate a remedial technology to the materials handling volume (clean import fill and contaminated export sediment/soil). Larger alternatives are more complex and would be more logistically difficult to permit, construct, and operate. A score of 0 represents a maximum handling volume (i.e., Alternative F), and a score of 10 represents no material handling (i.e., Alternative A).

- **Ability to Monitor Effectiveness (Metric 5b):** This metric addresses the amount of long-term monitoring that will be required for each alternative. The total area requiring monitoring is assumed to be proportional to the sum of the cap, *in situ* treatment, ENR, and MNR acreage. A score of 0 represents maximum acres requiring monitoring (i.e., Alternative F), and a score of 10 represents no required monitoring (i.e., Alternative A).

- **Availability of Specialists, Equipment, and Materials (Metric 5c):** This metric is concerned with the availability of services, equipment, materials, offsite treatment and disposal facilities, dredge and excavator operators, and material placement specialists necessary for implementation. The need for these equipment, materials, and specialists is assumed to be proportional to the size and complexity of the remedy. For Portland Harbor, this metric is focused on the volume of material requiring management and the associated transportation necessary to deliver materials to the site and remove material from the site. Transportation is quantified by the number of barge and rail loads necessary for delivery and removal. A score of 0 represents the maximum number of barge and rail loads needed to transport of dredging and import materials from and to the Site (i.e., Alternative F), and a score of 10 represents no delivery or removal (i.e., Alternative A).

The metrics are equally weighted to produce the overall technical and administrative implementability criterion score. Overall, the alternatives with more removal and longer construction scored lower than the less active alternatives.

5.3.6 Consideration of Public Concerns

The public involvement process is used to identify public preferences and concerns regarding the remedial alternatives. This includes consideration of concerns raised by individuals, community groups, local governments, local businesses, Tribes, federal and state agencies, and anyone with an interest in the site. This criterion will ultimately be evaluated by EPA and ODEQ during the selection of the preferred alternative in the Record of Decision.

The social analysis (SEA Environmental Decisions, Ltd. & AECOM 2016) gathered feedback from various stakeholder groups on priorities and concerns related to the remedial alternatives, and as regional concerns in terms of restoration, re-use, and longer-term redevelopment opportunities. Major concerns were expressed at public meetings and in written materials related to public access, berthing area and navigational channel access, disruptions to cultural practices, impacts to community, business disruptions, equality considerations, uncertainty, and risk reduction. Based on stakeholder feedback and mapping of stakeholder values, a quantitative/qualitative ranking of numerous metrics and evaluation of trade-offs between impacts on environmental quality, economic vitality, and social equity were evaluated in terms of stakeholder values.

Stakeholder group values and priorities were evaluated at public meetings, as well as by reviewing the written and oral value statements of a range of stakeholder groups, including communities, businesses, Tribes, non-governmental organizations, government, and recreational users. The social equity score of community values (SOC-2) from the social pillar analysis (SEA Environmental Decisions, Ltd. & AECOM 2016) was used in the NEBA for “consideration of public concerns.” Community values (SOC-2) quantified four metrics: stakeholder involvement; communication of uncertainty; archaeological site disturbance; and economic, recreation, Native American, and in-water re-use. The cumulative score for each alternative was the weighted average of the value scores listed above. Community value scores from the social pillar analysis were transformed to the NEBA score range of 0 to 10.

Alternatives A, B, D, E, and I scored the highest because they received the similar community value scores from the social pillar analysis. Some of the values are insensitive to the size of the remedy (i.e., archaeological disturbance), and the outcomes are expected to be similar (i.e., communication). Alternative F scored the lowest because its large cleanup scope negatively affects recreational and in-water re-use.

5.4 Costs

EPA-estimated total remedy costs range from $642 million (Alternative B) to $2.2 billion (Alternative F) non-discounted (EPA 2016). AECOM completed a separate cost analysis using the Lower Duwamish cost model adjusted for Portland Harbor remedial alternatives, which resulted in total remedy costs ranging from $1.1 billion (Alternative B) to $3.0 billion (Alternative F) non-discounted (Appendix E). AECOM-estimated costs were used in the NEBA analysis. EPA costs were used in the cost sensitivity analysis.

EPA presented best-estimate remedial costs using a 7 percent discount rate; a 0 percent discount rate was included as a sensitivity endpoint. AECOM elected to use non-discounted costs in the NEBA analysis because it is unknown how the remedy will be financed. Regardless of the ultimate public/private mix of parties responsible for the cleanup, a discount rate derived using Appendix C of the Office of Management and Budget (OMB) Circular A-94 is equivalent to a low-risk rate of return, one that is consistent with the premise of setting aside money today in a safe, secure investment to pay for future cleanup costs (OMB 2015). The 2015 interest rate listed in the OMB Circular is 1.7 percent. The rate of return, similar to an interest rate, is the parameter that accounts for the time value of money. Total remedy costs were estimated in constant dollars (2015; not adjusted for inflation or discount rates [non-discounted]). A discount rate of 2.3 percent was included in a sensitivity assessment (see Appendix E) and reflects recent economic assessments of interest and inflation rates.

6. Sensitivity Analysis

A sensitivity analysis was conducted on five different variables (criteria weighting, costs, truck versus rail transport, disposal options, and dredge production rates) to evaluate the robustness of AECOM's conclusions. Based on these sensitivity findings, the conclusions presented in this report are robust.

6.1 Weighting of CERCLA Criteria

A sensitivity analysis was performed on the NEBA to evaluate the effect of criteria weighting on the overall benefit scores. Four different sets of criteria weights were applied to the NEBA shown in Table 8. The "sensitivity" sets included:

1) Unweighted; Each evaluation criterion was assigned an equal weight. This weighting set has been used at other sediment cleanup sites (Table 6);

2) Weighted; The overall protectiveness criterion was not used, and therefore was assigned a 0 percent weight; permanence and long-term effectiveness were weighted more heavily than the other criterion (AnchorQEA 2012);

3) Weighted; The weighting used in the NEBA analysis - the overall protectiveness criterion was assigned a 25 percent weight and the balancing criteria were equally weighted (each 16.25 percent); and

4) Weighted; Lower Duwamish Final FS weighting (AECOM 2012).

Table 8. Sensitivity Analysis of Weighted Benefit Evaluation Criteria – Input Parameters

Scenario:	1	2	**3**	4
CERCLA Evaluation Criteria	Unweighted	Weighted, Overall Protectiveness Not Weighted	**Portland Harbor Sustainability Project**	Weighted, Lower Duwamish Final FS
Overall Protectiveness	17%	0%	**25%**	25%
Permanence	17%	25%	**16%**	20%
Long-term Effectiveness	17%	30%	**16%**	30%
Management of Short-term Risks	17%	25%	**16%**	15%
Implementability	17%	10%	**16%**	5%
Consideration of Public Concerns	17%	10%	**10%**	5%

Table 8 notes: The table lists the four different weighting scenarios used for the sensitivity analysis. Compliance with Applicable or Relevant and Appropriate Requirements and state acceptance criteria are not included in analysis. **BOLD** indicates the weighting scenario used in this report. Scenario 3 is weighted and has evenly weighted balancing criteria and weighting of overall protectiveness.

The NEBA was run with these four weighting sets to determine the sensitivity of overall benefit scores for the five alternatives under different weighting scenarios. The magnitudes of the alternative-specific benefit scores are somewhat sensitive to different weighting sets (Figure 10), but the findings did not change. The variance among alternative-specific overall benefit scores ranged between 0.7 and 1.7 benefit points of each other. Results were relatively close because the incremental benefits of the larger alternatives were outweighed by the incremental dis-benefits associated with the prolonged short-term risks associated with long construction times (with minimal change in post-construction risks). Alternatives B and D received the highest benefit score among three of the four weighting sets, suggesting that results, although sensitive, are robust. In the fourth scenario set, Alternatives B, D, E, and I benefit rankings were similar, illustrating that Alternatives A and F were disproportionate in benefits compared to the others, but otherwise there were no distinguishable differences in benefit. However, when the benefits are expressed per dollar spent (see benefit/cost scores in Figure 11), Alternative B always receives the highest benefit/cost scores, regardless of the evaluation criteria weighting. Figure 11 indicates that added cost does not translate into proportional overall benefits, regardless of the applied evaluation criteria weighting set.

Figure 10. Sensitivity Analysis Output: Overall Benefit Scores Using Different CERCLA Criteria Weighting

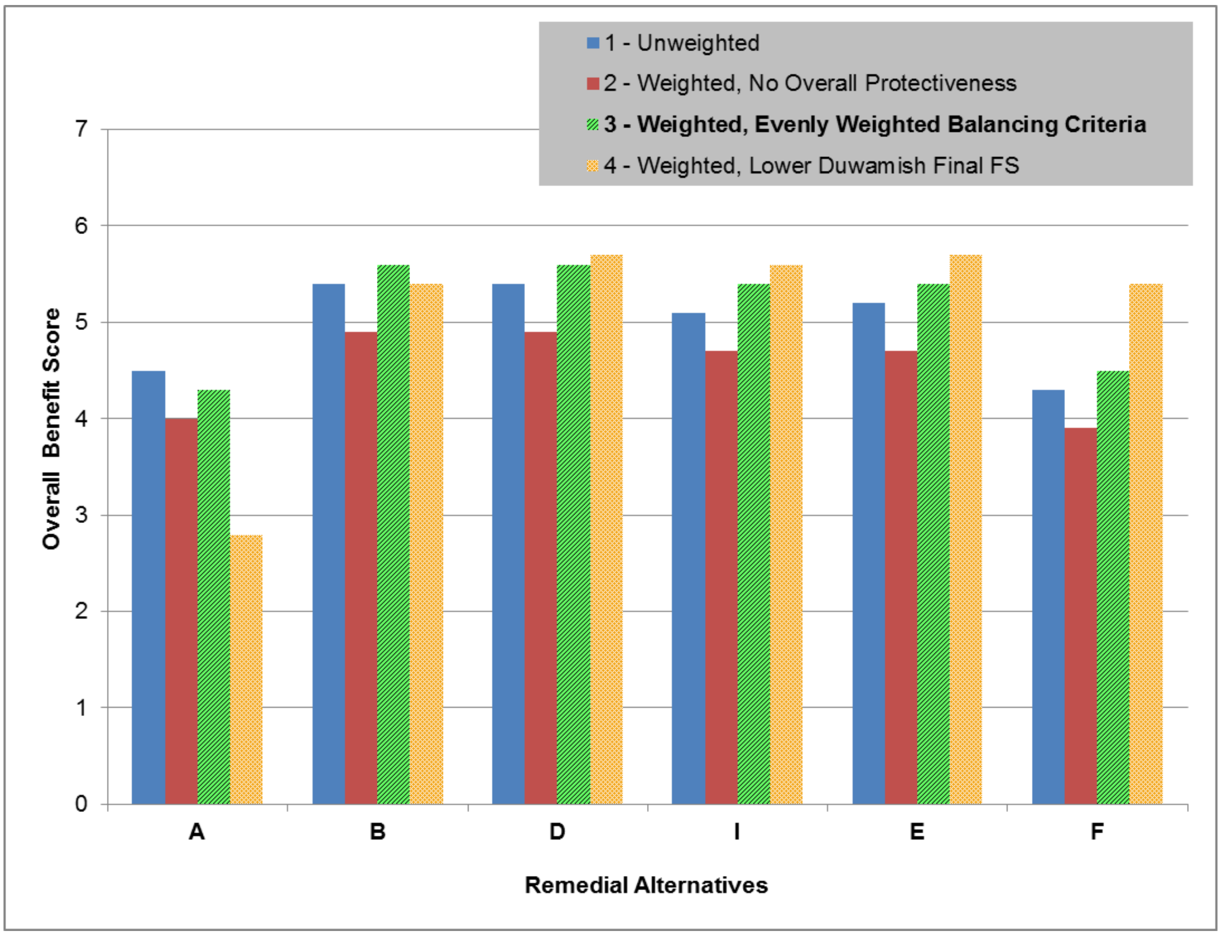


Figure 10 notes**:** Overall benefit scores using different evaluation criteria weighting sets, grouped by remedial alternative; **BOLD** indicates the scenario used in this NEBA analysis.

Figure 11. Remedial Alternative Benefit/Cost Scores Using Different Evaluation Criteria Weighting

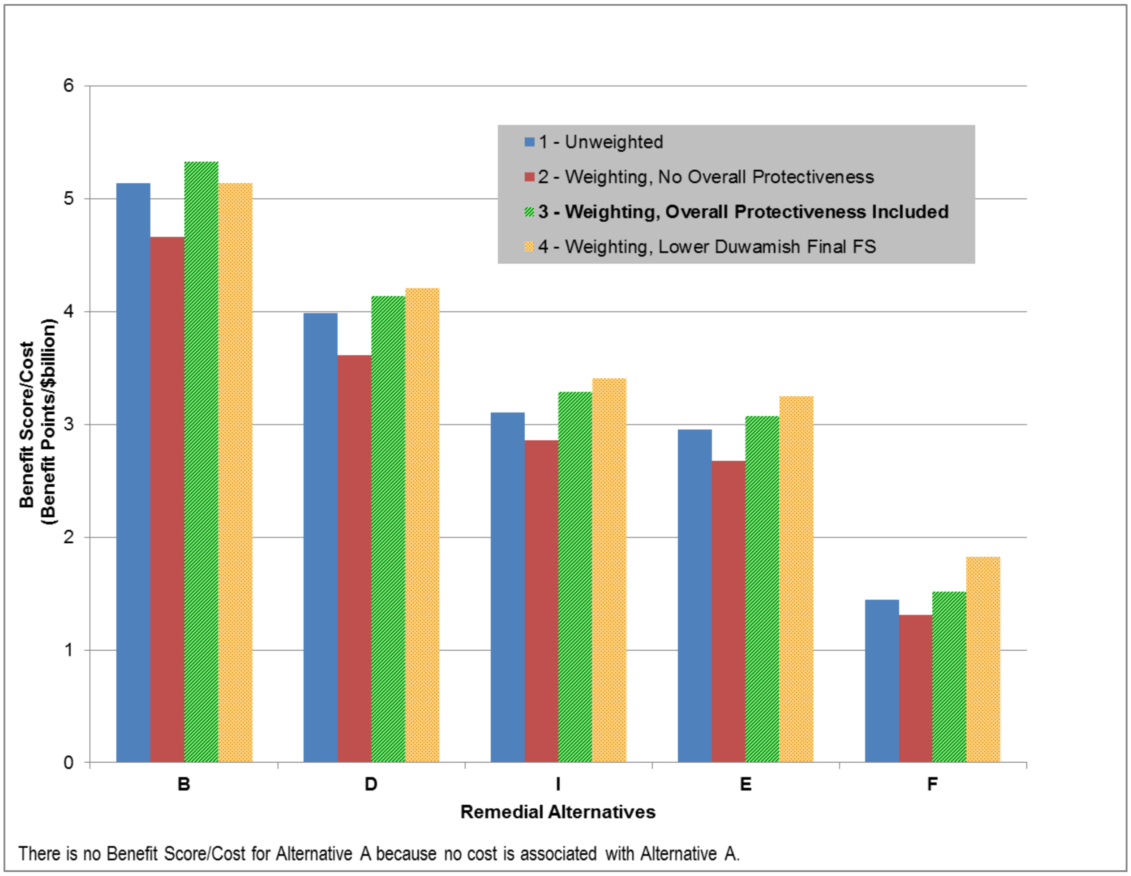


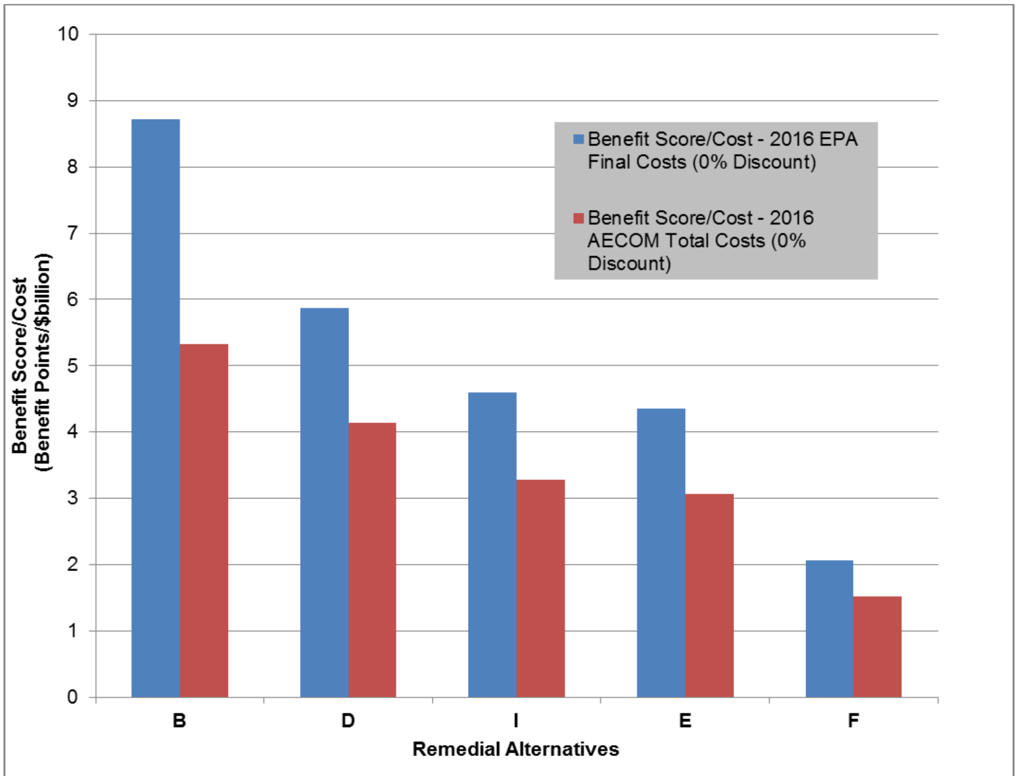
Figure 11 notes: Benefit/cost scores for each remedial alternative using different evaluation criteria weighting sets, grouped by remedial alternative; **BOLD** indicates the scenario used in this NEBA analysis.

The results of the sensitivity analysis indicate that, although the evaluation criteria weighting sets have an effect on the magnitude of the benefit and benefit/cost scores, they do not have a significant effect on the relative alternative ranks; Alternatives B, D, and E receive the highest benefit scores regardless of weighting set, and Alternative B receives the highest benefit/cost score regardless of weighting set.

6.2 Costs

A sensitivity analysis was performed on cost assumptions by comparing the changes in the benefit/cost score when EPA versus AECOM total remedy cost estimates are used as is inputs to the NEBA. Zero percent discount EPA costs (Section 5.4) and AECOM costs (Appendix E) were used in the analysis. Figure 12 compares the benefit/cost scores for each alternative using the two costs; the results of the cost sensitivity analysis indicate that costs have an effect on the magnitude of the benefit/cost scores but do not have an effect on the rankings. Alternative B provides the best cost/benefit value.

Figure 12. Comparative Benefit/Cost Scores Relative to EPA and AECOM Cost Estimates



There is no Benefit Score/Cost for Alternative A because no cost is associated with Alternative A.

6.3 Waste Transportation

Waste transportation assumptions (see SiteWise™ environmental footprint analysis in Section 2.0) included 70 miles of transport by barge from Portland Harbor to a former pulp mill plant located up the Columbia River in Bingen, Washington, transloading from barge to truck, and then travelling an additional 70 miles by truck to landfills in Roosevelt, Washington (Subtitle D) or Arlington, Oregon (Subtitle C). Both landfills are located an approximately equal distance from the transloading facility. Roosevelt Landfill, the facility designated for disposal of Subtitle D (non-hazardous) waste, is also accessible via rail. Using rail instead of trucks to transport non-hazardous waste would reduce GHG emissions for Alternative I by 20,228 metric tons, representing a 32 percent reduction in GHG emissions for waste transportation and 3.3 percent for the entire project. Using rail to transport non-hazardous waste from the transloading facility to the landfill also reduces worker accident risk for Alternative I by more than 11 recordable injuries (see Section 2.3.2 and Appendix B). Similar reductions are expected for the other remedial alternatives. Rail is a more sustainable transport option compared to trucking.

6.4 Subtitle D Landfill versus CDF

The 2016 EPA FS evaluated two alternative DMM scenarios:

- DMM Scenario 1: Combination of on-site CDF and off-site disposal, applied only to Alternatives E, F and I because the estimated dredge volumes under these alternatives meet the minimum quantity for placement in a CDF.

- DMM Scenario 2: Off-site disposal, applied to all alternatives.

The environmental footprint analysis described in Section 2.2 only evaluated DMM Scenario 2 for consistency across remedial alternatives. However, a sensitivity analysis was conducted to evaluate the environmental impacts associated with construction and use of a CDF. A quantitative analysis was completed by changing input disposal volumes in SiteWise™ for Alternatives E, F, and I based on the disposal quantities provided in the EPA cost estimates (EPA 2016, Appendix G). For each alternative, 670,000 cubic yards of non-hazardous waste was diverted from non-hazardous Subtitle D waste disposal to the on-site CDF, thereby reducing the quantities of dredged material associated with mechanical dewatering, in-barge stabilization, transloading, and waste transportation. The environmental impacts of CDF construction were not evaluated.

Figure 13 shows the results of the sensitivity analysis of the two DMM scenarios for Alternative I. The comparison of DMM scenarios for Alternatives E and F had similar results (see Appendix B). For each alternative, water consumption and electricity usage are insensitive to the DMM scenario selected. However, each of the other metrics quantified in SiteWise™ were reduced for DMM Scenario 1 (i.e., use of a CDF for a portion of the non-hazardous waste disposal).

Figure 13. DMM Scenario Comparison

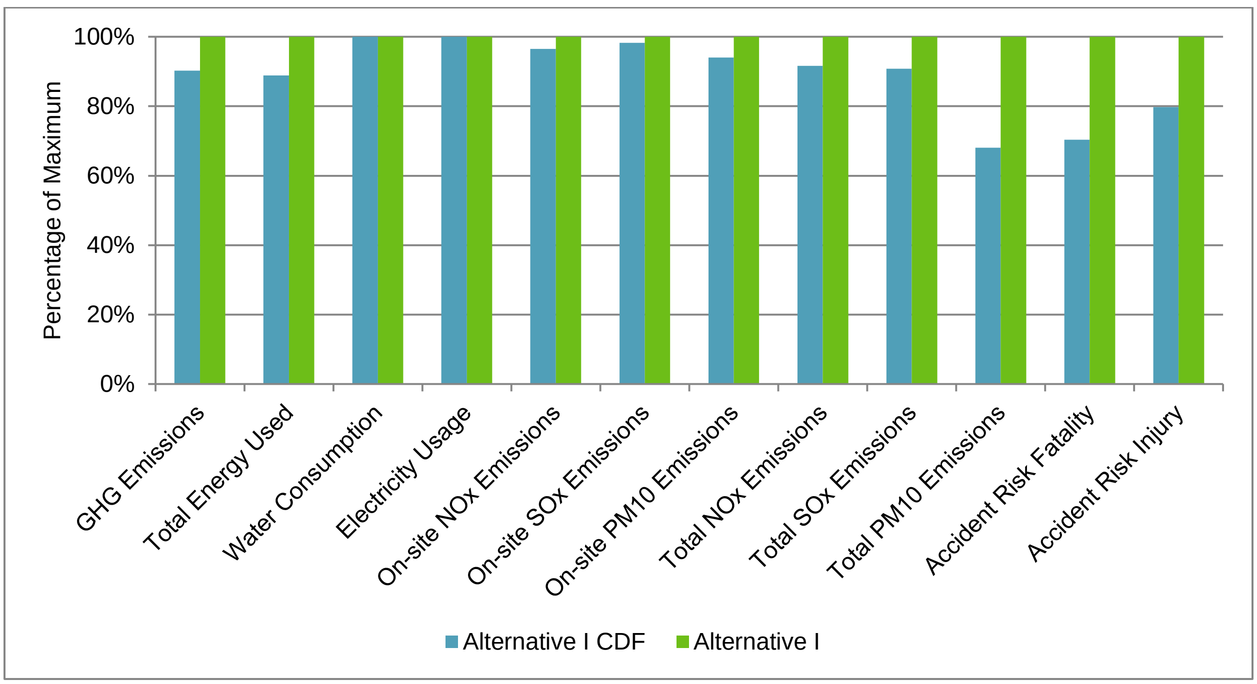


Figure 13 notes: The results for each metric quantified in SiteWise™ for DMM Scenarios 1 (waste disposal in on-site CDF and Subtitle D landfill) and 2 (disposal in Subtitle D landfill) for Alternative I, normalized to off-site disposal (DMM Scenario 2) to show relative difference between DMM scenarios.

For Alternative I, GHG emissions were reduced by 6 percent in DMM Scenario 1 (CDF) compared to DMM Scenario 2. Air pollutant (NO_X, SO_X, PM10) emissions were reduced by between 8 and 32 percent. PM10 emission reductions for DMM Scenario 1 were most significant due to less on-road diesel consumption associated with waste disposal. Expected worker injuries were reduced by 20 percent primarily due to less road transportation associated with landfill disposal. Non-hazardous waste disposal weight was reduced by 43 percent. Similar percent reductions were estimated for Alternatives E and F, except slightly less benefit for Alternative F because a larger proportion of dredge material still requires off-site disposal (see Appendix B). On average, about a 10 to 15 percent reduction in the environmental sustainability metrics calculated in SiteWise™ is expected by use of a CDF for local disposal of a portion of the dredge material in Alternatives E, F, and I. However, even with the use of a CDF for Alternatives E, F, and I (DMM Scenario 1), Alternatives B and D (DMM Scenario 2) still have smaller environmental footprints in terms of the environmental metrics quantified in SiteWise™.

6.5 Dredge Production Rates

As discussed in Section 2.2, the daily dredging production rates used in SiteWise™ calculations range from about 312 cubic yards (for confined dredging with a 25-ton, 1-cubic yard crawler crane) to 1,488 cubic yards (for open water dredging with a 100-ton, 4-cubic yard crawler crane) per day per dredge. The blended dredge rate for open water and confined dredging ranges from 1,362 cubic yards per day for Alternative B to 1,459 cubic yards per day for Alternative F, depending on the relative proportion of open water and confined dredging estimated for each alternative (EPA 2016).

These blended rates are lower than those assumed in the 2015 EPA FS (EPA 2015), but slightly higher than those in the Lower Duwamish Final FS (AECOM 2012), and recent Pacific Northwest sediment remediation projects, which range from 300 to 1,000 tons per day (see Appendix E). Reducing the average production rates in SiteWise™ by approximately 30 percent (to 1,000 cubic yards per day for open water dredging), the total hours of operation would increase for each alternative and result in proportional increases in air emissions (GHGs and air pollutants) and accident risk metrics (i.e., injuries and fatalities). A 30 percent decrease in the production rate for open water dredging results in an increase in operating hours of 33 percent for Alternative B, 38 percent for Alternative D, 41 percent for Alternative E, 44 percent for Alternative F, and 39 percent for Alternative I. The increase in operating hours is proportional to the increase in the volume of open water dredging between each alternative (see Appendix B).

Similarly, metrics such as GHG, NO_X, SO_X, and PM10 emissions, and worker accident risk (measured in estimated number of injuries and fatalities) would increase by similar proportions for each alternative if the lower, more realistic production rate is used in the environmental footprint calculations.

7. Conclusions

Cost estimates and their associated total weighted benefits can be used to determine whether a remedial alternative is sustainable and whether the remedy costs are disproportionate to the benefits provided by the alternative. Table 9 summarizes the overall net environmental benefit scores and calculated cost/benefit ratios for Alternatives A, B, D, E, F, and I. The total benefit scores for the remedial alternatives evaluated range from 4.3 to 5.6. The costs range from $1,051,000,000 to $2,969,000,000 (non-discounted). Alternative B provides the highest environmental benefit per dollar spent. Alternative D provides the second highest benefit per dollar spent. Larger alternatives have a point of diminishing return with no additional benefits for the added cost of cleanup.

Table 9. Summary of NEBA – Alternative Benefits Scores

	Evaluation Criteria	Weighting Factor	Remedial Alternatives and Scores					
			A	B	D	E	F	I
1	Overall Protectiveness of Human Health and the Environment	25%	2.0	7.5	8.0	8.2	8.0	8.0
2	Permanence	16%	0.0	1.9	2.5	3.3	5.2	3.0
3	Long-term Effectiveness	16%	0.0	5.0	5.8	6.2	6.9	6.0
4	Management of Short-term Risks	16%	10.0	7.4	6.2	4.5	0.0	5.0
5	Technical and Administrative Implementability	16%	10.0	5.5	4.8	3.7	0.5	3.7
6	Consideration of Public Concerns	10%	5.1	5.1	5.1	5.1	5.0	5.1
	Total Weighted Benefits		**4.3**	**5.6**	**5.6**	**5.4**	**4.5**	**5.4**
	2016 AECOM Costs (0% Discount) ($millions net present value)		**$ -**	**$ 1,051**	**$ 1,355**	**$ 1,758**	**$ 2,969**	**$ 1,644**
	Benefit/cost (Benefit points per $billion)		**NA**	**5.3**	**4.1**	**3.1**	**1.5**	**3.3**

Table 9 notes**:** The remedial alternatives are scored on linear scale of 0 to 10 based on quantitative metric scores. Metric scores are aggregated into criteria scores, and overall scores based on the criteria weighting factor (shown in Table 9 above). See Appendix D for metric scores and their basis. A score of 0 represents a lowest benefit or a poor performing alternative. A score of 10 represents the highest benefit or an excellent performing alternative.

This section identified the most sustainable remedial alternative among those evaluated that provides the most benefit for the most stakeholders for the least risk and least cost. A sensitivity analysis (Section 6) was conducted to evaluate the robustness of AECOM's results.

7.1 Overall Cost-benefit Score

A series of figures are provided that illustrate the results of the NEBA. Alternatives B and D have the highest net environmental benefit scores (score 5.6) among the alternatives evaluated. Alternative B provides the highest benefit per dollar spent (score 5.3). Alternative A has a positive score because the range of scores is from 0 to 10 and therefore cannot be negative; the score for Alternative A is used as a baseline for the comparison between no action and remedial action. None of the alternatives achieve a perfect score of 10 because dis-benefits (impacts) associated with remedial action exist. The total weighted benefit scores are lower for larger alternatives, indicating that more dredging has substantial adverse effects during construction that tend to outweigh the long-term benefits. This is especially true because none of the alternatives achieve many of the risk-based cleanup levels.

Figure 14 shows the weighted benefit score for each alternative with an overlay of cost. More expensive alternatives did not show proportional increases in overall benefit.

Figure 15 plots benefits versus the cost for the alternatives. This graphic shows the same benefit rankings as Figure 14 but provides a visual representation of the spread of costs. Figure 15 is called a “dominated curve” and shows the alternative that achieves the best cost-effectiveness, which is Alternative B. This figure indicates that added cost does not necessarily translate into proportional overall benefits. Alternative B provides the most benefit for the cost and is the point of diminishing return compared to the larger alternatives (D, E, F, and I).

Figure 14. Benefits and Costs for Remedial Alternatives

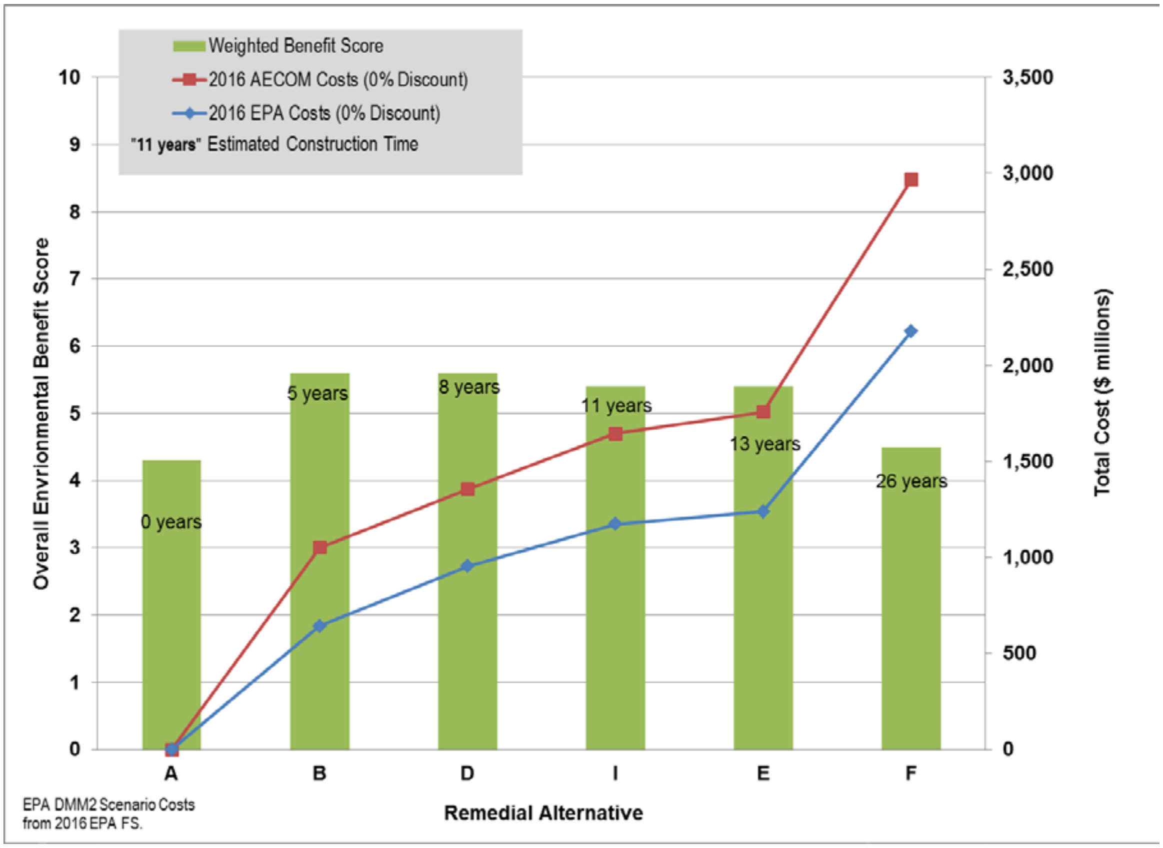
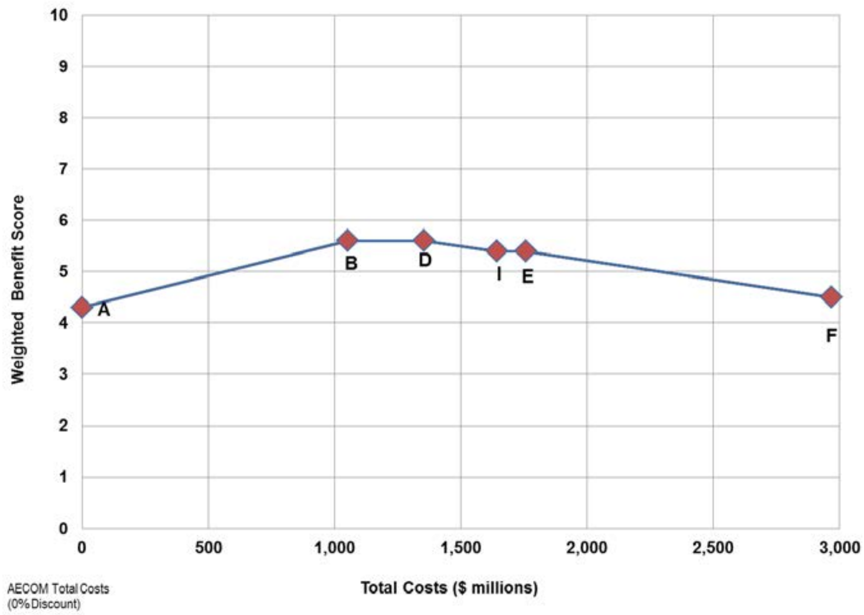


Figure 15: Benefit Scores vs. Costs for Remedial Alternatives



7.2 Post-construction Risk

As discussed in Section 4, the increased cost of the larger-scope alternatives does not show large proportional increases in human health benefit and risk reduction (Figures 9a and 9b). There is a point of diminishing returns in the risk-benefit with the larger remedial alternatives. In addition, all remedial alternatives will likely reach similar risk levels over time (see 2012 AnchorQEA Draft FS).

Figure 16 shows the *incremental* cost-effectiveness (i.e., incremental dollars per incremental reduction in SWAC (as percentage points), on the y-axis) versus the percent reduction in SWAC achieved by each alternative (as percentage points, on the x-axis). This figure is called the “knee-in-the-curve” graphic and is consistent with EPA Guidelines for Economic Analysis (EPA 2010b). The location of the “knee” indicates a scenario that is the most cost-effective; scenarios following this “knee” yield lower incremental reductions in SWAC per incremental dollars spent. The “knee” is located at Alternative B, indicating that the more expensive options are progressively less cost-effective when compared to the alternative preceding them in cost. Alternatives I and F are the least cost-effective.

Figure 17 shows the cumulative SWAC reduction (total return) and the cumulative SWAC reduction divided by the total cost (average return) versus to the total cost for each remedial alternative. The SWAC reduction (total return) achieved by each remedial alternative increases as more money is spent. However, as the cost of the remedial alternative increases, the amount of SWAC reduction achieved for each dollar spent (average return) decreases; this indicates that the larger-scale alternatives do not achieve SWAC reductions proportional to the amount of money spent. Figure 17 illustrates that Alternative B provides the most SWAC reduction per dollar spent.

As stated in the US Navy guidance (NAVFAC 2012), when a remedial technology is not effective in meeting the remedial goals and achieving the required level of protectiveness, the technology is simply not sustainable. In terms of risk reduction, a sustainable remedy should have cleanup goals that are risk-based, that are achievable in a reasonable restoration time, and that consider the ongoing contributions of background concentrations. Active and energy-intensive remedial options are still applicable in suitable situations, appropriate target areas, and with transparent exit strategies developed for the rest of the site.

Figure 16. Knee-in-the-curve Cost-effectiveness vs. SWAC Reduction

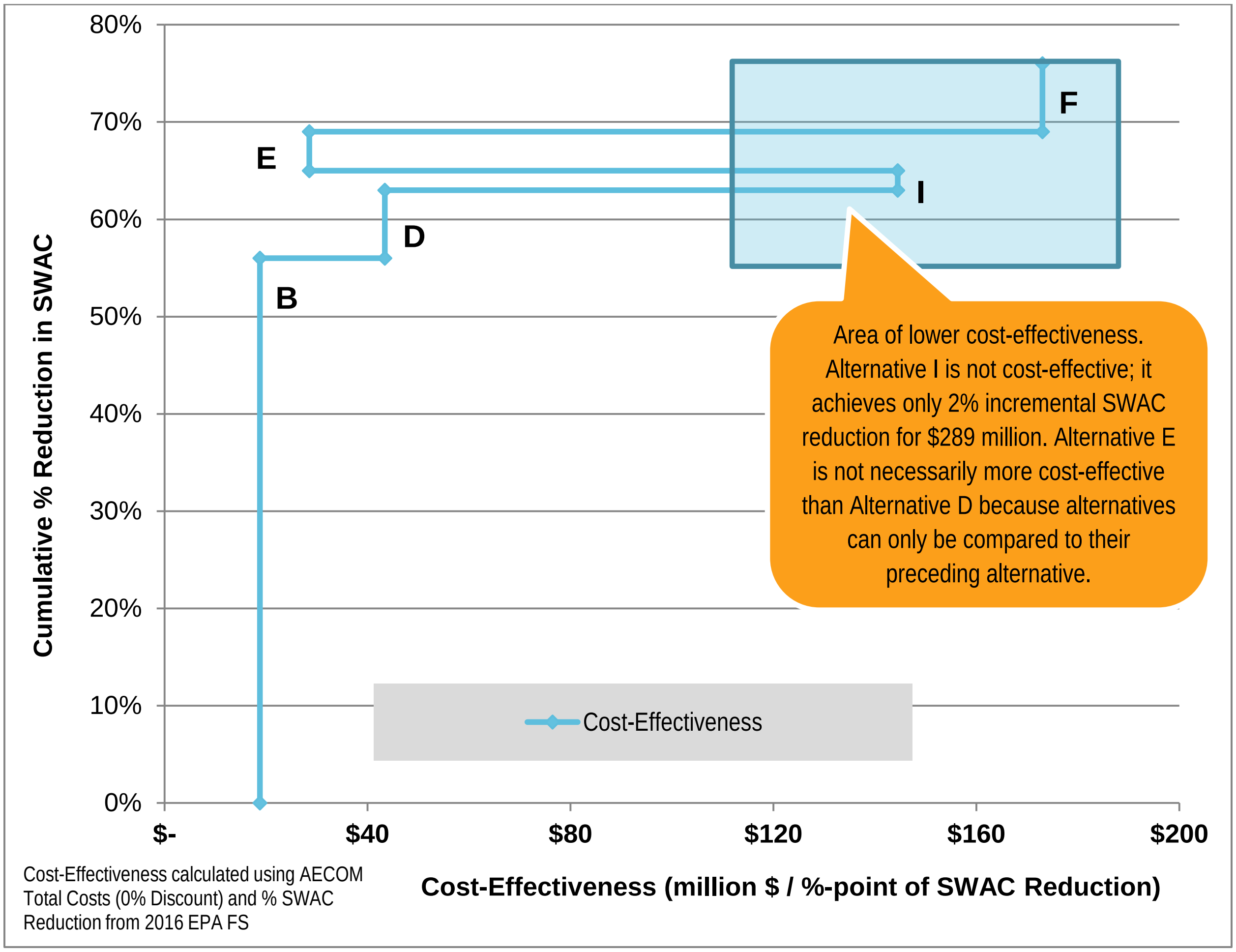


Figure 16 note**:** Alternatives are sorted and displayed by cumulative SWAC reduction. Cost-effectiveness is only relative to the preceding alternative. Cost-effectiveness is calculated as the incremental dollars spent divided by the incremental reduction in SWAC (as percentage points).

Figure 17. Total Cost vs. Cumulative SWAC Reductions

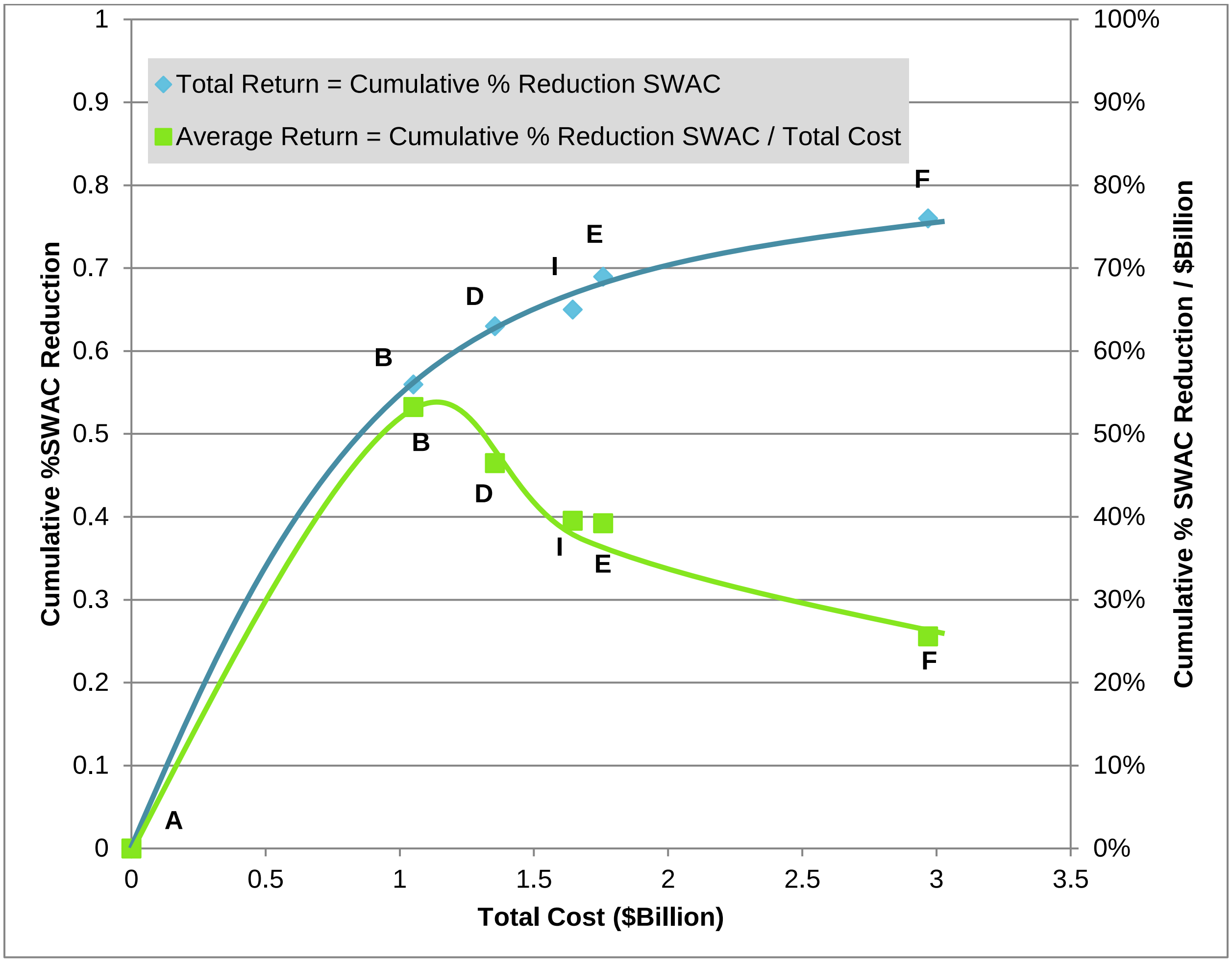


Figure 17 note**:** Cost-effectiveness calculated using AECOM adjusted remedial costs (0% NPV) and post-construction T=0 SWACs.

Collectively, Figures 14 through 17 provide various approaches to identify where costs may be disproportionate to benefits. Although the results of the NEBA should be interpreted with the assumptions and sensitivities in mind, the results indicate that Alternative B is the most sustainable remedy and, at a minimum, Alternatives I and F are disproportionately costly compared to their benefits in relation to the other remedial alternatives.

7.3 Limitations

The environmental analysis utilized information presented in the 2016 EPA FS when possible. However, the EPA FS did not include a few key metrics typically included in an evaluation of remedial alternatives for sediment sites. In particular, resolution of the following areas of uncertainty would likely have a meaningful effect on the results of the NEBA:

- Time 0 SWACs calculations did not include MNR processes occurring during construction and used data that, in some cases, were over 10 years old.

- Evaluation of SWACs and residual risk at Time 45 were not quantified in the 2016 EPA FS. Long-term effects of the alternatives and residual risks have not been sufficiently characterized.

- Dredge volumes are a sensitive parameter that has a large effect on construction time frame and cost. The dredge volume sensitivity was evaluated in a separate report (see Appendix E).

Because MNR is continually occurring at the Portland Harbor Superfund Site, regardless of active construction, Time 0 SWACs would be lower than predicted for each remedial alternative had these processes been considered in the analysis. Long-term effectiveness of the alternatives is one of the key criteria in the NEBA and selection of a remedial alternative; however, the 2016 EPA FS does not provide sufficient information to quantify metrics typically used to evaluate that criterion (i.e., SWACs and residual risk at Time 45). Inclusion of these analyses would enhance the NEBA and the overall evaluation of alternatives in the FS.

7.4 Summary

In summary, Alternative B is the most sustainable remedy in terms of the environmental pillar. The net environmental impacts of the more aggressive alternatives far outweigh the small incremental improvements in risk reduction for the more aggressive remedies.

- Alternative B provides the best environmental benefit for the cost (5.3) followed by Alternative D (4.1).

- Alternatives with longer construction times have substantially higher air emissions than the alternatives with shorter ones; these include GHG emissions and criteria air pollutants.

- Alternatives E, D, and I can achieve RAO 1 immediately after construction, but none of the alternatives will achieve RAO 2 (fish and shellfish consumption). Institutional controls will be needed for the site for all alternatives. Alternative B will reach achievable background levels faster because of ongoing natural recovery processes, shorter construction time, and less remobilization of contaminants during construction.

- The SWAC reduction reaches a point of diminishing return compared to the active construction footprint.

- Up to 54 percent of shoreline business and 40 percent of recreational access will be disturbed by cleanup activities (for Alternative F). The larger remedial alternatives will result in longer disturbance times to water-dependent businesses.

- Noise/air/light impacts (quality of life) are proportional to construction times (bigger remedy = more impacts); impacts are focused on nearby neighborhoods and transport corridors.

- Extent of traffic impacts will depend upon details of sediment transport, transloading, and disposal, which are as yet unknown.

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Appendix A
SiteWise™ Results

Remedial Alternatives	GHG Emissions	Total energy Used	Water Consumption	Electricity Usage	Onsite NO_x Emissions	Onsite SO_x Emissions	Onsite PM_{10} Emissions	Total NO_x Emissions	Total SO_x Emissions	Total PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
	metric ton	MMBTU	gallons	MWH	metric ton	metric ton	metric ton	metric ton	metric ton	metric ton		
Alternative B	345843.99	2.30E+06	3.35E+03	6.57E+00	3.73E+02	5.11E+01	2.00E+01	6.03E+02	2.52E+02	2.56E+02	7.97E-02	1.08E+01
Alternative D	545208.59	3.59E+06	6.44E+03	1.26E+01	5.71E+02	7.85E+01	3.08E+01	9.12E+02	3.44E+02	4.40E+02	1.42E-01	1.85E+01
Alternative E	652317.98	4.49E+06	1.12E+04	2.20E+01	8.52E+02	1.17E+02	4.62E+01	1.35E+03	4.74E+02	7.16E+02	2.37E-01	2.97E+01
Alternative F	1055494.61	7.56E+06	2.60E+04	5.09E+01	1.61E+03	2.20E+02	8.78E+01	2.54E+03	8.40E+02	1.54E+03	5.16E-01	6.20E+01
Alternative I	613022.35	4.19E+06	9.61E+03	1.88E+01	7.87E+02	1.08E+02	4.25E+01	1.24E+03	4.39E+02	6.30E+02	2.08E-01	2.65E+01

Additional Sustainability Metrics

Remedial Alternatives	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Topsoil Consumption	Costing	Lost Hours - Injury	Percent Electricity from Renewable Sources	Final Cost with Footprint Reduction
	tons	tons	cubic yards	$		%	$
Alternative B	693843.00	3.59E+05	0.00E+00	6.42E+08	8.65E+01	16.5%	6.42E+08
Alternative D	1599182.00	3.59E+05	0.00E+00	9.53E+08	1.48E+02	16.5%	9.53E+08
Alternative E	2975613.00	3.59E+05	0.00E+00	1.24E+09	2.37E+02	16.5%	1.24E+09
Alternative F	7149152.00	3.59E+05	0.00E+00	2.18E+09	4.96E+02	16.5%	2.18E+09
Alternative I	2534454.00	3.59E+05	0.00E+00	1.17E+09	2.12E+02	16.5%	1.17E+09

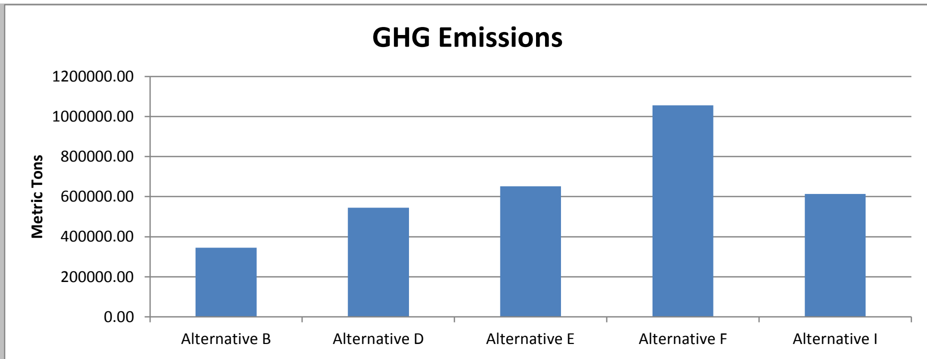
Relative Impact

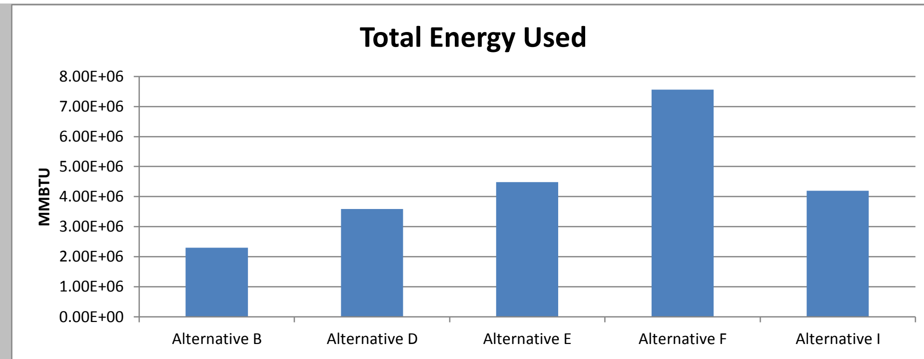
Remedial Alternatives	GHG Emissions	Energy Usage	Water Usage	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx emissions	Total SOx Emissions	Total PM10 Emissions	*Accident Risk Fatality	*Accident Risk Injury	Community Impacts	Resources Lost
Alternative B	Medium	Medium	Low	Low	Low	Low	Low	Low	Medium	Low	Low	Low	user select	user select
Alternative D	Medium	Medium	Low	Low	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	user select	user select
Alternative E	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	user select	user select
Alternative F	High	High	High	High	High	High	High	High	High	High	Low	Low	user select	user select
Alternative I	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	user select	user select

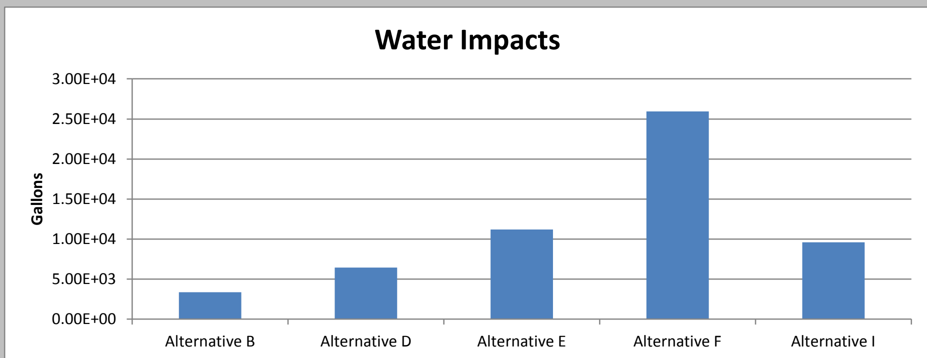
Relative Impact (User Override)

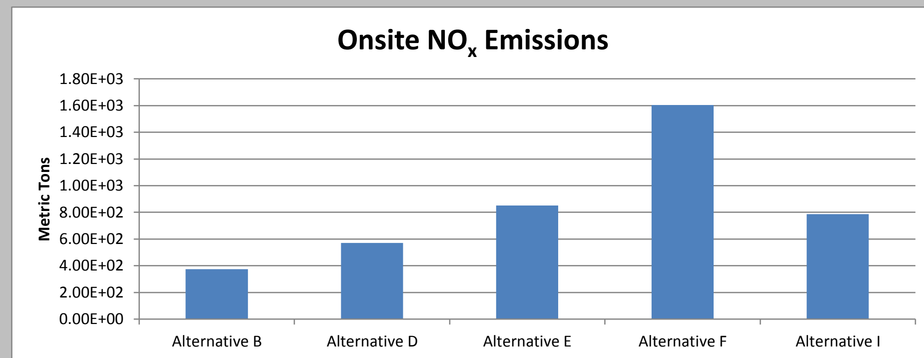
Remedial Alternatives	GHG Emissions	Energy Usage	Water Usage	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx Emissions	Total SOx Emissions	Total PM10 Emissions	*Accident Risk Fatality	*Accident Risk Injury	Community Impacts	Resources Lost
Alternative B	Medium	Medium	Low	Low	Low	Low	Low	Low	Medium	Low	Low	Low	user select	user select
Alternative D	Medium	Medium	Low	Low	Medium	Medium	Medium	Medium	Medium	Low	Low	Low	user select	user select
Alternative E	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	user select	user select
Alternative F	High	High	High	High	High	High	High	High	High	High	High	High	user select	user select
Alternative I	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	user select	user select

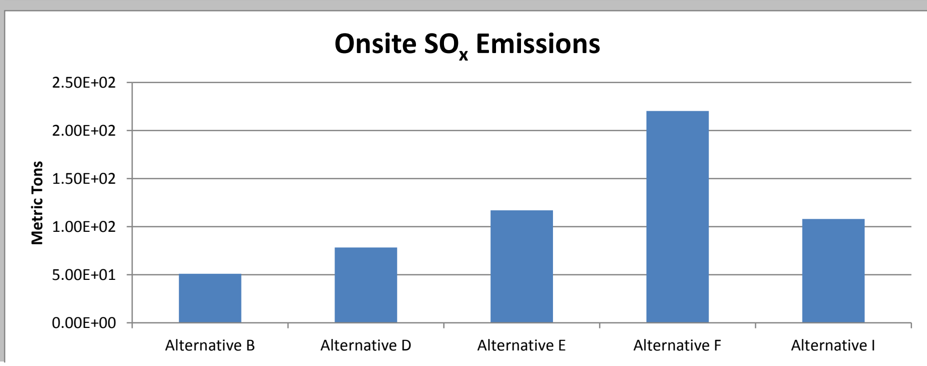
*Accident Risk is an estimate of how many accidents may occur. This risk is not the same as Cancer Risk, which is the probablity (for a single person) of getting cancer. Accident risk is not comparable to Cancer Risk due to inherent fundamental differences.

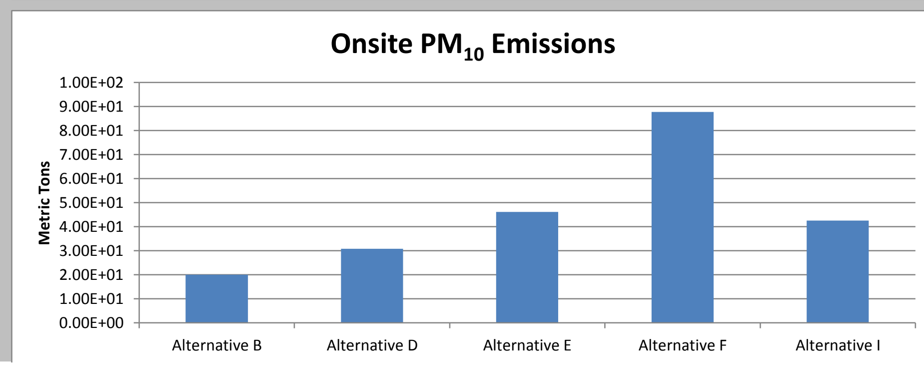

GHG Emissions
Metric Tons
1200000.00
1000000.00
800000.00
600000.00
400000.00
200000.00
0.00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I

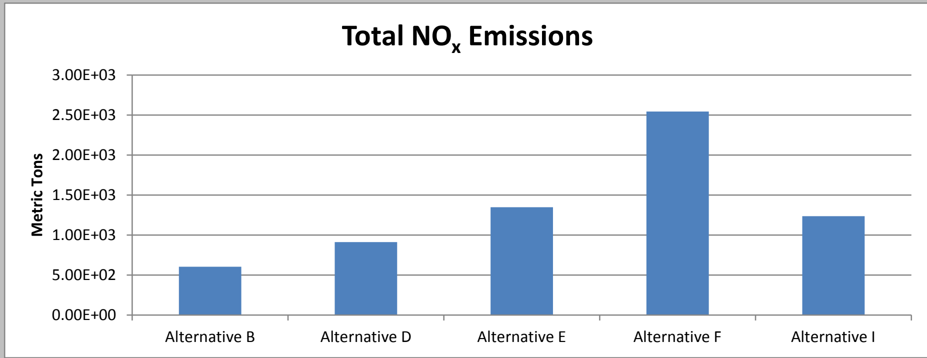

Total Energy Used
MMBTU
8.00E+06
7.00E+06
6.00E+06
5.00E+06
4.00E+06
3.00E+06
2.00E+06
1.00E+06
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I

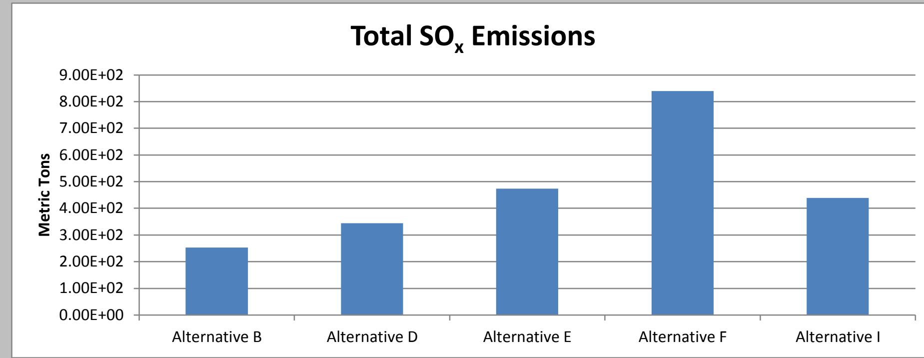

Water Impacts
Gallons
3.00E+04
2.50E+04
2.00E+04
1.50E+04
1.00E+04
5.00E+03
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I

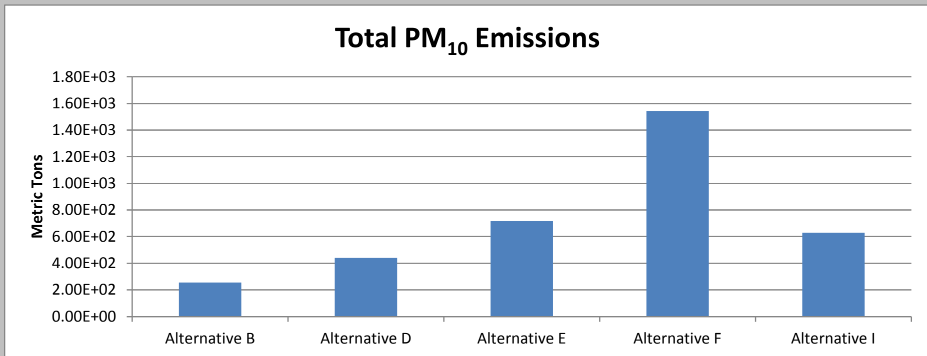

Onsite NOx Emissions
Metric Tons
1.80E+03
1.60E+03
1.40E+03
1.20E+03
1.00E+03
8.00E+02
6.00E+02
4.00E+02
2.00E+02
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I

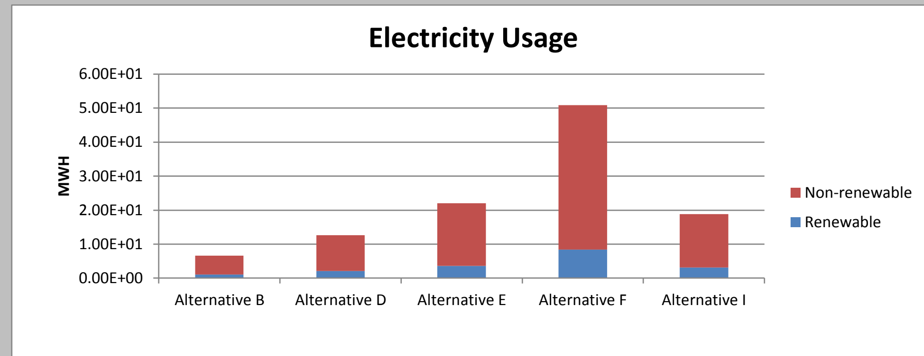

Onsite SOx Emissions
Metric Tons
2.50E+02
2.00E+02
1.50E+02
1.00E+02
5.00E+01
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Onsite PM10 Emissions
Metric Tons
1.00E+02
9.00E+01
8.00E+01
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Total NO_x Emissions
Metric Tons
3.00E+03
2.50E+03
2.00E+03
1.50E+03
1.00E+03
5.00E+02
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Total SO_x Emissions
Metric Tons
9.00E+02
8.00E+02
7.00E+02
6.00E+02
5.00E+02
4.00E+02
3.00E+02
2.00E+02
1.00E+02
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Total PM_{10} Emissions
Metric Tons
1.80E+03
1.60E+03
1.40E+03
1.20E+03
1.00E+03
8.00E+02
6.00E+02
4.00E+02
2.00E+02
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Electricity Usage
MWH
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
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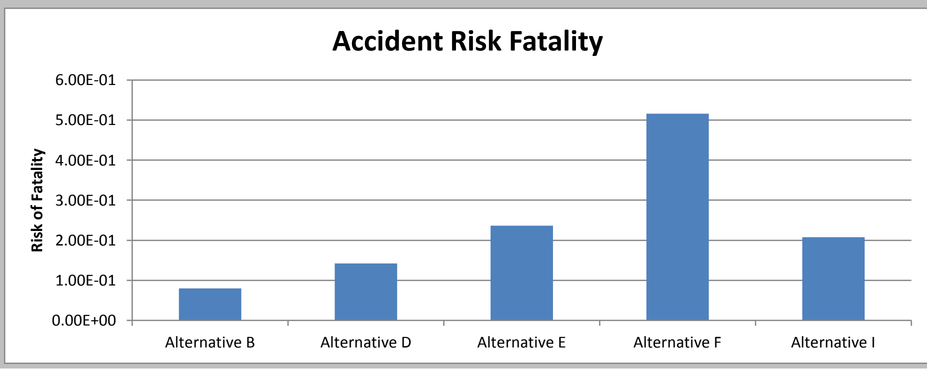
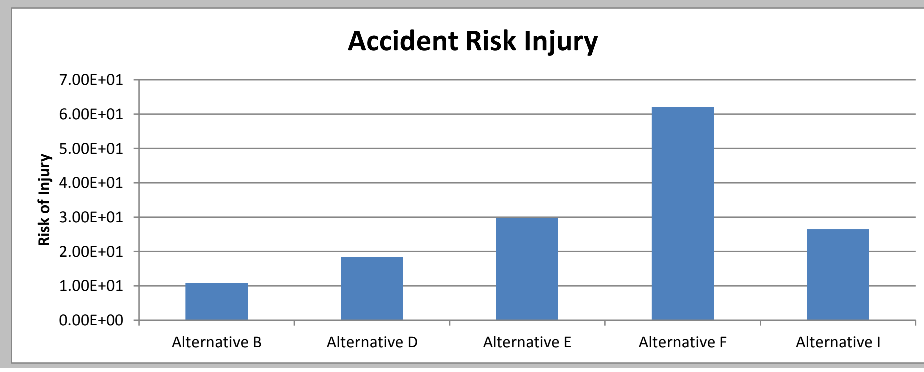
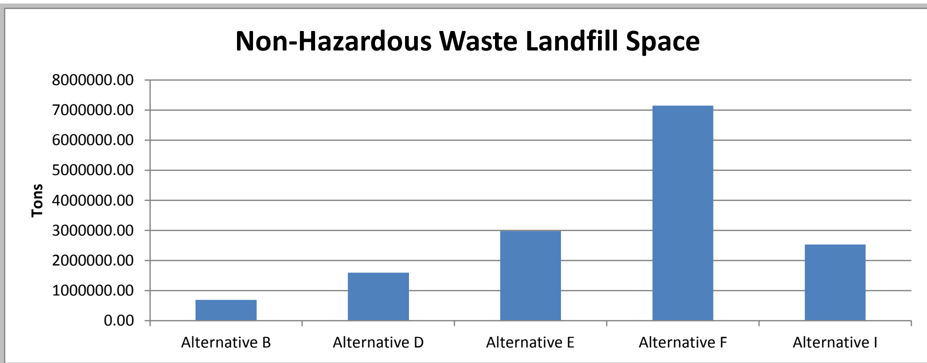
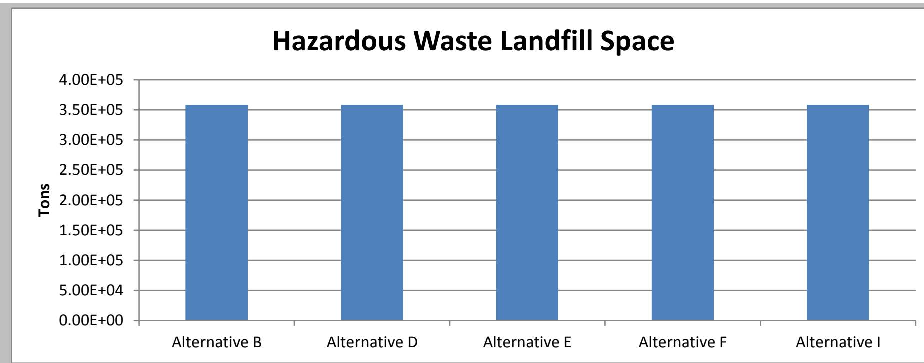
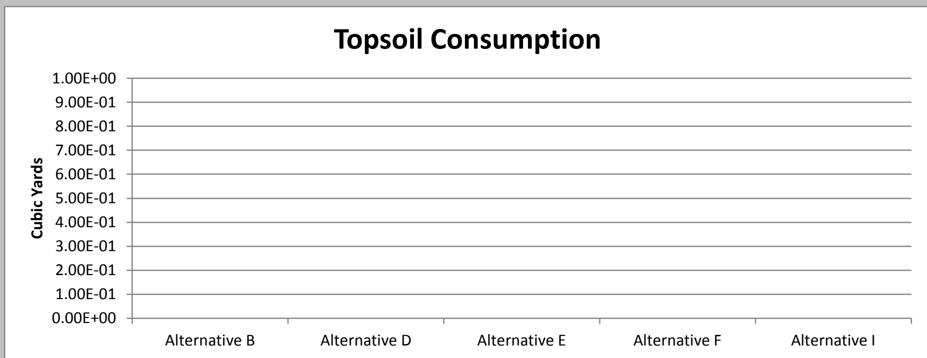
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I
Non-renewable
Renewable

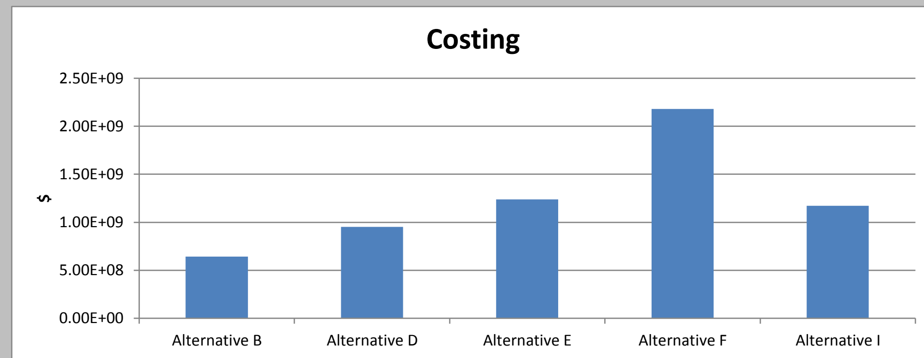

Accident Risk Fatality
Risk of Fatality
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I

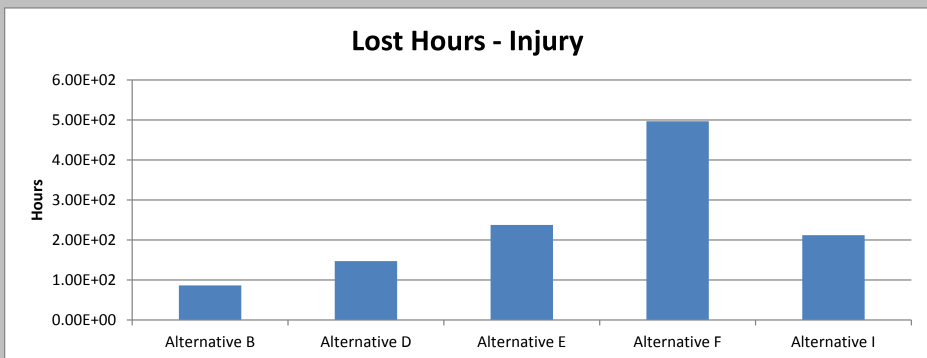

Accident Risk Injury
Risk of Injury
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I

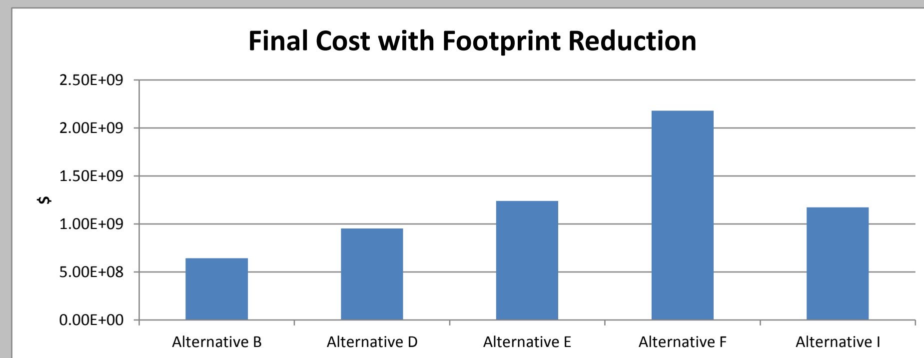

Non-Hazardous Waste Landfill Space
Tons
8000000.00
7000000.00
6000000.00
5000000.00
4000000.00
3000000.00
2000000.00
1000000.00
0.00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I

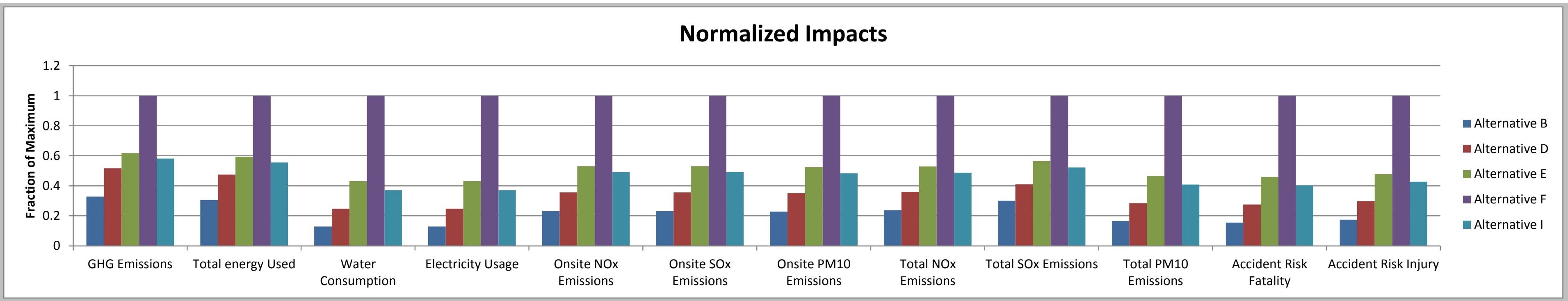

Hazardous Waste Landfill Space
Tons
4.00E+05
3.50E+05
3.00E+05
2.50E+05
2.00E+05
1.50E+05
1.00E+05
5.00E+04
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Topsoil Consumption
Cubic Yards
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Costing
$
2.50E+09
2.00E+09
1.50E+09
1.00E+09
5.00E+08
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Lost Hours - Injury
Hours
6.00E+02
5.00E+02
4.00E+02
3.00E+02
2.00E+02
1.00E+02
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Final Cost with Footprint Reduction
$
2.50E+09
2.00E+09
1.50E+09
1.00E+09
5.00E+08
0.00E+00
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I


Normalized Impacts
Fraction of Maximum
1.2
1
0.8
0.6
0.4
0.2
0
GHG Emissions
Total energy Used
Water Consumption
Electricity Usage
Onsite NOx Emissions
Onsite SOx Emissions
Onsite PM10 Emissions
Total NOx Emissions
Total SOx Emissions
Total PM10 Emissions
Accident Risk Fatality
Accident Risk Injury
Alternative B
Alternative D
Alternative E
Alternative F
Alternative I

Appendix B
SiteWise^{TM} Supplemental Calculations

Waste Quantities

Description	Value	Units	Reference
Moda Center Height	140	feet	https://en.wikipedia.org/wiki/Moda_Center
Moda Center Area	785,000	square feet	https://en.wikipedia.org/wiki/Moda_Center
Moda Center Volume	109,900,000	cubic feet	
Moda Center Volume	4,070,370	cubic yards	EPA, 2015 (1.5 tons/cubic yard)

Remedial Alternatives	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Total Landfill Space	Total Landfill Space	Moda Center Volumes	Truck Trips (140 miles round trip)
	tons	tons	tons	CY	#	#
Alternative B	693,843	359,000	1,052,843	701,895	0.17	52,642
Alternative D	1,599,182	359,000	1,958,182	1,305,455	0.32	97,909
Alternative E	2,975,613	359,000	3,334,613	2,223,075	0.55	166,731
Alternative F	7,149,152	359,000	7,508,152	5,005,435	1.23	375,408
Alternative I	2,534,454	359,000	2,893,454	1,928,969	0.47	144,673

Ecological Footprint

Description	Value	Units	Reference
CO_2 absorbed	2.02	gCO_2/gbiomass	Alfredo Provini et al. (1998) Ecologia Applicata, Italy: CittàStud
growth rate for Douglas Fir in Pacific Coast	2.058	long ton dm/ acre year	Representative Carbon Sequestration Rates and Saturation Periods for Key Agricultural & Forestry Practices, EPA

Remedial Alternatives	GHG Emissions	Douglas Fir Forest Sequestration
	metric tons	Acres
Alternative B	345,770	37.13
Alternative D	545,093	58.54
Alternative E	652,204	70.04
Alternative F	1,046,430	112.37
Alternative I	613,846	65.92
Multnomah County, 2013	7,695,000	826.35

Comparison of Truck with Rail Transportation of Waste for Alternative I

Remedial Alternatives	GHG Emissions metric ton	Accident Risk Fatality	Accident Risk Injury	% Reduction of Alternative I Total	% Reduction of Waste Disposal
Alternative I Rail Waste Only	43,014	0.00	0.00	3.3%	32.0%
Alternative I Trucking Waste Only	63,243	0.14	11.14	--	--
Alternative I Total	613,022	0.21	26.50	--	--

Sensitivity Analysis of Truck vs. Rail Transport of Waste to Subtitle D Landfill for Alternative I

Remedial Alternatives	GHG Emissions	Total energy Used	Water Consumption	Electricity Usage	Onsite NO_x Emissions	Onsite SO_x Emissions	Onsite PM_{10} Emissions	Total NO_x Emissions	Total SO_x Emissions	Total PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
	metric ton	MMBTU	gallons	MWH	metric ton	metric ton	metric ton	metric ton	metric ton	metric ton		
Alternative I Rail Waste	43014.07	6.30E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.18E+02	1.24E+02	4.76E+02	0.00E+00	0.00E+00
Alternative I Truck Waste	63242.51	9.73E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E+02	8.64E+01	4.61E+02	1.38E-01	1.11E+01

Additional Sustainability Metrics

Remedial Alternatives	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Topsoil Consumption	Costing	Lost Hours - Injury	Percent Electricity from Renewable Sources	Final Cost with Footprint Reduction
	tons	tons	cubic yards	$		%	$
Alternative I Rail Waste	2534454.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.0%	0.00E+00
Alternative I Truck Waste	2534454.00	0.00E+00	0.00E+00	0.00E+00	8.91E+01	0.0%	0.00E+00

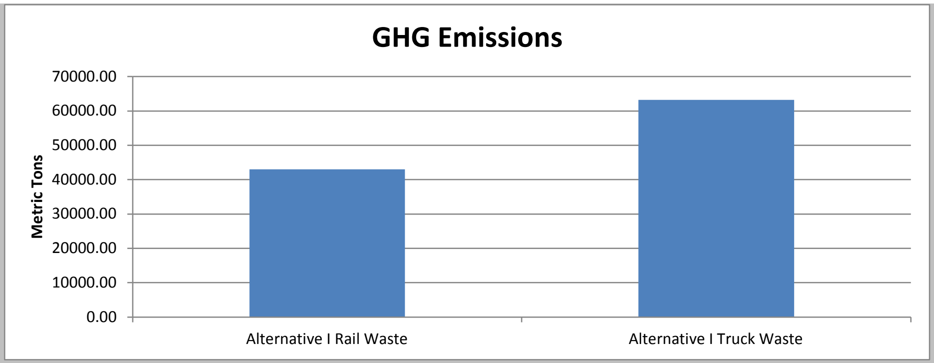
Relative Impact

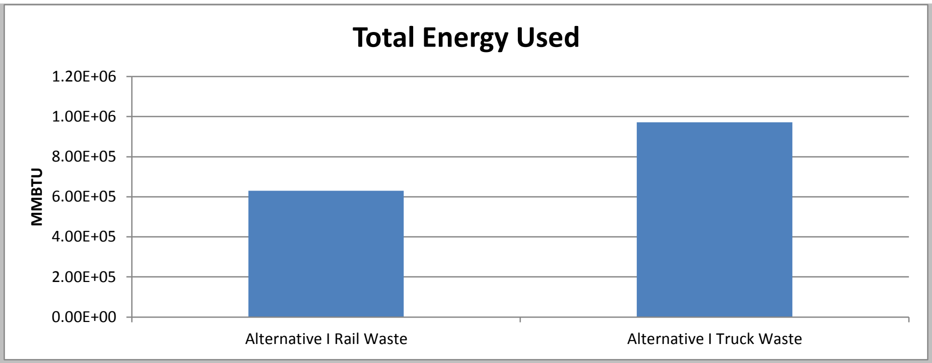
Remedial Alternatives	GHG Emissions	Energy Usage	Water Usage	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx emissions	Total SOx Emissions	Total PM10 Emissions	*Accident Risk Fatality	*Accident Risk Injury	Community Impacts	Resources Lost
Alternative I Rail Waste	Medium	Medium	Low	Low	Low	Low	Low	High	High	High	Low	Low	user select	user select
Alternative I Truck Waste	High	High	Low	Low	Low	Low	Low	Medium	Medium	High	Low	Low	user select	user select

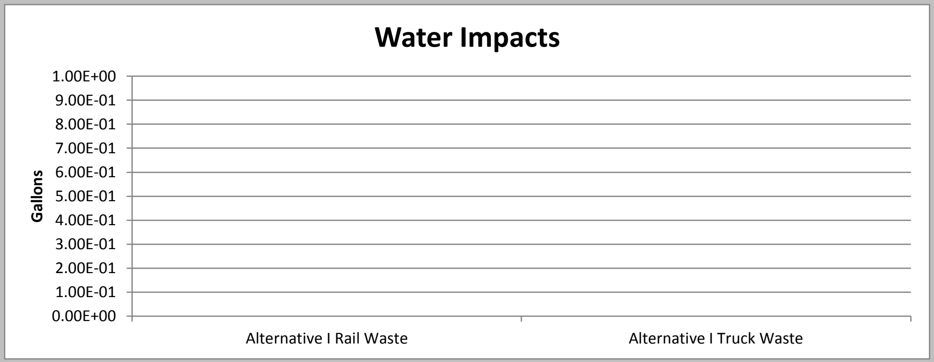
Relative Impact (User Override)

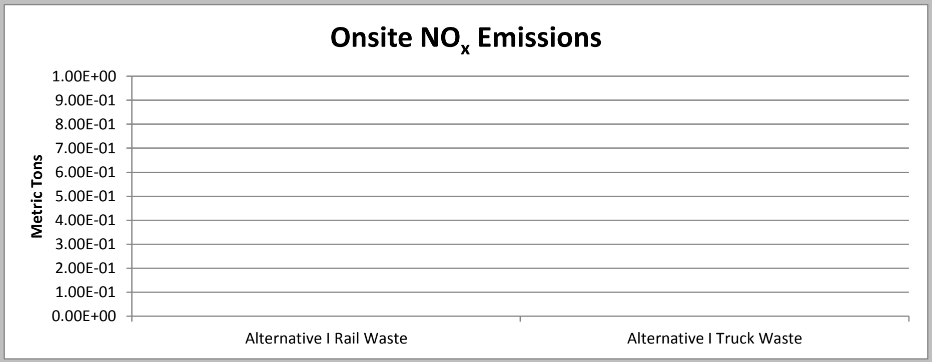
Remedial Alternatives	GHG Emissions	Energy Usage	Water Usage	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx Emissions	Total SOx Emissions	Total PM10 Emissions	*Accident Risk Fatality	*Accident Risk Injury	Community Impacts	Resources Lost
Alternative I Rail Waste	Medium	Medium	Low	Low	Low	Low	Low	High	High	High	Low	Low	user select	user select
Alternative I Truck Waste	High	High	Low	Low	Low	Low	Low	Medium	Medium	High	Low	Low	user select	user select

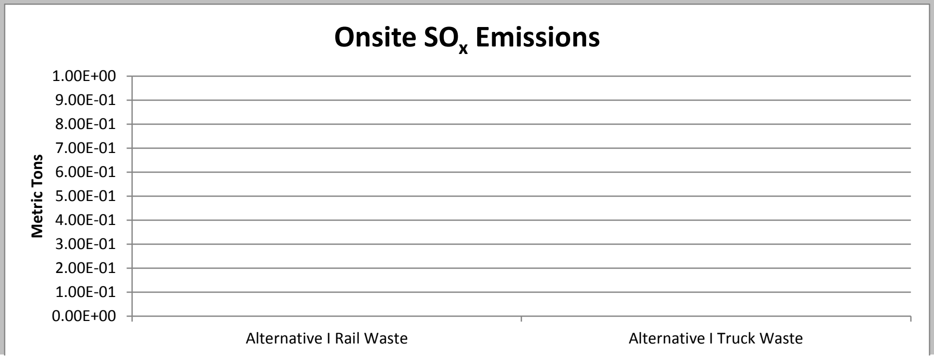
*Accident Risk is an estimate of how many accidents may occur. This risk is not the same as Cancer Risk, which is the probability (for a single person) of getting cancer. Accident risk is not comparable to Cancer Risk due to inherent fundamental differences.

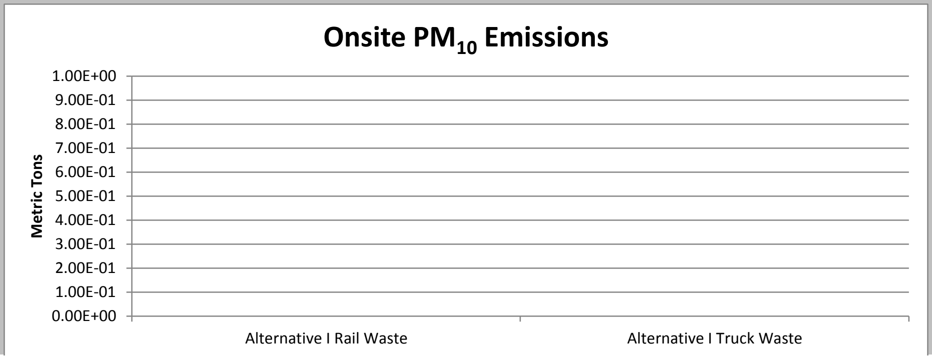

GHG Emissions
Metric Tons
70000.00
60000.00
50000.00
40000.00
30000.00
20000.00
10000.00
0.00
Alternative I Rail Waste
Alternative I Truck Waste

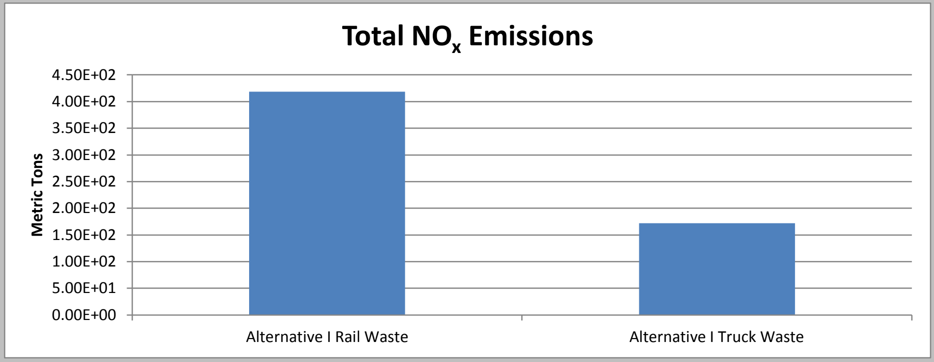

Total Energy Used
MMBTU
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

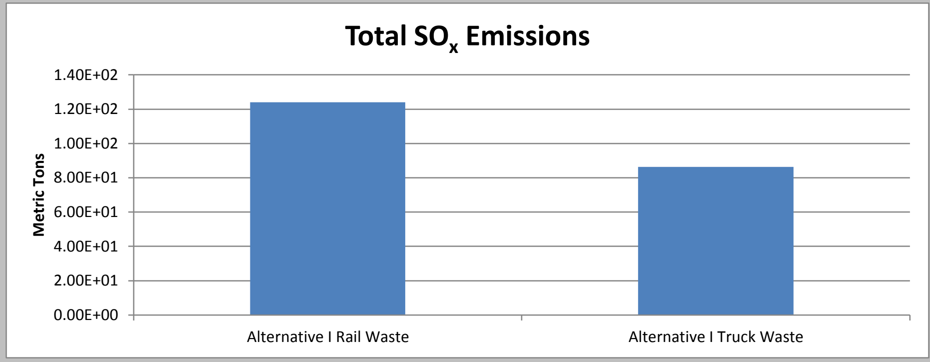

Water Impacts
Gallons
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

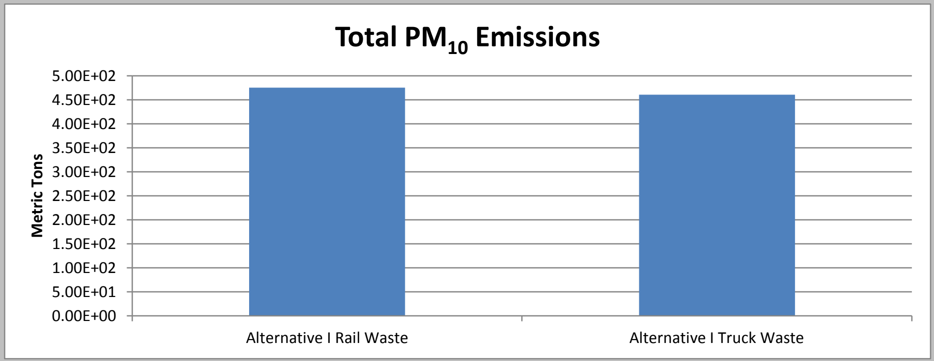

Onsite NO_x Emissions
Metric Tons
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

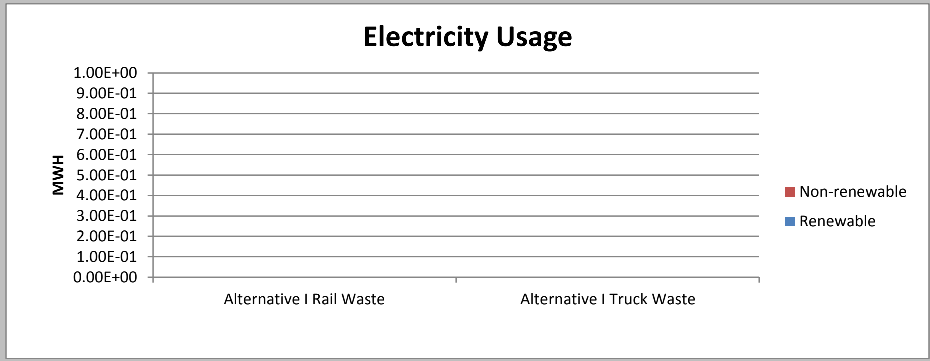

Onsite SO_x Emissions
Metric Tons
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

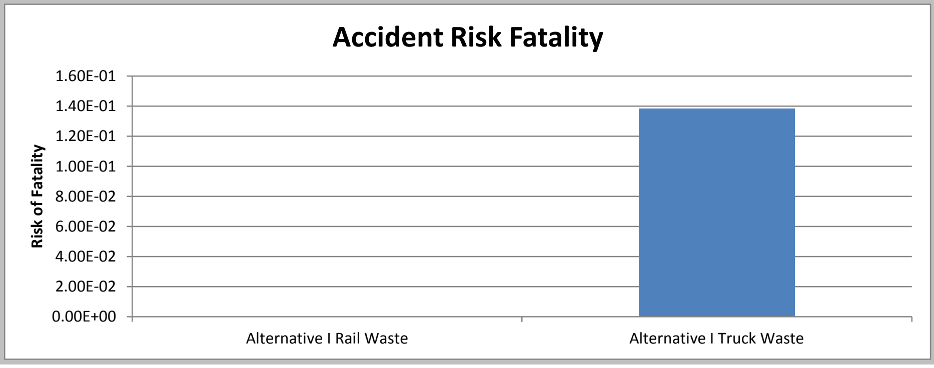

Onsite PM_{10} Emissions
Metric Tons
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

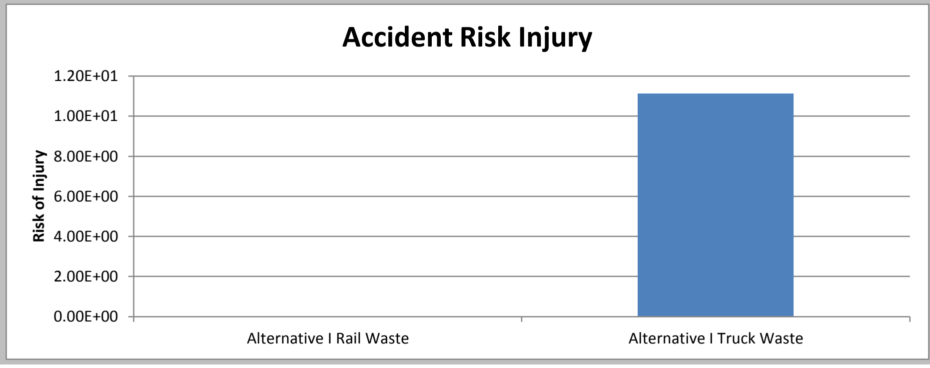

Total NO_x Emissions
Metric Tons
4.50E+02
4.00E+02
3.50E+02
3.00E+02
2.50E+02
2.00E+02
1.50E+02
1.00E+02
5.00E+01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

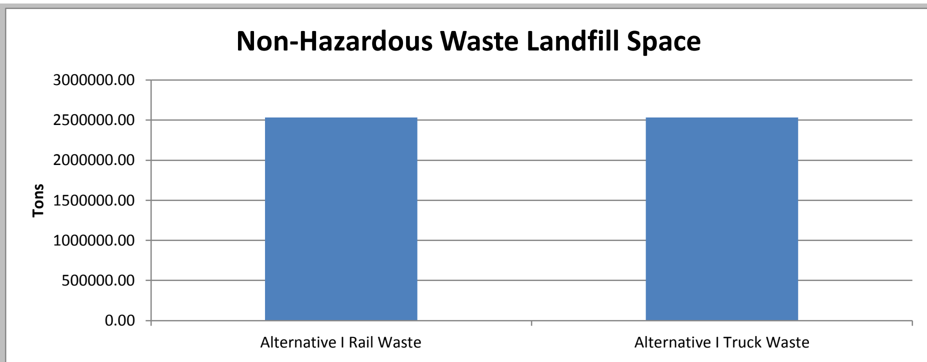

Total SO_x Emissions
Metric Tons
1.40E+02
1.20E+02
1.00E+02
8.00E+01
6.00E+01
4.00E+01
2.00E+01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

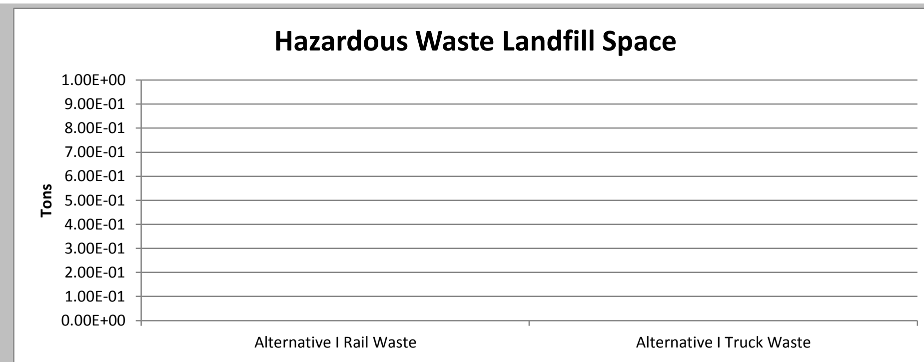

Total PM_{10} Emissions
Metric Tons
5.00E+02
4.50E+02
4.00E+02
3.50E+02
3.00E+02
2.50E+02
2.00E+02
1.50E+02
1.00E+02
5.00E+01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

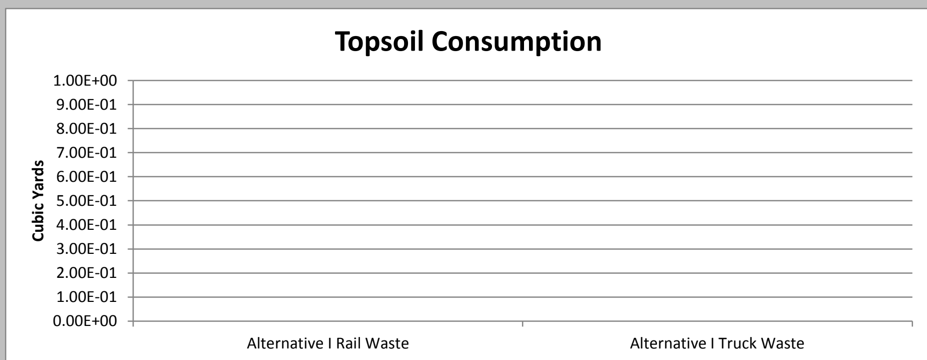

Electricity Usage
MWH
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste
Non-renewable
Renewable

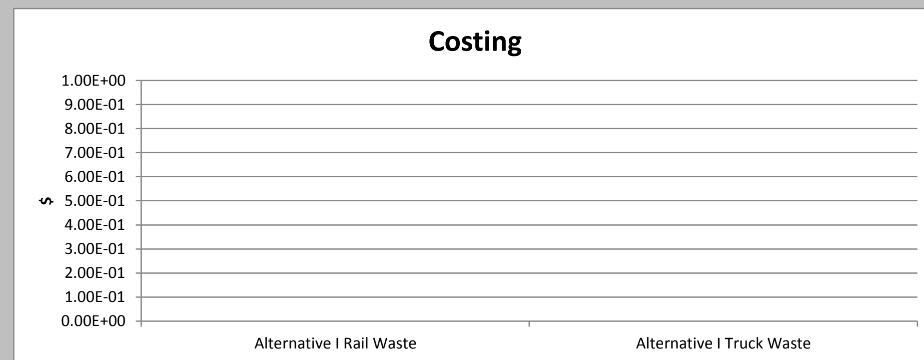

Accident Risk Fatality
Risk of Fatality
1.60E-01
1.40E-01
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

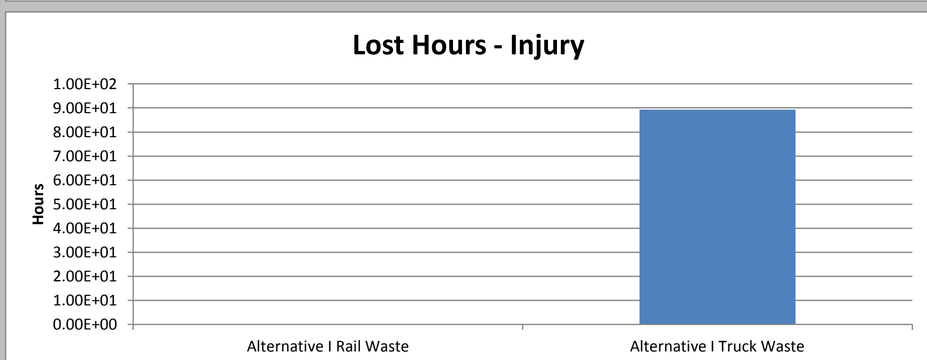

Accident Risk Injury
Risk of Injury
1.20E+01
1.00E+01
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste

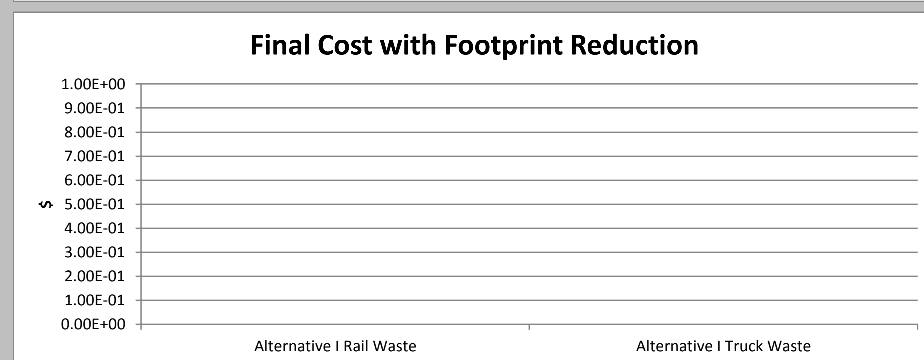

Non-Hazardous Waste Landfill Space
Tons
3000000.00
2500000.00
2000000.00
1500000.00
1000000.00
500000.00
0.00
Alternative I Rail Waste
Alternative I Truck Waste

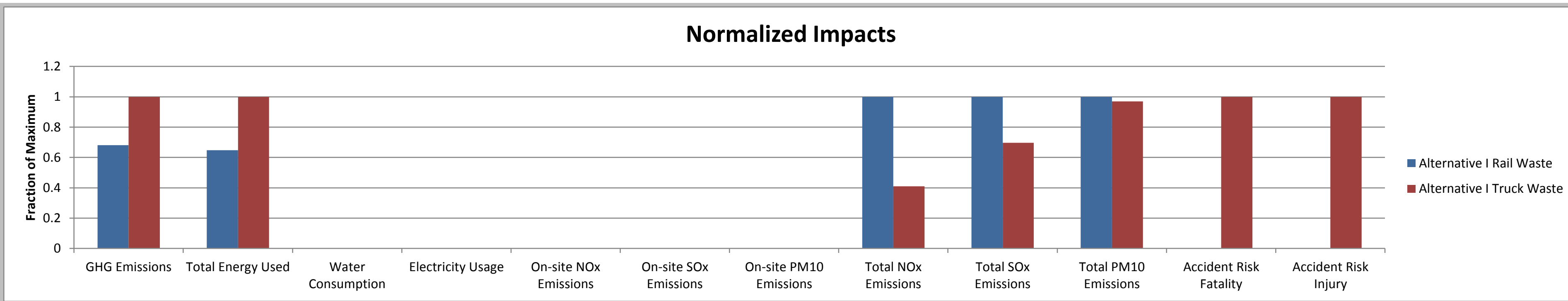

Hazardous Waste Landfill Space
Tons
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste


Topsoil Consumption
Cubic Yards
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste


Costing
$
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste


Lost Hours - Injury
Hours
1.00E+02
9.00E+01
8.00E+01
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste


Final Cost with Footprint Reduction
$
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative I Rail Waste
Alternative I Truck Waste


Normalized Impacts
Fraction of Maximum
1.2
1
0.8
0.6
0.4
0.2
0
GHG Emissions
Total Energy Used
Water Consumption
Electricity Usage
On-site NOx Emissions
On-site SOx Emissions
On-site PM10 Emissions
Total NOx Emissions
Total SOx Emissions
Total PM10 Emissions
Accident Risk Fatality
Accident Risk Injury
Alternative I Rail Waste
Alternative I Truck Waste

Sensitivity Analysis of Disposed Material Management (DMM) Scenarios

DMM Scenario 1: Combination of on-site confined disposal facility (CDF) and off-site landfill

DMM Scenario 2: Off-site landfill only

Remedial Alternatives	GHG Emissions	Total energy Used	Water Consumption	Electricity Usage	Onsite NO_x Emissions	Onsite SO_x Emissions	Onsite PM_{10} Emissions	Total NO_x Emissions	Total SO_x Emissions	Total PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
	metric ton	MMBTU	gallons	MWH	metric ton	metric ton	metric ton	metric ton	metric ton	metric ton		
Alternative E CDF	592647.74	4.02E+06	1.12E+04	2.20E+01	8.25E+02	1.15E+02	4.37E+01	1.24E+03	4.33E+02	5.15E+02	1.75E-01	2.43E+01
Alternative E	652317.98	4.49E+06	1.12E+04	2.20E+01	8.52E+02	1.17E+02	4.62E+01	1.35E+03	4.74E+02	7.16E+02	2.37E-01	2.97E+01
Alternative F CDF	995824.37	7.09E+06	2.60E+04	5.09E+01	1.58E+03	2.18E+02	8.53E+01	2.44E+03	8.00E+02	1.34E+03	4.54E-01	5.67E+01
Alternative F	1055494.61	7.56E+06	2.60E+04	5.09E+01	1.61E+03	2.20E+02	8.78E+01	2.54E+03	8.40E+02	1.54E+03	5.16E-01	6.20E+01
Alternative I CDF	553352.11	3.73E+06	9.61E+03	1.88E+01	7.60E+02	1.06E+02	4.00E+01	1.13E+03	3.99E+02	4.29E+02	1.46E-01	2.11E+01
Alternative I	613022.35	4.19E+06	9.61E+03	1.88E+01	7.87E+02	1.08E+02	4.25E+01	1.24E+03	4.39E+02	6.30E+02	2.08E-01	2.65E+01

Additional Sustainability Metrics

Remedial Alternatives	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Topsoil Consumption	Costing	Lost Hours - Injury	Percent Electricity from Renewable Sources	Final Cost with Footprint Reduction
	tons	tons	cubic yards	$		%	$
Alternative E CDF	1885188.00	3.59E+05	0.00E+00	1.24E+09	1.95E+02	16.5%	1.24E+09
Alternative E	2975613.00	3.59E+05	0.00E+00	1.24E+09	2.37E+02	16.5%	1.24E+09
Alternative F CDF	6058727.00	3.59E+05	0.00E+00	2.18E+09	4.53E+02	16.5%	2.18E+09
Alternative F	7149152.00	3.59E+05	0.00E+00	2.18E+09	4.96E+02	16.5%	2.18E+09
Alternative I CDF	1444029.00	3.59E+05	0.00E+00	1.17E+09	1.69E+02	16.5%	1.17E+09
Alternative I	2534454.00	3.59E+05	0.00E+00	1.17E+09	2.12E+02	16.5%	1.17E+09

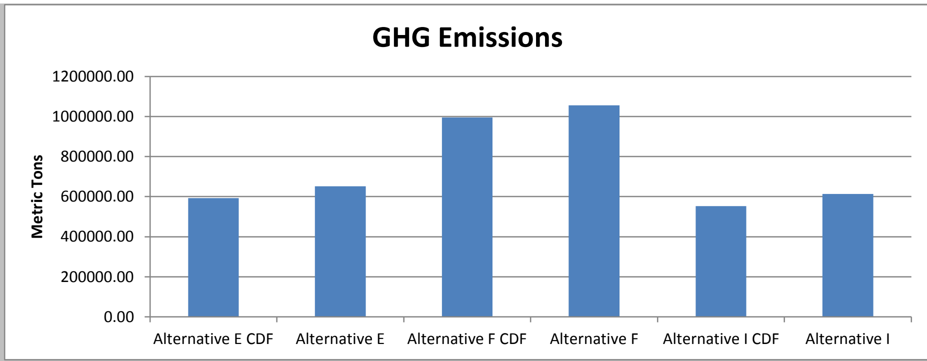
Relative Impact

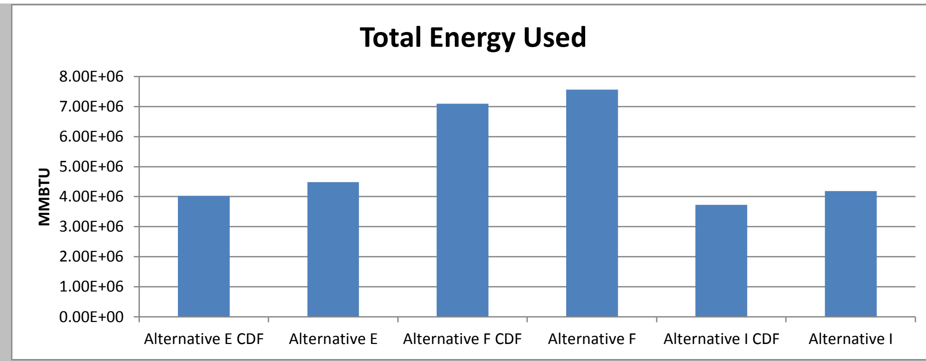
Remedial Alternatives	GHG Emissions	Energy Usage	Water Usage	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx emissions	Total SOx Emissions	Total PM10 Emissions	*Accident Risk Fatality	*Accident Risk Injury	Community Impacts	Resource s Lost
Alternative E CDF	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	user select	user select
Alternative E	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	user select	user select
Alternative F CDF	High	High	High	High	High	High	High	High	High	High	Low	Low	user select	user select
Alternative F	High	High	High	High	High	High	High	High	High	High	Low	Low	user select	user select
Alternative I CDF	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	user select	user select
Alternative I	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	user select	user select

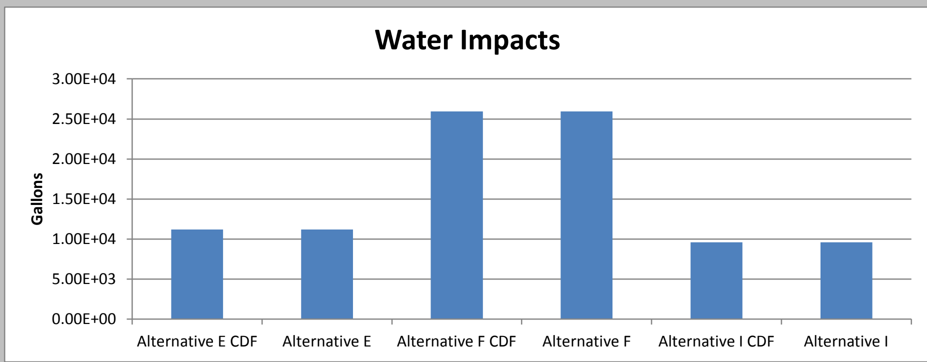
Relative Impact (User Override)

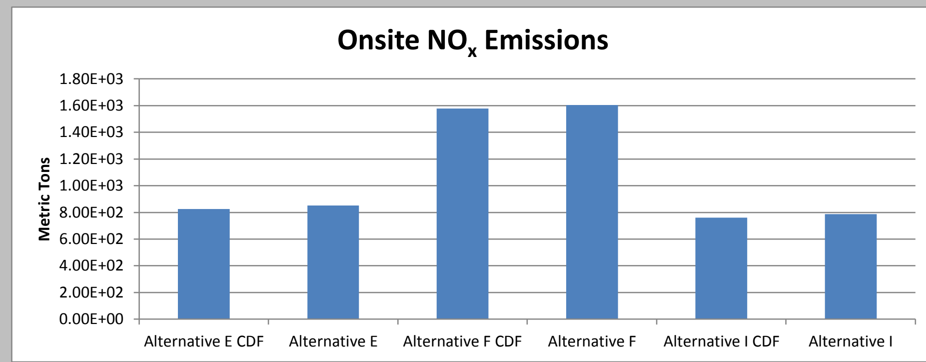
Remedial Alternatives	GHG Emissions	Energy Usage	Water Usage	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx Emissions	Total SOx Emissions	Total PM10 Emissions	*Accident Risk Fatality	*Accident Risk Injury	Community Impacts	Resource s Lost
Alternative E CDF	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	user select	user select
Alternative E	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Low	user select	user select
Alternative F CDF	High	High	High	High	High	High	High	High	High	High	Low	Low	user select	user select
Alternative F	High	High	High	High	High	High	High	High	High	High	Low	Low	user select	user select
Alternative I CDF	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	user select	user select
Alternative I	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	user select	user select

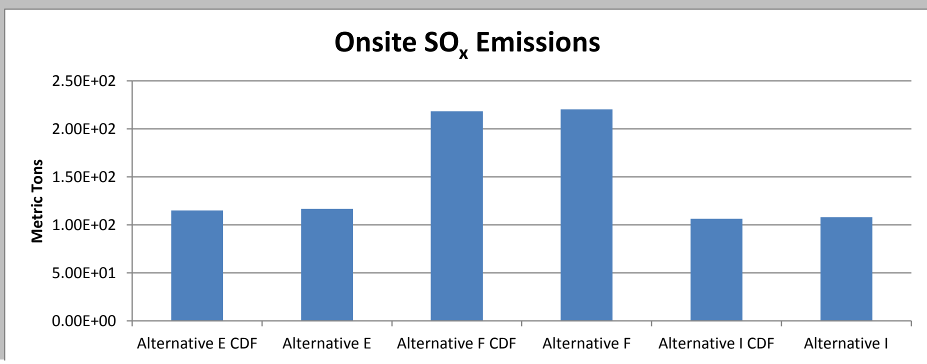
*Accident Risk is an estimate of how many accidents may occur. This risk is not the same as Cancer Risk, which is the probability (for a single person) of getting cancer. Accident risk is not comparable to Cancer Risk due to inherent fundamental differences.

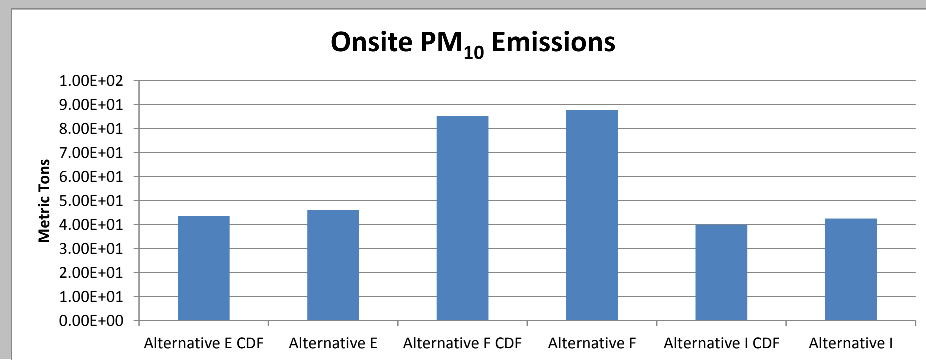

GHG Emissions
Metric Tons
1200000.00
1000000.00
800000.00
600000.00
400000.00
200000.00
0.00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I

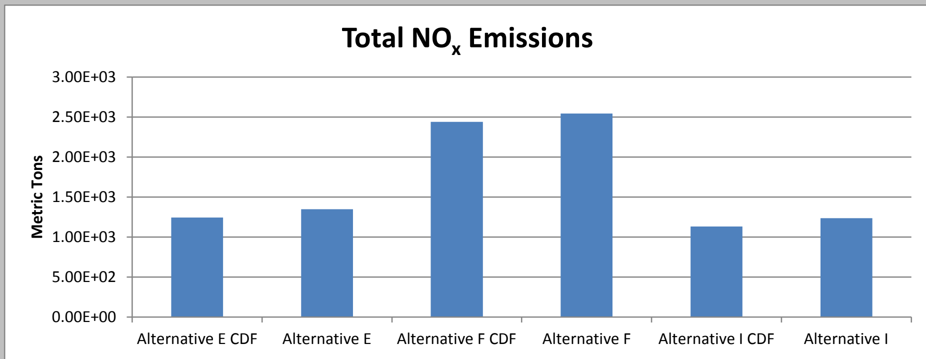

Total Energy Used
MMBTU
8.00E+06
7.00E+06
6.00E+06
5.00E+06
4.00E+06
3.00E+06
2.00E+06
1.00E+06
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I

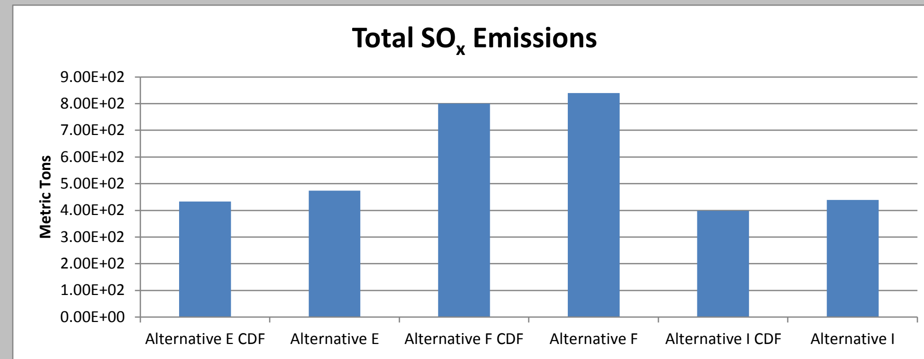

Water Impacts
Gallons
3.00E+04
2.50E+04
2.00E+04
1.50E+04
1.00E+04
5.00E+03
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I

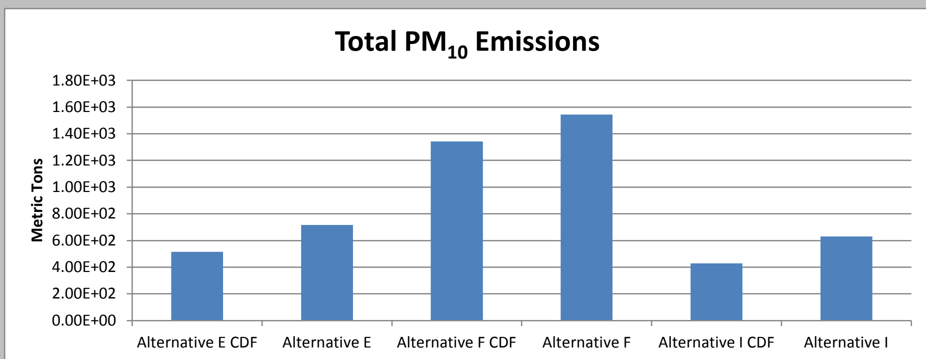

Onsite NO_x Emissions
Metric Tons
1.80E+03
1.60E+03
1.40E+03
1.20E+03
1.00E+03
8.00E+02
6.00E+02
4.00E+02
2.00E+02
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I

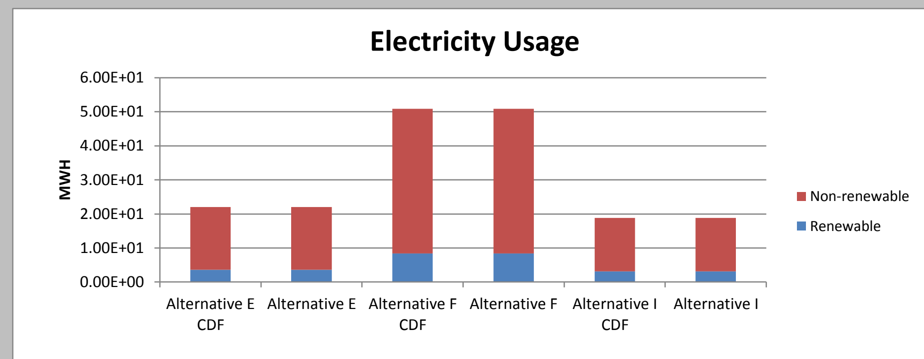

Onsite SO_x Emissions
Metric Tons
2.50E+02
2.00E+02
1.50E+02
1.00E+02
5.00E+01
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I

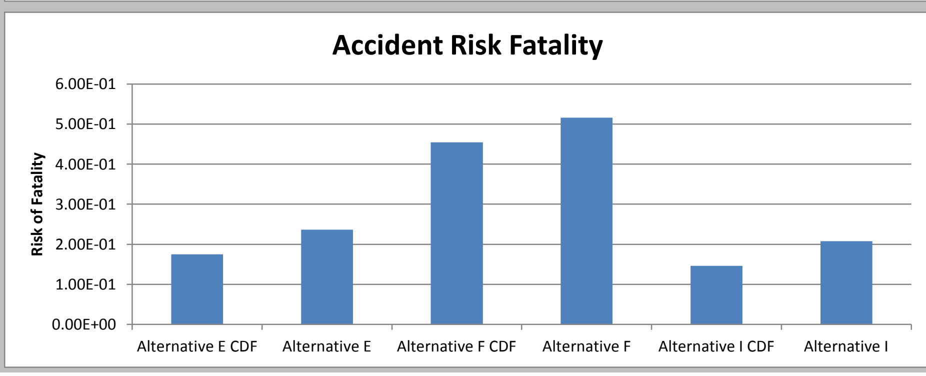

Onsite PM_{10} Emissions
Metric Tons
1.00E+02
9.00E+01
8.00E+01
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I

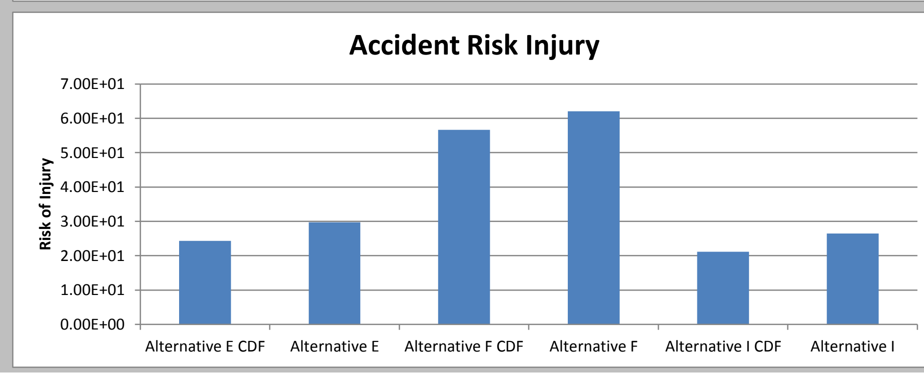

Total NO_x Emissions
Metric Tons
3.00E+03
2.50E+03
2.00E+03
1.50E+03
1.00E+03
5.00E+02
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I

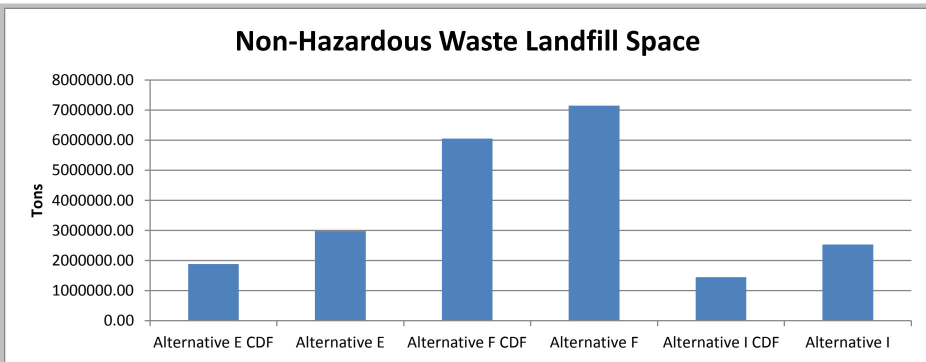

Total SO_x Emissions
Metric Tons
9.00E+02
8.00E+02
7.00E+02
6.00E+02
5.00E+02
4.00E+02
3.00E+02
2.00E+02
1.00E+02
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I


Total PM_{10} Emissions
Metric Tons
1.80E+03
1.60E+03
1.40E+03
1.20E+03
1.00E+03
8.00E+02
6.00E+02
4.00E+02
2.00E+02
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I


Electricity Usage
MWH
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I
Non-renewable
Renewable


Accident Risk Fatality
Risk of Fatality
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I


Accident Risk Injury
Risk of Injury
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I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Tons
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7000000.00
6000000.00
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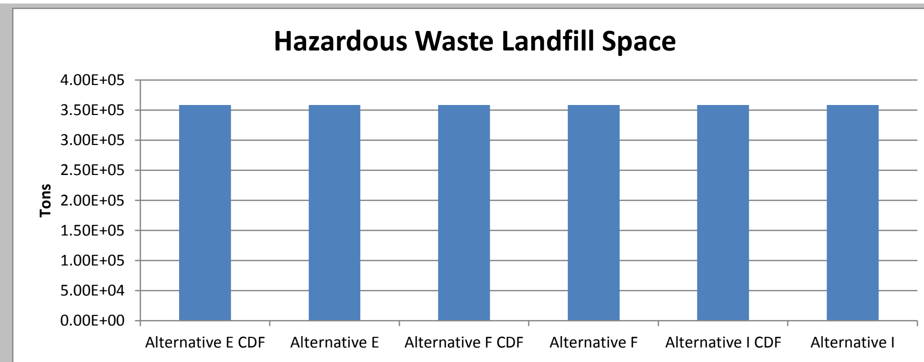
1000000.00
0.00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I


Hazardous Waste Landfill Space
Tons
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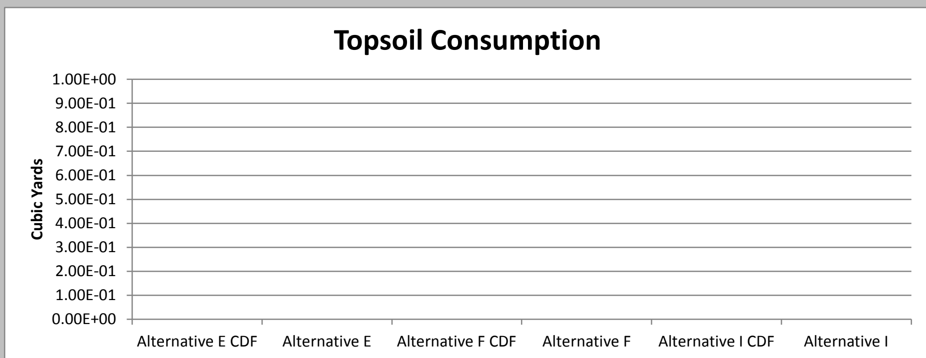
3.00E+05
2.50E+05
2.00E+05
1.50E+05
1.00E+05
5.00E+04
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I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Cubic Yards
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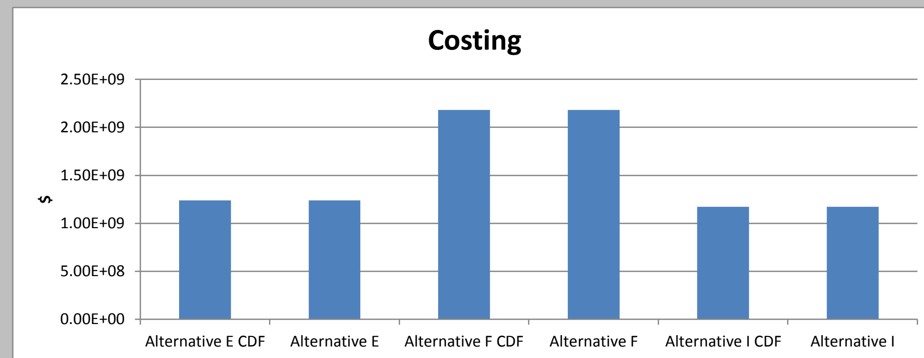
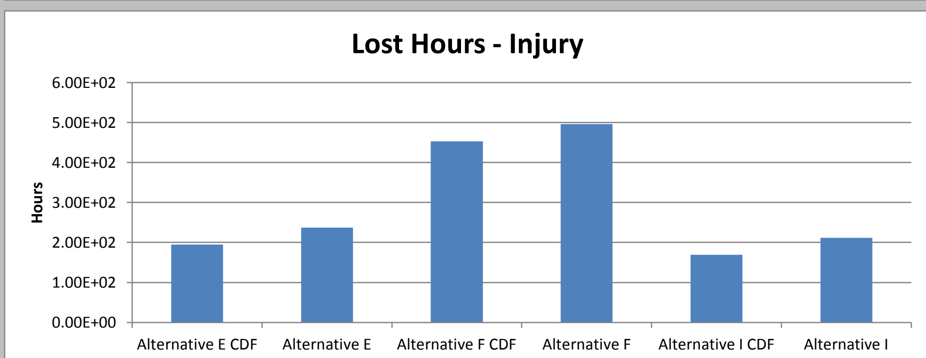
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I


Costing
$
2.50E+09
2.00E+09
1.50E+09
1.00E+09
5.00E+08
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I


Lost Hours - Injury
Hours
6.00E+02
5.00E+02
4.00E+02
3.00E+02
2.00E+02
1.00E+02
0.00E+00
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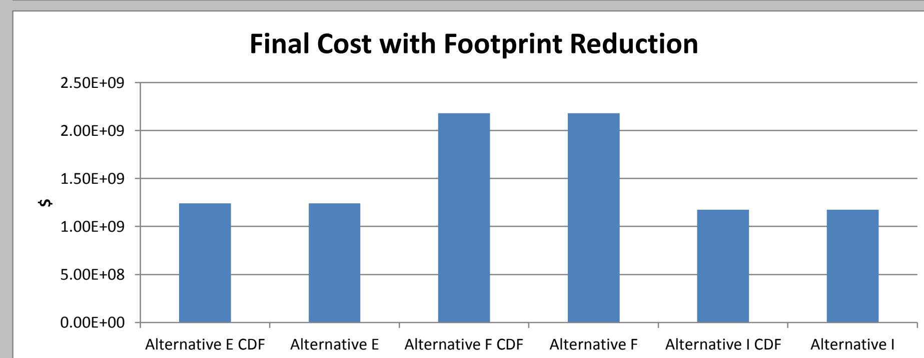
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I


Final Cost with Footprint Reduction
$
2.50E+09
2.00E+09
1.50E+09
1.00E+09
5.00E+08
0.00E+00
Alternative E CDF
Alternative E
Alternative F CDF
Alternative F
Alternative I CDF
Alternative I

SiteWise™ Sensitivity Analysis of Dredge Rates

	Alternative B		Alternative D		Alternative E		Alternative F		Alternative I	
SEDIMENT DREDGING	Open Water	Confined	Open Water	Confined	Open Water	Confined	Open Water	Confined	Open Water	Confined
Choose dredge equipment type from drop down menu	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical	Mechanical
Choose dredge fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input volume of material to be dredged (yd3)	513,841	63,042	1,035,580	72,466	1,835,521	92,616	4,339,288	123,286	1,556,599	93,151
Choose dredge equipment size	Crawler Crane, 100 ton, 4 CY	Crawler Crane, 25 ton, 1 CY	Crawler Crane, 100 ton, 4 CY	Crawler Crane, 25 ton, 1 CY	Crawler Crane, 100 ton, 4 CY	Crawler Crane, 25 ton, 1 CY	Crawler Crane, 100 ton, 4 CY	Crawler Crane, 25 ton, 1 CY	Crawler Crane, 100 ton, 4 CY	Crawler Crane, 25 ton, 1 CY
Suggested dredge equipment size	Crawler Crane, 200 ton, 8 CY	Crawler Crane, 100 ton, 4 CY	Crawler Crane, 200 ton, 8 CY	Crawler Crane, 100 ton, 4 CY	Crawler Crane, 200 ton, 8 CY	Crawler Crane, 150 ton, 6 CY	Crawler Crane, 200 ton, 8 CY	Crawler Crane, 200 ton, 8 CY	Crawler Crane, 200 ton, 8 CY	Crawler Crane, 150 ton, 6 CY
Input number of dredge tenders (default already present, user override possible)	1	1	1	1	1	1	1	1	1	1
Choose dredge tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for dredge tenders (hr) (default calculated value, user override possible)	4135	2410	8334	2770	14772	3540	34921	4713	12527	3561
Input number of scow tenders (default already present, user override possible)	2	4	2	4	2	4	2	4	2	4
Choose scow tender fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input operating time for scow tenders (hr) (default calculated value, user override possible)	4135	2410	8334	2770	14772	3540	34921	4713	12527	3561
Choose size of research vessel from drop down menu	Research Vessel (large)	Research Vessel (large)	Research Vessel (large)	Research Vessel (large)	Research Vessel (large)	Research Vessel (large)	Research Vessel (large)	Research Vessel (large)	Research Vessel (large)	Research Vessel (large)
Choose research vessel fuel type from drop down menu	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
Input number of research vessels (default already present, user override possible)	1	1	1	1	1	1	1	1	1	1
Input operating time for research vessels (hr) (default calculated value, user override possible)	4135	2410	8334	2770	14772	3540	34921	4713	12527	3561
Will diesel-run equipment be retrofitted with a particulate reduction technology?	No	No	No	No	No	No	No	No	No	No
Total Dredge Volume (CY)		576,883		1,108,046		1,928,137		4,462,574		1,649,750
Dredge Rate (CY/hr)	124	26	124	26	124	26	124	26	124	26
Dredge Rate (CY/day)	1,491	314	1,491	314	1,491	314	1,491	314	1,491	314
Blended Dredge Rate (CY/day)		1,362		1,414		1,435		1,459		1,425
SiteWise™ Dredge Hours		6,545		11,104		18,312		39,634		16,088
Real Dredge Rate (CY/day)	1,000	300	1,000	300	1,000	300	1,000	300	1,000	300
Real Dredge Rate (CY/hr)	83	25	83	25	83	25	83	25	83	25
Real Dredge Hours	6,166	2,522	12,427	2,899	22,026	3,705	52,071	4,931	18,679	3,726
Real Total Dredge Hours		8,688		15,326		25,731		57,003		22,405
Real Blended Dredge Rate (CY/day)		924		954		966		981		960
Real Blended Dredge Rate (CY/hour)		77		80		81		82		80
% Decrease in Dredge Rate	32%		33%		33%		33%		33%	
% Increase in Hours	33%		38%		41%		44%		39%	

Appendix C
GIS Overlap Analysis Tables and Figures

Table C-1. Infrastructure Shoreline Disturbance Analysis (Water-dependent Business)

EPA Alternative	Active Remedial Footprint (Dredge, Cap, Treatment, ENR)[a]		
	Overlap with Primary/ Secondary Shoreline Uses[b] (LF)	% Overlap of 106,835 LF of Infrastructure Access Shoreline	Total Active Shoreline (LF)[c]
B	23,569	22%	27,430
D	31,059	29%	38,881
E	41,131	38%	49,364
F	57,555	54%	67,311
I	37,815	35%	43,050

Notes:

LF = linear feet.

a. EPA 2015 remedial footprints for Alternatives B-F and EPA 2016 remedial footprint for Alternative I used in analysis. "Active" footprint defined as dredging, capping, treatment, and ENR combined.

b. Upland parcels identified as "primary" and "secondary" are marine/rail infrastructure users in City of Portland (source: City of Portland Planning Department's North Reach Specialized Infrastructure Access Map 2015). Rest of shoreline are remaining areas not designated for infrastructure use. Infrastructure Analysis Shoreline: Total LF of primary infrastructure shoreline is 79,864 LF and secondary infrastructure shoreline is 26,971 LF.
Combined Total Infrastructure Access Shoreline of 106,835 LF.

c. Active shoreline is the shoreline that is adjacent to the active remedial footprint.

1. Study Area: River Mile 1.9 through RM 11.8 comprising 137,537 LF of shoreline.
2. All results presented in LF, and represent the upland infrastructure shoreline features overlap with the active remedial footprints.
3. Active remedial footprint for Alternative I was hand-digitized in GIS using Figures 3.8-9B through 3.8-9F from the 2016 EPA FS.

Table C-2. Overwater Structures Disturbance Analysis (Water-dependent Business)

EPA Alternative	Active Remedial Footprint (Dredge, Cap, Treatment, ENR)[a]		
	Overlap with Overwater Structures[b,c] (SF)	% Overlap of 31,412,469 SF of Overwater Structures Area	Total Active Footprint (SF)
B	3,031,611	10%	8,712,355
D	3,717,693	12%	11,518,090
E	4,513,316	14%	14,209,605
F	6,805,231	22%	22,997,499
I	5,040,909	16%	12,666,837

Notes:

SF = square feet.

a. EPA 2015 remedial footprints for Alternatives B-F and EPA 2016 remedial footprint for Alternative I used in analysis. "Active" footprint defined as dredging, capping, treatment, and ENR combined.

b. "Overwater structures" is a GIS mapping layer identified in the draft FS (Anchor QEA 2012). Overwater structures includes docks, pilings, piers. Overwater Structures Analysis Area (with 100-foot buffer): 31,412,469 SF.

c. A 100-foot buffer was placed around the docks, pilings and structures to account for berthing and mooring areas.

1. Study Area: River Mile 1.9 through RM 11.8 comprising 95,473,688 SF of area.

2. All results presented in SF area, and represent the overwater structures overlap with the active remedial footprints.

3. Active remedial footprint for Alternative I was hand-digitized in GIS using Figures 3.8-9B through 3.8-9F from the 2016 EPA FS.

Table C-3. Recreational Shoreline Disturbance Analysis

EPA Alternative	Active Remedial Footprint (Dredge, Cap, Treatment, ENR)[a,c]		
	Overlap with Beach/Park Shoreline[b] (LF)	% Overlap of 23,512 LF of Beach/Park Shoreline	Total Active Beach Shoreline (LF)
B	3,963	17%	NA
D	5,237	22%	NA
E	6,365	27%	NA
F	9,407	40%	NA
I	4,979	21%	NA

Notes:

LF = linear feet.

a. EPA 2015 remedial footprints for Alternatives B-F and EPA 2016 remedial footprint for Alternative I used in analysis. "Active" footprint defined as dredging, capping, treatment, and ENR combined.

b. The beach areas were identified in human health risk assessment as beach access areas sampled for analysis. AECOM assumes these are part of the human health direct contact scenarios. Shoreline areas with adjacent public parks or boat access launch areas also included in this layer.
Beach and Parks Analysis Shoreline: 23,512 LF.

c. A 25-foot buffer was placed around the active footprints for Alternatives B, D, E, F, and I to account for nearshore connectivity with the remedy.

1. Study Area: River Mile 1.9 through RM 11.8 comprising 137,537 LF of shoreline.

2. All results presented in LF, and represent the upland beach/park shoreline features overlap with the active remedial footprints.

3. Active remedial footprint for Alternative I was hand-digitized in GIS using Figures 3.8-9B through 3.8-9F from the 2016 EPA FS.

Table C-4. Ecological Disturbance Analysis (Potential Nearshore High-value Habitat)

EPA Alternative	Active Remedial Footprint (Dredge, Cap, Treatment, ENR)[a]		
	Overlap with Habitat Area[b] (SF)	% Overlap of 20,585,066 SF of Habitat Area	Total Active Footprint (SF)
B	3,137,532	15%	8,712,355
D	4,163,325	20%	11,518,090
E	5,422,712	26%	14,209,605
F	8,129,329	39%	22,997,499
I	4,911,893	24%	12,666,837

Notes:

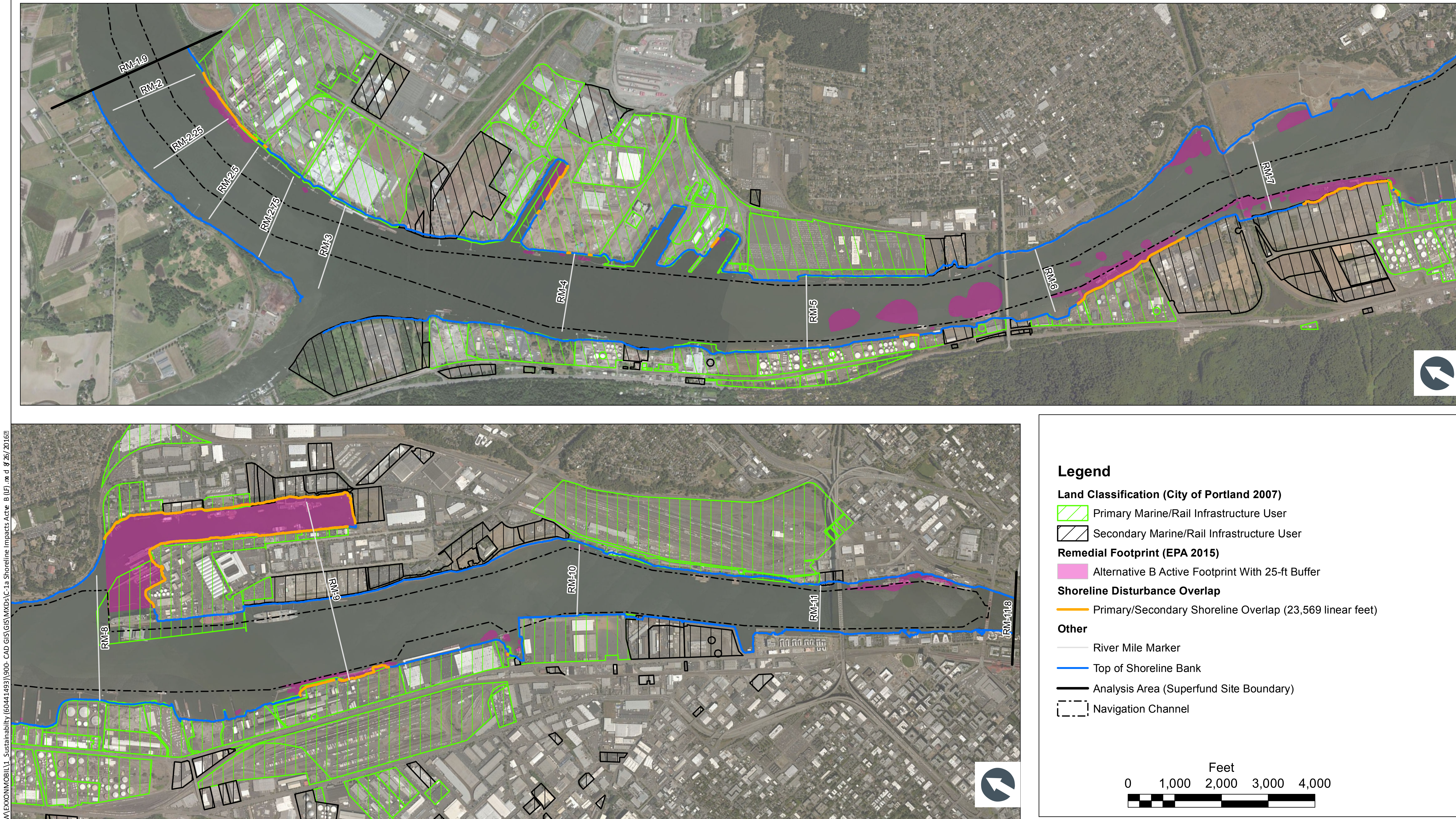
SF = square feet.

a. EPA 2015 remedial footprints for Alternatives B-F and EPA 2016 remedial footprint for Alternative I used in analysis. "Active" footprint defined as dredging, capping, treatment, and ENR combined.

b. "Potential Nearshore High-value Habitat Area" is a layer generated in GIS representative of the area between 13 ft NAVD88 (top of bank) and the -15 ft NAVD88 contours between RM 1.9 through 11.8.

Potential Nearshore High-value Habitat Analysis Area: 20,585,066 SF.

1. Study Area: River Mile 1.9 through RM 11.8 comprising 95,473,688 SF of area.
2. All results presented in SF area, and represent the potential nearshore high-value habitat overlap with the active remedial footprints.
3. Active remedial footprint for Alternative I was hand-digitized in GIS using Figures 3.8-9B through 3.8-9F from the 2016 EPA FS.



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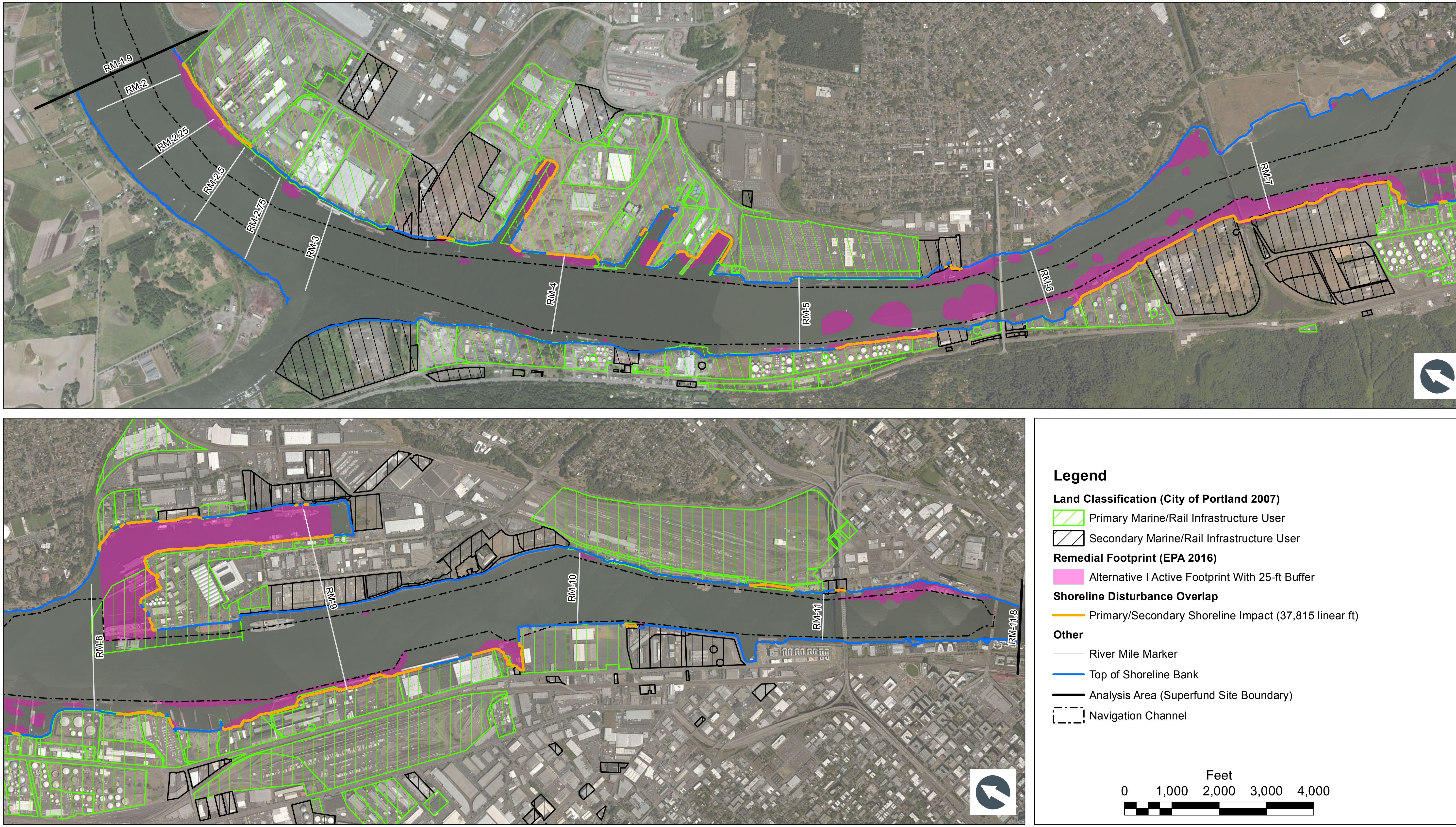
NOTES:
1. Analysis area from RM 1.9 to RM 11.8. Area includes a total of 137,537 linear ft of shoreline.
2. Remedial Alternatives from 2015 EPA Draft Final FS.
3. Land classification information from City of Portland Planning Department River Plan/North Reach map dated November 5, 2007.
4. A 25-foot buffer was placed around the active footprint to account for equipment work areas.

AECOM

Figure C-1a
Infrastructure Shoreline Disturbance: Alternative B Active Footprint
Portland Harbor Superfund Site Sustainability Project



NOTES:
1. Analysis area from RM 1.9 to RM 11.8. Area includes a total of 137,537 linear ft of shoreline.
2. Remedial Alternatives from 2016 EPA FS.
3. Land classification information from City of Portland Planning Department River Plan/North Reach map dated November 5, 2007.
4. A 25-foot buffer was placed around the active footprint to account for equipment work areas.

AECOM

Figure C-1b
Infrastructure Shoreline Disturbance: Alternative I Active Footprint
Portland Harbor Superfund Site Sustainability Project

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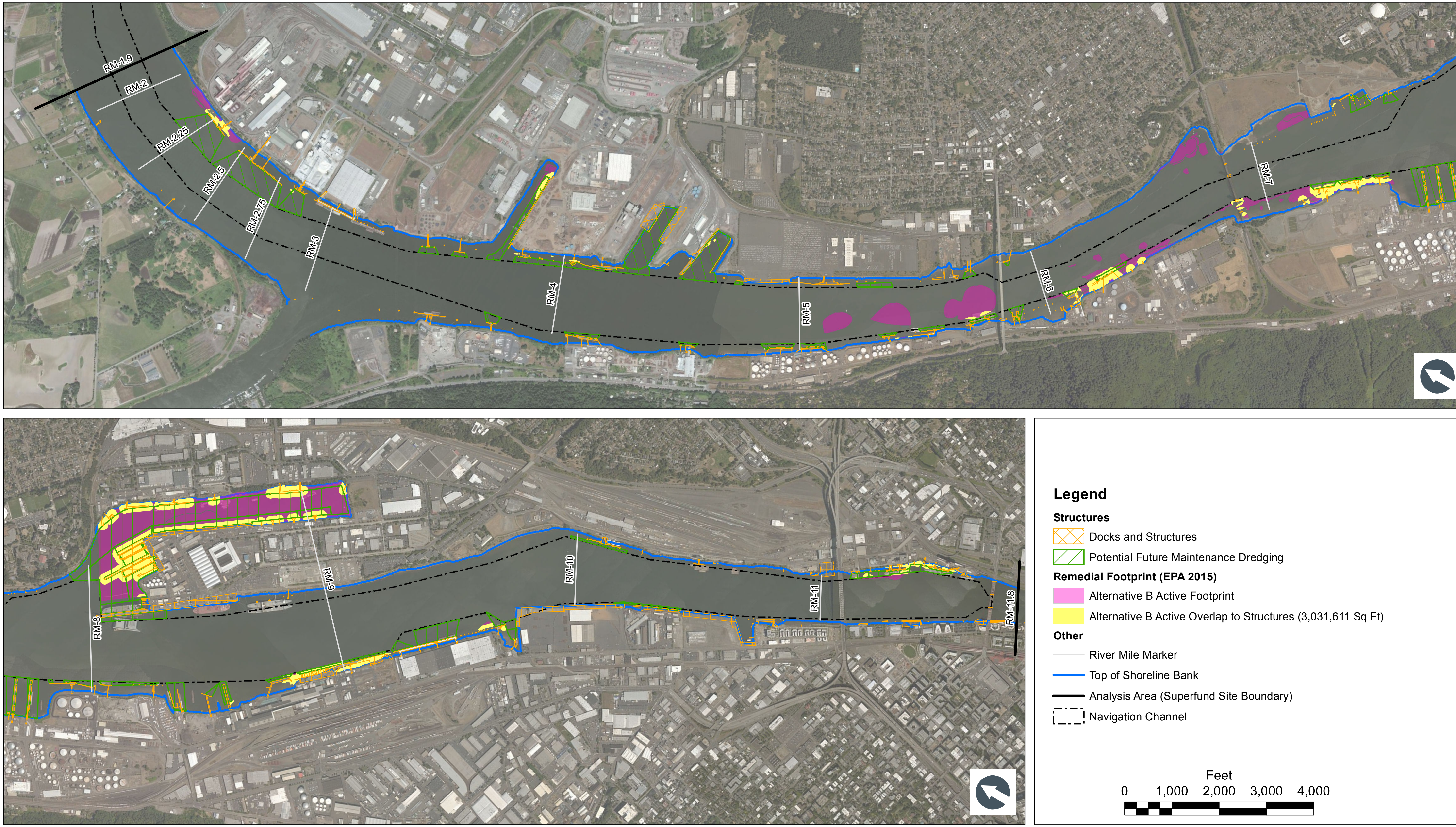

NOTES:
1. Remedial Alternatives from 2015 EPA Draft Final FS.
2. Overwater Structures, docks, mooring dolphins data from 2015 EPA Draft Final FS.
3. Potential future dredging areas represent active berthing areas outside of the navigation channel from AnchorQEA Draft FS (AnchorQEA 2012).

AECOM

Figure C-2a

Overwater Structures Disturbance: Alternative B Active Footprint

Portland Harbor Superfund Site Sustainability Project

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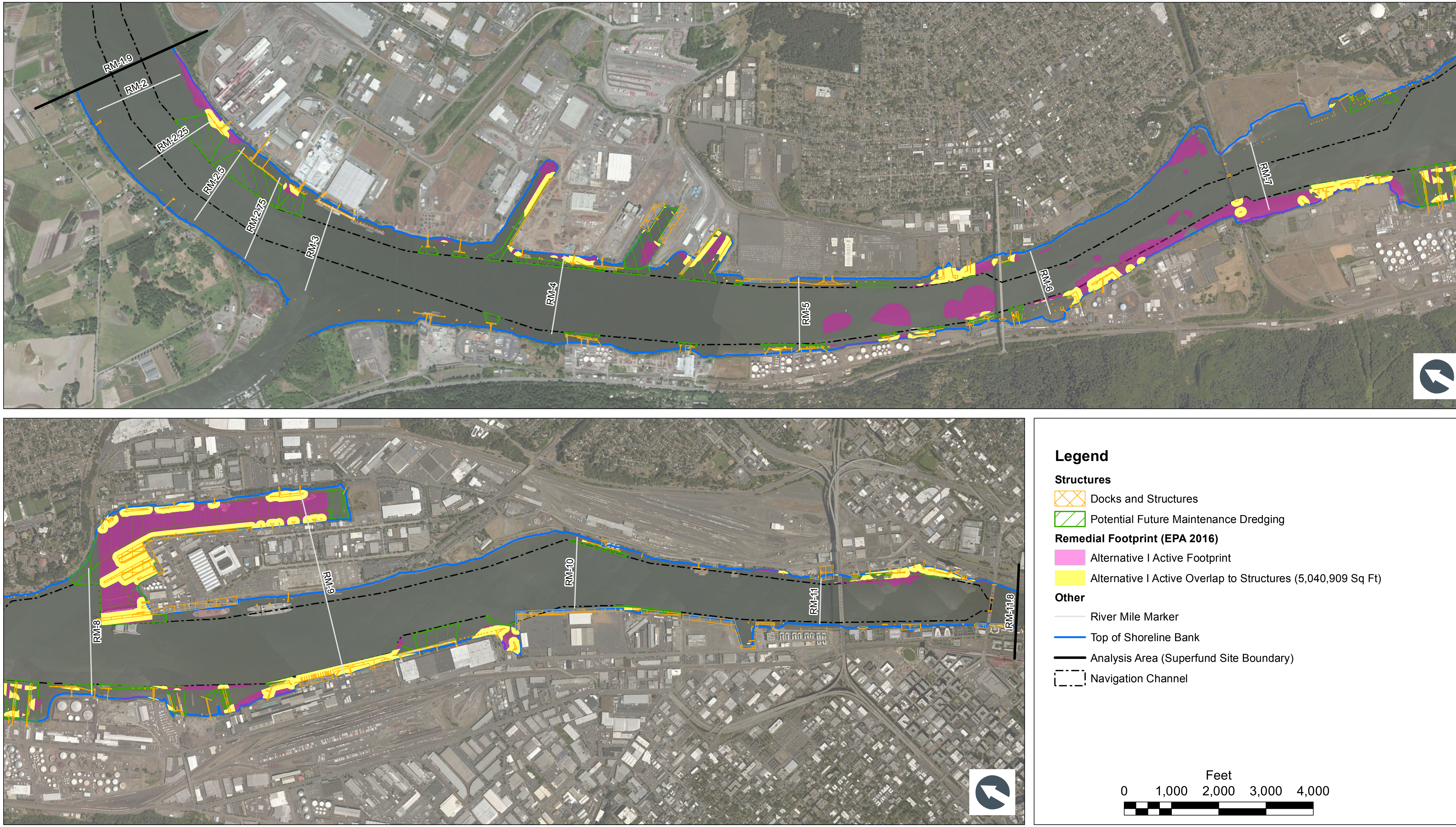

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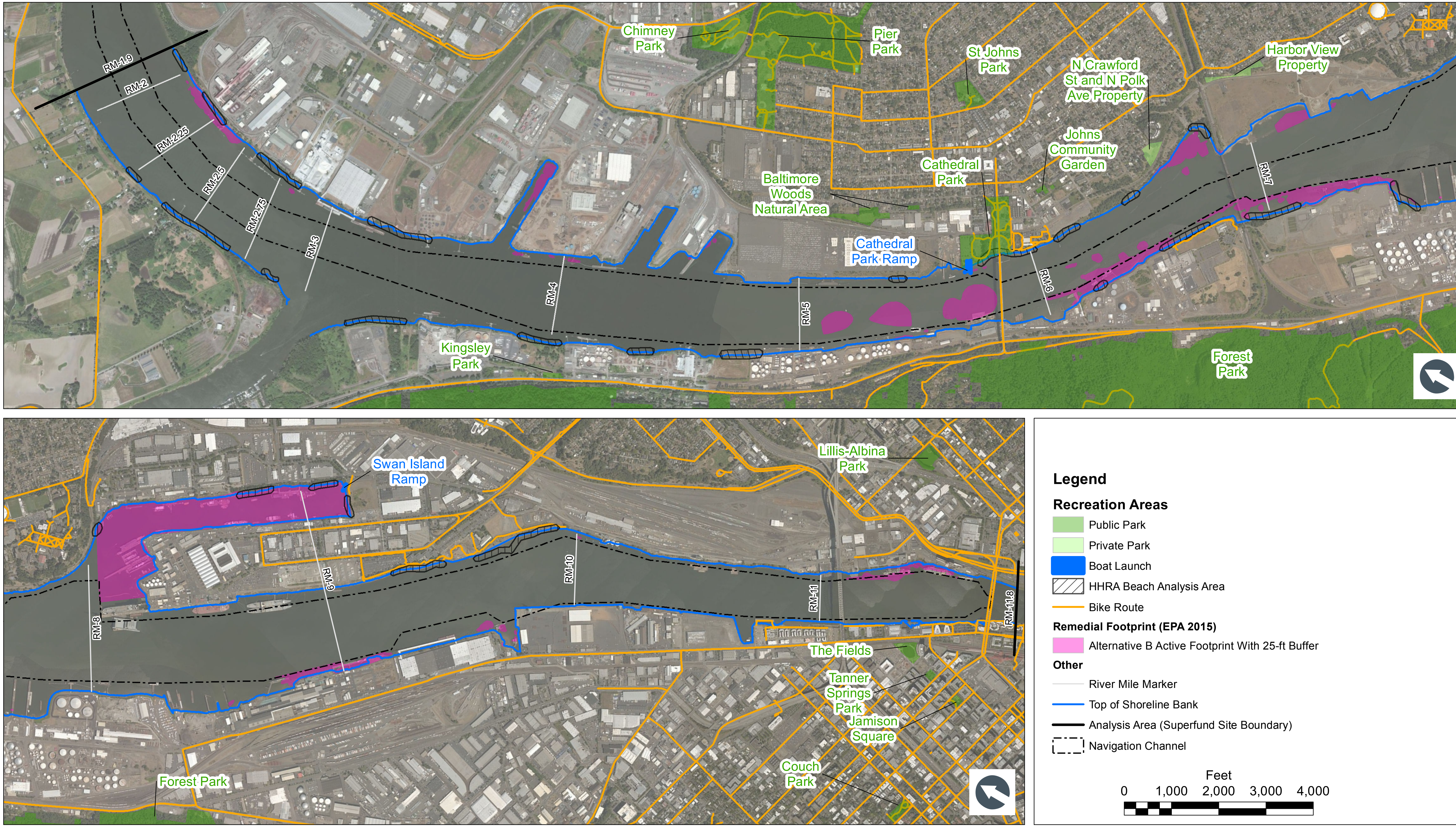
NOTES:
1. Remedial Alternatives from 2016 EPA FS.
2. Overwater Structures, docks, mooring dolphins data from 2015 EPA Draft Final FS.
3. Potential future dredging areas represent active berthing areas outside of the navigation channel from AnchorQEA Draft FS (AnchorQEA 2012).

AECOM

Figure C-2b

Overwater Structures Disturbance: Alternative I Active Footprint

Portland Harbor Superfund Site Sustainability Project



NOTES:
1. Parks and Bike Route data from City of Portland.
2. Boat Launch locations from State of Oregon Marine Board's Boating Access Sites Interactive Map.
3. Remedial Alternatives from 2015 EPA Draft Final FS.
4. Human Health Risk Assessment Beach Areas from 2015 EPA Draft Final FS.
5. Analysis area from RM 1.9 to RM 11.8.

AECOM

Figure C-3a
Recreational Shoreline Disturbance: Alternative B Active Footprints
Portland Harbor Superfund Site Sustainability Project

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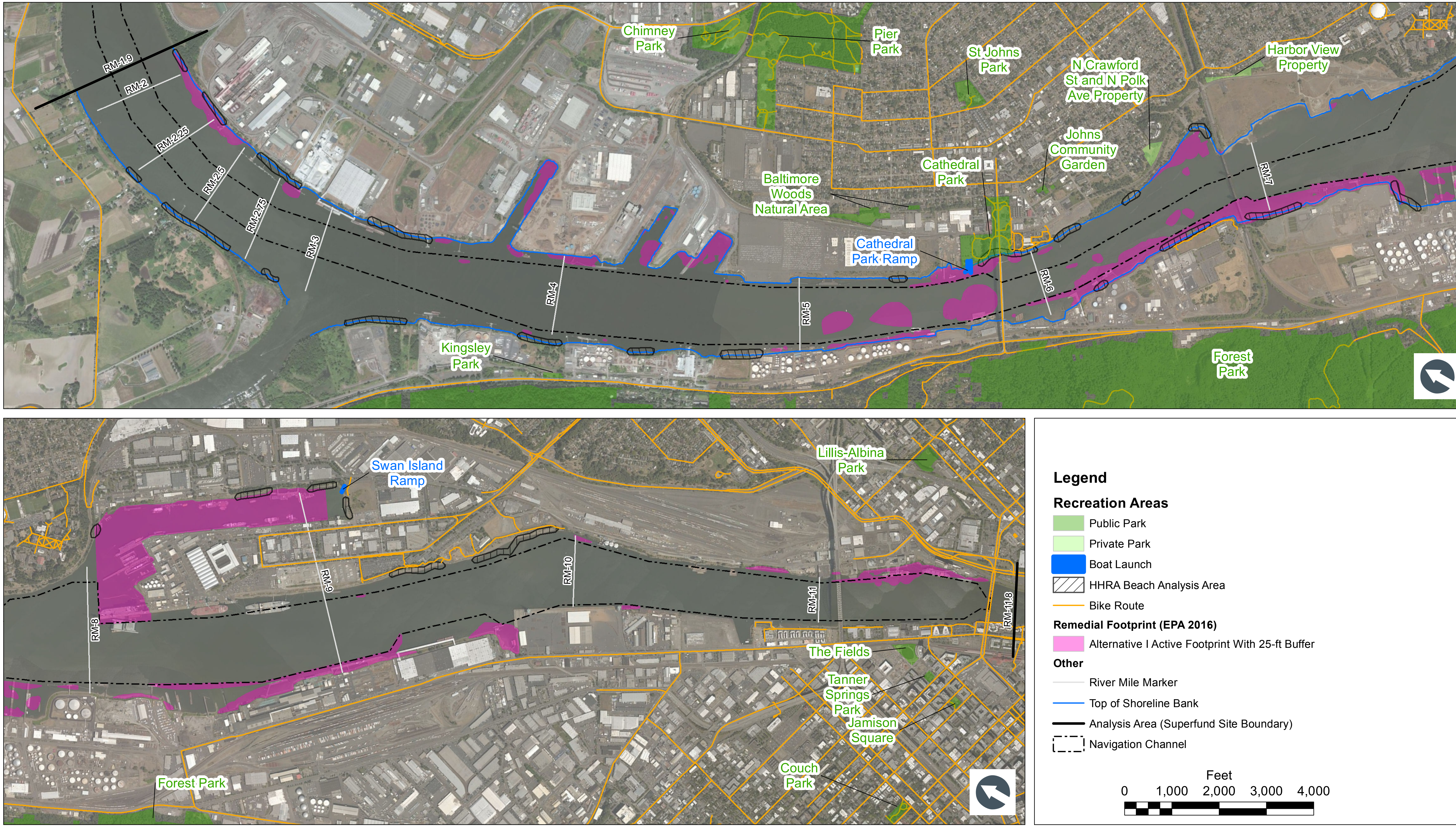

NOTES:
1. Parks and Bike Route data from City of Portland.
2. Boat Launch locations from State of Oregon Marine Board's Boating Access Sites Interactive Map.
3. Remedial Alternatives from 2016 EPA FS.
4. Human Health Risk Accessment Beach Areas from 2015 EPA Draft Final FS.
5. Analysis area from RM 1.9 to RM 11.8.

AECOM

Figure C-3b
Recreational Shoreline Disturbance: Alternative I Active Footprint
Portland Harbor Superfund Site Sustainability Project

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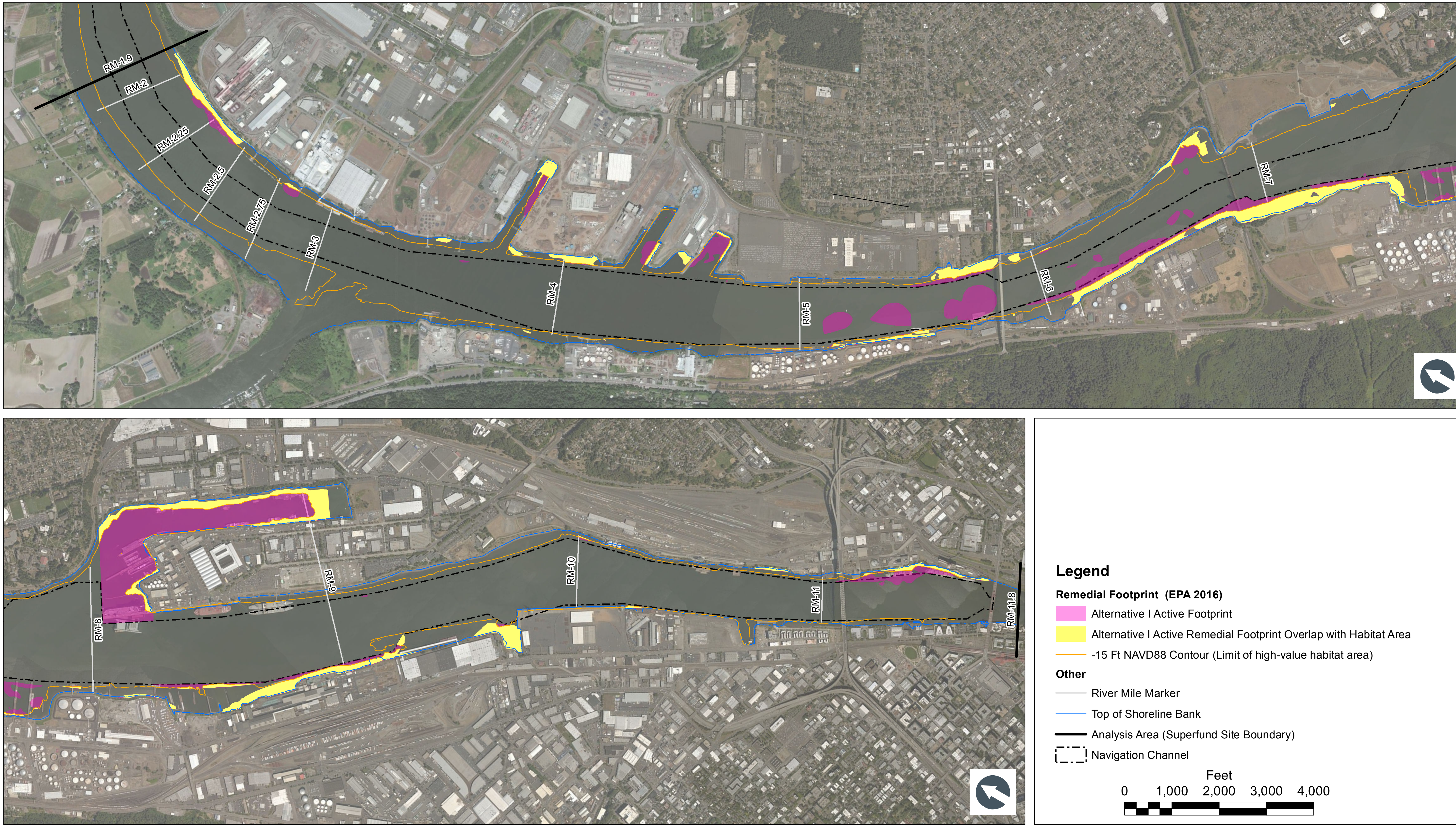

NOTES:
1. Nearshore habitat area defined as the area above the -15 ft NAVD88 contour.
2. Remedial Alternatives from 2016 EPA FS.

AECOM

Figure C-4
Ecological Disturbance (Nearshore Habitat Areas): Alternative I Active Footprint
Portland Harbor Superfund Site Sustainability Project

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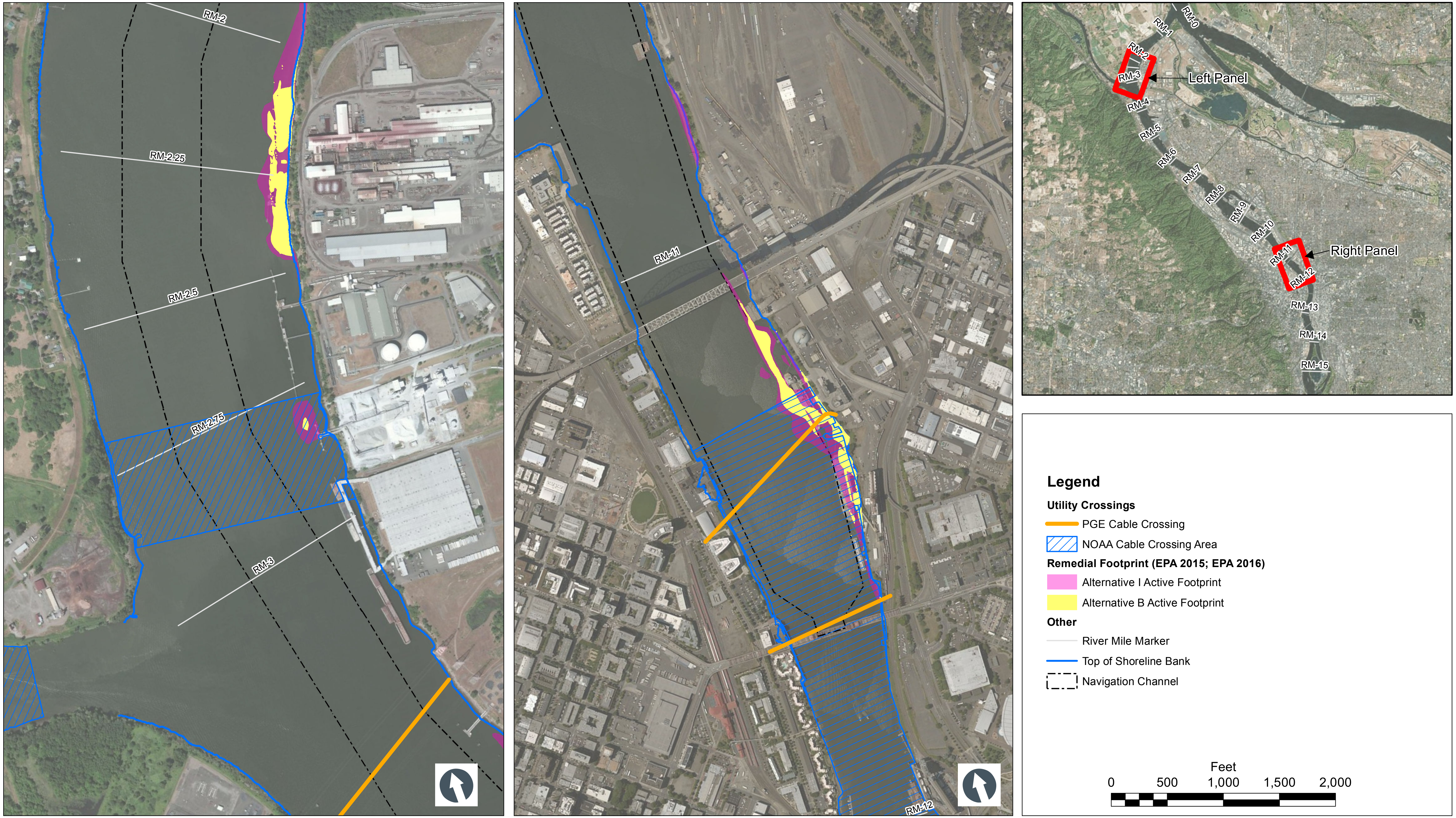

NOTES:
1. Remedial Alternative B from 2015 EPA Draft Final FS. Remedial Alternative I from 2016 EPA FS.
2. NOAA cable crossing areas from electronic navigation chart US1WC01M, downloaded from NOAA March, 2016.
3. PGE Cable Crossings data provided by PGE November 2015.

AECOM

Figure C-5
Utility Area Disturbance: Alternatives B and I Dredge Footprints
Portland Harbor Superfund Site Sustainability Project

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Appendix D
NEBA – Benefit Metrics and Scores

Appendix D. NEBA - Benefits Metrics and Scores

Evaluation Criteria			Weighting (%) Subweighting Factor (Fraction)	Benefit Scoring Basis		Units	Remedial Alternatives					
				Score 0	Score 10		A	B	D	E	F	I
1	Overall Protectiveness of Human Health and the Environment		25%			Overall Score	2.0	7.5	8.0	8.2	8.0	8.0
1a	Exposure at the end of construction	Average reduction in SWACs (for the focused COCs[a]) on a site-wide basis following construction. SWAC reductions from MNR are not considered. Each alternative has a different construction time.	4/5	0	76	% SWAC reduction	0	56	63	69	76	65
	Score 0 represents predicted exposure without construction (i.e., Alt A: 0% reduction in SWACs for the focused COCs); score 10 represents exposure at Time 0 following construction of Alt F (76% reduction in SWACs for the focused COCs).					Score	0.0	7.3	8.3	9.0	10.0	8.6
1b	Risks from implementation	AECOM construction time. Assume that impacts during dredging (including water quality and potential downstream transport) are proportional to construction time.	1/5	26	0	yrs	0	5	8	13	26	11
	Score 0 represents construction time for Alt F (26 yrs); score 10 represents no additional construction (i.e., Alt A: 0 yrs).					Score	10.0	8.1	6.9	5.0	0.0	5.8
2	Permanence		16%			Overall Score	0.0	1.9	2.5	3.3	5.2	3.0
2a	Reduction in the mass of contamination	Mass of PCBs removed. The PCB concentration in sediments at-depth is assumed to be the PCB SWAC. Uses EPA blended volume (between low and high).	1/3	0	289,305	kg PCB	0	72,221	112,698	165,148	289,305	147,343
	Score 0 represents no contamination removed (i.e., Alt A: 0 kg PCBs); score 10 represents the largest amount of contamination removed for the remedial alternatives (i.e., Alt F: 289,305 kg PCBs). However, score 10 does not indicate that all PCB contamination is removed from PH. Score 10 indicates the maximum PCB mass removed for all remedial alternatives compared in the NEBA.					Score	0	2.5	3.9	5.7	10.0	5.1
2b	Reduction in mobility of hazardous substances	Immobility rating based on the acres weighted by type of technology applied to total PH active remedial area. (PH Study Area = 2167 acres)	2/3	Weighted average based on the following:								
		Removal (dredge, dredge/cap)		weighting: 9		acres of PH	0	72	132	204	387	167
		Containment (capping, *In situ* treatment, ENR)		weighting: 6		acres of PH	0	129	135	125	146	124
		MNR		weighting: 1		acres of PH	0	1,966	1,900	1,838	1,634	1,876
	Weightings for each technology are based on best professional judgment. MNR does not score a 0 because monitoring and contingency actions would mitigate mobility of contaminated sediment. Removal does not score a 10 because some amount of contamination is lost during the dredging process. Therefore, 0 and 10 represent idealized alternatives in which sediments either are not remediated (0), or are removed completely from PH (10).					Score	0.0	1.6	1.8	2.0	2.8	1.9
3	Long-term Effectiveness		16%			Overall Score	0.0	5.0	5.8	6.2	6.9	6.0
3a	Human carcinogenic post-construction risks	RAO 1: Direct Contact to Tribal Fisher - Cumulative Carcinogenic Maximum Risk (river-mile scale)	1/3	4.0E-04	1.0E-05	Max Risks	4.0E-04	5.0E-05	2.0E-05	1.0E-05	1.0E-05	1.0E-05
		RAO 2: Subsistence Angler Consumption of Fish/ Shellfish – Cumulative Carcinogenic Risk (site-wide)		2.0E-03	1.0E-05	Risks	2.0E-03	4.0E-04	3.0E-04	2.0E-04	1.0E-04	2.0E-04
		RAO 2: Subsistence Angler Child Consumption of Fish/ Shellfish – Cumulative Non-cancer HI (site-wide)		138	1	HI	138	38	29	21	12	21
		RAO 2: Nursing Infant Consumption of Fish/ Shellfish – Non-cancer HI (site-wide)		3,333	1	HI	3,333	810	619	446	268	454
	Score 0 represents human risk predicted without construction (i.e., Alt A); score 10 represents minimal adverse human risks (i.e., Chemical Specific ARARs for remedial action: acceptable risk levels for human health are $1x10^{-5}$ for multiple carcinogens and a hazard index of 1 for non-carcinogens). The score gives an equal weight to all human risks.					Score	0.0	8.0	8.6	9.1	9.5	9.1
3b	Ecological post-construction risks	RAO 5: Direct Contact to Ecological Receptors: Acres where unacceptable benthic risk continues	1/3	1,289	0	acres	1,289	670	464	348	168	464
		RAO 6: Ecological Fish/ Shellfish Consumption – Maximum HQ of 4,4-DDE, PCBs, HxCDF, PeCDF, TCDD, and TCDF (river-mile)		138	1	Max HQ	138	34	19	15	15	19
	Score 0 represents ecological risk predicted without construction (i.e., Alt A); score 10 represents ecological risk with minimal adverse ecological effects (HI = 1).					Score	0.0	6.2	7.5	8.1	8.8	7.5

Appendix D. NEBA - Benefits Metrics and Scores

Evaluation Criteria			Weighting (%) Subweighting Factor (Fraction)	Benefit Scoring Basis		Units	Remedial Alternatives					
				Score 0	Score 10		A	B	D	E	F	I
3c	Degree of certainty that the remedial alternative will be successful	Degree of certainty rating based on weighted benefit of remedial technologies normalized to PH active remedial area (PH Study Area = 2167 acres).	1/6	Weighted average based on the following:								
		Dredge		weighting: 9.5		acres of PH	0	67	121	188	355	150
		Cap/partial dredge and cap		weighting: 9		acres of PH	0	28	56	81	150	81
		In situ treatment		weighting: 7		acres of PH	0	7	3	0	0	0
		ENR		weighting: 5		acres of PH	0	100	87	60	28	60
		MNR		weighting: 1		acres of PH	0	1,966	1,900	1,838	1,634	1,876
	Weightings for each technology are based on best professional judgment. MNR does not score a 0 because monitoring and contingency actions would mitigate mobility of contaminated sediment. Dredging does not score a 10 because some amount of contamination is lost during the dredging process. Therefore, 0 and 10 represent idealized alternatives in which sediments either are not remediated (0), or are removed completely from PH (10).					Score	0.0	1.6	1.9	2.1	3.0	2.0
3d	Reliability of ICs and engineering controls used to manage risk	Assume reliability of ICs and engineering controls is inversely proportional to the area assigned to technologies that leave contamination on site. Score inversely proportional to total acres of cap, *in situ* treatment, ENR, and MNR. Although Alt A does not have technology assignments, all contamination is left on site; therefore, the total PH study area is used to score Alt A.	1/6	2167	0	acres of PH	2167	2101	2046	1979	1812	2017
	Score 0 represents leaving all contamination in PH study area (i.e., Alt A); score 10 represents dredging all contamination in the PH study area.					Score	0.0	0.3	0.6	0.9	1.6	0.7
4	Management of Short-term Risks		16%			Overall Score	10.0	7.4	6.2	4.5	0.0	5.0
4a	Implementation risks: includes release of residual contamination into the water column during dredging, landfill usage, environmental impacts due to transportation of material and mining of sand, GHG emissions, particulate emissions, and other factors.	Material handling and removal volume; equals dredge volume, disposal volume, placement volume (including capping, ENR, and backfill volume), and residuals management (*ex situ* thermal treatment volume).	1/4	10.7	0	million cy	0	1.8	3.1	5.0	10.7	5.0
		Total GHG emissions		1,055	0	1000 mt	0	346	545	652	1055	613
	Score 0 represents maximum amount of material handled and GHG emissions (i.e., Alt F); score 10 represents no material handled and no GHG emissions (i.e., Alt A). The score gives equal weight to both implementation risks.					Score	10.0	7.5	6.0	4.6	0.0	4.7
4b	Disturbance during construction: active remedial footprint (dredge, cap, treatment, ENR) overlap with shoreline area that would disrupt infrastructure access, water-dependent business, recreational access, and habitat.	Active remedial footprint overlap with linear feet of shoreline designated for infrastructure and water-dependent businesses	1/4	54	0	%	0	22	29	38	54	35
		Active remedial footprint overlap with area of overwater structures (related to water-dependent business)		22	0	%	0	10	12	14	22	16
		Active remedial footprint overlap with habitat restoration areas		39	0	%	0	15	20	26	39	24
		Active remedial footprint overlap with beach areas, shoreline parks, and public access areas		40	0	%	0	17	22	27	40	21
	Score 0 represents maximum remedial footprint overlap (i.e., Alt F); score 10 represents no overlap (i.e., Alt A: 0 % overlap for designated shoreline, overwater structures, and habitat restoration). Score gives equal weight to all disturbances. Disturbance metrics for Alternatives B-F are based on remedial footprints from the 2015 EPA Draft Final FS. Disturbance metrics for Alternative I are based on remedial footprint from the 2016 EPA FS.					Score	10.0	5.8	4.6	3.3	0.0	3.7
4c	Accident risk during construction	Accident Risk - Injury	1/4	6.2E+01	0	Risks	0	1.1E+01	1.9E+01	3.0E+01	6.2E+01	2.7E+01
		Accident Risk - Fatality		5.2E-01	0	Risks	0	8.0E-02	1.4E-01	2.4E-01	5.2E-01	2.1E-01
	Score 0 represents accident risk predicted without construction (i.e., Alt A); score 10 represents accident risk with the maximum amount of construction (i.e., Alt F). The score gives an equal weight to both accident risks.					Score	10.0	8.4	7.1	5.3	0.0	5.8
4d	Effectiveness of protective measures to manage short-term risks	Assume effectiveness of protective measures (ICs and BMPs) that would be used to mitigate the risks during construction are related to impacts during dredging, which is proportional to AECOM construction time.	1/4	26	0	yrs	0	5	8	13	26	11
	Score 0 represents construction time for Alt F (26 yrs); score 10 represents no additional construction (i.e., Alt A: 0 yrs)					Score	10.0	8.1	6.9	5.0	0.0	5.8

Appendix D. NEBA - Benefits Metrics and Scores

Evaluation Criteria			Weighting (%) Subweighting Factor (Fraction)	Benefit Scoring Basis		Units	Remedial Alternatives					
				Score 0	Score 10		A	B	D	E	F	I
5	Technical and Administrative Implementability		16%			Overall Score	10.0	5.5	4.8	3.7	0.5	3.7
5a	Ability to construct and operate	Material handling volume; equals clean fill and contaminated sediment/soil.	1/3	6	0	million cy	0	1.0	1.8	2.8	5.9	3.1
	Score 0 represents maximum amount of material handled (i.e., Alt F); score 10 represents no material handled (i.e., Alt A).					Score	10.0	8.3	7.0	5.3	0.0	4.8
5b	Ability to monitor effectiveness	Total acres of cap, *in situ* treatment, ENR, and MNR that will require monitoring.	1/3	2095	0	acres	0	2095	2035	1963	1780	2000
	Score 0 represents maximum acres within the study area requiring monitoring (i.e., Alt B); score 10 represents no monitoring required (i.e., Alt A).					Score	10.0	0.0	0.3	0.6	1.5	0.5
5c	Availability of specialists, equipment, and materials	Equivalent of rail loads assumed to transport material to the site and remove material from the site assuming DMM 2.	1/3	105,982	0	rail loads	0	18,410	31,666	50,416	105,982	44,641
	Score 0 represents maximum rail loads to transport material (i.e., Alt F); score 10 represents no transportation of material (i.e., Alt A).					Score	10.0	8.3	7.0	5.2	0.0	5.8
6	Consideration of Public Concerns		10%			Overall Score	5.1	5.1	5.1	5.1	5.0	5.1
	SOC-2 Community Values Social Equity scores from the Social Analysis Report, scaled from 0 to 10. Higher score represents more public support and lower score represents less public support.											
	Total Weighted Benefits		100%			Score	4.3	5.6	5.6	5.4	4.5	5.4
	2016 AECOM Costs (0% Discount)					$millions net present value	$ -	$ 1,051	$ 1,355	$ 1,758	$ 2,969	$ 1,644
	Benefit/cost					Benefit points per $billion	NA	5.3	4.1	3.1	1.5	3.3

Notes:

a. Average reduction in site-wide SWACs for the focused COCs are calculated by taking the equal-weighted average of the percent reduction for each COC SWAC following construction (at Time 0) compared to Alternative A (No Action). Focused COCs include: PCBs, Total PAHs, DDx, TCDD, PeCDD, PeCDF. No improvements in SWAC over time by MNR processes considered in this analysis (not quantified in the 2016 EPA FS).

1. A score of 0 represents the lowest benefit or a poor performing alternative for the given metric; it is a non-negative unfavorable score, because the scale used in this NEBA is from 0 to 10. A score of 10 represents the highest benefit or an excellent performing alternative for the given metric. Scores of 0 and 10 do not always represent the lowest and highest performing alternatives in the suite of alternatives, but represent the high and low values shown in the *Benefit Scoring Basis* columns. The alternatives are scored on a linear scale between these endpoints.

2. Exposures and risks used to calculate benefit scores are values from Time 0 (immediately following construction).

3. Inputs and assumptions from the 2016 EPA FS are used in this analysis. Disturbance metrics for Alternatives B-F are based on remedial footprints from the 2015 EPA Draft Final FS. Disturbance metrics for Alternative I are based on remedial footprint from the 2016 EPA FS.

Alt = alternative; ARARs = applicable or relevant and appropriate requirements; BMPs = best management practices; COC = contaminant of concern; cy = cubic yards; DMM = disposed material management; ENR = enhanced natural recovery; EPA = United States Environmental Protection Agency; FS = feasibility study; GHG = greenhouse gas; HI = hazard index; HQ = hazard quotient; ICs = institutional controls; kg =kilogram; MNR = monitored natural recovery; mt = metric ton; NEBA = net environmental benefit analysis; PH = Portland Harbor; RAO = remedial action objective; SWAC = surface-weighted average concentration; yrs = years.

Appendix E
Cost and Time Analysis Report of EPA Feasibility Study Remedial Alternatives

Appendix E

Cost and Time Analysis Report of EPA Feasibility Study Remedial Alternatives

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1. Introduction

As part of the Portland Harbor Superfund Sustainability Project, this report describes the assumptions used to generate cost estimates associated with remedial alternatives B, D, E, F, and I as presented in the United States (US) Environmental Protection Agency (EPA) *Portland Harbor RI/FS Feasibility Study* (herein called the 2016 EPA FS) (EPA 2016a) and presented in EPA's Proposed Plan for the Portland Harbor Superfund Site (EPA 2016b). These are FS-level cost estimates in the range of +50 to -30% accuracy. The Portland Harbor Superfund Site (Site) is located in the Lower Willamette River and extends from approximately River Mile (RM) 1.9 to RM 11.8. The purpose of this analysis is threefold: (1) present an independent cost analysis along with the cost assumptions used; (2) estimate realistic construction times based on recent dredging experience in the Pacific Northwest; and (3) compare 2016 EPA FS cost assumptions with those used in this analysis as part of the Portland Harbor Sustainability Project. The cost estimates developed in this analysis were based on the AECOM tool developed for the Lower Duwamish Waterway (LDW) Final FS (AECOM 2012).

As described in the 2016 EPA FS, the remedial technologies potentially applied to the remedial alternatives include a combination of removal (mechanical dredging and dry excavation), partial removal and capping, isolation capping, enhanced natural recovery (ENR), monitored natural recovery (MNR), off-site dredge material disposal in Subtitle C and D landfills, and off-site thermal treatment for sediment that exceeds acceptable landfill criteria. Remedy volumes and acres, extracted from 2016 EPA FS, Appendix G, are summarized in Table 1.

This independent cost comparison was completed by running the 2016 EPA FS technology assignments, volumes, acreage, and implementation assumptions through a separate cost analysis spreadsheet tool developed by AECOM (AECOM 2012). If not otherwise stated, all assumptions are based on AECOM's previous project experience on the LDW and Portland Harbor.

2. Construction Time

The in-water window for the Lower Willamette River extends 185 calendar days, from July 1 to October 31, and December 1 to January 31, but adjustments to the construction season were made to account for varied work shift scenarios, holidays, and lost time typical of similar construction projects; the 2016 EPA FS assumed a construction season of 122 days. For reference, no in-water construction is allowed by the Oregon Department of Fish and Wildlife outside of the in-water work window unless specifically authorized by local, state, and/or federal agencies; thus, work outside the window was not included in this analysis.

Two construction work shift scenarios were used in this cost estimate to calculate a blended construction rate. The two scenarios assume that 50% of the construction season would follow Scenario 1 and 50% would follow Scenario 2. Scenario 1 assumes that construction would take place 6 days per week for a total of 24 hours a day. Scenario 2 assumes that construction would take place 5 days per week for a total of 12 hours a day. The blended rate assumes two scenarios for the following reasons:

- Scale of Implementation: Two shift scenarios were selected because construction contracting is anticipated to differ among the numerous potentially responsible parties (PRPs) involved. Scenario 1 would likely apply to relatively large remediation footprints (i.e., many acres of area) that would last multiple seasons, and Scenario 2 would likely apply to relatively smaller footprints (i.e., a few acres of area) that can be completed in a season or less.

- Commercial and Community impacts: Commercial vessel traffic and recreational use will be negatively impacted by in-water construction. Thus, 24-hours-a-day work may not be approved at all locations in Portland Harbor.

The construction season was further decreased by a total of 20 days, including 5 days for holidays and 15 days for general lost time (e.g., equipment failure, work stoppage, etc.). Applying the two work scenarios and downtime, the total achieved construction time was assumed to be approximately 88 work days per season. This equates to a seasonal efficiency of about 64% (i.e., contractor is assumed to actually work 88 days out of the possible 138 work days). The 2016 EPA FS assumed 104 work days over a 122-day work period (i.e., construction efficiency of 85%). EPA did account for one weekend day with a construction schedule of 6-days-per-week, but did not account for holidays or general lost time.

The seasonal efficiency assumed by AECOM is consistent with US Army Corps of Engineers (USACE) guidance (USACE 2008) and actual production rates performed at four recent dredging projects in the Pacific Northwest, one in Portland Harbor and three on the LDW, which used the latest water quality monitoring, backfill, and best management practices (BMP) requirements. These projects are Terminal 4 for Port of Portland (AnchorQEA 2009), Slip 4 for City of Seattle (Integral 2012), Terminal 117 for Port of Seattle (AECOM 2016a), and Plant 2 for Boeing (AMEC 2013; DOF 2014). A comparison of 2016 EPA FS assumptions, both EPA and AECOM, to the four recently completed Pacific Northwest projects is shown in Table 2. For reference, AECOM construction efficiency is on the lower end due to blended rate construction assumptions. In addition, the recently completed capping project at RM 13.5 by Portland General Electric (PGE) was completed over 32 calendar days at a seasonal efficiency of approximately 47% (AECOM 2016b).

For Alternative I, the total estimated construction time is 11 years, compared to EPA's 7 years (EPA 2016a). Estimated construction times for all alternatives evaluated in this analysis are presented in this report.

3. Cost Estimate

The cost estimating tool developed for the Lower Duwamish Final FS is divided into three main sections: capital costs, other construction costs, and post-construction monitoring costs. Capital costs are intended to provide an engineer's estimated cost for construction, which includes all contractor-related costs. Other construction costs include agency/PRP-related costs that are ancillary to construction, but necessary, including permitting, sales tax, contingency, third-party oversight, etc. Post-construction costs include all costs for long-term monitoring (LTM), operations and maintenance (O&M), and institutional controls (ICs). Main engineering assumptions are listed in Table 4 and AECOM cost assumptions are compared to 2016 EPA FS assumptions in Table 5. Detailed cost tables are provided in Attachment A.

3.1 Capital Costs

Capital costs included all contractor-related construction costs including pre-construction, contractor project management, removal, material placement, transport and disposal, construction quality assurance and quality control (QA/QC), and post-construction performance monitoring. These are costs directly related to construction and would typically be considered for an engineer's construction cost estimate used during project bidding.

The 2016 EPA FS assumptions also included contingency, agency project management, remedial design, and agency construction management in capital costs. However, AECOM separated these additional costs so that capital costs focus only on contractor work and not work performed by agencies and/or PRPs (e.g., third-party construction management, permitting, remedial design, reporting, etc.). In the AECOM cost model, design, management, and reporting costs are included in the total remedy cost but not in capital costs.

3.1.1 Pre-Construction

Pre-construction costs included expenses for initial and annual mobilization/demobilization, leasing land to stage equipment/materials, contractor work plan preparation and submittal, dock/pile removal and relocation, and installation of sheet pile walls. For reference, AECOM matched assumptions in the 2016 EPA FS for dock/pile removal and increased costs for sheet pile wall installation due to the unique nature of sheet pile installation (i.e., 80-foot-long sheet pile walls require custom fabrication).

3.1.2 Contractor Project Management

Contractor project management included all costs incurred by the contractor during the project. This included labor and supervision, construction office, and operating expenses.

3.1.3 Removal

Sediment removal at the site is assumed completed using mechanical equipment to match the 2016 EPA FS assumptions. Removal assumptions included three separate equipment operations (or “spreads”), including two for open water and one for shallow water/riverbank/confined spaces (e.g., between piers and the shoreline).

The two open water spreads included one barge-mounted crane with a 10-cubic yard (CY) bucket and a barge-mounted excavator with 4 CY bucket. The shallow water/confined spaces dredge consisted of a barge-mounted excavator with a 4 CY bucket. The three equipment spreads are assumed to work simultaneously with the deep water spreads having a higher production rate than the shallow water spread. The three dredges were selected to match EPA assumptions; thus, hydraulic dredging was not analyzed.

Additional factors for bucket fill efficiency, effective work time, and debris sweep were included to reduce removal efficiency and account for general downtime (e.g., moving equipment around the site, cleanup passes, etc.). The cost estimate assumed a combined removal rate for the three spreads to be approximately 2,700 CY/day for Scenario 1 (i.e., 24 hours/6 days) and 1,300 CY per operational day for Scenario 2 (i.e., 12 hours/5 days), assuming 100% efficiency. Estimated efficiency for the blended rate with all downtime is approximately 2,082 CY/day assuming approximately 64% efficiency. These rates are consistent with Lower Duwamish Final FS assumptions and other similar Pacific Northwest projects (see Table 2).

Sediment removal volumes used to estimate AECOM costs were selected to match 2016 EPA FS best estimate values (Appendix G in EPA 2016a). Dredge volumes assumed that a 1.75 multiplier was added to the neat line volume. Removal volumes and remedial technology areas are shown by remedial alternative in Table 1.

3.1.4 Material Placement

Material placement included the in-water installation of an isolation cap, ENR, backfill, armor stone, and reactive mat materials. Placement of the isolation cap, ENR, and backfill material consists of placing clean sand or carbon-amended sand within the assigned technology footprint. Armor stone is included as a component of the isolation cap materials. Installation of a reactive mat assumes the placement of a layer mat product (e.g., geotextile) filled with a specific chemical that reacts to bind pore water contaminants.

Cost estimates for the placement of clean or amended sand assumes that three spread types could be used: one derrick barge equipped with an 8 CY bucket for deep water, one derrick barge/barge-mounted excavator equipped with a 5 CY bucket for shallow water, and one barge-mounted excavator equipped with an approximately 2 CY bucket to place material in confined areas. For this analysis, deep water and shallow water are assumed to be mudline elevations below and above -10 feet mean lower low water, respectively (from Lower Duwamish Final FS related to limited reach and required precision of an articulated arm bucket).[1] Confined areas are assumed to include locations between piers/docks and the shoreline.

All material volumes placed for capping are assumed to match EPA assumptions. All amended sand is assumed to be amended with 4% granulated activated carbon by weight compared to 5% by weight assumed by EPA. For isolation capping, material would be placed to a thickness of 3 feet; for ENR and backfill, material would be placed to a thickness of 9 inches, which matches EPA assumptions. Capping is assumed to consist of either 3 feet of sand (engineered cap) or 2 feet of sand and 1 foot of armor stone (armored cap).

[1] *For reference, 2016 EPA FS assumed a 10 CY bucket for deep and shallow water material placement and a 2 CY bucket for confined placement.*

Additional factors for bucket fill efficiency and effective work time are included to reduce material placement efficiency and to account for debris removal, maintenance, repairs, and general downtime (e.g., moving equipment around the site). The cost estimate assumes that the three equipment spreads are working simultaneously and would achieve daily production rates of approximately 1,400, 1,100, and 325 CY per operational day for deep water, shallow water, and confined area, respectively.

Costs for procurement of capping material were adjusted to match EPA assumptions and include delivery via barge to the project site. Costs to purchase and place reactive mats were added to the cost estimate to match 2016 EPA FS assumptions.

3.1.5 Transportation and Disposal

Transportation and disposal costs include all activities that take place after dredging for upland disposal of contaminated sediments. These include transportation by barge to a transloading facility, barge unloading to an upland dewatering area in preparation for truck transport, and truck transport for disposal at an upland landfill. These options were selected to match 2016 EPA FS assumptions. Sediment disposal volumes for the landfills and thermal treatment were assigned based on 2016 EPA FS assumptions. Costs for the development of a transloading facility consisting of temporary structures (e.g., ecology blocks, filter fabric, etc.) and a temporary water treatment plant (e.g., baker tanks) were included to match EPA costs. Costs for disposal of all contaminated sediments were adjusted to match 2016 EPA FS assumptions, which include detailed quotes from local landfills (EPA 2016a).

3.1.5.1 Sediment Transportation

Contaminated sediments dredged from the river were assumed to be directly placed in a barge per 2016 EPA FS assumptions. Dredge material has a high water content that must be decanted prior to barge transportation and it was assumed that the sediment would be partially dewatered on-site via gravity dewatering. Gravity dewatering costs assume that the barge will be equipped to decant water to a small holding cell, and that this water would then be filtered through a granulated activated carbon filter bag prior to discharge. These methods are similar to those used for the Slip 4 (Integral 2012) and Terminal 117 (AECOM 2016a) early action areas on the LDW.

Once decanted, it was assumed that the barge would be transported approximately 80 miles up the Columbia River to a transloading facility in Bingen, Washington, per 2016 EPA FS assumptions. The transloading facility, referenced in the 2016 EPA FS, does not currently exist but is assumed to be constructed at an existing logging storage/transfer facility in Bingen. That entire facility encompasses approximately 160 acres, of which approximately 70% to 80% is currently in use. Based on a review of aerial photographs, this location could be sufficient for transloading area setup. Alternate transloading facilities closer to the site may become available during remedial design, but none are currently permitted on the Willamette River and therefore are not included in the cost estimates. Disposal of some dredge material at a local confined disposal facility (CDF) (not yet permitted) was also not included.

At the transloading facility, sediment would be removed from the barge using a land-based crane and placed in upland containment areas. Any excess water would be removed from the sediment (i.e., water management) at the transloading facility to prepare for truck transport approximately 70 miles to the landfill. The transloading area would provide a location for material to passively dewater and construction of an on-site water treatment plant to treat and discharge all excess water.

3.1.5.2 Sediment Disposal

Once all excess water is removed, it is assumed that dredged material would be trucked another 70 miles to upland landfills, either the Subtidal C landfill in Arlington, Oregon, or the Subtitle D landfill in Roosevelt, Washington. Both landfills have adequate capacity to receive dredged material.

Based on the 2016 EPA FS, a small portion of dredged sediment is assumed unsuitable for disposal at a Subtitle C landfill and thus would be subject to *ex situ* treatment via thermal desorption (i.e., incineration). Thus, costs for all sediment (dredged material) disposal, including Subtitle C, Subtitle D, and thermal desorption, were assumed to match 2016 EPA FS assumptions. The landfill locations and disposal costs were also updated to match 2016 EPA FS assumptions.

For sensitivity, disposal in an on-site confined disposal facility for a portion of the Subtidal D sediment (670,000 CY) was also included based on 2016 EPA FS assumptions.

3.2 Other Construction Costs

Other construction costs include expenses that are not directly spent on construction but would be incurred during remedy implementation by either agencies or PRPs. The other construction costs include:

- Typical project costs[2] including construction management (10%), contingency (35%), remedial design and third-party project management (30%), and sales tax (9.5%).
- Agency costs for permitting, QA/QC, reporting, and review.
- Baseline and final construction sampling for cleanup confirmation immediately following remedy completion (i.e., core, pore water, and surface sediment sampling).
- Construction QA/QC (i.e., progress surveys, water quality monitoring, and subsequent labor).
- Mitigation (costs updated to match 2016 EPA FS assumptions).
- Oregon Department of State Lands (DSL) mitigation fees were included for permanent placement of fill (i.e., capping, ENR, etc.) and long-term monitoring (i.e., MNR). Based on current known DSL fees, a one-time fee of $250,000 per acre was applied to areas of river bottom where fill would be placed and $1,000 per acre per year (i.e., $30,000 per acre for 30 years of monitoring) of long-term monitoring was assumed for areas where only monitoring would occur (AECOM personal email communication with Chris Bozzini of PGE, 2016).

3.3 Post-Construction Monitoring

Post-construction monitoring costs account for three types of monitoring: O&M of selected technologies; LTM for 30 years; and ICs. O&M of remedial technology areas is assumed to occur at various intervals to monitor for remedy compliance. O&M intervals assume visual inspection, physical monitoring (i.e., bathymetry), sampling (i.e., core, pore water, and surface sediment), and repair, as appropriate, for each technology:

- **Dredge** – Two events at years 1 and 4 post-construction (repair costs not included to match EPA assumptions).

[2] *These percentages were applied to total capital cost. Thus, these costs are directly related to capital costs.*

- **Cap and ENR** – Three events at years 1, 4, and 9 post-construction (also includes repair of 5% of the cap and ENR area during each event).
- **MNR** – Five events at years 1, 2, 4, 6, and 9 post-construction (repair costs not included to match EPA assumptions).

Cost estimates for LTM assume sampling surface sediment, fish tissue, and surface water media every 5 years post-construction for up to 30 years, at approximately four samples per acre, and any subsequent agency reporting and oversight.

ICs account for management of informational devices (e.g., surveillance, cleanup hotline, signage, public outreach, etc.) necessary to communicate health hazards (e.g., risk due to fish consumption) during and after construction for a time period of 50 years total. Original cost assumptions used for the Lower Duwamish Final FS were doubled for comparison to the 2016 EPA FS to account for the Portland Harbor area being approximately twice the size of the LDW. EPA assumed similar ICs but only applied costs every 5 years for a time period of 30 years total.

4. Discount Rate

Total estimated costs of the remedial alternatives are expressed as net present values (NPVs). NPV analysis is a standard method used to evaluate expenditures that occur over different time periods. The present value is the amount of money needed to be set aside at an initial point in time (base year) so that funds for implementing a remedial alternative would be available in the future. For this analysis, NPV rates of 7%, 2.3%, and 0% were selected. The real discount rate (i.e., interest less inflation) is the predictive parameter that accounts for the time value of money reflecting judgments of future economic conditions. Effects of real discount rates on costs were not explored for this analysis.

The *Guide to Developing and Documenting Cost Estimates during the Feasibility Study* (EPA 2000) recommends that a discount rate of 7% be used for estimating the NPV of cleanups conducted by non-federal parties. The rate of 7% approximates the marginal pre-tax rate of return on an average investment in the private sector and has been adjusted to eliminate the effect of expected inflation. A discount rate of 2.3% was selected as the best estimate cost for this analysis based on rates used for the Lower Duwamish Final FS (AECOM 2012) and AnchorQEA's 2012 Draft FS (AnchorQEA 2012).

While useful for comparing remedial alternatives, discounted costs may not be meaningful projections for contributing money to the cleanup or communicating actual cost burdens to Portland Harbor stakeholders. Certain parties (public, public-private entities) may not be able to set aside sufficient funds for investment (without incurring additional costs of bonding or borrowing) before remediation starts and will therefore not be able to take advantage of the interest accumulation assumption implied by the NPV calculation. For informational purposes, non-discounted costs for the remedial alternatives are also provided (i.e., 0% NPV).

Three NPV costs were estimated in this report by AECOM of 7%, 2.3%, and 0% for comparison with other calculated values.

5. Sensitivity Analysis

CERCLA requires a cost accuracy of +50% to -30% in feasibility studies (EPA 1988). Some of the biggest factors that typically affect remedial costs are the discount rates (discussed in previous section), construction times, and dredge volumes. Sensitivity to FS level cost assumptions for the Portland Harbor sediment remediation was explored by evaluating the cost effects of increasing dredge volume, non-concurrent construction activities, and constructing a CDF. Results are presented in Table 3. Detailed costs estimates for sensitivity scenarios are included in Attachment B.

Dredge volume was increased by assuming that ENR and MNR technologies could not be applied to the areas identified in the FS. It is assumed that more detailed sampling during remedial design, implementation, or post-construction monitoring would find that these areas could not reach project goals with the FS assigned technology of ENR or MNR. The additional dredge volume added by this assumption is referred to as loopback to represent that a technology had to revert (i.e., loopback) to a removal remedy.

ENR and MNR typically require increased monitoring as compared to dredging and capping; thus, adding loopback contingency in this manner scales sensitivity based on the extent of LTM required post-construction. For example, dredging and capping are typically considered to have a higher level of permanence because achievement of cleanup goals is sufficiently quantified post-remedial construction. However, ENR and MNR areas rely on time and deposition to reach cleanup goals.

The sensitivity analysis assumed that 15% of all ENR and MNR areas would not meet project goals at some time during the project life (e.g., during design, implementation, LTM, etc.) and would require removal (i.e., dredging). The sensitivity assumed that these areas would be dredged to a depth of 4 feet with a volume multiplier of 1.5 added to account for over-dredge and dredge-cut side slopes. Overall, an increase in dredge volumes also increases costs, the work period (i.e., construction time), transportation, and disposal.

Non-concurrent construction activities assumed that all dredging must be completed before material placement can begin. Dredging and capping construction would not occur simultaneously and would therefore increase the construction time; this sensitivity was selected to match the 2016 EPA FS assumptions. The purpose of this sensitivity was to determine the effect of increased construction time on costs. No other changes were made to the other cost assumptions discussed in previous sections. Adjusting for non-concurrent construction caused costs to increase slightly, but primarily resulted in an increased construction time. Costs were not significantly affected because non-concurrent construction only delays construction, but does not remove or adjust the cost. The only extra costs incurred are annual mobilizations and additional oversight, which are fairly minor in comparison to construction costs.

Construction of a CDF was assumed to reduce waste transportation and disposal costs by constructing a disposal facility near the project site. Construction of a CDF assumed that a location near the project site identified in the 2016 EPA FS would be prepared to receive approximately 670,000 CY of Subtitle D sediment dredged from Portland Harbor. CDF volumes and costs were assumed to match EPA assumptions with the purpose to determine the effect of reduced disposal costs. Construction of a CDF slightly reduces costs, but overall does not serve as a major cost reduction. The major benefit of a CDF would be reduced risk with transportation and lower overall project emissions by reducing transport.

6. Discussion

The following sections discuss the major differences between AECOM and EPA construction times and remedy costs. Independent cost estimates generated by Geosyntec, Integral, and de maximis are presented for Alternative I but are not discussed in detail.[3] Cost and construction time estimates are shown in Table 3 for comparison to EPA's estimates. Estimates are shown for capital costs and total remedy costs at 0%, 2.3%, and 7% NPV, if available. Figures 1 and 2 plot the construction times and total cost estimates for Alternatives B, D, E, F, and I at different NPVs.

6.1 Construction Time Comparison

AECOM construction time estimates are based on dredge production rate assumptions developed for the Lower Duwamish Final FS with bucket size assumptions adjusted to match the 2016 EPA FS. The production rates were developed through discussion with contractors, review of literature (USACE 2008), and comparison to previous projects (e.g., Slip 4 LDW remediation). The dredge production rates at Portland Harbor are assumed limited by a wide range of site constraints similar to LDW, including competing waterway uses (commercial, recreational boating, and fishing), available regional rail, critical shoreline structures (15 miles of exposed banks, bulkheads, docks, and armored slopes), proximity to communities, steep side slopes, vessel traffic, buried utilities, scattered debris, and transloading limitations. Minor extensions beyond the typical in-water window may be permitted on a case-by-case basis, although such extensions were not assumed given that permitting and approval requires extensive coordination and approvals from the governing resource Trustees (e.g., National Oceanic and Atmospheric Association Fisheries).

Considering these constraints, a blended average annual dredge production rate was developed. A seasonal dredge efficiency of 64% was assumed including downtime for weekends, maintenance, repair, and holidays. With these assumptions, the total estimated seasonal production rate was 184,000 CY/year. These daily FS assumptions are similar to production rates realized at several of the early action cleanups in the LDW between 2012 and 2014 (Terminal 117, Boeing Plant 2, Slip 4); see Table 2. For reference, 2016 EPA FS assumptions include a seasonal production of approximately 530,000 CY and seasonal efficiency of 85%, which does not include time for holidays or general downtime.

Portland Harbor is of similar size and possesses many similar site characteristics and constraints to the LDW. However, the extent and magnitude of Portland Harbor navigational and dredging constraints are significantly greater. For example, there are more utility crossings throughout the 2016 EPA FS dredge prism, compared to approximately two known utility crossings on the LDW. In addition, commercial navigation use of Portland Harbor is more widespread than LDW because of its extensive use by the Port of Portland, especially along the lower 6 miles.

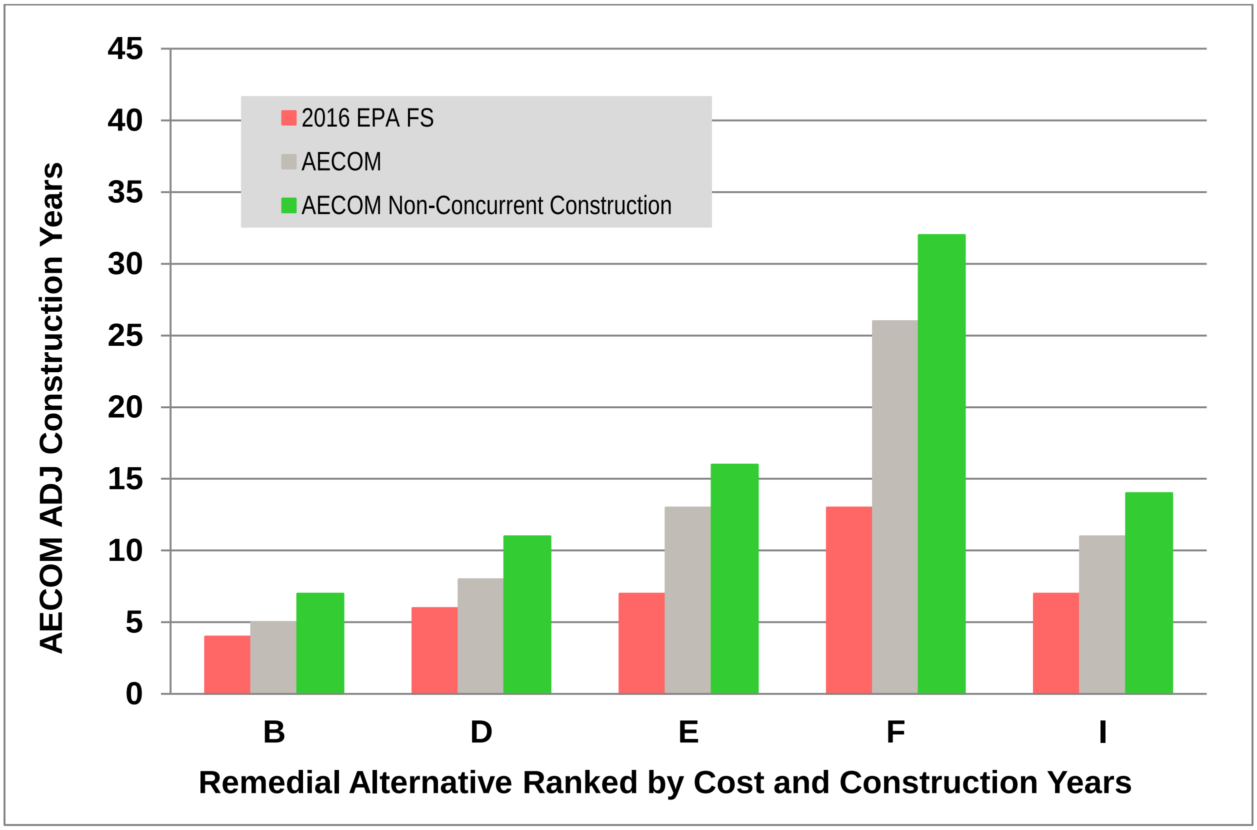
Despite these significant constraints for Portland Harbor, EPA assumed an average daily dredge production rate of approximately 1,700 CY/day per dredge spread (5,100 CY/day for three dredges), which is higher than that achieved by many recent Pacific Northwest projects (i.e., Boeing Plant 2); see Table 2. It is unlikely that every dredge footprint identified in the 2016 EPA FS could be completed with

[3] Geosyntec, de maximis, and Integral completed independent third-party cost estimate of the 2016 EPA FS using different tools and assumptions, which are included in Table 6 for comparison.

similar efficiency. Also, EPA assumed dredge rates are approximately 2.5 times greater than the assumed LDW dredge rate (694 CY/day). Additionally, EPA deferred key design considerations and evaluations to the design phase of the project, such as available rail capacity, navigational constraints, and available processing facilities, all of which have an effect on overall production rates. Any slowdown due to sediment disposal transport or processing would also slow down dredging production operations.

Finally, based on the production rates assumed in the 2016 EPA FS, the EPA estimated project duration of Alternative I is 4 years to remove 1,649,750 CY of sediment, plus 2 years for mobilization/demobilization, and another year for non-concurrent capping activities, for a total of 7 construction years. By contrast, the estimated AECOM duration to complete Alternative I ranges from 11 years (9 years of construction, plus 1 year for mobilization, and another year for demobilization) to 14 years when non-concurrent construction is taken into account. Figure 1 shows a comparison of construction years for each remedial alternative.

Figure 1. Construction Years and Costs for Remedial Alternatives



6.2 Cost Comparison

The differences between EPA and AECOM cost estimates are best shown by comparing capital costs, agency costs, and long-term costs. A summary of specific costs compared are shown in Table 7 and Figure 2. Capital costs consist of all expenses necessary for the contractor to complete the project (e.g., mobilization, removal, capping, disposal, mitigation, etc.). Agency, or PRP, costs include expenses for the agency, or their representative, to complete remedial design (RD), construction management (CM), project management (PM), oversight, contingency, and sales tax. Long-term costs include expenses for long-term agency review and oversight, O&M, LTM, and ICs. For comparison and reference, costs developed by Geosyntec (Geosyntec 2016) are also included. Cost estimate results, sensitivity analysis, and construction years are presented in Table 3. Cost estimates prepared by EPA, AECOM, and Geosyntec are shown graphically for comparison in Figure 2.

Figure 2. Remedial Alternative Cost Comparison

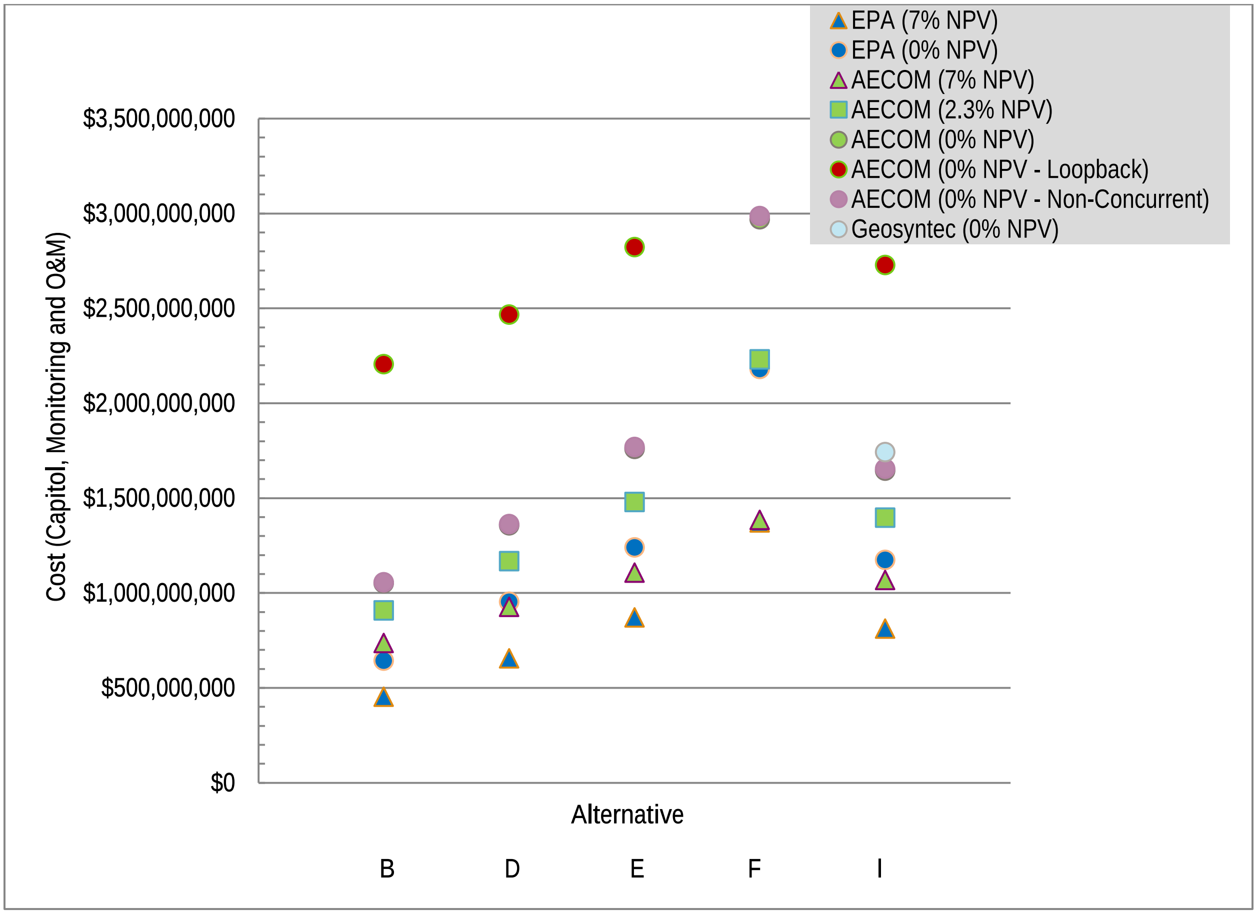


Figure 2 Notes: These are FS-level cost estimates in the range of +50 to -30% accuracy.

6.2.1 Capital Costs

EPA and AECOM assumptions for capital costs are inherently different. The purpose of AECOM's capital cost is to provide an engineer's estimate that could be used by an agency or PRP to bid a project. AECOM costs only include construction expenses and do not account for contingency of any sort. Because no contingency is applied, all AECOM capital costs are lower than the EPA costs. Results of this comparison for 2016 EPA FS Alternative I are shown in Table 7. Geosyntec costs, generated using engineering considerations similar to those for the AECOM estimates, are also shown for reference. The primary capital cost budget items for this comparison and their differences include the following:

- **Mobilization / demobilization**: AECOM has a longer construction time (11 years for AECOM, compared to 7 years for EPA). However, EPA estimated mobilization/demobilization as percentage (i.e., 1.6%) of capital costs based on lump sum estimates for the LDW. AECOM estimates for mobilization/demobilization are based on number of occurrences (i.e., annual rate). For reference, EPA capital costs are higher than AECOM's (because EPA estimates included design/management costs, whereas AECOM lumped those in total cost). However, with differences overall costs are approximately similar.

- **Sheet pile / turbidity curtain**: AECOM increased costs for sheet pile installation because the recommended 80-foot-long sheet pile walls are not a common item and are typically more expensive. However, AECOM did not include costs for turbidity curtains, which EPA included. If turbidity curtains are needed, AECOM assumes they would be included with equipment day rates and managed by equipment crews during day-to-day construction. Based on discussions with contractors and previous construction experience, turbidity curtains are not typically used extensively on projects of this type because they are not very effective in strong river currents. Instead, water quality is managed by using a debris boom to contain floating debris, turbidity monitoring stations, and BMPs.

- **Dredging**: EPA assumed an approximately $175,000 day rate for all three dredges combined (which includes material barges, surveys, and overhead and profit). Based on contractor recommendations, AECOM assumed a $43,600 day rate for three dredges (which includes material barges, surveying, and water quality monitoring). Based on previous experience, AECOM assumed that overhead and profit were already included in the daily rates. AECOM's day rate is significantly lower because it includes down-time costs, which are typically 30% to 40% of a barge day rate and construction efficiency is approximately 64%.

- **Material placement (capping/ ENR/ backfill/ Organoclay mat):** EPA assumed 5% use of granular activated carbon (GAC) in material placement, but AECOM assumed 4%. The average cost of EPA amended sand is approximately $110/CY, but it is important to note that sand and GAC unit costs change slightly between each EPA alternative. The average cost of sand in the AECOM estimate is $27/CY for clean sand and $215/CY for clean sand amended with 4% GAC by weight.

- **Disposal management (disposal/ transloading development/ mitigation**): AECOM matched EPA cost assumptions for Subtitle C and Subtitle D disposal and mitigation. AECOM costs are slightly lower for transloading area development and management than EPA costs. The assumptions used were those developed for the Lower Duwamish Final FS to construct a transloading facility in Seattle, Washington. It is assumed that a transloading facility in rural Washington State (i.e., Bingen, WA) will not cost more than a facility developed within a major metropolitan area.

- **Other construction costs:** As described in Section 3.2, other capital costs associated with construction planning and implementation, and verification include project management, construction management, remedial design, post-construction verification monitoring, baseline monitoring, and mitigation.

6.2.2 Agency/PRP Costs

AECOM assumed that agency/PRP costs would be applied only to capital costs, as percentages. These assumptions include costs for construction management, contingency, project management, and remedial design. AECOM applied a large percentage (~75%) to these costs (higher than 27% EPA applied) because of the high level of uncertainty at the FS stage. AECOM also included DSL costs, which are not accounted for by EPA.

6.2.3 Long-term Costs

EPA's O&M and LTM costs are much higher than AECOM's. This is because EPA assumes (1) more extensive (e.g., more sampling) and more frequent monitoring (e.g., more often) during and after construction; while AECOM's lower assumptions are based upon LDW FS assumptions, (2) application of agency/PRP cost percentages discussed in the previous section, and (3) contingency costs, which AECOM applies to all capital costs.

6.3 Alternative I Cost Estimates

This analysis compares all alternatives, but focuses on Alternative I because it is EPA's Proposed Plan (EPA 2016b). Four other individual cost estimates were created to compare 2016 EPA FS costs for Alternative I, including costs by AECOM, de maximis, Geosyntec, and Integral. The four independent cost estimates were created using different methods and tools. Results of each cost estimate are $1.62 billion, $1.79 billion, $1.72 billion, and $1.80 billion for AECOM, de maximis, Geosyntec, and Integral, respectively. While all of the cost results are similar, they are approximately 50% higher than EPA estimated costs of $1.17 billion. A comparison of all five costs is also shown in Table 6.

7. Conclusions

AECOM's total remedy cost estimates (NPV 0% discount) were approximately 45% higher than EPA's cost estimates (e.g., Alternative B 0% discount is $642 million compared to AECOM costs of $1,051 million for the same alternative).

EPA total cost for Alternative I 0% discount is $1.17 billion compared to AECOM total costs for $1.62 billion for the same alternative. Other independent cost estimates completed by de maximis, Geosyntec, and Integral were also approximately 50% higher at $1.79 billion, $1.72 billion, and $1.80 billion, respectively[4]. However, EPA is presenting Alternative I costs at a 7% discount, which results in a cost of $811 million. While assuming a 7% discount rate is recommended by the CERCLA guidance (EPA 1988), AECOM recommends a discount of 2.3% as a more reasonable alternative based on current economic conditions (OMB 2011).

Costs associated with remediation of areas and volumes identified in the 2016 EPA FS were estimated using AECOM's Lower Duwamish Final FS cost tool. When applicable, EPA assumptions were used but some modifications were necessary because (a) the cost spreadsheets are set up differently, (b) internal discrepancies were found within the EPA document, (c) revised cost assumptions based upon regional experience (e.g., no silt curtains used), or (d) adding cost items that EPA did not include (e.g., agency oversight costs, DSL costs). The goal was to estimate FS-level realistic cost estimates and construction times based on local experience.

Additional sensitivity costs were analyzed to explore the effect of increased construction times assuming dredge volume sensitivity based on the extent of ENR and MNR areas that could fail to achieve remedial goals and non-concurrent construction between dredging and capping technologies. Sensitivity cost estimates were completed for capital costs including NPV adjustments of 7%, 2.3%, and 0%. Assuming non-concurrent construction resulted in total cost increases (i.e., 0% NPV) of approximately 0.5% for all alternatives, AECOM construction times were estimated to be approximately 5, 8, 13, 26, and 11 years for FS Alternatives B, C, D, E, and I, respectively. The dredge production rates are limited by a wide range of site constraints, including competing waterway uses (commercial, recreational boating, and fishing).The following are key differences between the AECOM and EPA cost assumptions:

- EPA construction assumes that dredging and disposal management will be 85% efficient and equipment cycle times would be similar to production dredging (approximately 2-minute cycles) which is typically twice as fast as environmental dredging (approximately 4-minute cycles) based on past experience. However, AECOM based construction times from observed projects using similar equipment during remediation of the Lower Duwamish Early Action Areas (i.e., approximately 64% efficiency) with dredge cycle times of approximately 4 minutes.

- EPA assumed that 5% GAC by weight would be used in all material placement. Based on AECOM's previous experience, a smaller amount of carbon (i.e., 4% by weight for material placement) is typically sufficient.

[4] The Lower Willamette Group estimated a 0% NPV Alternative I cost of approximately $2.13 billion. The costs are higher due to longer construction times (i.e., 15 years), increased costs for mobilization/demobilization, and use of high end percentages for contingency, CM, PM, RD, and oversight (LWG 2016).

- EPA assumed capital costs would also include agency costs (i.e., contingency, CM, PM, RD, etc.). AECOM assumed capital costs could be used for contractor bids and would only include costs incurred by the contractor.

- EPA assumes low to mid-range contingency percentages (i.e., 10% to 20% and AECOM assumes high range (i.e., 35%). AECOM assumes a high contingency because project scope for a sediments project of this magnitude could likely change considerably between FS and final design.

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Table 1. 2016 EPA FS Removal Volumes and Remedial Technology Areas

EPA Remedial Alternative[1]	Dredge Volume[2]	Dredge Area	Dredge/Cap	Capping	ENR	MNR	Total Sand Placement[3,4]
	CY	acres	acres	acres	acres	acres	CY
B	576,883	67	6	23	100	1,966	444,400
D	1,108,046	121	11	45	87	1,900	645,400
E	1,928,136	188	15	66	60	1,838	874,400
F	4,462,574	355	32	118	28	1,634	1,454,400
I	1,649,750	150	17	64	60	1,876	815,000

Table 1 notes:

1. Remedial alternative volumes and acres used in this assessment do not include the confined disposal facility. All dredge material in assumed to go to a Subtidal C or D landfill.
2. Approximately 240,000 CY of sediment for each alternative was assumed to require Subtitle C disposal. The remaining sediment was assumed to only require Subtitle D disposal.
3. The riverbank volumes not included in this table, but were included in the cost analysis.
4. Total sand includes sand, beach mix, and armor volumes. This total accounts for capping, residuals, and backfill material.

CY = cubic yards; ENR = enhanced natural recovery; EPA = US Environmental Protection Agency; MNR = monitored natural recovery.

Table 2. Dredge Production Rate Comparison

Item		Cost Assumptions		Project Site (Construction Year) and Reference			
		EPA PH Assumptions EPA 2016a	AECOM PH Assumptions	Terminal 4 (2008) AnchorQEA 2009	Slip 4 (2012) Integral 2012	Terminal 117 Construction (2013 to 2014) AECOM 2016a	Plant 2 Construction (2013 to 2014) AMEC 2013; DOF 2014
Location		Lower Willamette, Portland, OR			Lower Duwamish Waterway, Seattle, WA		
Schedule	Hours per Day	24	24 to 12 (Blended)	12 to 16	8	12	20
	Days per Week	6	6 to 5 (Blended)	5 to 7	5	5, with some 7 during construction	6
Equipment Type and (Size)		Large to small derrick crane	Large to small derrick crane	Large derrick crane (20 and 10 CY bucket)	Large derrick crane (19 CY bucket)	Large derrick crane (19 CY bucket)	Medium excavator (4 CY bucket)
Average Daily Production for one piece of equipment (CY/day)		1,700	694	583	400 to 800	220 (avg)	726 to 1,255
Days per Season		104	88	22	45	64	67
Seasonal Production in CY (# of dredges)		530,000 (3)	184,000 (3)	12,819 (1)	10,000 (1)	14,000 (1)	41,314 (1)
Seasonal Work Efficiency		85%	64%	57%	Not Available	73%[1]	52%

Table 2 notes:
1. Terminal 117 had initially planned to work 5 days per week, and changed to 7 days per week because construction was progressing slower than anticipated. Thus, the work efficiency of 73% is much higher than would have been achieved.
2. The seasonal work efficiency for placing capping material at Willamette River Mile 13.5 was approximately 47%.

CY = cubic yards; PH = Portland Harbor Superfund Site.

Table 3. Cost Comparison and Sensitivity Analysis

2016 EPA FS Costs Blended Volumes (not High or Low Volumes)					
Remedial Alternative	B	D	E	F	I
Total Capital Costs	$352,097,000	$556,004,000	$827,465,000	$1,629,407,000	$751,359,000
Total Costs (7% Discount)	$451,460,000	$653,700,000	$869,530,000	$1,371,170,000	$811,290,000
Total Costs (0% Discount)	$642,421,000	$953,032,000	$1,239,797,000	$2,178,919,000	$1,173,299,000
Years of Construction	4	6	7	13	7
AECOM – Adjusted to meet EPA Assumptions[1]					
Remedial Alternative	B	D	E	F	I
Total Capital Costs	$394,440,710	$561,654,092	$783,416,531	$1,448,028,938	$719,932,263
Total Present Value Costs (7% Discount)	$735,000,000	$925,000,000	$1,106,000,000	$1,385,000,000	$1,067,000,000
Total Present Value Costs (2.3% Discount)	$907,000,000	$1,167,000,000	$1,478,000,000	$2,230,000,000	$1,396,000,000
Total Costs (0% Discount)	$1,051,000,000	$1,355,000,000	$1,758,000,000	$2,969,000,000	$1,644,000,000
Years of Construction	5	8	13	26	11
AECOM – Sensitivity Analysis with Non-Concurrent Construction[2]					
Remedial Alternative	B	D	E	F	I
Total Capital Costs	$397,191,817	$565,649,511	$788,829,601	$1,457,032,561	$724,977,610
Total Present Value Costs (7% Discount)	$705,000,000	$869,000,000	$1,017,000,000	$1,227,000,000	$986,000,000
Total Present Value Costs (2.3% Discount)	$898,000,000	$1,147,000,000	$1,439,000,000	$2,126,000,000	$1,363,000,000
Total Costs (0% Discount)	$1,056,000,000	$1,362,000,000	$1,768,000,000	$2,985,000,000	$1,653,000,000
Years of Construction	7	11	16	32	14
AECOM – Sensitivity Analysis with Loopback Volume[3]					
Remedial Alternative	B	D	E	F	I
Total Capital Costs	$1,019,693,613	$1,163,996,810	$1,359,831,736	$1,955,855,776	$1,307,557,402
Total Present Value Costs (7% Discount)	$1,743,000,000	$1,812,000,000	$1,849,000,000	$1,838,000,000	$1,859,000,000
Total Present Value Costs (2.3% Discount)	$2,008,000,000	$2,194,000,000	$2,414,000,000	$2,944,000,000	$2,367,000,000
Total Costs (0% Discount)	$2,205,000,000	$2,466,000,000	$2,821,000,000	$3,906,000,000	$2,728,000,000
Years of Construction	5	8	13	26	11

Table 3 notes:

1. These are FS-level cost estimates in the range of +50 to -30% accuracy.
2. Volumes match EPA plus other adjustments (sheet pile, dock/pile relocation, disposal costs, 3 dredges, added mitigation, added more GAC, doubled LTM, added DSL Mitigation).
3. Volumes match EPA assumptions/AECOM costs but assumed that dredging and capping do not occur concurrently. Rounded cost totals.
4. Volumes match EPA assumptions/AECOM costs plus including addition of contingency “loopback volume” for assumed modifications based technology performance (15% of ENR and MNR footprint).

DSL = Oregon Department of State Lands; EPA = US Environmental Protection Agency; GAC = granulated activated carbon; LTM = long-term monitoring

Table 4. Main Engineering Assumptions Pertaining to Cost Estimation

Item No.	Topic	Assumption[1]
Work Period		
1	In-water construction season and number of construction operating days	Construction season: 138 calendar days. Construction operating days per season: 88 days.
2	Work shifts	Two work shift scenarios assumed for developing seasonal blended construction rate estimates: (1) 24 hours per day, 6 days per week (50% of work), and (2) 12 hours per day, 5 days per week (50% of work).
3	Seasonal Efficiency	64% accounting for weekends and 20 days of maintenance/repair/holiday downtime.
Placement of Imported Aggregate Materials		
3	Equipment	4-CY bucket for water depth shallower than 10 feet, similar to EPA assumptions. 4-CY and 10-CY buckets for water depths deeper than 10 feet, similar to EPA assumptions.
4	Material source	Quarry material delivered to the site by barge.
5	Cap and backfill material volume	Capping: 3-foot cap thickness over application area, matching EPA assumptions.
6	ENR and thin-layer sand placement for dredge residuals management	Apply 9 inches of sand to achieve the goal of a minimum 6-inch-thick layer in both cases. For management of dredge residuals, apply to equivalent of 100% of dredged area (although placement may also occur outside of the dredge area).
7	*In situ* treatment	Apply granular activated carbon (4% organic carbon by weight) to a depth equivalent to the assumed cap, ENR, and backfill thickness.
Removal – Mechanical Dredging		
8	Equipment	Two derrick barge/clamshell and one precision excavator (3 separate dredge activities simultaneously in the river), matching EPA assumptions.
9	Average annual dredge production rate	2,700 to 1,300 CY/operational day averaged over the dredge season for three dredges, based on a combination of dredge equipment and operating regimes. This equates to 4,000 to 2,000 tons/operational day average dredge production rate over the 88 days of dredging.
10	Construction period	Based on dredging as the rate-limiting technology. The construction time frame is based on the dredge-cut prism volume estimate as opposed to the performance contingency volume estimate. One year is added for mobilization and another for demobilization. Capping will occur sometime during the dredging period, no additional time added.

Table 4. Main Engineering Assumptions Pertaining to Cost Estimation (continued)

Item No.	Topic	Assumption
Removal – Mechanical Dredging (continued)		
11	Dredge volume estimation	Total dredge volumes (sum of dredge-cut prism and performance contingency volumes of 1.75 multiplier on the neat cut volumes) are used to estimate costs. Volumes match 2016 EPA FS assumptions.
12	Gravity dewatered dredge material density	Wet bulk density of dewatered sediment for disposal: 1.5 Tons/CY.
13	Dredging debris sweep	Debris removal and on-barge handling occupy 10% of dredge operations at a lower effective bucket capacity of 40%. The need for debris removal was reviewed as commonly needed for many sediment dredging projects.
14	Capping and ENR/*in situ* treatment debris sweep	10% of the capping and ENR/*in situ* treatment footprint requires debris removal.
Transloading, Transport, and Landfilling of Dredged Materials		
15	Barge transport	Material barges for receipt of mechanically dredged sediment and transport to transloading facility (Bingen, WA). Capping materials delivered to the site by barge. Based on 2016 EPA FS assumptions.
16	Transloading	Gravity dewatered sediment transferred to 20-foot containers fitted with disposable liner and loaded onto truck chassis. Containers transported to local intermodal facility and transferred to railcars. Stormwater and wastewater generated at transloading facility treated on-site.
17	Truck transport	Lined 20-foot containers; one container per truck (20 tons). No material stabilization (e.g., with lime).
18	Landfill	Two regional Subtitle D facilities accept wet dredged materials: Allied Waste Services (Roosevelt, WA) and Waste Management Inc. (Columbia Ridge, OR); they are located approximately 80 and 140 miles from the site, respectively. Additionally, the Waste Management facility also accepts Subtitle C waste. Landfills used match EPA assumptions.
Monitoring and Maintenance		
19	Construction monitoring	Survey boat, labor, and equipment for routine bathymetric surveys and surface water quality testing during construction.
20	Other monitoring	Post-construction, baseline and long-term monitoring every 5 years for 30 years
21	Repair	5% of cap and ENR/*in situ* treatment areas. Fraction of remediation areas assumed to undergo repair by addition of clean import material (approximately 3.0 feet for caps and 9 inches for ENR/*in situ* treatment areas) following construction. Repair costs assume approximately 50% of any area requiring repair will include *in situ* treatment, consistent with the rest of the cost estimate.

Table 4. Main Engineering Assumptions Pertaining to Cost Estimation (continued)

Item No.	Topic	Assumption
22	ICs	Initial cost, annual cost, and periodic cost developed for implementing ICs. Assumed ICs would begin upon signing of the ROD and annual costs applied from Year 1 to Year 50. Some of the periodic costs (e.g., seafood consumption advisories) may apply to the project in perpetuity.
Monitoring and Maintenance		
23	Discount rate used for present value calculations	Best estimate cost assumes a 2.3% discount rate (consistent with Lower Duwamish Waterway Final FS [AECOM 2012]). The 0% and 7.0% (EPA 2000) are included for sensitivity.

Table 4 notes:
1. Cost assumptions based on Lower Duwamish Waterway Final FS Cost Model (AECOM 2012) and Portland Harbor June 2016 FS (EPA 2016a).

CY = cubic yards; ENR = enhanced natural recovery; EPA = US Environmental Protection Agency; ICs = institutional controls; ROD = Record of Decision; USACE = US Army Corps of Engineers.

Table 5. Comparison of Cost Assumptions between EPA and AECOM

Item	Cost Assumptions	2016 EPA FS Costs (App G)	AECOM Cost Model (Adjusted to match EPA volumes)
Dredge, Transportation, and Disposal	Neat volume multiplier	x 1.75	x 1.75
	Contingency dredge volume	Not Included (but added long-term monitoring contingency cost)	Not Included (but see sensitivity analysis)
	Dredge rates (open water)	2,382 CY/Day	Blended rate of 694 CY/Day
	Dredge rates (nearshore)	1,767 CY/Day	
	Dredge residuals management	12" sand	12" sand
	Sheet pile (etc.)	$2,750/LF	$6,300/LF
	Silt curtains	$96.92/LF	Not included
	Pile replacement	$7,479/EA	match
	Dock relocation	$100,498/EA	match
	Debris sweep	$13,107/acre	$30,000/acre
	Disposal costs Subtitle C and Thermal Treatment	$191/ton	match
	Disposal costs Subtitle D	$111/ton	match
Material Placement	Cap material costs	$34 to $74/CY; includes placement	$27/CY sand
	Sand amendment	GAC placement $523/ton	Material cost $135/ton
	11" sand layer	Geofabric (riverbank) $14,311/acre	Not included
	12" GAC layer	Placed 5% by weight, blended with ENR cap, and fill	Placed 4% by weight blended with ENR, cap, and fill
	Organoclay mat	Organoclay Mat $6.73/SF	match
	Cap thickness	36"	36"
	Armor stone	12"	incorporated into cap layer
	GAC dose	5%	4%
	ENR thickness	12"	12"
	Cap Placement Rate	1,500 CY/Day	~1,200 CY/Day
Other Construction Costs	Contingency	20%	35%
	Agency Review (Construction)	Not identified	700,000/Year
	Agency Oversight (LTM)	$308,000/Event every 5 years	$200,000/Year
	Discount Rate	7%	2.3%
	Project Management	2% to 5%	10%
	Remedial Design Costs	2% to 8%	20%
	Construction Management	3%	Included in "Project Management"
	Sales Tax	8%	9.5%
	Land Lease	$26,484/acre/year	$250,000/year
	Mitigation	$16 million (B), $27 million (D), $37 million (E), $64 million (F), and $36 million (I)	$125 million (B), $147 million (D), $166 million (E), $221 million (F), and $164 million (I) Used 2016 EPA FS high estimates and included Oregon DSL Mitigation

Table 5 notes: App = appendix; CY = cubic yards; EA = each; ENR = enhanced natural recovery; EPA = US Environmental Protection Agency; FS = feasibility study; GAC = granulated activated carbon; LF = linear feet; LTM = long-term monitoring;

Table 6. Portland Harbor Alternative I Cost Estimate Comparison

Source	Estimated Total Remedy Cost [a, b]	Estimated Construction Time (Years)
2016 EPA FS	$1.17 billion	7
AECOM	$1.62 billion	11
de maximis	$1.72 billion	9
Geosyntec	$1.79 billion	9
Integral	$1.80 billion	Not Calculated

Table 6 notes:

a. These are FS-level cost estimates in the range of +50 to -30% accuracy using 0% NPV (range of $1.2 to $2.6 billion among the average of the 4 estimates).

b. The Lower Willamette Group estimated a 0% NPV Alternative I cost of approximately $2.13 billion. The costs are higher due to longer construction times (i.e., 15 years), increased costs for mobilization/demobilization, and use of high end percentages for contingency, CM, PM, RD, and oversight (LWG 2016).

NPV = net present value

Table 7. Comparison of Cost Assumptions for Alternative I (0.0% NPV)

Key Cost Items	EPA	AECOM	Brief Description of Differences (presented as 0% NPV discount)
Mob / Demob and Pre-Con Site Development	$20M	$20M	EPA assumed mob/demob as 1.6% of capital costs based on Lower Duwamish Waterway FS (AECOM 2012) lump sum estimates. AECOM estimated itemized annual mob/demob costs. Methods were different, but total costs are similar.
Sheet pile / Silt curtain	$25M	$47M	AECOM increased sheet pile installation costs to account for cost to manufacture 80-foot-long sheet pile (per Geosyntec personnel communication). AECOM did not include costs for silt curtains. Silt curtains not typically used in the Pacific Northwest; instead water quality is managed by monitoring.
Dredging	$49M	$45M	EPA assumed faster construction but more expensive day rate for dredging equipment than AECOM. However, AECOM assumes dredging duration would be longer than EPA but lower day rate. Therefore costs are similar.
Capping / ENR / Backfill / Organoclay Mat	$30M	$58M	AECOM matched EPA material costs and placement areas but assumed 4% granulated activated carbon (GAC) compared to EPA assumptions of 5%. AECOM also assumed a lower production efficiency, which increased backfill costs.
Disposal / Pile and Dock Removal & Replacement	$368M	$373M	AECOM matched EPA cost assumptions for Subtitle C and D disposal, mitigation, and pile and dock removal & replacement; thus costs are approximately similar.
Mitigation	$163M	$599M	EPA used average costs for mitigation based on past projects near Portland Harbor. AECOM used high end costs for mitigation based on past projects near Portland Harbor (see EPA 2015 FS [EPA 2015]) and also added costs for Oregon Department of State Lands mitigation.
Contingency	$115M	$252M	EPA assumed low to mid-range contingency percentages (i.e., 10% to 20%) based on guidance (EPA 1988). AECOM assumed high range (i.e., 35%) which includes 20% toward scope contingency and 15% toward bid contingency. Scope contingency is toward the high end specified in the guidance (EPA 1988), because project scope for a sediments project of this magnitude could likely change considerably between FS and final design. Bid contingency of 15% is mid-range of the values
PM / CM / RD	$48M	$362M	EPA assumed low to mid-range percentages based on guidance for project management, construction management, and remedial design. AECOM assumed high range percentages based on significant level of unknowns at the FS level.
O&M and LTM	$422M	$316M	Both EPA and AECOM included sediment, tissue, and water monitoring post-construction, but EPA has more extensive coverage (e.g., more samples) but hard to confirm. EPA also includes robust sampling during construction (AECOM starts after construction). EPA included 20% contingency, but AECOM did not apply contingency to O&M and LTM costs. Both AECOM and EPA have three significant monitoring events post-construction within the first 8 years. EPA also included monitoring every 3, 5, and 7 years during construction, as well as every 5 years after the 7-year post-construction event (AECOM does not assume these extra events). AECOM does assume fish tissue monitoring every 3 to 5 years during construction.

Table 7 notes: These are FS-level cost estimates in the range of +50 to -30% accuracy. CY = cubic yard; EPA= US Environmental Protection Agency; ENR = enhanced natural recovery; FS = feasibility study; GAC= granulated activated carbon; PRP = potentially responsible party; PM = project management; CM = construction management; O&M = operations and maintenance; LTM = long-term monitoring; RD = remedial design.

Attachment A

AECOM Cost Estimate – Adjusted to Match 2016 EPA Feasibility Study Assumptions

Cost Summary for Portland Harbor Alternative B (with 0.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	5.1
Land Lease for Operations and Staging	$250,000	YEAR	5.1
Contractor Work Plan Submittals	$100,000	YEAR	5.1
Dock/PileRemoval and Relocation	$3,907,503	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$54,450,173
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	14.2
Construction Office and Operating Expense	$21,600	MONTH	14.2
Subtotal:			$1,187,878
DREDGING			
Shift Rate	$35,950	DAY	277.1
Gravity Dewatering (on the barge)	$10	CY	576,883
Subtotal:			$15,729,760
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$7,967,890	LS	1
Water Management	$10,000	DAY	277.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	693,843
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$156,302,839.83
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	3
Shift Rate (12 hours)	$12,500	DAY	157.0
Cap material procurement and delivery (sand)	$27	CY	340,519
Material procurement and delivery (carbon amended sand)	$215	CY	103,881
Reactive Mat	$1,173,039	LS	1
Subtotal:			$34,722,685
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	277.1
Subtotal:			$2,195,900
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$1,256,917
Compliance Testing (Capping)	alt specific	PROJECT	$926,941
Compliance Testing (ENR)	alt specific	PROJECT	$2,462,616
Subtotal:			$4,646,473
Mitigation	$2,260,000	Acre	15
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	129.3
Department of State Lands Fee (MNR)	$30,000	Acre	1,966
Subtotal:			$125,205,000
CAPITAL COST (BASE)			$394,440,710
CAPITAL COST (present value)			$394,440,710
Construction Contingency			$138,054,248.50
Sales Tax			$37,471,867
Project Management, Remedial Design and Baseline Monitoring			$118,332,213
Construction Management			$39,444,071
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$727,743,110
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,477,209
Operations and Maintenance (Capping)	alt specific	PROJECT	$4,897,190
Operations and Maintenance (ENR)	alt specific	PROJECT	$13,018,166
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$223,366,936
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$323,445,640
TOTAL COST (Net Present Value)			$1,051,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative B (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	5.1
Land Lease for Operations and Staging	$250,000	YEAR	5.1
Contractor Work Plan Submittals	$100,000	YEAR	5.1
Dock/PileRemoval and Relocation	$3,907,503	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$54,450,173
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	14.2
Construction Office and Operating Expense	$21,600	MONTH	14.2
Subtotal:			$1,187,878
DREDGING			
Shift Rate	$35,950	DAY	277.1
Gravity Dewatering (on the barge)	$10	CY	576,883
Subtotal:			$15,729,760
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$7,967,890	LS	1
Water Management	$10,000	DAY	277.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	693,843
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$156,302,839.83
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	3
Shift Rate (12 hours)	$12,500	DAY	157.0
Cap material procurement and delivery (sand)	$27	CY	340,519
Material procurement and delivery (carbon amended sand)	$215	CY	103,881
Reactive Mat	$1,173,039	LS	1
Subtotal:			$34,722,685
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	277.1
Subtotal:			$2,195,900
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$1,256,917
Compliance Testing (Capping)	alt specific	PROJECT	$926,941
Compliance Testing (ENR)	alt specific	PROJECT	$2,462,616
Subtotal:			$4,646,473
Mitigation	$2,260,000	Acre	15
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	129.3
Department of State Lands Fee (MNR)	$30,000	Acre	1,966
Subtotal:			$125,205,000
CAPITAL COST (BASE)			$394,440,710
CAPITAL COST (present value)			$376,538,365
Construction Contingency			$131,788,427.63
Sales Tax			$35,771,145
Project Management, Remedial Design and Baseline Monitoring			$112,961,509
Construction Management			$37,653,836
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$694,713,283
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,015,656
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,182,976
Operations and Maintenance (ENR)	alt specific	PROJECT	$8,511,736
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$147,307,160
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$212,104,795
TOTAL COST (Net Present Value)			$907,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative B (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	5.1
Land Lease for Operations and Staging	$250,000	YEAR	5.1
Contractor Work Plan Submittals	$100,000	YEAR	5.1
Dock/PileRemoval and Relocation	$3,907,503	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$54,450,173
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	14.2
Construction Office and Operating Expense	$21,600	MONTH	14.2
Subtotal:			$1,187,878
DREDGING			
Shift Rate	$35,950	DAY	277.1
Gravity Dewatering (on the barge)	$10	CY	576,883
Subtotal:			$15,729,760
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$7,967,890	LS	1
Water Management	$10,000	DAY	277.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	693,843
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$156,302,839.83
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	3
Shift Rate (12 hours)	$12,500	DAY	157.0
Cap material procurement and delivery (sand)	$27	CY	340,519
Material procurement and delivery (carbon amended sand)	$215	CY	103,881
Reactive Mat	$1,173,039	LS	1
Subtotal:			$34,722,685
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	277.1
Subtotal:			$2,195,900
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$1,256,917
Compliance Testing (Capping)	alt specific	PROJECT	$926,941
Compliance Testing (ENR)	alt specific	PROJECT	$2,462,616
Subtotal:			$4,646,473
Mitigation	$2,260,000	Acre	15
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	129.3
Department of State Lands Fee (MNR)	$30,000	Acre	1,966
Subtotal:			$125,205,000
CAPITAL COST (BASE)			$394,440,710
CAPITAL COST (present value)			$344,629,897
Construction Contingency			$120,620,463.91
Sales Tax			$32,739,840
Project Management, Remedial Design and Baseline Monitoring			$103,388,969
Construction Management			$34,462,990
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$635,842,160
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$486,231
Operations and Maintenance (Capping)	alt specific	PROJECT	$1,380,262
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,735,769
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$65,509,520
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$99,513,346
TOTAL COST (Net Present Value)			$735,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative D (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	8.0
Land Lease for Operations and Staging	$250,000	YEAR	8.0
Contractor Work Plan Submittals	$100,000	YEAR	8.0
Dock/PileRemoval and Relocation	$6,933,407	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$58,832,033
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	27.3
Construction Office and Operating Expense	$21,600	MONTH	27.3
Subtotal:			$2,281,613
DREDGING			
Shift Rate	$35,950	DAY	532.2
Gravity Dewatering (on the barge)	$10	CY	1,108,046
Subtotal:			$30,212,881
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$9,675,295	LS	1
Water Management	$10,000	DAY	532.2
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,599,182
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$261,054,049.52
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	5
Shift Rate (12 hours)	$12,500	DAY	228.0
Cap material procurement and delivery (sand)	$27	CY	483,603
Material procurement and delivery (carbon amended sand)	$215	CY	161,797
Reactive Mat	$1,173,039	LS	1
Subtotal:			$51,964,471
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	532.2
Subtotal:			$4,217,767
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,186,182
Compliance Testing (Capping)	alt specific	PROJECT	$1,494,559
Compliance Testing (ENR)	alt specific	PROJECT	$2,160,536
Subtotal:			$5,841,276
Mitigation	$2,260,000	Acre	25
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	135.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,900
Subtotal:			$147,250,000
CAPITAL COST (BASE)			$561,654,092
CAPITAL COST (present value)			$561,654,092
Construction Contingency			$196,578,932.14
Sales Tax			$53,357,139
Project Management, Remedial Design and Baseline Monitoring			$168,496,228
Construction Management			$56,165,409
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,036,251,799
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,500,252
Operations and Maintenance (Capping)	alt specific	PROJECT	$8,001,021
Operations and Maintenance (ENR)	alt specific	PROJECT	$11,389,799
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$215,979,531
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$318,556,742
TOTAL COST (Net Present Value)			$1,355,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative D (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	8.0
Land Lease for Operations and Staging	$250,000	YEAR	8.0
Contractor Work Plan Submittals	$100,000	YEAR	8.0
Dock/PileRemoval and Relocation	$6,933,407	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$58,832,033
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	27.3
Construction Office and Operating Expense	$21,600	MONTH	27.3
Subtotal:			$2,281,613
DREDGING			
Shift Rate	$35,950	DAY	532.2
Gravity Dewatering (on the barge)	$10	CY	1,108,046
Subtotal:			$30,212,881
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$9,675,295	LS	1
Water Management	$10,000	DAY	532.2
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,599,182
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$261,054,049.52
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	5
Shift Rate (12 hours)	$12,500	DAY	228.0
Cap material procurement and delivery (sand)	$27	CY	483,603
Material procurement and delivery (carbon amended sand)	$215	CY	161,797
Reactive Mat	$1,173,039	LS	1
Subtotal:			$51,964,471
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	532.2
Subtotal:			$4,217,767
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,186,182
Compliance Testing (Capping)	alt specific	PROJECT	$1,494,559
Compliance Testing (ENR)	alt specific	PROJECT	$2,160,536
Subtotal:			$5,841,276
Mitigation	$2,260,000	Acre	25
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	135.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,900
Subtotal:			$147,250,000
CAPITAL COST (BASE)			$561,654,092
CAPITAL COST (present value)			$519,284,850
Construction Contingency			$181,749,697.59
Sales Tax			$49,332,061
Project Management, Remedial Design and Baseline Monitoring			$155,785,455
Construction Management			$51,928,485
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$958,080,549
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,719,049
Operations and Maintenance (Capping)	alt specific	PROJECT	$5,199,514
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,447,139
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$142,435,277
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$208,888,248
TOTAL COST (Net Present Value)			$1,167,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative D (with 7% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	8.0
Land Lease for Operations and Staging	$250,000	YEAR	8.0
Contractor Work Plan Submittals	$100,000	YEAR	8.0
Dock/PileRemoval and Relocation	$6,933,407	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$58,832,033
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	27.3
Construction Office and Operating Expense	$21,600	MONTH	27.3
Subtotal:			$2,281,613
DREDGING			
Shift Rate	$35,950	DAY	532.2
Gravity Dewatering (on the barge)	$10	CY	1,108,046
Subtotal:			$30,212,881
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$9,675,295	LS	1
Water Management	$10,000	DAY	532.2
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,599,182
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$261,054,049.52
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	5
Shift Rate (12 hours)	$12,500	DAY	228.0
Cap material procurement and delivery (sand)	$27	CY	483,603
Material procurement and delivery (carbon amended sand)	$215	CY	161,797
Reactive Mat	$1,173,039	LS	1
Subtotal:			$51,964,471
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	532.2
Subtotal:			$4,217,767
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,186,182
Compliance Testing (Capping)	alt specific	PROJECT	$1,494,559
Compliance Testing (ENR)	alt specific	PROJECT	$2,160,536
Subtotal:			$5,841,276
Mitigation	$2,260,000	Acre	25
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	135.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,900
Subtotal:			$147,250,000
CAPITAL COST (BASE)			$561,654,092
CAPITAL COST (present value)			$448,317,901
Construction Contingency			$156,911,265.18
Sales Tax			$42,590,201
Project Management, Remedial Design and Baseline Monitoring			$134,495,370
Construction Management			$44,831,790
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$827,146,526
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$822,970
Operations and Maintenance (Capping)	alt specific	PROJECT	$2,253,980
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,268,598
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$63,342,927
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$98,090,039
TOTAL COST (Net Present Value)			$925,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	12.5
Land Lease for Operations and Staging	$250,000	YEAR	12.5
Contractor Work Plan Submittals	$100,000	YEAR	12.5
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,693,591
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	47.5
Construction Office and Operating Expense	$21,600	MONTH	47.5
Subtotal:			$3,970,287
DREDGING			
Shift Rate	$35,950	DAY	926.1
Gravity Dewatering (on the barge)	$10	CY	1,928,136
Subtotal:			$52,574,120
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	926.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,975,613
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$418,630,485
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	714,911
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,778,039
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	926.1
Subtotal:			$7,339,433
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$783,416,531
CAPITAL COST (present value)			$783,416,531
Construction Contingency			$274,195,785.96
Sales Tax			$74,424,570
Project Management, Remedial Design and Baseline Monitoring			$235,024,959
Construction Management			$78,341,653
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,445,403,500
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$3,726,974
Operations and Maintenance (Capping)	alt specific	PROJECT	$10,832,075
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,914,815
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$209,037,688
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$312,197,691
TOTAL COST (Net Present Value)			$1,758,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	12.5
Land Lease for Operations and Staging	$250,000	YEAR	12.5
Contractor Work Plan Submittals	$100,000	YEAR	12.5
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,693,591
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	47.5
Construction Office and Operating Expense	$21,600	MONTH	47.5
Subtotal:			$3,970,287
DREDGING			
Shift Rate	$35,950	DAY	926.1
Gravity Dewatering (on the barge)	$10	CY	1,928,136
Subtotal:			$52,574,120
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	926.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,975,613
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$418,630,485
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	714,911
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,778,039
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	926.1
Subtotal:			$7,339,433
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$783,416,531
CAPITAL COST (present value)			$689,903,063
Construction Contingency			$241,466,072.02
Sales Tax			$65,540,791
Project Management, Remedial Design and Baseline Monitoring			$206,970,919
Construction Management			$68,990,306
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,272,871,151
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,562,483
Operations and Maintenance (Capping)	alt specific	PROJECT	$7,038,695
Operations and Maintenance (ENR)	alt specific	PROJECT	$5,175,226
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$137,857,235
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$204,720,907
TOTAL COST (Net Present Value)			$1,478,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 7% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	12.5
Land Lease for Operations and Staging	$250,000	YEAR	12.5
Contractor Work Plan Submittals	$100,000	YEAR	12.5
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,693,591
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	47.5
Construction Office and Operating Expense	$21,600	MONTH	47.5
Subtotal:			$3,970,287
DREDGING			
Shift Rate	$35,950	DAY	926.1
Gravity Dewatering (on the barge)	$10	CY	1,928,136
Subtotal:			$52,574,120
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	926.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,975,613
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$418,630,485
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	714,911
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,778,039
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	926.1
Subtotal:			$7,339,433
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$783,416,531
CAPITAL COST (present value)			$547,224,626
Construction Contingency			$191,528,619.01
Sales Tax			$51,986,339
Project Management, Remedial Design and Baseline Monitoring			$164,167,388
Construction Management			$54,722,463
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,009,629,435
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,226,752
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,050,732
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,271,600
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$61,307,009
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$96,257,656
TOTAL COST (Net Present Value)			$1,106,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	26.2
Land Lease for Operations and Staging	$250,000	YEAR	26.2
Contractor Work Plan Submittals	$100,000	YEAR	26.2
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$81,180,668
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	109.9
Construction Office and Operating Expense	$21,600	MONTH	109.9
Subtotal:			$9,189,030
DREDGING			
Shift Rate	$35,950	DAY	2,143.4
Gravity Dewatering (on the barge)	$10	CY	4,462,574
Subtotal:			$121,680,162
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	2,143.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	7,149,152
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$899,188,434.25
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,236,016
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$88,210,964
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,143.4
Subtotal:			$16,986,749
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,448,028,938
CAPITAL COST (present value)			$1,448,028,938
Construction Contingency			$506,810,128.37
Sales Tax			$137,562,749
Project Management, Remedial Design and Baseline Monitoring			$434,408,681
Construction Management			$144,802,894
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,671,613,391
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$6,690,740
Operations and Maintenance (Capping)	alt specific	PROJECT	$19,830,738
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,834,513
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$186,180,694
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$297,222,826
TOTAL COST (Net Present Value)			$2,969,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	26.2
Land Lease for Operations and Staging	$250,000	YEAR	26.2
Contractor Work Plan Submittals	$100,000	YEAR	26.2
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$81,180,668
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	109.9
Construction Office and Operating Expense	$21,600	MONTH	109.9
Subtotal:			$9,189,030
DREDGING			
Shift Rate	$35,950	DAY	2,143.4
Gravity Dewatering (on the barge)	$10	CY	4,462,574
Subtotal:			$121,680,162
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	2,143.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	7,149,152
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$899,188,434.25
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,236,016
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$88,210,964
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,143.4
Subtotal:			$16,986,749
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,448,028,938
CAPITAL COST (present value)			$1,102,980,305
Construction Contingency			$386,043,106.74
Sales Tax			$104,783,129
Project Management, Remedial Design and Baseline Monitoring			$330,894,091
Construction Management			$110,298,030
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,034,998,663
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$4,600,222
Operations and Maintenance (Capping)	alt specific	PROJECT	$12,884,187
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,507,469
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$122,783,389
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$194,862,535
TOTAL COST (Net Present Value)			$2,230,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 7% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	26.2
Land Lease for Operations and Staging	$250,000	YEAR	26.2
Contractor Work Plan Submittals	$100,000	YEAR	26.2
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$81,180,668
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	109.9
Construction Office and Operating Expense	$21,600	MONTH	109.9
Subtotal:			$9,189,030
DREDGING			
Shift Rate	$35,950	DAY	2,143.4
Gravity Dewatering (on the barge)	$10	CY	4,462,574
Subtotal:			$121,680,162
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	2,143.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	7,149,152
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$899,188,434.25
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,236,016
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$88,210,964
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,143.4
Subtotal:			$16,986,749
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,448,028,938
CAPITAL COST (present value)			$700,641,164
Construction Contingency			$245,224,407.42
Sales Tax			$66,560,911
Project Management, Remedial Design and Baseline Monitoring			$210,192,349
Construction Management			$70,064,116
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,292,682,948
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,202,290
Operations and Maintenance (Capping)	alt specific	PROJECT	$5,582,659
Operations and Maintenance (ENR)	alt specific	PROJECT	$1,100,809
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$54,603,462
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$91,890,783
TOTAL COST (Net Present Value)			$1,385,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	11.0
Land Lease for Operations and Staging	$250,000	YEAR	11.0
Contractor Work Plan Submittals	$100,000	YEAR	11.0
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$68,427,871
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	40.6
Construction Office and Operating Expense	$21,600	MONTH	40.6
Subtotal:			$3,397,053
DREDGING			
Shift Rate	$35,950	DAY	792.4
Gravity Dewatering (on the barge)	$10	CY	1,649,750
Subtotal:			$44,983,421
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	792.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,534,454
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$368,324,748.63
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	648,563
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,211,757
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	792.4
Subtotal:			$6,279,759
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$719,932,263
CAPITAL COST (present value)			$719,932,263
Construction Contingency			$251,976,292.03
Sales Tax			$68,393,565
Project Management, Remedial Design and Baseline Monitoring			$215,979,678.88
Construction Management			$71,993,226
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,328,275,025
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$3,035,362
Operations and Maintenance (Capping)	alt specific	PROJECT	$10,897,436
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,914,815
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$213,292,620
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$315,826,372
TOTAL COST (Net Present Value)			$1,644,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	11.0
Land Lease for Operations and Staging	$250,000	YEAR	11.0
Contractor Work Plan Submittals	$100,000	YEAR	11.0
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$68,427,871
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	40.6
Construction Office and Operating Expense	$21,600	MONTH	40.6
Subtotal:			$3,397,053
DREDGING			
Shift Rate	$35,950	DAY	792.4
Gravity Dewatering (on the barge)	$10	CY	1,649,750
Subtotal:			$44,983,421
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	792.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,534,454
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$368,324,748.63
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	648,563
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,211,757
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	792.4
Subtotal:			$6,279,759
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$719,932,263
CAPITAL COST (present value)			$644,498,748
Construction Contingency			$225,574,561.79
Sales Tax			$61,227,381
Project Management, Remedial Design and Baseline Monitoring			$193,349,624.39
Construction Management			$64,449,875
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,189,100,190
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,086,965
Operations and Maintenance (Capping)	alt specific	PROJECT	$7,081,156
Operations and Maintenance (ENR)	alt specific	PROJECT	$5,175,226
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$140,663,299
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$207,093,913
TOTAL COST (Net Present Value)			$1,396,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 7% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	11.0
Land Lease for Operations and Staging	$250,000	YEAR	11.0
Contractor Work Plan Submittals	$100,000	YEAR	11.0
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$68,427,871
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	40.6
Construction Office and Operating Expense	$21,600	MONTH	40.6
Subtotal:			$3,397,053
DREDGING			
Shift Rate	$35,950	DAY	792.4
Gravity Dewatering (on the barge)	$10	CY	1,649,750
Subtotal:			$44,983,421
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	792.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,534,454
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$368,324,748.63
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	648,563
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,211,757
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	792.4
Subtotal:			$6,279,759
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$719,932,263
CAPITAL COST (present value)			$525,744,570
Construction Contingency			$184,010,599.50
Sales Tax			$49,945,734
Project Management, Remedial Design and Baseline Monitoring			$157,723,371.00
Construction Management			$52,574,457
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$969,998,732
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$999,104
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,069,125
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,271,600
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$62,554,904
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$97,296,296
TOTAL COST (Net Present Value)			$1,067,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

AECOM
Portland Harbor Sustainability Project,
Environmental Sustainability Analysis
Report Appendix E

Attachment B

Cost Sensitivity Analyses

AECOM
Portland Harbor Sustainability Project,
Environmental Sustainability Analysis
Report Appendix E

AECOM Cost Estimate including Loopback Volumes – Adjusted to Match 2016 EPA Feasibility Study Assumptions

Cost Summary for Portland Harbor Alternative B (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	5.1
Land Lease for Operations and Staging	$250,000	YEAR	5.1
Contractor Work Plan Submittals	$100,000	YEAR	5.1
Dock/PileRemoval and Relocation	$3,907,503	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$54,450,173
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	96.1
Construction Office and Operating Expense	$21,600	MONTH	96.1
Subtotal:			$8,037,247
DREDGING			
Shift Rate	$35,950	DAY	1,717.8
Gravity Dewatering (on the barge)	$10	CY	3,576,425
Subtotal:			$97,517,693
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$7,967,890	LS	1
Water Management	$10,000	DAY	1,717.8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	5,193,155
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$670,133,313.42
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	3
Shift Rate (12 hours)	$12,500	DAY	157.0
Cap material procurement and delivery (sand)	$27	CY	715,462
Material procurement and delivery (carbon amended sand)	$215	CY	103,881
Reactive Mat	$1,173,039	LS	1
Subtotal:			$44,846,138
ENHANCED NATURAL RECOVERY - All Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	1,874.7
Subtotal:			$14,857,574
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$1,256,917
Compliance Testing (Capping)	alt specific	PROJECT	$926,941
Compliance Testing (ENR)	alt specific	PROJECT	$2,462,616
Subtotal:			$4,646,473
Mitigation	$2,260,000	Acre	15
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	129.3
Department of State Lands Fee (MNR)	$30,000	Acre	1,966
Subtotal:			$125,205,000
CAPITAL COST (BASE)			$1,019,693,613
CAPITAL COST (present value)			$1,019,693,613
Construction Contingency			$356,892,764.42
Sales Tax			$96,870,893
Project Management, Remedial Design and Baseline Monitoring			$305,908,084
Construction Management			$101,969,361
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,881,334,715
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,477,209
Operations and Maintenance (Capping)	alt specific	PROJECT	$4,897,190
Operations and Maintenance (ENR)	alt specific	PROJECT	$13,018,166
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$223,366,936
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$323,445,640
TOTAL COST (Net Present Value)			$2,205,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative B (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	5.1
Land Lease for Operations and Staging	$250,000	YEAR	5.1
Contractor Work Plan Submittals	$100,000	YEAR	5.1
Dock/PileRemoval and Relocation	$3,907,503	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$54,450,173
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	96.1
Construction Office and Operating Expense	$21,600	MONTH	96.1
Subtotal:			$8,037,247
DREDGING			
Shift Rate	$35,950	DAY	1,717.8
Gravity Dewatering (on the barge)	$10	CY	3,576,425
Subtotal:			$97,517,693
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$7,967,890	LS	1
Water Management	$10,000	DAY	1,717.8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	5,193,155
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$670,133,313.42
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	3
Shift Rate (12 hours)	$12,500	DAY	157.0
Cap material procurement and delivery (sand)	$27	CY	715,462
Material procurement and delivery (carbon amended sand)	$215	CY	103,881
Reactive Mat	$1,173,039	LS	1
Subtotal:			$44,846,138
ENHANCED NATURAL RECOVERY - All Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	1,874.7
Subtotal:			$14,857,574
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$1,256,917
Compliance Testing (Capping)	alt specific	PROJECT	$926,941
Compliance Testing (ENR)	alt specific	PROJECT	$2,462,616
Subtotal:			$4,646,473
Mitigation	$2,260,000	Acre	15
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	129.3
Department of State Lands Fee (MNR)	$30,000	Acre	1,966
Subtotal:			$125,205,000
CAPITAL COST (BASE)			$1,019,693,613
CAPITAL COST (present value)			$973,413,128
Construction Contingency			$340,694,594.82
Sales Tax			$92,474,247
Project Management, Remedial Design and Baseline Monitoring			$292,023,938
Construction Management			$97,341,313
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,795,947,221
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,015,656
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,182,976
Operations and Maintenance (ENR)	alt specific	PROJECT	$8,511,736
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$147,307,160
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$212,104,795
TOTAL COST (Net Present Value)			$2,008,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative B (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	5.1
Land Lease for Operations and Staging	$250,000	YEAR	5.1
Contractor Work Plan Submittals	$100,000	YEAR	5.1
Dock/PileRemoval and Relocation	$3,907,503	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$54,450,173
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	96.1
Construction Office and Operating Expense	$21,600	MONTH	96.1
Subtotal:			$8,037,247
DREDGING			
Shift Rate	$35,950	DAY	1,717.8
Gravity Dewatering (on the barge)	$10	CY	3,576,425
Subtotal:			$97,517,693
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$7,967,890	LS	1
Water Management	$10,000	DAY	1,717.8
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	5,193,155
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$670,133,313.42
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	3
Shift Rate (12 hours)	$12,500	DAY	157.0
Cap material procurement and delivery (sand)	$27	CY	715,462
Material procurement and delivery (carbon amended sand)	$215	CY	103,881
Reactive Mat	$1,173,039	LS	1
Subtotal:			$44,846,138
ENHANCED NATURAL RECOVERY - All Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	1,874.7
Subtotal:			$14,857,574
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$1,256,917
Compliance Testing (Capping)	alt specific	PROJECT	$926,941
Compliance Testing (ENR)	alt specific	PROJECT	$2,462,616
Subtotal:			$4,646,473
Mitigation	$2,260,000	Acre	15
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	129.3
Department of State Lands Fee (MNR)	$30,000	Acre	1,966
Subtotal:			$125,205,000
CAPITAL COST (BASE)			$1,019,693,613
CAPITAL COST (present value)			$890,924,531
Construction Contingency			$311,823,585.87
Sales Tax			$84,637,830
Project Management, Remedial Design and Baseline Monitoring			$267,277,359
Construction Management			$89,092,453
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,643,755,760
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$486,231
Operations and Maintenance (Capping)	alt specific	PROJECT	$1,380,262
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,735,769
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$65,509,520
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$99,513,346
TOTAL COST (Net Present Value)			$1,743,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative D (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	8.0
Land Lease for Operations and Staging	$250,000	YEAR	8.0
Contractor Work Plan Submittals	$100,000	YEAR	8.0
Dock/PileRemoval and Relocation	$6,933,407	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$58,832,033
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	110.0
Construction Office and Operating Expense	$21,600	MONTH	110.0
Subtotal:			$9,199,737
DREDGING			
Shift Rate	$35,950	DAY	1,917.9
Gravity Dewatering (on the barge)	$10	CY	3,993,170
Subtotal:			$108,881,011
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$9,675,295	LS	1
Water Management	$10,000	DAY	1,917.9
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	5,926,868
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$755,284,445.02
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	5
Shift Rate (12 hours)	$12,500	DAY	228.0
Cap material procurement and delivery (sand)	$27	CY	844,244
Material procurement and delivery (carbon amended sand)	$215	CY	161,797
Reactive Mat	$1,173,039	LS	1
Subtotal:			$61,701,765
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,145.9
Subtotal:			$17,006,543
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,186,182
Compliance Testing (Capping)	alt specific	PROJECT	$1,494,559
Compliance Testing (ENR)	alt specific	PROJECT	$2,160,536
Subtotal:			$5,841,276
Mitigation	$2,260,000	Acre	25
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	135.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,900
Subtotal:			$147,250,000
CAPITAL COST (BASE)			$1,163,996,810
CAPITAL COST (present value)			$1,163,996,810
Construction Contingency			$407,398,883.63
Sales Tax			$110,579,697
Project Management, Remedial Design and Baseline Monitoring			$349,199,043
Construction Management			$116,399,681
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,147,574,115
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,500,252
Operations and Maintenance (Capping)	alt specific	PROJECT	$8,001,021
Operations and Maintenance (ENR)	alt specific	PROJECT	$11,389,799
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$215,979,531
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$318,556,742
TOTAL COST (Net Present Value)			$2,466,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative D (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	8.0
Land Lease for Operations and Staging	$250,000	YEAR	8.0
Contractor Work Plan Submittals	$100,000	YEAR	8.0
Dock/PileRemoval and Relocation	$6,933,407	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$58,832,033
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	110.0
Construction Office and Operating Expense	$21,600	MONTH	110.0
Subtotal:			$9,199,737
DREDGING			
Shift Rate	$35,950	DAY	1,917.9
Gravity Dewatering (on the barge)	$10	CY	3,993,170
Subtotal:			$108,881,011
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$9,675,295	LS	1
Water Management	$10,000	DAY	1,917.9
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	5,926,868
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$755,284,445.02
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	5
Shift Rate (12 hours)	$12,500	DAY	228.0
Cap material procurement and delivery (sand)	$27	CY	844,244
Material procurement and delivery (carbon amended sand)	$215	CY	161,797
Reactive Mat	$1,173,039	LS	1
Subtotal:			$61,701,765
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,145.9
Subtotal:			$17,006,543
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,186,182
Compliance Testing (Capping)	alt specific	PROJECT	$1,494,559
Compliance Testing (ENR)	alt specific	PROJECT	$2,160,536
Subtotal:			$5,841,276
Mitigation	$2,260,000	Acre	25
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	135.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,900
Subtotal:			$147,250,000
CAPITAL COST (BASE)			$1,163,996,810
CAPITAL COST (present value)			$1,076,188,918
Construction Contingency			$376,666,121.31
Sales Tax			$102,237,947
Project Management, Remedial Design and Baseline Monitoring			$322,856,675
Construction Management			$107,618,892
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,985,568,554
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,719,049
Operations and Maintenance (Capping)	alt specific	PROJECT	$5,199,514
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,447,139
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$142,435,277
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$208,888,248
TOTAL COST (Net Present Value)			$2,194,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative D (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	8.0
Land Lease for Operations and Staging	$250,000	YEAR	8.0
Contractor Work Plan Submittals	$100,000	YEAR	8.0
Dock/PileRemoval and Relocation	$6,933,407	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$58,832,033
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	110.0
Construction Office and Operating Expense	$21,600	MONTH	110.0
Subtotal:			$9,199,737
DREDGING			
Shift Rate	$35,950	DAY	1,917.9
Gravity Dewatering (on the barge)	$10	CY	3,993,170
Subtotal:			$108,881,011
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$9,675,295	LS	1
Water Management	$10,000	DAY	1,917.9
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	5,926,868
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$755,284,445.02
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	5
Shift Rate (12 hours)	$12,500	DAY	228.0
Cap material procurement and delivery (sand)	$27	CY	844,244
Material procurement and delivery (carbon amended sand)	$215	CY	161,797
Reactive Mat	$1,173,039	LS	1
Subtotal:			$61,701,765
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,145.9
Subtotal:			$17,006,543
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,186,182
Compliance Testing (Capping)	alt specific	PROJECT	$1,494,559
Compliance Testing (ENR)	alt specific	PROJECT	$2,160,536
Subtotal:			$5,841,276
Mitigation	$2,260,000	Acre	25
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	135.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,900
Subtotal:			$147,250,000
CAPITAL COST (BASE)			$1,163,996,810
CAPITAL COST (present value)			$929,113,869
Construction Contingency			$325,189,854.10
Sales Tax			$88,265,818
Project Management, Remedial Design and Baseline Monitoring			$278,734,161
Construction Management			$92,911,387
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,714,215,088
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$822,970
Operations and Maintenance (Capping)	alt specific	PROJECT	$2,253,980
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,268,598
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$63,342,927
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$98,090,039
TOTAL COST (Net Present Value)			$1,812,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	12.5
Land Lease for Operations and Staging	$250,000	YEAR	12.5
Contractor Work Plan Submittals	$100,000	YEAR	12.5
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,693,591
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	131.2
Construction Office and Operating Expense	$21,600	MONTH	131.2
Subtotal:			$10,968,470
DREDGING			
Shift Rate	$35,950	DAY	2,249.6
Gravity Dewatering (on the barge)	$10	CY	4,683,742
Subtotal:			$127,710,697
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	2,249.6
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	7,109,021
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$890,673,991
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	1,059,362
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$68,078,208
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,558.4
Subtotal:			$20,276,204
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$1,359,831,736
CAPITAL COST (present value)			$1,359,831,736
Construction Contingency			$475,941,107.70
Sales Tax			$129,184,015
Project Management, Remedial Design and Baseline Monitoring			$407,949,521
Construction Management			$135,983,174
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,508,889,553
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$3,726,974
Operations and Maintenance (Capping)	alt specific	PROJECT	$10,832,075
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,914,815
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$209,037,688
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$312,197,691
TOTAL COST (Net Present Value)			$2,821,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	12.5
Land Lease for Operations and Staging	$250,000	YEAR	12.5
Contractor Work Plan Submittals	$100,000	YEAR	12.5
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,693,591
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	131.2
Construction Office and Operating Expense	$21,600	MONTH	131.2
Subtotal:			$10,968,470
DREDGING			
Shift Rate	$35,950	DAY	2,249.6
Gravity Dewatering (on the barge)	$10	CY	4,683,742
Subtotal:			$127,710,697
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	2,249.6
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	7,109,021
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$890,673,991
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	1,059,362
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$68,078,208
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,558.4
Subtotal:			$20,276,204
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$1,359,831,736
CAPITAL COST (present value)			$1,197,513,765
Construction Contingency			$419,129,817.71
Sales Tax			$113,763,808
Project Management, Remedial Design and Baseline Monitoring			$359,254,129
Construction Management			$119,751,376
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,209,412,896
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,562,483
Operations and Maintenance (Capping)	alt specific	PROJECT	$7,038,695
Operations and Maintenance (ENR)	alt specific	PROJECT	$5,175,226
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$137,857,235
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$204,720,907
TOTAL COST (Net Present Value)			$2,414,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	12.5
Land Lease for Operations and Staging	$250,000	YEAR	12.5
Contractor Work Plan Submittals	$100,000	YEAR	12.5
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,693,591
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	131.2
Construction Office and Operating Expense	$21,600	MONTH	131.2
Subtotal:			$10,968,470
DREDGING			
Shift Rate	$35,950	DAY	2,249.6
Gravity Dewatering (on the barge)	$10	CY	4,683,742
Subtotal:			$127,710,697
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	2,249.6
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	7,109,021
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$890,673,991
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	1,059,362
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$68,078,208
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,558.4
Subtotal:			$20,276,204
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$1,359,831,736
CAPITAL COST (present value)			$949,856,664
Construction Contingency			$332,449,832.40
Sales Tax			$90,236,383
Project Management, Remedial Design and Baseline Monitoring			$284,956,999
Construction Management			$94,985,666
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,752,485,545
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,226,752
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,050,732
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,271,600
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$61,307,009
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$96,257,656
TOTAL COST (Net Present Value)			$1,849,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	26.2
Land Lease for Operations and Staging	$250,000	YEAR	26.2
Contractor Work Plan Submittals	$100,000	YEAR	26.2
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$81,180,668
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	195.7
Construction Office and Operating Expense	$21,600	MONTH	195.7
Subtotal:			$16,361,044
DREDGING			
Shift Rate	$35,950	DAY	3,302.6
Gravity Dewatering (on the barge)	$10	CY	6,876,088
Subtotal:			$187,489,002
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	3,302.6
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	10,769,424
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$1,312,630,690.62
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,537,705
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$96,356,575
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	3,816.3
Subtotal:			$30,244,864
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,955,855,776
CAPITAL COST (present value)			$1,955,855,776
Construction Contingency			$684,549,521.61
Sales Tax			$185,806,299
Project Management, Remedial Design and Baseline Monitoring			$586,756,733
Construction Management			$195,585,578
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$3,608,553,907
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$6,690,740
Operations and Maintenance (Capping)	alt specific	PROJECT	$19,830,738
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,834,513
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$186,180,694
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$297,222,826
TOTAL COST (Net Present Value)			$3,906,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	26.2
Land Lease for Operations and Staging	$250,000	YEAR	26.2
Contractor Work Plan Submittals	$100,000	YEAR	26.2
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$81,180,668
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	195.7
Construction Office and Operating Expense	$21,600	MONTH	195.7
Subtotal:			$16,361,044
DREDGING			
Shift Rate	$35,950	DAY	3,302.6
Gravity Dewatering (on the barge)	$10	CY	6,876,088
Subtotal:			$187,489,002
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	3,302.6
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	10,769,424
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$1,312,630,690.62
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,537,705
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$96,356,575
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	3,816.3
Subtotal:			$30,244,864
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,955,855,776
CAPITAL COST (present value)			$1,489,797,851
Construction Contingency			$521,429,247.85
Sales Tax			$141,530,796
Project Management, Remedial Design and Baseline Monitoring			$446,939,355
Construction Management			$148,979,785
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,748,677,035
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$4,600,222
Operations and Maintenance (Capping)	alt specific	PROJECT	$12,884,187
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,507,469
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$122,783,389
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$194,862,535
TOTAL COST (Net Present Value)			$2,944,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	26.2
Land Lease for Operations and Staging	$250,000	YEAR	26.2
Contractor Work Plan Submittals	$100,000	YEAR	26.2
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$81,180,668
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	195.7
Construction Office and Operating Expense	$21,600	MONTH	195.7
Subtotal:			$16,361,044
DREDGING			
Shift Rate	$35,950	DAY	3,302.6
Gravity Dewatering (on the barge)	$10	CY	6,876,088
Subtotal:			$187,489,002
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	3,302.6
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	10,769,424
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$1,312,630,690.62
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,537,705
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$96,356,575
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	3,816.3
Subtotal:			$30,244,864
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,955,855,776
CAPITAL COST (present value)			$946,357,515
Construction Contingency			$331,225,130.26
Sales Tax			$89,903,964
Project Management, Remedial Design and Baseline Monitoring			$283,907,255
Construction Management			$94,635,752
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,746,029,615
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,202,290
Operations and Maintenance (Capping)	alt specific	PROJECT	$5,582,659
Operations and Maintenance (ENR)	alt specific	PROJECT	$1,100,809
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$54,603,462
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$91,890,783
TOTAL COST (Net Present Value)			$1,838,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	11.0
Land Lease for Operations and Staging	$250,000	YEAR	11.0
Contractor Work Plan Submittals	$100,000	YEAR	11.0
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$68,427,871
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	124.6
Construction Office and Operating Expense	$21,600	MONTH	124.6
Subtotal:			$10,418,906
DREDGING			
Shift Rate	$35,950	DAY	2,142.4
Gravity Dewatering (on the barge)	$10	CY	4,460,532
Subtotal:			$121,624,472
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	2,142.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	6,750,626
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$849,820,068.01
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	999,911
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$67,698,145
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,430.2
Subtotal:			$19,260,287
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$1,307,557,402
CAPITAL COST (present value)			$1,307,557,402
Construction Contingency			$457,645,090.82
Sales Tax			$124,217,953
Project Management, Remedial Design and Baseline Monitoring			$392,267,220.70
Construction Management			$130,755,740
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,412,443,407
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$3,035,362
Operations and Maintenance (Capping)	alt specific	PROJECT	$10,897,436
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,914,815
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$213,292,620
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$315,826,372
TOTAL COST (Net Present Value)			$2,728,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	11.0
Land Lease for Operations and Staging	$250,000	YEAR	11.0
Contractor Work Plan Submittals	$100,000	YEAR	11.0
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$68,427,871
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	124.6
Construction Office and Operating Expense	$21,600	MONTH	124.6
Subtotal:			$10,418,906
DREDGING			
Shift Rate	$35,950	DAY	2,142.4
Gravity Dewatering (on the barge)	$10	CY	4,460,532
Subtotal:			$121,624,472
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	2,142.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	6,750,626
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$849,820,068.01
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	999,911
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$67,698,145
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,430.2
Subtotal:			$19,260,287
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$1,307,557,402
CAPITAL COST (present value)			$1,170,553,331
Construction Contingency			$409,693,665.95
Sales Tax			$111,202,566
Project Management, Remedial Design and Baseline Monitoring			$351,165,999.39
Construction Management			$117,055,333
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,159,670,896
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,086,965
Operations and Maintenance (Capping)	alt specific	PROJECT	$7,081,156
Operations and Maintenance (ENR)	alt specific	PROJECT	$5,175,226
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$140,663,299
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$207,093,913
TOTAL COST (Net Present Value)			$2,367,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	11.0
Land Lease for Operations and Staging	$250,000	YEAR	11.0
Contractor Work Plan Submittals	$100,000	YEAR	11.0
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$68,427,871
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	124.6
Construction Office and Operating Expense	$21,600	MONTH	124.6
Subtotal:			$10,418,906
DREDGING			
Shift Rate	$35,950	DAY	2,142.4
Gravity Dewatering (on the barge)	$10	CY	4,460,532
Subtotal:			$121,624,472
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	2,142.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	6,750,626
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$849,820,068.01
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	999,911
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$67,698,145
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,430.2
Subtotal:			$19,260,287
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$1,307,557,402
CAPITAL COST (present value)			$954,869,284
Construction Contingency			$334,204,249.30
Sales Tax			$90,712,582
Project Management, Remedial Design and Baseline Monitoring			$286,460,785.12
Construction Management			$95,486,928
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,761,733,828
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$999,104
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,069,125
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,271,600
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$62,554,904
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$97,296,296
TOTAL COST (Net Present Value)			$1,859,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

AECOM
Portland Harbor Sustainability Project,
Environmental Sustainability Analysis
Report Appendix E

AECOM Cost Estimate including Non-Concurrent Construction – Adjusted to Match 2016 EPA Feasibility Study Assumptions

Cost Summary for Portland Harbor Alternative B (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	6.9
Land Lease for Operations and Staging	$250,000	YEAR	6.9
Contractor Work Plan Submittals	$100,000	YEAR	6.9
Dock/PileRemoval and Relocation	$3,907,503	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$55,284,420
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	22.3
Construction Office and Operating Expense	$21,600	MONTH	22.3
Subtotal:			$1,860,794
DREDGING			
Shift Rate	$35,950	DAY	277.1
Gravity Dewatering (on the barge)	$10	CY	576,883
Subtotal:			$15,729,760
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$7,967,890	LS	1
Water Management	$10,000	DAY	277.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	693,843
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$156,302,839.83
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	3
Shift Rate (12 hours)	$12,500	DAY	157.0
Cap material procurement and delivery (sand)	$27	CY	340,519
Material procurement and delivery (carbon amended sand)	$215	CY	103,881
Reactive Mat	$1,173,039	LS	1
Subtotal:			$34,722,685
ENHANCED NATURAL RECOVERY - All Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	434.0
Subtotal:			$3,439,845
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$1,256,917
Compliance Testing (Capping)	alt specific	PROJECT	$926,941
Compliance Testing (ENR)	alt specific	PROJECT	$2,462,616
Subtotal:			$4,646,473
Mitigation	$2,260,000	Acre	15
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	129.3
Department of State Lands Fee (MNR)	$30,000	Acre	1,966
Subtotal:			$125,205,000
CAPITAL COST (BASE)			$397,191,817
CAPITAL COST (present value)			$397,191,817
Construction Contingency			$139,017,135.95
Sales Tax			$37,733,223
Project Management, Remedial Design and Baseline Monitoring			$119,157,545
Construction Management			$39,719,182
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$732,818,902
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,477,209
Operations and Maintenance (Capping)	alt specific	PROJECT	$4,897,190
Operations and Maintenance (ENR)	alt specific	PROJECT	$13,018,166
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$223,366,936
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$323,445,640
TOTAL COST (Net Present Value)			$1,056,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative B (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	6.9
Land Lease for Operations and Staging	$250,000	YEAR	6.9
Contractor Work Plan Submittals	$100,000	YEAR	6.9
Dock/PileRemoval and Relocation	$3,907,503	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$55,284,420
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	22.3
Construction Office and Operating Expense	$21,600	MONTH	22.3
Subtotal:			$1,860,794
DREDGING			
Shift Rate	$35,950	DAY	277.1
Gravity Dewatering (on the barge)	$10	CY	576,883
Subtotal:			$15,729,760
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$7,967,890	LS	1
Water Management	$10,000	DAY	277.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	693,843
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$156,302,839.83
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	3
Shift Rate (12 hours)	$12,500	DAY	157.0
Cap material procurement and delivery (sand)	$27	CY	340,519
Material procurement and delivery (carbon amended sand)	$215	CY	103,881
Reactive Mat	$1,173,039	LS	1
Subtotal:			$34,722,685
ENHANCED NATURAL RECOVERY - All Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	434.0
Subtotal:			$3,439,845
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$1,256,917
Compliance Testing (Capping)	alt specific	PROJECT	$926,941
Compliance Testing (ENR)	alt specific	PROJECT	$2,462,616
Subtotal:			$4,646,473
Mitigation	$2,260,000	Acre	15
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	129.3
Department of State Lands Fee (MNR)	$30,000	Acre	1,966
Subtotal:			$125,205,000
CAPITAL COST (BASE)			$397,191,817
CAPITAL COST (present value)			$371,760,410
Construction Contingency			$130,116,143.59
Sales Tax			$35,317,239
Project Management, Remedial Design and Baseline Monitoring			$111,528,123
Construction Management			$37,176,041
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$685,897,957
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,015,656
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,182,976
Operations and Maintenance (ENR)	alt specific	PROJECT	$8,511,736
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$147,307,160
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$212,104,795
TOTAL COST (Net Present Value)			$898,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative B (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	6.9
Land Lease for Operations and Staging	$250,000	YEAR	6.9
Contractor Work Plan Submittals	$100,000	YEAR	6.9
Dock/PileRemoval and Relocation	$3,907,503	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$55,284,420
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	22.3
Construction Office and Operating Expense	$21,600	MONTH	22.3
Subtotal:			$1,860,794
DREDGING			
Shift Rate	$35,950	DAY	277.1
Gravity Dewatering (on the barge)	$10	CY	576,883
Subtotal:			$15,729,760
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$7,967,890	LS	1
Water Management	$10,000	DAY	277.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	693,843
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$156,302,839.83
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	3
Shift Rate (12 hours)	$12,500	DAY	157.0
Cap material procurement and delivery (sand)	$27	CY	340,519
Material procurement and delivery (carbon amended sand)	$215	CY	103,881
Reactive Mat	$1,173,039	LS	1
Subtotal:			$34,722,685
ENHANCED NATURAL RECOVERY - All Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	434.0
Subtotal:			$3,439,845
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$1,256,917
Compliance Testing (Capping)	alt specific	PROJECT	$926,941
Compliance Testing (ENR)	alt specific	PROJECT	$2,462,616
Subtotal:			$4,646,473
Mitigation	$2,260,000	Acre	15
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	129.3
Department of State Lands Fee (MNR)	$30,000	Acre	1,966
Subtotal:			$125,205,000
CAPITAL COST (BASE)			$397,191,817
CAPITAL COST (present value)			$328,139,925
Construction Contingency			$114,848,973.70
Sales Tax			$31,173,293
Project Management, Remedial Design and Baseline Monitoring			$98,441,977
Construction Management			$32,813,992
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$605,418,161
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$486,231
Operations and Maintenance (Capping)	alt specific	PROJECT	$1,380,262
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,735,769
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$65,509,520
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$99,513,346
TOTAL COST (Net Present Value)			$705,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative D (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	10.6
Land Lease for Operations and Staging	$250,000	YEAR	10.6
Contractor Work Plan Submittals	$100,000	YEAR	10.6
Dock/PileRemoval and Relocation	$6,933,407	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$60,043,605
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	39.0
Construction Office and Operating Expense	$21,600	MONTH	39.0
Subtotal:			$3,258,885
DREDGING			
Shift Rate	$35,950	DAY	532.2
Gravity Dewatering (on the barge)	$10	CY	1,108,046
Subtotal:			$30,212,881
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$9,675,295	LS	1
Water Management	$10,000	DAY	532.2
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,599,182
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$261,054,049.52
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	5
Shift Rate (12 hours)	$12,500	DAY	228.0
Cap material procurement and delivery (sand)	$27	CY	483,603
Material procurement and delivery (carbon amended sand)	$215	CY	161,797
Reactive Mat	$1,173,039	LS	1
Subtotal:			$51,964,471
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	760.1
Subtotal:			$6,024,343
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,186,182
Compliance Testing (Capping)	alt specific	PROJECT	$1,494,559
Compliance Testing (ENR)	alt specific	PROJECT	$2,160,536
Subtotal:			$5,841,276
Mitigation	$2,260,000	Acre	25
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	135.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,900
Subtotal:			$147,250,000
CAPITAL COST (BASE)			$565,649,511
CAPITAL COST (present value)			$565,649,511
Construction Contingency			$197,977,329.00
Sales Tax			$53,736,704
Project Management, Remedial Design and Baseline Monitoring			$169,694,853
Construction Management			$56,564,951
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,043,623,349
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,500,252
Operations and Maintenance (Capping)	alt specific	PROJECT	$8,001,021
Operations and Maintenance (ENR)	alt specific	PROJECT	$11,389,799
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$215,979,531
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$318,556,742
TOTAL COST (Net Present Value)			$1,362,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative D (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	10.6
Land Lease for Operations and Staging	$250,000	YEAR	10.6
Contractor Work Plan Submittals	$100,000	YEAR	10.6
Dock/PileRemoval and Relocation	$6,933,407	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$60,043,605
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	39.0
Construction Office and Operating Expense	$21,600	MONTH	39.0
Subtotal:			$3,258,885
DREDGING			
Shift Rate	$35,950	DAY	532.2
Gravity Dewatering (on the barge)	$10	CY	1,108,046
Subtotal:			$30,212,881
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$9,675,295	LS	1
Water Management	$10,000	DAY	532.2
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,599,182
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$261,054,049.52
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	5
Shift Rate (12 hours)	$12,500	DAY	228.0
Cap material procurement and delivery (sand)	$27	CY	483,603
Material procurement and delivery (carbon amended sand)	$215	CY	161,797
Reactive Mat	$1,173,039	LS	1
Subtotal:			$51,964,471
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	760.1
Subtotal:			$6,024,343
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,186,182
Compliance Testing (Capping)	alt specific	PROJECT	$1,494,559
Compliance Testing (ENR)	alt specific	PROJECT	$2,160,536
Subtotal:			$5,841,276
Mitigation	$2,260,000	Acre	25
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	135.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,900
Subtotal:			$147,250,000
CAPITAL COST (BASE)			$565,649,511
CAPITAL COST (present value)			$508,398,227
Construction Contingency			$177,939,379.34
Sales Tax			$48,297,832
Project Management, Remedial Design and Baseline Monitoring			$152,519,468
Construction Management			$50,839,823
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$937,994,728
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,719,049
Operations and Maintenance (Capping)	alt specific	PROJECT	$5,199,514
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,447,139
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$142,435,277
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$208,888,248
TOTAL COST (Net Present Value)			$1,147,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative D (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	10.6
Land Lease for Operations and Staging	$250,000	YEAR	10.6
Contractor Work Plan Submittals	$100,000	YEAR	10.6
Dock/PileRemoval and Relocation	$6,933,407	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$60,043,605
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	39.0
Construction Office and Operating Expense	$21,600	MONTH	39.0
Subtotal:			$3,258,885
DREDGING			
Shift Rate	$35,950	DAY	532.2
Gravity Dewatering (on the barge)	$10	CY	1,108,046
Subtotal:			$30,212,881
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$9,675,295	LS	1
Water Management	$10,000	DAY	532.2
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,599,182
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$261,054,049.52
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL			
Debris Sweep	$30,000	ACRE	5
Shift Rate (12 hours)	$12,500	DAY	228.0
Cap material procurement and delivery (sand)	$27	CY	483,603
Material procurement and delivery (carbon amended sand)	$215	CY	161,797
Reactive Mat	$1,173,039	LS	1
Subtotal:			$51,964,471
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	760.1
Subtotal:			$6,024,343
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,186,182
Compliance Testing (Capping)	alt specific	PROJECT	$1,494,559
Compliance Testing (ENR)	alt specific	PROJECT	$2,160,536
Subtotal:			$5,841,276
Mitigation	$2,260,000	Acre	25
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	135.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,900
Subtotal:			$147,250,000
CAPITAL COST (BASE)			$565,649,511
CAPITAL COST (present value)			$417,580,294
Construction Contingency			$146,153,102.88
Sales Tax			$39,670,128
Project Management, Remedial Design and Baseline Monitoring			$125,274,088
Construction Management			$41,758,029
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$770,435,642
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$822,970
Operations and Maintenance (Capping)	alt specific	PROJECT	$2,253,980
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,268,598
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$63,342,927
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$98,090,039
TOTAL COST (Net Present Value)			$869,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	16.0
Land Lease for Operations and Staging	$250,000	YEAR	16.0
Contractor Work Plan Submittals	$100,000	YEAR	16.0
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$71,335,051
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	63.3
Construction Office and Operating Expense	$21,600	MONTH	63.3
Subtotal:			$5,294,313
DREDGING			
Shift Rate	$35,950	DAY	926.1
Gravity Dewatering (on the barge)	$10	CY	1,928,136
Subtotal:			$52,574,120
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	926.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,975,613
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$418,630,485
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	714,911
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,778,039
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	1,234.9
Subtotal:			$9,787,015
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$788,829,601
CAPITAL COST (present value)			$788,829,601
Construction Contingency			$276,090,360.20
Sales Tax			$74,938,812
Project Management, Remedial Design and Baseline Monitoring			$236,648,880
Construction Management			$78,882,960
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,455,390,613
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$3,726,974
Operations and Maintenance (Capping)	alt specific	PROJECT	$10,832,075
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,914,815
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$209,037,688
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$312,197,691
TOTAL COST (Net Present Value)			$1,768,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	16.0
Land Lease for Operations and Staging	$250,000	YEAR	16.0
Contractor Work Plan Submittals	$100,000	YEAR	16.0
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$71,335,051
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	63.3
Construction Office and Operating Expense	$21,600	MONTH	63.3
Subtotal:			$5,294,313
DREDGING			
Shift Rate	$35,950	DAY	926.1
Gravity Dewatering (on the barge)	$10	CY	1,928,136
Subtotal:			$52,574,120
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	926.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,975,613
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$418,630,485
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	714,911
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,778,039
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	1,234.9
Subtotal:			$9,787,015
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$788,829,601
CAPITAL COST (present value)			$669,053,810
Construction Contingency			$234,168,833.55
Sales Tax			$63,560,112
Project Management, Remedial Design and Baseline Monitoring			$200,716,143
Construction Management			$66,905,381
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,234,404,280
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,562,483
Operations and Maintenance (Capping)	alt specific	PROJECT	$7,038,695
Operations and Maintenance (ENR)	alt specific	PROJECT	$5,175,226
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$137,857,235
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$204,720,907
TOTAL COST (Net Present Value)			$1,439,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	16.0
Land Lease for Operations and Staging	$250,000	YEAR	16.0
Contractor Work Plan Submittals	$100,000	YEAR	16.0
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$71,335,051
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	63.3
Construction Office and Operating Expense	$21,600	MONTH	63.3
Subtotal:			$5,294,313
DREDGING			
Shift Rate	$35,950	DAY	926.1
Gravity Dewatering (on the barge)	$10	CY	1,928,136
Subtotal:			$52,574,120
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	926.1
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,975,613
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$418,630,485
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	714,911
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,778,039
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	1,234.9
Subtotal:			$9,787,015
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$788,829,601
CAPITAL COST (present value)			$498,822,836
Construction Contingency			$174,587,992.54
Sales Tax			$47,388,169
Project Management, Remedial Design and Baseline Monitoring			$149,646,851
Construction Management			$49,882,284
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$920,328,132
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,226,752
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,050,732
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,271,600
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$61,307,009
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$96,257,656
TOTAL COST (Net Present Value)			$1,017,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	32.0
Land Lease for Operations and Staging	$250,000	YEAR	32.0
Contractor Work Plan Submittals	$100,000	YEAR	32.0
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$83,910,929
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	136.3
Construction Office and Operating Expense	$21,600	MONTH	136.3
Subtotal:			$11,391,299
DREDGING			
Shift Rate	$35,950	DAY	2,143.4
Gravity Dewatering (on the barge)	$10	CY	4,462,574
Subtotal:			$121,680,162
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	2,143.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	7,149,152
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$899,188,434.25
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,236,016
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$88,210,964
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,657.1
Subtotal:			$21,057,843
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,457,032,561
CAPITAL COST (present value)			$1,457,032,561
Construction Contingency			$509,961,396.41
Sales Tax			$138,418,093
Project Management, Remedial Design and Baseline Monitoring			$437,109,768
Construction Management			$145,703,256
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,688,225,075
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$6,690,740
Operations and Maintenance (Capping)	alt specific	PROJECT	$19,830,738
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,834,513
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$186,180,694
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$297,222,826
TOTAL COST (Net Present Value)			$2,985,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	32.0
Land Lease for Operations and Staging	$250,000	YEAR	32.0
Contractor Work Plan Submittals	$100,000	YEAR	32.0
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$83,910,929
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	136.3
Construction Office and Operating Expense	$21,600	MONTH	136.3
Subtotal:			$11,391,299
DREDGING			
Shift Rate	$35,950	DAY	2,143.4
Gravity Dewatering (on the barge)	$10	CY	4,462,574
Subtotal:			$121,680,162
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	2,143.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	7,149,152
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$899,188,434.25
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,236,016
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$88,210,964
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,657.1
Subtotal:			$21,057,843
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,457,032,561
CAPITAL COST (present value)			$1,046,455,228
Construction Contingency			$366,259,329.69
Sales Tax			$99,413,247
Project Management, Remedial Design and Baseline Monitoring			$313,936,568
Construction Management			$104,645,523
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,930,709,895
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$4,600,222
Operations and Maintenance (Capping)	alt specific	PROJECT	$12,884,187
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,507,469
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$122,783,389
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$194,862,535
TOTAL COST (Net Present Value)			$2,126,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	32.0
Land Lease for Operations and Staging	$250,000	YEAR	32.0
Contractor Work Plan Submittals	$100,000	YEAR	32.0
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$83,910,929
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	136.3
Construction Office and Operating Expense	$21,600	MONTH	136.3
Subtotal:			$11,391,299
DREDGING			
Shift Rate	$35,950	DAY	2,143.4
Gravity Dewatering (on the barge)	$10	CY	4,462,574
Subtotal:			$121,680,162
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	2,143.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	7,149,152
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$899,188,434.25
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,236,016
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$88,210,964
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,657.1
Subtotal:			$21,057,843
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,457,032,561
CAPITAL COST (present value)			$615,476,219
Construction Contingency			$215,416,676.50
Sales Tax			$58,470,241
Project Management, Remedial Design and Baseline Monitoring			$184,642,866
Construction Management			$61,547,622
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,135,553,623
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,202,290
Operations and Maintenance (Capping)	alt specific	PROJECT	$5,582,659
Operations and Maintenance (ENR)	alt specific	PROJECT	$1,100,809
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$54,603,462
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$91,890,783
TOTAL COST (Net Present Value)			$1,227,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	14.2
Land Lease for Operations and Staging	$250,000	YEAR	14.2
Contractor Work Plan Submittals	$100,000	YEAR	14.2
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,957,822
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	55.4
Construction Office and Operating Expense	$21,600	MONTH	55.4
Subtotal:			$4,631,136
DREDGING			
Shift Rate	$35,950	DAY	792.4
Gravity Dewatering (on the barge)	$10	CY	1,649,750
Subtotal:			$44,983,421
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	792.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,534,454
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$368,324,748.63
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	648,563
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,211,757
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	1,080.2
Subtotal:			$8,561,072
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$724,977,610
CAPITAL COST (present value)			$724,977,610
Construction Contingency			$253,742,163.49
Sales Tax			$68,872,873
Project Management, Remedial Design and Baseline Monitoring			$217,493,282.99
Construction Management			$72,497,761
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,337,583,690
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$3,035,362
Operations and Maintenance (Capping)	alt specific	PROJECT	$10,897,436
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,914,815
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$213,292,620
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$315,826,372
TOTAL COST (Net Present Value)			$1,653,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	14.2
Land Lease for Operations and Staging	$250,000	YEAR	14.2
Contractor Work Plan Submittals	$100,000	YEAR	14.2
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,957,822
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	55.4
Construction Office and Operating Expense	$21,600	MONTH	55.4
Subtotal:			$4,631,136
DREDGING			
Shift Rate	$35,950	DAY	792.4
Gravity Dewatering (on the barge)	$10	CY	1,649,750
Subtotal:			$44,983,421
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	792.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,534,454
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$368,324,748.63
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	648,563
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,211,757
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	1,080.2
Subtotal:			$8,561,072
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$724,977,610
CAPITAL COST (present value)			$626,537,625
Construction Contingency			$219,288,168.64
Sales Tax			$59,521,074
Project Management, Remedial Design and Baseline Monitoring			$187,961,287.41
Construction Management			$62,653,762
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,155,961,918
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,086,965
Operations and Maintenance (Capping)	alt specific	PROJECT	$7,081,156
Operations and Maintenance (ENR)	alt specific	PROJECT	$5,175,226
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$140,663,299
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$207,093,913
TOTAL COST (Net Present Value)			$1,363,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 7.0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	14.2
Land Lease for Operations and Staging	$250,000	YEAR	14.2
Contractor Work Plan Submittals	$100,000	YEAR	14.2
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,957,822
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	55.4
Construction Office and Operating Expense	$21,600	MONTH	55.4
Subtotal:			$4,631,136
DREDGING			
Shift Rate	$35,950	DAY	792.4
Gravity Dewatering (on the barge)	$10	CY	1,649,750
Subtotal:			$44,983,421
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	792.4
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	2,534,454
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$368,324,748.63
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	648,563
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,211,757
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	1,080.2
Subtotal:			$8,561,072
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$724,977,610
CAPITAL COST (present value)			$481,603,140
Construction Contingency			$168,561,099.09
Sales Tax			$45,752,298
Project Management, Remedial Design and Baseline Monitoring			$144,480,942.07
Construction Management			$48,160,314
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$888,557,794
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$999,104
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,069,125
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,271,600
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$62,554,904
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$97,296,296
TOTAL COST (Net Present Value)			$986,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

AECOM
Portland Harbor Sustainability Project,
Environmental Sustainability Analysis
Report Appendix E

AECOM Cost Estimate including Confined Disposal Facility – Adjusted to Match 2016 EPA Feasibility Study Assumptions

Cost Summary for Portland Harbor Alternative E (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	12.5
Land Lease for Operations and Staging	$250,000	YEAR	12.5
Contractor Work Plan Submittals	$100,000	YEAR	12.5
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,693,591
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	47.5
Construction Office and Operating Expense	$21,600	MONTH	47.5
Subtotal:			$3,970,287
DREDGING			
Shift Rate	$35,950	DAY	926.1
Gravity Dewatering (on the barge)	$10	CY	1,928,136
Subtotal:			$52,574,120
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	926.1
Construct CDF	$52,439,400	LS	1
Fill CDF	$9.70	CY	670,000
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,885,188
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$356,531,710
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	714,911
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,778,039
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	926.1
Subtotal:			$7,339,433
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$721,317,756
CAPITAL COST (present value)			$721,317,756
Construction Contingency			$252,461,214.71
Sales Tax			$68,525,187
Project Management, Remedial Design and Baseline Monitoring			$216,395,327
Construction Management			$72,131,776
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,330,831,260
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$3,726,974
Operations and Maintenance (Capping)	alt specific	PROJECT	$10,832,075
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,914,815
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$209,037,688
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$312,197,691
TOTAL COST (Net Present Value)			$1,643,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	12.5
Land Lease for Operations and Staging	$250,000	YEAR	12.5
Contractor Work Plan Submittals	$100,000	YEAR	12.5
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,693,591
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	47.5
Construction Office and Operating Expense	$21,600	MONTH	47.5
Subtotal:			$3,970,287
DREDGING			
Shift Rate	$35,950	DAY	926.1
Gravity Dewatering (on the barge)	$10	CY	1,928,136
Subtotal:			$52,574,120
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	926.1
Construct CDF	$52,439,400	LS	1
Fill CDF	$9.70	CY	670,000
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,885,188
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$356,531,710
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	714,911
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,778,039
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	926.1
Subtotal:			$7,339,433
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$721,317,756
CAPITAL COST (present value)			$635,216,784
Construction Contingency			$222,325,874.34
Sales Tax			$60,345,594
Project Management, Remedial Design and Baseline Monitoring			$190,565,035
Construction Management			$63,521,678
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,171,974,966
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,562,483
Operations and Maintenance (Capping)	alt specific	PROJECT	$7,038,695
Operations and Maintenance (ENR)	alt specific	PROJECT	$5,175,226
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$137,857,235
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$204,720,907
TOTAL COST (Net Present Value)			$1,377,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative E (with 7% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	12.5
Land Lease for Operations and Staging	$250,000	YEAR	12.5
Contractor Work Plan Submittals	$100,000	YEAR	12.5
Dock/PileRemoval and Relocation	$15,701,434	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$69,693,591
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	47.5
Construction Office and Operating Expense	$21,600	MONTH	47.5
Subtotal:			$3,970,287
DREDGING			
Shift Rate	$35,950	DAY	926.1
Gravity Dewatering (on the barge)	$10	CY	1,928,136
Subtotal:			$52,574,120
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	926.1
Construct CDF	$52,439,400	LS	1
Fill CDF	$9.70	CY	670,000
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,885,188
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$356,531,710
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	7
Shift Rate (12 hours)	$12,500	DAY	308.8
Cap material procurement and delivery (sand)	$27	CY	714,911
Material procurement and delivery (carbon amended sand)	$215	CY	159,489
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,778,039
ENHANCED NATURAL RECOVERY -Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	926.1
Subtotal:			$7,339,433
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$3,317,855
Compliance Testing (Capping)	alt specific	PROJECT	$2,009,008
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,840,576
Mitigation	$2,260,000	Acre	35
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	125.4
Department of State Lands Fee (MNR)	$30,000	Acre	1,838
Subtotal:			$165,590,000
CAPITAL COST (BASE)			$721,317,756
CAPITAL COST (present value)			$503,847,983
Construction Contingency			$176,346,794.09
Sales Tax			$47,865,558
Project Management, Remedial Design and Baseline Monitoring			$151,154,395
Construction Management			$50,384,798
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$929,599,529
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$1,226,752
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,050,732
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,271,600
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$61,307,009
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$96,257,656
TOTAL COST (Net Present Value)			$1,026,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	26.2
Land Lease for Operations and Staging	$250,000	YEAR	26.2
Contractor Work Plan Submittals	$100,000	YEAR	26.2
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$81,180,668
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	109.9
Construction Office and Operating Expense	$21,600	MONTH	109.9
Subtotal:			$9,189,030
DREDGING			
Shift Rate	$35,950	DAY	2,143.4
Gravity Dewatering (on the barge)	$10	CY	4,462,574
Subtotal:			$121,680,162
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	2,143.4
Construct CDF	$52,439,400	LS	1
Fill CDF	$9.70	CY	670,000
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	6,058,727
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$837,089,659.25
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,236,016
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$88,210,964
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,143.4
Subtotal:			$16,986,749
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,385,930,163
CAPITAL COST (present value)			$1,385,930,163
Construction Contingency			$485,075,557.12
Sales Tax			$131,663,366
Project Management, Remedial Design and Baseline Monitoring			$415,779,049
Construction Management			$138,593,016
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$2,557,041,151
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$6,690,740
Operations and Maintenance (Capping)	alt specific	PROJECT	$19,830,738
Operations and Maintenance (ENR)	alt specific	PROJECT	$3,834,513
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$186,180,694
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$297,222,826
TOTAL COST (Net Present Value)			$2,854,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	26.2
Land Lease for Operations and Staging	$250,000	YEAR	26.2
Contractor Work Plan Submittals	$100,000	YEAR	26.2
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$81,180,668
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	109.9
Construction Office and Operating Expense	$21,600	MONTH	109.9
Subtotal:			$9,189,030
DREDGING			
Shift Rate	$35,950	DAY	2,143.4
Gravity Dewatering (on the barge)	$10	CY	4,462,574
Subtotal:			$121,680,162
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	2,143.4
Construct CDF	$52,439,400	LS	1
Fill CDF	$9.70	CY	670,000
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	6,058,727
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$837,089,659.25
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,236,016
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$88,210,964
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,143.4
Subtotal:			$16,986,749
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,385,930,163
CAPITAL COST (present value)			$1,055,678,953
Construction Contingency			$369,487,633.72
Sales Tax			$100,289,501
Project Management, Remedial Design and Baseline Monitoring			$316,703,686
Construction Management			$105,567,895
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,947,727,669
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$4,600,222
Operations and Maintenance (Capping)	alt specific	PROJECT	$12,884,187
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,507,469
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$122,783,389
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$194,862,535
TOTAL COST (Net Present Value)			$2,143,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative F (with 7% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	26.2
Land Lease for Operations and Staging	$250,000	YEAR	26.2
Contractor Work Plan Submittals	$100,000	YEAR	26.2
Dock/PileRemoval and Relocation	$20,718,583	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$81,180,668
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	109.9
Construction Office and Operating Expense	$21,600	MONTH	109.9
Subtotal:			$9,189,030
DREDGING			
Shift Rate	$35,950	DAY	2,143.4
Gravity Dewatering (on the barge)	$10	CY	4,462,574
Subtotal:			$121,680,162
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$15,651,213	LS	1
Water Management	$10,000	DAY	2,143.4
Construct CDF	$52,439,400	LS	1
Fill CDF	$9.70	CY	670,000
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	6,058,727
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$837,089,659.25
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	12
Shift Rate (12 hours)	$12,500	DAY	513.7
Cap material procurement and delivery (sand)	$27	CY	1,236,016
Material procurement and delivery (carbon amended sand)	$215	CY	218,384
Reactive Mat	$1,173,039	LS	1
Subtotal:			$88,210,964
ENHANCED NATURAL RECOVERY -Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	2,143.4
Subtotal:			$16,986,749
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$6,091,650
Compliance Testing (Capping)	alt specific	PROJECT	$3,633,421
Compliance Testing (ENR)	alt specific	PROJECT	$747,861
Subtotal:			$10,472,931
Mitigation	$2,260,000	Acre	60
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	146.0
Department of State Lands Fee (MNR)	$30,000	Acre	1,634
Subtotal:			$221,120,000
CAPITAL COST (BASE)			$1,385,930,163
CAPITAL COST (present value)			$670,594,142
Construction Contingency			$234,707,949.56
Sales Tax			$63,706,443
Project Management, Remedial Design and Baseline Monitoring			$201,178,242
Construction Management			$67,059,414
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,237,246,191
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,202,290
Operations and Maintenance (Capping)	alt specific	PROJECT	$5,582,659
Operations and Maintenance (ENR)	alt specific	PROJECT	$1,100,809
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$54,603,462
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$91,890,783
TOTAL COST (Net Present Value)			$1,329,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and ENR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; ENR = enhanced natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 0% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	11.0
Land Lease for Operations and Staging	$250,000	YEAR	11.0
Contractor Work Plan Submittals	$100,000	YEAR	11.0
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$68,427,871
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	40.6
Construction Office and Operating Expense	$21,600	MONTH	40.6
Subtotal:			$3,397,053
DREDGING			
Shift Rate	$35,950	DAY	792.4
Gravity Dewatering (on the barge)	$10	CY	1,649,750
Subtotal:			$44,983,421
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	792.4
Construct CDF	$52,439,400	LS	1
Fill CDF	$9.70	CY	670,000
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,444,029
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$306,225,973.63
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	648,563
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,211,757
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	792.4
Subtotal:			$6,279,759
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$657,833,488
CAPITAL COST (present value)			$657,833,488
Construction Contingency			$230,241,720.78
Sales Tax			$62,494,181
Project Management, Remedial Design and Baseline Monitoring			$197,350,046.38
Construction Management			$65,783,349
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,213,702,785
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$14,900,000
Reporting	alt specific	PROJECT	$2,500,000
Operations and Maintenance (Dredging)	alt specific	PROJECT	$3,035,362
Operations and Maintenance (Capping)	alt specific	PROJECT	$10,897,436
Operations and Maintenance (ENR)	alt specific	PROJECT	$7,914,815
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$213,292,620
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$13,266,140
Institutional Controls	alt specific	PROJECT	$50,020,000
Subtotal:			$315,826,372
TOTAL COST (Net Present Value)			$1,530,000,000

Notes:

1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.

CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 2.3% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	11.0
Land Lease for Operations and Staging	$250,000	YEAR	11.0
Contractor Work Plan Submittals	$100,000	YEAR	11.0
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$68,427,871
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	40.6
Construction Office and Operating Expense	$21,600	MONTH	40.6
Subtotal:			$3,397,053
DREDGING			
Shift Rate	$35,950	DAY	792.4
Gravity Dewatering (on the barge)	$10	CY	1,649,750
Subtotal:			$44,983,421
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	792.4
Construct CDF	$52,439,400	LS	1
Fill CDF	$9.70	CY	670,000
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,444,029
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$306,225,973.63
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	648,563
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,211,757
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	792.4
Subtotal:			$6,279,759
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$657,833,488
CAPITAL COST (present value)			$588,906,597
Construction Contingency			$206,117,309.10
Sales Tax			$55,946,127
Project Management, Remedial Design and Baseline Monitoring			$176,671,979.23
Construction Management			$58,890,660
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$1,086,532,672
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$11,487,787
Reporting	alt specific	PROJECT	$1,766,048
Operations and Maintenance (Dredging)	alt specific	PROJECT	$2,086,965
Operations and Maintenance (Capping)	alt specific	PROJECT	$7,081,156
Operations and Maintenance (ENR)	alt specific	PROJECT	$5,175,226
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$140,663,299
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$9,182,411
Institutional Controls	alt specific	PROJECT	$29,651,022
Subtotal:			$207,093,913
TOTAL COST (Net Present Value)			$1,294,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

Cost Summary for Portland Harbor Alternative I (with 7% Discount Rate)

TASK	UNIT COST	UNIT	QUANTITY / SUBTOTAL
PRECONSTRUCTION			
Mobilization, Demobilization and Site Restoration (project)	$48,050,000	LS	1
Mobilization, Demobilization and Site Restoration (seasonal)	$120,000	YEAR	11.0
Land Lease for Operations and Staging	$250,000	YEAR	11.0
Contractor Work Plan Submittals	$100,000	YEAR	11.0
Dock/PileRemoval and Relocation	$15,146,379	LS	1.0
Barge Protection	$80,000	LS	1
Subtotal:			$68,427,871
PROJECT MANAGEMENT (CONTRACTOR)			
Labor and Supervision	$62,000	MONTH	40.6
Construction Office and Operating Expense	$21,600	MONTH	40.6
Subtotal:			$3,397,053
DREDGING			
Shift Rate	$35,950	DAY	792.4
Gravity Dewatering (on the barge)	$10	CY	1,649,750
Subtotal:			$44,983,421
SEDIMENT HANDLING AND DISPOSAL			
Transloading Area Setup	$10,528,998	LS	1
Water Management	$10,000	DAY	792.4
Construct CDF	$52,439,400	LS	1
Fill CDF	$9.70	CY	670,000
Transload, Railcar Transport to and Tipping at Subtitle D Landfill	$111	TON	1,444,029
Transload, Railcar Transport to, Thermal Treatment and Tipping at Subtitle C Landfill	$191	TON	358,888
Subtotal:			$306,225,973.63
SEDIMENT CAPPING, DREDGE RESIDUALS, DREDGE BACKFILL, AND EMNR			
Debris Sweep	$30,000	ACRE	6
Shift Rate (12 hours)	$12,500	DAY	287.9
Cap material procurement and delivery (sand)	$27	CY	648,563
Material procurement and delivery (carbon amended sand)	$215	CY	166,437
Reactive Mat	$1,173,039	LS	1
Subtotal:			$58,211,757
ENHANCED NATURAL RECOVERY - Included in Capping			
Debris Sweep	$30,000	ACRE	0
Shift Rate (12 hours)	$12,500	DAY	0
Material procurement and delivery (sand)	$27	CY	0
Material procurement and delivery (carbon amended sand)	$215	CY	0
Subtotal:			$0
CONSTRUCTION QA/QC			
Construction Monitoring	$7,925	DAY	792.4
Subtotal:			$6,279,759
POST-CONSTRUCTION PERFORMANCE MONITORING			
Compliance Testing (Dredging)	alt specific	PROJECT	$2,678,081
Compliance Testing (Capping)	alt specific	PROJECT	$2,020,859
Compliance Testing (ENR)	alt specific	PROJECT	$1,513,713
Subtotal:			$6,212,653
Mitigation	$2,260,000	Acre	34
Department of State Lands Fee (Capping, EMNR, and In-situ Remediation)	$250,000	Acre	123.9
Department of State Lands Fee (MNR)	$30,000	Acre	1,876
Subtotal:			$164,095,000
CAPITAL COST (BASE)			$657,833,488
CAPITAL COST (present value)			$480,395,729
Construction Contingency			$168,138,505.13
Sales Tax			$45,637,594
Project Management, Remedial Design and Baseline Monitoring			$144,118,718.68
Construction Management			$48,039,573
TOTAL CAPITAL COST (INCLUDING SUM OF ABOVE)			$886,330,120
AGENCY OVERSIGHT, REPORTING, O&M, & MONITORING COSTS (present value)			
Agency Review and Oversight	alt specific	PROJECT	$7,679,776
Reporting	alt specific	PROJECT	$1,033,295
Operations and Maintenance (Dredging)	alt specific	PROJECT	$999,104
Operations and Maintenance (Capping)	alt specific	PROJECT	$3,069,125
Operations and Maintenance (ENR)	alt specific	PROJECT	$2,271,600
Operations and Maintenance (MNR >SQS)	alt specific	PROJECT	$62,554,904
Operations and Maintenance (MNR <SQS)	alt specific	PROJECT	$0
Long-term Monitoring	alt specific	PROJECT	$5,665,887
Institutional Controls	alt specific	PROJECT	$14,022,605
Subtotal:			$97,296,296
TOTAL COST (Net Present Value)			$984,000,000

Notes:
1. All cost values are estimates, and should not be interpreted as final construction or project costs.
2. Operating season based on 138-day fish window requirements and net 88 days of in-water work per season.
3. Operations & Maintenance and Monitoring Costs includes repair for capping and EMNR.
4. Present value calculation applied to both capital costs and O&M and monitoring costs starting at the beginning of construction.
CY = cubic yard; EMNR = enhanced monitored natural recovery; LS = lump sum; MNR = monitored natural recovery; O&M = operation and maintenance; QA/QC = quality assurance/quality control; SQS = sediment quality standard

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ECONOMIC CONSULTING

Portland Harbor Sustainability Project

Economic Impacts of EPA Portland Harbor Superfund Remedial Alternatives

September 2016

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Executive Summary

The Portland Harbor Sustainability Project ("PHSP") developed a sustainability framework to evaluate remedial alternatives proposed for the Portland Harbor Superfund Site ("Site"). This study comprises three reports that evaluate the sustainability of alternatives B, D, I, E, F, and A (a baseline or "No Further Action" alternative) as presented in the 2016 U.S. Environmental Protection Agency ("EPA") Portland Harbor RI/FS Feasibility Study ("FS") (EPA 2016a). These reports present evaluation of the following components:

A. Environmental Sustainability Analysis Report;

B. Economic Impact Analysis Report; and

C. Social Analysis Report.

This report is the second component of the PHSP and evaluates the impacts to the Portland regional economy of various remedial alternatives for the Site.[1] EPA has provided detailed information on seven alternatives,[2] including information on expenditures, but EPA has not included information on the impacts to the Portland regional economy of these alternatives. Our analysis indicates that (a) the EPA remedial alternatives would lead to both positive and negative impacts to the Portland regional economy, (b) the *net* impacts (i.e., including positive and negative influences) are negative (in other words, *all* EPA alternatives lead to net losses to the Portland regional economy), and (c) the size of the negative net impacts varies considerably among the alternatives, with substantially greater negative impacts on the Portland economy from the more expensive alternatives.

A. Overview of the Portland Harbor Superfund Site and EPA Remedial Alternatives

1. Portland Harbor Superfund Site

The Portland Harbor Superfund Site encompasses about 10 miles of the Willamette River in Portland, Oregon, from the Broadway Bridge at river mile ("RM") 11.8 to Sauvie Island at RM 1.9 (near the confluence of the Willamette and Columbia rivers). The Site includes contamination that has occurred from many sources over more than 100 years. Sources of contaminants include agricultural and urban development, U.S. wartime activities, industrial activities, combined sewer overflows, and storm water discharges.

[1] This study is an economic impact assessment. An economic impact assessment is distinct from both a cost-effectiveness analysis, which compares costs of alternatives to a measure of their environmental effectiveness, and a benefit-cost analysis, which includes monetary assessments of benefits and costs and permits evaluations of impacts on social well-being (see EPA 2011, p. 3).

[2] EPA initially developed and screened nine remedial alternatives, A through H; alternative C was determined after screening to be not distinctly different from alternative B and was therefore eliminated from consideration in EPA's detailed analyses. Alternative H was also omitted from detailed analyses based on implementability and cost.

EPA listed Portland Harbor as a Superfund site in December 2000. EPA's Proposed Plan for the Site, released at the same time as the FS in June 2016, identifies alternative I from the FS as the preferred remedial alternative (EPA 2016b).

2. EPA Portland Harbor Remedial Alternatives and Objectives of This Study

Table ES-1 summarizes EPA's estimates of the costs (measured by undiscounted expenditures) and duration of remediation activities, including dredging, capping, and other activities, under the five remedial alternatives we evaluate.[3]

Table ES-1. EPA Alternative Expenditure Estimates (Million 2016$)

	EPA Alternative				
	B	**D**	**I**	**E**	**F**
Years of Construction	4	6	7	7	13
Total Expenditures (Million 2016$)	$642	$953	$1,173	$1,240	$2,179

Note: Undiscounted expenditure estimates over a 31-year period (2020-2050).
Source: EPA (2016a)

EPA's estimates of costs (undiscounted) for the five alternatives range from about $642 million to almost $2.2 billion, with construction periods ranging from 4 to 13 years.[4] The total expenditures are based on a 31-year period that includes expenditures for activities such as long-term monitoring and periodic Site reviews. Note that these expenditures do not include past expenditures on interim cleanup activities[5] or past or future legal and other administrative fees.

Implementation of any of EPA's remedial alternatives would lead to both positive and negative impacts on the Portland regional economy. Remedial expenditures themselves within the region lead to positive impacts, since they increase the demand for local goods and services. In contrast, financing of the expenditures by local businesses and governments leads to negative impacts, both because expenditures on other goods and services would need to be reduced and because higher costs would make local businesses less competitive relative to companies in other regions of the United States (and, indeed, internationally). It is critical to include both positive and negative effects in order to provide a comprehensive and robust economic impact assessment.[6] Indeed, as discussed in the main report, two prior economic impact studies came to opposite conclusions using similar basic expenditure information—one finding positive impacts and the other finding negative impacts—because they each focused on only one of the two offsetting

[3] We do not evaluate the most expensive of the seven alternatives considered for detailed analysis by EPA, alternative G. Nor do we evaluate alternative A, EPA's "No Further Action" alternative, which should be thought of as a baseline scenario against which economic impacts are calculated throughout this report.

[4] Results using alternative estimates developed by AECOM of costs and construction durations for these five alternatives are provided in Appendix G.

[5] Some remedial activity has taken place within the Site. In particular, early actions were taken in 2005 at the Gasco site and in 2008 at the Terminal 4 site.

[6] EPA (2011) notes the importance of including information on the financing of project expenditures (see, e.g., p. 93). Note that our assessments do not include the potential effects of insurance payments, which are speculative and may also lead to premium increases that offset the insurance payments.

impacts. The model developed for this study accounts for both positive and negative economic impacts that lead to multiplier effects as changes in direct expenditures and financing spread through Portland and the surrounding region.

B. Portland Regional Economic Impacts of EPA Remedial Alternatives

This study uses a state-of-the-art economic impact model—the Policy Insight Plus Model from Regional Economic Models, Inc. ("REMI PI+")—to develop estimates of the impacts of the EPA alternatives on the seven-county Portland Metropolitan Statistical Area ("MSA") over the 31-year period from 2020, when we presume remediation would begin, to 2050. The REMI PI+ model takes as inputs expenditure and financing information and produces estimates of overall regional impacts based upon detailed modeling of multiplier and other market impacts (see Appendix A).

Because the expenditure and financing inputs occur in subareas within the MSA, we develop a four-region REMI PI+ model that distinguishes expenditures and financing in the City of Portland, the remainder of the Oregon MSA counties, the two Washington MSA counties, and the remainder of Oregon State. To supplement the REMI PI+ modeling, we developed a questionnaire to obtain information from riverfront businesses on how remediation might affect them, both through potential negative impacts due to disruption and through the potential positive impacts due to possible removal of "stigma" from the Superfund designation. Appendix H provides the qualitative results from this questionnaire.

1. Overall Economic Impacts to the Portland MSA

The EPA alternatives on balance are predicted to lead to *negative* impacts on the Portland regional economy, as the negative financing impacts are greater than the positive expenditure effects. (The report provides full information on both the positive and negative impacts.) Table ES-2 summarizes the estimated ranges for average annual losses to the Portland regional economy due to the EPA remedial alternatives as well as cumulative losses over the 31-year period from 2020-2050. The impacts are measured in terms of: (1) jobs; (2) Portland gross regional product ("GRP"), a regional measure equivalent to gross national product ("GNP," which is calculated for the United States as a whole); (3) personal income; and (4) population. The results assume that local governments, local businesses, and national/international entities share equally—i.e., one-third each—in the financing of remediation expenses. The ranges in Table ES-2 for a given EPA alternative reflect uncertainties in how the local government and local business costs might be financed, as discussed in the main report.

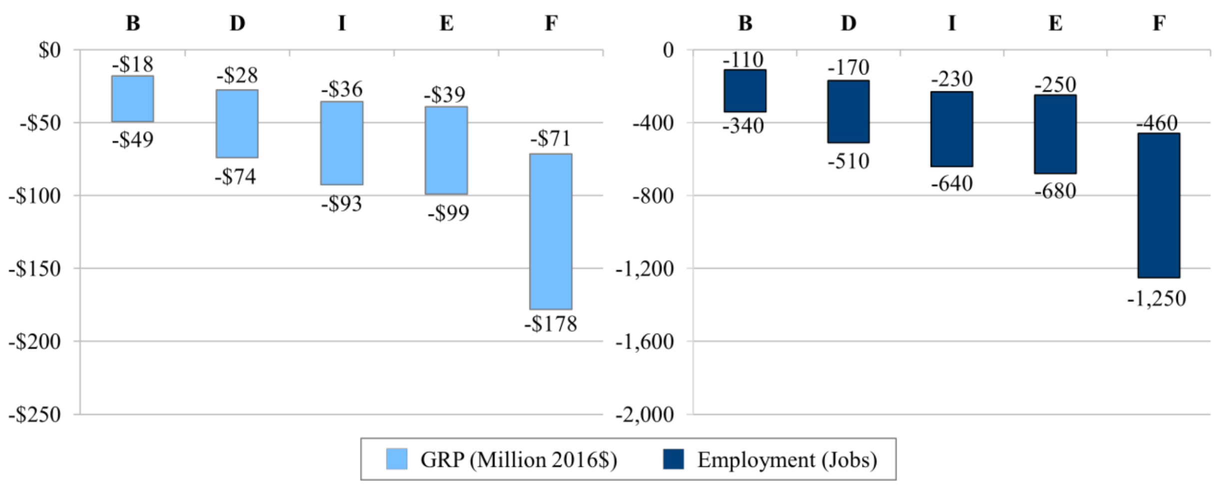
Table ES-2. Economic Impacts of Combined Expenditures and Financing of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Gross Regional Product (Million 2016$)										
Average Annual	-$18	-$49	-$28	-$74	-$36	-$93	-$39	-$99	-$71	-$178
Cumulative (3% DR)	-$381	-$815	-$575	-$1,233	-$747	-$1,544	-$821	-$1,648	-$1,432	-$3,030
Personal Income (Million 2016$)										
Average Annual	-$13	-$39	-$20	-$59	-$26	-$73	-$29	-$78	-$53	-$142
Cumulative (3% DR)	-$261	-$632	-$401	-$962	-$528	-$1,206	-$585	-$1,289	-$1,027	-$2,388
Total Employment (Jobs/Job-Years)										
Average Annual	-110	-340	-170	-510	-230	-640	-250	-680	-460	-1,250
Cumulative	-3,430	-10,430	-5,290	-15,780	-7,020	-19,810	-7,800	-21,180	-14,150	-38,860
Population (Persons/Person-Years)										
Average Annual	-290	-470	-440	-710	-570	-890	-620	-950	-1,100	-1,750
Cumulative	-9,010	-14,540	-13,770	-22,150	-17,690	-27,690	-19,270	-29,530	-34,160	-54,220

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate. Minimum and maximum values correspond to alternative assumed financing mechanisms for local governments and local businesses, as discussed in the main report and appendices.
Source: NERA calculations as explained in text.

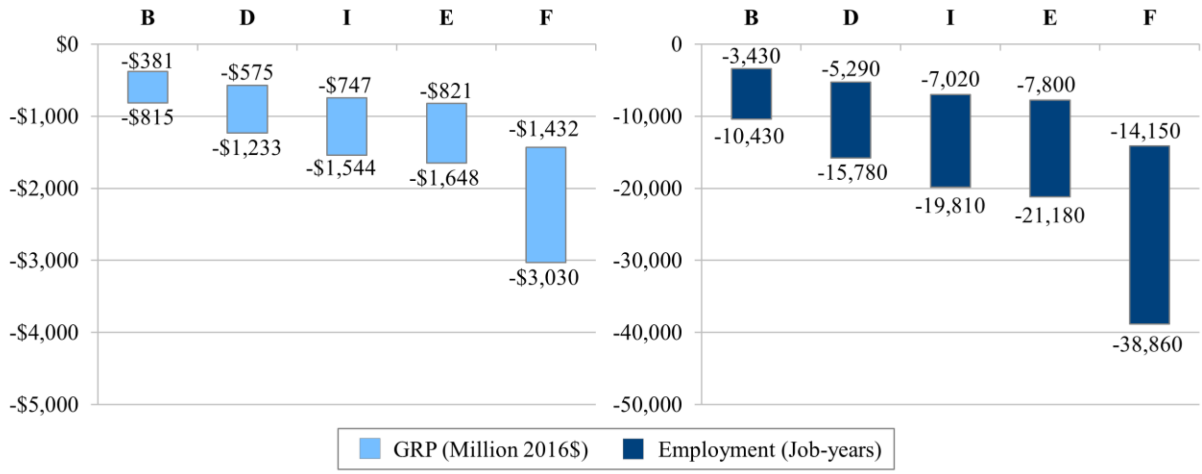
Figure ES-1 summarizes the ranges of average annual job and GRP impacts for the five EPA alternatives we evaluated, while Figure ES-2 shows ranges in terms of cumulative impacts over the 31-year period. Based on the maximum values from different financing assumptions, the average annual job loss ranges from about 340 under alternative B to 1,250 for alternative F. With regard to the equivalent GRP values, the range is from $49 million under alternative B to $178 million for alternative F.

Figure ES-1. Average Annual Economic Impacts of Combined Expenditures and Financing of EPA Alternatives on Portland MSA



Note: Minimum and maximum values correspond to alternative assumed financing mechanisms for local governments and local businesses, as discussed in the main report and appendices.
Source: NERA calculations as explained in text.

Figure ES-2. Cumulative Economic Impacts of Combined Expenditures and Financing of EPA Alternatives on Portland MSA



Note: Minimum and maximum values correspond to alternative assumed financing mechanisms for local governments and local businesses, as discussed in the main report and appendices.
Source: NERA calculations as explained in text.

The wide range for each alternative indicates that the potential losses could differ substantially based upon different assumptions on how the expenditures would be financed. For example, the estimated range of job losses over the 31-year period for alternative I ranges from 230 to 640 on an annual basis and from 7,020 to 19,810 on a cumulative basis (measured in job-years)

2. Detailed Sectoral and Wage-Level Impacts to the Portland MSA

Virtually all sectors of the Portland regional economy are negatively affected by the EPA alternatives as a result of the multiplier effects of expenditures and financing. Table ES-3 summarizes employment impacts on individual sectors.

Table ES-3. Employment Impacts by Sector of Combined Expenditures and Financing of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Forestry, Fishing, and Related Activities	0	-10	-10	-10	-10	-10	-10	-10	-10	-20
Mining	0	0	0	0	0	0	0	0	0	0
Utilities	0	0	0	0	0	0	0	0	0	0
Construction	0	-20	0	-30	0	-40	0	-40	10	-80
Manufacturing	-10	-20	-20	-30	-20	-30	-30	-40	-50	-70
Wholesale Trade	-10	-10	-10	-10	-10	-10	-10	-20	-20	-30
Retail Trade	-20	-30	-30	-50	-40	-60	-40	-70	-70	-120
Transportation and Warehousing	-20	-30	-20	-40	-30	-50	-30	-50	-50	-80
Information	0	0	0	0	0	0	0	-10	-10	-10
Finance and Insurance	-10	-10	-10	-10	-10	-10	-10	-20	-20	-30
Real Estate and Rental and Leasing	-10	-10	-10	-20	-10	-20	-10	-20	-20	-40
Professional, Scientific, and Technical Services	30	20	40	20	40	10	40	10	40	-10
Management of Companies and Enterprises	0	0	0	0	0	0	0	0	-10	-10
Administrative and Waste Management Services	0	-10	0	-20	0	-20	0	-20	0	-40
Educational Services	0	0	-10	-10	-10	-10	-10	-10	-10	-20
Health Care and Social Assistance	-20	-30	-30	-50	-40	-60	-40	-70	-80	-120
Arts, Entertainment, and Recreation	0	0	-10	-10	-10	-10	-10	-10	-10	-20
Accommodation and Food Services	-10	-20	-20	-30	-20	-30	-20	-40	-40	-70
Other Services, except Public Administration	-10	-20	-20	-30	-20	-30	-20	-40	-40	-60
Total Government Employment	-10	-130	-20	-190	-30	-230	-30	-240	-60	-430
Farm Employment	0	0	0	0	0	0	0	0	0	0
Total	-110	-340	-170	-510	-230	-640	-250	-680	-460	-1,250

Note: Rows may not sum to totals due to rounding.
Source: NERA calculations as explained in text.

Impacts on sectors will in turn lead to different job losses for different income groups. Job losses due to the EPA alternatives are predicted to lead to disproportionate losses for relatively high-wage jobs in the Portland region. Table ES-4 shows estimates of the range of average annual job losses divided into low-wage, medium-wage, and high-wage sectors. (These results are based upon the employment results by sector and average sector wages.) Table ES-5 shows that the loss in high-wage jobs makes up from 34 to 49 percent of the total average annual job losses due to the EPA alternatives.

Table ES-4. Employment Impacts by Wage Group of Combined Expenditures and Financing of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Low-wage	-20	-30	-30	-50	-40	-60	-50	-70	-80	-130
Medium-wage	-40	-140	-70	-210	-100	-270	-120	-290	-220	-550
High-wage	-40	-160	-70	-240	-80	-300	-90	-320	-160	-570
Total	-110	-340	-170	-510	-230	-640	-250	-680	-460	-1,250

Note: Low-wage jobs correspond to jobs in sectors with average annual incomes less than or equal to $30,000; medium-wage jobs correspond to jobs in sectors with average annual incomes greater than $30,000 and less than or equal to $80,000; high-wage jobs correspond to jobs in sectors with average annual incomes greater than $80,000. Rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

Table ES-5. Employment Impacts by Wage Group of Combined Expenditures and Financing of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (% Total)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Low-wage	19%	10%	19%	10%	18%	10%	18%	10%	17%	10%
Medium-wage	40%	41%	42%	42%	45%	42%	46%	43%	48%	44%
High-wage	40%	49%	39%	48%	37%	47%	36%	47%	34%	46%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Note: Low-wage jobs correspond to jobs in sectors with average annual incomes less than or equal to $30,000; medium-wage jobs correspond to jobs in sectors with average annual incomes greater than $30,000 and less than or equal to $80,000; high-wage jobs correspond to jobs in sectors with average annual incomes greater than $80,000. Rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

C. Conclusions

The following are our principal conclusions regarding the impacts of EPA's remedial alternatives for the Portland Harbor Superfund Site on the Portland regional economy:

1. *All EPA alternatives lead to net losses to the Portland regional economy*. Our estimates indicate that the negative impacts of financing outweigh the positive impacts of regional expenditures for all of the five EPA alternatives. These negative impacts are reflected in net losses in jobs, GRP, personal income, and population.

2. *Losses to the Portland regional economy are substantially greater for the more expensive EPA alternatives*. The estimated (maximum) average annual job loss is 1,250 jobs for alternative F, compared to 340 jobs for alternative B; for GRP, the corresponding range is from $178 million per year for alternative F compared to $49 million per year for alternative B.

3. *The size of the negative impacts is uncertain*. Uncertainties in how costs would be financed lead to ranges of estimated impacts. For example, the average estimated annual loss for alternative I ranges from 230 jobs to 640 jobs per year.

4. *Almost all sectors of the Portland regional economy are negatively affected*. Multiplier effects lead to negative impacts on virtually all sectors of the Portland regional economy, particularly under the more expensive remedial alternatives.

5. *Losses are concentrated in relatively high-wage sectors.* Roughly 40 percent of the estimated job losses due to the EPA alternatives are projected to be in relatively high-wage sectors.

I. Introduction

A. Background on Portland Harbor Superfund Site

The Portland Harbor Superfund site ("Site") is designated as the portion of the Willamette River from the Broadway Bridge at river mile ("RM") 11.8 to Sauvie Island at RM 1.9, with RM 0 defined as the point where the Willamette River flows into the Columbia River. The Site is located immediately northwest and downstream from the downtown area of Portland, Oregon, in an urban, industrial portion of the River.

Both historical and ongoing sources account for the current level of contamination at the Site. Since the late 1800s, the Site area has accommodated commercial and industrial activities, including shipping, ship building and dismantling, lumber milling, fuel storage and chemical production. Through the early 1900s, the waste from these activities was frequently discharged directly into the river. Pollutants from these sources also entered the river through groundwater and soil contamination. Other ongoing sources of contamination include sewer overflows and storm water runoff from land used for industrial, urban residential, agricultural and commercial purposes.

In December 2000, Portland Harbor was officially designated a Superfund site by the U.S. Environmental Protection Agency ("EPA"). An initial remedial investigation ("RI") conducted by the Lower Willamette Group ("LWG")[7] and submitted to EPA found that sediments from the Site contained a number of contaminants, including polychlorinated biphenyls ("PCBs"), DDT, polycyclic aromatic hydrocarbons ("PAHs"), and dioxins and furans.

EPA released a final Feasibility Study ("FS") in June 2016 that presented detailed information on seven remedial alternatives (EPA 2016a). At the same time, EPA released a Proposed Plan for the Site identifying alternative I as EPA's preferred alternative (EPA 2016b).

B. Overview of EPA Remedial Alternatives

EPA, in its FS, presented a strategy for developing, presenting, and screening remedial alternatives for the Portland Harbor Superfund Site. This strategy also involved prescribing a number of technology assignments (e.g., dredging, capping, enhanced natural recovery ("ENR"), etc.) to varying degrees in order to achieve specified remedial action levels ("RALs").

This strategy resulted in the initial identification of nine remedial alternatives. Alternatives included a "No Further Action" alternative[8] (labeled alternative A and required for study by EPA guidelines) and eight remedial alternatives (labeled alternatives B through I in order of increasing stringency apart from alternative I, which most closely resembles alternative E in

[7] See http://lwgportlandharbor.org/index.htm for an overview of the Lower Willamette Group's membership and initial investigation work.

[8] Some remedial activity has taken place within the site. In particular, early actions were taken in 2005 at the Gasco site and in 2008 at the Terminal 4 site.

stringency). Overall costs depend on stringency levels and on the remedial action footprint, and therefore costs increase from alternatives A through H. Costs for alternative I closely resemble those of alternative E. Table 1 provides an overview of the area and volume information by remedial technology assignments provided by EPA.

Table 1. Area and Volume Information for EPA Alternatives

	EPA Alternative								
	A	**B**	**C**	**D**	**I**	**E**	**F**	**G**	**H**
Capping (Acres)	-	23	30	45	64	66	118	185	535
Dredging (Acres)	-	72	87	132	167	204	387	572	1,632
ENR (Acres)	-	100	97	87	59.8	60	28	20	0
In-Situ Treatment (Acres)	-	7	5	3	0	0	0	0	0
MNR (Acres)	-	1,966	1,948	1,900	1876	1,838	1,634	1,391	0

Note: ENR—enhanced natural recovery; MNR—monitored natural recovery.
Source: EPA (2016a)

After identification of potential alternatives, EPA conducted analyses of seven of the FS alternatives against the nine evaluation criteria established by the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"). Alternative C was eliminated from EPA's detailed analyses as EPA concluded the alternative was not distinctly different from EPA alternative B. Alternative H was also eliminated primarily based upon implementability and cost.

This study evaluates the economic impacts of five of the EPA remedial alternatives—alternatives B, D, I, E, and F—against a baseline scenario consistent with alternative A, or "No Further Action." Table 2 summarizes the total expenditures associated with remedial activities under each of the five remedial alternatives studied.

Table 2. EPA Expenditure Estimates for EPA Alternatives Studied

	EPA Alternative				
	B	**D**	**I**	**E**	**F**
Total Expenditures (Million 2016$)					
Undiscounted	$642	$953	$1,173	$1,240	$2,179
3% Discount Rate	$475	$700	$867	$923	$1,552

Note: Present value as of January 1, 2016 using a 3% real discount rate.
Source: EPA (2016a)

C. Significance of River Activity to the Portland Regional Economy

Since its settlement, the greater Portland region has been a shipping and transportation hub due to its location at the confluence of the Willamette and Columbia Rivers, and to its proximity to the Pacific Ocean. From 2003 to 2012, the value of exports from the Portland metropolitan area more than doubled (Brookings 2012). By 2012, exports accounted for nearly 20 percent of economic activity in the greater Portland area (Brookings 2012). That same year, Portland city government and business leaders announced a plan to double regional exports from 2012 to 2017 (Read 2012). Exports from the Portland metropolitan region totaled over $18.8 billion (in 2015 dollars) in 2014 (ITA 2016).

Technology firms that specialize in computers and electronics comprise a large portion of the Portland regional economy. In 2010, computer and electronic manufactured goods accounted for over 56 percent of exports from the Portland region (Brookings 2012). Technology firms such as Intel and Tektronix are among the largest employers in the Portland region (Krattenmaker 2015).

Firms that specialize in clean technology and sustainability also help drive the Portland regional economy. Numerous green energy firms, such as Vestas Wind Systems, the largest producer of wind turbines in the world, have a substantial presence in the Portland metropolitan area (Yglesias 2012). As part of its initiative to increase exports, a "We Build Green Cities" campaign was launched to market Portland-based sustainability-focused firms to the rest of the world (Brookings 2012).

Portland Harbor—the harbor in which the Site is located—is still very much an active port and gateway, one which supports a large portion of the exports described above and employs approximately 40,000 workers (LWG 2016). The terminals at the port today handle grain, mineral bulks, automobiles, break-bulk cargo, and other goods (ECONorthwest 2013). Portland Harbor is currently the third-largest export center for grain in the world as well as the largest wheat exporting port in the United States (EPA 2016c). Moreover, the port is one of the largest automobile import gateways on the west coast of the United States (EPA 2016c). Thus, the Portland Harbor and related industrial activities contribute significantly to the regional economy.

D. Report Objectives

The objective of this report is to analyze the economic impacts of EPA's remedial alternatives on the Portland regional economy. This economic impact assessment is distinct from a benefit-cost analysis, which provides a monetary assessment of changes in social well-being (EPA 2011, p. 3). The EPA remedial alternatives studied in this report are estimated by EPA to cost between $642 million and more than $2 billion (undiscounted) and could disrupt the Willamette River for up to 13 years (or longer according to alternative estimates—see Table 3 below). EPA has not provided estimates of the potential impacts of the remedial alternatives on economic activity in the Portland region. EPA has, however, recognized the importance of economic impact analysis as a tool for weighing trade-offs associated with cleanup policies and programs (EPA 2011).

Prior economic impact assessments of Portland Harbor remediation, conducted in 2012 before the release of EPA's 2016 FS, arrived at seemingly conflicting conclusions. A Brattle Group report confined its analysis to the negative financing impacts of remediation and found negative economic impacts (Brattle 2012). In contrast, a study conducted by ECONorthwest considered only the positive expenditure impacts and found positive economic impacts (ECONorthwest 2012). This inconsistency indicates a need for an additional study that considers both impacts. Indeed, EPA has recognized that ignoring project financing will lead to an overstatement of the economic impacts of cleanup activity. (And similar reasoning would hold for ignoring the positive effects of project expenditures.) EPA guidelines specifically note that analysts should account for the region's need to finance the project along with the positive impacts of cleanup (EPA 2011, p. 80).

Our assessment reconciles previous findings by quantifying the positive and negative impacts associated with both remediation expenditures and financing, thereby providing information on the *net* impacts. We also use the most up-to-date information on the remedial alternatives put forward by EPA, including EPA's preferred alternative—alternative I.

E. Organization of the Report

The remainder of this report is organized as follows. Section II provides an overview of the data and methodology supporting our REMI PI+ study of the economic impacts of EPA's remedial alternatives on the Portland regional economy. Section III presents the results of the study. Lastly, Section IV summarizes the principal empirical results and draws conclusions regarding the impacts of the EPA alternatives on the Portland regional economy. Appendices to this report provide additional information on modeling tools (i.e., REMI PI+), detailed data and assumptions, detailed results, alternative results based on EPA's alternative waste disposal scenario,[9] alternative results based on AECOM estimates of costs and timing, and qualitative assessments regarding potential impacts on riverfront activities.

[9] EPA develops expenditure estimates under two disposed material management ("DMM") scenarios: DMM scenario 1, which involves construction of a confined disposal facility ("CDF") on-site as well as off-site disposal, and DMM scenario 2, which involves only off-site disposal. Impact estimates in the body of this report correspond to DMM scenario 2, the same DMM scenario which EPA evaluates in the main FS. Similar to EPA, we present impact estimates under DMM scenario 1 in an appendix to this report (see Appendix F).

II. Regional Economic Study Data and Methodology

This chapter describes the data and methodologies we use to estimate the impacts of the EPA alternatives on the Portland MSA regional economy. We first provide an overview of the modeling approach and then discuss specifics of the data and methodology.

A. Overview of Modeling Approach

Figure 1 summarizes the steps we use to model the economic impacts of the EPA alternatives on the Portland regional economy. The following is an overview of our process.

- We obtain remedial expenditures for the five alternatives we evaluate from the 2016 EPA FS. This includes detailed information for the various phases of construction and other expenditures, assumed to occur over a 31-year period. Note that our assessments do not include past expenditures on interim cleanup and past and future legal and other administrative fees.

- We assume that local governments, local businesses and national/international entities share equally in the financing of the remedial expenditures, and we develop alternative assumptions on the specifics of local financing that we use to develop a range of direct financing impacts for the alternatives. In addition, we evaluate the financing impacts if expenditures were financed entirely by each group. We do not include the potential effects of insurance recovery, which is speculative and may lead to premium increases.

- We utilize a regional economic model of the Portland regional economy provided by Regional Economic Models, Inc., Policy Insight Plus ("REMI PI+").

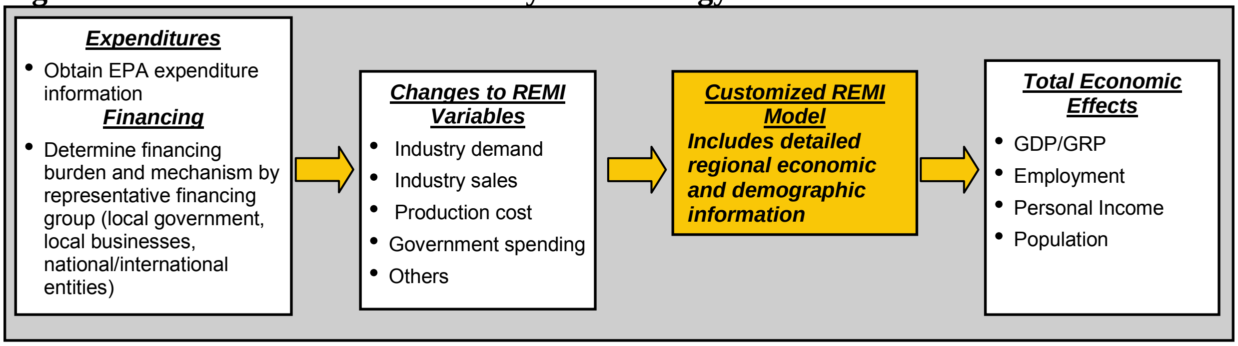
- We translate the detailed expenditures and financing data into appropriate REMI PI+ inputs.

- Using these inputs, we run simulations in REMI PI+ of the Portland regional economy under each of the five EPA alternatives considered for this study and under the various financing scenarios.

- Finally, we compare these simulations to REMI PI+'s "baseline" forecasts in order to determine the economic impacts of the remedial alternatives on the Portland regional economy, as measured by Gross Regional Product ("GRP"), employment, personal income and population. (See Appendix B for information on the REMI PI+ baseline forecast for Portland.)

The result of this approach is a set of estimates of the impacts of the five EPA alternatives on the Portland MSA regional economy.

Figure 1. Overview of REMI PI+ Study Methodology



B. REMI PI+ Model

We use REMI PI+ to develop estimates of the effects of the EPA alternatives. REMI PI+ is a state-of-the-art regional economic tool that has been developed and refined by researchers over more than twenty-five years. It is widely used by federal, state, and local agencies, as well as analysts in the private sector and academia, to estimate the effects of regulations, investments, closures, and other policy scenarios Appendix A provides additional background on REMI PI+.

1. REMI PI+ Model

The core of the REMI PI+ model is a set of input-output ("I/O") relationships among different industries. These relationships show how industries are related to one another, in terms of both inputs and outputs. Thus, they allow one to estimate how changes in one industry will affect demand for other industries (those that provide inputs to the industry in question). In addition, I/O models can be used to trace the effects that result from changes in the income of workers in the affected industries.

The REMI PI+ model goes well beyond the standard I/O relationships to incorporate other important feedback effects. The model includes demographic components, because the population of an area over the long run depends in part on the available economic opportunities. Changes in population in turn have feedback effects on the local economy, affecting the demand for housing and other goods. Other feedback effects include changes in wages as a result of changes in economic activity. If employment increases, for example, wages will tend to rise, affecting the competitive position of the region relative to other areas. The model also incorporates so-called agglomeration effects, which dictate that, if many firms in a given industry sector cluster in a specific region, the entire industry benefits through improved access to labor and other inputs.[10]

[10] EPA's *Handbook on the Benefits, Costs, and Impacts of Land Cleanup and Reuse* provides commentary, noting that the REMI PI+ model "offers a detailed representation that projects annual impacts including output, labor and capital, demographics, market share, wages, prices, and production costs at the regional level." Because all such models are based on current input-output relationships, REMI PI+ does not capture potential future changes in production processes and technology (see EPA 2011, p. 92). Although the model does not by itself include the effects of financing expenditures, we include detailed estimates of how expenditures would be financed in order to avoid this potential limitation of the REMI PI+ model (see EPA 2011, p. 93).

The REMI PI+ model incorporates detailed and up-to-date macroeconomic data from the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor Statistics, the U.S. Census Bureau, and other public sources.

2. Portland REMI PI+ Model

Each version of the REMI PI+ model is custom-built for the regions of interest, which can range from counties to entire countries. The model built for this project was compiled in late 2015, with version 1.7 of REMI's PI+ application. We developed a 4-region model in order to appropriately specify inputs and summarize outputs. We use the model to develop estimates of impacts in the seven-county Portland MSA.

Figure 2. Map of REMI PI+ Model Regions

Source: NERA

Figure 2 shows the geographic scope of the Portland REMI PI+ model. The model includes four regions:

1. City of Portland;
2. Five Oregon counties in the Portland metropolitan area ("Rest of MSA: OR");
3. Two Washington counties in the Portland metropolitan area ("Rest of MSA: WA"); and
4. Rest of Oregon ("Rest of OR State").

We input expenditure and financing information into the various REMI PI+ sub-regions and the relevant years and develop results for the seven-county Portland metropolitan region (which includes the City of Portland). Our simulations incorporate the results of the model over the 31-year period from 2020 to 2050. As noted above, the general methodology begins with a baseline simulation in REMI PI+ to develop baseline economic conditions over the relevant time period. The baseline can be thought of as consistent with EPA alternative A, the "No Further Action" alternative. We then add the inputs to reflect the expenditures and financing of each of the five EPA alternatives. By comparing the Portland regional economy with and without the five EPA alternatives, we are able to estimate what the EPA alternatives mean to the Portland region in terms of changes in employment, GRP, personal income, and population.

C. Expenditures of EPA Remedial Alternatives

This section provides information on expenditures for the EPA alternatives considered in this study and basic information on how they are modeled in REMI PI+.[11] We assume that expenditures begin in 2020 and end in 2050, consistent with EPA's 31-year remediation period. These expenditures include costs for activities related to implementing the various technology assignment measures during the construction period (such as dredging and capping) as well as costs related to ongoing activities such as long-term monitoring and periodic Site reviews.

1. Total Expenditures by EPA Remedial Alternative

Table 3 provides estimates of the total undiscounted expenditures for the five remedial alternatives. The table shows estimates developed by EPA as well as estimates developed by AECOM under alternative assumptions. EPA's (undiscounted) estimates range from about $642 million for alternative B to about $2.2 billion for alternative F. AECOM cost estimates are larger, with a range from approximately $1 billion to nearly $3 billion. Impacts presented in this report are based upon detailed EPA cost estimates; however, we also provide forecasted impacts using AECOM's cost and timing estimates in Appendix G.

Table 3. EPA and AECOM Expenditure Estimates for EPA Alternatives

	EPA Alternative				
	B	**D**	**I**	**E**	**F**
EPA Estimates					
Years of Construction	4	6	7	7	13
Total Expenditures (Million 2016$)	$642	$953	$1,173	$1,240	$2,179
AECOM-Adjusted Estimates					
Years of Construction	5	8	11	13	26
Total Expenditures (Million 2016$)	$1,051	$1,355	$1,644	$1,758	$2,969

Note: Undiscounted total expenditures.
Source: EPA (2016a) and AECOM (2016)

In addition to differences in total expenditures, EPA and AECOM estimates differ substantially in the estimated duration of the construction period (i.e., the time required to implement

[11] Additional information on detailed expenditure data and modeling assumptions is available in Appendix C.

necessary technology assignments such as dredging and capping). For EPA estimates, the time range is from 4 years for alternative B to 13 years for alternative F. In contrast, AECOM estimates that the range is from 4 years for alternative B to 26 years for alternative F. AECOM's estimates differ primarily because of differences in assumed production rates for dredging (i.e., quantity of dredged material per unit of time) and other activities, as well as differences in levels of reliance on certain technology measures.

2. Nature and Timing of EPA Remedial Expenditures

EPA provided detailed data in its 2016 FS on annual remediation expenditures for the alternatives over a generic 31-year remediation period. We presume remediation expenditures would occur according to this schedule beginning in 2020. The detailed data in the FS also includes a comprehensive list of estimates of all expenditures for labor and materials associated with remediation activities during the construction period as well as expenditures for ongoing activities such as periodic Site reviews.

Table 4 provides an overview of EPA's total estimated expenditures summarized in terms of general cost categories consistent with those used in the FS. Figure 3 illustrates the timing of expenditures by alternative over the 31-year remediation period (2020-2050).

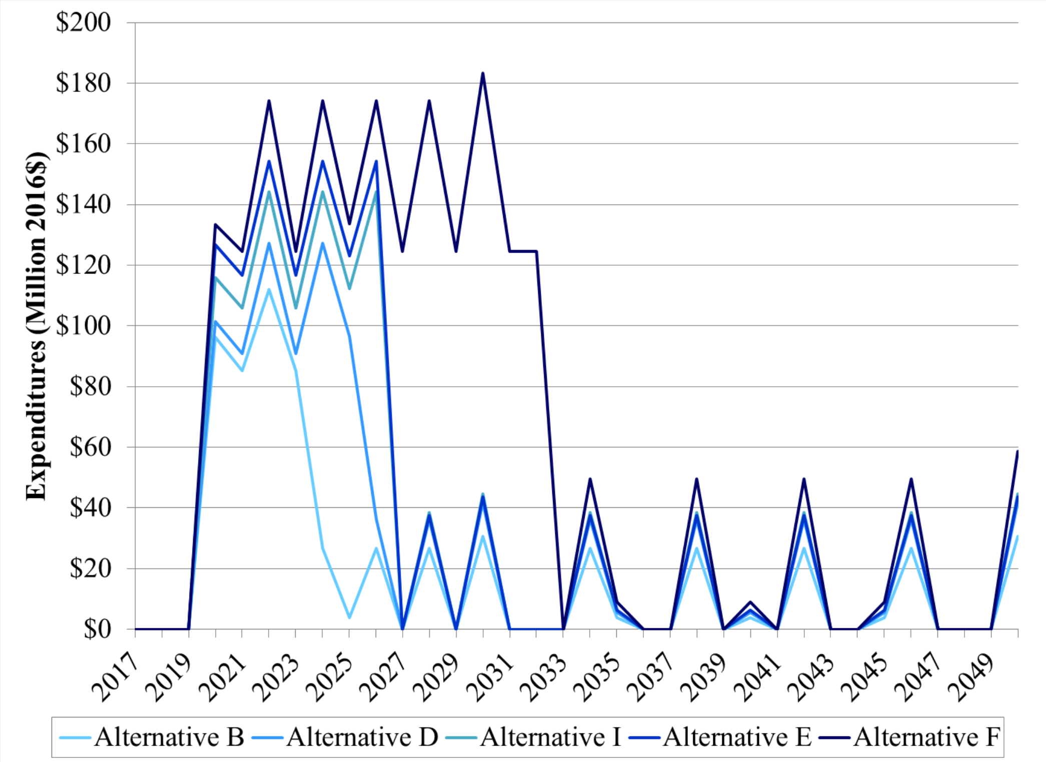
Table 4. EPA Alternative Expenditures by EPA Cost Category (Million 2016$)

	EPA Alternative				
EPA Cost Category	**B**	**D**	**I**	**E**	**F**
IC Capital Costs	$2	$3	$4	$4	$5
MNR Capital Costs	$11	$10	$10	$10	$9
Tech Assignment Capital Costs	$339	$542	$737	$814	$1,616
Site-Wide Monitoring and MNR Periodic Costs	$267	$364	$384	$375	$495
Long Term O&M Periodic Costs	$18	$28	$32	$32	$48
IC Periodic Costs	$3	$3	$4	$4	$5
5-Year Site Review Periodic Costs	$2	$2	$2	$2	$2
Total	$642	$953	$1,173	$1,240	$2,179

Note: Undiscounted totals over 31-year period (2020-2050). IC—institutional controls; MNR—monitored natural recovery; Tech Assignment—technology assignment measures (e.g., capping, dredging).

Source: EPA (2016a) and NERA calculations as explained in text.

Figure 3. EPA Alternative Expenditures by Year (Million 2016$)



Note: Undiscounted annual expenditures.
Source: EPA (2016a)

The remainder of this section provides an overview of the process of inputting these data into REMI PI+ in order to estimate the positive expenditure impacts of the EPA alternatives on the Portland region.

3. REMI PI+ Modeling of Expenditure Impacts

Remediation expenditures, when assessed alone, will benefit the Portland regional economy by increasing the demands for products and services across a range of industries. The demand for construction materials and personnel will increase during the construction period, and the ongoing periodic expenditures for monitoring and other activities also will increase the demand for various goods and services across a number of sectors in the Portland region. Both the construction and the ongoing periodic activities create “multiplier” effects on the regional economy—as the direct businesses buy various goods and services (“indirect” effects) and employees spend money within the area (“induced” effects).

In order to input expenditures into REMI PI+, expenditures must be assigned to sectors and model regions. Individual costs detailed in EPA’s FS are assigned to sectors based on EPA descriptions of costs and on the sector definitions in REMI’s 70-sector PI+ model. The majority of costs associated with remediation will occur in the City of Portland. Certain expenditures associated with activities such as waste disposal will occur in other REMI PI+ model regions or outside the Portland REMI PI+ model region altogether. Expenditures outside the Portland

REMI PI+ model region are not included as inputs to the model. Appendix C provides additional details regarding our assignments of EPA expenditures to REMI PI+ sectors and regions.

Table 5. EPA Alternative Expenditures by REMI PI+ Sector (Million 2016$)

	EPA Alternative				
REMI Sector	**B**	**D**	**I**	**E**	**F**
Administrative and support services	$270	$357	$451	$443	$569
Construction	$113,422	$152,041	$195,765	$209,263	$354,228
Management of companies and enterprises	$1,391	$1,391	$1,391	$1,391	$1,391
Nonmetallic mineral product manufacturing	$67,938	$103,548	$119,370	$121,253	$191,289
Plastics and rubber product manufacturing	$442	$743	$872	$850	$1,302
Printing and related support activities	$102	$102	$102	$102	$102
Professional, scientific, and technical services	$270,478	$372,360	$396,907	$388,077	$522,839
Rental and leasing services; Lessors of nonfinancial intangible assets	$30	$52	$58	$58	$92
Rail transportation	$3	$3	$3	$3	$3
Real estate	$2,597	$3,868	$4,503	$4,503	$8,317
Truck transportation	$6,762	$6,762	$6,762	$6,762	$6,762
Waste management and remediation services	$98,092	$131,508	$164,178	$175,753	$302,634
Water transportation	$13,831	$25,730	$37,976	$43,741	$98,405
N/A*	$67,062	$154,567	$244,964	$287,603	$690,990
Total	$642,419	$953,029	$1,173,303	$1,239,801	$2,178,923

Note: *Expenditures associated with waste disposal at Subtitle D Facility (Roosevelt Regional Landfill) are located outside the Portland region (and REMI PI+ model footprint) in Washington State. Undiscounted totals over 31-year period (2020-2050).

Source: EPA (2016a) and NERA calculations as explained in text.

Expenditures are generally modeled as increases in demand for goods and services in a sector and are subject to regional purchase coefficients, by which part of the increased demand is met by sales in other regions, as explained below. However, if demand is expected to be met exclusively by local industry (e.g., waste disposal at an existing facility), costs are modeled as increases in industry sales in the relevant region.

As noted, REMI PI+ generally uses estimated regional purchase coefficients to distribute the economic impacts of the purchases for the project to the regions in the REMI PI+ model (and implicitly to other regions outside the area). For example, since the regional purchase coefficient for the construction sector in the City of Portland in 2020 is 0.964, the model assumes that 96.4 percent of the value of construction activity will be spent in the City of Portland and directly contribute to the City of Portland economy (in terms of employment, income, and so forth).[12] The remaining purchases are assumed to be obtained from outside the city, either in the other model regions (i.e., the Oregon and Washington counties in the MSA and the rest of the state of Oregon) or outside the model area altogether (i.e., in the rest of the United States or out of the country). The REMI PI+ model assumes that purchases related to the EPA remedial alternatives that are made outside the model area would not affect the Portland regional economy.

[12] The RPCs in REMI do not take into account the possibility that specialized expertise would be needed from outside the region (e.g., experts in dredging who would not be available in the Portland region).

D. Financing of EPA Remedial Alternatives

This section provides information on the financing of remediation expenditures and its negative impacts on the regional economy.[13] The expenditures for EPA's alternatives at the Portland Harbor Superfund Site will have to be paid for by some mix of entities. In contrast to the positive effects of cleanup expenditures, financing by local businesses and governments leads to negative impacts on the Portland economy. Local businesses facing cost burdens will see increased production costs and decreased competitive positions, resulting in negative economic impacts to the region; local governments facing cost burdens will need to increase taxes or reduce other spending, similarly resulting in negative impacts.[14]

The process of determining responsibility for remedial expenditures is complicated and ongoing, with no resolution until after the specific remediation plan is selected; however, EPA has named more than 100 entities as potentially responsible parties ("PRPs") that may be liable for cleanup costs at the Site.[15] Certain entities that expected to face eventual liability entered into legal agreements with EPA to finance initial investigation activities. These entities formed a coalition called the Lower Willamette Group.[16] Thus, we have some sense of the potential universe of liable parties, as well as those who have already financed initial investigation activities.

This section provides additional information on the various categories of entities that might fund remediation expenditures in the future as well as the assumptions used to develop impacts for a range of financing cases. Because the nature of the financing is uncertain, we develop information that allows us to estimate a range of possible financing impacts on the Portland regional economy.

1. Potential Groups to Finance Expenditures

The size of the potential negative impacts of remediation financing depends in large part on the extent to which costs are borne by "local" versus "non-local" entities.

Local entities, in the context of the study, might include:

- Cities or other municipalities;
- The Port Authority;
- Other local governmental organizations; and
- Local businesses.

[13] Additional information on detailed financing data and modeling assumptions is available in Appendix D.

[14] We do not take into account the possibility that some business or government costs would be covered by insurance. Any insurance recovery is speculative and subject to additional complications (e.g., possibility of increased premiums).

[15] See: https://www3.epa.gov/region10/pdf/ph/uplands/gnl_address_list_september_2014.pdf

[16] See: http://lwgportlandharbor.org/

Non-local entities might include:

- National businesses;
- International businesses; and
- Federal government.

We consider the impacts of financing expenditures for three representative groups of potentially responsible parties:

1. Local governments ("local entity");
2. Local businesses ("local entity"); and
3. National/international businesses and federal government (or "non-local entities").

Each of these groups will be responsible for some share of the remediation costs;[17] however, the exact shares will be determined after the remediation plan is selected and are at this point uncertain. We develop a "mixed financing" case which assumes remediation costs are borne equally by each of the three groups.[18] As background, we show the economic impacts assuming costs are borne entirely by each group. In addition, we develop assumptions on the possibility of different financing mechanisms and timing for local businesses and governments that allow us to estimate potential ranges.

2. Financing by Local Governments

At least two local government entities have been identified as PRPs at the Portland Site—namely, the City of Portland and Port of Portland. As noted, both entities have, as members of LWG, already contributed financially to the initial cleanup investigation (e.g., the remedial investigation and feasibility study). Both of these entities are located within the Portland region and future remediation costs borne by these and other local government entities will have negative impacts on the regional economy.

The magnitude of these negative impacts is uncertain and will depend upon a number of factors, such as the mechanisms local government entities might use to finance remediation costs. We assume that local government budgets must be balanced—i.e., any increase in spending on remediation activities must be offset with a corresponding decrease in other spending or by an

[17] In fact, both local government and local businesses have already financed expenditures associated with initial Site investigations as members of LWG.

[18] Although certain costs—such as those associated with waste disposal—might occur outside the Portland region, those costs could very well be financed within the region. Our financing cases develop allocations based upon total remediation expenditures.

increase in taxes.[19] We model the impacts of both potential financing mechanisms for local governments in order to account for this uncertainty.

- Spending cuts. Local government entities such as the City or Port might elect to pay for increased costs related to remediation expenditures by decreasing spending on other government services (e.g., police, fire, etc.). We develop estimates of government spending cuts due to remediation financing based upon an assumed share of costs allocated to local government entities.

- Tax increases. Local government entities might instead elect to pay for increased costs related to remediation expenditures by increasing tax revenues. Local government entities are generally able to increase revenue by raising property tax rates for residential and commercial taxpayers. We develop estimates of property tax increases due to remediation financing based upon an assumed share of costs allocated to local government entities and on historical and forecasted economic data. (See Appendix D for additional details.)

In addition to the uncertainty in specific financing mechanisms, there is some uncertainty in how local government entities might elect to incur these costs over time. In particular, we consider two potential timing alternatives.

- Contemporaneous financing. Local government entities might elect to undertake measures that offset increases in spending on remediation activities (i.e., spending cuts or tax increases) in the same year as those expenditures associated with remediation activities are made. For example, if $100 million must be spent on cleanup activities in 2020, and government entities are responsible for ten percent of all costs, then under this approach local government entities would reduce spending or increase taxes by $10 million in 2020 to offset their cost burden in that year.

- Financing over time. Local government entities might instead elect to undertake measures that offset increases in spending on remediation activities (i.e., spending cuts or tax increases) on a regular, fixed schedule. This would involve financing costs with debt and making payments to creditors over time; under this scenario, government entities would be responsible for financing both principal (i.e., their share of remediation expenditures) and interest. Total costs to local governments and total spending cuts or tax increases would be greater than if financed contemporaneously. This "over time" approach to financing timing seems more likely due to the large variation in annual costs over the period according to EPA's schedule (see Figure 3). It could be challenging for local governments to make large changes in services provided or in taxes collected from one year to the next.

We develop four potential local government financing methods based upon all possible combinations of financing mechanisms and financing timing alternatives, as summarized in Table 6.

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[19]The Port of Portland also earns revenue from business transactions, but it is not clear this would be a viable mechanism for the Port, and certainly not for other government entities, to offset remediation expenditures.

Table 6. Overview of Financing Mechanisms for Local Governments

Local Entity	Financing Method	Financing Timing
Local Governments	Tax increase[1]	Contemporaneous
	Tax increase	Over time (3% real interest rate)
	Spending cut	Contemporaneous
	Spending cut[2]	Over time (3% real interest rate)

Notes: [1]Case corresponds to the minimum financing impact; [2]Case corresponds to the maximum financing impact.
Source: NERA as explained in text.

3. Financing by Local Businesses

A number of local businesses have been identified by EPA as PRPs at the Portland Harbor Site. For local businesses, remediation costs would directly increase the cost of doing business in the Portland region. We treat costs borne by local businesses as increases in production costs within the relevant sectors and regions. As with government financing, local businesses may decide either to incur cost increases in the same year as remediation expenditures (i.e., "contemporaneously") or to finance remediation spending over time and incur interest expenses. (Note that interest rates faced by businesses are generally higher than those faced by government entities; see Appendix D for information explaining our assumed interest rates.)

We develop two potential local government financing methods—contemporaneous production cost increases or production cost increases over time, as summarized in Table 7.

Table 7. Overview of Financing Mechanisms for Local Businesses

Local Entity	Financing Method	Financing Timing
Local Businesses	Cost increase[1]	Contemporaneous
	Cost increase[2]	Over time (5.5% real interest rate)

Notes: [1]Case corresponds to the minimum financing impact; [2]Case corresponds to the maximum financing impact.
Source: NERA as explained in text.

4. Financing by National/International Entities

PRPs at the Portland Site include a number of national and international entities. We assume expenditures allocated to non-local entities represent an introduction of net new spending in the economy (i.e., financing impacts are zero). In practice, the financing impacts of costs allocated to this group would depend upon where in a company's balance sheet the costs are incurred. Our assumption would understate the financing impacts of EPA's remedial alternatives if non-local entities impose financing costs on their local operations (in which case, impacts would resemble those under a local financing scenario).

5. Mixed Financing Case

Our mixed financing case (for which we calculate the net economic impact results) assumes one-third of costs are borne by each of the three broad groups (local governments, local businesses, and external entities). For background, we first show results assuming 100 percent financing by each of the three groups in the subsequent section on results.

III. Portland Regional Economic Impacts of EPA Remedial Alternatives

This chapter provides empirical results of our REMI PI+ modeling, comparing the baseline REMI PI+ values with estimates of the values under the various EPA alternatives. Following the methodology outlined in the previous chapter, we first provide information on REMI PI+ modeling of expenditures, ignoring financing considerations. We then provide results for the financing cases, the last of which is the mixed case we use in our modeling of the net impacts of expenditures and financing. The final sections of this chapter provide the net impacts of combining expenditures and financing.

The regional impacts are based on gains and losses in the following four REMI PI+ output variables:

- Gross Regional Product, the total value added for goods and services;
- Personal Income, aggregate personal income from all sources including wages, dividends and government transfer payments;
- Employment, total jobs (both full-time and part-time); and
- Population, the number of persons in the region.

We produce REMI PI+ output over the 31-year period from 2020 to 2050. Results in this chapter are generally reported both for the average annual impact over the period as well as the cumulative impact over the period. For values in dollars, the cumulative impacts are aggregated as a present value as of January 1, 2016 using a real (inflation-adjusted) discount rate of 3%.[20] The non-dollar values (jobs and population) are summed over the period without discounting, presented in job-years and person-years, respectively. As an example of the job-year calculation, if, for example, expenditures result in 100 additional jobs in 2020 and 100 additional jobs in 2021 (relative to the baseline level of jobs in those two years), the alternative would lead to a total of 200 job-years over the two-year period. To reflect the appropriate precision of the estimates, jobs and population are reported to the nearest 10 jobs or people. Appendix E provides the detailed annual results corresponding to the average and cumulative results presented in this chapter.

A. Positive Regional Economic Impacts of Expenditures

Table 8 provides the REMI PI+ results for expenditures. The EPA remediation expenditures by themselves add to Portland regional economic activity. In terms of employment, the job gains due to expenditures range from an average annual value of 160 for alternative B to an average annual value of 410 for alternative F. Over the 31-year period, the alternatives would add

[20] The Office of Management and Budget provides for the use of discount rates of 3% and 7% in federal rulemakings.

between 5,080 and 12,690 job-years. The population impacts are similar, reflecting the fact that changes in jobs tend to be associated with changes in population.

The positive impacts on GRP and personal income from expenditures are similar to one another and show the same increasing values for more expensive alternatives. Expenditures from EPA alternative B are projected to result in an average increase of about $18 million per year in the Portland regional economy, or about $385 million discounted over the 31-year period. Expenditures associated with EPA alternative F would result in regional economic impacts that are more than twice as large, with an annual increase of $45 million and a cumulative increase of about $964 million. Expenditures associated with EPA's preferred alternative I are projected to result in an increase of $29 million annually and $629 million discounted over the 31-year period.

Table 8. Economic Impacts of EPA Alternative Expenditures on Portland MSA

	B	D	I	E	F
Gross Regional Product (Million 2016$)					
Average Annual	$18	$25	$29	$29	$45
Cumulative (3% DR)	$385	$537	$629	$646	$964
Personal Income (Million 2016$)					
Average Annual	$16	$22	$26	$26	$40
Cumulative (3% DR)	$337	$467	$548	$563	$836
Total Employment (Jobs/Job-Years)					
Average Annual	160	230	270	270	410
Cumulative	5,080	7,090	8,250	8,440	12,690
Population (Persons/Person-Years)					
Average Annual	210	290	350	360	550
Cumulative	6,490	9,070	10,750	11,090	17,150

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

B. Negative Regional Economic Impacts of Financing

This section provides results for the various financing cases. As described in Chapter II, our combined results assume that expenditures are financed equally by local governments, local businesses and national/international entities.

This section provides results for cases in which expenditures are assumed to be financed entirely by local governments, entirely by local businesses, and under the mixed case previously described. Financing by national and international entities is assumed to lead to external financing, which would have no negative impacts on the Portland MSA economy as long as those costs were not borne by the local subsidiary. (Therefore, quantitative results for an equivalent "all national/international" case are not shown.)

1. Regional Economic Impacts of Local Government Financing

Table 9 shows the impacts of remediation financing if all of the expenditures were financed by local governments, based upon the methodologies explained in Chapter II. All of the impacts are negative, reflecting the fact that local government financing would require increases in taxes or decreases in other government spending (and thus withdrawals from the Portland MSA economy).

a. Differences across Remedial Alternatives

The potential losses from local government financing are predicted to be substantially greater for the more expensive remedial alternatives. Based upon the maximum jobs impacts, for example, the loss ranges from about 720 jobs per year for alternative B to 2,450 jobs per year for alternative F; the corresponding cumulative values are about 22,380 job-years for alternative B and about 75,890 job-years for alternative F. EPA’s preferred alternative I is projected to result in a loss of 1,320 jobs per year and 40,870 cumulative job-years over the 31-year period.

Table 9. Economic Impacts of Local Government Financing of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Gross Regional Product (Million 2016$)										
Average Annual	-$37	-$73	-$54	-$109	-$67	-$134	-$71	-$142	-$123	-$249
Cumulative (3% DR)	-$804	-$1,349	-$1,178	-$2,001	-$1,461	-$2,464	-$1,559	-$2,604	-$2,580	-$4,575
Personal Income (Million 2016$)										
Average Annual	-$35	-$77	-$52	-$114	-$64	-$141	-$68	-$149	-$117	-$261
Cumulative (3% DR)	-$731	-$1,378	-$1,073	-$2,044	-$1,334	-$2,517	-$1,425	-$2,659	-$2,345	-$4,672
Total Employment (Jobs/Job-Years)										
Average Annual	-340	-720	-500	-1,070	-620	-1,320	-660	-1,390	-1,110	-2,450
Cumulative	-10,620	-22,380	-15,600	-33,200	-19,320	-40,870	-20,560	-43,190	-34,460	-75,890
Population (Persons/Person-Years)										
Average Annual	-740	-880	-1,090	-1,310	-1,360	-1,610	-1,450	-1,700	-2,480	-2,990
Cumulative	-22,890	-27,290	-33,920	-40,490	-42,230	-49,840	-45,010	-52,670	-77,010	-92,550

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

b. Differences within Remedial Alternatives

In addition to differences across alternatives, the range of potential impacts for each individual alternative is large. The maximum values for each case are substantially greater than the minimum values (on the order of two times) for categories other than population, for which the range is smaller. For example, in the case of GRP impacts due to alternative B, the minimum value is an average annual loss of about $37 million per year and the maximum value is an average annual loss of about $73 million per year, a ratio of about 2.0. These values translate into cumulative losses of between about $804 million and $1.4 billion over the 31-year period. Employment ranges are similar, ranging from a minimum of about 340 jobs per year to a maximum of about 720 jobs per year. The cumulative values range from losses of about 10,620 job-years to 22,380 job-years.

2. Regional Economic Impacts of Local Business Financing

Table 10 shows the impacts of remediation financing if all of the expenditures were financed by local businesses, based upon the methodologies explained in Chapter II. As with local government financing, all of the impacts are negative, reflecting the fact that local business financing would mean decreased expenditures for other goods and services in the Portland MSA economy and a decreased competitive position. The negative impacts for local business financing are generally similar to or greater than local government financing impacts, due in part to the fact that increased production costs also make Portland area businesses less competitive relative to other regions.

Table 10. Economic Impacts of Local Business Financing of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Gross Regional Product (Million 2016$)										
Average Annual	-$70	-$124	-$101	-$182	-$124	-$223	-$132	-$236	-$221	-$407
Cumulative (3% DR)	-$1,473	-$2,191	-$2,120	-$3,216	-$2,616	-$3,936	-$2,791	-$4,153	-$4,493	-$7,176
Personal Income (Million 2016$)										
Average Annual	-$51	-$85	-$74	-$124	-$91	-$152	-$96	-$160	-$159	-$276
Cumulative (3% DR)	-$1,044	-$1,480	-$1,498	-$2,167	-$1,849	-$2,650	-$1,974	-$2,795	-$3,142	-$4,813
Total Employment (Jobs/Job-Years)										
Average Annual	-470	-750	-680	-1,100	-840	-1,340	-890	-1,420	-1,440	-2,440
Cumulative	-14,660	-23,310	-21,050	-34,120	-25,890	-41,690	-27,560	-43,970	-44,630	-75,660
Population (Persons/Person-Years)										
Average Annual	-780	-1,160	-1,130	-1,710	-1,410	-2,100	-1,500	-2,220	-2,470	-3,860
Cumulative	-24,080	-35,850	-35,080	-53,060	-43,640	-65,190	-46,650	-68,840	-76,700	-119,780

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

a. Differences across Remedial Alternatives

As with local government financing, the potential losses from local business financing would be substantially greater for the more expensive remedial alternatives. Based upon the maximum jobs impacts, for example, the loss ranges from about 750 jobs per year for alternative B to 2,440 jobs per year for alternative F; the corresponding cumulative values are about 23,310 job-years for alternative B and about 75,660 job-years for alternative F. EPA's preferred alternative I is projected to result in a loss of 1,340 jobs annually and 41,690 cumulative job-years over the 31-year period.

b. Differences within Remedial Alternatives

The maximum values for each case are substantially greater than the minimum values for categories other than population, for which the range is smaller. For example, in the case of GRP impacts due to local business financing of alternative B, the minimum value is an average annual loss of about $70 million per year and the maximum value is an average annual loss of about $124 million per year, a ratio of about 1.8. These values translate into cumulative losses of between about $1.5 billion and $2.2 billion over the 31-year period. Financing impacts on employment are similar, ranging from a minimum of about 470 jobs per year to a maximum of about 750 jobs per year. The cumulative values are about 14,660 job-years and 23,310 job-years.

3. Regional Economic Impacts of Mixed Case Financing

Table 11 shows the impacts of remediation financing for the mixed case in which remediation expenditures are financed by an equal combination of financing by local governments, local businesses, and national/international entities. As with local government and local business financing, all of the impacts are negative, reflecting the fact that local government or local business financing would mean decreased expenditures for other goods and services in the Portland MSA and a less competitive Portland economy. The negative impacts of the mixed financing case are smaller than the previous cases considered.

Table 11. Economic Impacts of Mixed Financing of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Gross Regional Product (Million 2016$)										
Average Annual	-$36	-$67	-$52	-$99	-$64	-$121	-$68	-$128	-$116	-$223
Cumulative (3% DR)	-$766	-$1,200	-$1,113	-$1,770	-$1,375	-$2,172	-$1,467	-$2,293	-$2,396	-$3,993
Personal Income (Million 2016$)										
Average Annual	-$29	-$55	-$42	-$81	-$52	-$99	-$55	-$105	-$94	-$183
Cumulative (3% DR)	-$598	-$969	-$869	-$1,429	-$1,076	-$1,754	-$1,148	-$1,852	-$1,863	-$3,224
Total Employment (Jobs/Job-Years)										
Average Annual	-270	-500	-400	-740	-490	-910	-520	-960	-870	-1,660
Cumulative	-8,510	-15,510	-12,380	-22,870	-15,260	-28,060	-16,240	-29,620	-26,840	-51,540
Population (Persons/Person-Years)										
Average Annual	-500	-680	-740	-1,010	-920	-1,240	-980	-1,310	-1,660	-2,300
Cumulative	-15,500	-21,030	-22,840	-31,220	-28,450	-38,450	-30,370	-40,630	-51,310	-71,360

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

a. Differences across Remedial Alternatives

As with the "pure" financing cases, the potential losses from the mixed financing case would be substantially greater for the more expensive remedial alternatives. Based upon the maximum jobs impacts, for example, the loss ranges from about 500 jobs per year for alternative B to 1,660 jobs per year for alternative F; the corresponding cumulative values are about 15,510 job-years for alternative B and about 51,540 job-years for alternative F. EPA's preferred alternative I is projected to result in a loss of 910 jobs per year and 28,060 cumulative job-years over the 31-year period.

b. Differences within Remedial Alternatives

This mixed financing case results in estimates qualitatively similar to the two "pure" financing cases. The maximum values for each case are substantially greater than the minimum values for categories other than population, for which the range is smaller. For example, in the case of GRP impacts due to alternative B, the minimum value is an average annual loss of about $36 million per year and the maximum value is an average annual loss of about $67 million per year, a ratio of about 1.9. These values translate into cumulative losses of between about $766 million and

$1.2 billion over the 31-year period. Employment ranges for alternative B are similar, ranging from a minimum of about 270 jobs per year to a maximum of about 500 jobs per year. The cumulative values are about 8,510 job-years and 15,510 job-years.

C. Net Regional Economic Impacts of Expenditures and Financing

The net impacts of the EPA remedial alternatives on the Portland MSA economy depend upon the combined effects of positive expenditure impacts and negative financing impacts. Table 12 provides the net effects of the five EPA alternatives considered on the Portland region. Because the financing results are developed as ranges, the net effects are presented as a set of ranges as well. Perhaps the most significant result is that the net effect is negative for all of the remedial alternatives. That is, the negative financing impacts are greater than the positive expenditure impacts.

These negative impacts are smaller than the financing impacts by themselves of course; but the general themes are similar to those for the individual financing cases.

Table 12. Economic Impacts of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Gross Regional Product (Million 2016$)										
Average Annual	-$18	-$49	-$28	-$74	-$36	-$93	-$39	-$99	-$71	-$178
Cumulative (3% DR)	-$381	-$815	-$575	-$1,233	-$747	-$1,544	-$821	-$1,648	-$1,432	-$3,030
Personal Income (Million 2016$)										
Average Annual	-$13	-$39	-$20	-$59	-$26	-$73	-$29	-$78	-$53	-$142
Cumulative (3% DR)	-$261	-$632	-$401	-$962	-$528	-$1,206	-$585	-$1,289	-$1,027	-$2,388
Total Employment (Jobs/Job-Years)										
Average Annual	-110	-340	-170	-510	-230	-640	-250	-680	-460	-1,250
Cumulative	-3,430	-10,430	-5,290	-15,780	-7,020	-19,810	-7,800	-21,180	-14,150	-38,860
Population (Persons/Person-Years)										
Average Annual	-290	-470	-440	-710	-570	-890	-620	-950	-1,100	-1,750
Cumulative	-9,010	-14,540	-13,770	-22,150	-17,690	-27,690	-19,270	-29,530	-34,160	-54,220

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.
Source: NERA calculations as explained in text.

a. Differences across Remedial Alternatives

The potential net losses from the combined case would be substantially greater for the more expensive remedial alternatives. Based upon the maximum jobs impacts, for example, the loss ranges from about 340 jobs per year for alternative B to 1,250 jobs per year for alternative F; the corresponding cumulative values are about 10,430 job-years for alternative B and about 38,860 job-years for alternative F. EPA's preferred alternative I is projected to result in a loss of 640 jobs per year and 19,810 cumulative job-years over the 31-year period.

The same trend toward greater losses for the more expensive alternatives is evident in the other measures of regional impacts. In terms of GRP for the maximum values, alternative B would result in a loss of about $49 million per year (or a cumulative value of about $815 million over the period), compared to about $178 million per year (or a cumulative value of about $3 billion) for alternative F. EPA's alternative I would result in a loss of $93 million per year or a cumulative value of about $1.5 billion over the period.

b. Differences within Remedial Alternatives

The maximum values for each case are substantially greater than the minimum values for categories other than population, for which the range is smaller. Indeed, the ratio of the maximum value to the minimum value is even greater than for the financing cases. In the case of GRP impacts due to alternative B, for example, the minimum value is an average annual loss of about $18 million per year and the maximum value is an average annual loss of about $49 million per year, a ratio of about 2.7. These values translate into cumulative losses of between about $381 million and $815 million over the 31-year period. Employment ranges for alternative B are similar, ranging from about a minimum of 110 jobs per year to a maximum of about 340 jobs per year. The cumulative values are losses of about 3,430 job-years and about 10,430 job-years.

D. Impacts on Portland Region Sectors and Wage Groups

1. Sector Results

Although remediation expenditures are largely concentrated in just a few sectors (e.g., construction, waste management, etc.), the economic impacts of EPA's remedial alternatives are widespread. Table 13 shows the full effects (on an average annual basis) of the five EPA alternatives on Portland regional employment by sector. In nearly every sector, the net effect of the EPA alternatives on jobs is negative (i.e., the negative impact of local business and government financing burdens on average annual jobs is greater than the positive impact of remediation expenditures). Effects on government employment are particularly large under financing cases which assume large decreases in government spending (rather than increases in taxes); for alternative F, for example, the maximum negative impact on government employment is 430 jobs per year.

Table 13. Employment Impacts by Sector of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Forestry, Fishing, and Related Activities	0	-10	-10	-10	-10	-10	-10	-10	-10	-20
Mining	0	0	0	0	0	0	0	0	0	0
Utilities	0	0	0	0	0	0	0	0	0	0
Construction	0	-20	0	-30	0	-40	0	-40	10	-80
Manufacturing	-10	-20	-20	-30	-20	-30	-30	-40	-50	-70
Wholesale Trade	-10	-10	-10	-10	-10	-10	-10	-20	-20	-30
Retail Trade	-20	-30	-30	-50	-40	-60	-40	-70	-70	-120
Transportation and Warehousing	-20	-30	-20	-40	-30	-50	-30	-50	-50	-80
Information	0	0	0	0	0	0	0	-10	-10	-10
Finance and Insurance	-10	-10	-10	-10	-10	-10	-10	-20	-20	-30
Real Estate and Rental and Leasing	-10	-10	-10	-20	-10	-20	-10	-20	-20	-40
Professional, Scientific, and Technical Services	30	20	40	20	40	10	40	10	40	-10
Management of Companies and Enterprises	0	0	0	0	0	0	0	0	-10	-10
Administrative and Waste Management Services	0	-10	0	-20	0	-20	0	-20	0	-40
Educational Services	0	0	-10	-10	-10	-10	-10	-10	-10	-20
Health Care and Social Assistance	-20	-30	-30	-50	-40	-60	-40	-70	-80	-120
Arts, Entertainment, and Recreation	0	0	-10	-10	-10	-10	-10	-10	-10	-20
Accommodation and Food Services	-10	-20	-20	-30	-20	-30	-20	-40	-40	-70
Other Services, except Public Administration	-10	-20	-20	-30	-20	-30	-20	-40	-40	-60
Total Government Employment	-10	-130	-20	-190	-30	-230	-30	-240	-60	-430
Farm Employment	0	0	0	0	0	0	0	0	0	0
Total	-110	-340	-170	-510	-230	-640	-250	-680	-460	-1,250

Note: Rows may not sum to totals due to rounding.
Source: NERA calculations as explained in text.

2. Wage Group Results

The sector employment effects of EPA's remedial alternatives can be categorized in terms of wage groups based upon average annual wage rates. Table 14 shows estimates of the range of average annual job losses divided into jobs in low-wage, medium-wage, and high-wage sectors.

Regardless of the various financing assumptions, the EPA alternatives disproportionately affect high-wage jobs in the Portland region; for alternative B, for example, the average annual loss in high-wage jobs ranges from about 40 to 160, while total losses range from about 110 to 340. Thus, the high-wage jobs represent between roughly 40 percent and 50 percent of total losses, as shown in Table 15 (and generally consistent across all alternatives and cases).

Table 14. Employment Impacts by Wage Group of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Low-wage	-20	-30	-30	-50	-40	-60	-50	-70	-80	-130
Medium-wage	-40	-140	-70	-210	-100	-270	-120	-290	-220	-550
High-wage	-40	-160	-70	-240	-80	-300	-90	-320	-160	-570
Total	-110	-340	-170	-510	-230	-640	-250	-680	-460	-1,250

Note: Low-wage jobs correspond to jobs in sectors with average annual incomes less than or equal to $30,000; medium-wage jobs correspond to jobs in sectors with average annual incomes greater than $30,000 and less than or equal to $80,000; high-wage jobs correspond to jobs in sectors with average annual incomes greater than $80,000. Rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

Table 15. Employment Impacts by Wage Group of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (% Total)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Low-wage	19%	10%	19%	10%	18%	10%	18%	10%	17%	10%
Medium-wage	40%	41%	42%	42%	45%	42%	46%	43%	48%	44%
High-wage	40%	49%	39%	48%	37%	47%	36%	47%	34%	46%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Note: Low-wage jobs correspond to jobs in sectors with average annual incomes less than or equal to $30,000; medium-wage jobs correspond to jobs in sectors with average annual incomes greater than $30,000 and less than or equal to $80,000; high-wage jobs correspond to jobs in sectors with average annual incomes greater than $80,000. Rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

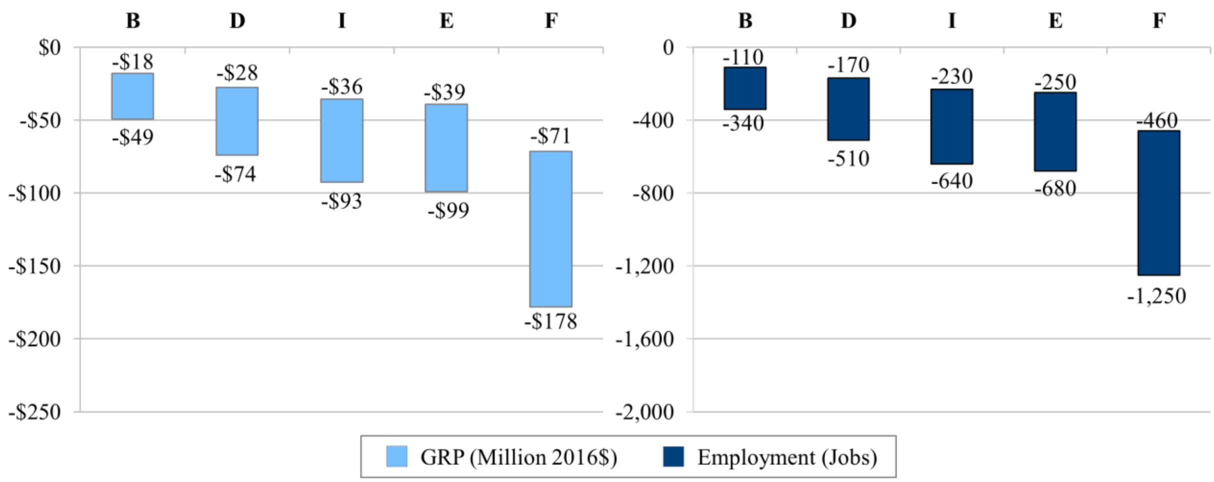
IV. Summary and Conclusions

This chapter summarizes the major results of this study, including an overview of major quantitative results and a summary of the major conclusions of the study. [21]

A. Estimated Impacts of EPA Remedial Alternatives on the Portland Regional Economy

Figure 4 summarizes the estimated average annual impacts of the EPA remedial alternatives on the Portland MSA economy, as measured by GRP and employment. The figure shows that all five EPA alternatives are projected to lead to net losses to the Portland regional economy. The figure also shows that there is a range of potential impacts based on uncertainties in how expenditures would be financed by local governments and businesses.

Figure 4. Economic Impacts of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA



Source: NERA calculations as explained in text.

These results provide indications of how losses increase with the specific EPA alternative and also of how sensitive the results are to uncertainties in the financing of expenditures. In the case of GRP impacts, for example, the maximum average annual impact (as measured by the maximum value) ranges from a loss of about $49 million per year for alternative B to a loss of about $178 million per year for alternative F. For alternative I, the range of potential impacts is from an average annual loss of $36 million to an average annual loss of $93 million.

[21] See Appendix H for a discussion of conclusions related to our qualitative assessment of potential impacts on riverfront businesses.

B. Conclusions Regarding Impacts of EPA Remedial Alternatives on the Portland Regional Economy

The following is a list of the principal conclusions regarding the economic impacts of the EPA alternatives:

1. *All EPA alternatives lead to net losses to the Portland regional economy*. Our estimates indicate that the negative impacts of financing outweigh the positive impacts of regional expenditures for all of the five EPA alternatives. These negative impacts are reflected in net losses in jobs, GRP, personal income, and population.

2. *Losses to the Portland regional economy are substantially greater for the more expensive EPA alternatives*. The estimated (maximum) average annual job loss is 1,250 jobs for alternative F, compared to 340 jobs for alternative B; for GRP, the corresponding range is from $178 million per year for alternative F compared to $49 million per year for alternative B.

3. *The size of the negative impacts is uncertain*. Uncertainties in how costs would be financed lead to substantial ranges in estimated impacts. For example, the average estimated annual loss for alternative I ranges from 230 jobs to 640 jobs per year.

4. *Almost all sectors of the Portland regional economy are negatively affected*. Multiplier effects lead to negative impacts on virtually all sectors of the Portland regional economy, particularly under the more expensive remedial alternatives.

5. *Losses are concentrated in relatively high-wage sectors.* Roughly 40 percent of the estimated job losses due to the EPA alternatives are projected to be in relatively high-wage sectors.

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Appendix A: Overview of the REMI PI+ Model

This overview is based on text prepared by Regional Economic Models, Inc. More detailed information is available from REMI PI+.[22]

REMI PI+ is a structural economic forecasting and policy analysis model. It integrates input-output, computable general equilibrium, econometric, and economic geography methodologies. The model is dynamic, with forecasts and simulations generated on an annual basis and behavioral responses to compensation, price, and other economic factors.

The model consists of thousands of simultaneous equations with a structure that is relatively straightforward. The exact number of equations used varies depending on the extent of industry, demographic, demand, and other detail in the specific model being used. The overall structure of the model can be summarized in five major blocks: (1) Output and Demand, (2) Labor and Capital Demand, (3) Population and Labor Supply, (4) Compensation, Prices, and Costs, and (5) Market Shares.

The Output and Demand block consists of output, demand, consumption, investment, government spending, exports, and imports, as well as feedback from output change due to the change in the productivity of intermediate inputs. The Labor and Capital Demand block includes labor intensity and productivity as well as demand for labor and capital. Labor force participation rate and migration equations are in the Population and Labor Supply block. The Compensation, Prices, and Costs block includes composite prices, determinants of production costs, the consumption price deflator, housing prices, and the compensation equations. The proportion of local, inter-regional, and export markets captured by each region is included in the Market Shares block.

Models can be built as single region, multi-region, or multi-region national models. A region is defined broadly as a sub-national area, and could consist of a state, province, county, or city, or any combination of sub-national areas.

Single-region models consist of an individual region, called the home region. The rest of the nation is also represented in the model. However, since the home region is only a small part of the total nation, the changes in the region do not have an endogenous effect on the variables in the rest of the nation.

Multiregional national models also include a central bank monetary response that constrains labor markets. Models that only encompass a relatively small portion of a nation are not endogenously constrained by changes in exchange rates or monetary responses.

The following sub-sections describe the five blocks of the REMI PI+ model in more depth.

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[22] See http://www.remi.com/index.php?page=documentation&hl=en_US.

A. Block 1: Output and Demand

This block includes output, demand, consumption, investment, government spending, import, commodity access, and export concepts. Output for each industry in the home region is determined by industry demand in all regions in the nation, the home region's share of each market, and international exports from the region.

For each industry, demand is determined by the amount of output, consumption, investment, and capital demand on that industry. Consumption depends on real disposable income per capita, relative prices, differential income elasticities, and population. Input productivity depends on access to inputs because a larger choice set of inputs means it is more likely that the input with the specific characteristics required for the job will be found. In the capital stock adjustment process, investment occurs to fill the difference between optimal and actual capital stock for residential, non-residential, and equipment investment. Government spending changes are determined by changes in the population.

B. Block 2: Labor and Capital Demand

The Labor and Capital Demand block includes the determination of labor productivity, labor intensity, and the optimal capital stocks. Industry-specific labor productivity depends on the availability of workers with differentiated skills for the occupations used in each industry. The occupational labor supply and commuting costs determine firms' access to a specialized labor force.

Labor intensity is determined by the cost of labor relative to the other factor inputs, capital and fuel. Demand for capital is driven by the optimal capital stock equation for both non-residential capital and equipment. Optimal capital stock for each industry depends on the relative cost of labor and capital, and the employment weighted by capital use for each industry. Employment in private industries is determined by the value added and employment per unit of value added in each industry.

C. Block 3: Population and Labor Supply

The Population and Labor Supply block includes detailed demographic information about the region. Population data is given for age, gender, and ethnic category, with birth and survival rates for each group. The size and labor force participation rate of each group determines the labor supply. These participation rates respond to changes in employment relative to the potential labor force and to changes in the real after-tax compensation rate. Migration includes retirement, military, international, and economic migration. Economic migration is determined by the relative real after-tax compensation rate, relative employment opportunity, and consumer access to variety.

D. Block 4: Compensation, Prices, and Costs

This block includes delivered prices, production costs, equipment cost, the consumption deflator, consumer prices, the price of housing, and the compensation equation. Economic geography concepts account for the productivity and price effects of access to specialized labor, goods, and services.

These prices measure the price of the industry output, taking into account the access to production locations. This access is important due to the specialization of production that takes place within each industry, and because transportation and transaction costs of distance are significant. Composite prices for each industry are then calculated based on the production costs of supplying regions, the effective distance to these regions, and the index of access to the variety of outputs in the industry relative to the access by other uses of the product.

The cost of production for each industry is determined by the cost of labor, capital, fuel, and intermediate inputs. Labor costs reflect a productivity adjustment to account for access to specialized labor, as well as underlying compensation rates. Capital costs include costs of non-residential structures and equipment, while fuel costs incorporate electricity, natural gas, and residual fuels.

The consumption deflator converts industry prices to prices for consumption commodities. For potential migrants, the consumer price is additionally calculated to include housing prices. Housing prices change from their initial level depending on changes in income and population density.

Compensation changes are due to changes in labor demand and supply conditions and changes in the national compensation rate. Changes in employment opportunities relative to the labor force and occupational demand change determine compensation rates by industry.

E. Block 5: Market Shares

The equations in the Market Shares block measure the proportion of local and export markets that are captured by each industry. These depend on relative production costs, the estimated price elasticity of demand, and the effective distance between the home region and each of the other regions. The change in share of a specific area in any region depends on changes in its delivered price and the quantity it produces compared with the same factors for competitors in that market. The share of local and external markets then drives the exports from and imports to the home economy.

Appendix B: REMI PI+ Baseline Forecasts

This appendix provides an overview of selected REMI PI+ baseline forecasts for the Portland MSA. Specifically, in Table B-1 we display the REMI PI+ baseline forecasted levels of gross regional product, employment and personal income for the years 2015, 2020, and 2050. (The REMI PI+ baseline includes annual forecasts; we provide selected years as a summary.) All of the changes to the variables that we provide in this report are changes to these REMI PI+ baseline forecasts.

Table B-1. Selected REMI PI+ Baseline Forecast Levels for the Portland Metropolitan Statistical Area

	Portland MSA		
	2016	**2020**	**2050**
Gross Regional/State Product (Billion 2015$)	$152	$169	$321
Personal Income (Billion 2015$)	$116	$131	$242
Total Employment (Thousand Jobs)	1,473	1,506	1,763
Population (Thousand Persons)	2,400	2,505	3,062

Note: Portland MSA corresponds to the sum of three REMI sub-regions: City of Portland, Rest of MSA in Oregon, and Rest of MSA in Washington.

Source: REMI PI+

Appendix C: Detailed Expenditure Data and Modeling Assumptions

This appendix provides details on the data and assumptions supporting the modeling of the expenditure impacts of EPA's remedial alternatives. (Note that alternative expenditure and impact estimates using AECOM costs are provided in Appendix F.)

A. EPA Remedial Alternative Expenditures

Expenditure information for the EPA alternatives is obtained from EPA's FS (EPA (2016a)). Remediation timing assumptions are based upon EPA's 31-year remediation schedule, summarized in terms of EPA's general cost categories in Table C-1. NERA assumes the remediation period begins in 2020 (i.e., year zero in Table C-1 corresponds to 2020).

Table C-1. EPA Alternative Timing by Cost Category (Years of Activity)

	EPA Alternative				
	B	**D**	**I**	**E**	**F**
Technology Assignments Measures Capital Construction Costs	0 - 3	0 - 5	0 - 6	0 - 6	0 - 12
Institutional Controls Capital Costs	0 - 3	0 - 5	0 - 6	0 - 6	0 - 12
MNR Capital Costs	0	0	0	0	0
Site-Wide Monitoring and MNR Periodic Costs	2, 4, 6, 8, 10, 14, 18, 22, 26, 30	2, 4, 6, 8, 10, 14, 18, 22, 26, 30	2, 4, 6, 8, 10, 14, 18, 22, 26, 30	2, 4, 6, 8, 10, 14, 18, 22, 26, 30	2, 4, 6, 8, 10, 14, 18, 22, 26, 30
Long Term O&M Periodic Costs	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30
Institutional Controls Periodic Costs	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30
5-Year Site Review Periodic Costs	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30

Source: EPA (2016a)

Table C-2 summarizes annual and total remediation expenditures by EPA's remedial alternatives.

Table C-2. EPA Alternative Expenditures (Thousand 2016$)

	EPA Alternative				
Year	**B**	**D**	**I**	**E**	**F**
2020	$96,209	$101,401	$116,077	$126,773	$133,415
2021	$85,296	$90,920	$105,880	$116,782	$124,666
2022	$112,040	$127,294	$144,306	$154,249	$174,165
2023	$85,296	$90,920	$105,880	$116,782	$124,666
2024	$26,744	$127,294	$144,306	$154,249	$174,165
2025	$3,814	$96,468	$112,161	$123,059	$133,754
2026	$26,744	$36,374	$144,306	$154,249	$174,165
2027	$0	$0	$0	$0	$124,666
2028	$26,744	$36,374	$38,426	$37,467	$174,165
2029	$0	$0	$0	$0	$124,666
2030	$30,558	$41,922	$44,707	$43,744	$183,253
2031	$0	$0	$0	$0	$124,666
2032	$0	$0	$0	$0	$124,666
2033	$0	$0	$0	$0	$0
2034	$26,744	$36,374	$38,426	$37,467	$49,499
2035	$3,814	$5,548	$6,281	$6,277	$9,088
2036	$0	$0	$0	$0	$0
2037	$0	$0	$0	$0	$0
2038	$26,744	$36,374	$38,426	$37,467	$49,499
2039	$0	$0	$0	$0	$0
2040	$3,814	$5,548	$6,281	$6,277	$9,088
2041	$0	$0	$0	$0	$0
2042	$26,744	$36,374	$38,426	$37,467	$49,499
2043	$0	$0	$0	$0	$0
2044	$0	$0	$0	$0	$0
2045	$3,814	$5,548	$6,281	$6,277	$9,088
2046	$26,744	$36,374	$38,426	$37,467	$49,499
2047	$0	$0	$0	$0	$0
2048	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0
2050	$30,558	$41,922	$44,707	$43,744	$58,587
Total	$642,419	$953,029	$1,173,303	$1,239,801	$2,178,923

Note: Shaded areas correspond to EPA's construction duration for each alternative; undiscounted totals over 31-year period (2020-2050).

Source: EPA (2016a)

B. EPA Remedial Alternative Expenditures as Inputs to REMI PI+

In order to input the expenditures associated with remediation activities under the EPA alternatives into the REMI PI+ model, expenditures must first be assigned to the appropriate sectors, variables, and regions.

While EPA generally summarizes remediation activities as corresponding to the categories in Table C-1, expenditure estimates for each alternative are in fact based upon detailed engineering cost estimates. Appendix G to EPA's FS provides a series of tables, or "cost worksheets," providing details on each individual cost item associated with the various remedial alternatives (i.e., description, unit cost, quantity, total cost). We develop a database of EPA costs by alternative based upon the cost worksheets. We rely upon this database, as well as other information provided in the FS and FS appendices, in order to assign costs to sectors and variables and to model regions.

1. Expenditures by REMI PI+ Sectors and Variables

Individual cost items are assigned to one or more REMI PI+ sectors based upon EPA's descriptions of the nature of each cost and the sector definitions in REMI's 70 sector PI+ model. Table C-3 provides an overview of the amount and share of expenditures assigned to various REMI sectors.

Table C-3. EPA Alternative Expenditures by REMI PI+ Sector (Thousand 2016$)

	Expenditures					Percent of Total				
REMI Sector	**B**	**D**	**I**	**E**	**F**	**B**	**D**	**I**	**E**	**F**
Administrative and support services	$270	$357	$451	$443	$569	0%	0%	0%	0%	0%
Construction	$113,422	$152,041	$195,765	$209,263	$354,228	18%	16%	17%	17%	16%
Management of companies and enterprises	$1,391	$1,391	$1,391	$1,391	$1,391	0%	0%	0%	0%	0%
Nonmetallic mineral product manufacturing	$67,938	$103,548	$119,370	$121,253	$191,289	11%	11%	10%	10%	9%
Plastics and rubber product manufacturing	$442	$743	$872	$850	$1,302	0%	0%	0%	0%	0%
Printing and related support activities	$102	$102	$102	$102	$102	0%	0%	0%	0%	0%
Professional, scientific, and technical services	$270,478	$372,360	$396,907	$388,077	$522,839	42%	39%	34%	31%	24%
Rail transportation	$3	$3	$3	$3	$3	0%	0%	0%	0%	0%
Real estate	$2,597	$3,868	$4,503	$4,503	$8,317	0%	0%	0%	0%	0%
Rental and leasing services; Lessors of nonfinancial intangible assets	$30	$52	$58	$58	$92	0%	0%	0%	0%	0%
Truck transportation	$6,762	$6,762	$6,762	$6,762	$6,762	1%	1%	1%	1%	0%
Waste management and remediation services	$98,092	$131,508	$164,178	$175,753	$302,634	15%	14%	14%	14%	14%
Water transportation	$13,831	$25,730	$37,976	$43,741	$98,405	2%	3%	3%	4%	5%
N/A*	$67,062	$154,567	$244,964	$287,603	$690,990	10%	16%	21%	23%	32%
Total	$642,419	$953,029	$1,173,303	$1,239,801	$2,178,923	100%	100%	100%	100%	100%

Notes: *Expenditures associated with waste disposal at Subtitle D Facility (Roosevelt Regional Landfill) are located outside the Portland region (and REMI PI+ model footprint) in Washington State; IC—institutional controls; MNR—monitored natural recovery; Tech Assignment—technology assignment measures (e.g., capping, dredging); undiscounted totals over 31-year period (2020-2050).

Source: EPA (2016a) and NERA calculations as explained in text.

Expenditures are generally input as increases in exogenous final demand within a given sector and are subject to the associated regional purchase coefficients ("RPCs") within that sector; however, certain demands associated with remediation activities, based upon the nature of those activities, would be met exclusively by local industry (e.g., waste disposal at an existing waste management facility specified by EPA). In this case, expenditures are input as increases in industry sales. Table C-3 summarizes expenditures for the EPA alternatives by EPA cost category and REMI PI+ variable and sector. Note that the REMI PI+ model establishes RPCs on an average basis at the sector level and does not take into account the possibility that certain activities within a sector could require highly specialized labor from outside the region (e.g., specialists in dredging). Thus, the REMI PI+ results might overstate the RPCs and thus the potential positive impacts of remediation expenditures in the Portland MSA.

Table C-4. EPA Alternative Expenditures by EPA Cost Category and REMI PI+ Variable and Sector (Thousand 2016$)

			EPA Alternative				
EPA Cost Category	**REMI Variable**	**REMI Sector**	**B**	**D**	**I**	**E**	**F**
IC Capital Costs	Final Demand	Administrative and support services	$111	$166	$225	$220	$300
		Construction	$116	$145	$174	$172	$214
		Management of companies and enterprises	$523	$523	$523	$523	$523
		Plastics and rubber product manufacturing	$51	$89	$100	$98	$158
		Printing and related support activities	$11	$11	$11	$11	$11
		Professional, scientific, and technical services	$1,652	$2,141	$2,659	$2,616	$3,329
		Water transportation	$13	$22	$25	$24	$39
		Rental and leasing services; Lessors of nonfinancial intangible assets	$4	$8	$9	$9	$14
MNR Capital Costs	Final Demand	Construction	$3,118	$2,995	$2,913	$2,855	$2,500
		Professional, scientific, and technical services	$7,795	$7,486	$7,283	$7,137	$6,249
Tech Assignment Capital Costs	Final Demand	Construction	$88,655	$126,702	$169,922	$183,620	$327,706
		Nonmetallic mineral product manufacturing	$55,089	$83,747	$97,226	$99,289	$158,996
		Plastics and rubber product manufacturing	$75	$108	$152	$143	$182
		Professional, scientific, and technical services	$6,633	$9,582	$11,927	$12,557	$22,346
		Real estate	$2,597	$3,868	$4,503	$4,503	$8,317
		Truck transportation	$6,758	$6,758	$6,758	$6,758	$6,758
		Waste management and remediation services	$47,039	$80,454	$113,125	$124,699	$251,581
		Water transportation	$13,742	$25,579	$37,807	$43,575	$98,140
	Industry Sales	Waste management and remediation services	$51,053	$51,053	$51,053	$51,053	$51,053
	N/A*	N/A*	$67,062	$154,567	$244,964	$287,603	$690,990
Site-Wide Monitoring and MNR Periodic Costs	Final Demand	Construction	$18,340	$17,615	$17,137	$16,792	$14,704
		Professional, scientific, and technical services	$249,095	$346,125	$367,123	$357,883	$480,287
Long Term O&M Periodic Costs	Final Demand	Construction	$3,193	$4,585	$5,619	$5,825	$9,104
		Nonmetallic mineral product manufacturing	$12,848	$19,800	$22,144	$21,964	$32,294
		Plastics and rubber product manufacturing	$22	$34	$47	$43	$56
		Professional, scientific, and technical services	$2,409	$3,663	$4,172	$4,175	$6,218
IC Periodic Costs		Administrative and support services	$74	$105	$140	$137	$183
		Management of companies and enterprises	$513	$513	$513	$513	$513
		Plastics and rubber product manufacturing	$294	$511	$573	$565	$906
		Printing and related support activities	$90	$90	$90	$90	$90
		Professional, scientific, and technical services	$1,495	$1,963	$2,345	$2,311	$3,010
		Rental and leasing services; Lessors of nonfinancial intangible assets	$26	$44	$50	$49	$79
		Water Transportation	$73	$126	$141	$139	$223
5-Year Site Review Periodic Costs	Final Demand	Administrative and support services	$86	$86	$86	$86	$86
		Management of companies and enterprises	$355	$355	$355	$355	$355
		Professional, scientific, and technical services	$1,399	$1,399	$1,399	$1,399	$1,399
		Rail transportation	$3	$3	$3	$3	$3
		Truck transportation	$4	$4	$4	$4	$4
		Water transportation	$3	$3	$3	$3	$3
Total			$642,419	$953,029	$1,173,303	$1,239,801	$2,178,923

Notes: *Expenditures associated with waste disposal at Subtitle D Facility (Roosevelt Regional Landfill) are located outside the Portland region (and REMI PI+ model footprint) in Washington State; IC—institutional controls; MNR—monitored natural recovery; Tech Assignment—technology assignment measures (e.g., capping, dredging); undiscounted totals over 31-year period (2020-2050).

Source: EPA (2016a) and NERA calculations as explained in text.

2. Expenditures by REMI PI+ Model Regions

The vast majority of remedial expenditures are associated with activities occurring at the Superfund Site and within the City of Portland; however, three general categories of expenditures related to disposed material management are assumed to occur outside the City of Portland.

1. Activities at Transload Facility. Transloading is the process by which dredged materials are transferred from one mode of transportation to another before being hauled to a final disposal facility. Transloading will occur at a designated transload facility. For purposes

of developing cost estimate, EPA assumes the transload facility will be located off-site in the state of Oregon (and outside the Portland MSA). As such, we assign all expenditures associated with activities that are expected to occur at the transload facility (e.g., facility development and permitting, offloading of sediments, dewatering and water treatment, loading trucks, etc.) to the Rest of Oregon State REMI PI+ model region.

2. Disposal at Subtitle D Facility. EPA assumes waste suitable for disposal in a Subtitle D facility will be disposed of at the Roosevelt Regional Landfill in in Roosevelt, WA. This facility is located outside our REMI PI+ model region; therefore, expenditures associated with waste disposal at this facility are excluded from the modeling.

3. Disposal at Subtitle C Facility. EPA assumes waste not suitable for disposal in a Subtitle D facility will be disposed of at Chemical Waste Management of the Northwest in Arlington, OR. This facility is located in the Rest of Oregon State region, and expenditures associated with waste disposal at this facility are included in this region.

Tables C-5 through C-9 provide expenditures by EPA cost category and REMI PI+ variable, sector, and region for EPA alternatives B through E. As described, most costs occur at the Site within the City of Portland, and certain costs associated with disposed material management occur either in the Rest of Oregon State region or outside the Region.

Table C-5. EPA Alternative B Remediation Expenditures by EPA Cost Category and REMI PI+ Variable, Sector, and Region (Thousand 2016$)

			REMI Region					
EPA Cost Category	REMI Variable	REMI Sector	City of Portland	Rest of MSA: OR	Rest of MSA: WA	Rest of OR State	Outside Region	Total
IC Capital Costs	Final Demand	Administrative and support services	$111	$0	$0	$0	$0	$111
		Construction	$116	$0	$0	$0	$0	$116
		Management of companies and enterprises	$523	$0	$0	$0	$0	$523
		Plastics and rubber product manufacturing	$51	$0	$0	$0	$0	$51
		Printing and related support activities	$11	$0	$0	$0	$0	$11
		Professional, scientific, and technical services	$1,652	$0	$0	$0	$0	$1,652
		Water transportation	$13	$0	$0	$0	$0	$13
		Rental and leasing services; Lessors of nonfinancial intangible assets	$4	$0	$0	$0	$0	$4
MNR Capital Costs	Final Demand	Construction	$3,118	$0	$0	$0	$0	$3,118
		Professional, scientific, and technical services	$7,795	$0	$0	$0	$0	$7,795
Tech Assignment Capital Costs	Final Demand	Construction	$77,075	$0	$0	$11,580	$0	$88,655
		Nonmetallic mineral product manufacturing	$48,555	$0	$0	$6,534	$0	$55,089
		Plastics and rubber product manufacturing	$75	$0	$0	$0	$0	$75
		Professional, scientific, and technical services	$3,267	$0	$0	$3,366	$0	$6,633
		Real estate	$0	$0	$0	$2,597	$0	$2,597
		Truck transportation	$130	$0	$0	$6,627	$0	$6,758
		Waste management and remediation services	$42,252	$0	$0	$4,786	$0	$47,039
		Water transportation	$3,436	$0	$0	$10,307	$0	$13,742
	Industry Sales	Waste management and remediation services	$0	$0	$0	$51,053	$0	$51,053
	N/A*	N/A*	$0	$0	$0	$0	$67,062	$67,062
Site-Wide Monitoring and MNR Periodic Costs	Final Demand	Construction	$18,340	$0	$0	$0	$0	$18,340
		Professional, scientific, and technical services	$249,095	$0	$0	$0	$0	$249,095
Long Term O&M Periodic Costs	Final Demand	Construction	$3,193	$0	$0	$0	$0	$3,193
		Nonmetallic mineral product manufacturing	$12,848	$0	$0	$0	$0	$12,848
		Plastics and rubber product manufacturing	$22	$0	$0	$0	$0	$22
		Professional, scientific, and technical services	$2,409	$0	$0	$0	$0	$2,409
IC Periodic Costs	Final Demand	Administrative and support services	$74	$0	$0	$0	$0	$74
		Management of companies and enterprises	$513	$0	$0	$0	$0	$513
		Plastics and rubber product manufacturing	$294	$0	$0	$0	$0	$294
		Printing and related support activities	$90	$0	$0	$0	$0	$90
		Professional, scientific, and technical services	$1,495	$0	$0	$0	$0	$1,495
		Rental and leasing services; Lessors of nonfinancial intangible assets	$26	$0	$0	$0	$0	$26
		Water Transportation	$73	$0	$0	$0	$0	$73
5-Year Site Review Periodic Costs	Final Demand	Administrative and support services	$86	$0	$0	$0	$0	$86
		Management of companies and enterprises	$355	$0	$0	$0	$0	$355
		Professional, scientific, and technical services	$1,399	$0	$0	$0	$0	$1,399
		Rail transportation	$3	$0	$0	$0	$0	$3
		Truck transportation	$4	$0	$0	$0	$0	$4
		Water transportation	$3	$0	$0	$0	$0	$3
Total			$478,507	$0	$0	$96,850	$67,062	$642,419

Notes: *Expenditures associated with waste disposal at Subtitle D Facility (Roosevelt Regional Landfill) are located outside the Portland region (and REMI PI+ model footprint) in Washington State; IC—institutional controls; MNR—monitored natural recovery; Tech Assignment—technology assignment measures (e.g., capping, dredging); undiscounted totals over 31-year period (2020-2050).

Source: EPA (2016a) and NERA calculations as explained in text.

Table C-6. EPA Alternative D Remediation Expenditures by EPA Cost Category and REMI PI+ Variable, Sector, and Region (Thousand 2016$)

			REMI Region					
EPA Cost Category	REMI Variable	REMI Sector	City of Portland	Rest of MSA: OR	Rest of MSA: WA	Rest of OR State	Outside Region	Total
IC Capital Costs	Final Demand	Administrative and support services	$166	$0	$0	$0	$0	$166
		Construction	$145	$0	$0	$0	$0	$145
		Management of companies and enterprises	$523	$0	$0	$0	$0	$523
		Plastics and rubber product manufacturing	$89	$0	$0	$0	$0	$89
		Printing and related support activities	$11	$0	$0	$0	$0	$11
		Professional, scientific, and technical services	$2,141	$0	$0	$0	$0	$2,141
		Water transportation	$22	$0	$0	$0	$0	$22
		Rental and leasing services; Lessors of nonfinancial intangible assets	$8	$0	$0	$0	$0	$8
MNR Capital Costs	Final Demand	Construction	$2,995	$0	$0	$0	$0	$2,995
		Professional, scientific, and technical services	$7,486	$0	$0	$0	$0	$7,486
Tech Assignment Capital Costs	Final Demand	Construction	$112,719	$0	$0	$13,982	$0	$126,702
		Nonmetallic mineral product manufacturing	$71,733	$0	$0	$12,014	$0	$83,747
		Plastics and rubber product manufacturing	$108	$0	$0	$0	$0	$108
		Professional, scientific, and technical services	$5,055	$0	$0	$4,527	$0	$9,582
		Real estate	$0	$0	$0	$3,868	$0	$3,868
		Truck transportation	$130	$0	$0	$6,627	$0	$6,758
		Waste management and remediation services	$74,314	$0	$0	$6,140	$0	$80,454
		Water transportation	$6,395	$0	$0	$19,184	$0	$25,579
	Industry Sales	Waste management and remediation services	$0	$0	$0	$51,053	$0	$51,053
	N/A*	N/A*	$0	$0	$0	$0	$154,567	$154,567
Site-Wide Monitoring and MNR Periodic Costs	Final Demand	Construction	$17,615	$0	$0	$0	$0	$17,615
		Professional, scientific, and technical services	$346,125	$0	$0	$0	$0	$346,125
Long Term O&M Periodic Costs	Final Demand	Construction	$4,585	$0	$0	$0	$0	$4,585
		Nonmetallic mineral product manufacturing	$19,800	$0	$0	$0	$0	$19,800
		Plastics and rubber product manufacturing	$34	$0	$0	$0	$0	$34
		Professional, scientific, and technical services	$3,663	$0	$0	$0	$0	$3,663
IC Periodic Costs	Final Demand	Administrative and support services	$105	$0	$0	$0	$0	$105
		Management of companies and enterprises	$513	$0	$0	$0	$0	$513
		Plastics and rubber product manufacturing	$511	$0	$0	$0	$0	$511
		Printing and related support activities	$90	$0	$0	$0	$0	$90
		Professional, scientific, and technical services	$1,963	$0	$0	$0	$0	$1,963
		Rental and leasing services; Lessors of nonfinancial intangible assets	$44	$0	$0	$0	$0	$44
		Water Transportation	$126	$0	$0	$0	$0	$126
5-Year Site Review Periodic Costs	Final Demand	Administrative and support services	$86	$0	$0	$0	$0	$86
		Management of companies and enterprises	$355	$0	$0	$0	$0	$355
		Professional, scientific, and technical services	$1,399	$0	$0	$0	$0	$1,399
		Rail transportation	$3	$0	$0	$0	$0	$3
		Truck transportation	$4	$0	$0	$0	$0	$4
		Water transportation	$3	$0	$0	$0	$0	$3
Total			$681,066	$0	$0	$117,397	$154,567	$953,029

Notes: *Expenditures associated with waste disposal at Subtitle D Facility (Roosevelt Regional Landfill) are located outside the Portland region (and REMI PI+ model footprint) in Washington State; IC—institutional controls; MNR—monitored natural recovery; Tech Assignment—technology assignment measures (e.g., capping, dredging); undiscounted totals over 31-year period (2020-2050).

Source: EPA (2016a) and NERA calculations as explained in text.

Table C-7. EPA Alternative I Remediation Expenditures by EPA Cost Category and REMI PI+ Variable, Sector, and Region (Thousand 2016$)

			REMI Region					
EPA Cost Category	REMI Variable	REMI Sector	City of Portland	Rest of MSA: OR	Rest of MSA: WA	Rest of OR State	Outside Region	Total
IC Capital Costs	Final Demand	Administrative and support services	$225	$0	$0	$0	$0	$225
		Construction	$174	$0	$0	$0	$0	$174
		Management of companies and enterprises	$523	$0	$0	$0	$0	$523
		Plastics and rubber product manufacturing	$100	$0	$0	$0	$0	$100
		Printing and related support activities	$11	$0	$0	$0	$0	$11
		Professional, scientific, and technical services	$2,659	$0	$0	$0	$0	$2,659
		Water transportation	$25	$0	$0	$0	$0	$25
		Rental and leasing services; Lessors of nonfinancial intangible assets	$9	$0	$0	$0	$0	$9
MNR Capital Costs	Final Demand	Construction	$2,913	$0	$0	$0	$0	$2,913
		Professional, scientific, and technical services	$7,283	$0	$0	$0	$0	$7,283
Tech Assignment Capital Costs	Final Demand	Construction	$153,583	$0	$0	$16,339	$0	$169,922
		Nonmetallic mineral product manufacturing	$79,550	$0	$0	$17,676	$0	$97,226
		Plastics and rubber product manufacturing	$152	$0	$0	$0	$0	$152
		Professional, scientific, and technical services	$6,638	$0	$0	$5,289	$0	$11,927
		Real estate	$0	$0	$0	$4,503	$0	$4,503
		Truck transportation	$130	$0	$0	$6,627	$0	$6,758
		Waste management and remediation services	$105,605	$0	$0	$7,520	$0	$113,125
		Water transportation	$9,452	$0	$0	$28,355	$0	$37,807
	Industry Sales	Waste management and remediation services	$0	$0	$0	$51,053	$0	$51,053
	N/A*	N/A*	$0	$0	$0	$0	$244,964	$244,964
Site-Wide Monitoring and MNR Periodic Costs	Final Demand	Construction	$17,137	$0	$0	$0	$0	$17,137
		Professional, scientific, and technical services	$367,123	$0	$0	$0	$0	$367,123
Long Term O&M Periodic Costs	Final Demand	Construction	$5,619	$0	$0	$0	$0	$5,619
		Nonmetallic mineral product manufacturing	$22,144	$0	$0	$0	$0	$22,144
		Plastics and rubber product manufacturing	$47	$0	$0	$0	$0	$47
		Professional, scientific, and technical services	$4,172	$0	$0	$0	$0	$4,172
IC Periodic Costs	Final Demand	Administrative and support services	$140	$0	$0	$0	$0	$140
		Management of companies and enterprises	$513	$0	$0	$0	$0	$513
		Plastics and rubber product manufacturing	$573	$0	$0	$0	$0	$573
		Printing and related support activities	$90	$0	$0	$0	$0	$90
		Professional, scientific, and technical services	$2,345	$0	$0	$0	$0	$2,345
		Rental and leasing services; Lessors of nonfinancial intangible assets	$50	$0	$0	$0	$0	$50
		Water Transportation	$141	$0	$0	$0	$0	$141
5-Year Site Review Periodic Costs	Final Demand	Administrative and support services	$86	$0	$0	$0	$0	$86
		Management of companies and enterprises	$355	$0	$0	$0	$0	$355
		Professional, scientific, and technical services	$1,399	$0	$0	$0	$0	$1,399
		Rail transportation	$3	$0	$0	$0	$0	$3
		Truck transportation	$4	$0	$0	$0	$0	$4
		Water transportation	$3	$0	$0	$0	$0	$3
Total			$790,975	$0	$0	$137,363	$244,964	$1,173,303

Notes: *Expenditures associated with waste disposal at Subtitle D Facility (Roosevelt Regional Landfill) are located outside the Portland region (and REMI PI+ model footprint) in Washington State; IC—institutional controls; MNR—monitored natural recovery; Tech Assignment—technology assignment measures (e.g., capping, dredging); undiscounted totals over 31-year period (2020-2050).

Source: EPA (2016) and NERA calculations as explained in text.

Table C-8. EPA Alternative E Remediation Expenditures by EPA Cost Category and REMI PI+ Variable, Sector, and Region (Thousand 2016$)

EPA Cost Category	REMI Variable	REMI Sector	REMI Region City of Portland	Rest of MSA: OR	Rest of MSA: WA	Rest of OR State	Outside Region	Total
IC Capital Costs	Final Demand	Administrative and support services	$220	$0	$0	$0	$0	$220
		Construction	$172	$0	$0	$0	$0	$172
		Management of companies and enterprises	$523	$0	$0	$0	$0	$523
		Plastics and rubber product manufacturing	$98	$0	$0	$0	$0	$98
		Printing and related support activities	$11	$0	$0	$0	$0	$11
		Professional, scientific, and technical services	$2,616	$0	$0	$0	$0	$2,616
		Water transportation	$24	$0	$0	$0	$0	$24
		Rental and leasing services; Lessors of nonfinancial intangible assets	$9	$0	$0	$0	$0	$9
MNR Capital Costs	Final Demand	Construction	$2,855	$0	$0	$0	$0	$2,855
		Professional, scientific, and technical services	$7,137	$0	$0	$0	$0	$7,137
Tech Assignment Capital Costs	Final Demand	Construction	$166,151	$0	$0	$17,469	$0	$183,620
		Nonmetallic mineral product manufacturing	$78,942	$0	$0	$20,347	$0	$99,289
		Plastics and rubber product manufacturing	$143	$0	$0	$0	$0	$143
		Professional, scientific, and technical services	$7,100	$0	$0	$5,458	$0	$12,557
		Real estate	$0	$0	$0	$4,503	$0	$4,503
		Truck transportation	$130	$0	$0	$6,627	$0	$6,758
		Waste management and remediation services	$116,470	$0	$0	$8,229	$0	$124,699
		Water transportation	$10,894	$0	$0	$32,681	$0	$43,575
	Industry Sales	Waste management and remediation services	$0	$0	$0	$51,053	$0	$51,053
	N/A*	N/A*	$0	$0	$0	$0	$287,603	$287,603
Site-Wide Monitoring and MNR Periodic Costs	Final Demand	Construction	$16,792	$0	$0	$0	$0	$16,792
		Professional, scientific, and technical services	$357,883	$0	$0	$0	$0	$357,883
Long Term O&M Periodic Costs	Final Demand	Construction	$5,825	$0	$0	$0	$0	$5,825
		Nonmetallic mineral product manufacturing	$21,964	$0	$0	$0	$0	$21,964
		Plastics and rubber product manufacturing	$43	$0	$0	$0	$0	$43
		Professional, scientific, and technical services	$4,175	$0	$0	$0	$0	$4,175
IC Periodic Costs	Final Demand	Administrative and support services	$137	$0	$0	$0	$0	$137
		Management of companies and enterprises	$513	$0	$0	$0	$0	$513
		Plastics and rubber product manufacturing	$565	$0	$0	$0	$0	$565
		Printing and related support activities	$90	$0	$0	$0	$0	$90
		Professional, scientific, and technical services	$2,311	$0	$0	$0	$0	$2,311
		Rental and leasing services; Lessors of nonfinancial intangible assets	$49	$0	$0	$0	$0	$49
		Water Transportation	$139	$0	$0	$0	$0	$139
5-Year Site Review Periodic Costs	Final Demand	Administrative and support services	$86	$0	$0	$0	$0	$86
		Management of companies and enterprises	$355	$0	$0	$0	$0	$355
		Professional, scientific, and technical services	$1,399	$0	$0	$0	$0	$1,399
		Rail transportation	$3	$0	$0	$0	$0	$3
		Truck transportation	$4	$0	$0	$0	$0	$4
		Water transportation	$3	$0	$0	$0	$0	$3
Total			$805,830	$0	$0	$146,368	$287,603	$1,239,801

Notes: *Expenditures associated with waste disposal at Subtitle D Facility (Roosevelt Regional Landfill) are located outside the Portland region (and REMI PI+ model footprint) in Washington State; IC—institutional controls; MNR—monitored natural recovery; Tech Assignment—technology assignment measures (e.g., capping, dredging); undiscounted totals over 31-year period (2020-2050).

Source: EPA (2016a) and NERA calculations as explained in text.

Table C-9. EPA Alternative F Remediation Expenditures by EPA Cost Category and REMI PI+ Variable, Sector, and Region (Thousand 2016$)

			REMI Region					
EPA Cost Category	REMI Variable	REMI Sector	City of Portland	Rest of MSA: OR	Rest of MSA: WA	Rest of OR State	Outside Region	Total
IC Capital Costs	Final Demand	Administrative and support services	$300	$0	$0	$0	$0	$300
		Construction	$214	$0	$0	$0	$0	$214
		Management of companies and enterprises	$523	$0	$0	$0	$0	$523
		Plastics and rubber product manufacturing	$158	$0	$0	$0	$0	$158
		Printing and related support activities	$11	$0	$0	$0	$0	$11
		Professional, scientific, and technical services	$3,329	$0	$0	$0	$0	$3,329
		Water transportation	$39	$0	$0	$0	$0	$39
		Rental and leasing services; Lessors of nonfinancial intangible assets	$14	$0	$0	$0	$0	$14
MNR Capital Costs	Final Demand	Construction	$2,500	$0	$0	$0	$0	$2,500
		Professional, scientific, and technical services	$6,249	$0	$0	$0	$0	$6,249
Tech Assignment Capital Costs	Final Demand	Construction	$299,242	$0	$0	$28,464	$0	$327,706
		Nonmetallic mineral product manufacturing	$113,383	$0	$0	$45,612	$0	$158,996
		Plastics and rubber product manufacturing	$182	$0	$0	$0	$0	$182
		Professional, scientific, and technical services	$12,845	$0	$0	$9,501	$0	$22,346
		Real estate	$0	$0	$0	$8,317	$0	$8,317
		Truck transportation	$130	$0	$0	$6,627	$0	$6,758
		Waste management and remediation services	$236,896	$0	$0	$14,685	$0	$251,581
		Water transportation	$24,535	$0	$0	$73,605	$0	$98,140
	Industry Sales	Waste management and remediation services	$0	$0	$0	$51,053	$0	$51,053
	N/A*	N/A*	$0	$0	$0	$0	$690,990	$690,990
Site-Wide Monitoring and MNR Periodic Costs	Final Demand	Construction	$14,704	$0	$0	$0	$0	$14,704
		Professional, scientific, and technical services	$480,287	$0	$0	$0	$0	$480,287
Long Term O&M Periodic Costs	Final Demand	Construction	$9,104	$0	$0	$0	$0	$9,104
		Nonmetallic mineral product manufacturing	$32,294	$0	$0	$0	$0	$32,294
		Plastics and rubber product manufacturing	$56	$0	$0	$0	$0	$56
		Professional, scientific, and technical services	$6,218	$0	$0	$0	$0	$6,218
IC Periodic Costs	Final Demand	Administrative and support services	$183	$0	$0	$0	$0	$183
		Management of companies and enterprises	$513	$0	$0	$0	$0	$513
		Plastics and rubber product manufacturing	$906	$0	$0	$0	$0	$906
		Printing and related support activities	$90	$0	$0	$0	$0	$90
		Professional, scientific, and technical services	$3,010	$0	$0	$0	$0	$3,010
		Rental and leasing services; Lessors of nonfinancial intangible assets	$79	$0	$0	$0	$0	$79
		Water Transportation	$223	$0	$0	$0	$0	$223
5-Year Site Review Periodic Costs	Final Demand	Administrative and support services	$86	$0	$0	$0	$0	$86
		Management of companies and enterprises	$355	$0	$0	$0	$0	$355
		Professional, scientific, and technical services	$1,399	$0	$0	$0	$0	$1,399
		Rail transportation	$3	$0	$0	$0	$0	$3
		Truck transportation	$4	$0	$0	$0	$0	$4
		Water transportation	$3	$0	$0	$0	$0	$3
Total			$1,250,068	$0	$0	$237,865	$690,990	$2,178,923

Notes: *Expenditures associated with waste disposal at Subtitle D Facility (Roosevelt Regional Landfill) are located outside the Portland region (and REMI PI+ model footprint) in Washington State; IC—institutional controls; MNR—monitored natural recovery; Tech Assignment—technology assignment measures (e.g., capping, dredging); undiscounted totals over 31-year period (2020-2050).

Source: EPA (2016a) and NERA calculations as explained in text.

Appendix D: Detailed Financing Data and Modeling Assumptions

This appendix provides additional details on the data and assumptions supporting the modeling of the financing impacts of EPA's remedial alternatives. As described in the report, we develop a number of illustrative financing mechanisms (i.e., financing methods and timing) and financing cases (i.e., allocations to groups) in order to estimate ranges of possible negative impacts. This appendix summarizes assumptions underlying those cases and mechanisms and provides detailed information on model inputs by financing case and mechanism.

A. Overview of Local Entity Financing Cases

In order to model the potential impacts of remediation financing, we consider the impacts of financing expenditures for three groups of potentially responsible parties:

1. Local governments ("local entity");
2. Local businesses ("local entity"); and
3. National/international businesses and federal government ("non-local entities").

The share of remediation costs to be borne by each group is at this point uncertain. We develop an illustrative "mixed financing" case that assumes one-third of remediation costs are borne by each of the three groups. (Note that all costs—even those that occur outside the Portland region—might be financed by local entities.) In addition, we show the potential range of economic impacts assuming costs are borne entirely by each group. In other words, we develop the following sensitivity cases in terms of cost allocations:

1. <u>All local governments</u>.
2. <u>All local businesses</u>.
3. <u>All national/international entities</u>. We assume costs allocated to this group represent an introduction of new spending to the region and financing impacts are zero (qualitatively noted and not shown).
4. <u>Mixed financing</u>. We calculate net economic impacts (i.e., combined effects of expenditures and financing) of EPA's remedial alternatives based upon this financing case.

In addition to the above sensitivities in relative cost allocations, we also consider a number of alternative assumptions on specific financing mechanisms. As described in Section II.D, this set of assumptions varies by local entity. Table D-1 provides an overview of the various mechanisms considered for each local entity. Assumptions underlying the implementation of these various mechanisms in REMI PI+ are provided in the following sections.

Throughout this report, we generally present ranges of impacts based upon the minimum and maximum results considering all combinations of mechanisms for a given case. The mechanisms corresponding to the minimum and maximum impacts for each entity are noted in Table D-1.

Table D-1. Overview of Financing Mechanisms by Local Entity

Local Entity	Financing Method	Financing Timing	REMI Variables
Local Governments	Tax increase[1]	Contemporaneous	Production cost; personal taxes
	Tax increase	Over time (3% real interest rate)	Production cost; personal taxes
	Spending cut	Contemporaneous	Local government spending
	Spending cut[2]	Over time (3% real interest rate)	Local government spending
Local Businesses	Cost increase[1]	Contemporaneous	Production cost
	Cost increase[2]	Over time (5.5% real interest rate)	Production cost

Notes: [1]Case corresponds to the minimum financing impact; [2]Case corresponds to the maximum financing impact.
Source: NERA as explained in text.

B. Local Government Financing Assumptions and Inputs

Implementing in REMI PI+ the various government financing mechanisms described in Table D-1 requires certain additional information. In particular, we develop information related to: (1) tax burden for local government tax increases; and (2) local government interest rate.

1. Tax Burden for Local Government Tax Increases

As noted in Section II.D, local governments generally raise revenue through property taxes. These taxes are imposed on residential, commercial, and industrial property owners in the Portland Region, and the effect of property tax increases will vary by taxpayer group (as will the input specifications in REMI PI+).

We assume that the relative share of property tax increases levied upon residential and commercial/industrial property owners due to remediation financing is consistent with the historical share of property taxes collected from residential versus commercial/industrial property owners in the state of Oregon. In 2010, 47 percent of Oregon State property taxes were collected from residential customers, while 53 percent were collected from commercial/industrial customers;[23] we divide the tax increases accordingly.

In order to input estimated tax increases into the REMI PI+ model, we must specify specific variables, sectors (if applicable), and regions. We assume that all government financing impacts (related to both tax increases and spending cuts) occur within the City of Portland.[24] Increases in residential property taxes are input as increases in personal taxes, which is equivalent to a

[23] Tax Foundation. *State and Local Property Taxes Target Commercial and Industrial Property*. http://taxfoundation.org/article/state-and-local-property-taxes-target-commercial-and-industrial-property

[24] This assumption is generally consistent with the jurisdictions of the local government entities that have been named as PRPs and are members of the LWG. The City of Portland's jurisdiction is the City, and the Port of Portland's jurisdiction has historically included areas in Multnomah County, and was expanded to include areas in Washington and Clackamas counties in 1973. Note that the impacts on the Portland MSA would not be appreciably different if we allocated some of the tax burden to other jurisdictions within the metropolitan region.

decrease in after-tax income and consistent with the direct economic effects of such a tax increase. Increases in commercial/industrial property taxes are input as increases in production costs—or the cost of doing business in the City of Portland—in all sectors based upon each sector's annual share of baseline value added in the City of Portland. Implementation of local government spending cuts is more straightforward; financing of remediation expenditures is input directly as decreases in local government spending in order to balance the local government budget.

2. Local Government Interest Rate

Interest rates local government entities might face in 2020 and beyond are at this point highly uncertain; however, current interest rates for local government entities might serve as an indication of the rates going forward. The City of Portland, for example, can issue general obligation bonds for construction and capital improvements. According to the most recent Comprehensive Annual Financial Report (CAFR) for the City of Portland, in March of 2015, the City sold $17.1 million of general obligation bonds that will be paid off over 14 years with interest rates ranging from 2 percent to 5 percent.[25]

For purposes of our analysis we assume the interest rates currently faced by the City of Portland represent a range of the possible interest rates for general obligation bonds and for government entities generally. Since we anticipate bonds in this case would be issued for periods longer than 14 years, we assume that bonds will be issued at interest rates closer to the upper bound of five percent in nominal terms. According to the Federal Reserve Bank of Philadelphia, the ten-year expected inflation rate is estimated at approximately 2 percent.[26] We adjust the nominal interest rate of 5 percent to a real interest rate assuming an inflation rate of 2 percent, resulting in a real interest rate of 3 percent for general obligation bonds.

3. Local Government Financing Inputs

Tables D-2 and D-3 summarize the local government financing REMI inputs for the all local government and mixed financing cases.

[25] City of Portland. *Comprehensive Annual Financial Report (CAFR) for the Fiscal Year Ended June 30, 2015*. https://www.portlandoregon.gov/brfs/article/555505.

[26] Federal Reserve Bank of Philadelphia. https://www.philadelphiafed.org/research-and-data/real-time-center/survey-of-professional-forecasters/historical-data/inflation-forecasts.

Table D-2. Local Government Financing Inputs: All Government Case (Million 2016$)

			EPA Alternative				
Financing Mechanism	**REMI Variable**	**REMI Sector**	**B**	**D**	**I**	**E**	**F**
Contemporaneous Tax Increase	Production Cost	All sectors (based on baseline share of regional value added)	$298	$442	$544	$575	$1,010
	Personal Taxes	N/A	$336	$498	$614	$648	$1,139
	Total		$634	$940	$1,158	$1,223	$2,150
Tax Increase Over Time	Production Cost	All sectors (based on baseline share of regional value added)	$462	$685	$843	$891	$1,566
	Personal Taxes	N/A	$521	$772	$951	$1,005	$1,766
	Total		$982	$1,457	$1,794	$1,896	$3,332
Contemporaneous Spending Cuts	Local Government Spending	N/A	$634	$940	$1,158	$1,223	$2,150
Spending Cuts Over Time	Local Government Spending	N/A	$982	$1,457	$1,794	$1,896	$3,332

Notes: Undiscounted totals over 31-year period (2020-2050).
Source: EPA (2016a) and NERA calculations as explained in text.

Table D-3. Local Government Financing Inputs: Mixed Financing Case (Million 2016$)

			EPA Alternative				
Financing Mechanism	**REMI Variable**	**REMI Sector**	**B**	**D**		**E**	**F**
Contemporaneous Tax Increase	Production Cost	All sectors (based on baseline share of regional value added)	$99	$147	$181	$192	$337
	Personal Taxes	N/A	$112	$166	$205	$216	$380
	Total		$211	$313	$386	$408	$717
Tax Increase Over Time	Production Cost	All sectors (based on baseline share of regional value added)	$154	$228	$281	$297	$522
	Personal Taxes	N/A	$174	$257	$317	$335	$589
	Total		$327	$486	$598	$632	$1,111
Contemporaneous Spending Cuts	Local Government Spending	N/A	$211	$313	$386	$408	$717
Spending Cuts Over Time	Local Government Spending	N/A	$327	$486	$598	$632	$1,111

Notes: Undiscounted totals over 31-year period (2020-2050).
Source: EPA (2016a) and NERA calculations as explained in text.

C. Local Business Financing Assumptions and Inputs

Implementing the various local business financing mechanisms described in Table D-1 in REMI PI+ requires certain additional information and assumptions. In particular, we develop information related to (1) representative sectoral impacts of production cost increases; and (2) the local business interest rate.

1. Sectoral Impacts of Production Cost Increases

As noted in Section II.D, costs allocated to local businesses increase the cost of doing business (i.e., production cost) within each affected business sector. In order to input expected cost increases into REMI PI+, we must develop assumptions about the specific sectors in which affected businesses might operate. Cost allocations to businesses within specific sectors are at this point highly uncertain.

In order to estimate the potential impacts of local business remediation financing, we allocate production cost increases to sectors based upon the sectors in which current, private-sector LWG members operate. Table D-4 provides a mapping of LWG members to REMI PI+ sectors based upon the nature of their major activities. Table D-5 provides sector shares of production cost increases for local business financing based upon the mapping of LWG members to REMI PI+ sectors. (Specific companies are not identified in the table.)

Table D-4. Mapping of LWG Members to REMI PI+ Sectors

	Agriculture and forestry support activities	Chemical manu-facturing	Computer and electronic product manu-facturing	Other trans-portation equipment manu-facturing	Pipeline trans-portation	Primary metal manu-facturing	Rail trans-portation	Repair and main-tenance	Utilities	Ware-housing and storage	Total
LWG Member 1		100%									100%
LWG Member 2	50%	50%									100%
LWG Member 3							100%				100%
LWG Member 4					50%					50%	100%
LWG Member 5				100%							100%
LWG Member 6					50%					50%	100%
LWG Member 7									100%		100%
LWG Member 8						100%					100%
LWG Member 9					50%					50%	100%
LWG Member 10			100%								100%
LWG Member 11								100%			100%
LWG Member 12							100%				100%

Source: LWG and NERA calculations as explained in text

Table D-5. Sector Shares of Production Cost Increases for Local Business Financing

REMI Sector	Sector Share
Agriculture and forestry support activities	4%
Chemical manufacturing	13%
Computer and electronic product manufacturing	8%
Other transportation equipment manufacturing	8%
Pipeline transportation	13%
Primary metal manufacturing	8%
Rail transportation	17%
Repair and maintenance	8%
Utilities	8%
Warehousing and storage	13%
Total	100%

Source: LWG and NERA calculations as explained in text

2. Local Business Interest Rate

Interest rates in the future for local businesses are likely more uncertain than those faced by local governments. We develop an illustrative interest rate for local businesses based on the U.S. Small Business Administration ("SBA") 7(A) program, which provides guaranteed rates for small businesses.[27] Rates under the program are variable and highly context specific, but an estimate from industry professionals suggests a range between 6 and 9 percent.[28] For our analysis, we assume the mid-point of 7.5 percent nominally. We assume a roughly 2 percent

[27] U.S. Small Business Administration. https://www.sba.gov/content/7a-loan-amounts-fees-interest-rates.

[28] FitBizLoans.com. https://fitbizloans.com/sba-7a-loans/.

inflation rate according to the Philadelphia Fed projection noted above, and thus we arrive at a real interest rate for small business financing of 5.5 percent.

3. Local Business Financing Inputs

Tables D-6 and D-7 summarize the local business financing inputs for the all local business and mixed financing cases.

Table D-6. Local Business Financing Inputs: All Local Businesses Case (Million 2016$)

			EPA Alternative				
Financing Mechanism	**REMI Variable**	**REMI Sector**	**B**	**D**	**I**	**E**	**F**
Contemporaneous Cost Increase	Production Cost	Repair and maintenance	$53	$78	$96	$102	$179
		Utilities	$53	$78	$96	$102	$179
		Agriculture and forestry support activities	$26	$39	$48	$51	$90
		Chemical manufacturing	$79	$118	$145	$153	$269
		Computer and electronic product manufacturing	$53	$78	$96	$102	$179
		Other transportation equipment manufacturing	$53	$78	$96	$102	$179
		Pipeline transportation	$79	$118	$145	$153	$269
		Primary metal manufacturing	$53	$78	$96	$102	$179
		Rail transportation	$106	$157	$193	$204	$358
		Warehousing and storage	$79	$118	$145	$153	$269
	Total		$634	$940	$1,158	$1,223	$2,150
Cost Increase Over Time	Production Cost	Repair and maintenance	$111	$165	$203	$215	$377
		Utilities	$111	$165	$203	$215	$377
		Agriculture and forestry support activities	$56	$82	$102	$107	$189
		Chemical manufacturing	$167	$247	$305	$322	$566
		Computer and electronic product manufacturing	$111	$165	$203	$215	$377
		Other transportation equipment manufacturing	$111	$165	$203	$215	$377
		Pipeline transportation	$167	$247	$305	$322	$566
		Primary metal manufacturing	$111	$165	$203	$215	$377
		Rail transportation	$222	$330	$406	$429	$754
		Warehousing and storage	$167	$247	$305	$322	$566
	Total		$1,334	$1,980	$2,437	$2,575	$4,526

Notes: Undiscounted totals over 31-year period (2020-2050).
Source: EPA (2016a) and NERA calculations as explained in text.

Table D-7. Local Business Financing Inputs: Mixed Financing Case (Million 2016$)

Financing Mechanism	REMI Variable	REMI Sector	EPA Alternative B	D	I	E	F
Contemporaneous Cost Increase	Production Cost	Repair and maintenance	$18	$26	$32	$34	$60
		Utilities	$18	$26	$32	$34	$60
		Agriculture and forestry support activities	$9	$13	$16	$17	$30
		Chemical manufacturing	$26	$39	$48	$51	$90
		Computer and electronic product manufacturing	$18	$26	$32	$34	$60
		Other transportation equipment manufacturing	$18	$26	$32	$34	$60
		Pipeline transportation	$26	$39	$48	$51	$90
		Primary metal manufacturing	$18	$26	$32	$34	$60
		Rail transportation	$35	$52	$64	$68	$119
		Warehousing and storage	$26	$39	$48	$51	$90
	Total		$211	$313	$386	$408	$717
Cost Increase Over Time	Production Cost	Repair and maintenance	$37	$55	$68	$72	$126
		Utilities	$37	$55	$68	$72	$126
		Agriculture and forestry support activities	$19	$27	$34	$36	$63
		Chemical manufacturing	$56	$82	$102	$107	$189
		Computer and electronic product manufacturing	$37	$55	$68	$72	$126
		Other transportation equipment manufacturing	$37	$55	$68	$72	$126
		Pipeline transportation	$56	$82	$102	$107	$189
		Primary metal manufacturing	$37	$55	$68	$72	$126
		Rail transportation	$74	$110	$135	$143	$251
		Warehousing and storage	$56	$82	$102	$107	$189
	Total		$445	$660	$812	$858	$1,509

Notes: Undiscounted totals over 31-year period (2020-2050).
Source: EPA (2016a) and NERA calculations as explained in text.

D. Financing by National/International Entities

As noted above, we assume expenditures allocated to non-local entities represent an introduction of net new spending in the economy (i.e., financing impacts are zero); therefore, expenditures allocated to national/international entities are not input into REMI PI+ as bearing financing costs. In practice, the financing impacts of costs allocated to this group would depend upon where in a company's balance sheet the costs are incurred. Our assumption would understate the financing impacts of EPA's remedial alternatives if non-local entities impose financing costs on their local operations (in which case, impacts would resemble those under a local financing scenario).

Appendix E: Annual Results

A. Positive Regional Economic Impacts of Expenditures

Table E-1. Present Value and Annual Economic Impacts of EPA Alternative Expenditures on Portland MSA: GRP (Million 2016$) and Personal Income (Million 2016$)

	GRP (Million 2016$)					Personal Income (Million 2016$)				
	B	D	I	E	F	B	D	I	E	F
PV	$385	$537	$629	$646	$964	$337	$467	$548	$563	$836
2020	$66	$66	$73	$77	$74	$41	$41	$45	$48	$45
2021	$54	$55	$62	$67	$66	$37	$37	$42	$45	$44
2022	$91	$105	$115	$119	$134	$62	$71	$78	$80	$89
2023	$55	$56	$63	$68	$67	$43	$44	$50	$53	$53
2024	$38	$103	$113	$116	$132	$35	$75	$82	$85	$95
2025	$2	$57	$65	$69	$71	$11	$49	$55	$59	$61
2026	$31	$47	$107	$110	$125	$28	$44	$83	$85	$96
2027	-$6	-$6	-$4	-$4	$57	$5	$11	$17	$17	$56
2028	$29	$39	$42	$40	$119	$25	$36	$42	$42	$94
2029	-$6	-$9	-$11	-$11	$53	$3	$6	$8	$8	$55
2030	$33	$44	$45	$43	$125	$27	$37	$40	$39	$98
2031	-$5	-$8	-$11	-$11	$51	$4	$5	$6	$6	$55
2032	-$5	-$8	-$11	-$11	$48	$2	$3	$3	$3	$52
2033	-$5	-$8	-$10	-$10	-$13	$1	$1	$2	$2	$14
2034	$31	$41	$43	$41	$50	$23	$31	$33	$32	$49
2035	$2	$1	$1	$1	-$5	$6	$7	$8	$8	$14
2036	-$2	-$3	-$4	-$4	-$13	$3	$4	$4	$4	$7
2037	-$2	-$3	-$4	-$4	-$12	$2	$3	$4	$4	$5
2038	$34	$45	$48	$47	$55	$24	$32	$34	$34	$44
2039	$0	$0	$0	$0	-$5	$4	$6	$7	$7	$9
2040	$3	$4	$5	$5	$4	$5	$8	$9	$9	$12
2041	-$1	-$1	-$1	-$1	-$4	$3	$4	$5	$5	$7
2042	$34	$46	$49	$48	$62	$24	$32	$35	$34	$45
2043	$0	$0	$1	$1	$0	$5	$6	$7	$7	$11
2044	-$1	-$1	$0	$0	$0	$4	$5	$6	$6	$9
2045	$3	$4	$5	$5	$7	$5	$7	$8	$8	$12
2046	$34	$46	$49	$48	$65	$24	$32	$35	$34	$46
2047	$0	$1	$1	$1	$2	$5	$7	$8	$8	$12
2048	$0	$0	$0	$0	$1	$4	$5	$6	$6	$10
2049	-$1	-$1	-$1	-$1	$0	$3	$4	$5	$5	$8
2050	$38	$51	$55	$54	$72	$26	$35	$38	$37	$51

Notes: Present values (PV) as of January 1, 2016 using a 3% real discount rate.
Source: NERA calculations as explained in text.

Table E-2. Cumulative and Annual Economic Impacts of EPA Alternative Expenditures on Portland MSA: Total Employment (Jobs) and Population (Persons)

	Total Employment (Jobs)					Population (Persons)				
	B	D	I	E	F	B	D	I	E	F
Cumulative	5,080	7,090	8,250	8,440	12,690	6,490	9,070	10,750	11,090	17,150
2020	620	620	690	720	690	150	150	170	180	170
2021	510	510	580	620	600	240	240	270	290	280
2022	840	960	1,060	1,090	1,220	390	410	460	480	500
2023	510	520	580	630	620	440	460	510	540	550
2024	360	920	1,010	1,040	1,180	440	590	660	690	730
2025	40	520	590	630	650	380	620	690	730	760
2026	290	440	950	970	1,100	390	610	800	840	890
2027	-20	0	20	30	520	330	520	670	710	880
2028	260	360	400	390	1,030	340	520	670	690	980
2029	-20	-30	-40	-40	480	280	440	560	580	950
2030	280	380	400	390	1,040	310	460	570	590	1,050
2031	-10	-30	-40	-40	460	260	390	480	490	1,010
2032	-20	-30	-40	-40	440	220	330	410	420	970
2033	-20	-30	-40	-40	-20	190	280	340	350	830
2034	260	340	360	350	460	220	320	380	380	810
2035	30	30	40	40	30	190	270	330	330	700
2036	0	0	0	0	-40	160	230	280	280	600
2037	0	0	0	0	-40	140	200	240	240	510
2038	260	360	380	370	460	170	250	280	290	540
2039	10	20	20	20	10	140	200	240	240	450
2040	30	50	60	60	60	130	180	210	210	400
2041	10	10	10	10	10	100	150	170	180	330
2042	260	350	380	370	480	140	200	220	220	380
2043	20	20	30	30	40	110	160	180	180	310
2044	10	10	20	20	30	90	130	150	150	260
2045	30	40	50	50	80	80	120	130	130	230
2046	250	340	360	350	480	120	170	180	180	280
2047	20	20	30	30	50	100	130	140	140	230
2048	10	10	20	20	30	80	110	120	110	190
2049	10	10	10	10	20	60	90	90	90	150
2050	260	360	380	380	510	110	150	160	150	230

Notes: Cumulative impacts undiscounted and measured in job-years (employment) and person-years (population); rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

B. Negative Regional Economic Impacts of Financing

1. Negative Regional Economic Impacts of Local Government Financing

Table E-3. Present Value and Annual Economic Impacts of Local Government Financing of EPA Alternatives on Portland MSA: GRP (Million 2016$)

	GRP (Million 2016$)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
PV	-$804	-$1,349	-$1,178	-$2,001	-$1,461	-$2,464	-$1,559	-$2,604	-$2,580	-$4,575
2020	-$108	-$78	-$114	-$116	-$130	-$142	-$142	-$150	-$149	-$264
2021	-$112	-$81	-$119	-$119	-$138	-$147	-$152	-$155	-$162	-$273
2022	-$152	-$81	-$171	-$121	-$194	-$149	-$209	-$157	-$233	-$276
2023	-$133	-$81	-$144	-$120	-$166	-$147	-$182	-$156	-$196	-$274
2024	-$72	-$79	-$185	-$117	-$211	-$144	-$226	-$153	-$253	-$268
2025	-$37	-$77	-$156	-$114	-$181	-$140	-$197	-$148	-$216	-$260
2026	-$49	-$74	-$92	-$111	-$214	-$136	-$229	-$144	-$257	-$253
2027	-$17	-$73	-$41	-$108	-$65	-$133	-$70	-$140	-$209	-$246
2028	-$39	-$71	-$63	-$105	-$84	-$130	-$87	-$137	-$256	-$241
2029	-$12	-$70	-$22	-$104	-$33	-$128	-$35	-$135	-$209	-$237
2030	-$41	-$69	-$59	-$103	-$69	-$126	-$69	-$134	-$267	-$235
2031	-$13	-$69	-$19	-$102	-$23	-$126	-$24	-$133	-$214	-$234
2032	-$11	-$69	-$16	-$102	-$19	-$126	-$20	-$133	-$212	-$233
2033	-$9	-$69	-$13	-$102	-$16	-$126	-$16	-$133	-$81	-$234
2034	-$36	-$69	-$49	-$103	-$54	-$126	-$54	-$134	-$109	-$235
2035	-$17	-$70	-$24	-$103	-$28	-$127	-$29	-$134	-$60	-$236
2036	-$13	-$70	-$18	-$104	-$22	-$128	-$23	-$135	-$42	-$237
2037	-$11	-$70	-$16	-$105	-$20	-$129	-$21	-$136	-$34	-$239
2038	-$37	-$71	-$52	-$105	-$58	-$130	-$58	-$137	-$81	-$240
2039	-$14	-$71	-$20	-$106	-$24	-$130	-$25	-$138	-$38	-$242
2040	-$16	-$72	-$23	-$106	-$28	-$131	-$29	-$138	-$44	-$243
2041	-$10	-$72	-$15	-$107	-$19	-$132	-$20	-$139	-$33	-$245
2042	-$36	-$73	-$51	-$108	-$56	-$132	-$56	-$140	-$82	-$246
2043	-$13	-$73	-$19	-$108	-$22	-$133	-$23	-$141	-$39	-$247
2044	-$11	-$73	-$16	-$109	-$19	-$134	-$20	-$142	-$35	-$249
2045	-$13	-$74	-$18	-$109	-$22	-$135	-$23	-$142	-$40	-$250
2046	-$36	-$74	-$50	-$110	-$54	-$136	-$54	-$143	-$81	-$252
2047	-$13	-$75	-$19	-$111	-$21	-$136	-$22	-$144	-$37	-$253
2048	-$11	-$75	-$16	-$111	-$18	-$137	-$19	-$145	-$32	-$254
2049	-$9	-$75	-$13	-$112	-$15	-$138	-$16	-$145	-$28	-$256
2050	-$39	-$76	-$54	-$113	-$60	-$139	-$59	-$147	-$85	-$258

Notes: Present values (PV) as of January 1, 2016 using a 3% real discount rate.
Source: NERA calculations as explained in text.

Table E-4. Present Value and Annual Economic Impacts of Local Government Financing of EPA Alternatives on Portland MSA: Personal Income (Million 2016$)

	Personal Income (2016$)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
PV	-$731	-$1,378	-$1,073	-$2,044	-$1,334	-$2,517	-$1,425	-$2,659	-$2,345	-$4,672
2020	-$66	-$56	-$70	-$83	-$80	-$103	-$87	-$108	-$92	-$191
2021	-$76	-$63	-$81	-$93	-$94	-$115	-$103	-$121	-$110	-$213
2022	-$107	-$68	-$119	-$100	-$136	-$123	-$146	-$130	-$162	-$229
2023	-$102	-$70	-$110	-$105	-$127	-$129	-$140	-$136	-$150	-$239
2024	-$68	-$72	-$140	-$107	-$160	-$132	-$172	-$139	-$191	-$245
2025	-$46	-$73	-$129	-$108	-$148	-$133	-$162	-$141	-$177	-$248
2026	-$50	-$73	-$92	-$109	-$172	-$134	-$185	-$142	-$206	-$249
2027	-$29	-$74	-$58	-$109	-$86	-$134	-$93	-$142	-$183	-$249
2028	-$41	-$74	-$68	-$109	-$92	-$135	-$96	-$142	-$214	-$250
2029	-$24	-$74	-$41	-$110	-$58	-$135	-$61	-$143	-$191	-$251
2030	-$39	-$74	-$60	-$110	-$75	-$136	-$77	-$144	-$227	-$252
2031	-$23	-$75	-$35	-$111	-$46	-$136	-$48	-$144	-$199	-$253
2032	-$20	-$75	-$31	-$111	-$39	-$137	-$41	-$145	-$198	-$254
2033	-$18	-$76	-$27	-$112	-$34	-$138	-$36	-$146	-$118	-$256
2034	-$33	-$76	-$47	-$113	-$55	-$139	-$56	-$147	-$127	-$258
2035	-$22	-$77	-$33	-$114	-$40	-$140	-$42	-$148	-$94	-$260
2036	-$19	-$77	-$29	-$115	-$35	-$141	-$37	-$149	-$77	-$262
2037	-$17	-$78	-$26	-$116	-$32	-$142	-$34	-$150	-$68	-$264
2038	-$32	-$79	-$46	-$117	-$54	-$144	-$55	-$152	-$92	-$267
2039	-$20	-$79	-$29	-$118	-$36	-$145	-$37	-$153	-$66	-$269
2040	-$20	-$80	-$30	-$119	-$36	-$146	-$38	-$155	-$66	-$272
2041	-$16	-$81	-$24	-$120	-$30	-$148	-$32	-$156	-$57	-$274
2042	-$31	-$82	-$44	-$121	-$51	-$149	-$52	-$157	-$84	-$277
2043	-$18	-$82	-$27	-$122	-$33	-$150	-$34	-$159	-$60	-$279
2044	-$16	-$83	-$24	-$123	-$30	-$152	-$31	-$160	-$55	-$282
2045	-$17	-$84	-$25	-$124	-$30	-$153	-$32	-$162	-$56	-$284
2046	-$31	-$85	-$43	-$126	-$49	-$155	-$50	-$164	-$80	-$288
2047	-$19	-$86	-$27	-$127	-$32	-$156	-$33	-$165	-$56	-$290
2048	-$17	-$87	-$24	-$128	-$29	-$158	-$30	-$167	-$52	-$293
2049	-$15	-$88	-$22	-$130	-$27	-$160	-$28	-$169	-$48	-$297
2050	-$33	-$89	-$47	-$132	-$53	-$162	-$54	-$172	-$82	-$301

Notes: Present values (PV) as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

Table E-5. Cumulative and Annual Economic Impacts of Local Government Financing of EPA Alternatives on Portland MSA: Total Employment (Jobs)

	Total Employment (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Cumulative	-10,620	-22,380	-15,600	-33,200	-19,320	-40,870	-20,560	-43,190	-34,460	-75,890
2020	-1,080	-820	-1,140	-1,220	-1,300	-1,500	-1,420	-1,580	-1,490	-2,790
2021	-1,090	-840	-1,160	-1,250	-1,340	-1,540	-1,480	-1,630	-1,580	-2,860
2022	-1,450	-850	-1,630	-1,260	-1,850	-1,550	-1,990	-1,640	-2,220	-2,870
2023	-1,250	-840	-1,340	-1,240	-1,550	-1,530	-1,700	-1,620	-1,830	-2,840
2024	-660	-820	-1,700	-1,220	-1,940	-1,500	-2,080	-1,580	-2,330	-2,780
2025	-340	-790	-1,410	-1,180	-1,640	-1,450	-1,790	-1,530	-1,950	-2,700
2026	-450	-770	-820	-1,140	-1,900	-1,410	-2,040	-1,490	-2,290	-2,610
2027	-170	-750	-380	-1,110	-580	-1,370	-630	-1,450	-1,840	-2,540
2028	-360	-730	-570	-1,090	-750	-1,340	-780	-1,410	-2,220	-2,480
2029	-130	-720	-220	-1,060	-320	-1,310	-340	-1,380	-1,790	-2,430
2030	-370	-700	-530	-1,050	-620	-1,290	-620	-1,360	-2,240	-2,390
2031	-130	-700	-190	-1,040	-240	-1,280	-260	-1,350	-1,790	-2,370
2032	-120	-690	-170	-1,030	-210	-1,270	-220	-1,340	-1,770	-2,350
2033	-100	-690	-150	-1,030	-180	-1,260	-190	-1,340	-720	-2,350
2034	-310	-690	-430	-1,020	-480	-1,260	-490	-1,330	-950	-2,340
2035	-160	-690	-230	-1,020	-270	-1,260	-290	-1,330	-570	-2,340
2036	-130	-690	-190	-1,020	-230	-1,260	-240	-1,330	-430	-2,340
2037	-120	-690	-170	-1,020	-210	-1,260	-220	-1,330	-380	-2,340
2038	-310	-690	-440	-1,020	-490	-1,260	-500	-1,330	-730	-2,340
2039	-130	-690	-200	-1,020	-240	-1,260	-250	-1,330	-400	-2,340
2040	-150	-690	-220	-1,020	-260	-1,260	-280	-1,330	-440	-2,330
2041	-100	-690	-160	-1,020	-200	-1,260	-210	-1,330	-360	-2,330
2042	-290	-690	-410	-1,020	-470	-1,250	-470	-1,330	-710	-2,330
2043	-120	-690	-180	-1,020	-210	-1,250	-220	-1,320	-390	-2,330
2044	-110	-680	-160	-1,020	-190	-1,250	-200	-1,320	-360	-2,320
2045	-120	-680	-170	-1,010	-210	-1,250	-220	-1,320	-390	-2,320
2046	-280	-680	-390	-1,010	-430	-1,250	-430	-1,320	-670	-2,320
2047	-120	-680	-170	-1,010	-200	-1,240	-210	-1,320	-360	-2,310
2048	-100	-680	-150	-1,010	-180	-1,240	-180	-1,310	-320	-2,310
2049	-90	-680	-130	-1,010	-150	-1,240	-160	-1,310	-290	-2,300
2050	-290	-680	-400	-1,010	-450	-1,240	-450	-1,310	-670	-2,300

Notes: Cumulative impacts undiscounted and measured in job-years; rows may not sum to totals due to rounding.
Source: NERA calculations as explained in text.

Table E-6. Cumulative and Annual Economic Impacts of Local Government Financing of EPA Alternatives on Portland MSA: Population (Persons)

	Population (Persons)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Cumulative	-22,890	-27,290	-33,920	-40,490	-42,230	-49,840	-45,010	-52,670	-77,010	-92,550
2020	-530	-190	-560	-290	-640	-350	-700	-370	-740	-650
2021	-890	-340	-940	-510	-1,090	-620	-1,200	-660	-1,270	-1,160
2022	-1,360	-470	-1,490	-690	-1,700	-850	-1,850	-900	-2,010	-1,590
2023	-1,620	-570	-1,750	-850	-2,020	-1,050	-2,200	-1,110	-2,380	-1,950
2024	-1,550	-660	-2,180	-980	-2,500	-1,210	-2,710	-1,280	-2,970	-2,250
2025	-1,400	-730	-2,380	-1,090	-2,730	-1,340	-2,970	-1,420	-3,250	-2,490
2026	-1,360	-790	-2,260	-1,170	-3,100	-1,450	-3,350	-1,530	-3,690	-2,680
2027	-1,190	-840	-2,000	-1,240	-2,700	-1,530	-2,920	-1,620	-3,820	-2,840
2028	-1,180	-880	-1,940	-1,300	-2,580	-1,600	-2,780	-1,690	-4,170	-2,970
2029	-1,030	-910	-1,690	-1,340	-2,260	-1,650	-2,440	-1,750	-4,220	-3,070
2030	-1,050	-930	-1,680	-1,380	-2,200	-1,700	-2,350	-1,790	-4,540	-3,150
2031	-920	-950	-1,470	-1,410	-1,930	-1,730	-2,060	-1,830	-4,530	-3,220
2032	-810	-970	-1,310	-1,430	-1,710	-1,760	-1,820	-1,860	-4,550	-3,280
2033	-720	-980	-1,160	-1,450	-1,510	-1,790	-1,610	-1,890	-4,000	-3,320
2034	-760	-990	-1,180	-1,470	-1,500	-1,810	-1,590	-1,910	-3,770	-3,360
2035	-680	-1,000	-1,060	-1,480	-1,350	-1,830	-1,430	-1,930	-3,360	-3,390
2036	-610	-1,010	-950	-1,490	-1,200	-1,840	-1,270	-1,940	-2,980	-3,410
2037	-540	-1,010	-840	-1,500	-1,070	-1,850	-1,130	-1,950	-2,640	-3,430
2038	-590	-1,020	-900	-1,510	-1,110	-1,850	-1,160	-1,960	-2,540	-3,440
2039	-500	-1,020	-780	-1,510	-960	-1,860	-1,000	-1,960	-2,220	-3,450
2040	-460	-1,020	-700	-1,510	-870	-1,860	-910	-1,970	-1,980	-3,450
2041	-390	-1,020	-610	-1,510	-750	-1,860	-780	-1,960	-1,720	-3,450
2042	-450	-1,020	-670	-1,510	-800	-1,860	-830	-1,960	-1,700	-3,450
2043	-380	-1,010	-570	-1,500	-680	-1,850	-700	-1,960	-1,460	-3,440
2044	-320	-1,010	-480	-1,500	-580	-1,840	-590	-1,950	-1,250	-3,430
2045	-280	-1,010	-430	-1,490	-510	-1,840	-520	-1,940	-1,100	-3,410
2046	-340	-1,000	-500	-1,490	-570	-1,830	-580	-1,930	-1,120	-3,400
2047	-280	-1,000	-410	-1,480	-470	-1,820	-470	-1,920	-920	-3,380
2048	-240	-990	-340	-1,470	-390	-1,810	-390	-1,910	-760	-3,360
2049	-200	-990	-280	-1,470	-320	-1,800	-310	-1,910	-620	-3,350
2050	-290	-980	-400	-1,460	-440	-1,800	-430	-1,900	-730	-3,340

Notes: Cumulative impacts undiscounted and measured in person-years; rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

2. Negative Regional Economic Impacts of Local Business Financing

Table E-7. Present Value and Annual Economic Impacts of Local Business Financing of EPA Alternatives on Portland MSA: GRP (Million 2016$)

	GRP (Million 2016$)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
PV	-$1,473	-$2,191	-$2,120	-$3,216	-$2,616	-$3,936	-$2,791	-$4,153	-$4,493	-$7,176
2020	-$93	-$43	-$98	-$63	-$112	-$77	-$122	-$82	-$128	-$142
2021	-$133	-$67	-$141	-$98	-$163	-$119	-$178	-$126	-$189	-$218
2022	-$193	-$85	-$212	-$125	-$241	-$153	-$260	-$162	-$285	-$279
2023	-$207	-$100	-$224	-$146	-$257	-$178	-$280	-$188	-$302	-$324
2024	-$172	-$110	-$273	-$161	-$311	-$197	-$335	-$207	-$369	-$358
2025	-$133	-$117	-$274	-$171	-$313	-$209	-$340	-$221	-$371	-$381
2026	-$127	-$122	-$227	-$178	-$349	-$218	-$376	-$230	-$415	-$396
2027	-$93	-$125	-$171	-$183	-$244	-$224	-$263	-$236	-$397	-$407
2028	-$95	-$127	-$165	-$187	-$225	-$228	-$239	-$241	-$434	-$415
2029	-$68	-$129	-$119	-$189	-$166	-$231	-$178	-$244	-$410	-$421
2030	-$80	-$130	-$129	-$191	-$168	-$233	-$176	-$246	-$451	-$425
2031	-$56	-$131	-$91	-$192	-$120	-$234	-$127	-$247	-$421	-$427
2032	-$45	-$131	-$72	-$192	-$94	-$236	-$99	-$249	-$410	-$429
2033	-$36	-$132	-$57	-$193	-$74	-$236	-$78	-$249	-$296	-$431
2034	-$53	-$132	-$77	-$194	-$93	-$237	-$95	-$250	-$274	-$432
2035	-$41	-$132	-$60	-$194	-$72	-$238	-$74	-$251	-$212	-$434
2036	-$33	-$133	-$48	-$195	-$58	-$239	-$61	-$252	-$165	-$436
2037	-$28	-$133	-$40	-$196	-$49	-$240	-$51	-$253	-$130	-$437
2038	-$48	-$134	-$67	-$196	-$76	-$241	-$77	-$254	-$147	-$439
2039	-$34	-$134	-$48	-$197	-$55	-$241	-$57	-$255	-$108	-$441
2040	-$33	-$135	-$46	-$198	-$53	-$242	-$55	-$256	-$98	-$442
2041	-$27	-$135	-$38	-$198	-$44	-$243	-$46	-$256	-$79	-$444
2042	-$47	-$135	-$65	-$199	-$73	-$244	-$74	-$257	-$111	-$445
2043	-$34	-$136	-$47	-$200	-$53	-$245	-$55	-$258	-$83	-$447
2044	-$29	-$136	-$40	-$200	-$46	-$246	-$48	-$259	-$72	-$449
2045	-$28	-$137	-$40	-$201	-$46	-$246	-$48	-$260	-$71	-$451
2046	-$48	-$137	-$66	-$202	-$73	-$248	-$74	-$261	-$105	-$453
2047	-$35	-$138	-$48	-$203	-$54	-$249	-$56	-$262	-$79	-$455
2048	-$30	-$138	-$41	-$204	-$47	-$250	-$49	-$263	-$70	-$456
2049	-$26	-$139	-$36	-$205	-$42	-$251	-$43	-$265	-$61	-$459
2050	-$51	-$140	-$70	-$206	-$78	-$252	-$78	-$266	-$108	-$461

Notes: Present values (PV) as of January 1, 2016 using a 3% real discount rate.
Source: NERA calculations as explained in text.

Table E-8. Present Value and Annual Economic Impacts of Local Business Financing of EPA Alternatives on Portland MSA: Personal Income (Million 2016$)

	Personal Income (2016$)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
PV	-$1,044	-$1,480	-$1,498	-$2,167	-$1,849	-$2,650	-$1,974	-$2,795	-$3,142	-$4,813
2020	-$52	-$24	-$55	-$35	-$62	-$43	-$68	-$46	-$71	-$79
2021	-$77	-$38	-$81	-$56	-$94	-$69	-$103	-$73	-$109	-$125
2022	-$114	-$51	-$124	-$74	-$141	-$91	-$153	-$96	-$167	-$165
2023	-$127	-$61	-$137	-$89	-$157	-$109	-$170	-$114	-$184	-$197
2024	-$111	-$69	-$168	-$100	-$192	-$122	-$207	-$129	-$227	-$222
2025	-$93	-$75	-$174	-$109	-$199	-$133	-$216	-$140	-$235	-$241
2026	-$90	-$79	-$153	-$115	-$223	-$141	-$240	-$149	-$265	-$255
2027	-$71	-$82	-$124	-$120	-$170	-$147	-$184	-$155	-$260	-$267
2028	-$72	-$85	-$120	-$124	-$161	-$152	-$172	-$160	-$285	-$275
2029	-$56	-$87	-$95	-$127	-$129	-$156	-$138	-$164	-$276	-$282
2030	-$62	-$89	-$99	-$130	-$128	-$159	-$135	-$167	-$302	-$288
2031	-$48	-$90	-$77	-$131	-$101	-$160	-$107	-$169	-$288	-$291
2032	-$41	-$90	-$65	-$132	-$84	-$162	-$89	-$171	-$283	-$293
2033	-$35	-$91	-$54	-$133	-$71	-$163	-$75	-$172	-$223	-$295
2034	-$43	-$92	-$64	-$134	-$78	-$164	-$81	-$173	-$209	-$297
2035	-$36	-$92	-$53	-$135	-$65	-$165	-$69	-$174	-$173	-$299
2036	-$31	-$92	-$46	-$135	-$57	-$166	-$60	-$175	-$145	-$301
2037	-$28	-$93	-$41	-$136	-$50	-$167	-$53	-$176	-$123	-$303
2038	-$37	-$93	-$53	-$137	-$63	-$167	-$65	-$177	-$128	-$304
2039	-$30	-$94	-$43	-$138	-$52	-$168	-$54	-$178	-$105	-$306
2040	-$29	-$94	-$41	-$138	-$50	-$169	-$52	-$178	-$96	-$308
2041	-$25	-$95	-$36	-$139	-$44	-$170	-$46	-$179	-$83	-$309
2042	-$35	-$95	-$50	-$140	-$58	-$171	-$60	-$180	-$97	-$311
2043	-$29	-$96	-$41	-$140	-$48	-$172	-$50	-$181	-$81	-$312
2044	-$26	-$96	-$37	-$141	-$44	-$173	-$46	-$182	-$74	-$314
2045	-$25	-$97	-$36	-$142	-$43	-$174	-$45	-$183	-$72	-$316
2046	-$35	-$97	-$49	-$143	-$57	-$175	-$58	-$184	-$88	-$318
2047	-$29	-$98	-$41	-$143	-$47	-$176	-$49	-$185	-$75	-$320
2048	-$27	-$98	-$37	-$144	-$44	-$177	-$46	-$186	-$69	-$322
2049	-$25	-$99	-$34	-$145	-$41	-$178	-$43	-$188	-$64	-$325
2050	-$37	-$100	-$52	-$147	-$59	-$180	-$61	-$190	-$88	-$329

Notes: Present values (PV) as of January 1, 2016 using a 3% real discount rate.
Source: NERA calculations as explained in text.

Table E-9. Cumulative and Annual Economic Impacts of Local Business Financing of EPA Alternatives on Portland MSA: Total Employment (Jobs)

	Total Employment (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Cumulative	-14,660	-23,310	-21,050	-34,120	-25,890	-41,690	-27,560	-43,970	-44,630	-75,660
2020	-790	-360	-830	-540	-940	-660	-1,030	-690	-1,080	-1,190
2021	-1,050	-530	-1,120	-780	-1,290	-950	-1,410	-1,000	-1,490	-1,720
2022	-1,480	-660	-1,630	-960	-1,850	-1,170	-1,990	-1,230	-2,180	-2,120
2023	-1,530	-740	-1,650	-1,080	-1,890	-1,320	-2,060	-1,400	-2,220	-2,400
2024	-1,210	-800	-1,980	-1,170	-2,250	-1,420	-2,420	-1,500	-2,670	-2,570
2025	-920	-830	-1,920	-1,210	-2,190	-1,480	-2,380	-1,560	-2,590	-2,670
2026	-870	-840	-1,540	-1,230	-2,400	-1,500	-2,580	-1,580	-2,850	-2,710
2027	-610	-850	-1,120	-1,230	-1,590	-1,510	-1,710	-1,590	-2,640	-2,720
2028	-640	-840	-1,080	-1,230	-1,470	-1,500	-1,560	-1,580	-2,850	-2,710
2029	-440	-830	-760	-1,220	-1,050	-1,490	-1,120	-1,570	-2,610	-2,690
2030	-520	-820	-830	-1,200	-1,070	-1,470	-1,110	-1,550	-2,840	-2,660
2031	-350	-820	-570	-1,190	-740	-1,460	-780	-1,540	-2,590	-2,640
2032	-280	-810	-450	-1,190	-580	-1,450	-620	-1,530	-2,500	-2,620
2033	-230	-800	-360	-1,180	-460	-1,440	-490	-1,520	-1,750	-2,600
2034	-340	-800	-490	-1,170	-590	-1,430	-600	-1,500	-1,640	-2,580
2035	-250	-790	-370	-1,160	-450	-1,420	-460	-1,490	-1,250	-2,570
2036	-210	-790	-300	-1,150	-370	-1,410	-380	-1,480	-980	-2,550
2037	-180	-780	-260	-1,140	-310	-1,400	-330	-1,470	-780	-2,530
2038	-300	-770	-420	-1,130	-480	-1,390	-490	-1,460	-890	-2,520
2039	-210	-770	-290	-1,130	-340	-1,380	-350	-1,450	-650	-2,500
2040	-200	-760	-280	-1,120	-330	-1,370	-350	-1,440	-590	-2,480
2041	-170	-760	-230	-1,110	-280	-1,360	-290	-1,430	-490	-2,470
2042	-280	-750	-390	-1,100	-440	-1,350	-450	-1,420	-680	-2,450
2043	-200	-740	-270	-1,090	-320	-1,340	-330	-1,410	-500	-2,430
2044	-170	-740	-240	-1,080	-280	-1,330	-290	-1,400	-440	-2,410
2045	-170	-730	-230	-1,080	-280	-1,320	-290	-1,390	-440	-2,400
2046	-270	-730	-370	-1,070	-420	-1,310	-430	-1,380	-610	-2,380
2047	-190	-720	-260	-1,060	-310	-1,300	-310	-1,370	-460	-2,360
2048	-170	-720	-230	-1,050	-270	-1,290	-280	-1,360	-410	-2,340
2049	-150	-710	-200	-1,040	-240	-1,280	-250	-1,350	-360	-2,330
2050	-270	-710	-380	-1,040	-420	-1,270	-430	-1,340	-600	-2,320

Notes: Cumulative impacts undiscounted and measured in job-years; rows may not sum to totals due to rounding.
Source: NERA calculations as explained in text.

Table E-10. Cumulative and Annual Economic Impacts of Local Business Financing of EPA Alternatives on Portland MSA: Population (Persons)

	Population (Persons)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Cumulative	-24,080	-35,850	-35,080	-53,060	-43,640	-65,190	-46,650	-68,840	-76,700	-119,780
2020	-290	-130	-310	-200	-350	-240	-390	-260	-410	-450
2021	-560	-270	-600	-400	-690	-490	-750	-520	-800	-910
2022	-920	-410	-990	-610	-1,140	-750	-1,230	-790	-1,340	-1,380
2023	-1,190	-550	-1,280	-820	-1,470	-1,000	-1,600	-1,060	-1,730	-1,840
2024	-1,280	-680	-1,660	-1,010	-1,890	-1,240	-2,050	-1,310	-2,230	-2,270
2025	-1,290	-800	-1,920	-1,180	-2,190	-1,450	-2,380	-1,530	-2,590	-2,660
2026	-1,320	-910	-1,990	-1,340	-2,550	-1,640	-2,750	-1,740	-3,020	-3,010
2027	-1,260	-1,000	-1,940	-1,480	-2,500	-1,810	-2,700	-1,910	-3,270	-3,320
2028	-1,260	-1,080	-1,950	-1,600	-2,510	-1,960	-2,700	-2,070	-3,610	-3,590
2029	-1,180	-1,150	-1,840	-1,700	-2,380	-2,090	-2,570	-2,200	-3,790	-3,820
2030	-1,170	-1,210	-1,820	-1,790	-2,350	-2,190	-2,520	-2,310	-4,070	-4,020
2031	-1,080	-1,260	-1,690	-1,860	-2,190	-2,280	-2,340	-2,410	-4,190	-4,190
2032	-1,000	-1,300	-1,570	-1,920	-2,020	-2,360	-2,170	-2,490	-4,280	-4,330
2033	-920	-1,340	-1,440	-1,970	-1,860	-2,420	-1,990	-2,560	-4,060	-4,450
2034	-900	-1,360	-1,400	-2,020	-1,790	-2,480	-1,910	-2,620	-3,920	-4,540
2035	-840	-1,390	-1,290	-2,050	-1,650	-2,520	-1,760	-2,660	-3,670	-4,620
2036	-770	-1,410	-1,190	-2,080	-1,510	-2,550	-1,610	-2,700	-3,400	-4,690
2037	-700	-1,420	-1,080	-2,100	-1,380	-2,580	-1,470	-2,720	-3,120	-4,730
2038	-700	-1,430	-1,060	-2,110	-1,340	-2,600	-1,420	-2,740	-2,950	-4,770
2039	-640	-1,430	-970	-2,120	-1,220	-2,610	-1,290	-2,750	-2,680	-4,790
2040	-590	-1,430	-890	-2,130	-1,120	-2,610	-1,180	-2,760	-2,450	-4,800
2041	-530	-1,430	-810	-2,120	-1,010	-2,610	-1,070	-2,760	-2,200	-4,800
2042	-540	-1,430	-810	-2,120	-990	-2,600	-1,040	-2,750	-2,080	-4,780
2043	-490	-1,420	-730	-2,110	-900	-2,590	-940	-2,730	-1,870	-4,760
2044	-440	-1,410	-660	-2,090	-810	-2,570	-840	-2,720	-1,670	-4,730
2045	-400	-1,400	-600	-2,080	-730	-2,550	-770	-2,700	-1,500	-4,700
2046	-420	-1,390	-610	-2,060	-730	-2,530	-760	-2,670	-1,430	-4,660
2047	-380	-1,370	-550	-2,040	-660	-2,500	-690	-2,640	-1,270	-4,610
2048	-350	-1,360	-500	-2,010	-600	-2,480	-620	-2,620	-1,130	-4,560
2049	-320	-1,340	-450	-1,990	-530	-2,450	-550	-2,590	-990	-4,510
2050	-350	-1,330	-490	-1,970	-570	-2,420	-590	-2,560	-990	-4,460

Notes: Cumulative impacts undiscounted and measured in person-years; rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

3. Negative Regional Economic Impacts of Mixed Financing Case

Table E-11. Present Value and Annual Economic Impacts of Mixed Financing of EPA Alternatives on Portland MSA: GRP (Million 2016$)

	GRP (Million 2016$)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
PV	-$766	-$1,200	-$1,113	-$1,770	-$1,375	-$2,172	-$1,467	-$2,293	-$2,396	-$3,993
2020	-$68	-$41	-$71	-$60	-$82	-$74	-$89	-$78	-$94	-$136
2021	-$83	-$50	-$88	-$73	-$102	-$90	-$112	-$95	-$119	-$166
2022	-$117	-$56	-$130	-$83	-$148	-$102	-$159	-$108	-$176	-$188
2023	-$116	-$61	-$125	-$90	-$144	-$111	-$157	-$117	-$170	-$203
2024	-$83	-$64	-$156	-$95	-$178	-$116	-$191	-$123	-$212	-$213
2025	-$59	-$66	-$147	-$97	-$169	-$119	-$183	-$126	-$200	-$218
2026	-$60	-$67	-$109	-$98	-$192	-$121	-$206	-$127	-$229	-$221
2027	-$37	-$67	-$73	-$99	-$106	-$121	-$114	-$128	-$207	-$223
2028	-$46	-$68	-$78	-$99	-$106	-$122	-$111	-$129	-$235	-$224
2029	-$27	-$68	-$48	-$100	-$68	-$122	-$73	-$129	-$211	-$224
2030	-$41	-$68	-$64	-$100	-$80	-$122	-$83	-$129	-$245	-$225
2031	-$23	-$68	-$37	-$100	-$49	-$123	-$51	-$129	-$216	-$225
2032	-$18	-$68	-$29	-$100	-$38	-$123	-$40	-$130	-$212	-$226
2033	-$15	-$68	-$23	-$100	-$30	-$123	-$31	-$130	-$129	-$226
2034	-$29	-$68	-$42	-$101	-$49	-$124	-$49	-$130	-$130	-$227
2035	-$19	-$69	-$28	-$101	-$33	-$124	-$34	-$131	-$92	-$228
2036	-$15	-$69	-$22	-$101	-$26	-$124	-$27	-$131	-$69	-$229
2037	-$12	-$69	-$18	-$102	-$22	-$125	-$23	-$132	-$55	-$230
2038	-$28	-$69	-$39	-$102	-$44	-$126	-$44	-$133	-$76	-$231
2039	-$15	-$70	-$22	-$103	-$26	-$126	-$26	-$133	-$48	-$232
2040	-$16	-$70	-$22	-$103	-$26	-$127	-$27	-$134	-$47	-$233
2041	-$12	-$70	-$17	-$103	-$20	-$127	-$21	-$134	-$37	-$234
2042	-$27	-$70	-$38	-$104	-$42	-$127	-$42	-$135	-$63	-$235
2043	-$15	-$71	-$21	-$104	-$24	-$128	-$25	-$135	-$40	-$236
2044	-$13	-$71	-$18	-$105	-$21	-$128	-$21	-$136	-$34	-$237
2045	-$13	-$71	-$19	-$105	-$22	-$129	-$22	-$136	-$36	-$238
2046	-$28	-$71	-$38	-$106	-$42	-$130	-$42	-$137	-$61	-$239
2047	-$15	-$72	-$21	-$106	-$24	-$130	-$25	-$137	-$38	-$240
2048	-$13	-$72	-$18	-$106	-$21	-$131	-$21	-$138	-$33	-$241
2049	-$11	-$72	-$15	-$107	-$18	-$131	-$18	-$139	-$28	-$242
2050	-$29	-$73	-$41	-$108	-$45	-$132	-$45	-$140	-$63	-$244

Notes: Present values (PV) as of January 1, 2016 using a 3% real discount rate.
Source: NERA calculations as explained in text.

Table E-12. Present Value and Annual Economic Impacts of Mixed Financing of EPA Alternatives on Portland MSA: Personal Income (Million 2016$)

	Personal Income (2016$)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
PV	-$598	-$969	-$869	-$1,429	-$1,076	-$1,754	-$1,148	-$1,852	-$1,863	-$3,224
2020	-$40	-$27	-$42	-$40	-$48	-$49	-$52	-$52	-$55	-$91
2021	-$52	-$34	-$55	-$50	-$64	-$62	-$70	-$65	-$74	-$114
2022	-$75	-$40	-$83	-$59	-$94	-$73	-$102	-$77	-$112	-$134
2023	-$78	-$45	-$84	-$66	-$97	-$81	-$106	-$85	-$114	-$148
2024	-$62	-$48	-$105	-$71	-$120	-$87	-$129	-$91	-$143	-$159
2025	-$48	-$50	-$103	-$74	-$119	-$91	-$129	-$96	-$141	-$166
2026	-$48	-$52	-$84	-$76	-$135	-$94	-$145	-$99	-$161	-$172
2027	-$34	-$53	-$63	-$78	-$88	-$96	-$95	-$101	-$152	-$176
2028	-$38	-$54	-$64	-$80	-$87	-$98	-$92	-$103	-$171	-$179
2029	-$27	-$55	-$47	-$81	-$64	-$99	-$68	-$105	-$160	-$182
2030	-$34	-$56	-$54	-$82	-$69	-$100	-$72	-$106	-$181	-$184
2031	-$24	-$56	-$38	-$82	-$50	-$101	-$53	-$107	-$166	-$185
2032	-$20	-$56	-$32	-$83	-$42	-$102	-$44	-$107	-$164	-$187
2033	-$17	-$57	-$27	-$83	-$35	-$102	-$37	-$108	-$117	-$188
2034	-$25	-$57	-$37	-$84	-$44	-$103	-$46	-$109	-$115	-$189
2035	-$19	-$57	-$29	-$84	-$35	-$104	-$37	-$109	-$91	-$190
2036	-$17	-$58	-$25	-$85	-$30	-$104	-$32	-$110	-$75	-$192
2037	-$15	-$58	-$22	-$85	-$27	-$105	-$29	-$111	-$64	-$193
2038	-$23	-$58	-$33	-$86	-$39	-$106	-$40	-$111	-$74	-$194
2039	-$16	-$59	-$24	-$87	-$29	-$106	-$30	-$112	-$57	-$196
2040	-$16	-$59	-$23	-$87	-$28	-$107	-$29	-$113	-$54	-$197
2041	-$13	-$59	-$20	-$88	-$24	-$108	-$25	-$114	-$46	-$198
2042	-$22	-$60	-$31	-$88	-$36	-$108	-$37	-$114	-$60	-$199
2043	-$15	-$60	-$22	-$89	-$26	-$109	-$27	-$115	-$47	-$201
2044	-$14	-$61	-$20	-$89	-$24	-$110	-$25	-$116	-$42	-$202
2045	-$14	-$61	-$20	-$90	-$24	-$111	-$25	-$117	-$42	-$204
2046	-$22	-$61	-$30	-$91	-$35	-$112	-$35	-$118	-$55	-$205
2047	-$15	-$62	-$22	-$91	-$26	-$112	-$26	-$119	-$43	-$207
2048	-$14	-$62	-$20	-$92	-$23	-$113	-$24	-$119	-$39	-$209
2049	-$13	-$63	-$18	-$93	-$22	-$114	-$22	-$121	-$36	-$210
2050	-$23	-$64	-$32	-$94	-$37	-$116	-$37	-$122	-$56	-$213

Notes: Present values (PV) as of January 1, 2016 using a 3% real discount rate.
Source: NERA calculations as explained in text.

Table E-13. Cumulative and Annual Economic Impacts of Mixed Financing of EPA Alternatives on Portland MSA: Total Employment (Jobs)

	Total Employment (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Cumulative	-8,510	-15,510	-12,380	-22,870	-15,260	-28,060	-16,240	-29,620	-26,840	-51,540
2020	-630	-400	-660	-590	-760	-720	-830	-770	-870	-1,340
2021	-730	-460	-770	-680	-890	-840	-980	-890	-1,040	-1,550
2022	-1,000	-510	-1,110	-750	-1,260	-920	-1,360	-970	-1,500	-1,700
2023	-950	-540	-1,020	-790	-1,180	-970	-1,290	-1,030	-1,390	-1,780
2024	-650	-550	-1,260	-810	-1,430	-1,000	-1,540	-1,050	-1,710	-1,820
2025	-440	-550	-1,140	-820	-1,310	-1,000	-1,430	-1,050	-1,560	-1,830
2026	-460	-550	-810	-810	-1,470	-990	-1,580	-1,050	-1,760	-1,820
2027	-270	-550	-520	-800	-750	-980	-810	-1,040	-1,530	-1,800
2028	-340	-540	-570	-790	-760	-970	-800	-1,020	-1,730	-1,770
2029	-190	-530	-340	-780	-470	-950	-500	-1,010	-1,510	-1,750
2030	-300	-520	-460	-770	-570	-940	-590	-990	-1,740	-1,720
2031	-160	-520	-260	-760	-340	-930	-350	-980	-1,500	-1,710
2032	-130	-510	-210	-760	-270	-930	-280	-980	-1,460	-1,700
2033	-110	-510	-170	-750	-220	-920	-230	-970	-850	-1,690
2034	-220	-510	-310	-750	-360	-910	-360	-970	-890	-1,680
2035	-140	-500	-200	-740	-240	-910	-250	-960	-620	-1,670
2036	-110	-500	-160	-740	-190	-910	-200	-960	-480	-1,660
2037	-90	-500	-140	-740	-170	-900	-180	-950	-390	-1,660
2038	-200	-500	-280	-730	-320	-900	-320	-950	-540	-1,650
2039	-110	-490	-160	-730	-190	-890	-200	-940	-350	-1,640
2040	-110	-490	-160	-730	-190	-890	-200	-940	-340	-1,640
2041	-90	-490	-130	-720	-150	-890	-160	-940	-280	-1,630
2042	-190	-490	-260	-720	-300	-880	-300	-930	-460	-1,620
2043	-100	-480	-150	-710	-170	-880	-180	-930	-290	-1,610
2044	-90	-480	-130	-710	-150	-870	-160	-920	-260	-1,610
2045	-90	-480	-130	-710	-160	-870	-160	-920	-270	-1,600
2046	-180	-480	-250	-700	-280	-860	-280	-910	-420	-1,590
2047	-100	-470	-140	-700	-160	-860	-170	-910	-260	-1,580
2048	-90	-470	-120	-700	-140	-860	-150	-900	-240	-1,580
2049	-70	-470	-100	-690	-120	-850	-130	-900	-210	-1,570
2050	-180	-470	-260	-690	-280	-850	-290	-900	-410	-1,560

Notes: Cumulative impacts undiscounted and measured in job-years; rows may not sum to totals due to rounding.
Source: NERA calculations as explained in text.

Table E-14. Cumulative and Annual Economic Impacts of Mixed Financing of EPA Alternatives on Portland MSA: Population (Persons)

	Population (Persons)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Cumulative	-15,500	-21,030	-22,840	-31,220	-28,450	-38,450	-30,370	-40,630	-51,310	-71,360
2020	-280	-110	-290	-160	-330	-200	-360	-210	-380	-370
2021	-490	-200	-520	-300	-590	-370	-650	-390	-690	-690
2022	-760	-290	-830	-440	-950	-540	-1,030	-570	-1,120	-1,000
2023	-940	-380	-1,020	-560	-1,170	-690	-1,280	-730	-1,380	-1,270
2024	-950	-450	-1,290	-670	-1,470	-820	-1,600	-870	-1,750	-1,520
2025	-900	-510	-1,440	-760	-1,650	-940	-1,800	-990	-1,960	-1,730
2026	-900	-570	-1,430	-840	-1,900	-1,040	-2,050	-1,100	-2,260	-1,920
2027	-820	-620	-1,320	-910	-1,740	-1,120	-1,890	-1,180	-2,380	-2,080
2028	-810	-650	-1,300	-970	-1,710	-1,190	-1,840	-1,260	-2,620	-2,210
2029	-730	-690	-1,180	-1,020	-1,560	-1,250	-1,680	-1,320	-2,690	-2,320
2030	-740	-710	-1,170	-1,060	-1,520	-1,300	-1,630	-1,380	-2,900	-2,420
2031	-660	-740	-1,060	-1,090	-1,370	-1,350	-1,470	-1,420	-2,930	-2,490
2032	-600	-760	-960	-1,120	-1,240	-1,380	-1,330	-1,460	-2,970	-2,560
2033	-540	-770	-860	-1,150	-1,120	-1,410	-1,200	-1,490	-2,710	-2,620
2034	-550	-790	-860	-1,170	-1,090	-1,430	-1,160	-1,520	-2,580	-2,660
2035	-500	-800	-780	-1,180	-990	-1,450	-1,060	-1,540	-2,360	-2,700
2036	-450	-800	-700	-1,190	-900	-1,470	-950	-1,550	-2,130	-2,730
2037	-400	-810	-630	-1,200	-800	-1,480	-850	-1,560	-1,920	-2,750
2038	-420	-810	-640	-1,210	-800	-1,490	-840	-1,570	-1,830	-2,760
2039	-370	-820	-570	-1,210	-710	-1,490	-750	-1,580	-1,630	-2,770
2040	-340	-820	-520	-1,210	-650	-1,490	-680	-1,580	-1,470	-2,770
2041	-300	-810	-460	-1,210	-570	-1,490	-600	-1,580	-1,300	-2,770
2042	-320	-810	-480	-1,210	-580	-1,490	-600	-1,570	-1,250	-2,760
2043	-280	-810	-420	-1,200	-510	-1,480	-530	-1,560	-1,090	-2,750
2044	-240	-800	-360	-1,190	-440	-1,470	-460	-1,560	-950	-2,740
2045	-220	-800	-330	-1,190	-390	-1,460	-410	-1,550	-840	-2,720
2046	-240	-790	-360	-1,180	-420	-1,450	-420	-1,530	-830	-2,700
2047	-210	-790	-310	-1,170	-360	-1,440	-360	-1,520	-710	-2,680
2048	-180	-780	-270	-1,160	-310	-1,430	-310	-1,510	-610	-2,660
2049	-160	-770	-230	-1,150	-260	-1,420	-270	-1,500	-510	-2,630
2050	-200	-770	-280	-1,140	-320	-1,400	-320	-1,480	-550	-2,610

Notes: Cumulative impacts undiscounted and measured in person-years; rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

C. Net Regional Economic Impacts of Expenditures and Financing

Table E-15. Present Value and Annual Economic Impacts of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA: GRP (Million 2016$)

	GRP (Million 2016$)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
PV	-$381	-$815	-$575	-$1,233	-$747	-$1,544	-$821	-$1,648	-$1,432	-$3,030
2020	-$1	$26	-$5	$6	-$8	-$1	-$12	-$1	-$19	-$62
2021	-$29	$5	-$33	-$18	-$40	-$28	-$45	-$28	-$53	-$100
2022	-$26	$35	-$25	$22	-$33	$13	-$41	$11	-$42	-$55
2023	-$61	-$6	-$69	-$34	-$81	-$47	-$89	-$49	-$102	-$136
2024	-$45	-$26	-$53	$8	-$65	-$3	-$75	-$6	-$80	-$82
2025	-$57	-$64	-$90	-$40	-$104	-$54	-$114	-$56	-$129	-$147
2026	-$29	-$36	-$62	-$51	-$84	-$13	-$96	-$17	-$104	-$96
2027	-$43	-$73	-$78	-$105	-$110	-$125	-$118	-$132	-$150	-$166
2028	-$17	-$39	-$38	-$60	-$64	-$80	-$71	-$88	-$116	-$104
2029	-$33	-$74	-$57	-$109	-$79	-$133	-$84	-$140	-$159	-$172
2030	-$8	-$35	-$20	-$56	-$35	-$78	-$40	-$86	-$120	-$100
2031	-$28	-$73	-$45	-$108	-$59	-$133	-$62	-$140	-$166	-$175
2032	-$23	-$73	-$38	-$109	-$49	-$133	-$51	-$141	-$163	-$177
2033	-$19	-$73	-$31	-$108	-$40	-$133	-$41	-$140	-$141	-$239
2034	$2	-$37	-$1	-$59	-$6	-$81	-$8	-$89	-$80	-$177
2035	-$17	-$67	-$26	-$100	-$32	-$123	-$33	-$130	-$97	-$233
2036	-$17	-$71	-$25	-$105	-$30	-$129	-$31	-$135	-$82	-$242
2037	-$14	-$71	-$21	-$105	-$26	-$129	-$27	-$136	-$67	-$242
2038	$6	-$36	$6	-$57	$4	-$78	$3	-$86	-$21	-$175
2039	-$16	-$70	-$22	-$103	-$26	-$126	-$27	-$133	-$54	-$237
2040	-$13	-$67	-$18	-$99	-$21	-$122	-$22	-$129	-$43	-$229
2041	-$13	-$71	-$18	-$105	-$21	-$128	-$22	-$135	-$40	-$238
2042	$7	-$36	$8	-$57	$7	-$78	$6	-$86	-$1	-$172
2043	-$15	-$70	-$21	-$104	-$24	-$127	-$24	-$134	-$39	-$235
2044	-$13	-$71	-$19	-$105	-$21	-$129	-$22	-$136	-$35	-$237
2045	-$11	-$69	-$15	-$101	-$17	-$124	-$18	-$131	-$28	-$230
2046	$7	-$37	$9	-$59	$8	-$80	$6	-$89	$4	-$174
2047	-$15	-$71	-$21	-$105	-$23	-$129	-$24	-$136	-$35	-$238
2048	-$13	-$72	-$19	-$107	-$21	-$131	-$22	-$138	-$32	-$240
2049	-$12	-$73	-$17	-$108	-$19	-$132	-$19	-$140	-$29	-$242
2050	$8	-$35	$11	-$56	$10	-$77	$9	-$86	$9	-$171

Notes: Present values (PV) as of January 1, 2016 using a 3% real discount rate.
Source: NERA calculations as explained in text.

Table E-16. Present Value and Annual Economic Impacts of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA: Personal Income (Million 2016$)

	Personal Income (2016$)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
PV	-$261	-$632	-$401	-$962	-$528	-$1,206	-$585	-$1,289	-$1,027	-$2,388
2020	$1	$14	-$1	$1	-$3	-$4	-$5	-$4	-$10	-$45
2021	-$15	$3	-$18	-$13	-$22	-$20	-$25	-$20	-$31	-$71
2022	-$13	$22	-$12	$12	-$17	$5	-$22	$4	-$23	-$44
2023	-$35	-$1	-$40	-$21	-$47	-$31	-$52	-$32	-$61	-$95
2024	-$27	-$13	-$31	$4	-$38	-$4	-$44	-$7	-$48	-$64
2025	-$36	-$39	-$54	-$25	-$63	-$35	-$70	-$37	-$80	-$106
2026	-$20	-$24	-$39	-$32	-$52	-$11	-$60	-$14	-$66	-$76
2027	-$30	-$48	-$52	-$68	-$71	-$79	-$77	-$84	-$96	-$120
2028	-$13	-$29	-$28	-$43	-$45	-$56	-$50	-$62	-$77	-$85
2029	-$24	-$52	-$41	-$75	-$56	-$91	-$60	-$96	-$105	-$127
2030	-$8	-$29	-$18	-$45	-$29	-$60	-$33	-$67	-$82	-$86
2031	-$20	-$52	-$33	-$77	-$44	-$95	-$47	-$101	-$112	-$131
2032	-$18	-$54	-$29	-$80	-$39	-$98	-$41	-$104	-$113	-$135
2033	-$16	-$55	-$26	-$82	-$34	-$101	-$36	-$106	-$103	-$174
2034	-$2	-$34	-$6	-$53	-$12	-$70	-$14	-$77	-$66	-$140
2035	-$13	-$52	-$21	-$77	-$27	-$95	-$28	-$101	-$77	-$176
2036	-$13	-$55	-$21	-$81	-$26	-$100	-$27	-$106	-$69	-$185
2037	-$12	-$56	-$19	-$82	-$24	-$101	-$25	-$107	-$60	-$188
2038	$1	-$35	-$1	-$54	-$4	-$71	-$6	-$78	-$30	-$150
2039	-$12	-$54	-$18	-$81	-$22	-$99	-$23	-$105	-$48	-$187
2040	-$10	-$54	-$16	-$80	-$19	-$98	-$20	-$104	-$42	-$185
2041	-$11	-$57	-$16	-$84	-$19	-$103	-$20	-$109	-$40	-$191
2042	$2	-$36	$1	-$56	-$1	-$74	-$2	-$80	-$15	-$154
2043	-$11	-$56	-$16	-$82	-$19	-$102	-$20	-$108	-$36	-$190
2044	-$10	-$57	-$15	-$84	-$18	-$104	-$19	-$110	-$33	-$193
2045	-$9	-$56	-$13	-$83	-$16	-$103	-$17	-$109	-$30	-$192
2046	$2	-$38	$2	-$59	$0	-$77	-$1	-$84	-$9	-$159
2047	-$10	-$57	-$15	-$84	-$18	-$104	-$18	-$111	-$31	-$195
2048	-$10	-$58	-$14	-$87	-$17	-$107	-$18	-$113	-$30	-$199
2049	-$10	-$60	-$14	-$89	-$16	-$109	-$17	-$115	-$28	-$202
2050	$3	-$38	$3	-$59	$1	-$78	$0	-$85	-$5	-$163

Notes: Present values (PV) as of January 1, 2016 using a 3% real discount rate.
Source: NERA calculations as explained in text.

Table E-17. Cumulative and Annual Economic Impacts of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA: Total Employment (Jobs)

	Total Employment (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Cumulative	-3,430	-10,430	-5,290	-15,780	-7,020	-19,810	-7,800	-21,180	-14,150	-38,860
2020	0	230	-40	30	-70	-40	-100	-40	-180	-650
2021	-220	40	-260	-180	-320	-260	-360	-270	-440	-950
2022	-160	330	-150	210	-200	130	-270	110	-280	-470
2023	-440	-30	-510	-280	-590	-390	-660	-400	-770	-1,160
2024	-280	-190	-340	110	-420	20	-500	-10	-530	-650
2025	-390	-510	-620	-300	-720	-410	-800	-420	-910	-1,190
2026	-170	-260	-370	-370	-530	-50	-610	-70	-660	-720
2027	-290	-570	-520	-810	-720	-960	-780	-1,010	-1,010	-1,280
2028	-80	-280	-200	-430	-370	-570	-420	-640	-710	-750
2029	-220	-550	-370	-810	-510	-990	-540	-1,050	-1,030	-1,270
2030	-20	-240	-80	-390	-170	-540	-210	-610	-700	-680
2031	-180	-530	-290	-790	-380	-970	-390	-1,020	-1,040	-1,250
2032	-150	-530	-240	-790	-310	-970	-330	-1,020	-1,020	-1,260
2033	-130	-530	-200	-780	-260	-960	-270	-1,010	-870	-1,710
2034	40	-250	40	-400	0	-560	-10	-620	-430	-1,220
2035	-110	-480	-160	-710	-200	-870	-210	-920	-590	-1,650
2036	-110	-500	-160	-740	-190	-910	-200	-960	-510	-1,700
2037	-90	-500	-140	-740	-170	-900	-180	-950	-420	-1,690
2038	60	-230	70	-380	60	-520	50	-580	-80	-1,190
2039	-100	-480	-140	-710	-170	-870	-170	-920	-340	-1,640
2040	-80	-460	-120	-680	-140	-830	-140	-880	-280	-1,570
2041	-80	-480	-120	-710	-140	-870	-150	-920	-270	-1,620
2042	70	-230	90	-370	80	-510	70	-560	30	-1,140
2043	-90	-470	-120	-690	-140	-850	-150	-900	-250	-1,570
2044	-80	-470	-110	-700	-130	-860	-140	-900	-230	-1,580
2045	-60	-450	-90	-670	-110	-820	-110	-870	-190	-1,520
2046	70	-230	90	-360	80	-500	70	-560	60	-1,110
2047	-80	-460	-120	-680	-130	-830	-140	-880	-220	-1,540
2048	-80	-460	-110	-680	-120	-840	-130	-880	-200	-1,540
2049	-70	-460	-100	-690	-110	-840	-120	-890	-180	-1,540
2050	80	-210	100	-330	100	-470	90	-520	90	-1,060

Notes: Cumulative impacts undiscounted and measured in job-years; rows may not sum to totals due to rounding.
Source: NERA calculations as explained in text.

Table E-18. Cumulative and Annual Economic Impacts of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA: Population (Persons)

	Population (Persons)									
	B		D		I		E		F	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Cumulative	-9,010	-14,540	-13,770	-22,150	-17,690	-27,690	-19,270	-29,530	-34,160	-54,220
2020	-130	40	-140	-10	-170	-30	-190	-30	-210	-200
2021	-250	30	-280	-70	-330	-110	-370	-110	-410	-410
2022	-380	90	-420	-30	-490	-80	-550	-90	-620	-500
2023	-500	60	-560	-100	-660	-170	-730	-180	-830	-720
2024	-510	-10	-690	-70	-810	-160	-910	-170	-1,020	-790
2025	-520	-130	-820	-150	-960	-250	-1,070	-260	-1,200	-970
2026	-510	-180	-820	-230	-1,090	-240	-1,210	-260	-1,360	-1,030
2027	-500	-290	-800	-400	-1,070	-450	-1,180	-480	-1,510	-1,200
2028	-470	-320	-780	-450	-1,040	-530	-1,150	-570	-1,630	-1,230
2029	-450	-410	-740	-580	-1,000	-700	-1,100	-740	-1,740	-1,370
2030	-430	-410	-710	-600	-950	-730	-1,040	-790	-1,840	-1,360
2031	-410	-480	-670	-710	-900	-870	-980	-930	-1,930	-1,490
2032	-380	-540	-630	-790	-840	-980	-910	-1,040	-2,000	-1,590
2033	-360	-590	-580	-870	-780	-1,070	-840	-1,140	-1,880	-1,790
2034	-330	-570	-540	-850	-720	-1,060	-780	-1,130	-1,770	-1,850
2035	-310	-610	-510	-910	-670	-1,130	-720	-1,200	-1,660	-2,000
2036	-290	-640	-470	-960	-620	-1,190	-670	-1,270	-1,540	-2,130
2037	-270	-670	-430	-1,000	-570	-1,240	-610	-1,320	-1,410	-2,240
2038	-250	-640	-400	-960	-520	-1,200	-560	-1,290	-1,290	-2,230
2039	-230	-670	-370	-1,010	-480	-1,260	-510	-1,340	-1,180	-2,320
2040	-210	-690	-340	-1,030	-440	-1,280	-470	-1,370	-1,070	-2,380
2041	-190	-710	-310	-1,060	-400	-1,320	-420	-1,400	-970	-2,440
2042	-180	-670	-280	-1,010	-360	-1,260	-380	-1,350	-870	-2,380
2043	-160	-690	-260	-1,040	-320	-1,300	-340	-1,380	-780	-2,440
2044	-150	-710	-230	-1,060	-290	-1,320	-310	-1,410	-690	-2,480
2045	-140	-720	-210	-1,070	-260	-1,330	-280	-1,420	-620	-2,490
2046	-120	-670	-190	-1,010	-240	-1,270	-250	-1,360	-540	-2,420
2047	-110	-690	-170	-1,040	-210	-1,300	-220	-1,380	-480	-2,450
2048	-100	-700	-160	-1,050	-190	-1,310	-200	-1,390	-420	-2,470
2049	-100	-710	-140	-1,060	-170	-1,320	-180	-1,410	-360	-2,490
2050	-90	-660	-130	-990	-160	-1,250	-160	-1,330	-320	-2,390

Notes: Cumulative impacts undiscounted and measured in person-years; rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

Appendix F: DMM Scenario 1 Results

This appendix provides regional economic impact results for the EPA alternatives under disposed material management ("DMM") scenario 1, which involves construction of an on-site confined disposal facility ("CDF") as well as off-site disposal. DMM scenario 2 assumes all waste is disposed of at off-site facilities, and impact estimates associated with this disposal scenario are presented in the report body.

DMM scenario 1 was evaluated as a potentially viable disposal option that could result in cost savings for certain alternatives. EPA assumes a CDF could be constructed at the Port of Portland Terminal 4 (in the City of Portland model region) with a capacity of 670,000 cubic yards of material. EPA assumes a minimum threshold of 1,005,000 cubic yards of dredged contaminated sediments is necessary to justify CDF construction; therefore, DMM scenario 1 is only evaluated for alternatives I, E, and F (of those considered in this report).

Section A provides an overview of changes in remediation costs (and subsequently, REMI PI+ model inputs) for the EPA alternatives under DMM scenario 1 relative to DMM scenario 2. Sections B through E reproduce all tables from Section III of the report using the DMM scenario 1 cost and timing estimates from EPA.

A. Overview of DMM Scenario 1

Table F-1 provides an overview of DMM scenario 1 cost savings for the relevant alternatives. Costs developed to reflect the alternative assumptions under this disposal scenario include construction of a CDF, placement of a portion of the volume of dredged sediments into the CDF, and off-site disposal of the remaining volume of dredged or excavated sediment and riverbank soils. Cost estimates produced by EPA assume maximum utilization of CDF disposal capacity under each relevant alternative, and therefore savings are a constant $79 million. Table F-2 breaks down cost savings by REMI PI+ model region, showing that DMM scenario 1 results in greater expenditures in City of Portland due to CDF construction and on-site disposal as well as savings in the rest of Oregon associated with less reliance on off-site disposal.

Table F-1. DMM Scenario 1 Cost Savings for Relevant EPA Alternatives

	EPA Alternative		
	I	E	F
DMM Scenario 1	$1,094	$1,160	$2,100
DMM Scenario 2	$1,173	$1,240	$2,179
Cost Savings	$79	$79	$79

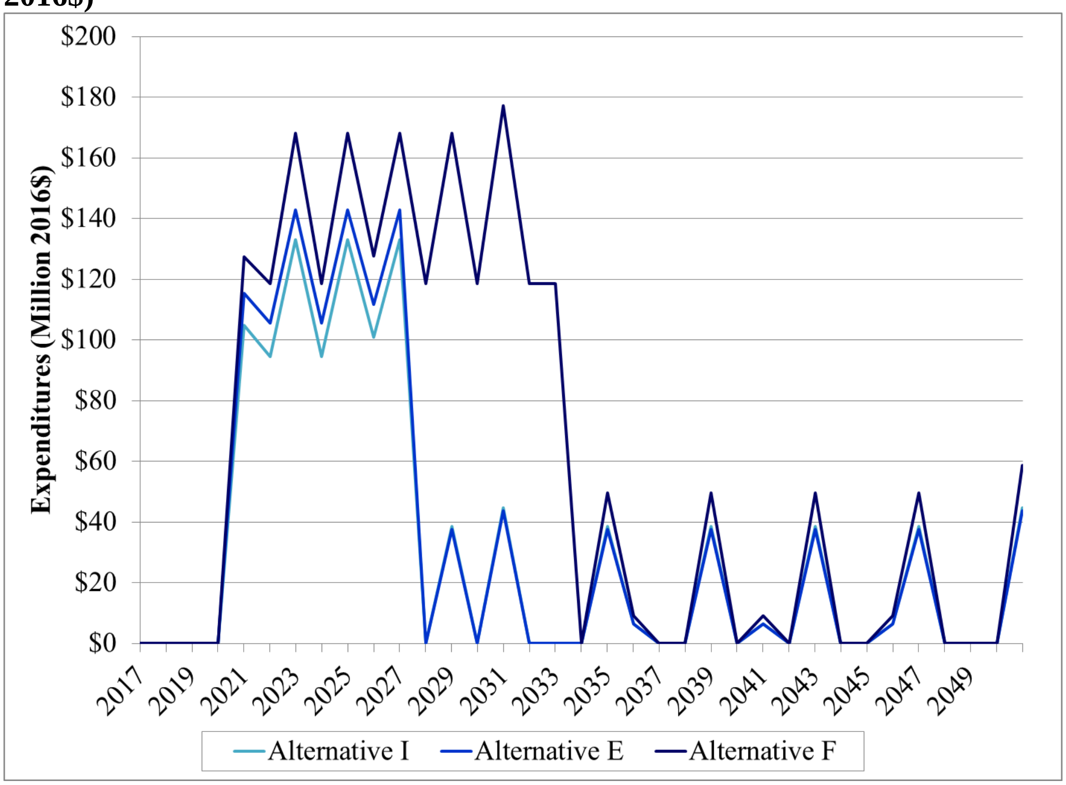
Source: EPA (2016a)

Table F-2. DMM Scenario 1 Cost Savings for Relevant EPA Alternatives by REMI PI+ Region

	REMI Region					
	City of Portland	Rest of MSA: OR	Rest of MSA: WA	Rest of OR State	Outside Region	Total
Alternative I						
DMM Scenario 1	$827	$0	$0	$127	$140	$1,094
DMM Scenario 2	$791	$0	$0	$137	$245	$1,173
Cost Savings	-$36	$0	$0	$10	$105	$79
Alternative E						
DMM Scenario 1	$842	$0	$0	$136	$182	$1,160
DMM Scenario 2	$806	$0	$0	$146	$288	$1,240
Cost Savings	-$36	$0	$0	$10	$105	$79
Alternative F						
DMM Scenario 1	$1,286	$0	$0	$228	$586	$2,100
DMM Scenario 2	$1,250	$0	$0	$238	$691	$2,179
Cost Savings	-$36	$0	$0	$10	$105	$79

Source: EPA (2016a)

Figure F-1. DMM Scenario 1 Expenditures for Relevant EPA Alternatives by Year (Million 2016$)



Note: Undiscounted annual expenditures.
Source: EPA (2016a), AECOM (2016), and NERA calculations as explained in text

B. Positive Regional Economic Impacts of Expenditures

Table F-3. Economic Impacts of EPA Alternative Expenditures on Portland MSA

	I	E	F
Gross Regional Product (Million 2016$)			
Average Annual	$30	$31	$46
Cumulative (3% DR)	$666	$683	$999
Personal Income (Million 2016$)			
Average Annual	$28	$28	$42
Cumulative (3% DR)	$591	$607	$876
Total Employment (Jobs/Job-Years)			
Average Annual	280	290	430
Cumulative	8,800	9,000	13,200
Population (Persons/Person-Years)			
Average Annual	380	390	580
Cumulative	11,690	12,030	18,030

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

C. Negative Regional Economic Impacts of Financing

1. Negative Regional Economic Impacts of Local Government Financing

Table F-4. Economic Impacts of Local Government Financing of EPA Alternatives on Portland MSA

	I		E		F	
	Min	Max	Min	Max	Min	Max
Gross Regional Product (Million 2016$)						
Average Annual	-$62	-$125	-$66	-$132	-$118	-$240
Cumulative (3% DR)	-$1,350	-$2,297	-$1,447	-$2,437	-$2,480	-$4,408
Personal Income (Million 2016$)						
Average Annual	-$60	-$131	-$64	-$139	-$113	-$252
Cumulative (3% DR)	-$1,231	-$2,346	-$1,322	-$2,489	-$2,253	-$4,502
Total Employment (Jobs/Job-Years)						
Average Annual	-580	-1,230	-620	-1,300	-1,070	-2,360
Cumulative	-17,880	-38,110	-19,120	-40,420	-33,140	-73,130
Population (Persons/Person-Years)						
Average Annual	-1,260	-1,500	-1,350	-1,590	-2,390	-2,880
Cumulative	-39,050	-46,470	-41,820	-49,300	-74,030	-89,180

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

2. Negative Regional Economic Impacts of Local Business Financing

Table F-5. Economic Impacts of Local Business Financing of EPA Alternatives on Portland MSA

	I		E		F	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
Gross Regional Product (Million 2016$)						
Average Annual	-$115	-$209	-$123	-$221	-$213	-$393
Cumulative (3% DR)	-$2,417	-$3,677	-$2,592	-$3,894	-$4,322	-$6,923
Personal Income (Million 2016$)						
Average Annual	-$84	-$142	-$90	-$151	-$154	-$267
Cumulative (3% DR)	-$1,707	-$2,476	-$1,832	-$2,622	-$3,022	-$4,645
Total Employment (Jobs/Job-Years)						
Average Annual	-770	-1,260	-830	-1,330	-1,390	-2,360
Cumulative	-23,970	-38,970	-25,640	-41,250	-42,960	-73,010
Population (Persons/Person-Years)						
Average Annual	-1,300	-1,960	-1,390	-2,080	-2,380	-3,730
Cumulative	-40,220	-60,830	-43,230	-64,480	-73,720	-115,510

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

3. Negative Regional Economic Impacts of Mixed Case Financing

Table F-6. Economic Impacts of Mixed Financing of EPA Alternatives on Portland MSA

	I		E		F	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
Gross Regional Product (Million 2016$)						
Average Annual	-$60	-$113	-$64	-$120	-$112	-$215
Cumulative (3% DR)	-$1,271	-$2,027	-$1,362	-$2,149	-$2,304	-$3,850
Personal Income (Million 2016$)						
Average Annual	-$48	-$93	-$52	-$98	-$90	-$176
Cumulative (3% DR)	-$993	-$1,637	-$1,066	-$1,735	-$1,791	-$3,108
Total Employment (Jobs/Job-Years)						
Average Annual	-460	-840	-490	-900	-830	-1,600
Cumulative	-14,140	-26,190	-15,120	-27,750	-25,830	-49,700
Population (Persons/Person-Years)						
Average Annual	-850	-1,160	-910	-1,230	-1,590	-2,220
Cumulative	-26,260	-35,840	-28,180	-38,020	-49,310	-68,770

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

D. Net Regional Economic Impacts of Expenditures and Financing

Table F-7. Economic Impacts of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	I		E		F	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
Gross Regional Product (Million 2016$)						
Average Annual	-$30	-$83	-$33	-$89	-$66	-$169
Cumulative (3% DR)	-$604	-$1,361	-$679	-$1,465	-$1,306	-$2,852
Personal Income (Million 2016$)						
Average Annual	-$21	-$65	-$23	-$70	-$48	-$134
Cumulative (3% DR)	-$402	-$1,046	-$459	-$1,128	-$915	-$2,233
Total Employment (Jobs/Job-Years)						
Average Annual	-170	-560	-200	-610	-410	-1,180
Cumulative	-5,330	-17,390	-6,120	-18,760	-12,630	-36,500
Population (Persons/Person-Years)						
Average Annual	-470	-780	-520	-840	-1,010	-1,640
Cumulative	-14,570	-24,150	-16,140	-26,000	-31,270	-50,740

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

E. Impacts on Portland Region Sectors and Wage Groups

1. Sector Results

Table F-8. Employment Impacts by Sector of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (Jobs)					
	I		E		F	
	Min	Max	Min	Max	Min	Max
Forestry, Fishing, and Related Activities	-10	-10	-10	-10	-10	-20
Mining	0	0	0	0	0	0
Utilities	0	0	0	0	0	0
Construction	20	-30	20	-30	20	-70
Manufacturing	-20	-30	-20	-30	-40	-60
Wholesale Trade	-10	-10	-10	-10	-20	-30
Retail Trade	-30	-60	-40	-60	-70	-110
Transportation and Warehousing	-30	-40	-30	-50	-50	-80
Information	0	0	0	0	-10	-10
Finance and Insurance	-10	-10	-10	-10	-20	-30
Real Estate and Rental and Leasing	-10	-20	-10	-20	-20	-40
Professional, Scientific, and Technical Services	50	20	40	20	50	0
Management of Companies and Enterprises	0	0	0	0	-10	0
Administrative and Waste Management Services	0	-20	0	-20	0	-30
Educational Services	-10	-10	-10	-10	-10	-20
Health Care and Social Assistance	-30	-50	-40	-60	-70	-110
Arts, Entertainment, and Recreation	-10	-10	-10	-10	-10	-20
Accommodation and Food Services	-20	-30	-20	-30	-40	-60
Other Services, except Public Administration	-20	-30	-20	-30	-40	-60
Total Government Employment	-20	-210	-30	-230	-50	-420
Farm Employment	0	0	0	0	0	0
Total	-170	-560	-200	-610	-410	-1,180

Note: Rows may not sum to totals due to rounding.
Source: NERA calculations as explained in text.

2. Wage Group Results

Table F-9. Employment Impacts by Wage Group of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (Jobs)					
	I		E		F	
	Min	Max	Min	Max	Min	Max
Low-wage	-30	-60	-40	-60	-70	-120
Medium-wage	-70	-230	-80	-250	-190	-510
High-wage	-70	-280	-80	-300	-150	-550
Total	-170	-560	-200	-610	-410	-1,180

Note: Low-wage jobs correspond to jobs in sectors with average annual incomes less than or equal to $30,000; medium-wage jobs correspond to jobs in sectors with average annual incomes greater than $30,000 and less than or equal to $80,000; high-wage jobs correspond to jobs in sectors with average annual incomes greater than $80,000. Rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

Table F-10. Employment Impacts by Wage Group of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (% Total)					
	I		E		F	
	Min	Max	Min	Max	Min	Max
Low-wage	20%	10%	19%	10%	18%	10%
Medium-wage	38%	40%	40%	41%	46%	43%
High-wage	42%	49%	40%	49%	36%	46%
Total	100%	100%	100%	100%	100%	100%

Note: Low-wage jobs correspond to jobs in sectors with average annual incomes less than or equal to $30,000; medium-wage jobs correspond to jobs in sectors with average annual incomes greater than $30,000 and less than or equal to $80,000; high-wage jobs correspond to jobs in sectors with average annual incomes greater than $80,000. Rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

Appendix G: AECOM Cost and Timing Results

This appendix provides regional economic impact results using AECOM's "adjusted" cost and timing estimates for the EPA alternatives. The cost estimates are referred to as "adjusted" because AECOM did not develop entirely original cost estimates for the EPA alternatives. Instead, AECOM carefully reviewed the information underlying EPA's cost and timing estimates and made adjustments to certain input assumptions based on experience and professional judgment.

Section A provides an overview of AECOM's cost and timing estimates as implemented in the REMI PI+ model. Sections B through E reproduce all tables from Section III of the report using the AECOM cost and timing estimates for the EPA alternatives.

A. Overview of AECOM Cost and Timing Estimates

Table G-1 provides an overview of EPA and AECOM cost and timing estimates for the EPA alternatives. As noted in the report, AECOM cost estimates are larger in magnitude (about 35 percent to 65 percent larger), and timing estimates are generally longer (about 25 percent to 100 percent larger), with the timing difference increasing with alternative "stringency" (i.e., moving from B to F).

Table G-1. EPA and AECOM Cost and Timing Estimates for EPA Alternatives

	EPA Alternative				
	B	**D**	**I**	**E**	**F**
Years of Construction					
EPA	4	6	7	7	13
AECOM	5	8	11	13	26
Increase (% EPA)	25%	33%	57%	86%	100%
Total Costs (Million 2016$)					
EPA	$642	$953	$1,173	$1,240	$2,179
AECOM	$1,051	$1,355	$1,644	$1,758	$2,969
Increase (% EPA)	64%	42%	40%	42%	36%

Note: Undiscounted totals.
Source: EPA (2016a) and AECOM (2016)

Implementing the AECOM cost and timing estimates in REMI PI+ required two adjustments to the inputs described in Appendix C:

1. Timing Adjustment. We adjust the timing assumptions for any EPA cost item that corresponds to construction activities for consistency with AECOM's schedule. In particular, we spread any costs categorized by EPA as related to "technology assignment measures capital construction costs" or to "institutional controls capital costs" over AECOM's longer construction period.

2. Cost Adjustment. Once timing assumptions are adjusted for consistency with the AECOM schedule, we scale each individual EPA cost item by the percent increase in total cost for each alternative under the AECOM cost estimates.

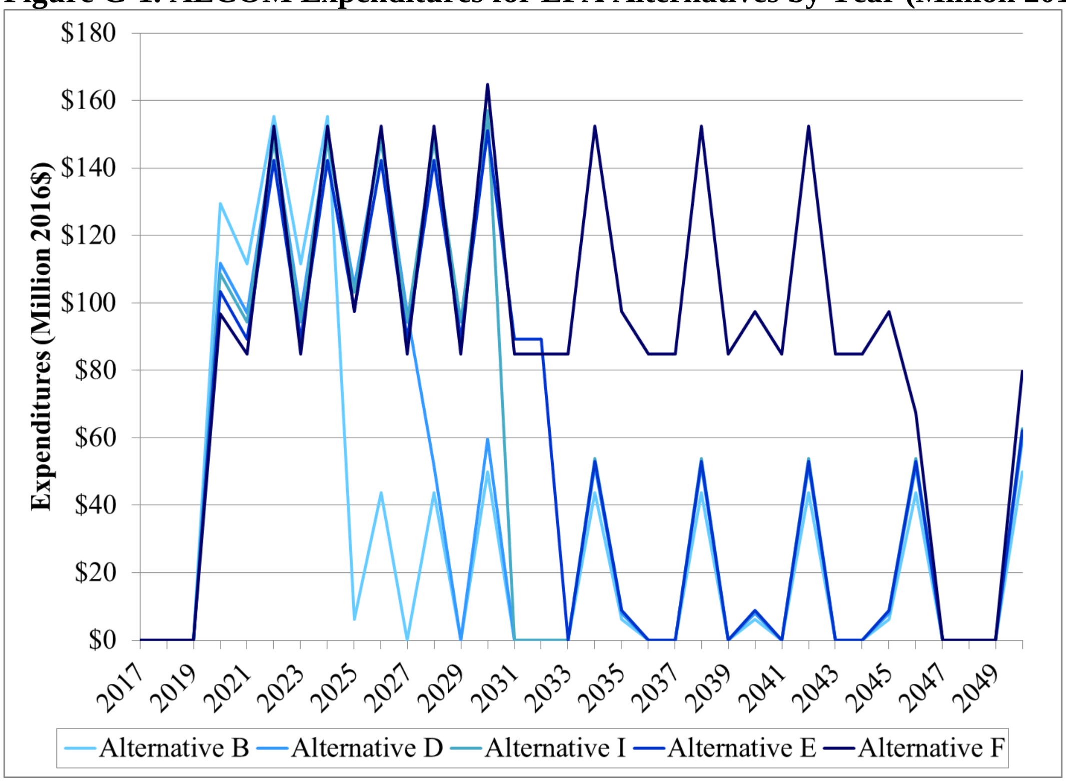
Table G-2 provides an overview of the adjusted timing assumptions by EPA cost category for the AECOM estimates. Figure G-1 illustrates the timing of AECOM expenditure estimates as implemented in REMI by alternative.

Table G-2. AECOM Timing for EPA Alternatives by Cost Category

	EPA Alternative				
	B	D	I	E	F
Technology Assignments Measures Capital Construction Costs	0 - 5	0 - 8	0 - 11	0 - 13	0 - 26
Institutional Controls Capital Costs	0 - 5	0 - 8	0 - 11	0 - 13	0 - 26
MNR Capital Costs	0	0	0	0	0
Site-Wide Monitoring and MNR Periodic Costs	2, 4, 6, 8, 10, 14, 18, 22, 26, 30	2, 4, 6, 8, 10, 14, 18, 22, 26, 30	2, 4, 6, 8, 10, 14, 18, 22, 26, 30	2, 4, 6, 8, 10, 14, 18, 22, 26, 30	2, 4, 6, 8, 10, 14, 18, 22, 26, 30
Long Term O&M Periodic Costs	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30
Institutional Controls Periodic Costs	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30
5-Year Site Review Periodic Costs	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30	5, 10, 15, 20, 25, 30

Source: EPA (2016a), AECOM (2016), and NERA calculations as explained in text.

Figure G-1. AECOM Expenditures for EPA Alternatives by Year (Million 2016$)



Note: Undiscounted annual expenditures.
Source: EPA (2016a), AECOM (2016), and NERA calculations as explained in text

B. Positive Regional Economic Impacts of Expenditures

Table G-3. Economic Impacts of EPA Alternative Expenditures on Portland MSA

	B	D	I	E	F
Gross Regional Product (Million 2016$)					
Average Annual	$29	$35	$40	$41	$60
Cumulative (3% DR)	$625	$752	$852	$870	$1,184
Personal Income (Million 2016$)					
Average Annual	$26	$31	$36	$37	$53
Cumulative (3% DR)	$547	$654	$741	$756	$1,010
Total Employment (Jobs/Job-Years)					
Average Annual	270	320	360	370	530
Cumulative	8,280	9,970	11,300	11,580	16,390
Population (Persons/Person-Years)					
Average Annual	340	410	480	490	690
Cumulative	10,560	12,790	14,800	15,290	21,490

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

C. Negative Regional Economic Impacts of Financing

3. Negative Regional Economic Impacts of Local Government Financing

Table G-4. Economic Impacts of Local Government Financing of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Gross Regional Product (Million 2016$)										
Average Annual	-$60	-$120	-$77	-$155	-$93	-$188	-$99	-$201	-$160	-$339
Cumulative (3% DR)	-$1,299	-$2,207	-$1,633	-$2,845	-$1,943	-$3,452	-$2,042	-$3,691	-$2,994	-$6,233
Personal Income (Million 2016$)										
Average Annual	-$57	-$126	-$73	-$162	-$88	-$197	-$93	-$211	-$146	-$356
Cumulative (3% DR)	-$1,182	-$2,254	-$1,486	-$2,906	-$1,766	-$3,526	-$1,850	-$3,770	-$2,639	-$6,364
Total Employment (Jobs/Job-Years)										
Average Annual	-560	-1,180	-700	-1,520	-840	-1,850	-880	-1,980	-1,350	-3,340
Cumulative	-17,210	-36,610	-21,740	-47,200	-25,970	-57,270	-27,400	-61,240	-41,890	-103,400
Population (Persons/Person-Years)										
Average Annual	-1,200	-1,440	-1,540	-1,860	-1,850	-2,250	-1,970	-2,410	-2,970	-4,070
Cumulative	-37,240	-44,650	-47,590	-57,560	-57,460	-69,830	-60,930	-74,680	-92,110	-126,090

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

4. Negative Regional Economic Impacts of Local Business Financing

Table G-5. Economic Impacts of Local Business Financing of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Gross Regional Product (Million 2016$)										
Average Annual	-$112	-$201	-$140	-$257	-$168	-$310	-$177	-$331	-$282	-$550
Cumulative (3% DR)	-$2,351	-$3,537	-$2,896	-$4,527	-$3,415	-$5,462	-$3,570	-$5,829	-$5,131	-$9,678
Personal Income (Million 2016$)										
Average Annual	-$82	-$137	-$102	-$175	-$121	-$211	-$128	-$225	-$195	-$372
Cumulative (3% DR)	-$1,661	-$2,382	-$2,038	-$3,045	-$2,394	-$3,670	-$2,494	-$3,915	-$3,487	-$6,477
Total Employment (Jobs/Job-Years)										
Average Annual	-750	-1,210	-930	-1,550	-1,100	-1,860	-1,150	-1,990	-1,720	-3,280
Cumulative	-23,390	-37,490	-28,800	-47,900	-34,020	-57,710	-35,670	-61,550	-53,410	-101,760
Population (Persons/Person-Years)										
Average Annual	-1,260	-1,890	-1,560	-2,420	-1,860	-2,930	-1,950	-3,130	-2,810	-5,220
Cumulative	-39,000	-58,470	-48,440	-75,150	-57,720	-90,890	-60,600	-97,080	-87,210	-161,880

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

5. Negative Regional Economic Impacts of Mixed Case Financing

Table G-6. Economic Impacts of Mixed Financing of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Gross Regional Product (Million 2016$)										
Average Annual	-$58	-$109	-$73	-$140	-$88	-$169	-$93	-$180	-$150	-$302
Cumulative (3% DR)	-$1,229	-$1,949	-$1,530	-$2,503	-$1,813	-$3,027	-$1,901	-$3,234	-$2,758	-$5,413
Personal Income (Million 2016$)										
Average Annual	-$47	-$89	-$59	-$114	-$71	-$138	-$75	-$148	-$116	-$248
Cumulative (3% DR)	-$958	-$1,574	-$1,192	-$2,021	-$1,410	-$2,444	-$1,474	-$2,611	-$2,084	-$4,369
Total Employment (Jobs/Job-Years)										
Average Annual	-440	-810	-550	-1,040	-660	-1,260	-690	-1,350	-1,050	-2,250
Cumulative	-13,680	-25,180	-17,100	-32,320	-20,330	-39,080	-21,400	-41,740	-32,440	-69,840
Population (Persons/Person-Years)										
Average Annual	-810	-1,110	-1,030	-1,430	-1,240	-1,740	-1,310	-1,860	-1,940	-3,130
Cumulative	-25,180	-34,430	-31,880	-44,400	-38,320	-53,870	-40,500	-57,600	-59,990	-97,110

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

D. Net Regional Economic Impacts of Expenditures and Financing

Table G-7. Economic Impacts of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Gross Regional Product (Million 2016$)										
Average Annual	-$29	-$80	-$38	-$105	-$48	-$129	-$52	-$140	-$90	-$242
Cumulative (3% DR)	-$604	-$1,324	-$778	-$1,751	-$960	-$2,175	-$1,031	-$2,363	-$1,575	-$4,230
Personal Income (Million 2016$)										
Average Annual	-$21	-$63	-$27	-$83	-$35	-$103	-$38	-$111	-$63	-$194
Cumulative (3% DR)	-$412	-$1,027	-$538	-$1,367	-$668	-$1,703	-$718	-$1,855	-$1,074	-$3,361
Total Employment (Jobs/Job-Years)										
Average Annual	-170	-550	-230	-720	-290	-900	-320	-970	-520	-1,720
Cumulative	-5,400	-16,900	-7,130	-22,350	-9,020	-27,780	-9,830	-30,170	-16,050	-53,470
Population (Persons/Person-Years)										
Average Annual	-470	-770	-620	-1,020	-760	-1,260	-810	-1,360	-1,240	-2,440
Cumulative	-14,610	-23,870	-19,080	-31,610	-23,520	-39,070	-25,200	-42,310	-38,490	-75,630

Note: Cumulative GRP and personal income impacts calculated as present values as of January 1, 2016 using a 3% real discount rate.

Source: NERA calculations as explained in text.

E. Impacts on Portland Region Sectors and Wage Groups

6. Sector Results

Table G-8. Employment Impacts by Sector of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Forestry, Fishing, and Related Activities	0	-10	-10	-10	-10	-10	-10	-10	-10	-20
Mining	0	0	0	0	0	0	0	0	0	0
Utilities	0	0	0	0	0	0	0	0	0	0
Construction	0	-20	0	-30	0	-40	0	-40	10	-80
Manufacturing	-10	-20	-20	-30	-20	-30	-30	-40	-50	-70
Wholesale Trade	-10	-10	-10	-10	-10	-10	-10	-20	-20	-30
Retail Trade	-20	-30	-30	-50	-40	-60	-40	-70	-70	-120
Transportation and Warehousing	-20	-30	-20	-40	-30	-50	-30	-50	-50	-80
Information	0	0	0	0	0	0	0	-10	-10	-10
Finance and Insurance	-10	-10	-10	-10	-10	-10	-10	-20	-20	-30
Real Estate and Rental and Leasing	-10	-10	-10	-20	-10	-20	-10	-20	-20	-40
Professional, Scientific, and Technical Services	30	20	40	20	40	10	40	10	40	-10
Management of Companies and Enterprises	0	0	0	0	0	0	0	0	-10	-10
Administrative and Waste Management Services	0	-10	0	-20	0	-20	0	-20	0	-40
Educational Services	0	0	-10	-10	-10	-10	-10	-10	-10	-20
Health Care and Social Assistance	-20	-30	-30	-50	-40	-60	-40	-70	-80	-120
Arts, Entertainment, and Recreation	0	0	-10	-10	-10	-10	-10	-10	-10	-20
Accommodation and Food Services	-10	-20	-20	-30	-20	-30	-20	-40	-40	-70
Other Services, except Public Administration	-10	-20	-20	-30	-20	-30	-20	-40	-40	-60
Total Government Employment	-10	-130	-20	-190	-30	-230	-30	-240	-60	-430
Farm Employment	0	0	0	0	0	0	0	0	0	0
Total	-110	-340	-170	-510	-230	-640	-250	-680	-460	-1,250

Note: Rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

7. Wage Group Results

Table G-9. Employment Impacts by Wage Group of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (Jobs)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Low-wage	-20	-30	-30	-50	-40	-60	-50	-70	-80	-130
Medium-wage	-40	-140	-70	-210	-100	-270	-120	-290	-220	-550
High-wage	-40	-160	-70	-240	-80	-300	-90	-320	-160	-570
Total	-110	-340	-170	-510	-230	-640	-250	-680	-460	-1,250

Note: Low-wage jobs correspond to jobs in sectors with average annual incomes less than or equal to $30,000; medium-wage jobs correspond to jobs in sectors with average annual incomes greater than $30,000 and less than or equal to $80,000; high-wage jobs correspond to jobs in sectors with average annual incomes greater than $80,000. Rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

Table G-10. Employment Impacts by Wage Group of Combined Expenditures and Financing (Mixed Case) of EPA Alternatives on Portland MSA

	Average Annual Employment Impact (% Total)									
	B		D		I		E		F	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Low-wage	19%	10%	19%	10%	18%	10%	18%	10%	17%	10%
Medium-wage	40%	41%	42%	42%	45%	42%	46%	43%	48%	44%
High-wage	40%	49%	39%	48%	37%	47%	36%	47%	34%	46%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Note: Low-wage jobs correspond to jobs in sectors with average annual incomes less than or equal to $30,000; medium-wage jobs correspond to jobs in sectors with average annual incomes greater than $30,000 and less than or equal to $80,000; high-wage jobs correspond to jobs in sectors with average annual incomes greater than $80,000. Rows may not sum to totals due to rounding.

Source: NERA calculations as explained in text.

Appendix H: Qualitative Impacts of EPA Remedial Alternatives on Riverfront Businesses

In addition to the economic impacts of remediation expenditures and financing, the EPA alternatives could have additional impacts on economic activity along the river, and these direct impacts could lead to additional "multiplier" effects on the regional economy. During remediation, dredging and other remediation activities could potentially disrupt river activities or normal commerce. On the other hand, after remediation, additional economic activities and development may occur in the area due to the elimination or reduction of a potential "stigma" effect from Superfund designation, leading to gains to the regional economy.

We developed a questionnaire to provide indications of the potential qualitative nature of these two effects. This chapter provides information on the questionnaire and an overview of the qualitative results.

A. Business Questionnaire

The primary purpose of NERA's questionnaire was to understand how businesses with operations on the Willamette River might be affected by dredging and other remediation activities related to the EPA alternatives, both during and after remediation. We developed a series of questions regarding the potential impacts of remediation.

Over 20 riverfront organizations were invited to participate in the questionnaire, and we received more than half a dozen responses.[29] Invitees included riverfront organizations with operations along the river as well as local government organizations. NERA conducted interviews on a confidential basis, with the understanding that participants would not be identified and no attribution of responses would be reported. Participants were provided with a copy of the questionnaire before our interview in order to prepare responses. Many questions were operational in nature and required internal discussion and collaboration in order to develop accurate responses.

Questions (other than background questions on the organization and participants) generally focused on:

- Organization's current use of the River (particularly during EPA's in-water work window[30]);
- Likelihood of changes in organization's local operations due to disrupted access;
- Effects of other potential ongoing construction impacts (e.g., noise and/or traffic);

[29] We invited certain local government organizations to participate in the questionnaire process. Responses are generally tallied only for "business" stakeholders, of which there were six.

[30] EPA's assumes in-water work is conducted during the period from July 1 through October 31 to minimize impacts on the aquatic environment.

- Potential long-term impacts of stigma and stigma removal; and
- Potential indicators of long-term remediation success.

The following sections provide an overview of the questionnaire results, organized into effects related to disruption and effects related to stigma removal. Responses were generally nuanced and depended upon each business' specific operations and circumstances; however, as noted, interviews were conducted on a confidential basis. Participants are not identified, and such detailed information on the nature of any businesses' operations along the river are omitted to maintain anonymity. Instead, we categorize sometimes nuanced responses in order to develop tabulations and address as appropriate in the text.

B. Qualitative Disruption Effects

Based upon the NERA questionnaire conducted with potentially affected businesses and upon EPA's descriptions of the activities associated with remediation, we identified three types of potential disruption that would result in negative direct (and multiplier) effects in the Portland region:

1. Disrupted river access;
2. Increased traffic; and
3. Increased noise.

Participants were asked to comment on levels of concern associated with these various potential disruptions, as well as anticipated reactions (e.g., reliance on other shipping methods, production cuts, relocation, etc.). Questionnaire results provide the basis for qualitative assessments of these potential effects.

1. Current Reliance on the River

All businesses interview relied upon access to the river annually and during EPA's proposed 123-day in-water work window. Most businesses relied upon river access as a means of shipping or receiving goods, while some used the river as a source of water for industrial processes. As summarized in Table H-1, the frequency with which participants relied upon river access varied from a few days a month to everyday.

Table H-1. Frequency of River Use

Frequency of River Use	No. Respondents
Everyday	2
Several times a week	2
A few days a month	2

Source: NERA questionnaire.

2. Qualitative Impacts of Disrupted River Access

Five of six participants considered changes in their river operations "very likely" if access to the navigation channel were disrupted during EPA's in-water work window.

Table H-2. Likelihood of Operational Changes Due to Disrupted Access

Likelihood of Change in Operations	No. Respondents
Very Likely	5
Somewhat Likely	0
Not Likely	0
Not Sure	1

Source: NERA questionnaire.

The nature of expected operational changes depended upon the nature of existing operations in the area.

- Participants with nearby facilities with port access (e.g., on the Columbia River in Washington) would likely consider relocating operations.
- Participants without nearby facilities—particularly those with highly specialized and stationary equipment—would consider maintaining production but shipping by other higher-cost means in the near term (e.g., relying more upon rail or trucks); eventually this group might eliminate local production all together.

The construction period of the EPA Alternatives considered in the main body of this report ranges in duration from 4 to 13 years under the EPA information (with longer durations considered in Appendix F based on AECOM information), and anticipated operational changes depend upon the duration of disrupted access. Most participants considered longer periods of disruption as being increasingly worse for business, and reactions to longer term disruption were generally more severe (i.e., relocation or permanent shutdown of riverfront facilities).

Table H-3. Effect of Increased Construction Duration on Level of Disruption

Disruption to Business over Time	No. Respondents
Longer interventions are increasingly worse	4
Negative impacts are the same on daily basis	1
Not sure	1

Source: NERA questionnaire.

Table H-4. Likelihood of Operational Changes Due to Disrupted Access

Reaction to Disruption in Shipping	Short-term	Long-term
Certain to Shutdown	0	0
Certain to Relocate	1	0
Likely to Either Relocate or Shutdown	0	4
Likely to Cut Production	4	1
Likely Unaffected	1	1

Source: NERA questionnaire.

3. Qualitative Impacts of Truck Traffic and Noise

Remediation might also result in increased noise and truck traffic during the construction period due to remedial activities. In addition, increased reliance on trucks as a means of transporting goods in response to river disruption could increase traffic further.

We found questionnaire participants generally were not concerned with the potential for increased noise. Only one participant expressed any concern with increased noise due to the remedial alternatives. (Noise would more likely affect the tourism industry, for example river cruises or waterfront hotels; we did not survey these groups.)

Table H-5. Level of Concern with Increased Noise

Concern with Noise	No. Respondents
Substantial	0
Some	1
None	5

Source: NERA questionnaire.

Most participants, on the other hand, expressed concern with disruption related to increased truck traffic. A number of businesses already rely upon trucks in their production processes, and others might consider trucks as an alternative if disrupted river access results in higher costs to ship via water. Increased traffic would result in slower services and increased costs.

Table H-6. Level of Concern with Increased Traffic

Concern with Traffic	No. Respondents
Substantial	3
Some	2
None	1

Source: NERA questionnaire.

C. Qualitative “Stigma” Removal Effects

As part of the questionnaire, we also discussed issues related to Superfund site stigma with participants, as stigma removal could potentially lead to positive direct and multiplier effects. In particular, we asked participants whether they: (1) believe there is a stigma associated with the Superfund listing; (2) believe stigma affects business in the region; and (3) believe remediation might remove this stigma. Tables H-7 through H-9 tally responses to each of these questions.

Table H-7. Belief in Stigma Associated with Superfund Listing

Stigma Associated with Superfund	No. Respondents
Yes	5
No	0
Not Sure	1

Source: NERA questionnaire.

Table H-8. Belief that Stigma Affects Businesses

Stigma Affects Businesses	No. Respondents
Yes	5
No	1
Don't Know	0

Source: NERA questionnaire.

Table H-9. Belief that Remediation Might Remove Stigma

Remediation Might Remove Stigma	No. Respondents
Yes	4
No	1
Don't Know	1

Source: NERA questionnaire.

Most participants believe there is indeed a stigma associated with site listing and that this stigma affects businesses. Many respondents thought that stigma effects have depressed property values, as businesses who might desire to operate in the area are concerned about potential liability for cleanup costs.

A majority of participants believe that remediation might remove this stigma; however, participants cautioned that stigma removal would require two major changes:

1. Legal certainty for new entrants fearing liability; and

2. Long-term perception of remediation success.

Participants were asked to describe potential indicators of long-term remediation success. Responses were generally varied but included the following:

- Short construction period and limited business disruption;

- Reduction of risks in a cost-effective manner;

- Certainty through a remedial agreement and no litigation; and

- Bearable economic impacts on the community (e.g., few to no bankruptcies, limited tax and utility rate increases).

D. Qualitative Conclusions Related to Impact of Remediation on Riverfront Businesses

The impacts of remediation on river businesses are uncertain and difficult to quantify; however, certain qualitative conclusions can be drawn from participants' responses to NERA's questionnaire. The questionnaire responses generally identified two impact categories as potentially significant:

1. Negative impacts related to business disruption; and

2. Positive impacts related to stigma removal.

Questionnaire respondents did not consider increased noise a concern but did indicate potential increased truck traffic is of some concern.

With regard to the effects of business disruption, virtually all the respondents indicated that the changes in their river operations were "very likely" if access were disrupted during the EPA's in-water work window. The types of changes depended on the nature of the available options.

- Participants with nearby facilities with port access (e.g., on the Columbia River in Washington) would likely consider relocating operations.

- Participants without nearby facilities—particularly those with highly specialized and stationary equipment—would consider maintaining production but shipping by other higher-cost means in the near term (e.g., relying more on rail or trucks); eventually this group might eliminate local production all together.

Most participants responded that remedial alternatives with longer durations would lead to greater disruption and more severe reactions (i.e., relocation or permanent shutdown of riverfront facilities).

With regard to stigma effects, most respondents believed there was a stigma associated with the listing as a Superfund site and that this stigma affected business. A majority believes that remediation might remove this stigma; however, participants cautioned that stigma removal would require two major changes.

1. Legal certainty for new entrants fearing liability; and

2. Long-term perception of remediation success.

In summary the questionnaire results suggest that the net effect of business disruption and stigma removal on the Portland regional economy is ambiguous (i.e., one positive, one negative). It was not possible to develop quantitative estimates of the potential magnitude of these two effects. We suspect, however, that the net effect is likely small in magnitude relative to the direct effects quantified from the remedial expenditures and financing.

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Portland Harbor Sustainability Project

Evaluation of EPA Portland Harbor Superfund Site Remedial Alternatives

Social Analysis Report

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Executive Summary – Social Analysis

Social equity is one of the three pillars of sustainability and provides one platform for stakeholder trade-off evaluation and remedy decision making. This part of the sustainability assessment evaluates the social sustainability of five remedial alternatives (B, D, E, I and F) presented in the 2016 EPA Feasibility Study for the Portland Harbor Superfund Site; results are compared relative to baseline or Alternative A (no further action). This Report, the Social Analysis Report, is one of three reports that compose the Portland Harbor Sustainability Project (PHSP). The other two reports cover the environmental pillar and the economic pillar of sustainability. The purpose of this report is to evaluate the trade-offs among the remedial alternatives in terms of stakeholder values and priorities.

Background

The complex environmental issues and enormous cleanup costs associated with sediment sites can result in a remediation process that is adversarial (NRC 1997, 2001, 2007). To manage disparate objectives and progress with an informed and balanced decision-making process, there is an increasing use of (and policy requirement for) comparative risk assessments, multi-criteria decision analysis, cost-benefit analysis, or similar tools that consider the risks, benefits, and costs of a remedial alternatives. Extensive research has been carried out in the last decade or two that helps inform risk-based and stakeholder-based remedial and disposal decisions (NRC 1997; PIANC 2006a,b, and 2009a,b; Cura et al. 2004; USACE 2003). United States Environmental Protection Agency (EPA) guidelines also suggest that "*All remedies that may potentially meet the removal or remedial action objectives…should be evaluated prior to selecting the remedy*" (EPA 2005). Such thinking is further supported by a recent US Presidential executive memo (Donovan et al. 2015), which directs that human needs must drive regulatory decisions. The memo directs that consideration of "affected communities' needs," and how these might be impacted, must underlie decision-making. The PHSP is a significant step forward in developing a sustainability framework that can be used as an aid to environmental decision making for complex sediment remedies.

The evolution of sediment decision-making is an expanding perspective on the questions of appropriate endpoints, costs, and beneficiaries; moving from purely ecological or human-health risk of sediments, to a broader systems-based perspective that examines environmental, economic, and social risk, at a range of spatial and temporal scales throughout the lifetime of a remedial project. This broader scope and scale drive the perspective and focus of the PHSP. By integrating the three pillars into a common framework allows EPA or other agencies to develop conclusions of potential trade-offs among the remedial alternatives. The application of a sustainability framework to complex environmental decisions is consistent with recent US executive directive, requiring that federal decision making should consider community needs and how they are affected.

Approach - Metrics and Stakeholder Values

The metrics quantified in other pillar assessments (environmental and economic) were adapted and integrated into a stakeholder values-based assessment that was supplemented to include social equity metrics. Metrics were aggregated into one of four Stakeholder Group (SG) Values for each pillar; these values were identified in a broad-based review of sustainability projects and regional stakeholder documents. The values identified are those belonging to individual stakeholder groups and may not represent the values of all stakeholders or the authors or sponsors of this Social Analysis Report. Then, the sorted metrics were scored in the Excel-based Sustainable Value Assessment (SVA) tool developed for this project.

A six month exploratory effort was conducted to identify Portland Harbor SGs and their values. Over 280 separate SGs, including many which are potentially underrepresented in the decision process, were identified and placed in a project-specific stakeholder mapping database. These SGs included regional businesses and industries adjacent to or dependent on the river (including potentially responsible parties to the clean-up); neighborhood, community, and Tribal groups; recreational clubs and other associations; environmental, social justice, and other non-governmental organizations; and local, regional, state, and federal government entities. In parallel with the stakeholder mapping effort, a documentation review was conducted to collect information on inferred and elicited stakeholder values and priorities in terms of Portland Harbor remediation, restoration, planning and development issues. This review included publications, websites, newsletters, journals, brochures, meeting minutes, interviews, and written comments.

SG Values were linked to specific indicators or metrics that could be used to score each remedial alternative in terms of the SG Value. A total of 49 metrics were grouped into 12 SG Values and scored for each of five alternatives (B, D, E, I, and F). The 12 SG Values (sorted by sustainability pillar) are listed in Table SOC-1.

Table SOC-1. The 12 SG Values (Value-based Indicators)

Environmental Quality	Economic Viability	Social Equity
Fish & Wildlife	Economic Vitality	Quality of Life & Recreation
Habitat	Jobs	Community Values
Resilience	Infrastructure	Acceptable Remedy
Low Impact Remedy	Cost-Effectiveness	Health & Safety

Impact (negative) and/or benefit (positive) scores were determined for each metric and each remedial alternative on a scale of -10 to +10. The metric scores were then aggregated according to their respective SG Values to generate SG Value scores.

Social Tool Developed to Evaluate Trade-Offs

The SVA tool was developed as a sediment remediation-specific multi-criteria assessment tool and used to evaluate trade-offs between environmental, economic, and social costs and benefits in terms of SG Values for remedial alternatives and to compare the overall SG Values-based sustainability of each remedial alternative. Comparing each remedial alternative in terms of disparate SG Values provides a platform for dialogue and communication on trade-offs, and supplements more established evaluation of incremental environmental benefits versus costs, such as those evaluated in the CERCLA-linked NEBA. When the diverse impacts of remedial options are considered, stakeholders can better understand the full range of potential consequences of such a major undertaking, supporting better-informed decisions, and ideally, avoiding single-issue decision making.

Values-Based Sustainability Results

Figure SOC-1 shows the aggregated scores for each SG Value, weighted equally and summed for each of the remedial alternatives. The following are the major results of the comparative assessment.

- The net sustainability scores (i.e., the sum of the negative and positive scores) show a clear pattern, with progressively lower net scores for the larger and more expensive alternatives.

- A closer look makes clear that the difference between remedial alternatives is driven not by increased benefits for the higher-scoring alternatives, but by increasing negative impacts for the more extensive alternatives.
- The positive benefit scores (the bars above the zero line) decrease slightly from Alternative B to the larger and more extensive alternatives. Most of the SG Values with positive scores (Fish & Wildlife, Acceptable Remedy, Cost Effectiveness, and Community Values) are among those that are frequently reflected in SG priority differences, and result in trade-offs that produce slightly decreasing net benefits scores across most alternatives (they are scored with both positive and negative values). The higher Resilience score for Alternative F reflects the more extensive removal-based remediation for that alternative.
- In contrast, for the values that have net negative scores, the environmental, economic, and social impacts of a large remediation increase as the remedial alternatives become more extensive.
- For the EPA remedial alternatives under consideration, the small incremental decrease in risk for more aggressive alternatives is outweighed by the increased environmental, economic, and social costs and impacts.

Figure SOC-1. Stakeholder Group Values-Based Sustainability Scores

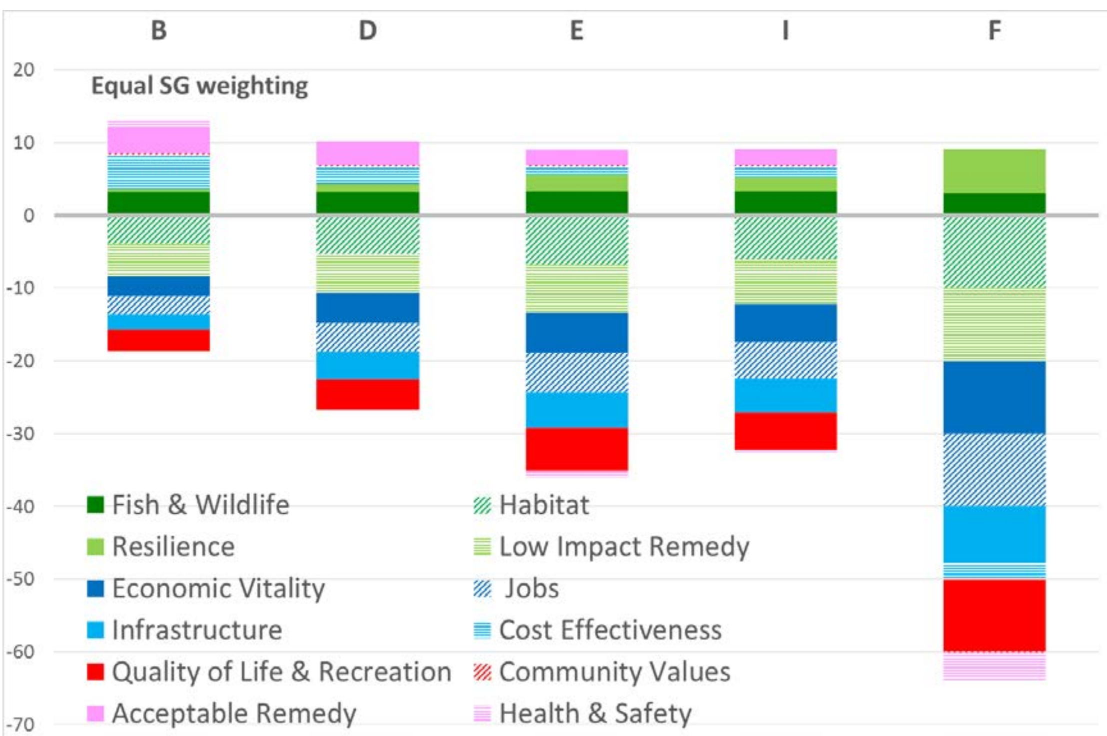

Figure SOC-1 Notes: SG Values weighted equally; metrics weighted according to relevance to values. Bars for some SG Values (e.g., Community Values) are not visible on the graph, as their aggregate scores are small relative to other SG Values.

Sensitivity Analysis

A sensitivity analysis was completed using different weightings to represent differing priorities among stakeholder groups,[1] and comparing SG Value scores using AECOM vs EPA cost and time estimates. The following are results from this analysis.

- The SVA tool is sensitive to various stakeholder inputs—the relative Value and pillar scores change in response to different SG priorities, identifying trade-offs, opportunities for optimization, and sources of potential disagreement.

- There were also some differences observed in time-sensitive metrics when EPA versus AECOM costs and construction times were used.

- However, the conclusions are robust—when a broad range of positive and negative impacts of large-scale remediation is considered, regardless of the weighting approach used, the overall relative sustainability rankings of the remedial alternatives remained the same.

Summary of Relative Sustainability Scores

In summary, the overall values-based sustainability scores of the Portland Harbor remedial alternatives can be ranked as: **Alternative B ≥ Alternative D > Alternative I > Alternative E >> Alternative F.**

This social sustainability assessment suggests that all remedial options have environmental, economic and social impacts, and that these impacts increase in proportion to the magnitude of the remedial alternative. The relatively small incremental increase in permanence and risk reduction for the more extensive options is more than offset by the increased impacts. These conclusions are robust—when a broad range of positive and negative impacts of large-scale remediation is considered, regardless of the weighting approach used, the overall relative sustainability rankings of the remedial alternatives remained the same.

Relevance

The PHSP is a significant step forward in developing a sustainability framework that can be used as an aid to environmental decision making for complex sediment remedies. A comprehensive analyses of the environmental, economic and social impacts (the three pillars of sustainability) associated with remedial alternatives provides a broader basis for decision-making rather than focusing on a narrow set of criteria. Moreover, integrating all of these factors into a common framework allows ones to develop robust conclusions of potential trade-offs among the remediation alternatives.

Our quantitative assessment of SG Values is extensive, new, and robust. It advances the incorporation of sustainability considerations, and we strongly believe it is a worthwhile effort that should be considered by EPA as it decides on a final remediation plan for the Portland Harbor Superfund Site. Indeed, this framework should be used for decision-making at other environmental sites, within the existing CERCLA evaluation process.

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[1] *It is important to note that the intent is not to represent all stakeholders, but to illustrate how trade-offs are affected when differing priorities are considered. Nor is the intent to speak for the selected SGs. Rather, the intent is to apply a diverse set of plausible SG Value and metric priorities for SGs for which we have documentation on their inferred values. Five representative SGs were identified for this purpose.*

For Portland Harbor, as with other contaminated sites, risks, benefits, and costs are not borne equally in terms of time, space, stakeholders, or demographics. These issues should be kept in mind when the trade-offs described in this report are considered – it is important to consider the needs of a diverse population. It is primarily for this reason that the equal SG Value weighting scheme was developed. Although some SGs are very active and vocal, there is evidence of diverse values and priorities throughout the region, and these disparate priorities should be considered, even if not all stakeholders are fully engaged in the decision making. Adverse spatial and demographic equity issues can, to some extent, be minimized by using best management practices, considering community needs in design, and minimizing footprints.

For this tool to be most useful in optimizing sustainable options, a wide range of remedial options with a broad range of potential risk reductions should be evaluated, to identify the point where additional impacts overwhelm the additional gains. Identification of the risks and benefits of most interest to stakeholders can allow for negotiation and optimization of alternatives under consideration, and for collaborative design of more sustainable options.

The application of sustainability tools for complex environmental issues should, ideally, be considered early in the remedial process and with a high level of stakeholder engagement, in order to develop more realistic and effective options. Because this study was conducted after completion of the Portland Harbor FS, the broad range of sustainability considerations were not incorporated into the development of remedial alternatives. The goal for large, complex projects should be to envision a sustainable approach from the beginning of a project, with collaborative input from a large group of stakeholders. An informed, transparent, and balanced decision making process will enable selection of a remedy that more stakeholders can support earlier in the process.

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Appendices

List of Acronyms

BG	Business groups, a representative stakeholder group used in sensitivity analysis
CAG	Portland Harbor Community Advisory Group
CC	Community Comments, a representative stakeholder group used in sensitivity analysis
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	Community Forum, a representative stakeholder group used in sensitivity analysis
COC	contaminant of concern
CS	City Survey, a representative stakeholder group used in sensitivity analysis
ECON	Economic pillar abbreviation, this report
EJ	environmental justice
ENR	enhanced natural recovery
ENV	Environmental pillar abbreviation, this report
EPA	United States Environmental Protection Agency
ERA	Ecological risk assessment
EU	European Union
FS	Feasibility Study
GHG	greenhouse gas
GIS	Geographic Information Systems
GRO	Gentle Remediation Options
GRP	gross regional product
HQ	hazard quotient
kg	kilogram
LWG	Lower Willamette Group
MCDA	multi-criteria decision analysis
MNR	monitored natural recovery
MOU	Memorandum of Understanding
MRW	Metric Relevance Weighting
NAVD88	North American Vertical Datum 1988
NCP	National Contingency Plan
NEBA	Net Environmental Benefit Analysis
NERA	NERA Economic Consulting
NGO	non-governmental organization
NRDA	natural resource damage assessment
ODEQ	Oregon Department of Environmental Quality
OKT	Oregon's Kitchen Table
OPA	Oil Pollution Act
PCB	polychlorinated biphenyl
PHCC	Portland Harbor Community Coalition
PHSG	Portland Harbor Sustainability Group
PHSP	Portland Harbor Sustainability Project
ppb	parts per billion
PRP	Potentially responsible party
REMI	Regional Economic Model, Inc.
RI	remedial investigation
RM	River Mile
SETAC	Society of Environmental Toxicity and Chemistry
SG	stakeholder group
SHPO	State Historic Preservation Office
SOC	Social pillar abbreviation, this report
SVA	Sustainable Value Assessment

Acronyms (Continued)

SWAC	Surface Weighted Average Concentration
TG	Tribal groups, a representative stakeholder group used in sensitivity analysis
US	United States
$B	billions of dollars

1. Introduction

The Portland Harbor Sustainability Project (PHSP) developed a sustainability framework to evaluate remedial alternatives proposed for the Portland Harbor Superfund Site (Site). This study comprises three reports that evaluate the sustainability of Alternatives B, D, E, I, F, and A (baseline, no-action) as presented in the United States (US) Environmental Protection Agency (EPA) *Portland Harbor Feasibility Study* (herein called the 2016 EPA FS) (EPA 2016a). These reports present evaluation of the following components:

A. Environmental Sustainability Analysis Report;
B. Economic Impact Analysis Report; and
C. Social Analysis Report.

This report is the third component of the PHSP and evaluates the social equity pillar of sustainability, including assessment of stakeholder values and aggregation of the environmental, social, and economic pillars of sustainability in a values-based trade-off assessment.

In the context of remediation, sustainability is defined as "*the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact, and that the optimum remediation solution is selected through the use of a balanced decision-making process*" (SURF-UK). The sustainable remediation frameworks developed by AECOM and others focus on the triple bottom line, or the three "pillars" of sustainability—environmental, economic, and social. Evaluations of sustainability then consider the implications of trade-offs between these pillars. Under this paradigm, Dernbach and Cheever (2015) state that "*the key action principle for sustainable development is integrated decision making—the integration of development and environmental objectives and considerations (including environmental quality, social justice, and economic viability) in deliberations*." For the purposes of stakeholder outreach and communication in this project, sustainability is addressed in terms of environmental quality, social equity, and economic viability.

1.1 Purpose

Remedial alternatives should be informed not only by considerations of regulatory compliance but also by stakeholder goals, values, and expectations. The three pillars of sustainability—environmental quality, economic viability, and social equity—must be considered in terms of diverse stakeholders' values. The determination of the most sustainable approach depends on the boundaries established (spatial and temporal) and the priority given to specific stakeholder values. To address this, the PHSP social sustainability assessment evaluated the remedial alternatives presented in the 2016 EPA FS in terms of their impacts on social equity and also scored all three pillars of sustainability in terms of diverse stakeholder group (SG) Values. This integrated assessment was used to communicate the trade-offs of each remedial alternative.

This project has developed a sustainability assessment framework to examine the relative sustainability of remedial alternatives being considered by EPA for Portland Harbor. Results from this framework can help in the design and selection of a sustainable, cost-effective remedy for sediments in the Site. To achieve this, this social sustainability assessment integrated inputs from the environmental (AECOM 2016) and economic (NERA 2016) assessments with indicators of social sustainability to examine trade-offs and overall measures of values-linked sustainability.

1.2 Report organization

Section 1 presents the introduction and purpose of this report.

Section 2 provides an overview of the project approach and reviews sediment-relevant indicators of sustainability in the recent literature.

Section 3 describes the mapping of SGs of relevance to Portland Harbor, with a short description of key SGs.

Section 4 describes the values and priorities for SGs identified in this study, links these to the sustainability pillars, and maps SG value statements to these defined SG Values.

Section 5 discusses the linkages between stakeholder-relevant values to metrics, which allows remedial alternatives to be scored in terms of values.

Section 6 describes the metric and value scoring process, and results.

Section 7 aggregates metric scores to develop overall SG Value scores for each remedial alternative, and aggregates SG Value scores to generate environmental, economic, and social sustainability scores (pillar scores) for each remedial alternative.

Section 8 evaluates how diverse community and SG priorities affect the relative sustainability scores of remedial alternatives (sensitivity analysis).

Section 9 examines uncertainty, sensitivity, and robustness of results.

Section 10 provides literature references.

Tables and figures are found throughout the document and within each section. Appendices follow the main text and are included at the end of document either in text format or CD as Excel files. Appendix A provides background for methods selection. Appendix B identifies the different SGs. Appendix C provides the stakeholder value mapping database linked to each stakeholder. Appendix D provides the detailed sensitivity analysis of different weightings explored among five different representative SGs. Appendix E presents the qualitative social equity assessment. This appendix discusses, for each SG Value, the spatial, temporal, and demographic issues that affect the distribution of costs and benefits of remediation. Appendix F is the input values that feed into the SVA tool.

1.3 Definitions

The following definitions are relevant aspects of the social sustainability analysis and are provided here for clarity.

Indicators – a transition term between a stakeholder value and a metric. Indicators represent priorities expressed by stakeholders. The array of values queried for this project were aggregated into 12 value-linked indicators (four per pillar) and called SG Values.

Mapping – the process of identifying a diversity of stakeholders that are relevant to the project and determining their priorities.

Metric – a measurable attribute that correlates with a parameter of interest and is used as an indicator of that parameter. How the metric was quantified, scored, and scaled relative to a stated goal or baseline is defined in the measurement basis tables and discussion.

Stakeholder – an individual, organization, or other entity that directly or indirectly affects, or is affected by, site releases or cleanup activities; or other interested parties. Stakeholders are site specific and can include members of the local community (for example, residents, regular visitors, nearby businesses, economic development corporations, and river users), regulatory agencies having jurisdiction over the cleanup, site owners or responsible parties, and future users of the property (ASTM 2013).

Stakeholder Group – a representative group of one or more stakeholders that holds a shared set of values, priorities, and expectations related to the Site.

Sustainable Values Assessment (SVA) Tool – an Excel-based tool developed for the PHSP that evaluates trade-offs between environmental, economic, and social pillars and the costs and benefits in terms of SG Values for various remedial alternatives.

SG Value – one of 12 general categories of priorities or interests related to the Site, inferred from a review of SG publications, web pages, interviews, surveys, written comments, or meetings, to which each metric was linked in the SVA tool. SG Values for this project included Fish & Wildlife, Habitat, Resilience, Low Impact Remedy, Economic Vitality, Jobs, Infrastructure, Cost-Effectiveness, Quality Of Life & Recreation, Community Values, Acceptable Remedy, and Health & Safety.

2. Project Approach

2.1 Background – considering stakeholder values and objectives in remedial planning

It is increasingly recognized that remediation and restoration approaches should be designed with final site uses in mind. EPA encourages the consideration of reasonably anticipated future land use when carrying out response actions (Woodford 2010). EPA has carried out or overseen response actions that protect human health and the environment and also allow those sites to be re-used safely and productively. Although, at this point, the bulk of such work has focused on land-based brownfield regeneration, a large-scale restoration of a contaminated waterway should be amenable to similar logic. The European Court of Auditors (ECA 2012) recommended that the European Union (EU) develop a "methodology for the definition of site-specific remediation standards taking account of final site use." In terms of brownfields regeneration, "hard" end use is defined as land use that results in the sealing of soils. Similarly, approaches that result in the extensive removal or covering of sediments can lead to "hard" end uses in waterways or near the coast. "Economic Reclamation" (Krzysztofik et al. 2012) is often driven by economic value of land use, allowing for built development such as industries, logistics, services, or housing; these may require more rigorous or rapid cleanup than other uses, but, in waterways, continued urbanization, industrial, or agricultural use in a catchment may suggest cleanup goals bearing catchment history and use, and thus regional background, in mind.

"Soft" end use,[2] which is called ecological land re-use in the US (ITRC 2006) is land use in which soils remain unsealed; in sediment terms, this may involve monitored natural recovery (MNR) and other, less invasive, remedial approaches. "Environmental reclamation,"[1] often driven by a desire to retain soil function and other ecosystem services (which may be more difficult to economically value), protects biologically productive soils, including those used for agriculture, habitat, forestry, amenity, and landscaping; in sediments this may preserve the essential habitat, food chain, nutrient cycling, and resiliency functions of benthic communities (Apitz 2012) while also supporting infrastructure, navigation, and other waterway uses. Such functions may be amenable to less rigorous or longer-term cleanup, and passive remedial technologies or *in situ* management may be indicated.

The EU Court of Auditors (ECA 2012) recommended that Member States should "consider making more frequent the interim greenfield use of regenerated brownfield sites." A recent Society of Environmental Toxicity and Chemistry (SETAC) workshop concluded that restoration feasibility should consider environmental, social, economic, and cultural contexts, in concert with the ecological risk assessment (ERA), so the two processes can inform and benefit each other. The workshop participants went on to recommend that a robust ERA characterizes existing conditions and considers both pre-impact conditions and desired restoration outcomes to understand benefits and costs related to restoration activities (Kapustka et al. 2016). To achieve this, Kapustka et al. recommended that risk managers, risk assessors and stakeholders begin with an ecological planning framework (i.e., restoration management goals and planning must be well integrated into the problem formulation phase of an ERA up front). They stated that "when remediation is to occur in areas which will remain heavily used and/or urbanized, then social ecology (and the needs and activities of the humans which are inseparable parts of urban ecosystems) should be an important part of the decision-making process."

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[2] *http://www.zerobrownfields.eu/*

Such thinking is further supported by a recent US Presidential executive memo (Donovan et al. 2015), which directed that human needs (supported by ecosystem services) must drive regulatory decisions. This approach recognizes that social and economic needs depend on healthy ecosystems; the latter must be protected if the former are to be sustained. The memo directs that consideration of “affected communities’ needs,” and how these might be impacted, must underlie decision-making. Therefore, to comply with the EPA executive memo and the National Contingency Plan (NCP), EPA needs to integrate sustainability into its assessment of remedial options.

2.2 Project approach – developing a social framework

The above discussion makes clear that, in order to best inform sustainable remediation strategies, it is essential that the ultimate goals for site re-use (and restoration) are borne in mind, and that these re-use goals must embrace the needs and priorities of a diverse stakeholder community. Although it would make sense to include aspects of restoration, development, and re-use of the Site and its adjacent shorelines in the remedial decision-making process, these issues are not part of the remedial alternatives under consideration and, thus, cannot explicitly be part of a comparative assessment of the sustainability of the remedial alternatives. However, the values, goals, and objectives of stakeholders in light of not only site remediation, but also in terms of regional restoration, planning, and development, can be taken into account when trade-offs between the costs, risks, and benefits of remedial alternatives are compared.

Figure 2-1 illustrates the overarching approach to the social sustainability assessment in this project. Once SG Values were identified, all sustainability metrics were mapped to them. Three parallel assessment approaches were followed: an evaluation that looked at the trade-offs between SG Values for each remedial alternative, weighing all SG Values and metrics equally (Section 7), a sensitivity assessment when SG-based weightings are used for specific stakeholder groups (Section 8 and Appendix D), and a qualitative assessment of the equity impacts (Appendix E). The equity assessment is an evaluation of how the risks and benefits of each alternative are distributed in space, time, and demographically, and how any disparities might be addressed to enhance equitable outcomes.

Figure 2-1. Social sustainability project approach

A review of the literature suggested that social aspects of sediment-focused sustainability assessments are still in their infancy; they tend to be qualitative and include only a few indicators. Although many sustainability frameworks identify social indicators or metrics, no standardized approach to their evaluation was found, nor was there an established model for integrating social (or overall) sustainability in the context of stakeholders' values. Thus, a framework (Figure 2-1) and calculation tool (the Sustainable Values Assessment tool, SVA tool, described below) were developed to provide a transparent evaluation of social sustainability for Portland Harbor.

2.2.1 Step 1 – Develop social indicator values

Criteria used for sediment decision-making evaluate "fitness for purpose" (i.e., will a sediment management alternative adequately fulfil the technical requirements) and "sustainability criteria" (Bardos et al. 2012). Criteria for these two purposes may overlap but are not exactly the same. The fitness for purpose and sustainability of a remedial alternative are evaluated using different approaches and address different decisions. The PHSP assessed the sustainability of a range of proposed remediation strategies for contaminated sediment in Portland Harbor. This document focuses on social equity, but, where appropriate, the other pillars—environmental quality and economic viability—are incorporated into stakeholder values.

A coherent set of criteria to inform a decision should be as follows (Burgman 2005):

- Exhaustive (allow a clear delineation between alternatives)
- Cohesive (alternatives that rank higher on one criterion should be preferred)
- Clear (linked to decisions, in scientific terms and in the minds of decision makers)
- Not redundant (avoiding bias and double-counting), and
- Relevant (meaningful to the actual decision process)

Thus, although the literature presents a vast range of potential indicators for all three pillars of sustainability (environmental, social, economic), all indicators selected for use and/or integration should be carefully reviewed to ensure that, singly and together, they meet the above criteria.

This social sustainability assessment integrated inputs from the environmental (AECOM 2016) and economic (NERA 2016) assessments with indicators of social sustainability to examine trade-offs and overall measures of values-linked sustainability.

The development of a list of indicators for social sustainability began with a literature review of sediment-related sustainability indicators, with a focus on social indicators. The tables below summarize the sustainability indicators identified in the most relevant studies. Table 2-1 summarizes the indicators of environmental quality reported in five different studies, and the relevant indicator (SG Values) developed for this study (in the final column); Table 2-2 summarizes the indicators of economic viability; and Table 2-3 summarizes the indicators of social equity. The tables are color-coded showing which pillar each indicator represents. Throughout this report, green is used to indicate environmental quality; blue is used for economic viability; and red is used to represent the social equity pillar. The indicators of sediment-related sustainability were grouped into 12 SG Values, as shown below, and detailed in Tables 2-1, 2-2, and 2-3:

Environmental Quality	Economic Viability	Social Equity
Fish & Wildlife (ENV-1)	Economic Vitality (ECON-1)	Quality of Life & Recreation (SOC-1)
Habitat (ENV-2)	Jobs (ECON-2)	Community Values (SOC-2)
Resilience (ENV-3)	Infrastructure (ECON-3)	Acceptable Remedy (SOC-3)
Low Impact Remedy (ENV-4)	Cost-Effectiveness (ECON-4)	Health & Safety (SCO-4)

Although not all indicator categories are addressed in all the frameworks reviewed, the frameworks summarized here are among the most representative, broadest, and most recent. The far right column of each table identifies the SG Values considered in this study, which are reflected by each sustainability indicator category. SG Values will be discussed further in Section 4. The indicator lists were also used to identify which metrics should be used to quantify SG Values.

2.2.2 Step 2 – Identify stakeholders and their priorities

The process of identifying stakeholders and their priorities relevant to Portland Harbor is discussed in Section 3 (stakeholder mapping). This section also identifies some key stakeholder groups that have been active in the Portland Harbor remediation decision process.

2.2.3 Step 3 – Map stakeholder values

The process of evaluating and quantifying the stakeholder values identified specifically for Portland Harbor is discussed in Section 4 (stakeholder values). A total of 26 values (types of values) were identified related to environmental, economic, social, and implementability concerns. Eventually, these 26 project-specific values were aggregated into the 12 SG Values for clarity, ease of quantification and evaluation.

2.2.4 Step 4 – Link SG Values to metrics

SG Values were linked to metrics that could be used to score each remedial alternative in terms of the SG Value; these metrics are relevant and sensitive to the remedial alternatives under consideration (Section 5). Where possible, metrics were identified that were standard, quantitative, and logically and clearly linked to (and correlating with) the SG Values. Where all these expectations could not be met, the metric that came closest to this was selected.

Measurable environmental metrics were quantified for the environmental pillar within the sustainability analysis (AECOM 2016). Information used to quantify environmental metrics was extracted from the 2015 Draft Final FS (herein called the 2015 EPA FS) (EPA 2015a) and 2016 EPA FS (EPA 2016) or the 2012 Draft FS (AnchorQEA 2012). Other metrics were generated by AECOM using an environmental footprint tool (SiteWise™; NAVFAC 2015), or quantified using geographic information system (GIS) overlay analysis. The majority of the environmental metrics were then aggregated and used in AECOM's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-linked Net Environmental Benefit Analysis (NEBA) tool to rank the environmental benefit of the remedial alternatives in the context of CERCLA criteria (EPA 1998). Details of this work can be found in the environmental report (AECOM 2016).

Similarly, remedial alternative impacts on economic viability were evaluated in the economic assessment (NERA 2016), which included custom applications of the Regional Economic Model, Inc. (REMI) model, an established, state-of-the-art economic impact model. The REMI model takes as inputs expenditure and financing information and produces estimates of overall regional impacts based upon detailed modeling of multiplier and other market impacts. NERA Economic Consulting (NERA) also assessed potential qualitative impacts on riverfront businesses—including potential negative impacts due to disruption during remediation and potential positive effects due to “stigma” removal when remediation is complete—based upon responses from a riverfront business questionnaire. A detailed discussion of these measurements is provided in Section 6.

2.2.5 Step 5 – Score and weight the metrics

In this step (Section 6), an Excel-driven calculation tool, the Sustainable Values Assessment (SVA) tool, aggregates sustainability metrics from all pillars from a social perspective. The SVA evaluates trade-offs between environmental, economic, and social costs and benefits in terms of SG Values. It develops a quantitative score for remedial alternatives in terms of stakeholder values. This approach uses SG Value-linked evaluation criteria to determine overall SG Values-based sustainability of alternatives under consideration.

2.2.6 Step 6 – Aggregate into 12 SG Values and 3 pillar scores

In this step (Section 7), metrics are aggregated to generate SG Value scores; SG Value scores are then aggregated to generate overall pillar scores. At this stage, all metrics and SG Values are weighted only by their relevance weights (see Section 6.3 for the Metric Relevance Weighting, or MRW, approach). All SG Values and metrics are given equal priority in aggregation, treating all SG Values and metrics as equally important to overall sustainability.

2.2.7 Step 7 – Sensitivity analysis

All metrics and SG Values are treated as equally important to overall sustainability above. However, not all SGs prioritize these SG Values and metrics equally. In Step 7 (Section 8), metric and SG Value scores are weighted to reflect the inferred priorities of different representative SGs. Weighting will affect the aggregation of metrics to SG Value scores and SG Values to overall pillar sustainability scores. This sensitivity analysis is being carried out to address two objectives: (1) to demonstrate the use of the SVA tool to address SG-specific priorities and communicate trade-offs in terms of these priorities, and (2) to evaluate the sensitivity and robustness of SVA-based assessment of the relative sustainability of remedial alternatives to differing SG priorities. A sensitivity assessment was also carried out comparing results using EPA (2016a) and AECOM (2016) adjusted cost and time values.

Step 7 also includes a qualitative equity assessment, presented in Appendix E. A qualitative equity assessment is an approach to addressing the potentially uneven distribution of costs, risks, and benefits for any remediation practice.

Table 2-1. Indicators of environmental quality in sediment-relevant sustainability assessments

Other Sediment-related Sustainability Frameworks						PHSP Stakeholder Value[g]
SuRF category[a]	UK-Cefas sediment indicators[b]	SMOCS indicators[c]	Linkov indicators[d]	Bergen indicators[e]	Sustainability practices[f]	
Environment 1: Impacts on air	Emissions that may affect climate change or air quality, such as greenhouse gases (e.g., CO2, CH4, N2O), NOX, SOX, particulates (especially PM5 and PM10), O3, VOCs, ozone-depleting substances, etc. (Note: Does not include any odorous effects, bioaerosols, allergens, or dust, as these are included in 'Social 3: Impacts on neighborhoods or regions'.)	Risk of contaminant/nutrient release; complete ecological exposure pathways; release of greenhouse gases	Exposure and potential for transport	Greenhouse gas impact	Reduce emissions of greenhouse gases; Reduce emissions of criteria pollutants	ENV-4: Low Impact Remedy
Environment 2: Impacts on sediment, soil, porewater, and ground conditions	Changes in physical, chemical, or biological sediment or soil condition that affects the functions or services provided by sediments and soils. May include sediment/soil quality (chemistry), water filtration and purification processes, contaminant attenuation, sediment/soil structure, and/or organic matter content or quality; soil/sediment, coastal and/or wetland erosion and stability, geotechnical properties, compaction and other damage to structure affecting stability, drainage, or provision of another ecosystem good or service. Impacts on geological SSSIs and geoparks.	Risk of contaminant/nutrient release; complete ecological exposure pathways	Source/ destination water and sediment compatibility; water quality; sediment stability; material stability and potential for erosion		Minimize soil and habitat disturbance	ENV-4: Low Impact Remedy
Environment 3: Impacts on groundwater and surface waters	Release of contaminants (including nutrients), dissolved organic carbon or silt/particulates, affecting suitability of water for potable or other uses, water body status (under WFD) and other legislative water quality objectives, biological function (aquatic ecosystems) and chemical function, mobilization of dissolved substances. Effects of water abstraction included, such as lowering river levels or water tables or potential acidification. (Note: Does not include any water abstraction use or disposal issues, as this is covered in 'Environmental 5: Use of natural resources and generation of wastes'.)	Risk of contaminant/nutrient release; complete ecological exposure pathways		Reduction of environmental risk (PCB flux from sediments)	Prevent runoff and negative impacts to surface water; Minimize bioavailability of contaminants through source and plume control; Prevent off-site migration of contamination	ENV-4: Low Impact Remedy

Table 2-1 (Continued). Indicators of environmental quality in sediment-relevant sustainability assessments

Other Sediment-related Sustainability Frameworks						PHSP Stakeholder Value[g]
SuRF category[a]	UK-Cefas sediment indicators[b]	SMOCS indicators[c]	Linkov indicators[d]	Bergen indicators[e]	Sustainability practices[f]	
Environment 4: Impacts on ecology	Direct consequences for flora, fauna, and food chains, especially protected species, biodiversity, and impacts on SSSIs. Introduction of alien species. Significant changes in ecological community structure or function. Loss of habitat. Impacts of light, noise, and vibration on ecology. Use of decontamination equipment or disposal sites or operations that affect fauna (e.g., affecting bird or bat flight, or animal migration, etc.; environmental windows). Impacts on fish or marine mammals. (Note: Does not include effects on soil and aquatic ecosystems, which are covered in 'Environmental 2: Impacts on soil and ground conditions' and 'Environmental 3: Impacts on water', while impacts of light, noise, and vibration on humans are covered in 'Social 3: Impacts on neighborhoods and regions'.)	Ecological hazard quotients; complete ecological exposure pathways; expected loss of species; expected time to full recolonization; invasive species risk	Benefits and impacts to individual animals and habitats (short-term); Impacts of benefits to populations and habitats (long-term); other considerations		Maximize biodiversity; Protect native ecosystem and avoid introduction of non-native species; Minimize risk to ecological receptors	ENV-1: Fish & Wildlife; ENV-2: Habitat
Environment 5: Use of natural resources and generation of wastes	Consequences for land and water resources, use of primary resources and substitution of primary resources within the project or external to it, including raw and recycled aggregates. Use of energy/fuels taking into account their type/origin and the possibility of generating renewable energy by the project. Handling of materials on-site, off-site and waste disposal resources. Water abstraction, use and disposal.	volume of remnants for disposal			Minimize fresh water consumption; maximize water reuse; Conserve groundwater resources; Use native vegetation requiring little or no irrigation; Favor low-energy technologies (e.g., bioremediation, phytoremediation) where possible and effective; Preserve natural resources; Use telemetry or remote data collection when possible; Use passive sampling devices where feasible; Use or generate renewable energy to the extent possible; Minimize material extraction and use; Minimize waste; maximize materials re-use; recycle or re-use project waste streams	ENV-4: Low Impact Remedy
Environment 6: Intrusiveness	Impacts on flooding or increased risk of flooding, coastal erosion; alteration of landforms that affect environment, (e.g. a "natural" view). (Note: Does not include effects on built environment and protection of archaeological resources, which are covered in 'Social 3: Impacts on neighborhoods or regions', while effects on ecology are covered in 'Environmental 4: Impacts on ecology'.)				Favor minimally invasive in situ technologies	Resilience

Table 2-1 notes: When an indicator is mapped to the environmental pillar, it is highlighted green; blue highlights indicate the economic pillar and red highlights indicate the social pillar. White (no highlight) means this was not addressed in the framework. The far right column indicates the stakeholder value within which these indicators are considered in this assessment (see Section 5). Footnotes: a) SuRF-UK (2011); b) Vivian et al. (2011); c) SMOCS (2013); d) Linkov (2014); e) Sparrevik et al. (2014); f) Favara et al. (2009); g) this report.

Table 2-2. Indicators of economic viability in sediment-relevant sustainability assessments

<table>
<tr><th colspan="6">Other Sediment-related Sustainability Frameworks</th><th rowspan="2">PHSP Stakeholder Value[g]</th></tr>
<tr><th>SuRF category[a]</th><th>UK-Cefas sediment indicators[b]</th><th>SMOCS indicators[c]</th><th>Linkov indicators[d]</th><th>Bergen indicators[e]</th><th>Sustainability practices[f]</th></tr>
<tr><td rowspan="2">Economic 1: Direct economic costs and benefits</td><td rowspan="2">Direct financial costs and benefits of remediation, disposal option or beneficial re-use for organization, consequences of capital and operation costs, and sensitivity to alteration (e.g., uplift in site value to facilitate future development, minimization of risk, or threat of legal action)</td><td rowspan="2">Transport cost; disposal cost; treatment cost; method/infrastructure cost; public relation cost; subsidies; tax abatements; financial profit (ben. use); reduced cost (to disposal); Potential markets (ben use); economic demand (ben use)</td><td>Short-term: Direct construction costs; cost sharing project requirements; project monitoring costs; market and infrastructure limitations</td><td></td><td></td><td>ECON-1: Economic vitality; ECON-2: Jobs; ECON-4: Cost-Effectiveness</td></tr>
<tr><td>Long-term: O&M; changes to commercial and recreational fisheries; ESS; hurricane/flood protection benefits; development and improvement; capacity issues; cumulative indirect and opportunity costs and benefits</td><td></td><td>Consider the net economic result; Consider cost of the “sustainability delta,” if any</td><td>ECON-1: Economic Vitality; ECON-2: Jobs; ECON-3: Infrastructure; ECON-4: Cost-Effectiveness</td></tr>
<tr><td>Economic 2: Indirect economic costs and benefits</td><td>Long-term or indirect impacts and benefits, such as financing debt, allocation of financial resources internally, changes in site/local land/property values, and fines and punitive damages (e.g., following legal action, so includes solicitor and technical costs during defense). Consequences of an area's economic performance. Tax implications. Financial consequences of impact on corporate reputation. (excluding factors considered under induced economic benefit)</td><td></td><td>Indirect and opportunity costs or benefits</td><td>Maximize governmental/ minimize municipal funding; Maximize municipal/ minimize governmental financing</td><td>Invest in carbon offsets (listed as environmental and economic)</td><td>ECON-1: Economic Vitality; ECON-2: Jobs</td></tr>
<tr><td>Economic 3: Employment and employment capital</td><td>Job creation, employment levels (short- and long-term), skill levels before and after, opportunities for education and training, innovation and new skills</td><td>loss/gain of jobs</td><td></td><td></td><td>Maximize employment and educational opportunities (economic and social); Use locally sourced materials (all pillars)</td><td>ECON-2: Jobs</td></tr>
</table>

Table 2-2 (Continued). Indicators of economic viability in sediment-relevant sustainability assessments

Other Sediment-related Sustainability Frameworks						PHSP Stakeholder Value[g]
SuRF category[a]	UK-Cefas sediment indicators[b]	SMOCS indicators[c]	Linkov indicators[d]	Bergen indicators[e]	Sustainability practices[f]	
Economic 4: Induced economic benefit	Creating opportunities for inward investment, use of funding schemes, ability to affect other projects in the area / by client to enhance economic value		Beneficial use	Area for property development (land reclaimed)	Improve the tax base/economic value of the property/local community (economic and social)	ECON-1: Economic Vitality
Economic 5: Life span and project risks	Duration of the risk management (remediation) benefit, e.g., fixed in time for a containment system); factors that might impact the chances of success of the remediation works and issues that may affect works, including community, contractual, environmental, procurement, and technological risks. ELD liability implications?				Favor technologies that permanently destroy contaminants (environmental and social)	SOC-3: Acceptable Remedy
Economic 6: Project flexibility	Ability of project to respond to changing circumstances, including discovery of additional contamination, different sediment materials, or timescales. Robustness of solution to climate change effects. Robustness of solution to altering economic circumstances. Requirements for ongoing institutional controls. Ability to respond to changing regulation or its implementation				Use operations data to continually optimize and improve the remedy;	SOC-3: Acceptable Remedy

Table 2-2 notes: When an indicator is mapped to the environmental pillar, it is highlighted green; blue highlights indicate the economic pillar and red highlights indicate the social pillar. White (no highlight) means this was not addressed in the framework. The far right column indicates the SG Value within which these indicators are considered in this assessment (see Section 5). Footnotes as in Table 2.1.

Table 2-3. Indicators of social equity in sediment-relevant sustainability assessments

Other Sediment-related Sustainability Frameworks						PHSP Stakeholder Value[g]
SuRF category[a]	UK-Cefas sediment indicators[b]	SMOCS indicators[c]	Linkov indicators[d]	Bergen indicators[e]	Sustainability practices[f]	
Social 1: Human health and safety	Risk management performance of the project in terms of delivery of mitigation of unacceptable human health risks. Risk management performance in the short term, including risks to site workers, site neighbors, and the public from remediation works and their ancillary operations (includes hazardous process emissions such as bioaerosols, allergens, and PM10, as well as impacts from operating machinery and traffic movements, excavations, etc.).	Complete human exposure pathways; largest cancer risk for any pathway	Operational safety; navigational safety; exposure to contaminants	Reduction of human health risk	Minimize health and safety risk during remedy implementation; Assess current, potential, and perceived risks to human health, including contractors and public, over the remedy life cycle (economic, environmental, and social)	SOC-4: Health & Safety
Social 2: Ethical and equity considerations	How are social justice and/or equality addressed? Is the spirit of the 'polluter pays principle' upheld with regard to the distribution of impacts and benefits? Are the effects of works disproportionate to, or more beneficial towards, particular groups? What is the duration of remedial works and are there issues of intergenerational equity (e.g., avoidable transfer of contamination impacts to future generations)? Are the businesses involved operating ethically (e.g., open procurement processes)? Does the treatment approach raise any ethical concerns for stakeholders (e.g., use of genetically modified organisms)?	Public acceptance (concern assessment results)	Other conflicting uses; affected populations	Disposal site location	Avoid environmental and human health impacts in already disproportionately impacted communities (environmental and social)	SOC-2: Community Values (and equity assessment)
Social 3: Impacts on neighborhoods or regions	Impacts to local community, including dust, light, noise, odor, and vibrations during works and associated with traffic, including both working-day and night-time / weekend operations. Effect of antisocial use of site, and its impact of other regeneration activities. Impacts on the built environment, architectural conservation, conservation of archaeological resources. Effect of the project on local culture and vitality. (Note: Does not include effects or perceptions of a "natural" view, which is covered in 'Environment 6: Intrusiveness'.)	Availability of sites; Odor nuisance; noise pollution; monetary loss (expected); archaeological sites (number, effect, distance); jobs (local loss and/or gain); money (local loss and/or gain); local business impact	Short-term air quality (related to equipment and transport)	Construction impacts (spatial influence); marine archaeological preservation	Maximize acres of a site available for reuse; Maximize acres of a site available for reuse; Minimize noise, odor, and lighting disturbance; Consider net positive/negative impact of the remedy on local community; Prevent cultural resource losses; Maintain or improve public access to open space	SOC-1: Quality of Life & Recreation

Table 2-3 (Continued). Indicators of social equity in sediment-relevant sustainability assessments

Other Sediment-related Sustainability Frameworks						PHSP Stakeholder Value[g]
SuRF category[a]	UK-Cefas sediment indicators[b]	SMOCS indicators[c]	Linkov indicators[d]	Bergen indicators[e]	Sustainability practices[f]	
Social 4: Community involvement and satisfaction	Impacts of works on public access to services (all sectors –commercial, residential, educational, leisure, amenity). Inclusivity and engagement in decision-making process. Transparency and involvement of local community, directly or through representative bodies	Impairment of bathing waters; positively affected areas; created amenity areas; negatively affected areas; loss of tourists (expected)	Recreation, education and research; cultural and historical; aesthetics		Integrate stakeholders into decision-making process; Solicit community involvement to increase public acceptance and awareness of long-term activities and restrictions; Create goodwill in the community through public outreach and open access to project information; Consider future land uses during remedy selection and choose remedy appropriately; Link remediation to restoration/enhancement goals; Incorporate community values in remediation/restoration design	SOC-2: Community Values
Social 5: Compliance with policy objectives and strategies	Compliance of the works with policies, regulatory standards, and good practice as set out nationally, by local authority, at the request of community and/or in line with industry working practices and expectations. Do sediments to be disposed of or beneficially used meet regulatory criteria for endpoint?	Required environmental impact assessments; required applications				SOC-3: Acceptable Remedy
Social 6: Uncertainty and evidence	How has sustainability assessment been carried out and what has it considered? Quality of investigations, assessments, (including sustainability) and plans, and their ability to cope with variation. Accuracy of record taking and storage. Requirements for validation/verification.					SOC-2: Community Values

Table 2-3 notes: When an indicator is mapped to the environmental pillar, it is highlighted green; blue highlights indicate the economic pillar and red highlights indicate the social pillar. White (no highlight) means this was not addressed in the framework. The far right column indicates the SG Value within which these indicators are considered in this assessment (see Section 5). Footnotes as in Table 2.1.

3. Stakeholder Mapping

Assessment of the social equity impacts of remediation approaches requires that stakeholder values are considered and communicated. There are many ways of defining stakeholders, but one approach is to address the extent to which various SGs are affected by a decision and the extent to which they can affect the decision (Cundy et al. 2013). A full consideration of stakeholders will seek to identify all SGs that are affected by or can affect a decision, including those that are marginalized or unengaged community members that have not actively participated in the process.[3] Key players and context setters, due to the time or resources they can bring to a decision process, will ensure that their viewpoints are being considered in the process. Unengaged subjects, on the other hand, due to a lack of resources, interest, or awareness, may not have their needs and values addressed unless a special effort is made to identify and consider their values.

A well-designed stakeholder outreach program should consider, reach out to, and involve as diverse a range of SGs as possible, ideally transforming subjects into key players, but it is important to also ensure that the needs of unengaged subjects are at least considered in the decision process, as a valid social assessment requires broad engagement. Engaging only potentially responsible parties (PRPs) and regulators can bias an evaluation; non-governmental organizations (NGOs), and community and neighborhood groups are also important. Large SGs can support and represent broad communities, but it is important to remember that, when such groups seek to speak with one voice, this will possibly mask a diversity of viewpoints.

3.1 Who are the stakeholders (stakeholder mapping and database)

To address this issue, a broad-based review of stakeholders for the Site was carried out. This review began at a project kick-off workshop in June 2015. Brainstorming with the project team and some stakeholders identified an initial list of regional stakeholder categories, groups, and interests. These included regional businesses and industries, upstream, near, or dependent on the river (including PRPs); neighborhood, community, and Tribal groups; recreational and other clubs and associations; environmental, social justice, and other NGOs; and local, regional, state, and federal government entities.

This initial list was expanded using an extensive online review of stakeholder web pages and documents, and inputs from local experts and the project team over the next 6 months. This effort was carried out in parallel with an effort to identify any documentation of stakeholder values and priorities in terms of Portland Harbor remediation and restoration, but also to broaden the scope and ensure the consideration of underrepresented SGs, also in terms of Portland Harbor planning and development. Whenever documents or SG web pages identified partner organizations, or when a reviewed document identified groups that were met with and/or consulted in terms of regional or local remediation, restoration, planning, or development, these SGs were also reviewed and, if appropriate, added to the database.

To date, more than 280 separate SGs have been identified and placed in the stakeholder mapping database (see Appendix B). This database identifies SG name and focus, and, if available, web page, contact person, phone number, email, and organization role and/or vision (largely based upon data from web pages). It contains a substantial proportion of Portland Harbor-relevant NGO, community,

[3] *Cundy et al. 2013 identifies four types of stakeholder groups: (1) those who are affected and have influence (e.g., active community members that are engaged, “key players”), (2) those that are not affected but can influence the decision (e.g., regulators or “context setters”), (3) those that are affected but not engaged and have minimal influence (“unengaged subjects”) and (4) those that are not affected and have minimal influence.*

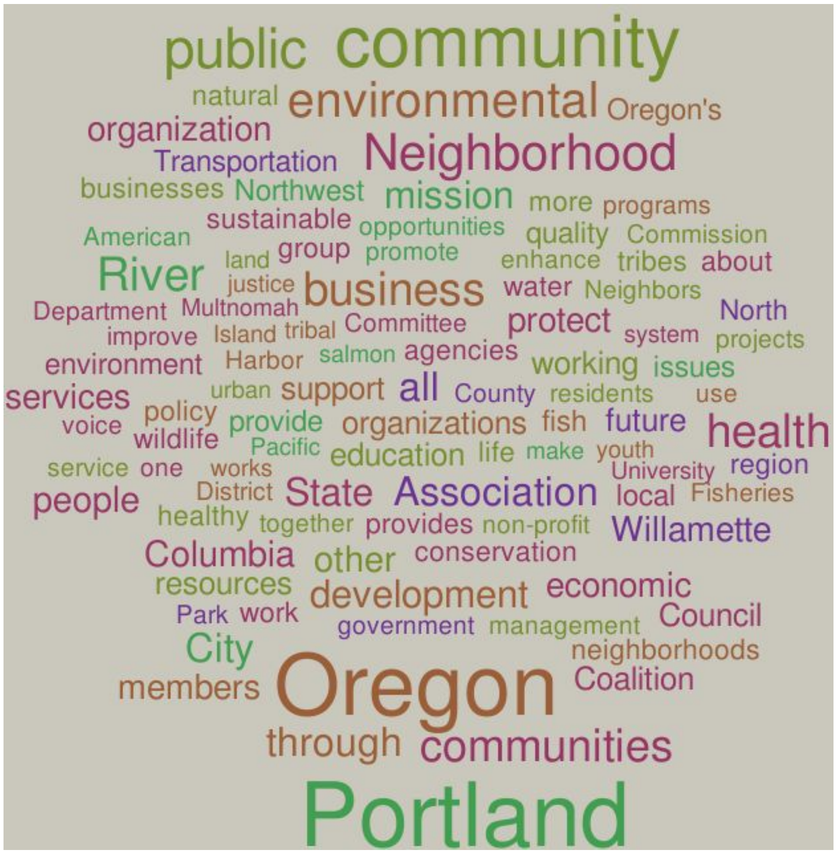
government, and business groups, with diverse priorities and interests. Although there are large SGs such as the Lower Willamette Group (LWG), the Portland Harbor Community Advisory Group (CAG) and others, many smaller SGs are also included that may have consulted with, or were represented by, the larger entities. The types of stakeholders identified during the exploratory phase of the project included:

- Businesses: using the river, near the river, regional
- Commercial users: commercial fishing, industrial near the river, industrial upland
- Recreational users: anglers, boats, swimmers, cyclists, walkers
- Local community: residents, NGOs
- Government: federal, local, state
- PRPs
- Tourism
- Tribes
- Other

This database is robust and captures a diversity of SGs that have been captured in the extensive and collaborative stakeholder mapping effort. A word cloud tool was used to illustrate the breadth and focus expressed in stakeholder literature.[4] Figure 3-1 illustrates a word cloud for the stakeholder mapping database, using the words in the SG names and their web-based mission or vision statements. As can be seen, community and neighborhood issues are represented, as are environmental values, Tribes, businesses, and industries. Issues stated to be of concern to SGs include justice, health, sustainability, development, community and many others. The word cloud provides a qualitative assessment of material in the SG database; this illustrates that the stakeholder mapping has been broad and representative. At the moment, the lower weighting of business-related words results from the fact that organizational values and mission statements for most NGOs and government departments (as well as business-related groups and councils) are in the database, but equivalent statements for individual businesses are lacking, as equivalent relevant mission statements were generally not on business web pages.

[4] *A word cloud tool assesses the frequency of use of words in a document and then illustrates the most common words. Relative word frequency is reflected in the relative size of the word in the word cloud.*

Figure 3-1. Word cloud from SG mapping database



3.2 Key stakeholder groups for Portland Harbor

Although the discussion in Section 3.1 regarding the stakeholder database demonstrates the breadth and diversity of SGs and interests in Portland Harbor, some key SGs, focused on a range of issues, have engaged in the decision and outreach process thus far, and speak (or claim to speak) for a broad cross-section of stakeholders. The purpose, membership, web pages, and logos of these key groups (largely based on information from their web pages) are briefly described below. Most of these key SGs have produced information and resources about their Portland Harbor priorities on their web pages, and can be contacted for support or background on their focus issues[5].

3.2.1 Portland Harbor Partnership

The Portland Harbor Partnership was created to support a broad community outreach effort during the Site remedial investigation (RI) and FS CERCLA process. The Partnership is a public-private partnership made up of public entities and local businesses working in cooperation with Portland State University and Oregon State University to support a broad community outreach effort. The purpose of this outreach is to raise awareness about the Site and to encourage everyone to have a voice in the future of Portland Harbor and the river overall. The Portland Harbor Partners include:

- Port of Portland
- Oregon Department of State Lands
- Calbag Metals
- EVRAZ Portland
- Gunderson LLC
- NW Natural
- Schnitzer Steel
- Vigor Industrial,
- Portland General Electric (PGE)

The Partners have a strong local presence and are a small subset of the PRPs for the Site. A PRP is any person, company, or public entity that owns property in a contaminated site or may be designated by EPA as potentially having responsibility for cleanup of the Site. There are over 100 PRPs identified by EPA as associated with the Site. The Partners came together to make sure their community has a voice in the cleanup.

The Partnership is working in cooperation with Portland State University Hatfield School of Government and Oregon State University Extension Service. In their documents, the Portland Harbor Partnership has listed many other organizations with which they have consulted; those found on the web have been added to the stakeholder database.

Website: http://www.portlandharborpartnership.com/

Logo: "Your river needs your voice."

[5] *These SGs are described here for background and as a resource; they were used as a guide to inform SGs and make sure the representative SGs used for the stakeholder sensitivity analysis described in Appendix D were relevant. The groupings used in the sensitivity analysis are different from, but informed by, the list provided in this section.*

3.2.2 Lower Willamette Group

The LWG is composed of the 10 parties who signed agreements with EPA to conduct the RI and FS for the Site and four other parties who have contributed financially to the project. The LWG, a small subset of PRPs identified by EPA, has been working with EPA to complete the RI/FS of the Site for more than 14 years.

The members of the LWG are:

- Arkema Inc.
- Bayer CropScience, Inc.
- BNSF Railway Company
- Chevron U.S.A., Inc.
- City of Portland
- EVRAZ
- Gunderson LLC
- Kinder Morgan Liquids Terminals
- NW Natural
- Phillips 66 Company
- Port of Portland
- Siltronic Corporation
- TOC Holdings Co.
- Union Pacific Railroad Company

Website: http://lwgportlandharbor.org/

Logo: LWG LOWER WILLAMETTE GROUP

3.2.3 Portland Harbor Community Coalition

The Portland Harbor Community Coalition (PHCC) is a group of individual community members, community of color organizations, conservation organizations, environmental justice (EJ) organizations, higher educational institutions, and Native American organizations, all invested in the outcome of the Willamette River's Superfund site cleanup.

Mission: To raise the voices and build capacity of the local community-based EJ communities, ensuring these communities are able to influence the final outcome of the Site cleanup process. EJ communities in this case are defined as those most disproportionately at risk of negative health impacts from Willamette River contaminants.

Goals:

- Create a more inclusive, equitable community-based cleanup process by actively engaging EJ communities in early and meaningful decision-making.
- Work with partners and municipal collaborators to assess, develop, and deliver equitable and engaged services advancing triple-bottom-line justice.
- Engage youth from EJ communities in this process.

- Catalyze thoughtful discussion, analysis, and implementation of environmental, economic, and social justice issues surrounding the Site through community events, media, and education.
- Support EJ communities to use their stories and statements to advance their priorities on equitable involvement, public health, and sustainability in the cleanup process, and to speak up if the Record of Decision and cleanup plan do not reflect community priorities.

Organizations listed as part of PHCC:

- Right 2 Survive
- Czech School of Portland
- East European Coalition
- Green Anchors Partners
- Groundwork Portland
- Iraqi Society of Portland
- Lideres Verde
- Verde
- Asian Pacific American Network of Oregon (APANO)
- Portland Youth and Elders Council
- Wiconi International
- Wisdom of the Elders
- American Indian Movement (Portland Chapter)
- Oregon American Federation of State, County and Municipal Employees (AFSCME)

PHCC Advisory Partners:

- Willamette River Keeper
- Environmental Defense Fund (San Francisco office)
- Audubon Society (Portland)
- Sierra Club Oregon Chapter
- Neighbors for Clean Air
- Portland Harbor CAG
- streetroots
- Oregon Physicians for Social Responsibility
- Resolutions Northwest
- Voice Public Involvement
- Impact NW
- Latino Network
- Occupy St John's
- University of Portland

In their documents, the PHCC has listed many other organizations with which they have consulted. Those found on the web have been added to the stakeholder database.

Website: http://ourfutureriver.org/

Logo:

3.2.4 Portland Harbor Community Advisory Group (CAG)

The CAG Mission Statement is "To ensure a PH Cleanup that restores, enriches, and protects the environment for fish, wildlife, human health, and recreation, through community participation." The CAG is composed of individuals from neighborhood associations; environmental, health, recreation, and business groups; and concerned citizens. They have worked closely with the community, EPA, Oregon's Department of Environmental Quality (ODEQ), LWG, the City of Portland, the Port of Portland, and the Tribes affected by the Site.

Groups listed as part of CAG:

- PanFish (Oregon Bass and Panfish Club)
- Willamette River Keeper
- Audubon Society (Portland)
- Sierra Club Oregon Chapter
- The Northwest District Association (NWDA) Air Quality Committee
- Portland Harbor Community Coalition
- Oregon State Public Interest Research Group (OSPIRG)
- Environmental Justice Action Group Portland, Oregon
- Organizing People/Activating Leaders (OPAL)
- Northwest Toxics Community Coalition
- St. Johns Neighborhood Association
- University Park Neighborhood Association
- Cathedral Park Neighborhood Association (NPNS)
- Linnton Neighborhood Association Environmental Committee
- NW Industrial Neighborhood Association (NINA)

In their documents, CAG has listed many other organizations with which they have consulted. Those found on the internet have been added to the stakeholder database.

Website: http://www.portlandharborcag.info/

Logo:

3.2.5 Oregon Department of Environmental Quality

ODEQ's roles and responsibilities on the Site are partly defined in a Memorandum of Understanding (MOU) between ODEQ and EPA dated February 2001. The MOU designates ODEQ as the lead agency for overseeing upland source control actions and EPA as the lead agency for overseeing in-water actions. The respective agencies support each other in their lead roles. Since EPA designated Portland Harbor as a Superfund Site in December 2000, ODEQ has been an active participant on the "Government Team" and has provided substantial resources in the areas of engineering, risk assessment, and hydrogeology.

They have also worked to integrate their oversight of upland cleanup sites with EPA's oversight of in-water activities.

Different state agencies that have worked with ODEQ on the Site include:

- Oregon State Historic Preservation Office (SHPO)
- Governor (State of Oregon)
- Oregon Health Authority
- Oregon Department of State Lands
- Oregon Department of Transportation
- Oregon Economic Development Department (Business Oregon)
- Oregon Department of Fish and Wildlife

Website: http://www.deq.state.or.us/lq/cu/nwr/portlandharbor/

Logo:

3.2.6 Natural Resource Trustee Council

The public natural resources of the Site—the water, fish, birds, and wildlife—are not owned by any individual but are held in trust for the public. Responsibility for protecting the natural resources is shared among federal and state agencies and Tribes who own, manage, or have an interest in the resources and who are named as Trustees of the resources on behalf of the public.

When natural resources are injured by releases of hazardous substances or oil, laws, such as CERCLA and the Oil Pollution Act (OPA), empower the Trustees to obtain compensation for harm to trust resources and to plan and carry out actions to restore injured resources through a process called natural resource damage assessment (NRDA).

To coordinate their damage assessment and restoration planning actions, the Trustees for Portland Harbor natural resources formed the Portland Harbor Natural Resource Trustee Council in 2002. The Trustee Council currently consists of representatives of eight Trustees:

- Confederated Tribes of Siletz Indians (CTSI)
- Confederated Tribes of the Warm Springs Reservation of Oregon
- Confederated Tribes of the Umatilla Indian Reservation
- Confederated Tribes of the Grand Ronde Community of Oregon
- Nez Perce Tribe
- Oregon Department of Fish and Wildlife
- National Oceanic and Atmospheric Association
- US Fish and Wildlife Service

The Confederated Tribes and Bands of the Yakama Nation, although a trustee for Portland Harbor, has withdrawn from the Trustee Council and is no longer participating in the restoration planning efforts described on the web page and in their documents.

The scope of trusteeship is outlined in the NCP, 40 Code of Federal Regulations, Subpart G, which describes trust responsibilities of federal, state, and Tribal entities (natural resource trustees). Natural resource trustees act on behalf of the public to address injuries to natural resources. CERCLA, OPA, and their implementing regulations provide guidance to natural resource trustees on conducting an NRDA. The trustees (1) assess natural resource injuries (including the services provided by those resources) caused by the releases of hazardous substances and/or oil; (2) quantify those injuries; (3) seek compensation from the parties responsible for the discharges; and (4) use the recoveries to restore, rehabilitate, replace, or acquire the equivalent of those injured natural resources and services.

The Trustee Council members possess a broad spectrum of legal authority for NRDA activities at the Site derived from a wide variety of federal and state statutes and regulations, Tribal treaties, agreements and regulations, and land ownership. By exercising their authorities jointly through the Trustee Council, the Trustees are able to more efficiently and effectively fulfill their public trust responsibilities.

Website: http://www.fws.gov/oregonfwo/Contaminants/PortlandHarbor/

PORTLAND HARBOR
Natural Resource Trustee Council

Logo:

4. Stakeholder Values

This section identifies the key stakeholder values of interest for the SGs identified in Section 3 and maps them to the sustainability SG Values/indicators identified in Section 2. These values are linked to quantified metrics in Section 5 in terms of stakeholder values.

4.1 Identification of SG Values and priorities

Social aspects of sustainability are evaluated within this project by linking all sustainability metrics to SG Values, and then using these SG Values to aggregate and communicate outcomes. To achieve this, a coherent set of SG Values of relevance to Portland Harbor remediation needed to be identified. The SG mission and objective statements collected in the stakeholder mapping exercise provided insights into stakeholder priorities. In parallel, an online review of all documents that could be found that addressed stakeholder viewpoints on Portland Harbor remediation, restoration, planning, and development was carried out by the project team; this review is described in greater detail below. Other past or ongoing sediment sustainability assessments were reviewed. This review resulted in a long list of candidate positive values, paired with related concerns, in terms of Portland Harbor. Review and removal of duplication and jargon resulted in a list of 26 SG Values, related to the three pillars of sustainability. Table 4-1 shows the SG Value list developed (N=26). The values were the predominant list of values expressed in literature, public meetings, and online commentary. This list is similar to the values generated in different sustainability frameworks shown in Tables 2-1 through 2-3.

During the SG Value mapping effort (see below in Section 4.2), stakeholder value statements were mapped to this SG Value list. When sustainability SG Values and metrics were aggregated (see Sections 5 and 6), a shortened list of SG Values was developed. Some of the SG Values in Table 4-1 became metrics (the indicators of an SG Value that were scored). Aspects of implementability proved to be a major concern expressed in community meetings and stakeholder documents. Thus, metrics of implementability were linked to the SG Value "Acceptable Remedy;" one of the SG Values considered in the Social Equity pillar.

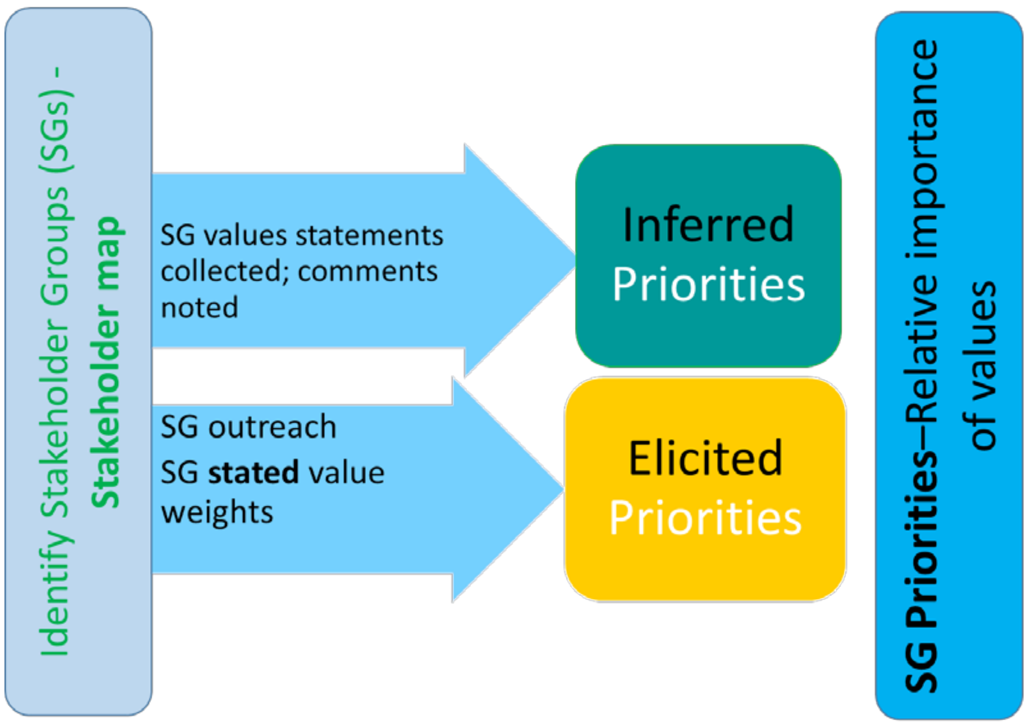
Table 4-1. SG Values to which stakeholder value statements were mapped

Stakeholder Values Identified Specifically for Portland Harbor (26)	
Environmental	**Social**
Risk reduction (ecological)	Quality of life
Fish and Wildlife	Aesthetics
Restoration	Community values (involvement)
Resilience	Fairness
Green Practices (low impact remedy)	Traditional practices / cultural values
Economic	Human health and safety
Economic Vitality	Clear air and water
Tourism	Recreation
Jobs	Access to river
Infrastructure improvement	**Implementability**
Navigable river	Permanence of cleanup
Development	Avoidance of recontamination
Cost-effectiveness	Successful remedy
	Timely cleanup
	Regulatory compliance

4.2 SG Value mapping

Many methods can be used to determine stakeholder values, each of which has strengths and weaknesses (e.g., Linkov et al. 2006). Figure 4-1 describes two approaches to determining the priorities of stakeholders or SGs. Once stakeholders have been identified, they can be asked what their values or priorities are, using a range of tools such as surveys, collaborative and interactive workshops, or structured approaches, such as those used in some formal multi-criteria decision analysis (MCDA; see Appendix A tools [Linkov et al. 2006]). In this report, such an approach is termed "elicited values." It is also possible to infer the values and priorities of SGs by looking at what they have stated is important to them, in documents, public comments, interviews, and other sources, without directly asking them about specific values. This approach has the advantage of allowing a breadth not possible when collecting elicited values. In this project, such an approach to determine stakeholder priorities is called "inferred values."

Figure 4-1. Approaches to determining the priorities of stakeholders or stakeholder groups



A number of stakeholder surveys, focusing on a range of issues, have been carried out by organizations in the region. Although the results (when available) have provided insights into specific values or expectations, none have addressed a broad enough range of values to allow for the ranking of stakeholder priorities for all the SG Values considered in this study.

The broadest and most applicable of these surveys was carried out in 2016 by the City of Portland's Bureau of Environmental Services, in partnership with Oregon's Kitchen Table (OKT). They conducted an online consultation with Portland residents in March 2016 to better understand their opinions and values regarding cleanup of the Site in the Willamette River north of downtown Portland (DHM Research 2016). A total of 2,704 residents (including 67 via paper) responded to the survey. The raw data for both the paper and online versions were provided by OKT to DHM Research for processing and analysis. An analysis by DHM Research included a summary of results as well as findings and examples of responses to open-ended questions (DHM Research 2016). Open-ended questions were not fully included in the report. Although the report stated that all responses to open-ended questions are available upon request from OKT, our requests to the City and OKT did not yield these, nor requested raw results. However, the data reported by DHM Research were used in this report to determine the SG priorities for the values addressed by the survey (see Section 8 and Appendix D), using survey respondents as a representative SG.

Although MCDA approaches and surveys can provide detailed stakeholder elicited values, they can only reflect the values of the stakeholders or SGs who participate in the survey or elicitation process. Thus, they can have bias, either when some SGs are not considered and consulted, or when specific SGs, for various reasons, decline to participate. Participants can also seek to influence outcomes by influencing inputs, disproportionately participating, or providing “strategic” responses (e.g., Mitchell and Carson 1989). Strategic responses occur when answers are designed to influence a particular expected outcome. Those eliciting views can also bias outcomes if outreach efforts and surveys are not designed appropriately. Similarly, public meetings and interest groups, even with the best intentions, can over-represent the viewpoints of those who have the resources, in terms of money, time, or access, to make themselves heard. At times, more vocal organizations and/or individuals may, whether intentionally or not, suppress or discourage the expression of differing points of view. SGs that seek to speak for a large cross-section of the community can serve the community by aggregating information, providing resources, reaching out to the under-represented, and informing and educating the public. However, in trying to speak with a uniform voice, they may obscure a diversity of values and priorities that might be revealed if smaller and more diverse groups were willing or able to participate. Furthermore, many members of the community may be affected by a large project, such as the Site cleanup, but may be unaware, unwilling, or unable to make their viewpoints known. For all these reasons, the incorporation of stakeholder values into a project is challenging, and all approaches have the potential to introduce bias or lack broad representation.

To address these concerns, this project focused primarily on the determination of inferred values, with some elicited inputs. However, as will be described later, the project-specific model developed to integrate inputs and assess sustainability trade-offs is designed to use information from all sources of data on stakeholder priorities and to provide inputs for more formalized decision analysis (such as MCDA), should such an effort be developed in the future.

Inferred values were identified using a “value mapping” process. SG statements pertaining to SG Values from a variety of sources were “mapped” to one of the 26 SG Values listed in Table 4-1 to build a database of “value statements” for as many SGs as possible in the Stakeholder map (Appendix B). “Value statements” ranged from a single word to one or more paragraphs; these were each pasted into a cell of an Excel spreadsheet in a row for the SG, and a column for the SG Value addressed in the statement. Where there are several statements from a given source for a specific SG Value, they were all placed in the same SG/SG Value cell.

Value statements were drawn from a broad variety of sources:

- SG web pages (mission statements or other linked pages)
- Produced literature (news articles, journal articles, reports, fliers, brochures)
- Interviews with points of contact
- Extracts from third-party surveys
- Written comments to EPA

- Notes or transcriptions from public meetings, forums, and webinars (e.g., EPA, CAG, Audubon Society, League of Women Voters)
- Notes from neighborhood and business group meetings (e.g., Portland Business Alliance, Northeast Coalition of Neighborhoods, Northeast Industrial Business Alliance)

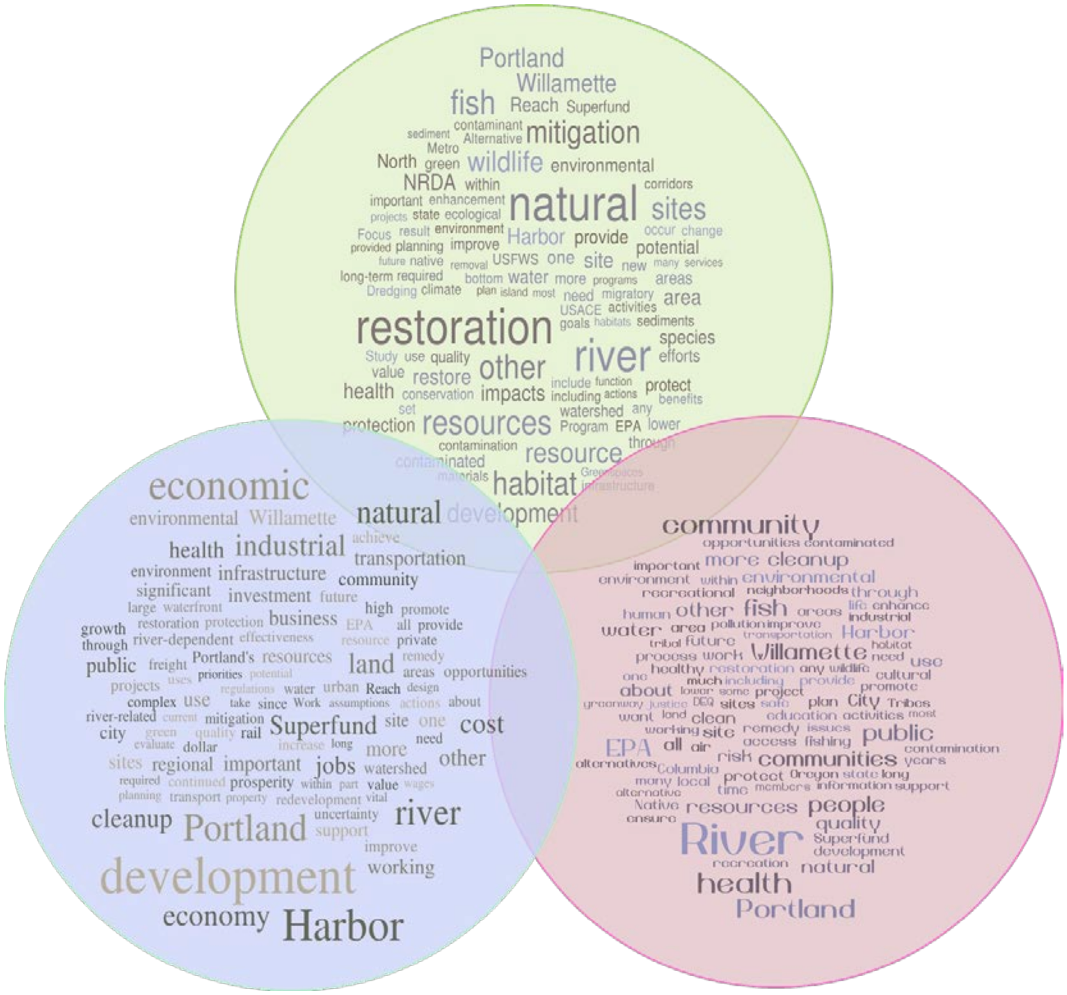
Where no documentation could be found to determine the values and priorities of an SG, they were qualitatively identified (+/- reflecting whether something was assumed to be a priority or not) using general local knowledge and professional judgment.

To address the fact that not all SGs whose interest might be affected had produced statements about the Site and future cleanup, a broad net was used to evaluate regional priorities and values—any document or statement that could be found and that provided statements on SG Values relevant to Portland Harbor remediation, restoration, development, or planning was reviewed. More than 500 documents, web pages, meetings, interviews, etc., were reviewed, but not all provided relevant value statements. All documents, including meeting notes that were reviewed were archived in an EndNote™ database, and references or web links were noted in the Excel database for all value statements in the value map. The resultant "value map" or database of SG Value statements is very large. This value map database is appended as a sortable and searchable Excel file "PHSP SOCIAL Appendix C Value Map database.xlsx".

This collection of SG Value statements provides an evidence base for the diverse values of Portland SGs, considering NGOs, community groups, agencies, businesses, and other groups on an equal footing. Every effort has been made to capture the views of as many sectors of the Portland community as possible; the database can be expanded as more information becomes available. However, this database illustrates that SG values and priorities are diverse; what is critical to one group may be of little interest to another. This provides a strong argument for developing a framework where all SG Values are given equal footing, but also suggests that the sensitivity and robustness of assessment outcomes to differing priorities should be evaluated. Both approaches are described below.

It is difficult to illustrate such largely linguistic information in a simple or quantitative manner. Figure 4-2 illustrates a word storm—a collection of word clouds–using the text from the SG Value statements for SG Values mapped to the pillars: environmental quality (green), economic viability (blue), and social equity (red).

Figure 4-2. Word storm generated from the SG Value statement database



5. Linking SG Values to Metrics

Although values themselves can be considered subjective, in this project, SG Values were linked to indicators or metrics that could be used to score each remedial alternative in terms of the SG Value. Where possible, metrics were identified that were standard, quantitative, and logically and clearly linked to (and correlating with) the SG Values. Selected metrics were also relevant and sensitive to the remedial alternatives under consideration. Where all these expectations could not be met, the metric that came closest to this was selected; the degree to which these expectations were met is noted and taken into account in SG Value scoring. Many metrics used in this analysis are described in detail in the environmental and economic reports for this project (AECOM 2016; NERA 2016). Stakeholder metrics that were not developed or quantified in the other two pillar reports (environmental and economic) are detailed below. This section summarizes the metrics used to evaluate the SG Values in each pillar, and the basis or source of the metrics used.

A total of 26 metrics were quantified in this report and aggregated into one of the 12 indicator value groups (SG Values). Table 5-1 describes the metrics associated with the Environmental Quality SG Values, Table 5-2 describes those for the Economic Viability SG Values, and Table 5-3 lists those for the Social Equity SG Values. The SG Values listed in these tables are not identical to those in Table 4-1. Various aspects of implementability were raised as concerns by community members in every public meeting and in many documents about the Portland Harbor remediation. Thus, metrics of implementability were incorporated into the Social Equity pillar, under the SG Value SOC-3: Acceptable Remedy. Other SG Values in Table 4-1 were simplified and aggregated so that, ultimately, there are four key SG Values for each pillar (12 total). In some cases, other values in Table 4-1 have become metrics that are used to evaluate the SG Values. Where an SG Value has more than one metric, this can represent different aspects of the same SG Value. For instance, SOC-4: Health & Safety has metrics that address short-term risks to workers and the public during remediation and longer-term risk after remediation. Multiple metrics can also provide different lines of evidence for the same aspect of an SG Value. For instance, ECON-4 has multiple metrics, as “cost-effectiveness” can be defined a number of ways.

Data sources and scoring approaches for these metrics and their aggregation to SG Value and pillar scores are described in subsequent sections.

Table 5-1. SG Values and metrics associated with the Environmental Quality pillar

Environmental Quality			
SG Value	Metric Label	Metric	Measurement Basis; notes
Fish & Wildlife (ENV-1)	ENV-1a	1a. Residual risk, T0	Based on average of: 1) Average reduction in SWACs on a site-wide basis following construction for the focused COCs, and 2) RAO 5: Hazard Index - Direct Contact, equal to the sum of the HQs for PCBs, total PAHs, DDx, BEHP, Chlordanes, Lead, and Mercury, and 3) RAO 6: Hazard Index - Consumption, equal to the sum of the HQs for 4,4-DDE, PCBs, HxCDF, PeCDF, TCDD, and TCDF
	ENV-1b	1b. Downstream risk	Based on total Mass Exiting the Study Area for Each Alternative (Total PCB kg), adjusted for AECOM years. Note: this metric is based on 2012 FS because the 2015/2016 FS does not address
	ENV-1c	1c. Reliance on controls	Proportional to total acres of cap, in situ treatment, ENR, and MNR. Assume reliability of ICs and engineering controls is inversely proportional to the area of technologies that leave contamination on site. Although Alt A does not have technology assignments, all contamination is left on site; therefore, the total PH study area is used to score Alt A
	ENV-1d	1d. Construction risk	Based on construction time (currently adjusted construction time) This is a dis-benefit (undesirable outcome) Set to zero as this seems DUPLICATIVE OF ENV-1b. If no data are available for ENV-1b, this can be switched on instead
	ENV-1e	1e. Residual Risk, T45	Based on Year 45 PCB SWAC, site-wide, from Table 9.3.1-1 2012 Draft FS (Section 9 tables)
Habitat (ENV-2)	ENV-2a	2a. Nearshore habitat	% overlap of active remediation to nearshore habitat area above -15 ft elevation; scored, inverted
	ENV-2b	2b. Benthic habitat	Acreas of active remediation
	ENV-2c	2c. Shoreline habitat	GIS overlap of active remedy (dredge, cap, treatment and ENR) with shoreline
Resilience (ENV-3)	ENV-3a	3a. Flood risk	Net volume removed (reduces flood risk)
	ENV-3b	3b. Vulnerability in place	Inversely proportional to total acres of caps, in situ treatment, ENR, and MNR. Assign A as 100% MNR. Assume reliability of ICs and engineering controls is inversely proportional to the area of technologies that leave contamination on site
Low Impact Remedy (ENV-4)	ENV-4a	4a. Air Emissions	Based on SiteWise emissions, NOx, SOx , PM10, and Greenhouse Gases (GHG)
	ENV-4b	4b. Energy consumption	Based on SiteWise energy use
	ENV-4c	4c. Water consumption	Based on SiteWise water use
	ENV-4d	4d. Hazardous landfill use	Based on SiiteWise Hazardous landfill use
	ENV-4e	4e. Non-hazardous landfill use	Tons disposed in non-hazardous landfills (or CDF?) This is an undesirable impact
	ENV-4f	4f. Volume of sediment treated	Volume sediment treated; EPA draft FS, high values
	ENV-4g	4g. Contaminant mobilization	Total Mass Exiting the Study Area for Each Alternative (Total PCB kg), adjusted for AECOM years (in input table). Note: this metric is based on 2012 FS because the 2015/2016 FS does not address

Table 5-2. SG Values and metrics associated with the Economic Viability pillar

Economic Viability			
SG Value	Metric Label	Metric	Measurement Basis; notes
Economic Vitality (ECON-1)	ECON-1a	1a. Economic (long-term)	Based on Gross regional product (GRP) impacts - REMI model (NERA); used upper and lower limits of GRP estimates from local business; local government and mixed scenarios; scored and averaged.
	ECON-1b	1b. Economic (short-term)	Based on "illustrative qualitative impacts of disruption" discussion using NERA professional judgement from stakeholder surveys.
	ECON-1c	1c.Tourism	Based on GIS overlap analysis of active overlap with beach/park areas. Note: Fishing not considered as no good metric or evidence of economic impact could be found
	ECON-1d	1d. Real Estate stigma removal	Qualitative; based on expert knowledge;NERA interviews with stakeholders This is a benefit - desirable outcome
Jobs (ECON-2)	ECON-2a	2a. Employment (local)	Based on REMI model (NERA); used upper and lower limits of job estimates from local business; local government and mixed scenarios; scored and averaged.
Infrastructure (ECON-3)	ECON-3a	3a. Road traffic	Proportional to total volume handled - assuming larger remedies will require greater local equipment inputs and regional disposal. regional, not Willamette; trucks from Colombia
	ECON-3b	3b. Construction time	Adjusted construction times, with the assumption that quicker is more desirable (>70% of those surveyed support a treatment which is <8 years; but this preference is more reflected in the social scoring of this) - inverted, as this is an indicator of infrastructure impact
	ECON-3c	3c. Utilities	Fraction overwater structures impacted is the surrugate; used SF overwater structure impacted by active remediation; scored so 100% impact would be a score of -10 (rather than giving max possible impact max score. This covers berthing areas as well. This is a dis-benefit
	ECON-3d	3d.River infrastructure	Based on GIS assessment of overwater structure overlap as a surrogate as other infrastructure should be near shoreline as well.
	ECON-3e	3e. Navigational channel	Based on GIS layer of nav channel
Cost Effectiveness (ECON-4)	ECON-4a	4a. Capital cost	Based on total capital costs, adjusted
	ECON-4b	4b. Long-term cost	Need for long-term maintenance and monitoring. Based on number of acres that require institutional controls - sum of acres of Capping and ENR - CDF not included in estimates. Landfill maintaintenace included in tipping fees. Scored based on sum of capping and ENR but not dredging/capping or in situ treatment. This is an undesirable impact
	ECON-4c	4c. Cost-effectiveness (T0)	% reduction in SWAC (T0) divided by $M adjusted cost; this is a desirable impact
	ECON-4d	4d. Cost effectiveness (T45)	% reduction in SWAC (T45) per cost. Note: based upon 2012 draft FS; This is a desirable outcome
	ECON-4e	4e. Net environmental benefit	Based on benefit points per billion $ in (NEBA)

Table 5-3. SG Values and metrics associated with the Social Equity pillar

Social Equity			
SG Value	Metric Label	Metric	Measurement Basis; notes
Quality of Life/ Recreation (SOC-1)	SOC-1a	1a. Quality of life	Impact on quality of life is proportional to volume and time. It is a short-term metric relevant to impacts during construction
	SOC-1b	1b. Recreation: water quality	Assumed to be proportional to construction time; impacts should abate when construction complete. Based on AECOM adjusted construction times
	SOC-1c	1c. Other water recreation	Based on GIS overlap analysis; active overlap with beach/park areas
	SOC-1d	1d. Access to river	Based on GIS overlap analysis; Overlap of active remedy (dredge, cap, treatment and ENR) with shoreline (total active shoreline) (City of Portland, non-business areas)
Community Values (SOC-2)	SOC-2a	2a. Stakeholder involvement	Based on professional judgement based upon EPA involvement of stakeholders in process. Inform (2), consult (4), involve (6), collaborate (8), empower (10). Not sensitive to specific remedies
	SOC-2b	2b. Amenability to re-use	Aggregate score considering stigma reduction, recreation/fishing, Native American views, in-water re-use. Did not score for re-uses on shore such as hiking,biking as remedial plans don't address restoration
	SOC-2c	2c. Communication of uncertainty	Judgement based upon review of public outreach process by EPA and various stakeholder groups. In public meetings, and in documents. Not sensitive to specific remedies
	SOC-2d	2d. Archaeological sites	Based on archeological and culturally sensitive sites in internal review of available maps by qualified archaeologist. Semi-qualitative
Acceptable Remedy (SOC-3)	SOC-3a	3a. Permanence	Based on mass of PCBs removed and reduction of mobility of hazardous substances
	SOC-3b	3b. Effectiveness	Based on human health and ecological risk reduction, a score based upon the relative permanence of remedies, and the extent to which institutional controls will be required
	SOC-3c	3c. Implementability	Based upon EPA CERCLA comparative scoring tables (consumer reports figure) - 2 points for each quartile of implementability symbol; full black circle = 8; half black = 4, all white circle = 0; A scored as 10..
	SOC-3d	3d. Socially optimal construction time	Based on ratio of adjusted construction time (AECOM) to "optimal" time of 7 years or fewer (based upon third party survey)
	SOC-3e	3e. Time-effectiveness	Based on time to achieve RAOs vs construction time - time-effectiveness of treatment. Reflects potential reduction in time gained by construction time. Note: Ratio of AnchorQEA 2012 draft FS construction period (years) and time to achieve RAOs. Use >45 as 45 years. 45 year estimates were not included in the 2015/2016 EPA FS
Health & Safety (SOC-4)	SOC-4a	4a. Worker safety	Based on SiteWise estimates of worker accidental injury and fatality risk. Note: the score gives an equal weight to both accident and death risks
	SOC-4b	4b. Human health risk	Based on 1) Human health risk reductions at T0; giving an equal weight to all human risks in 2016 FS; and 2) Year 45 PCB SWAC, site-wide, from Table 9.3.1-1 2012 Draft FS (Section 9 tables), relative to a background of 9 ppb
	SOC-4c	4c. Fish consumption risk (short term)	Based on total Mass Exiting the Study Area for Each Alternative (Total PCB kg), adjusted for AECOM years. Note: this metric is based on 2012 FS because the 2015/2016 EPA FS does not address

6. Metric and SG Value Scoring

As described in the project approach section, the first step defined SG Values and linked them to each pillar (12 value groupings), and then the representative metrics used to quantify those SG Values were developed (49 metrics). No tool existed to aggregate sustainability metrics from all pillars from a social perspective. Thus, an Excel-driven calculation tool, the Sustainable Values Assessment (SVA) tool was developed for this project.

The SVA tool evaluates trade-offs between environmental, economic, and social costs and benefits in terms of SG Values. It develops a quantitative score for remedial alternatives in terms of stakeholder values. This approach uses SG Value-linked evaluation criteria to determine overall SG Values-based sustainability of alternatives under consideration. Comparing each remedial alternative's environmental, economic, and social costs and benefits, in terms of disparate SG Values, provides a platform for dialogue and communication on trade-offs, and supplements more established evaluation of incremental environmental benefits vs. costs, such as those evaluated using CERCLA-linked NEBA (AECOM 2016). When the full range of impacts of remedial alternatives is considered, stakeholders can better understand the potential consequences of such a significant undertaking, supporting better-informed decisions, and, ideally, avoiding single-issue decision-making.

The SG Values used in this analysis were based on a review of sustainability indicators, as described in Section 2.2.1, as well as iterative project team collaboration, stakeholder value mapping, outreach, and professional judgment during project development. These SG Values fall under three pillars: Environmental Quality, Economic Viability, and Social Equity, as listed in Tables 5.1 through 5.3. The SG Value scores were quantified by aggregating the scores of individual metrics that reasonably reflect each SG Value. The specific metrics that fall under each SG Value are described in Section 5. Risk and/or benefit scores for each SG Value of each remedial alternative were determined using the weighted average of scores for metrics linked to each SG Value. Scores for pillars were calculated by further aggregating the scores of the four pillar-linked SG Values as weighted averages (see Section 7.2.2).

6.1 Methods

The framework for the SVA tool was developed specifically for this project, building and adapting from several methods reviewed or used on other decision-making projects (Appendix A), including the AECOM CERCLA-linked NEBA calculation tool (AECOM 2016). The SVA tool scores and aggregates multiple lines of evidence of risks and benefits to selected endpoints, and then uses the output to identify trade-offs resulting from different alternatives under consideration, building on an approach developed for evaluating the ecosystem impacts of dredged material management practices (Apitz 2008; see Appendix A). However, while Apitz (2008) looked at impacts on ecosystem endpoints and services, this framework was developed to look at impacts and trade-offs between SG Values.

For each remedial alternative under consideration (Alternatives B, D, E, F, and I; all relative to Baseline, or Alternative A), the approach to calculating the scores for each SG Value and aggregating them into a pillar score included:

1) Metrics linked to each SG Value are scored for each remedial alternative. For instance, the metric "Risk Reduction" based on alternative Surface Weighted Average Concentration (SWAC) reduction is one metric linked to the SG Value "Fish & Wildlife" (see Section 5).
    a. Every metric is given a "metric relevance weight (MRW)", based upon its relevance to the SG Value (see Section 6.3).

2) SG Values are scored as the relevance-weighted average of metrics (see Section 7.1).
3) Pillars are scored as the average of SG Value scores (see Section 7.2).
4) Alternative trade-offs are evaluated by comparing SG Value and pillar scores for each alternative (see Section 7.3).

Individual metrics that reflect each SG Value were selected and assessed. In the context of SG Values, metrics were scored based upon inputs from a range of project assessments: CERCLA-linked NEBA (AECOM 2016); SiteWise™ (AECOM 2016); NERA economic assessment (NERA 2016); Portland Harbor 2012 Draft FS (AnchorQEA 2012); 2015 EPA FS (EPA 2015a) and 2016 EPA FS (2016a); GIS overlays (AECOM 2016); and stakeholder and value mapping (this report).

For each alternative, a risk or benefit score is calculated for each metric. Unlike the CERCLA-linked NEBA approach (AECOM 2012, 2016), metrics were not scored from 0 to 10, but in a manner that reflects whether an outcome is desirable or undesirable, in terms of SG Values. Thus, while NEBA metrics are scored from 0 (least desirable outcome) to +10 (most desirable outcome), SVA metrics were scored from -10 (most undesirable outcome or maximum risk) to +10 (most desirable or maximum benefit). A score of 0, then, is a neutral (or baseline) outcome for a metric, which can have both desirable and undesirable outcomes. However, many metrics have only a positive (for benefits such as a reduction in toxicity) or a negative (for risks, such as toxic emissions) outcome. In the initial part of this report, metrics and SG Values are only weighted based upon their MRW. However, as described in Section 8, SG Values and/or metrics can also be weighted based upon SG priorities.

In some cases, the metrics for a given SG Value will reflect both risks and benefits; the aggregated SG Value score will depend on the aggregate of these metric scores (see, for example, metric SOC-2b, Amenability to re-use). Metrics may be average scores of multiple components. For example, accident risk is the average of the injury risk and the fatality risk (from SiteWise™ results; AECOM 2016). This allows multiple components of a metric to contribute to the risk or benefit score. Endpoints were chosen to score each metric from -10 to +10. In general, the endpoints for the metric scoring are the Alternative A ("no action" or baseline) and Alternative F (the largest-scope alternative considered in this analysis); but at times an endpoint can be defined by a regulatory goal, background or another basis. In general, a score of -10 represents a significant negative impact and thus a poorly performing alternative for that metric, and a score of +10 represents an optimally performing alternative for that metric. Note that, depending on the basis for a metric's scale, the alternatives may not always cover the full range (-10 to 10) if all alternatives have less-than-optimal results for that measure. In most cases, metrics are scored relative to baseline (Alternative A) or a goal or threshold. A large number of choices were made in selecting each metric and it's scoring range (defining what 0, 10, and -10 represent). These choices were made using best professional judgment. The basis for these choices is documented in the scoring tables and sections below.

Each metric was given a metric relevance weight (MRW) that determines its contribution to the aggregated SG Value score (see Section 6.3). These weights, shown in Tables 6-1 through 6-3, were determined based on a set of criteria described below. Best professional judgment was used for the relevance ranking (from 1 to 3). Once SG Value scores are calculated using the weighted metric scores, overall remedial alternative pillar scores were determined. These pillar scores are the average of the SG Value scores linked to the pillar (each pillar has four SG Values).

6.2 SVA layout

The SVA is an Excel-driven calculation tool, with calculation sheets linked to two input tables. The first input table, the “metric indicator input table” (Appendix F), holds data from 59 indicators used to quantify the metrics for each of the remedial alternatives. The data for these indicators are drawn from the 2012, 2015, and 2016 FS documents, and from calculations in the environmental report (AECOM 2016) and economic assessment (NERA 2016). These indicators are then linked to the value scoring tables, where metric and value scores are calculated as described in Section 6.3 and Section 7. The other input table, “SG weights”, provides value and metric weights based upon the inferred or stated values/priorities gleaned from our literature review for selected representative SGs, as well as some narrative on the basis of those weights. This input table can have different SG weights inserted by or for other SGs, and the tool will re-calculate outputs, but the current version is focused on the representative SGs used in the sensitivity analysis described in Section 8 and Appendix D. Appendix D describes the approach to SG weighting, and how these weights are used in SG-value based calculation sheets, which evaluate the metric, value, and pillar scores considering SG priorities.

6.3 Weighting of metrics and SG Values – Metric Relevance Weighting (MRW)

A score was calculated for each SG Value for each remedial alternative. The total SG Value score is the weighted average of the metric scores. The weightings emphasize the relevance of each metric, based upon a variety of criteria adapted from other approaches (see Appendix A; Workgroup 1995; Johnston et al. 2002; Apitz 2008). However, while the weightings described in these works focused on factors influencing uncertainty in a metric’s ability to predict risk, the focus of the weightings for this work is the uncertainty and relevance of a metric in estimating an SG Value. Thus, four criteria were developed to determine a metric’s “relevance weight” (MRW) in terms of SG Values. Each metric is scored on a scale of 1 to 3 for each of the criteria below, based on the following:

- Clear and logical basis: Is there a clear and logical basis for the metric as an indicator of the SG Value? Scoring basis:
    - It should be clear to most stakeholders, regulators, and specialists how this metric represents the value: 3
    - It should be clear to some stakeholders how this metric represents the value: 2
    - It should be understandable, after explanation, how this metric represents the value: 1
- Sensitive: Is the metric sensitive to differences between the remedial alternatives? Scoring basis:
    - Metric scores are sensitive to the full range of alternatives: 3
    - Metric scores are somewhat sensitive to the full range of alternatives: 2
    - Metric is not sensitive to differences in the alternatives: 1
- Quantitative: Is the metric quantitative? Scoring basis:
    - Metric is quantitative: 3
    - Metric is semi-quantitative: 2
    - Metric is qualitative: 1
- Standard method: Is the metric based on standard methods? Scoring basis:
    - The methods used to generate the metric scores are standard or well-established: 3

- o The methods used to generate the metric scores are non-standard, but commonly used or published methods: 2
- o The methods used to generate the metric scores are non-standard, not commonly used, or not yet published: 1

The mean values of the scores for these criteria are then the metric's MRW, which will be used to weight metrics in the SG Value score calculations. If there are sub-metrics (for example, ENV-1a, Residual Risk, T0 has three sub-metrics), then the MRW for the net metric is the average of those for the sub-metrics. These MRW values are then used, along with metric scores to calculate the centroid, or weighted average, score for each remedial alternative in terms of each SG Value:

$$\text{SG Value Score}_j = \Sigma_{i\text{-}n} (\text{metric score}_i * \text{MRW}_i)/\Sigma_{i\text{-}n}\text{MRW}$$

This section describes the generation of SG Value and pillar scores when all metrics and SG Values are weighted only based on their MRWs. Section 8 and Appendix D (sensitivity analysis) describe a further layer of weighting based upon representative SG priorities.

Table 6-1 lists the MRWs used for metrics for the Environmental Quality pillar. Table 6-2 lists the MRWs used for metrics for the Economic Viability pillar. Table 6-3 lists the MRWs used for metrics for the Social Equity pillar.

Table 6-1. MRWs used for metrics for the Environmental Quality pillar

Evaluation Criteria		Relevance Weighting	Clear and logical basis?	Sensitive ?	Quanti-tative?	Standard method?
ENV-1 Fish and Wildlife	a1.Risk reduction, SWAC, T=0	3.00	3	3	3	3
	a2. Risk reduction, contact	3.00	3	3	3	3
	a3. Risk reduction, consumption	3.00	3	3	3	3
	a. Residual Risk, T0	3.00				
	b. Downstream risk	2.50	2	3	3	2
	c. Reliance on controls	2.50	2	3	3	2
	d. Construction risk	2.50	2	3	3	2
	e. Residual Risk, T45	2.50	2	3	3	2
ENV-2 Habitat	a. Nearshore habitat	2.50	3	3	3	1
	b. Benthic habitat	2.50	3	3	3	1
	c. Shoreline habitat	2.50	3	3	3	1
ENV-3 Resilience	a. Flood risk	2.50	2	3	3	2
	b. Vulnerability in place	2.25	2	3	3	1
ENV-4 Low Impact Remedy	a1.Total NOx Emissions	3.00	3	3	3	3
	a2.Total SOx Emissions	3.00	3	3	3	3
	a3. Total PM10 Emissions	3.00	3	3	3	3
	a4. GHG inputs	3.00	3	3	3	3
	a.Air emissions centroid value	3.00				
	b. Energy consumption	3.00	3	3	3	3
	c. Water consumption	3.00	3	3	3	3
	d. Hazardous landfill use	3.00	3	3	3	3
	e. Non-hazadous landfill use	3.00	3	3	3	3
	f. Volume of sediment treated	3.00	3	3	3	3
	g. Contaminant mobilization	2.25	2	3	3	1

Table 6-2. MRWs used for metrics for the Economic Viability pillar

Evaluation Criteria		Relevance Weighting	Clear and logical basis?	Sensitive?	Quanti-tative?	Standard method?
ECON-1 Economic Vitality	a1.GRP, mixed; average annual, upper	3.00	3	3	3	3
	a2.GRP, mixed, average annual lower	3.00	3	3	3	3
	a3. GRP, mixed; cumualtive upper	3.00	3	3	3	3
	a4. GRP, mixed; cumualtive lower	3.00	3	3	3	3
	a.Economic (long-term) centroid	3.00				
	b. Economic (short-term)	2.50	3	3	3	1
	c.Tourism	2.25	2	3	3	1
	d. Real Estate stigma removal	2.25	3	3	2	1
ECON-2 Jobs	a1.Jobs, annual average mixed; upper	3.00	3	3	3	3
	a2.Jobs, annual average, mixed lower	3.00	3	3	3	3
	a3. Jobs, cumulative upper	3.00	3	3	3	3
	a4. Jobs, cumulative upper	3.00	3	3	3	3
ECON-3 Infrastructure	a. Road traffic	2.50	2	3	3	2
	b. Construction impacts	2.75	3	3	3	2
	c. Utilities	1.75	2	2	2	1
	d. River infrastructure	2.50	3	3	3	1
	e. Navigational channel	2.50	3	2	3	2
ECON-4 Cost Effectiveness	a. Capital cost	3.00	3	3	3	3
	b. Long-term cost	2.75	3	3	3	2
	c. Cost-effectiveness (% SWAC reduction per $ T0)	2.25	2	3	3	1
	d. Cost effectiveness (% SWAC reduction per $ T45)	2.25	2	3	3	1
	e. Net environmental cost- benefit	2.75	2	3	3	3

Table 6-3. MRWs used for metrics for the Social Equity pillar

Evaluation Criteria		Relevance Weighting	Clear and logical basis?	Sensitive?	Quanti-tative?	Standard method?
SOC-1 Quality of Life & Recreation	a. Quality of life	2.50	2	3	3	2
	b. Recreation: water quality	2.50	2	3	3	2
	c. Other water recreation	2.25	2	3	3	1
	d. Access to river	2.25	2	3	3	1
SOC-2 Community Values	a. Stakeholder involvement	2.00	3	1	2	2
	b1.Economic re-use	2.25	3	3	2	1
	b2. Recreation re-use	2.25	2	3	3	1
	b3.Tribal re-use	2.25	2	3	3	1
	b4. In-water re-use	2.25	2	3	3	1
	b. Re-use centroid value	2.25				
	c. Communication of uncertainty	1.00	1	1	1	1
	d. Archaeological sites	2.25	3	3	1	2
SOC-3 Acceptable Remedy	a1. Permanence: Reduction of contaminant mass	3.00	3	3	3	3
	a2. Permanence: Reduction in mobility of hazardous substances	2.50	2	3	3	2
	a. Permanence centroid	2.75				
	b1. Effectiveness: Human risk reduction	3.00	3	3	3	3
	b2. Effectiveness: Ecological risk reduction	3.00	3	3	3	3
	b3. Effectiveness: Degree of certainty that the remedial alternative will be successful	2.50	2	3	3	2
	b4. Effectiveness: Reliability of ICs and engineering controls used to manage risk	2.50	2	3	3	2
	b. Effectiveness centroid	2.75				
	c. Implementability	2.75	3	3	3	2
	d. Socially optimal construction time	2.50	3	3	3	1
	e. Time-effectiveness	2.00	1	3	3	1
SOC-4 Health & Safety	a. Worker safety	3.00	3	3	3	3
	b1. Human health risk, T0	3.00	3	3	3	3
	b2. Human health, T45	2.50	2	3	3	2
	b. Human health centroid value	2.75				
	c. Fish consumption risk (short term)	2.50	2.0	3.0	3.0	2.0

6.4 Environmental Quality SG Value and metric approaches and scores

6.4.1 ENV-1: Fish & Wildlife

Impacts on the SG Value Fish & Wildlife were evaluated using a number of metrics that indicate aspects of risk to fish and wildlife at a range of timescales; risks during construction, at the end of construction (Time, T=0) and long term (T=45). For Portland Harbor, Fish & Wildlife was quantified using five metrics (the first of which was calculated using three sub-metrics):

6.4.1.1 Risk Reduction, (SWAC reduction, direct contact, consumption), (ENV-1a):

This metric reflects post-construction ecological risk remaining immediately after construction (T=0). This is scored as the relevance-weighted average of ENV-1a1, ENV-1a2, and ENV-1a3 (described below).

SWAC Reduction Post-construction (T=0) (ENV-1a1): The first sub-metric evaluates the average reduction in SWACs for the focused contaminants of concern (COCs)[6] on a site-wide basis immediately following construction (thus, as each alternative has a different construction time, these are risks at different times, depending on the alternative). SWAC reductions from MNR are not considered. These values are calculated based upon the 2016 EPA FS, and the values calculated as reported in the environmental report (AECOM 2016). These scores reflect a reduction in risk, and thus a benefit, or desirable outcome, and thus are all scored positively. A low score of 0 represented 0 percent average SWAC reduction (i.e., Alternative A), and a high score of 10 represented a 76 percent average SWAC reduction (i.e., Alternative F). Average SWAC reductions are presented as individual COC SWAC reductions occurring immediately after construction has finished. Therefore, alternative-specific average SWAC reductions occur at different times. For example, a 56 percent average SWAC reduction would occur after 5 years of construction predicted for Alternative B, and a 76 percent average SWAC reduction would occur after 26 years of construction predicted for Alternative F. The alternatives with a higher percentage of average SWAC reductions score higher than the alternatives with a lower percentage of average SWAC reductions, regardless of the length of construction (AECOM 2016).

Direct Contact Risk Reduction (ENV-1a2): The second sub-metric evaluates direct contact risk reduction based upon the number of acres where unacceptable benthic risks continue (RAO5), based upon the 2016 EPA FS (Section 4 text). These scores reflect a reduction in risk, and thus a benefit, or desirable outcome, and thus are all scored positively. A low score of 0 represented the baseline level of 1,289 acres with unacceptable benthic risk (i.e., Alternative A), and a high score of 10 represents the objective of 0 acres with unacceptable risk. Alternative F, the most aggressive alternative, still has, according to the 2016 EPA FS, 167.6 acres of unacceptable risk, and thus scores only 8.7. Results are post-construction (T=0).

Consumption Risk Reduction (ENV-1a3): The third sub-metric evaluates the post-construction risk (T=0) to ecological receptors from ingestion of COCs in sediment. Metric scores are based upon the maximum hazard quotient (HQ) for the contaminants 4,4-DDE, polychlorinated biphenyls (PCBs), HxCDF, PeCDF, TCDD, and TCDF calculated on a river-mile basis, based on the 2016 EPA FS (Section 4 text). These scores reflect a reduction in risk, and thus a benefit, or desirable outcome, and thus are all scored

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[6] *Focused COCs include polychlorinated biphenyls [PCBs], Total polycyclic aromatic hydrocarbons [PAHs], isomers and metabolites of dichlorodiphenyltrichloroethane [DDx], 2,3,7,8-Tetrachlorodibenzo-p-dioxin [TCDD], 1,2,3,7,8-Pentachlorodibenzodioxin [PeCDD], and 1,2,3,7,8-Pentachlorodibenzofuran [PeCDF]. SWAC reductions from Monitored Natural Recovery (MNR) over time are not considered. Each alternative has a different construction time.*

positively. A low score of 0 represented residual risks without construction (i.e., Alternative A), and a high score of 10 represents acceptable ecological risks (i.e., HQ of 1).

6.4.1.2 Downstream Risk (ENV-1b):

This metric evaluates the short-term risk to fish as a result of contaminants released during the construction process. This issue is not addressed in the 2016 FS (EPA 2016a). However, it is considered an important aspect of this SG Value. Thus, data from the 2012 Draft FS (AnchorQEA 2012) were used to develop an indicator. Total mass PCBs exiting the study area were taken from Figure 9.5.3-1 of the 2012 Draft FS. These graphs summarize the total contaminant mass (kilograms [kg]) PCBs exiting the study area during the construction period for each alternative. Alternatives that include the largest dredging volumes are projected to result in a greater mass of downstream contaminant transport during construction. These extracted values were corrected by dividing them by the construction years in the 2012 Draft FS, and multiplying them by the AECOM (2106) adjusted construction years for each alternative. Alternative I was deemed close enough to Alternative E that the total mass exiting the Site for Alternative E, corrected for the construction years for Alternative I, was used for this metric. These scores reflect an increase in risk (in the short term), and thus a risk or an undesirable outcome, and all have negative scores. A score of 0 represented residual risks without construction (i.e., Alternative A), and a score of -10 represents the maximum risk (i.e., Alternative F).

6.4.1.3 Reliance on Controls (ENV-1c):

Metric scores are inversely proportional to total acres remediated in place, which are allocated to be capped, treated, enhanced natural recovery (ENR), and MNR. This assumes that reliability of institutional controls and engineering controls is inversely proportional to the area of technologies that leave contamination on-site. Thus, the sums of the acres assigned to each of these technologies for each alternative is the indicator for this metric. Although Alternative A does not have technology assignments, all contamination is left on-site; therefore, the total Portland Harbor study area is used to score Alternative A. Thus, less area requiring control relative to baseline is scored as a benefit based upon the EPA remedial alternative descriptions in the 2016 FS (EPA 2016a). These scores reflect a reduction in exposure, and thus a benefit, or desirable outcome, and thus all have positive scores. All remedial alternatives would use similar institutional and engineering controls to manage residual risk. However, the degree to which they need to use these controls would differ. Institutional controls relevant to this value could include environmental covenants, monitoring, and restricted navigation areas. Therefore, reliability was mainly scored based on engineering controls, which would be needed to manage and monitor contaminants remaining on-site. Alternatives with more dredging received higher scores because removal of contaminants is a more reliable technology in the long term and because it does not rely on covenants or other devices to address potential exposure of contaminants left in place. This metric is scored as an inverse proportion to the surface area where buried contamination potentially remains on-site; thus the reduction in area requiring control is seen as a benefit. For this metric, the acres with caps, ENR, and MNR in the Portland Harbor cleanup area are summed for each alternative. The metric is scored from no remediation (score 0, i.e., Alternative A) to all of the cleanup area dredged (score 10).

6.4.1.4 Construction Risk (ENV-1d):

This metric is scored based on adjusted construction time (AECOM 2016). This metric weight was set to 0, as this is duplicative, but less quantitatively representative, of the risk reflected in ENV-1b. This metric was left in the SVA model for future applications in which there may not be acceptable indicators of ENV-1b.

6.4.1.5 Residual Risks (T45) (ENV-1e):

This metric reflects long-term residual risks to fish and wildlife. This issue was not addressed in the 2016 EPA FS (EPA 2016a). However, it is considered an important aspect of this SG Value. Thus, data from the 2012 Draft FS (AnchorQEA 2012) were used to develop an indicator. This metric is based upon Year 45 PCB SWAC, site-wide, for reasonably matched remedial alternatives in the 2012 Draft FS (Section 9 tables). These scores reflect a reduction in risk, and thus a benefit, or desirable outcome, and all impacts have positive scores. A low score of 0 represented residual risks without construction (i.e., Alternative A), and a high score of 10 represents the lowest level achieved (14 parts per billion [ppb] PBC SWAC at Year 45 for Alternative F).

6.4.1.6 Fish & Wildlife SG Value score

The Fish & Wildlife SG Value score is the centroid; the MRW-weighted average of metric scores ENV-1a, ENV-1b, ENV-1c, and ENV-1e. Table 6-4 summarizes the approach for ENV-1 scoring. Figure 6-1 shows the Fish & Wildlife metric scores for each remedial alternative; Figure 6-2 illustrates the same results but plots the aggregated metric scores for each alternative. In this manner, it is clear how different metrics aggregate to form the net SG Value scores (with equal weighting).

6.4.1.7 Discussion, Fish & Wildlife

Three of four metrics (ENV-1a, ENV-1c, and ENV-1e) have positive scores for all alternatives. For the residual risk scores (ENV-1e), the larger alternatives manage more sediment but do not reduce risk to a greater extent. ENV-1c, based on the extent to which sediment is removed, provides a greater proportional increase for the more extensive options, but the scores are small for all alternatives, as a large proportion of sediment (albeit the relatively less contaminated sediment), is left in place, even in Alternative F. ENV-1b, on the other hand, reflecting the downstream risk due to contaminant resuspension during (and, most likely, for some time after) construction, has a large proportional increase for the longer construction times. Figure 6-2 illustrates that, when the metrics are combined, the relative importance of this metric to the overall SG Value score becomes larger progressing from less extensive to more extensive alternatives. It is, however, important to note that the metric scores in these figures are unweighted; when they are aggregated for SG Value and pillar scores, they will be weighted based on their relevance scores (Section 6.3) and, in Section 8, by SG priorities. Both these weighting approaches will alter the relative importance of individual metrics in overall SG Value scores.

Figure 6-1. Metric scores for ENV-1 (Fish & Wildlife), Equal weighting

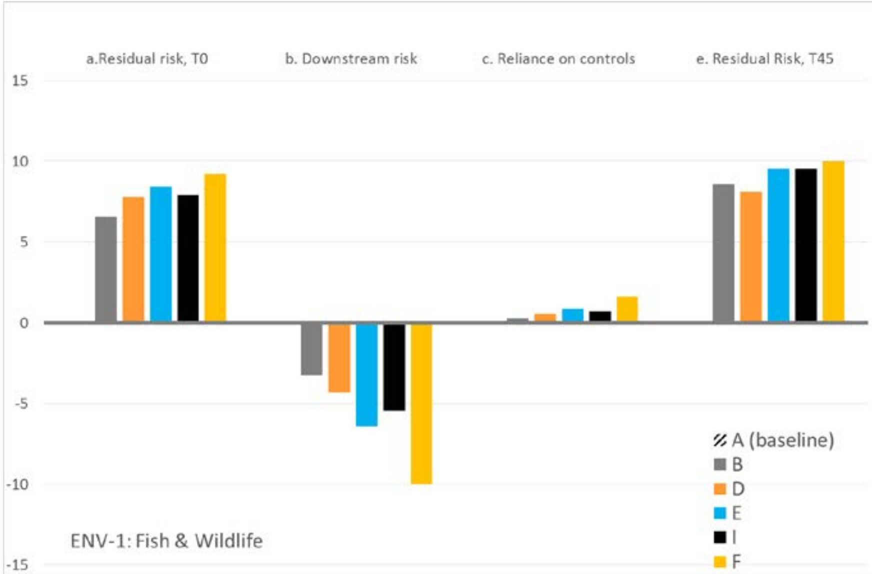


Figure 6-1 Note: ENV-1d not shown in figure because it is not used in this assessment; it is duplicative of ENV-1b.

Figure 6-2. Stacked Fish & Wildlife metric scores for each remedial alternative, Equal weighting

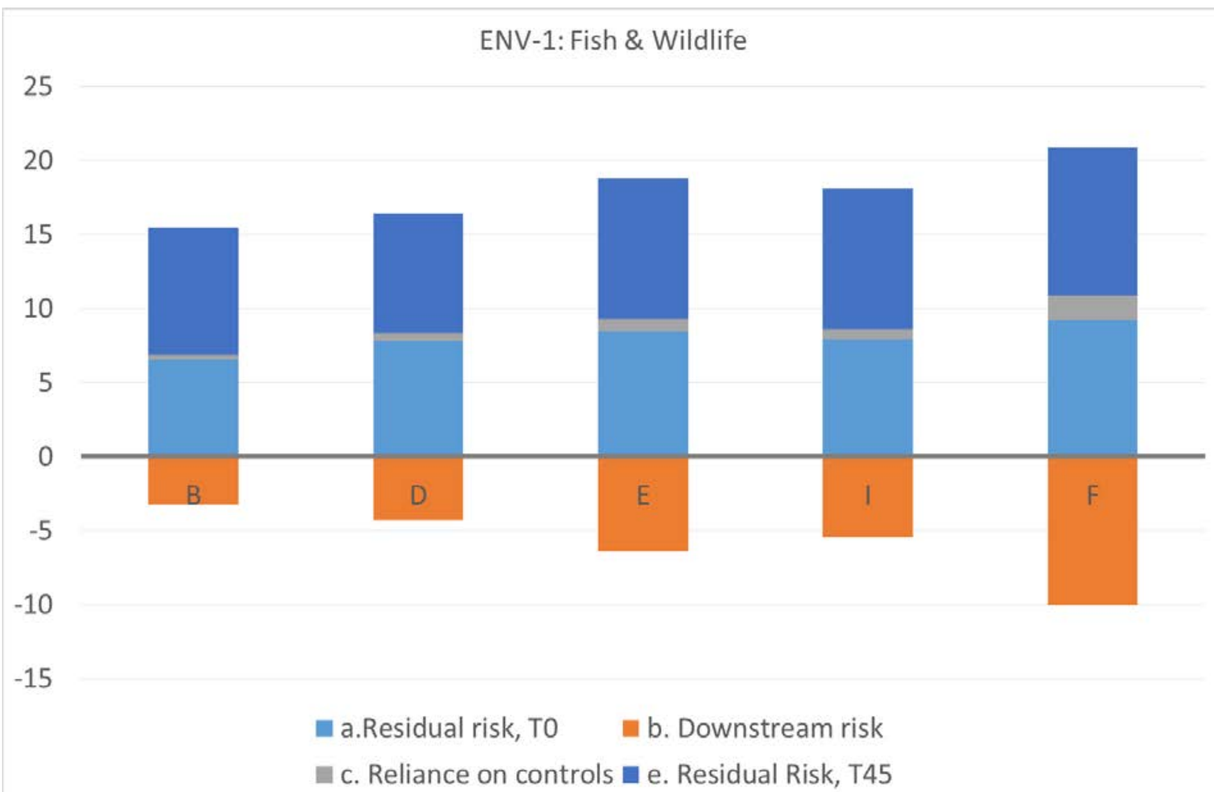


Table 6-4. Scores, weights, and approaches for ENV-1 metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis		Units	Site-wide Remedial Alternatives					
					Minimum Impact	Maximum Impact		A (baseline)	B	D	E	I	F
Environmental Quality				ENV Pillar centroid score				0.0	-1.2	-1.6	-1.9	-1.7	-2.7
ENV-1 Fish & Wildlife	a1.Risk reduction, SWAC, T=0	Exposure at end of construction. Average reduction in SWACs on a site-wide basis following construction for the focused COCs. SWAC reductions from MNR are not considered. Each alternative has a different construction time. This is a benefit (desirable outcome)	3.00	0.33	0	76	%	0	56	63	69	65	76
	Score 0 represents predicted exposure without construction (i.e., Alt A: 0% reduction in SWACs for the focused COCs); score 10 represents exposure at time 0 following construction of Alt F (76% reduction in SWACs for the focused COCs).						Score	0.0	7.3	8.3	9.0	8.6	10.0
	a2. Risk reduction, contact	RAO 5:Acres where unacceptable benthic risks continues - Direct Contact	3.00	0.33	0.0	1289	acres	1289	670	464	348	464	168
	Score 0 represents predicted HI without construction (i.e., Alt A: 0% reduction in HI for the focused COCs); score 10 represents minimum exposure at time 0 following construction							0.00	4.8	6.4	7.3	6.4	8.7
	a3. Risk reduction, consumption	RAO 6: Maximum Hazard Quotient - Consumption, equal to the max HQ of 4,4-DDE, PCBs, HxCDF, PeCDF, TCDD, and TCDF (river-mile)	3.00	0.33	1.0	138	max HQ	138	34	19	15	19	15
	Score 0 represents predicted HI without construction (i.e., Alt A: 0% reduction in HI for the focused COCs); score 10 represents minimum exposure at time 0 following construction							0.00	7.59	8.69	8.98	8.69	8.98
	a. Residual Risk, T0		3.00	3.00			Score	0.0	6.6	7.8	8.4	7.9	9.2
	b. Downstream risk	Total Mass Exiting the Study Area for Each Alternative (Total PCB kg), adjusted for AECOM years (in input table). Note: this metric is based on 2012 FS as the 2015/2016 FS does not address	2.50	3.00	93	0	Total PCB kg (adj.)	0	30	40	60	50	93
	Score 0 represents baseline; -10 represents maximum downstream transport						Score	0.0	-3.2	-4.3	-6.4	-5.4	-10.0
	c. Reliance on controls	Inversely proportional to total acres of cap, in situ treatment, ENR, and MNR. Assume reliability of ICs and engineering controls is inversely proportional to the area of technologies that leave contamination on site. Although Alt A does not have technology assignments, all contamination is left on site; therefore, the total PH study area is used to score Alt A. Thus, less area requiring control relative to baseline is scored as a benefit.	2.50	3.00	2167	1812	Acres of PH	2167	2102	2046	1979	2017	1812
	Score of 0 represents leaving all contamination in PH active remedial footprint; score of 10 represents dredging all contamination in the PH active remedial area.						Score	0.0	0.3	0.6	0.9	0.7	1.6
	d. Construction risk	Based on construction time (currently adjusted construction time). This is a dis-benefit (undesirable outcome) Set to zero as this seems DUPLICATIVE OF ENV-1b. If no data are available for ENV-1b, this can be switched on instead	2.50	0.00	26	0	years	0	5	8	13	11	26
	Score -10 represents construction time for Alt F (36 years); score 0 represents no additional construction (i.e., Alt A: 0 yrs).						Score						
	e. Residual Risk, T45	Based on Year 45 PCB SWAC, site-wide, from Table 9.3.1-1 2012 Draft FS (Section 9 tables) Note: Score of 10 is set at projected lowest SWAC value, rather than background (9 ppb) as an objective, but this could be changed	2.50	3.00	35.0	14.0	ppb	35.0	17.0	18.0	15.0	15.0	14.0
	Score 0 represents ecological risk predicted without construction (i.e., Alt A: average HQ = 63); score 10 represents lowest ecological						Score	0.0	8.6	8.1	9.5	9.5	10.0
	ENV-1. Fish & Wildlife centroid values		*3.00*				*Score*	0.0	3.2	3.3	3.4	3.4	3.0

6.4.2 ENV-2: Habitat

Three types of habitat were defined: high-value nearshore habitat, benthic habitat, and shoreline habitat. Spatially, these areas are not distinct, as they overlap to some extent (but not completely), but they represent different essential habitat for different organisms and ecosystem services, and are thus evaluated and scored separately as proxies for those endpoints. In this project, construction-related habitat impacts were scored using the following metrics:

6.4.2.1 Nearshore habitat (ENV-2a):

The high-value nearshore habitat encompasses an important depth range designated by National Oceanic and Atmospheric Administration for fish. To quantify construction-related disturbances to this habitat area, the alternative-specific active remedial areas from the 2015 EPA FS that overlap with water-related habitat areas were calculated. The “active” remedial area was defined as the sum of dredging, capping, treatment, and ENR areas in addition to a 25-foot buffer surrounding active remedial areas. Nearshore high-value habitat areas represent the area from +13 feet North American Vertical Datum 1988 (NAVD88) (top of bank) to -15 feet NAVD88 between River Mile (RM) 1.9 and RM 11.8; overlap with this area was used to quantify construction-related disturbances to nearshore areas. See the environmental pillar report for details (AECOM 2016). This habitat disturbance is an undesirable impact (risk), so all impacts have negative scores. Alternatives are scored from 0 for no disturbance (Alternative A) to a score of -10 for maximum disturbance (Alternative F). This nearshore, high value habitat has been identified as essential for fish and other important endpoints by a number of SGs.

6.4.2.2 Benthic habitat (ENV-2b):

The benthic habitat includes all in-water, sediment bottom areas within the study area. This metric is scored based upon acres of active remediation. These are drawn from the 2016 EPA FS. This habitat disturbance is an undesirable impact (risk), so all have negative scores. Alternatives are scored from 0 for no disturbance (Alternative A) to a score of -10 for maximum disturbance (Alternative F). Benthic habitat will overlap nearshore habitat, but will also represent benthic habitat in deeper waters. The focus of this metric is on benthic organisms, and thus different endpoints and services than are the focus of the other habitat metrics.

6.4.2.3 Shoreline habitat (ENV-2c):

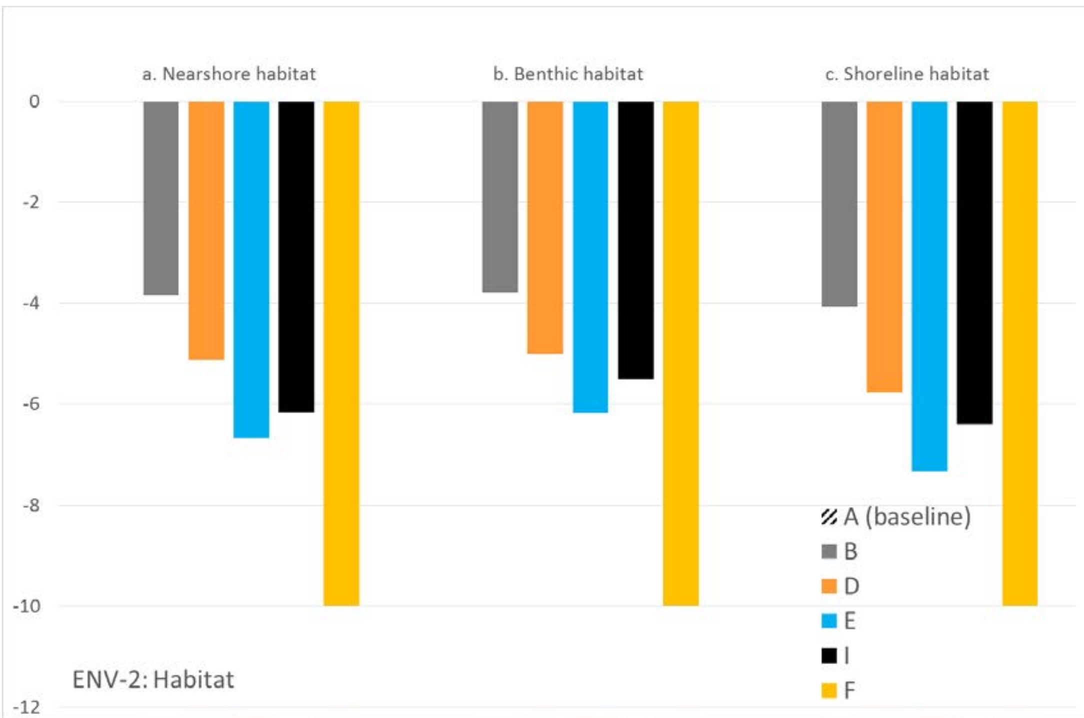
Shoreline habitat, as an interface between terrestrial and riverine ecosystems, represents an ecotome (a transitional zone between two communities containing the characteristic species of each); and, hydrologically, a hyporheic zone (a region beneath and alongside a stream bed, where there is mixing of shallow groundwater and surface water) and are thus regions of interest. To quantify construction-related disturbances to shoreline habitat, this metric is scored based on the linear feet of alternative-specific active remedial areas from the 2015 EPA FS that overlap with shorelines. The “active” remedial area was defined as the sum of dredging, capping, treatment, and ENR areas in addition to a 25-foot buffer surrounding active remedial areas. This disturbance is an undesirable impact (risk), so all have negative scores. Alternatives are scored from 0 for no disturbance (Alternative A) to a score of -10 for maximum disturbance (Alternative F). Shoreline habitat overlaps physically with the nearshore and benthic habitats, but represents different endpoints and services. Habitat (ENV-2) SG Value score

The Habitat (ENV-2) SG Value score is the centroid; the relevance-weighted average of metric scores ENV-2a, ENV-2b, and ENV-2c. The relevance score of this SG Value is the mean of the metric relevance scores. Table 6-5 summarizes the approach for ENV-2 scoring. Figure 6-3 shows the Habitat metric scores for each remedial alternative.

6.4.2.4 Discussion, Habitat

Sediment remediation will disrupt, at least in the short term and, in some cases, over the long term, various types of habitats, interfering with ecosystem functioning and services (Apitz 2012). As can be seen in Figure 6-4, all three metrics have negative scores, with a large increase in negative impacts as one progresses from the alternatives with the smaller footprint to the larger footprints. The relative change differs for the various habitat types, as the impact is dependent upon the spatial overlap between management footprints and specific habitat types. It has been demonstrated that, in many cases, benthic and other habitats can recover from remedial impacts (Germano & Associates Inc. 2014), but the relative times of these impacts, and recovery potential, were not evaluated or scored in this analysis. This assessment did not evaluate any potential post-remediation habitat restoration, mitigation or enhancement, as it was outside the scope of the analysis.

Figure 6-3. Metric scores for ENV-2 (Habitat), Equal weighting



6.4.3 ENV-3: Resilience

In this project, Resilience was scored using the two metrics: flood risk and vulnerability.

6.4.3.1 Flood risk (ENV-3a):

This metric was scored based on the assumption that a net change in river bottom elevation will change the river's water capacity and thus affect flood risk during extreme flow events. Thus, a net gain in sediment elevation increases flood risk and a net loss would decrease flood risk. Thus, this metric is scored based upon net changes in river bottom sediment volume, based upon the 2016 EPA FS Appendix P: Flood Rise Evaluation; Table P-15 (EPA 2016b). In all cases, these were net removals in sediment volume, so the unit for this indicator is cubic yards net volume removed. This impact could have been negative (with a net gain) but as all alternatives (barring the baseline) result in a net volume removal, all are scored as a positive benefit to flood risk, a desirable impact. Alternatives were given a score of +10 (for maximum volume removal; Alternative F) to 0 (for baseline, or no net removal).

6.4.3.2 Vulnerability in place (ENV-3b):

Metric scores are inversely proportional to total acres of remedial alternatives, which are allocated to be capped, treated *in situ*, and subject to ENR and MNR. This assumes that vulnerability to events such as floods, earthquakes, and other disturbance is inversely proportional to the area of technologies that leave contamination on-site. Thus, the sums of the acres assigned to each of these technologies for each alternative is the indicator for this metric. Although Alternative A does not have technology assignments, all contamination is left on-site; therefore, the total Portland Harbor study area is used to score Alternative A. Thus, less area with contaminants left in place relative to baseline is scored as a benefit based upon the EPA remedial alternative descriptions in the 2016 EPA FS (EPA 2016a). For this metric, the acres with caps, ENR, *in situ*, and MNR in the Portland Harbor cleanup area are summed for each alternative. The metric is zero remediation (score 0, i.e., Alternative A) to all of the cleanup area removed (score 10).

6.4.3.3 Resilience score

- The Resilience (ENV-3) SG Value score is the centroid; the relevance-weighted average of metric scores ENV-3a and ENV-3b. The relevance score of this SG Value is the mean of the metric relevance scores. It encompasses the storm/weather or other type of disturbance resilience of a specific structure (river/creek/shoreline) or technology (cap) based on modifications posed by the remedial alternative.

For any given remedial alternative, there can be both negative and positive factors that are aggregated into the overall Resilience score. Table 6-5 summarizes the approach for ENV-3 scoring. Figure 6-4 shows the Habitat metric scores for each remedial alternative; Figure 6-5 shows the same results, in a stacked bar graph.

Figure 6-4. Metric scores for ENV-3 (Resilience), Equal weighting

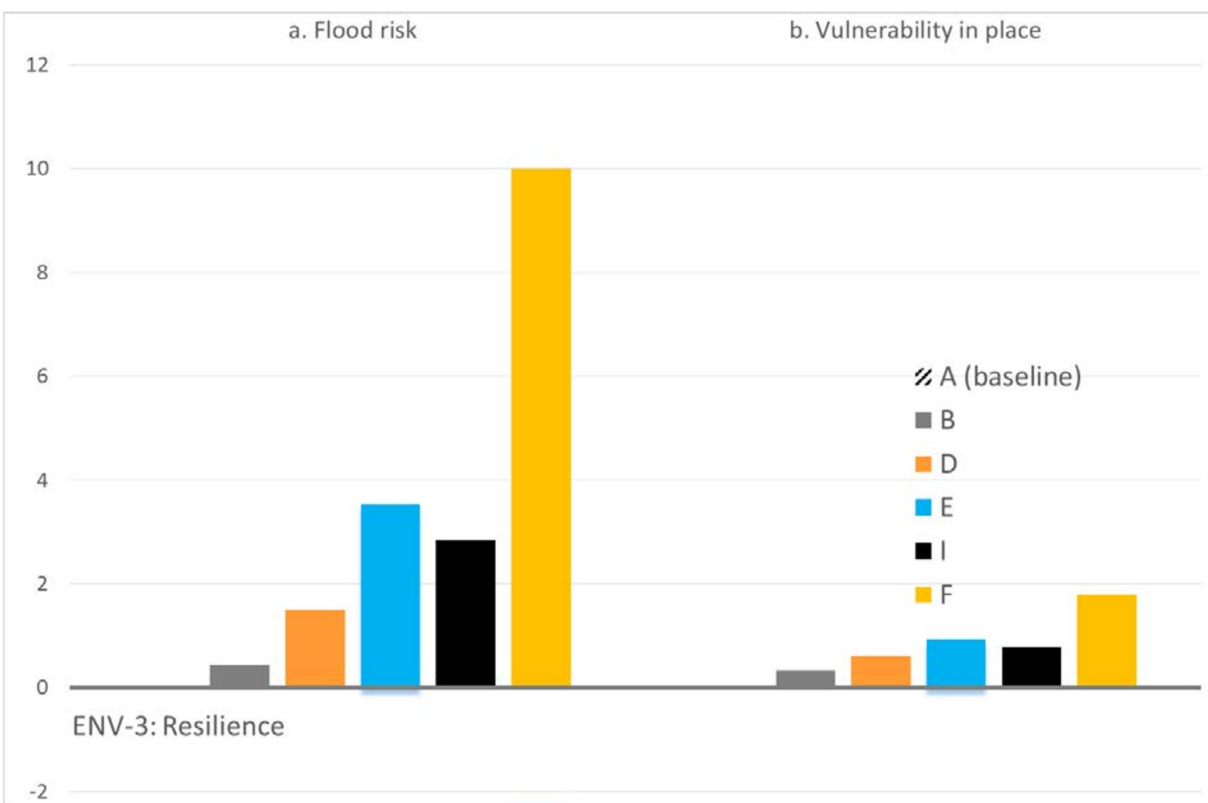
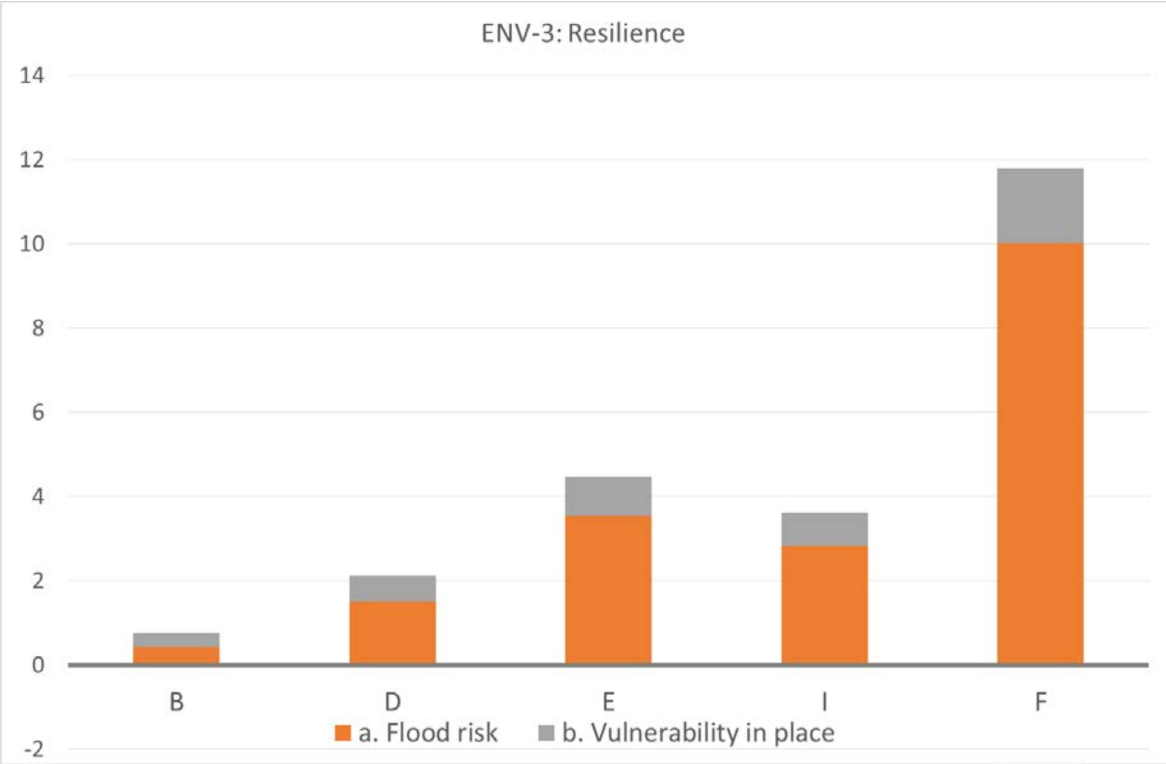


Figure 6-5. Stacked ENV-3 (Resilience) metric scores for each remedial alternative, Equal weighting



6.4.3.4 Discussion, Resilience

Sediment processes have been interrupted by the damming and redirection of rivers; land claims such as coastal, watershed, and urban developments; development of erosion control structures and other infrastructure. These man-made infrastructures and their management requirements have produced both intended and unintended changes in geomorphology and hydrodynamics. These alterations can create conditions requiring increased levels of dredging and management to maintain “desirable” socioeconomic conditions, and significantly altered habitats (Wenning and Apitz 2013).

Coastlines, rivers, islands, and ecosystems will naturally realign in response to these changes, so it is reasonable to conclude that the long-term costs of maintenance dredging and shoreline preservation and defense construction projects will increase. The same concerns apply to the restoration or remediation of damaged habitat or construction of new ecological habitat in order to achieve the mitigation offset required of infrastructure projects. Faced with the possibilities of rapid changes in erosional or depositional forces, the fate of sediment is of critical concern because it represents the foundation for long-term, stable functioning of aquatic ecosystems. If morphological and ecosystem structural changes are inevitable, it is essential to ensure that we do all we can to maintain and enhance essential functions while allowing for the continuing utilization of river and coastal systems (Wenning and Apitz 2013).

The stability of remediation, disposal, and restoration activities in the face of more natural disasters such as earthquakes, extreme storms, droughts, and floods) should be considered. Based upon comments in public meetings, an issue of great concern to the public is the earthquake stability of any confined disposal facilities, as well as of any contaminants contained in place.

Policy and management interventions must be guided by a sound understanding of how systems may respond to reversible and irreversible natural and anthropogenic change, singly and in combination; where knowledge is uncertain, approaches should be flexible and adaptive.

However, most of these issues could not be addressed in this study. The locations of any containment facilities have not yet been determined. The recent FS (EPA 2016a) does not address resilience to an extent that allowed for the development of sensitive metrics. Repeated inquiries to EPA Region 10 on this issue did not yield any response. Thus, in this report, resilience is addressed in terms of the extent to which contaminated sediments are left in place and, thus, may be re-exposed or mobilized due to extreme events, and the extent to which net changes in river sediment volume might affect flood risk.

As ENV-3c is scored based upon the relative extent of in-place management, the more extensive alternatives have higher scores, but, as all alternatives leave a large proportion of contaminated sediment (albeit sediment contaminated at relatively low concentrations), none of the alternatives score very high for this metric. If more detailed information were available on alternative disposal plans, more metrics for resilience could be developed. Potential metrics include a measure for disposal site vulnerability to extreme events such as earthquakes and floods (a significant concern raised in many public meetings), and the potential impact of remediation and disposal alternatives on regional vulnerability to such events.

Table 6-5. Scores, weights, and approaches for ENV-2 and ENV-3 metrics and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis: Minimum Impact	Risk/Benefit Scoring Basis: Maximum Impact	Units	A (baseline)	B	D	E	I	F
ENV-2 Habitat	a. Nearshore habitat	% overlap of active remediation to nearshore habitat area above -15 ft elevation; scored, inverted. This impact is an undesirable impact	2.50	3.00	0	39	%	0	15	20	26	24	39
	Score of 0 is no disturbance; score of -10 is maximum disturbance						Score	0.0	-3.8	-5.1	-6.7	-6.2	-10.0
	b. Benthic habitat	Acreas of active remediation; Taken from habitat sheet. This is an undesirable impact	2.50	3.00	0	22997499	Square feet	0.0	8712355	11518090	14209605	12666837	22997499
	Score of 0 is no disturbance; score of -10 is maximum disturbance						Score	0.0	-3.8	-5.0	-6.2	-5.5	-10.0
	c. Shoreline habitat	Overlap of active remedy (dredge, cap, treatment and ENR) with shoreline	2.50	3.00	0	67311	linear feet	0	27430	38881	49364	43050	67311
	Score of 0 is no disturbance; score of -10 is maximum disturbance						Score	0.0	-4.1	-5.8	-7.3	-6.4	-10.0
	ENV-2. Habitat centroid values		*3.00*				*Score*	0.0	-3.9	-5.3	-6.7	-6.0	-10.0
	a. Flood risk	Net volume removed (reduces flood risk) - if there were a net gain this scoring would have to be changed to allow for negative scores; net loss is a desirable effect	2.50	3.00	0	3019537	cyt	0	131569	453697	1065947	855407	3019537
	Score of 0 is no net removal score of 10 is maximum removal. If net gain, scoring needs to change						Score	0.0	0.4	1.5	3.5	2.8	10.0
	b. Vulnerability in place	Inversely proportional to total acres of caps, in situ treatment, ENR, and MNR. Assign A as 100% MNR for this. Assume reliability of ICs and engineering controls is inversely proportional to the area of technologies that leave contamination on site. Thus, a reduction in this is a benefit	2.25	3.00	2167	0	acres	2167	2096	2035	1964	2000	1780
	Score of 0 represents leaving all contamination in PH active remedial footprint; score of 10 represents dredging all contamination in the PH active remedial area. This is used as concerns are about long-term stability after storm, earthquake and/or flood. Not ideal as vulnerability should be a function of contaminant load as well as extent.						Score	0.00	0.33	0.61	0.94	0.77	1.79
	ENV-3. Resilience centroid		*3.00*				*Score*	0.0	0.4	1.1	2.3	1.9	6.1

6.4.4 ENV-4: Low Impact Remedy

The SG Value "Low Impact Remedy" is one that addresses the environmental footprint of remedial activities. These values are the focus of many life-cycle assessment approaches, and of green and sustainable remediation frameworks. The environmental footprints of Alternatives B, D, E, F and I were quantified in SiteWise™ (AECOM 2016). SiteWise™ is a series of publicly available Microsoft Excel spreadsheets used to calculate the environmental footprint of remediation activities in terms of sustainability metrics. This tool is based on life cycle equivalents used to quantify common environmental metrics, as well as some social impacts. Details of environmental footprint calculations can be found in the environmental report (AECOM 2016). Other metrics considered for this SG Value address the volume of sediment treated and contaminant mobilization.

In this project, Low Impact Remedy was scored using the following seven metrics:

6.4.4.1 Air emissions (ENV-4a):

This metric was scored based upon SiteWise™-generated data (AECOM 2016) for each remedial alternative's air (NO_x, SO_x, and PM_{10}) and greenhouse gas (GHG) emissions. It is important to note that the scale of the GHG impact may be larger than are many of the other remedial alternative short-term and long-term impacts, which are largely local or regional. These are undesirable impacts, so all have negative scores. For each of these, each sub-metric (NOx, SOx, PM_{10} and GHG) for each remedial alternative was scored from -10 (for maximum emissions; Alternative F) to 0 (for baseline, or no increased emissions; Alternative A); the metric score was the average of these scores.

6.4.4.2 Energy consumption (ENV-4b):

This metric was scored based upon SiteWise™-generated data (AECOM 2016) for each remedial alternative's energy consumption. These are undesirable impacts, so all have negative scores. Each remedial alternative was scored from -10 (for maximum consumption; Alternative F) to 0 (for baseline, or no increased consumption; Alternative A).

6.4.4.3 Water consumption (ENV-4c):

This metric was scored based upon SiteWise™-generated data (AECOM 2016) for each remedial alternative's water consumption. These are undesirable impacts, so all have negative scores. For each of these, each remedial alternative was scored from -10 (for maximum consumption; Alternative F) to 0 (for baseline, or no increased consumption; Alternative A).

6.4.4.4 Hazardous landfill use (ENV-4d):

This metric was scored based upon SiteWise™-generated data (AECOM 2016) for each remedial alternative's hazardous landfill use. These are undesirable impacts, so all have negative scores. For each of these, each remedial alternative was scored from -10 (for maximum use; Alternative F) to 0 (for baseline, or no increased use; Alternative A).

6.4.4.5 Non-hazardous landfill use (ENV-4e):

This metric was scored based upon SiteWise™-generated data (AECOM 2016) for each remedial alternative's total volume of sediment disposed (non-hazardous). These are undesirable impacts, so all have negative scores. For each of these, each remedial alternative was scored from -10 (for maximum disposed; Alternative F) to 0 (for baseline, or no increased disposal; Alternative A).

6.4.4.6 Volume of sediment treated (ENV-4f):

This metric was scored based upon the volumes of sediment treated in the 2016 EPA FS (EPA 2016a). These are undesirable impacts, so all have negative scores. For each of these, each remedial alternative was scored from -10 (for maximum treated; Alternative F) to 0 (for baseline, or no treatment; Alternative A).

6.4.4.7 Contaminant mobilization (ENV-4g):

This metric was scored based upon estimates of contaminant mobilization in the 2012 Draft FS, as described in ENV-1b. The same metric is used, but in this case it is an indicator for a different SG Value, so this is not a duplicative metric. These are undesirable impacts, so all have negative scores. For each of these, each remedial alternative was scored from -10 (for maximum releases; Alternative F) to 0 (for baseline, or no extra releases; Alternative A).

6.4.4.8 Low Impact Remedy SG Value score

The Low Impact Remedy SG Value score is the centroid; the relevance-weighted average of metric scores ENV-4a, ENV-4b, ENV-4c, ENV-4d, ENV-4e, ENV-4f, and ENV-4g. Table 6-6 summarizes the approach for ENV-4 scoring. Figure 6-6 shows the Low Impact Remedy metric scores for each remedial alternative.

6.4.4.9 Discussion, Low Impact Remedy

Not surprisingly, for metrics based upon environmental footprints, the scores for all the metrics for this SG Value are negative, with a large increase in impact from the less extensive to the more extensive and larger remedies. The relative increase is correlated with longer construction times and more material handled.

Figure 6-6. Metric scores for ENV-4 (Low Impact Remedy), Equal weighting

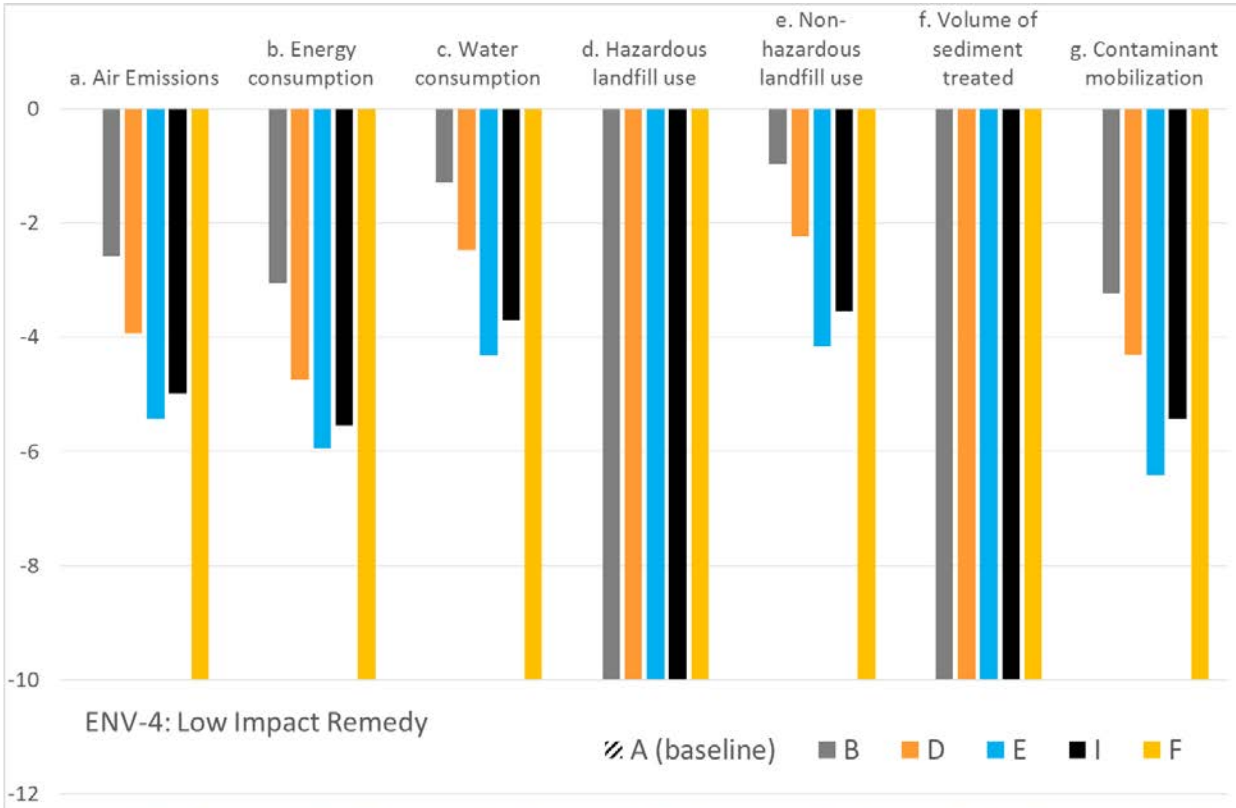


Table 6-6. Scores, weights, and approaches for ENV-4 metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis		Units	Site-wide Remedial Alternatives					
					Minimum Impact	Maximum Impact		A (baseline)	B	D	E	I	F
ENV-4 Low Impact Remedy	a1.Total NOx Emissions	Total project NOx emissions. This is an undesirable impact	3.00	0.25	0	2541	metric tons	0	603	912	1,346	1,236	2,541
	Score 0 represents baseline (i.e., Alt A: 0 emissions); score -10 represents maximum emissions.						Score	0.0	-2.4	-3.6	-5.3	-4.9	-10.0
	a2.Total SOx Emissions	Total project SOx emissions. This is an undesirable impact	3.00	0.25	0	840	metric tons	0.0	252	344	474	439	840
	Score 0 represents baseline (i.e., Alt A: 0 emissions); score -10 represents maximum emissions.						Score	0.0	-3.0	-4.1	-5.6	-5.2	-10.0
	a3. Total PM10 Emissions	Total project PM10 emissions. This is an undesirable impact	3.00	0.25	0	1544	metric tons	0.0	256	440	716	630	1544
	Score 0 represents baseline (i.e., Alt A: 0 emissions); score -10 represents maximum emissions.						Score	0.0	-1.7	-2.8	-4.6	-4.1	-10.0
	a4. GHG inputs	Total GHG emissions; undesirable impact	3.00	0.25	0	1055495	metric tons	0.0	345844.0	545208.6	652318.0	613022.3	1055494.6
	Score 0 represents baseline (i.e., Alt A: 0 emissions); score -10 represents maximum emissions.						Score	0.0	-3.3	-5.2	-6.2	-5.8	-10.0
	a.Air emissions centroid value		3.00	3.00			Score	0.0	-2.6	-3.9	-5.4	-5.0	-10.0
	b. Energy consumption	SiteWiseTM energy use, converted to 1-10 scores, then to negaitve scores. This is a dis-benefit, and thus, these are converted to negative numbers.	3.00	3.00	0	7557125	MMBTU	0	2,303,796	3,591,636	4,488,367	4,190,923	7,557,125
	Score 0 represents baseline; score -10 represents maximum consumption						Score	0.0	-3.0	-4.8	-5.9	-5.5	-10.0
	c. Water consumption	SiteWiseTM water use; converted to 0-10 score; inverted. This is an undesirable impact	3.00	3.00	0	25956	gallons	0	3,352	6,437	11,213	9,611	25,956
	Score 0 represents baseline; score -10 represents maximum consumption						Score	0.0	-1.3	-2.5	-4.3	-3.7	-10.0
	d. Hazardous landfill use	Based on SiiteWise Hazardous landfill use	3.00	3.00	0	358888	tons	0	358,888	358,888	358,888	358,888	358,888
	Score 0 represents baseline; score -10 represents maximum disposal						Score	0.0	-10.0	-10.0	-10.0	-10.0	-10.0
	e. Non-hazardous landfill use	Tons disposed in non-hazardous landfills (or CDF?) This is an undesirable impact	3.00	3.00	0	7149152	tons	0.0	693843	1599182	2975613	2534454	7149152
	Score 0 represents baseline; score -10 represents maximum disposal						Score	0.0	-1.0	-2.2	-4.2	-3.5	-10.0
	f. Volume of sediment treated	Volume sediment treated; EPA draft FS, high values; scored to max, negative impact	3.00	3.00	0	208000	cy	0	208000	208000	208000	208000	208000
	Score 0 represents baseline; score -10 represents maximum treatment						Score	0.0	-10.0	-10.0	-10.0	-10.0	-10.0
	g. Contaminant mobilization	Total Mass Exiting the Study Area for Each Alternative (Total PCB kg), adjusted for AECOM years (in input table). Note: this metric is based on 2012 FS as the 2015/2016 FS does not address	2.25	3.00	0	93	Total PCB kg (adj.)	0	30	40	60	50	93
	Score 0 represents baseline; -10 represents maximum downstream transport						Score	0.0	-3.2	-4.3	-6.4	-5.4	-10.0
	ENV-4. Low Impact Remedy centroid values		*3.00*				*Score*	0.0	-4.5	-5.4	-6.6	-6.2	-10.0

6.5 Economic Viability SG Value and metric approaches and scores

6.5.1 ECON-1: Economic Vitality

Impacts on the SG Value Economic Vitality reflect impacts on the Portland Greater Metropolitan Region from the remedial alternatives. For Portland Harbor, Economic Vitality was quantified using four metrics:

6.5.1.1 Economic (long-term) (ECON-1a):

This metric reflects the combined expenditure and financing impacts of the remedial alternatives on the Portland gross regional product (GRP). These SG Values were based upon the mixed financing scenario from NERA (2016). Upper and lower estimates GRP average annual and cumulative economic impacts (which, for these alternatives, were all economic losses) were scored for each alternative; the metric score was the average of these scores for each alternative. All scenarios in the economic assessment (NERA 2016) showed net economic losses for all remediation alternatives, so all have negative scores, although economic gains, had they been identified, would have been given positive scores. Each remedial alternative was scored from -10 (for maximum economic loss; Alternative F) to 0 (for baseline, or no economic loss; Alternative A). Table 6-7 illustrates the data used to score ECON-1a.

These impacts are large relative to those in ECON-1b through -1d, but are scaled in the same manner. See discussion of the other metrics.

6.5.1.2 Economic (short-term) (ECON-1b):

NERA carried out interviews with local business representatives to determine whether and how Portland Harbor remediation might affect them (NERA 2016). With regard to the effects of business disruption, virtually all the respondents indicated that the changes in their river operations were “very likely” if access were disrupted during EPA’s in-water work window. The types of changes depended on the nature of the available options. It was not possible to develop quantitative estimates of the potential magnitude of these two effects. They suggested, however, that the net effect is likely small in magnitude relative to the direct effects quantified from the remedial expenditures and financing.

As an indicator of such effects in this study, the fraction of infrastructure shoreline impact, from GIS analysis, was used. This indicator, based on the AECOM (2016) GIS overlay analysis, looks at the proportion of shoreline infrastructure that is critical to business operations, which is impacted by alternative active remedial footprints. For each of these, each remedial alternative was scored from -10 (for maximum overlap; Alternative F) to 0 (for baseline, or no overlap; Alternative A). These impacts are small relative to those in ECON-1a, but are scaled in the same manner. However, it was decided that the impacts from ECON-1a were orders of magnitude larger than ECON-1b, and that the latter was also addressed in other metrics and values. Thus, for this report, the SG weights for ECON-1b through 1d are set to zero, and they are not aggregated in the ECON-1 SG Value score. The metric scores, however, are left in the report for information purposes.

6.5.1.3 Tourism (ECON-1c):

Though there is a range of potential impacts on tourism, the indicator used for this metric was the linear foot overlap of the active remediation on beach/park areas, based on the GIS overlay analysis (AECOM 2016). Impacts on fishing were not addressed, as no acceptable metric (or evidence of economic impact) could be found. These impacts are small relative to those in ECON-1a, but are scaled in the same manner. However, the team decided that the impacts from ECON-1a were orders of magnitude larger than ECON-1c, and that the latter was also addressed in other metrics and values. Thus, for this report, the SG weight for ECON-1c was set to zero, and not aggregated in the ECON-1 SG Value score. The metric scores, however, are left in the report for information purposes.

6.5.1.4 Real estate stigma removal (ECON-1d):

These scores are based upon illustrative qualitative impacts of potential increases in property value (and development) due to a reduction of Superfund stigma due to cleanup from NERA (2016). These scores are based upon professional judgment based on stakeholder surveys and interviews, as well as some qualitative estimates. It is assumed that the benefits will not be accrued until after the cleanup is complete. Thus, due to economic discounting, the relative economic benefit is greater for remedies that are completed sooner. This is a desirable impact (a benefit) so it is scored positively. For each of these, each remedial alternative was scored from +10 (for maximum economic gain) to 0 (for baseline, or no economic gain; Alternative A). Discounting results in no alternative having a score of 10. It should be noted that these impacts are small relative to those in ECON-1a but are scaled in the same manner. However, the team decided that the impacts from ECON-1a were orders of magnitude larger than ECON-1d, and that the latter was also addressed in other metrics and values. Thus, for this report, the SG weight for ECON-1b-d was set to zero, and not aggregated in the ECON-1 SG Value score. The metric scores, however, are left in the report for information purposes.

6.5.1.5 Economic Vitality SG Value score

The Economic Vitality SG Value score is the centroid; the relevance-weighted average of metric scores ECON-1a, ECON-1b, ECON-1c, and ECON-1d. As the latter three metrics are weighted at 0, due to the reasons described above, the ECON-1 score is based solely on ECON-1a. Table 6-7 summarizes the approach for ECON-1 scoring. Figures 6-7 and 6-8 illustrate the Economic Vitality metric scores for each remedial alternative; for information. It is important to note that the scores for ECON-1b–1d were not used in the aggregation.

6.5.1.6 Discussion, Economic Vitality

Three Economic Vitality metrics increase from the least to the most extensive remedy; all are negative impacts on the regional economy (NERA 2016); the last, Real Estate Stigma Removal, is positive and increases for the more extensive options, but is highly uncertain. The relative increase in negative impact is proportional to remedy costs (ECON-1a and ECON-1b) or remedy footprint. ECON-1d, which reflects real estate value uplift due to stigma removal, has a positive impact (for property owners), though this metric was largely qualitatively scored. It should also be noted, from a social equity viewpoint, that property value increases, though beneficial to some, can also result in gentrification, resulting in disparities in benefit distribution, a social justice issue (Collin 2008; McConville 2013). Only ECON-1a is used in the SG Value score, as the other three metrics were quantitatively much smaller in impact, and addressed in other metrics. They are described here for information purposes, and are retained in the SVA tool for applications when a quantitative assessment of GRP impacts is not available.

Figure 6-7. Metric scores for ECON-1 (Economic Vitality), Equal weighting

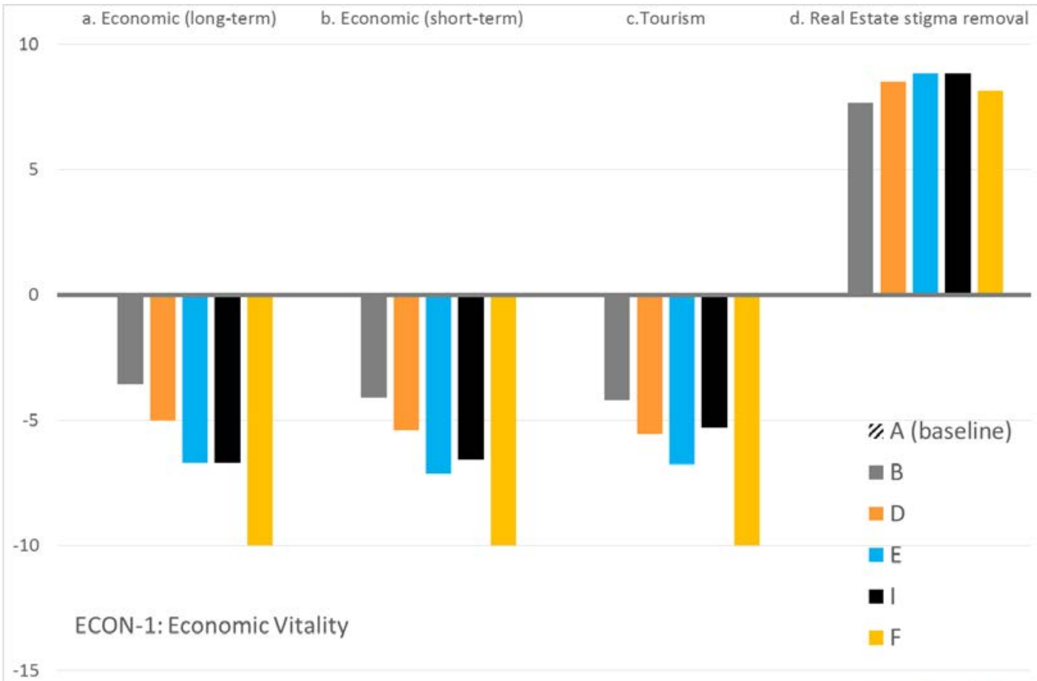


Figure 6-7 and 6-8 Notes: Metrics b–d are not aggregated in final score, as they are quantitatively minor compared to the impact of ECON-1a, and would distort its score. They are plotted here for information purposes.

Figure 6-8. Metric scores for ECON-1 (Economic Vitality), stacked, Equal weighting

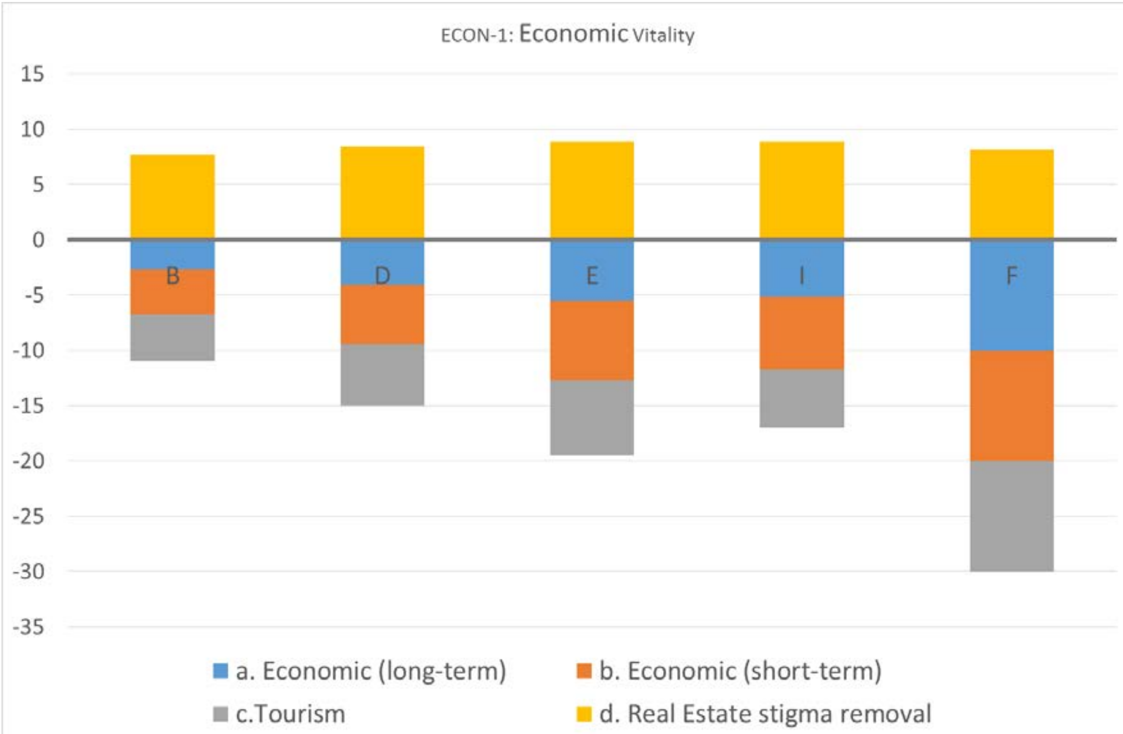


Table 6-7. Approaches for ECON-1 metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis: Minimum Impact	Risk/Benefit Scoring Basis: Maximum Impact	Units	Site-wide Remedial Alternatives: A (baseline)	B	D	E	I	F
Economic Viability				ECON Pillar centroid score				0.0	-0.6	-2.3	-3.7	-3.3	-7.5
ECON-1 Economic Vitality	a1.GRP, mixed; average annual, upper	REMI gross regional product impact	3.00	0.25	-71	0	$M 2015	0	-18	-28	-39	-36	-71
	Score 0 represents baseline (i.e., Alt A); score -10 represents maximum loss; +10 represents maximum gain						Score	0.0	-2.5	-3.9	-5.5	-5.1	-10.0
	a2.GRP, mixed, average annual lower	REMI gross regional product impact	3.00	0.25	-178	0	$M 2015	0	-49	-74	-99	-93	-178
	Score 0 represents baseline (i.e., Alt A); score -10 represents maximum loss; +10 represents maximum gain						Score	0.0	-2.8	-4.2	-5.6	-5.2	-10.0
	a3. GRP, mixed; cumulative upper	REMI gross regional product impact	3.00	0.25	-1,432	0.0	$M 2015	0.0	-381	-575	-821	-747	-1432
	Score 0 represents baseline (i.e., Alt A); score -10 represents maximum loss; +10 represents maximum gain						Score	0.0	-2.7	-4.0	-5.7	-5.2	-10.0
	a4. GRP, mixed; cumulative lower	REMI gross regional product impact	3.00	0.25	-3,030	0.0	$M 2015	0.0	-815	-1233	-1648	-1544	-3030
	Score 0 represents baseline (i.e., Alt A); score -10 represents maximum loss; +10 represents maximum gain						Score	0.0	-2.7	-4.1	-5.4	-5.1	-10.0
	a. Economic (long-term) centroid		3.00	3.00			Score	0.0	-2.7	-4.0	-5.6	-5.2	-10.0
	b. Economic (short-term)	Used fraction Infrastructure shoreline impact, from GIS analysis. This is a dis-benefit	2.50	0.00	0.00	0.54	fraction	0.0	0.2	0.3	0.4	0.4	0.5
	Score 0 represents baseline; score -10 represents maximum GRP loss; 10 would have been maximum GRP gain						Score	0.0	-4.1	-5.4	-7.1	-6.6	-10.0
	c. Tourism	Parks: GIS overlays and analysis Based on active overlap with beach/park areas. Scored to max, inverted- undesirable impact. Fishing not considered as no good metric or evidence of economic impact could be found	2.25	0.00	0	9407	feet	0	3963	5237	6365	4979	9407
	Score 0 represents baseline; score -10 represents maximum treatment						Score	0.0	-4.2	-5.6	-6.8	-5.3	-10.0
	d. Real estate stigma removal	Qualitative; based on expert knowledge; NERA interviews with stakeholders This is a benefit, desirable outcome	2.25	0.00				Qualitative; based on expert knowledge					
	Score 0 is baseline; 10 is maximum GRP increase from stigma removal (these are averaged over scenarios, thus 10 not in final scores)						Score	0.0	7.7	8.5	8.8	8.8	8.2
	ECON-1. Economic Vitality centroid values		*3.00*				*Score*	0.0	-2.7	-4.0	-5.6	-5.2	-10.0

6.5.2 ECON-2: Jobs

6.5.2.1 Employment (local) (ECON-2a):

This metric reflects the combined expenditure and financing impact of the remedial alternatives on jobs in the Portland greater metropolitan region. These scores were based upon the mixed financing scenario from NERA (2016). Upper and lower estimates of average annual and cumulative job losses were scored for each alternative; the metric score was the average of these scores for each alternative. All scenarios in the economic assessment (NERA 2016) showed net job losses for all remediation alternatives, so all have negative scores. Economic gains, had they been identified, would have been given positive scores. For sub-metric, each remedial alternative was scored from -10 (for maximum job loss; Alternative F) to 0 (for baseline, or no job loss; Alternative A). Table 6-8 illustrates the values used to score ECON-2a1-4.

6.5.2.2 Jobs SG Value score

There is only one metric for ECON-2, so the score for this SG Value is the average score for ECON-2a1-4; its relevance score is the relevance score for ECON-2a. Table 6-8 summarizes the approach for ECON-2 scoring; as there is only one score to consider, no graph is provided.

6.5.2.3 Discussion, Jobs

It has been stated in stakeholder materials (e.g., CAG 2015) and by EPA in public meetings (Apitz 2016a, b, c; d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c) that the Portland Harbor remediation will bring jobs to the region (based upon the conclusions of the ECONorthwest [2012] study, one of two previous studies on this issue; the second is Brattle Group [2012], which predicted job losses). However, the work carried out for this project, using the dynamic REMI model and considering the combined impact of both project expenditure and financing, has shown that a net loss of jobs will occur in the region, that this job loss will impact all sectors, and that this potential loss is greater for the more extensive remedies (NERA 2016). As jobs are an important factor for many community groups (e.g., EPA 2015b), this finding is critical in addressing community values as well as economic impacts.

Table 6-8. Approaches for ECON-2 metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis: Minimum Impact	Risk/Benefit Scoring Basis: Maximum Impact	Units	Site-wide Remedial Alternatives: A (baseline)	B	D	E	I	F
ECON-2 Jobs	a1.Jobs, annual average mixed; upper	REMI regional annual job impact	3.00	0.25	-460	0	jobs	0	-110	-170	-250	-230	-460
	Score 0 represents baseline (i.e., Alt A); score -10 represents maximum loss; +10 represents maximum gain						Score	0.0	-2.4	-3.7	-5.4	-5.0	-10.0
	a2.Jobs, annual average, mixed lower	REMI regional annual job impact	3.00	0.25	-1,250	0	jobs	0	-340	-510	-680	-640	-1,250
	Score 0 represents baseline (i.e., Alt A); score -10 represents maximum loss; +10 represents maximum gain						Score	0.0	-2.7	-4.1	-5.4	-5.1	-10.0
	a3. Jobs, cumulative upper	REMI regional cumulative job impact	3.00	0.25	-14,150	0.0	job years	0.0	-3430	-5290	-7800	-7020	-14150
	Score 0 represents baseline (i.e., Alt A); score -10 represents maximum loss; +10 represents maximum gain						Score	0.0	-2.4	-3.7	-5.5	-5.0	-10.0
	a4. Jobs, cumulative upper	REMI regional cumulative job impact	3.00	0.25	-38,860	0.0	job years	0.0	-10430	-15780	-21180	-19810	-38860
	Score 0 represents baseline (i.e., Alt A); score -10 represents maximum loss; +10 represents maximum gain						Score	0.0	-2.7	-4.1	-5.5	-5.1	-10.0
	ECON-2. Jobs centroid		3.00				Score	0.0	-2.6	-3.9	-5.5	-5.0	-10.0

6.5.3 ECON-3: Infrastructure

Impacts on infrastructure are evaluated considering the potential impacts of remedial alternatives on a range of infrastructure types, mostly based on GIS overlay analysis. For Portland Harbor, Infrastructure was quantified using five metrics:

6.5.3.1 Road traffic (ECON-3a):

Although final disposal sites and transloading and transportation plans have not been finalized, road traffic impacts should be proportional to volume of sediment handled, so this is used as an indicator of this metric. As disposal sites may be some distance from Portland, a proportion of this road traffic impact is regional, not local to Portland. Furthermore, a proportion of this traffic will be via barges and/or trains. Volumes removed are based on the 2016 FS (EPA 2016a). This is an undesirable impact, so it is scored negatively, from a score of 0 (for no net impact of traffic; Alternative A) to -10 (for maximum impact; Alternative F).

6.5.3.2 Construction time (ECON-3b):

A number of metrics of infrastructure impact are listed in this SG Value; this metric is meant to capture those land-based impacts not listed. It is assumed that impacts are proportional to construction time. The data used to score this metric are not based on EPA (2016); they are based on adjusted construction times based on extensive experience in the Pacific Northwest (AECOM 2016a). This is an undesirable impact, so it is scored negatively, from a score of 0 (for no net impact of traffic; Alternative A) to -10 (for maximum impact; Alternative F).

6.5.3.3 Utilities (ECON-3c):

Sediment remediation can result in utility disruption if the footprint overlaps with underwater cables or pipes. This metric was scored based upon a quick overlay assessment, based upon encroachment into cable overlay regions. These scores are qualitative; the resolution and scale of the available data made quantitative assessment difficult. This is an undesirable impact, so it is scored negatively, from a score of 0 (for no net impact of utilities; Alternative A) to -10 (for maximum impact; Alternatives D, E and F).

6.5.3.4 River infrastructure (ECON-3d):

This metric reflects remedy impact on in-water infrastructure (other than berthing areas, which are scored in ECON-3g). GIS was used to analyze construction-related land use disturbances. Aerial photographs and GIS layers from the City of Portland and the 2012 Draft FS (AnchorQEA 2012) were compared to evaluate disturbances to shoreline infrastructure during construction. The active remedial footprint overlap with the upland shoreline perimeter of specialized infrastructure areas was used to quantify disturbances to infrastructure access along the river. Specialized infrastructure areas were those designated as primary or secondary infrastructure by the City of Portland. Details can be found in the environmental report (AECOM 2016). This is an undesirable impact, so all impacts are scored negatively. Alternatives are scored from 0 (no impact, or baseline; Alternative A) to -10 (maximum impact; all shoreline infrastructure).

6.5.3.5 Navigational channel (ECON-3e):

This metric reflects impacts of active in-place management (i.e., capping and ENR) on the navigation channel. It is based upon a GIS examination of the navigation channel and the active remedial footprint (EPA 2016a). This metric was not used (i.e., set to 0 for all alternatives), as there was no evidence of such an overlap. It appears there is no capping or ENR technology assigned in the authorized navigation channel.

6.5.3.6 Infrastructure SG Value score

The Infrastructure SG Value score is the centroid; the relevance-weighted average of metric scores ECON-3a, ECON-3b, ECON-3c, ECON-3d, and ECON-3e, though the latter was set to zero. Table 6-9 summarizes the approach for ECON-3 scoring. Figure 6-9 shows the Infrastructure metric scores for each remedial alternative (with equal weighting).

6.5.3.7 Discussion, Infrastructure

All metrics for this SG Value (ECON-3b, ECON-3c, ECON-3d, and ECON-3e) have negative impacts, with most increasing with alternative volume and/or footprint.

Figure 6-9. Metric scores for ECON-3 (Infrastructure), Equal weighting

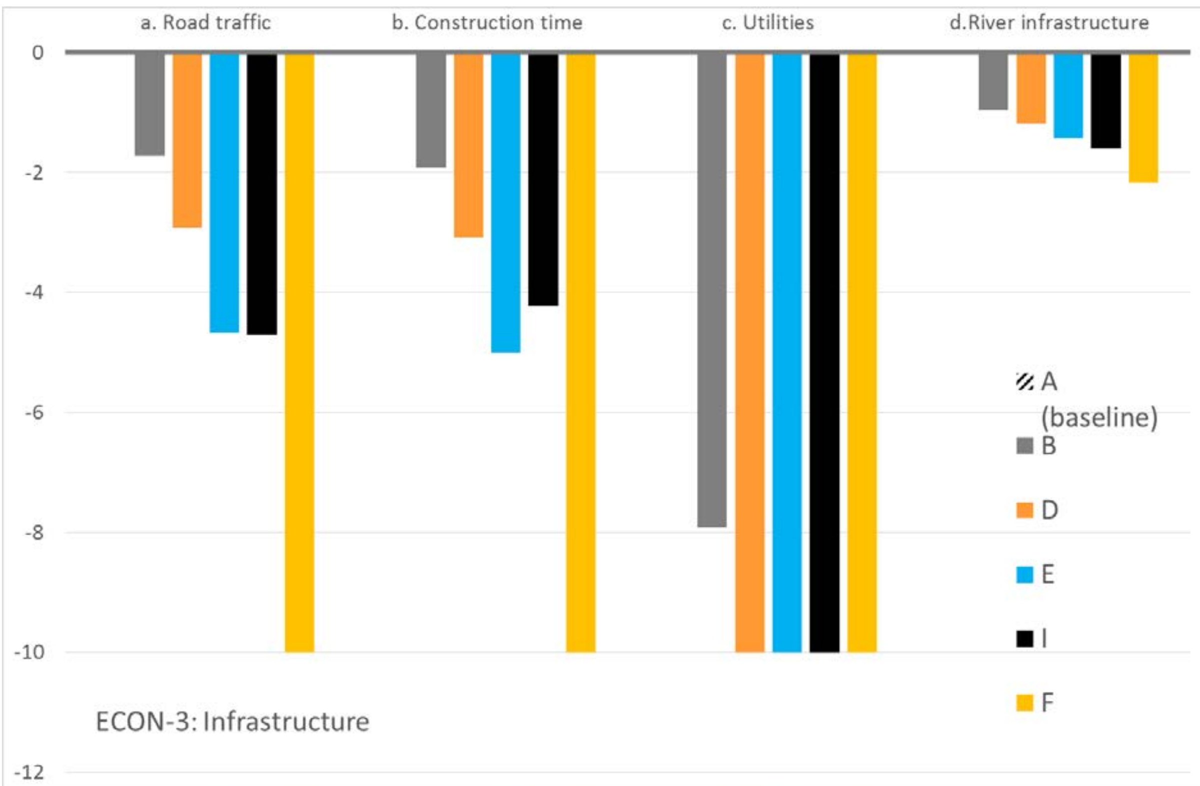


Table 6-9. Scores, weights, and approaches for ECON-3 metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis: Minimum Impact	Risk/Benefit Scoring Basis: Maximum Impact	Units	Site-wide Remedial Alternatives: A (baseline)	B	D	E	I	F
ECON-3 Infrastruc-ture	a. Road traffic	Proportional to total volume handled - assume larger remedies will require greater local equipment inputs and regional disposal. regional, not Willamette	2.50	3.00	0	11	total volume handled (Mcy)	0.00	1.84	3.12	4.99	5.01	10.65
	Score 0 is baseline; -10 is maximum road disruption						Score	0.0	-1.7	-2.9	-4.7	-4.7	-10.0
	b. Construction impacts	Adjusted construction times, with the assumption that quicker is more desirable (>70% of those surveyed support a remedy which is <8 years; but this preference is more reflected in the social scoring of this) - inverted, as this is an indicator of infrastructure impact	2.75	3.00	0	26	years (alt)	0	5	8	13	11	26
	Score 0 is baseline; score of -10 is maximum construction time						Score	0.0	-1.9	-3.1	-5.0	-4.2	-10.0
	c. Utilities	Based on quick GIS overlay assessment by AECOM; based upon encroachment into cable overlay regions. Rough estimate. City utilities.	1.75	3.00	0	438000	SF	0	347000	438000	438000	438000	438000
	Score of 0 is baseline; -10 is maximum potential cable crossing encroachment						Score	0.0	-7.9	-10.0	-10.0	-10.0	-10.0
	d. River infrastructure	Fraction overwater structures impacted is the surrogate; used SF overwater structure impacted by active remediation; scored so 100% impact would be a score of -10 (rather than giving max possible impact max score). This covers berthing areas as well. This is a dis-benefit	2.50	3.00	0.00	100	%	0.00	9.65	11.84	14.37	16.05	21.66
	Score of 0 is baseline; score of -10 would be 100% disturbance. So, max impact is not -10						Score	0.0	-1.0	-1.2	-1.4	-1.6	-2.2
	e. Navigational channel	Based on GIS layer of navigational channel	2.50	3.00	0	0		0	0	0	0	0	0
	Score of 0 is baseline; score of -10 would be 100% disturbance. So, max impact is not -10						Score	0.0	0.0	0.0	0.0	0.0	0.0
	ECON-3. Infrastructure Centroid		*3.00*					0.0	-2.1	-3.8	-4.9	-4.7	-7.9

6.5.4 ECON-4: Cost-Effectiveness

For Portland Harbor, Cost-Effectiveness was quantified using five metrics:

6.5.4.1 Capital cost (ECON-4a):

Capital cost is scored based upon the remedial alternative capital costs calculated in in the environmental report (AECOM 2016); details of the cost estimates can be found there. Costs are an undesirable impact and thus are given negative scores. Alternatives are scored from 0 (baseline, Alternative A) to -10 for the most costly alternative (Alternative F).

6.5.4.2 Long-term cost (ECON-4b):

Long-term costs are driven by the need for long-term maintenance and monitoring. Thus, the indicator for this metric is the number of acres that require institutional controls (capping and ENR); confined disposal facility volume is not included in the estimates. Landfill maintenance is included in tipping fees. This is scored based on the sum of acres of sediment requiring capping and ENR but not dredging/capping or *in situ* treatment, from the FS (EPA 2016a). Costs for maintenance are an undesirable impact and thus are scored negatively. Alternatives are scored from 0 (baseline, Alternative A) to -10 for the most costly alternative (Alternative F).

6.5.4.3 Cost-effectiveness, T=0 (ECON-4c):

Cost-effectiveness at the time of construction completion is based upon the percent PCB, PAH, DDx, TCDD, PeCDD and PeCDF SWAC, based upon the FS (EPA 2016a); and the AECOM 0% discount costs in billions of dollars ($B). Table 6-10 provides the supporting data and calculations for the metric scores. Cost-effectiveness is a desirable outcome (benefit), so all alternatives are given positive scores. Alternatives are scored from 0 for the lowest SWAC reduction per $B (Alternative F) to a score of +10 for the highest SWAC reduction per $B (Alternative B, as Alternative A could not be scored). Although the more extensive alternatives reduce SWAC to a somewhat greater extent, this reduction is not proportional to increased costs.

6.5.4.4 Cost-effectiveness, T=45 (ECON-4d):

This metric of long-term cost-effectiveness reflects the reduction of contaminant levels at year 45, per cost. The 2015 FS (EPA 2015a) did not address this point (there are concerns over the river models), but the issue of long-term contaminant levels was repeatedly brought up by community members in public meetings, so data from the 2012 Draft FS (AnchorQEA 2012) were used to address this issue. Fewer data were available; this estimate is based on the modeled PCB levels for equivalent alternatives, using the same costs as for ECON-4c (AECOM 2016). Cost-effectiveness is a desirable outcome (benefit), so all alternatives are scored positively. Alternatives are scored from 0 for the lowest SWAC reduction per $B (Alternative F) to a score of +10 for the highest SWAC reduction per $B (Alternative B, as Alternative A could not be scored). Although the more extensive alternatives reduce SWAC to a somewhat greater extent, this reduction is not proportional to increased costs.

6.5.4.5 Net Environmental Benefit (ECON-4e):

This metric is the number generated by the CERCLA-linked NEBA (AECOM 2016) for each alternative. This represents the net CERCLA-linked benefit score, divided by alternative cost. The net benefit points per $B from the NEBA were used (AECOM 2016). As an indicator of cost-effectiveness, this is a desirable outcome (benefit), so all alternatives are scored positively. Alternatives are scored from 0 for the lowest SWAC reduction per $B (Alternative F) to a score of +10 for the highest SWAC reduction per $B (Alternative B, as Alternative A could not be scored).

6.5.4.6 Cost-Effectiveness SG Value score

The Cost-Effectiveness SG Value score is the centroid; the relevance-weighted average of metric scores ECON-4a, ECON-4b, ECON-4c, ECON-4d, and ECON-4e, with the exception of Alternative A, which is scored using only the first two metrics, as an estimate of cost-normalized benefits is not possible when there are no costs. Table 6-10 summarizes the approach for ECON-4 scoring. Figure 6-10 shows the Cost-Effectiveness metric scores for each remedial alternative; Figure 6-11 illustrates the same results, but plots the aggregated metric scores for each alternative. In this manner, it is clear how different metrics aggregate to form the net SG Value scores (with equal weighting).

6.5.4.7 Discussion: Cost-Effectiveness

Cost-Effectiveness is an indication of the “bang for the buck” of a given remedial alternative. A major focus of NEBA, a determination of the relative benefit gained for a given investment is an important indicator in remedy selection. However, a number of components of cost and ways of measuring effectiveness exist, so there are a range of metrics for this SG Value. This SG Value is reflected in five metrics, two that address relative costs (ECON-4a and ECON-4b) and three that address different aspects of cost-effectiveness (ECON-4c, ECON-4d, and ECON-4e). ECON-4b, which reflects long-term cost from monitoring and maintenance, is the only metric that does not increase among the more extensive alternatives. For the less extensive alternatives, monitoring costs over time, may become significant, and should be borne in mind for a cost-relevant score. As these costs may be borne in a different timeframe than are capital costs, the distribution of such costs as a function of time may cause some temporal distributional disparities. The cost-effectiveness metrics (ECON-4c, ECON-4d, and ECON-4e) examine three aspects of cost-effectiveness, but all show that the more extensive and expensive alternatives, as they do not provide significant improvements in risk reduction or net environmental benefit, are less cost-effective than the less extensive alternatives, with the cost-effectiveness of Alternative B being greater than the other alternatives using all three metrics. It is, however, important to note that the metric scores in these figures are unweighted; when they are aggregated for SG Value and pillar scores, they will be weighted based on their relevance scores (Section 7) and, in Section 8, by SG priorities. Both these weighting approaches will alter the relative importance of individual metrics in overall SG Value weights.

Figure 6-10. Metric scores for ECON-4 (Cost-Effectiveness), Equal weighting.

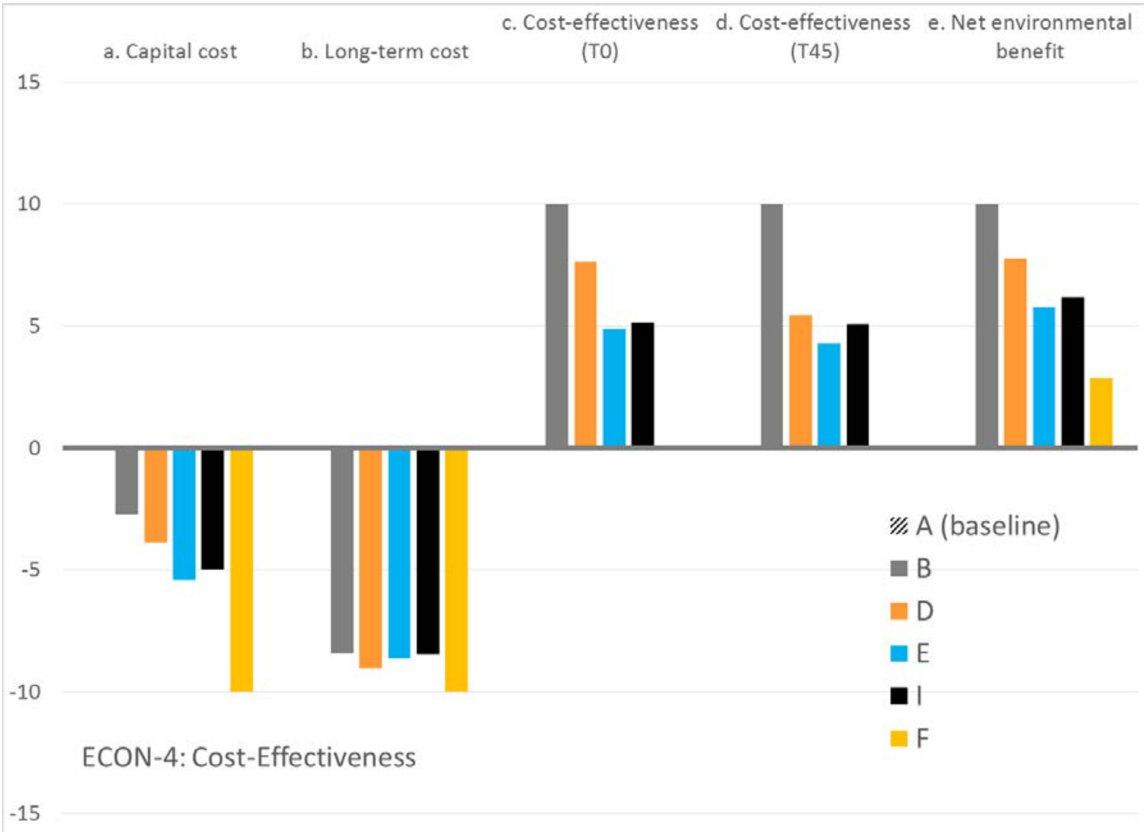


Figure 6-10 and 6-11 note: Alternative F scores 0 for some metrics.

Figure 6-11. Stacked Cost-Effectiveness metric scores for each remedial alternative, Equal weighting

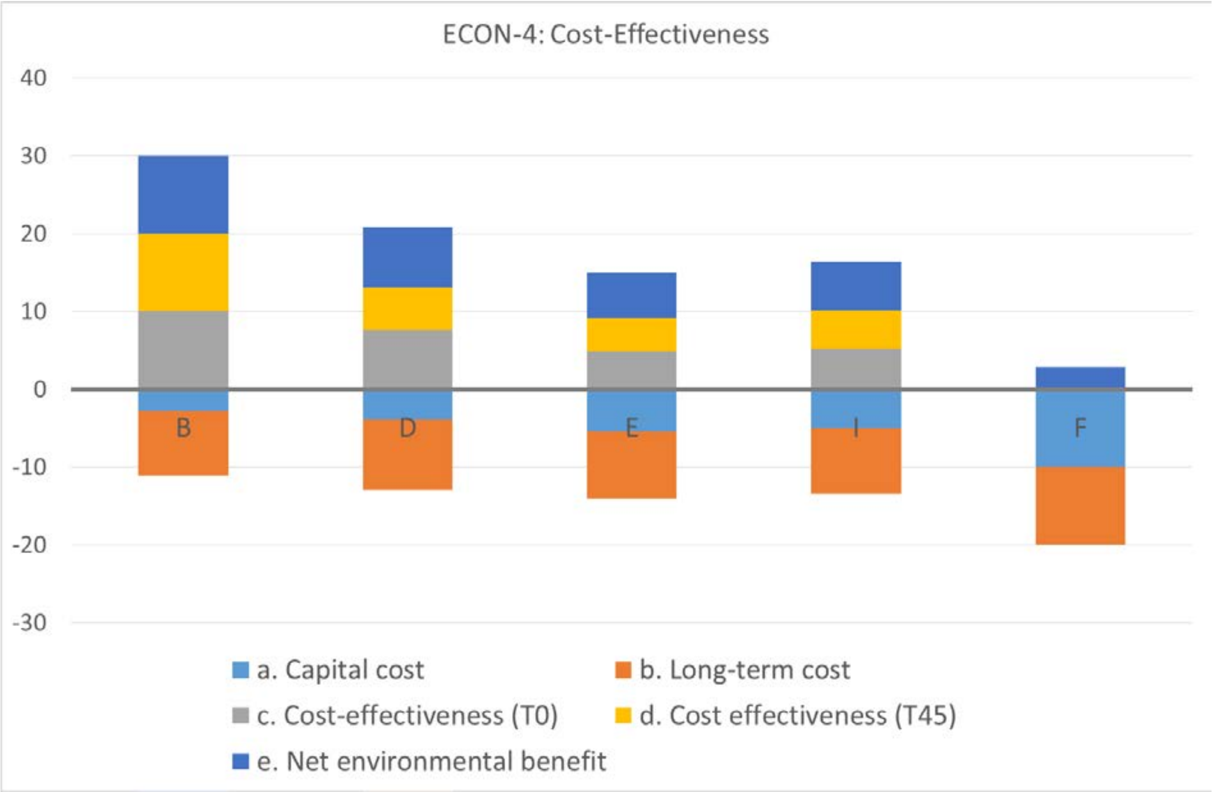


Table 6-10. Scores, weights, and approaches for ECON-4 metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis: Minimum Impact	Risk/Benefit Scoring Basis: Maximum Impact	Units	Site-wide Remedial Alternatives: A (baseline)	B	D	E	I	F
ECON-4 Cost-Effective-ness	a. Capital cost	Scored based on total capital costs, adjusted	3.00	0.20	0	1448	$M	0	394	562	783	720	1448
	Score of 0 is baseline; -10 is maximum cost						Score	0.0	-2.7	-3.9	-5.4	-5.0	-10.0
	b. Long-term cost	Need for long-term maintenance and monitoring. Based on number of acres that require institutional controls - sum of acres of Capping and ENR - CDF not included in estimates. Landfill maintenance included in tipping fees. Scored based on sum of capping and ENR but not dredging/capping or in situ treatment. This is an undesirable impact	2.75	3.00	0.000	146.000	acres	0	123	132	126	124	146
	Score of 0 is baseline; -10 is maximum volume requiring monitoring and maintenance						Score	0.0	-8.4	-9.0	-8.6	-8.5	-10.0
	c. Cost-effectiveness (% SWAC reduction per $ T0)	% reduction in SWAC (T0) divided by $M adjusted cost; this is a desirable impact	2.25	3.00	0.026	0.053	% red'n in SWAC per $M	NA	0.053	0.047	0.039	0.040	0.026
	Scored 0 (no benefit); scaled other options max-min with 10 being highest reduction per SWAC percent; 0 being lowest; Note: option A has no score; not included a aggregated cost score for option A						Score	0.0	10.0	7.6	4.9	5.1	0.0
	d. Cost-effectiveness (% SWAC reduction per $ T45)	% reduction in SWAC (T45) per cost. Note: based upon 2012 draft FS; This is a desirable outcome	2.25	3.00	0.00020	0.00049	% red'n in SWAC per $M	n/a	0.00049	0.00036	0.00033	0.00035	0.00020
	Score of 0 would be the risk reduction with no cost; score of -10 is the most costly option; Note: option A has no score; not included a aggregated cost score for option A						Score	0.0	10.0	5.4	4.3	5.1	0.0
	e. Net environmental cost- benefit	Benefit points per billion $ in NEBA; as no cost for A did not score A. This is a desirable outcome	2.75	3.00	0.000	5.328	benefit points per $B in NEBA	n/a	5.33	4.13	3.07	3.28	1.52
	Score of 0 is no benefits; score of 10 is max ratio. Note: option A has no score; not included a aggregated cost score for option A						Score	0.0	10.0	7.8	5.8	6.2	2.8
	ECON-4. Cost-effectiveness centroid score (missing entity not in calcs)		*3.00*					0.0	4.8	2.5	1.1	1.5	-2.1

6.6 Social Equity SG Value and metric approaches and scores

Although, in this social sustainability assessment, SG Values relevant to all three pillars are assessed, integrating more traditional environmental and economic assessments into a different, SG Value-focused approach, the Social Equity pillar has some SG Values and metrics not usually addressed in these frameworks, as well as some that are considered in emerging sustainability decision frameworks (Section 2.2.1). Although the integration of social equity and stakeholder and community impacts and values into sediment sustainability assessments is an important emerging issue (see Appendix A), the challenge of identifying clear, objective, and quantifiable metrics remains. In this framework, social metrics are linked to the SG Values of Quality of Life & Recreation, Community Values, Acceptable Remedy and Health & Safety; metrics and their indicators were selected to be as quantifiable, transparent, objective, and relevant as was possible for this less standard assessment pillar. Where such metrics were not available, the basis of professional judgments is laid out, and relevance scores are adapted to reflect these challenges.

6.6.1 SOC-1: Quality of Life & Recreation

Impacts on the SG Value Quality of Life & Recreation reflect impacts on the quality of life of Portland neighborhoods, visitors, tourists, and workers. For Portland Harbor, Quality of Life & Recreation were quantified using four metrics:

6.6.1.1 Quality of Life (SOC-1a):

Quality of life impacts are those impacts to the local community that result from remedial actions, including dust, light, noise, odor, and vibrations during work and associated with traffic, including both daytime and nighttime or weekend operations. The magnitude of such effects will vary in space and time, especially for such a large site (or set of sites). These impacts can be difficult to quantify, especially in a predictive assessment, but they should be proportional to both the volume of sediment being managed, and the timespan of a remedial action, so these are used as indicators of this metric. Sediment volumes for each alternative are taken from the FS (EPA 2016a) and remediation times are based on the AECOM adjusted times (AECOM 2016). Each indicator is scored, and the metric score is the average of these two scores. These are undesirable impacts (risks), so are scored negatively. Volume and time are scored from 0 (for baseline, Alternative A) to -10 (for the longest-running and largest alternative, Alternative F), so the metric, which is the average of the two, falls on the same scale.

6.6.1.2 Recreation: water quality (SOC-1b):

This metric reflects the impacts that water quality (i.e., turbidity, contamination, and odor) changes due to remedial actions will have on in-water recreation. Although EPA has determined that there is no human health risk concern from in-water recreation (EPA 2015, 2016a), real or perceived water quality issues may still deter some stakeholders from in-water recreation. Construction time (AECOM 2016) was used as an indicator for this metric. It is assumed that this impact will abate when construction is complete. This is an undesirable impact (risk), so is scored negatively. This metric is scored from 0 (for baseline, Alternative A) to -10 (for the longest-running alternative, Alternative F).

6.6.1.3 Other water recreation (SOC-1c):

This metric reflects impacts the remedial alternatives may have on other recreational uses of the river or riverfront. It is scored based upon the linear foot overlap of the active remediation on beach/park areas, based on the GIS overlay analysis (AECOM 2016). This is an undesirable impact (risk), so is scored negatively. This metric is scored from 0 (for baseline, Alternative A) to -10 (for the largest overlap; Alternative F).

6.6.1.4 Access to river (SOC-1d):

This metric reflects any impacts that remedial activities might have on river access for recreation, social, cultural, spiritual, or educational purposes. Although most discussions on access focus on recreational activities based on beach and park areas (see SOC-1c, above), there are a number of reasons why various SGs or community members may want to access the river. This metric does not address the relative safety, legality, or other issues which might be relevant to access to some parts of the river, but treats all river access equally. This metric was scored based upon GIS overlap analysis, the overlap between remedial footprint and the shoreline (AECOM 2016). This is an undesirable impact (risk), so is scored negatively. This metric is scored from 0 (for baseline, Alternative A) to -10 (for the largest overlap; Alternative F).

6.6.1.5 Quality of Life & Recreation SG Value score

The Quality of Life & Recreation SG Value score is the centroid; the relevance-weighted average of metric scores SOC-1a, SOC-1b, SOC-1c, and SOC-1d. Table 6-11 summarizes the approach for SOC-1 scoring. Figure 6-12 shows the Quality of Life & Recreation metric scores for each remedial alternative.

6.6.1.6 Discussion: Quality of Life & Recreation

All metrics for this SG Value have negative impacts; the negative impacts increase as alternatives have larger footprints, volumes, and construction times. The relative increase in impacts as a function of alternative depends, for two of the metrics, on spatially specific overlaps on key areas. All these impacts should be short-term, and should abate when construction is complete. Improvements to this value which might stem from a cleaner river are reflected in SOC-2b (Amenability to re-use), as well as in ENV-1 (Fish & Wildlife) and SOC-4 (Health & Safety).

Figure 6-12. Metric scores for SOC-1 (Quality of Life & Recreation), Equal weighting

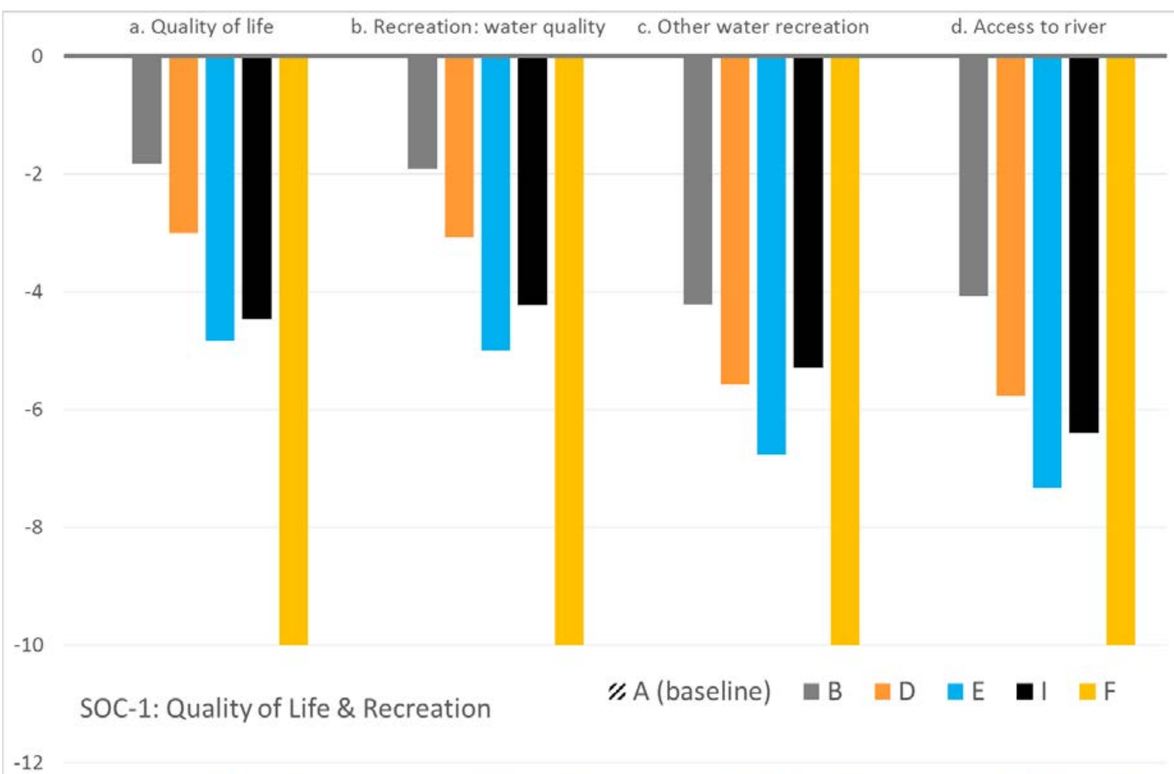


Table 6-11. Scores, weights, and approaches for SOC-1 and SOC-2 metrics and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis: Minimum Impact	Risk/Benefit Scoring Basis: Maximum Impact	Units	Site-wide Remedial Alternatives: A (baseline)	B	D	E	I	F
Social Equity			SOC Pillar centroid score					0.9	0.4	-0.2	-1.1	-0.7	-3.5
SOC-1 Quality of Life & Recreation	a. Quality of life	Impact on quality of life is proportional to volume and time. Average score for volume and time; adjusted values. This impact is a dis-benefit			0.0	10.7	Mcy	0.0	1.8	3.1	5.0	5.0	10.7
			Total volume handled				Score	0.0	-1.7	-2.9	-4.7	-4.7	-10.0
					0.0	26.0	years (adj)	0.0	5.0	8.0	13.0	11.0	26.0
			AECOM adjusted years construction				Score	0.0	-1.9	-3.1	-5.0	-4.2	-10.0
	Quality of life score. Score 0 is baseline; score of -10 is maximum impact on quality of life		*2.50*	*3.00*			*Score*	0.00	-1.82	-3.00	-4.84	-4.47	-10.00
	b. Recreation: water quality	Proportional to construction time; impacts should abate when construction is complete. This impact is a dis-benefit	2.50	3.00	0.0	26.0	years	0.0	5.0	8.0	13.0	11.0	26.0
	Score of 0 is baseline; score of -10 is maximum impacts						Score	0.0	-1.9	-3.1	-5.0	-4.2	-10.0
	c. Other water recreation	GIS analysis of active overlap with beach/park areas	2.25	3.00	0	9407	LF	0	3963	5237	6365	4979	9407
	Score 0 is baseline; -10 is maximum overlap						Score	0.0	-4.2	-5.6	-6.8	-5.3	-10.0
	d. Access to river	Total active shoreline	2.25	3.00	0	67311	LF	0	27430	38881	49364	43050	67311
	Score o is baseline and no action; -10 is maximum active shoreline						Score	0.0	-4.1	-5.8	-7.3	-6.4	-10.0
	SOC-1 Quality of Life & Recreation centroid score		*3.00*					0.0	-2.9	-4.3	-5.9	-5.1	-10.0
SOC-2 Commu-nity Values	a. Stakeholder involvement	Judgement based upon observation of process of agency public outreach in the last 12 months. Not sensitive to specific remedies	2.00	3.00				EPA is doing the same outreach for all alternatives- consult, mostly, but with some minor involvement - scoring all as 5 (mid-way between consult and involve scores)					
	Scoring is: Inform (2), consult (4), involve (6), collaborate (8), empower (10)						Score	5.0	5.0	5.0	5.0	5.0	5.0
	b1.Economic re-use	Qualitative score based upon stigma removal benefit. This is a benefit (desirable outcome)	2.25	0.33	0	0	%	Qual; based on expert knowledge					
	Score 0 represents predicted exposure without construction (i.e., Alt A: 0% reduction in SWACs for the focused COCs); score 10 represents exposure at time 0 following construction of Alt F (76% reduction in SWACs for the focused COCs).						Score	0.0	7.7	8.5	8.8	8.8	8.2
	b2. Recreation re-use	SWAC reduction and nearshore, high value habitat impacts (fishing and clamming values), averaged			0.0	39	%	0.0	15	20	26	24	39
			% Remedial overlap with habitat (25%)				Score	0.0	-3.8	-5.1	-6.7	-6.2	-10.0
					0.0	76	%	0.0	56	63	69	65	76
			% Reduction in SWAC, T=0 (75%)				Score	0.0	7.3	8.3	9.0	8.6	10.0
	Score 0 represents baseline; score of +10 indicates maximum benefit		2.25				Score	0.0	4.5	4.9	5.1	4.9	5.0
	b3Tribal re-use	Based upon Tribal cmts in documents and public meetings on concerns over permanence, etc. Scored based up extent of removal, relative to complete removal; which is a stated objective of some Tribes	2.25	0.33	0	2167		0	67	121	188	150	355
	Score 0 represents predicted HI without construction (i.e., Alt A: 0% reduction in HI for the focused COCs); score of 10 represents minimum exposure at time 0 following construction						Score	-10.0	-9.4	-8.9	-8.3	-8.6	-6.7
	b4. In-water re-use	Based on active footprint NOToverlapping with nearshore valuable habitat assuming that in place management may limit some river use	2.25	0.33	0.0	14868170		0	5574823	7354765	8786893	7754944	14868170
	Score 0 represents predicted HI without construction (i.e., Alt A: 0% reduction in HI for the focused COCs); score 10 represents minimum exposure at time 0 following construction							0.00	-3.75	-4.95	-5.91	-5.22	-10.00
	b. Re-use centroid value		2.25	3.00			Score	-2.5	-0.2	0.0	0.0	0.0	-0.8
	c. Communication of uncertainty	Judgement based upon observation of process. Not sensitive to specific remedies	1.00	3.00				This is an insensitive measure. Uncertainty is poorly communicated in public outreach, slightly addressed in documentation. Score of -4 across alternatives					
	Professional judgement:score of 10 would be detailed, transparent discussion of uncertainty of all aspects of project; -10 would be no acknowledgement of uncertainty						Score	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0
	d. Archaeological sites	Based on number and extent of impact on archeological and culturally sensitive sites in internal review of available maps.	2.25	3.00	0	10		Some evidence of potential impact based on review by archeologist; specific sites are confidential; insensitive endpoint and difficult to quantify. Scored the same for all alternatives.					
	Score 0 is no impact; -10 is extensive impact						Score	0.0	-2.0	-2.0	-2.0	-2.0	-2.0
	SOC-2 Community Values centroid score		*3.00*					0.1	0.1	0.2	0.2	0.2	0.0

6.6.2 SOC-2: Community Values

For this section, impacts on Community Values were quantified using four metrics:

6.6.2.1 Stakeholder involvement (SOC-2a):

This metric addressed the extent to which stakeholders are involved in the decision process. As the overall Superfund process, in terms of public involvement and outreach, is the same for all alternatives under consideration, this metric is not a sensitive one (i.e., the score will be the same for all alternatives), but it is an important indicator of community involvement. There are various ways in which stakeholders can be involved in a decision-making process. Cundy et al. (2013) have classified these approaches as follows:

- Inform
    - Provide balanced and objective information to assist public understanding
- Consult
    - Obtain public feedback on analysis, alternatives, and/or decisions
- Involve
    - Interact throughout the process to ensure public concerns and aspirations are understood and considered
- Collaborate
    - Partner directly in each aspect of decision, including alternative development and selection
- Empower
    - Place final decision-making power with public

To score this metric, stakeholder engagement by EPA was reviewed, with a view to scoring based upon where along the Cundy et al. (2013) hierarchy this process fell. Scores were assigned as the following: no outreach or involvement (0); Inform (2); Consult (4); Involve (6); Collaborate (8); and Empower (10). Based upon professional judgment, the level of stakeholder involvement at this site (and, most likely, in any Superfund process, given the format of decision-making, unless the community is more involved in remedial design early on) is somewhere between consult and involve, so all alternatives are scored as 5 (between consult and involve) for this metric.

6.6.2.2 Amenability to re-use (SOC-2b):

There is a range of potential re-uses of the river, its habitat, and shoreline after remediation, and different SGs have very different visions for re-use, depending on their focus, location, background, and priorities. To address this, an aggregate score, considering how remedial alternatives affected re-development (based on stigma reduction), recreation and fishing, in-water re-use, and Tribal objectives was generated. Re-uses on shore, such as hiking and biking access, nature park development, etc., although very important to many SGs, were not scored, as they are not addressed in the remedial alternatives in EPA (2016a). Access was not scored, as it is a short-term impact that should not affect eventual re-use. Table 6-11 shows the basis of the re-use score, and the aggregation for an overall re-use score for each alternative. As can be seen, this metric aggregates scores that are both desirable and undesirable; the aggregate scores can be positive or negative. For this reason, this is also one of the metrics for which Alternative A is non-zero. The overall Amenability to re-use score is the MRW-weighted average of the sub-metric scores.

6.6.2.3 Economic re-use (SOC-2b1):

The first sub-metric evaluates economic re-use as a function of redevelopment potential after cleanup. This is scored based on the same approach as in ECON-1d. These scores are based upon illustrative qualitative impacts of potential increases in property value (and development) due to a reduction of Superfund stigma due to cleanup from NERA (2016). These scores are based upon professional judgment based on stakeholder surveys and interviews, as well as some qualitative estimates. It is assumed that the benefits will not be accrued until after the cleanup is complete. Thus, due to economic discounting, the relative economic benefit is greater for remedies that are completed sooner. This is a desirable impact (a benefit) so it is scored positively. For each of these re-use types, each remedial alternative was scored from +10 (for maximum economic gain) to 0 (for baseline, or no economic gain; Alternative A); these economic gains are assumed to be proportional to improvements in economic re-use potential. Discounting results in no alternative having a score of 10.

6.6.2.4 Recreational re-use (SOC-2b2):

The recreational re-use sub-metric metric focused on fishing. There are two intermediate metrics scored, and the score for this sub-metric is the average score of the two. The first intermediate metric is the percent active footprint overlap with high-value habitat, which is scored as in ENV-2a. The second sub-metric is based upon an alternative's percent reduction in SWAC, which is scored as described in ENV-1a1. It should be noted, however, that, due to background and residual contaminant levels, fish advisories will remain in place for an indefinite time after remediation is complete. Thus, fish consumption will still be limited. Access is not scored as it will be a short-term impact.

6.6.2.5 Tribal re-use (SOC-2b3):

This sub-metric is based upon Tribal comments in documents and public meetings on concerns over the permanence of treatment options. Tribal representatives have stated that complete removal of contaminated sediments is what will protect their treaty fishing rights. This sub-metric is scored based upon extent of removal, relative to complete removal; which is a stated objective of some Tribes. Thus, this is scored based upon the acres of contaminated sediment completely removed—those that are dredged. This is scored as -10 for no removal (Alternative A) and +10 for complete dredging of the 2,167 acres. On this scale, even the EPA (2016a) option of H scores only 4.1, as it has 1,526 acres of removal. This score thus reflects the strong Tribal preference for removal, which is not fully met by any alternatives under consideration. Although it can be argued that this sub-metric gives one category of stakeholders a disproportionate voice, this is justified (particularly in the Pacific Northwest) by the large role Tribal groups play in the region. Because of their historical sovereignty in the region, regional Tribes retain treaty rights in conditionally ceded and usual and accustomed lands (with historical use). Responsibility for protecting the natural resources is shared among federal and state agencies and Tribes who own, manage, or have an interest in the resources and who are named as Trustees of the resources on behalf of the public; many Tribes play a role on the Natural Resource Trustee Board. Tribal members have been active in having Portland Harbor listed as a Superfund site and continue to play an active role in the outreach, commenting, and decision process (e.g., CAG 2015; Fricano et al. 2015; ODEQ 2015; Ward 2015). Yakama Nation has been particularly active at public meetings, and other stakeholders and community members frequently comment on or inquire regarding Tribal viewpoints (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c). This metric is based upon a review of the public comments, written and verbal, listed above. Most public comments from the Tribes about the Portland Harbor remediation state that none of the proposed remedies are extensive enough, and that they would like to see “G+”, an even more extensive removal action. However, they favor the most extensive actions under consideration more favorably than the less extensive actions. Alternatives have both positive and negative scores for this metric, and it is one of the few metrics for which Alternative A has a non-0 score.

6.6.2.6 In-water re-use (SOC-2b4):

This sub-metric reflects impacts on potential re-use in water. The indicator is the difference between the active footprint (acres) and the acres of nearshore high-value habitat, based on the GIS overlay results (AECOM 2016). This assumes the potential for some infrastructure development in areas that are not high-value habitat, but in-place management may interfere with that re-use. Ideally, this metric would consider not the full active footprint, but the active footprint that is not dredging. However, this was not evaluated in the GIS overlay analysis, so it is assumed that the total active footprint is reasonably representative as an indicator. This is scored as -10 for the largest potential impact (Alternative F) to 0 for no impact (Alternative A).

6.6.2.7 Communication of uncertainty (SOC-2c):

The remedial Alternatives evaluated are those developed and communicated by EPA (2016a); thus, information about remedial options is communicated primarily by EPA in their documents, web site and public outreach. This metric addresses how well (or not) uncertainty about various aspects of the Portland Harbor remedial alternatives is communicated by a range of stakeholders, but, in particular, by EPA. As no clear, quantifiable indicator could be established for this metric, it is more subjective than most, but it is an important component of effective stakeholder outreach. Based upon attending or reviewing notes from a large number of community and stakeholder outreach meetings regarding the 2015 EPA FS (EPA 2015a); as well as reviewing web pages and associated documents, this metric was given a professional judgment score of -4, for all alternatives (as the communication is the same across the board in this process). In many public meetings (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c) EPA, CAG, and other stakeholder representatives have made strong statements about various aspects of the draft FS without clearly communicating the background and uncertainty surrounding those statements. This score is somewhat offset by the fact that the supporting documents (including the draft FS) are publicly available online, but a number of stakeholders (CAG 2015; Fricano et al. 2015; ODEQ 2015; Ward 2015) as well as the National Remedy Review Board itself (Legare and Ells 2015) have raised concerns about how uncertainty was addressed in various aspects of the draft FS (EPA 2015a).

6.6.2.8 Archaeological sites (SOC-2d):

This metric addresses potential impacts on cultural landmarks or archaeological sites by the alternative remedial footprints. This metric was evaluated by visually reviewing a publicly available map of significant cultural and archaeological resources (Portland 2010), and evaluating the areas where the remedial alternative footprints would be. No evidence of potential impact was found. However, not all significant cultural and archaeological sites are placed on publicly available maps. The team consulted with archaeological experts (AECOM), to evaluate whether there are potential impacts to cultural and archaeological sites that are not listed on publicly available maps. A records search was conducted using the SHPO Oregon Archaeological Records Remote Access database to determine the extent of previously recorded archaeological resources within the Site (RM 1-11). An internal AECOM memo stated that "*Previous cultural resource investigations have documented many historic and pre-contact archaeological resources, demonstrating general archaeological sensitivity within the vicinity of the Project. The records search revealed that eight archaeological resources are located in-water or along the riverbank of the Portland Harbor Superfund Site*" (For confidentiality purposes, the exact locations are not provided). In addition, the potential exists for undocumented archaeological resources in areas that have not been surveyed within the Site. The review suggested that all active footprints had the potential for impact, but it was not possible to provide quantitative comparisons, with the level of detail available. Thus, all active alternatives were scored -2, and Alternative A was scored 0. This was thus an insensitive metric.

6.6.2.9 Community Values score

The Community Values score is the centroid; the relevance-weighted average of metric scores SOC-2a, SOC-2b, SOC-2c, and SOC-2d. Table 6-11 summarizes the approach for SOC-2 scoring. Figure 6-13 shows the Community Values metric scores for each remedial alternative; Figure 6-14 illustrates the same results, but plots the aggregated metric scores for each alternative. In this manner, it is clear how different metrics aggregate to form the net SG Value scores (with equal weighting).

6.6.2.10 Discussion: Community Values

A number of stakeholder outreach and community involvement efforts (see Section 3.1) seek to involve and consider Community Values in remedy selection. However, stakeholder communities can be diverse in terms of their values and priorities. Portland is no exception, as was demonstrated in Section 4.2. Based upon a review of emerging social sustainability indicators (Section 2.2), some metrics and indicators of community values are defined in this section. However, to address the diversity of SG values and priorities, the sensitivity and robustness of this SG Values-based sustainability assessment to a range of SG priorities is examined in Section 8. Given the contentious nature of Superfund decision-making in general, and the Portland Harbor remediation specifically, the consideration, and scoring, of Community Values is, more than many of the other SG Values described here, likely to raise concerns about subjectivity. An SG Value score focusing on values, by its nature, cannot be entirely objective. For that reason, some sustainability reviews have few socially relevant metrics, or pay lip service, at best, to social sustainability. In similar approaches to sustainability such as life-cycle assessment and ecosystem services assessment, there is a tendency to focus on more easily quantified parameters (such as environmental and economic impacts) due to the lack of equivalently quantitative data on other categories of impact (Apitz 2013). However, one can question whether it is more important to be highly quantitative but possibly not relevant (by leaving out important factors), or whether less quantitative, but broader scope assessments might provide very different answers about what products, alternatives, or scenarios might be most sustainable. Thus, there is an opportunity to develop more qualitative or semi-quantitative approaches to help define the full scope of losses and gains as a result of proposals, policies, and scenarios. Such approaches may help expand the scope of assessments, as well as identify data gaps and uncertainties (Apitz 2012). The metrics chosen for this SG Value were grounded in the emerging literature (see Section 2.2) and scored using transparent approaches that were as comprehensive, relevant, quantitative, and sensitive as possible. However, given the information available, and the Superfund process itself, three of the metrics (SOC-2 a, c and d) were insensitive across alternatives. Although these metrics do not distinguish between alternatives, they do provide some important insights into the decision process itself, and efforts at future sites could seek to improve stakeholder involvement and the communication of uncertainty. Clearly, this approach should still be subject to rigorous peer and community review.

One metric, SOC-2a, had positive scores for all alternatives, but was not sensitive to alternatives (i.e., the score was the same across the board). This metric was scored based upon a published hierarchy of stakeholder involvement modes (Cundy et al. 2013) using professional judgment based upon a review of extensive stakeholder outreach efforts by EPA. A second metric, SOC-2c, had negative scores for all metrics and was also insensitive. It was scored, as was SOC-2a, based upon professional judgment of stakeholder outreach and communication, by EPA and other SGs. The score assigned, -4, is conservative, as an argument could be made for a much lower score based upon the extent of unqualified statements made in public meetings, documents, and web pages. However, as it was difficult to define a quantitative metric, the team decided to be conservative in this metric score. SOC-2b sought to address a range of potential re-uses, so it is an aggregated score, based upon scores developed for a variety of metrics for other SG Values. It is quantitative and based upon quantitative metrics; the selection and combination of these metrics can be seen as somewhat subjective, but the selection was designed with completeness and transparency in mind. As this is an aggregated score, scores range from negative (Alternative A) to positive. There is no increase as one moves to the more aggressive alternatives (as metrics aggregated in this metric have both positive and negative scores), until Alternative F, for which positive scores are offset by the negative ones. Overall, the metrics in this SG Value are scored in a transparent and well-documented manner. Absolute scores assigned are, by necessity, based upon somewhat qualitative and subjective approaches. However, as they are grounded in a careful review of stakeholder value statements (Appendix C) and alternative characteristics, it is likely that scoring by another individual with similar background information would assign different absolute, but similar relative, scores. Thus, this approach, by virtue of addressing issues often left out of sustainability assessments, should provide more completeness and balance to the overall assessment.

It is, however, important to note that the metric scores in these figures are only weighted using their MRWs; when they are aggregated for SG Value and pillar scores, they will be weighted based on their relevance scores (Section 7) and by SG priorities (Section 8). This will, in effect, provide another layer of consideration of community values. Both these weighting approaches will alter the relative importance of individual metrics in overall SG Value weights.

Figure 6-13. Metric scores for SOC-2 (Community Values), Equal weighting

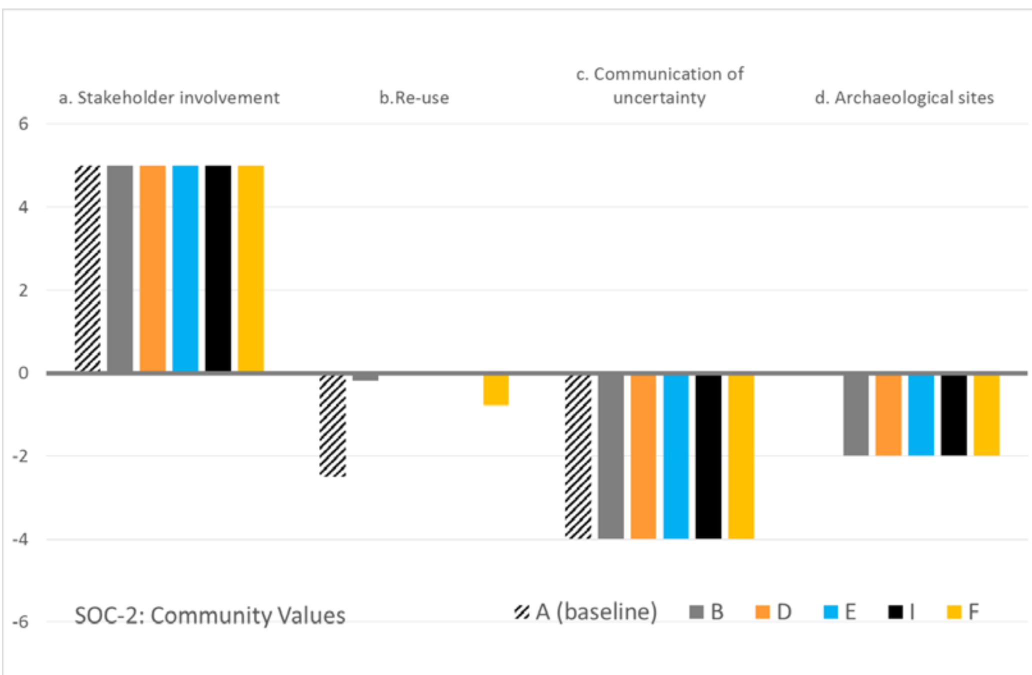


Figure 6-14. Stacked Cost-Effectiveness metric scores for each remedial alternative, Equal weighting

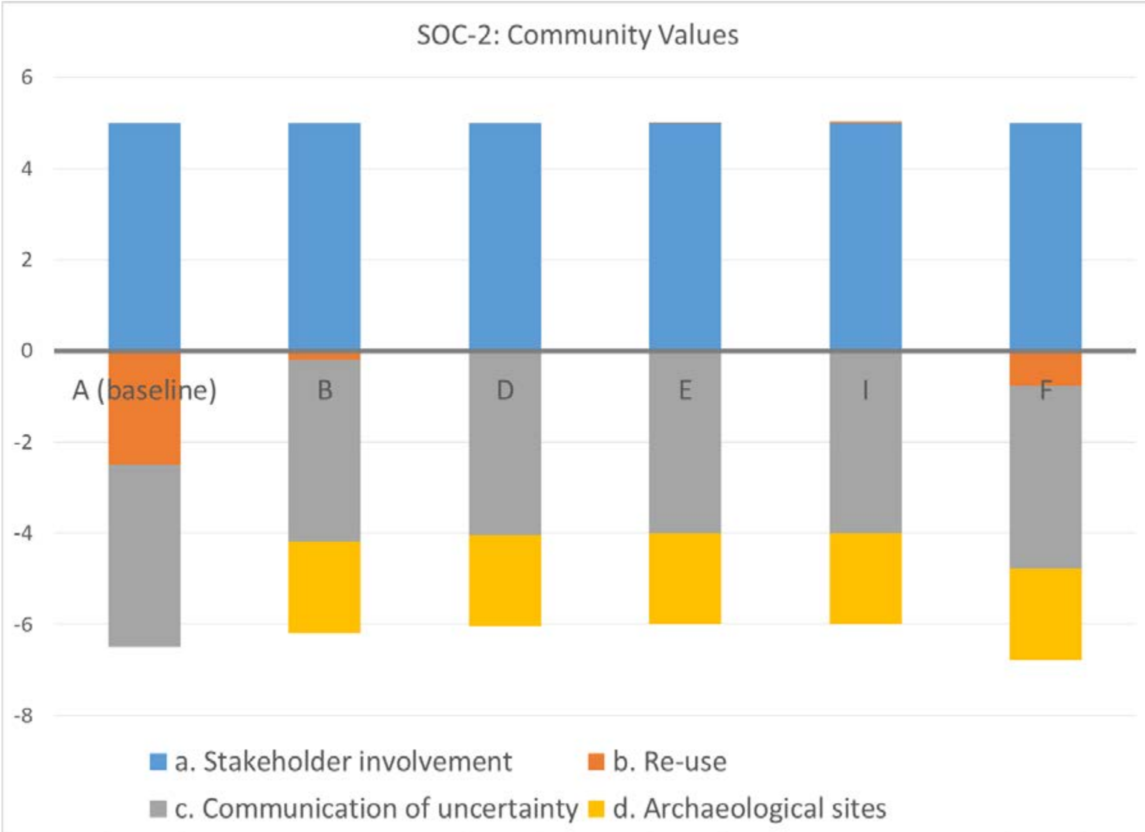


Figure 6-14 notes: SOC-2b scores are near 0 for some alternatives and are thus not visible in the figure.

6.6.3 SOC-3: Acceptable Remedy

For this section, impacts on the SG Value Acceptable Remedy were quantified using five metrics:

6.6.3.1 Permanence (SOC-3a):

The permanence of a remedy, or the removal of as high a proportion of contaminants or contaminated sediments from the river, is a significant concern to many SGs. For project consistency, this metric was scored in a manner similar to the one used in the CERCLA-linked NEBA permanence scores (AECOM 2016). Permanence was evaluated based on the extent to which contaminants (PCBs) are permanently removed from the Site and the degree to which site media are treated to permanently reduce the toxicity, mobility, and volume of site contaminants. In general, remedial alternatives that emphasize the removal of contaminated sediments have a lower potential for subsurface sediment to be exposed than alternatives emphasizing capping, ENR, *in situ*, and MNR. For this analysis, the MRW-weighted average of Reduction in the Mass of Contamination (SOC-3a1) and Reduction in Mobility of Hazardous Substances (SOC-3a2) was used to represent permanence (AECOM 2016). Permanence is a desirable outcome (benefit); all alternatives are scored positively. As this is an aggregated metric, the alternative scores do not span the full range from 0 (Alternative 10) to maximum permanence, but Alternative F, the most extensive alternative, does score the highest.

Permanence: Reduction of contaminant mass (SOC-3a1): This sub-metric is scored based on the mass (kg) of PCBs removed from the Site. The PCB concentration in sediments at-depth is assumed to be the PCB SWAC, so mass removed is calculated by multiplying volumes of sediment units by their SWAC. This calculation uses EPA blended volume (between low and high) and is calculated as reported in the environmental report (AECOM 2016) for the NEBA metric 2a. A score of 0 represents no contamination removed (i.e., Alt A: 0 kg PCBs); a score of +10 represents the largest amount of contamination removed for the remedial alternatives (i.e., Alt F: 289,305 kg PCBs). However, score 10 does not indicate that all PCB contamination is removed from Portland Harbor. Score 10 indicates the maximum PCB mass removed for all remedial alternatives compared in the NEBA.

Permanence: Reduction of mobility of hazardous substances (SOC-3a2): This sub-metric is scored based on the acres of a given remedial approach assigned to an alternative; these are weighted based on their relative degree of permanence, as in Table 6-12. Although the approach is similar to that used in the environmental report (AECOM 2016) for the CERCLA-linked NEBA metric 2b, in this values-linked framework, this approach assigns all contaminated areas of Alternative A as MNR (for comparability). As a result, as MNR is weighted as 1, the minimum score is that for Alternative A (0.9) and the maximum score (Alternative F) is 7.3. This is not to suggest that monitored natural recovery is to be carried out in the baseline option, but that the acres of MNR in each alternative are indicators of permanence here, and, in that context, are used to indicate permanence for Alternative A as well.

6.6.3.2 Effectiveness (SOC-3b):

Effectiveness over the long term addresses how well the remedy reduces risks; for example, whether contamination is removed or left in place to be managed over the long term, and whether controls are adequate to maintain protection against exposures to contamination left in place in the long term (AECOM 2016). For project consistency, the NEBA effectiveness scores were used as indicators for this metric. The long-term effectiveness evaluation criterion is evaluated by considering the following four metrics (details can be seen in the environmental report [AECOM 2016]):

- The magnitude of residual human risks (SOC-3b1)
- The magnitude of residual ecological risks (SOC-3b2)

- The degree of certainty that the remedial alternative will be successful (SOC-3b3)
- The reliability of institutional controls and engineering controls used to manage risks to the extent they are necessary (SOC-3b4)

The overall score for SOC-2b is a weighted average of these four sub-metrics. These are each weighted by their MRWs, but also as they are weighted in the environmental report (AECOM 2016). Thus, SOC-2b1 and SOC-2b2 are each 1/3 of the overall score, while SOC-2b3 and SOC-2b4 are both weighted 1/6.

These metrics are summarized below.

Effectiveness: Human risk reduction (sub-metric SOC-3b1): Post-construction (T=0) risk is the risk predicted to remain on-site from exposure to surface sediment containing residual concentrations of risk drivers after construction completion. For sub-metric SOC-3b1, four carcinogenic or non-cancer risks were averaged: carcinogenic risks from direct contact (RAO1), carcinogenic risks from seafood consumption (fish and shellfish tissue) (RAO2), child non-cancer HQs (RAO2), and nursing infant non-cancer HQs (RAO2). These values are all based on the 2016 EPA FS, Section 4 text. A low score of 0 represented residual risks without construction (i.e., Alternative A), and a high score of 10 represents minimal adverse human risks (i.e., acceptable risk levels for human health are $1x10^{-5}$ for multiple carcinogens and a hazard index of 1 for non-carcinogens). Fish and shellfish contaminant concentrations (and the associated seafood consumption risks) are predicted to increase during dredging activities. These calculations do not include these effects and therefore may understate risks throughout the construction period, particularly for alternatives with larger dredging footprints (AECOM 2016).

Effectiveness: Ecological risk reduction (sub-metric SOC-3b2): The second metric evaluates the risk to ecological receptors from ingestion of and direct contact with COCs in sediment. For sub-metric SOC-3b2, two indicators are scored and then the weighted average is used as the sub-metric score. The first indicator is the acres of sediment where unacceptable benthic risk remains after cleanup (RAO5), with 0 as a goal. The second indicator is the maximum HQ, consumption, which is equal to the maximum HQ for 4,4-DDE, PCBs, HxCDF, PeCDF, TCDD, and TCDF (by river-mile). A low score of 0 represented risks without construction (i.e., Alternative A), and a high score of 10 represents acceptable ecological risks (i.e., HQ of 1). These values are all based on the EPA 2016 FS, Section 4 text.

Effectiveness: Degree of certainty that the remedial alternative will be successful (sub-metric SOC-3b3): The predicted outcomes and success of remediation for all remedial alternatives have some uncertainty, particularly those that rely more on natural recovery. Uncertainties include the effectiveness of source control, the rates of natural recovery, concentrations of incoming sediment from upstream and lateral sources, and the effectiveness of remedial technologies. Therefore, the remedial alternatives were scored based on the remedial technologies that would be employed. For sub-metric SOC-3b3, each remedial technology was weighted based on best professional judgment. This analysis assumed that the remedial technologies that depend on construction only (i.e., capping and dredging) have a higher degree of certainty of success than remedial technologies that depend on natural recovery (i.e., ENR and MNR) (see AECOM 2016). The remedial alternatives are scored based on the weighted average of the acreage for each technology used in the Portland Harbor cleanup area.

Effectiveness: Reliability of Institutional Controls and Engineering Controls used to Manage Risk (sub-metric SCO-3b4): All remedial alternatives would use similar institutional and engineering controls to manage residual risk. However, the degree to which they need to use these controls may differ depending on the amount of contamination left in-place. Institutional controls include seafood consumption advisories, public outreach and education programs, and environmental covenants and restricted navigation areas. Seafood consumption advisories would remain in effect for all remedial alternatives. Reliability was scored based on engineering controls, which would be needed to manage and monitor contaminants remaining on-site. Alternatives with more dredging received higher scores both because removal of contaminants is a more reliable technology in the long term, and because it does not rely on covenants or other devices to address potential exposure of contaminants left in place. This metric is scored as an inverse proportion to the surface area where buried contamination potentially remains on-site. For this metric, the acres with caps, ENR/*in situ*, and MNR in the Portland Harbor cleanup area are summed for each alternative. The metric is zero remediation (score 0, i.e., Alternative A) to all of the cleanup area removed (score 10).

Effectiveness is a desirable outcome (benefit); all alternatives are scored positively. As this is an aggregated metric, the alternative scores do not span the full range from 0 (Alternative 10) to maximum permanence, but Alternative F, the most extensive alternative, does score the highest.

6.6.3.3 Implementability (SOC-3c):

Unlike the CERCLA-linked NEBA (AECOM 2016), for this project, implementability was scored based upon the qualitative assessment in EPA (2016a), as shown in Figure 6-15. Based upon the consumer-report type graphic, the circles were converted to points by assigning 2 points per black quartile on the EPA implementability circles (with Alternative A assigned a score of 10). For example:

- Open circle = 0 points
- One black quartile = 2 points
- Half back circle = 4 points
- ¾ black circle = 6 points
- Full black circle = 8 points

Figure 6-15. EPA summary of comparative analysis for remedial alternatives (from EPA 2016a)

		Threshold Criteria		Balancing Criteria				
Remedial Alternative	Description	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Present Value Cost (Dollars)
Contaminated Sediment Alternatives								
A	No Action/No Further Action	–	–	NA	NA	NA	NA	NA
B	Dredge/Cap 95 acres; ENR 100 acres MNR 1,966 acres; In-situ 7 acres Ex-situ 234,455 cy; Disposal 668,455 cy	–	–	○	○	◑	●	$
D	Dredge/Cap 177 acres; ENR 87 acres MNR 1,900 acres; In-situ 3 acres Ex-situ 234,455 cy; Disposal 1,339,192 cy	–	+	◔	◔	◕	◕	$
E	Dredge/Cap 269 acres; ENR 60 acres MNR 1,838 acres; Ex-situ 234,455 cy; Disposal 2,300,086 cy	+	+	◑	◑	◕	◑	$$
F	Dredge/Cap 505 acres; ENR 28 acres MNR 1,634 acres; Ex-situ 234,455 cy; Disposal 5,222,800 cy	+	+	◕	◕	◔	◔	$$$
G	Dredge/Cap 756 acres; ENR 19 acres MNR 1,391 acres; Ex-situ 234,455 cy; Disposal 8,432,900 cy	+	+	●	●	○	○	$$$$
I	Dredge/Cap 231 acres; ENR 60 acres MNR 1,876 acres; Ex-situ 234,455 cy; Disposal 1,987,600 cy	+	+	◑	◑	◕	◑	$$

6.6.3.4 Socially optimal construction time (SOC-3d):

A frequently expressed concern during public comments on the Portland Harbor cleanup is how long it will take (e.g., CAG 2015; Fricano et al. 2015; ODEQ 2015; Ward 2015; Apitz 2016a, d, b, c; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c). Many members of the public feel that the process has already taken too long. Many express a desire to see it done, while others are concerned about the length of time over which there will be impacts on the community. A third-party survey (SCI 2015) asked members of the community whether they would support remedial actions of various timespans. Greater than 75 percent stated they would support an action lasting 9 years or fewer; support dropped off quickly for longer remedial actions. This metric seeks to score remedial alternatives based upon "optimal" construction times. AECOM-adjusted remedy construction years (AECOM 2016) were divided by 7. A ratio of 1 (7 years' construction) was scored at 0; the maximum ratio (Alternative F) was scored -10. Shorter remedies (Alternatives A and B) had positive scores.

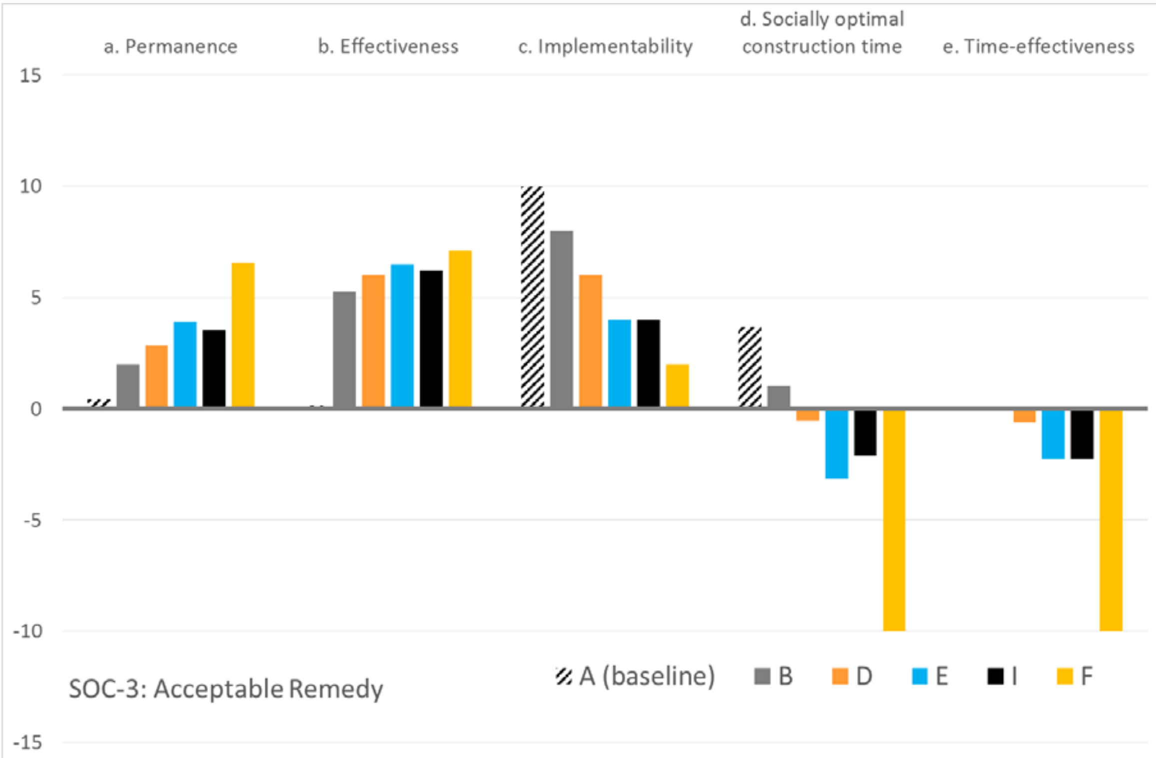
6.6.3.5 Time-effectiveness (SOC-3d):

A statement repeatedly made by EPA representatives at public meetings is "all alternatives will get us there, but some will get us there faster" (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c). This metric seeks to address, rather than "bang for the buck," the "bang for the time" in terms of years of construction to achieve RAOs—it scores any potential reduction in recovery time achieved by remediation. Unfortunately, as has been addressed before, the draft FS (EPA 2015a) does not model long-term contaminant levels. Thus, for this metric, data from the 2012 Draft FS (AnchorQEA 2012) was used, although this is also rather uncertain due to differences in remedial alternatives and modeling assumptions. Estimated times to attain RAOs, as well as construction years, were taken for reasonably matched alternatives in the 2012 Draft FS (AnchorQEA 2012). Construction years were divided by time to achieve RAOs, and scores were based on this ratio. Table 6-14 illustrates the basis of these calculations. Alternative I was treated the same as Alternative E. Alternatives were then scored from 0 for the most time-effective alternative, Alternative B (as Alternative A could not be scored) to -10 for the least time-effective alternative.

6.6.3.6 Acceptable Remedy score

The Acceptable Remedy score is the centroid; the MRW-weighted average of metric scores SOC-3a, SOC-3b, SOC-3c, SOC-3d, and SOC-3e, with the exception of Alternative A, which could not be scored for SOC-3e, and thus that score was left out when its centroid was calculated. The relevance score of this SG Value is the mean of the metric relevance scores. Tables 6-12 through 6-14 summarize the approach for SOC-3 scoring. Figure 6-16 shows the Acceptable Remedy metric scores for each remedial alternative; Figure 6-17 illustrates the same results, but plots the aggregated metric scores for each alternative. In this manner, it is clear how different metrics aggregate to form the net SG Value scores (with equal weighting).

Figure 6-16. Metric scores for SOC-3 (Acceptable Remedy), Equal weighting



6.6.3.7 Discussion: Acceptable Remedy

As can be seen in Section 2.2, technical aspects of remedial alternatives are considered in economic and/or social indicators in a variety of frameworks, but a number of technical aspects of remedial alternatives (e.g., permanence, effectiveness, time) were repeatedly addressed by community members during public comments (e.g., CAG 2015; Fricano et al. 2015; ODEQ 2015; Ward 2015; Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c) as both important concerns and points of contention. For this reason, although these technical aspects were initially pulled out as a separate pillar for the SG Values-based assessment, they were ultimately integrated into the Social Equity pillar as a specific SG Value to be assessed. It should be noted, however, that although several of the metrics evaluated here are closely aligned to the CERCLA criteria scored and evaluated using the CERCLA-linked NEBA tool (AECOM 2016), the focus here, SG Values differs, and thus there are some differences in scoring approaches. This section seeks to provide quantified metrics for those remedy aspects that are of concern to different SGs. As will be seen in Section 8, the extents to which various SGs prioritize the metrics in this SG Value differ greatly.

The first metric for this SG Value, SOC-3a, is a function of the amount of sediment removed in an alternative; thus, scores are progressively higher for the more aggressive alternatives. Effectiveness (SOC-3b), on the other hand, reflects the relative extent to which the alternatives reduce risk. As discussed above, there is only a minor net increase in ecological and human health risk reduction for the progressively more extensive alternatives, so some increase in score occurs for the more aggressive alternatives; however, it is not very large. Metric SOC-3c is based upon EPA's assessment of the alternatives (EPA 2016a); extensive remedies are subject to greater technical and administrative challenges and thus the more extensive remedies have lower scores than do the less extensive remedies. The last two metrics, SOC-3d and SOC-3e, reflect different aspects of the time of remediation, reflecting the priorities of different types of SGs. The first, SOC-3d, reflects the fact that longer remedies will have longer-term impacts on local communities. A third-party survey (SCI 2015) has shown that, in spite of a desire to see sites cleaned up, the community support for large-scale remedial activities drops off quickly when remedial actions take more than 7 years. Thus, remedies shorter than this time score positively, while remedies longer than this time score negatively. The second time-dependent metric, SOC-3e, on the other hand, reflects issues of greater concern to those who are paying for or carrying out remediation. A statement repeatedly made by EPA representatives at public meetings is “all alternatives will get us there, but some will get us there faster” (e.g., Apitz 2016a, d, b, c; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c). This metric seeks to address whether longer construction times are worth the relatively more rapid attainment of those goals (recognizing that no alternative under consideration will result in a removal of fish advisories [EPA 2015a]). This metric suggests there is little time benefit for the longer-term alternatives, so the longer-term alternatives score much lower than do the shorter-term alternatives. In aggregate, Figure 6-17 shows that all alternatives have a net positive score for the sum of SOC-3a, SOC-3b, and SOC-3c, though the relative importance of these metrics differs. However, the negative scores from SOC-3d and SOC-3e play an increasingly negative role in the net scores for Alternatives D, E, and F. How these different aspects affect overall acceptability of a remedial alternative will heavily depend upon SG priorities, as will be seen in Section 8.

Figure 6-17. Stacked Acceptable Remedy metric scores for each remedial alternative, Equal weighting

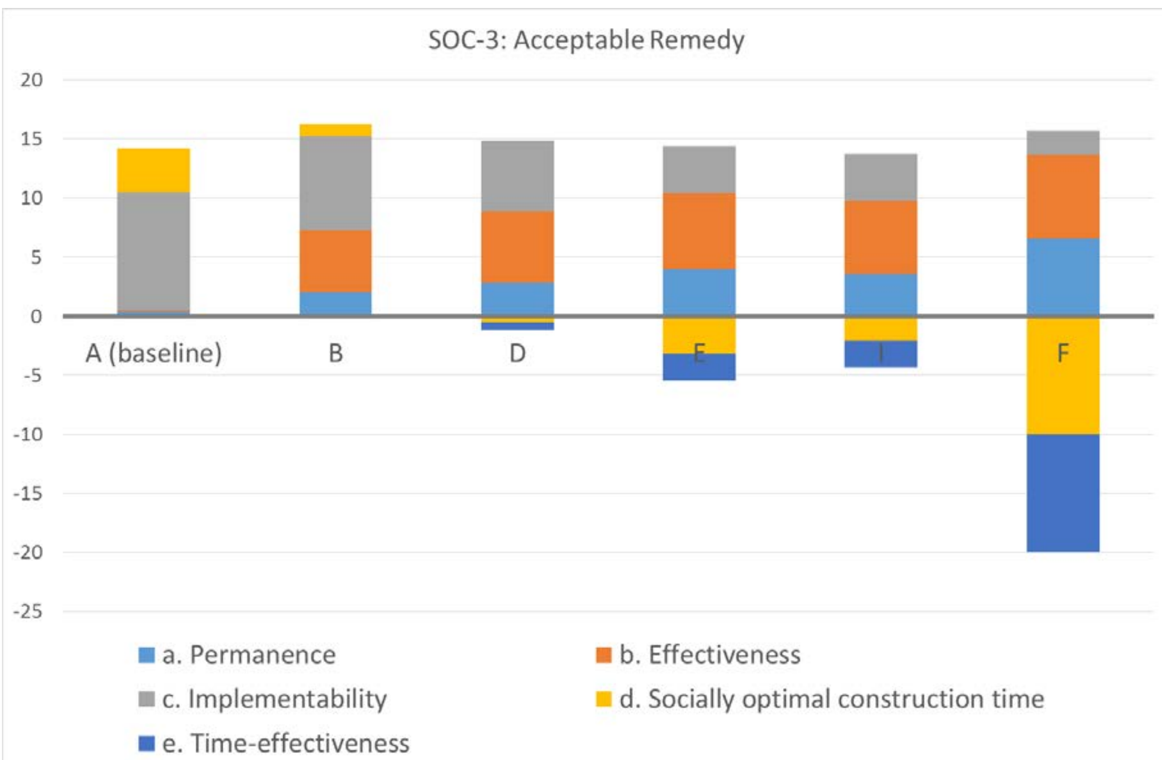


Table 6-12. Scores, weights, and approaches for SOC-3a metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis: Minimum Impact	Risk/Benefit Scoring Basis: Maximum Impact	Units	Site-wide Remedial Alternatives: A (baseline)	B	D	E	I	F
SOC-3 Acceptable Remedy	a1. Permanence: Reduction of contaminant mass	Mass of PCBs removed. The PCB concentration in sediments at-depth is assumed to be the PCB SWAC. Uses EPA blended volume (between low and high).	3.00		0	289,305	kg PCB	0	72,221	112,698	165,148	147,343	289,305
	Score 0 represents no contamination removed (i.e., Alt A: 0 kg PCBs); score 10 represents the largest amount of contamination removed for the remedial alternatives (i.e., Alt F: 413,930 kg PCBs). However, score 10 does not indicate that all PCB contamination is removed from PH. Score 10 indicates the maximum PCB mass removed for all remedial alternatives compared in the NEBA.						Score	0.0	2.5	3.9	5.7	5.1	10.0
	a2. Permanence: Reduction in mobility of hazardous substances	Immobility rating based on the acres weighted by type of technology applied to total PH active remedial area. (PH Active Remedial Area = 2450 acres)	2.50		Weighted average based on the following:								
		Removal (dredge, dredge/cap)			weighting:	9	acres of PH	0	73	132	203	167	387
		Containment (capping, *In situ* treatment, ENR)			weighting:	6	acres of PH	0	130	135	126	124	146
		MNR			weighting:	1	acres of PH	2,167	1,966	1,900	1,838	1,876	1,634
	Scoring is an aggregate based on technology weighting. Note: differs from NEBA approach in that it assigns all area as MNR in A and uses relevance weighting						Score	0.9	1.4	1.6	1.8	1.7	2.4
	a. Permanence centroid		2.75	3.00			Score	0.4	2.0	2.8	3.9	3.5	6.6

Table 6-13. Scores, weights, and approaches for SOC-3b metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis: Minimum Impact	Risk/Benefit Scoring Basis: Maximum Impact	Units	Site-wide Remedial Alternatives: A (baseline)	B	D	E	I	F
SOC-3 Acceptable Remedy	b1. Effectiveness: Human risk reduction	RAO1: Cumulative Carcinogenic Risk - Direct Contact		0.25	4.0E-04	1.0E-05	Risks	4.0E-04	5.0E-05	2.0E-05	1.0E-05	1.0E-05	1.0E-05
		RAO 2: Cumulative Carcinogenic Risk - Subsistence Angler Consumption of contaminated fish and shellfish (site-wide)		0.25	2.0E-03	1.0E-05	Risks	2.0E-03	4.0E-04	3.0E-04	2.0E-04	2.0E-04	1.0E-04
		RAO 2: Cumulative Child Non-cancer Hazard Index - Subsistence Child Consumption of contaminated fish and shellfish (site-wide)		0.25	138	1	HI	138	38	29	21	21	12
		RAO 2: Nursing Infant Non-cancer Hazard Index - Consumption of contaminated fish and shellfish		0.25	3,333	1	HI	3,333	810	619	446	454	268
	Score 0 represents human risk predicted without construction (i.e., Alt A); score 10 represents minimal adverse human risks (i.e., Chemical Specific ARARs for remedial action: acceptable risk levels for human health are 1x10^{-5} for multiple carcinogens and a hazard index of 1 for noncarcinogens). The score gives an equal weight to all human risks.		3.00	1/3			Score	0.0	8.0	8.6	9.1	9.1	9.5
	b2. Effectiveness: Ecological risk reduction	RAO 5:Acres where unacceptable benthic risks continues - Direct Contact			1,289	0	acres	1,289	670	464	348	464	168
		RAO 6: Maximum Hazard Quotient - Consumption, equal to the max HQ of 4,4-DDE, PCBs, HxCDF, PeCDF, TCDD, and TCDF (river-mile)			138	1	max HQ	138	34	19	15	19	15
	Score 0 represents ecological risk predicted without construction (i.e., Alt A); score 10 represents ecological risk with minimal adverse ecological effects (HI = 1).		3.00	1/3			Score	0.0	6.2	7.5	8.1	7.5	8.8
	b3. Effectiveness: Degree of certainty that the remedial alternative will be successful	Degree of certainty rating based on weighted benefit of remedial technologies normalized to PH active remedial area. (PH Active Remedial Area = 2450 acres)			Weighted average based on the following:								
		Dredge and dredge/cap			weighting:	9	acres of PH	0	73	132	203	167	387
		Cap			weighting:	8	acres of PH	0	23	45	66	64	118
		In situ treatment			weighting:	7	acres of PH	0	7	3	0	0	0
		ENR			weighting:	5	acres of PH	0	100	87	60	60	28
		MNR			weighting:	1	acres of PH	2,167	1,966	1,900	1,838	1,876	1,634
	Weightings for each technology are based on best professional judgment. MNR does not score a 0 because monitoring and contingency actions would mitigate mobility of contaminated sediment. Dredging does not score a 10 because some amount of contamination is lost during the dredging process. Therefore, 0 and 10 represent idealized alternatives in which sediments either are not remediated (0), or are removed completely from the PH (10).		2.50	1/6				0.9	1.4	1.6	1.8	1.7	2.5
	b4. Effectiveness: Reliability of ICs and engineering controls used to manage risk	Inversely proportional to total acres of cap, *in situ* treatment, ENR, and MNR. Assume reliability of ICs and engineering controls is inversely proportional to the area of technologies that leave contamination on-site. Although Alternative A does not have technology assignments, all contamination is left on-site; therefore, the total PH study area is used to score Alternative A.			2167	0	acres of PH	2167	2096	2035	1964	2000	1780
	Score of 0 represents leaving all contamination in PH remedial footprint; score of 10 represents dredging all contamination in the PH remedial area.		2.50	1/6			Score	0.0	0.3	0.6	0.9	0.8	1.8
	b. Effectiveness centroid (Note: differs from NEBA approach in that A is scored as MNR)		2.75	3.00				0.1	5.2	6.0	6.5	6.2	7.1

Table 6-14. Scores, weights, and approaches for SOC-3c, d, e and overall metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis		Units	Site-wide Remedial Alternatives					
					Minimum Impact	Maximum Impact		A (baseline)	B	D	E	I	F
SOC-3 Acceptable Remedy	c. Implementability	Table 15; EPA proposed plan - 2 points per quartile in scoring circle. Full black circle is 8 points and full open circle is 0; Alternative A given 10 points because it is more implementable than any other option.	2.75	3.00									
	Based upon 2016 Proposed plan, Table 15; 2 points per quartile. A scored as 10.						Score	10.0	8.0	6.0	4.0	4.0	2.0
	d. Socially optimal construction time	Ratio of adjusted construction time (AECOM) to "optimal" time of 7 years or fewer (based upon survey). Scored so a ratio of 1 scores zero; max scores -10, shorter scores positive	2.50	3.00	1	3.7	AECOM years/7	0.0	0.7	1.1	1.9	1.6	3.7
	Score of 0 is 7 years; fewer years nets a higher score; -10 is max ratio						Score	3.7	1.1	-0.5	-3.2	-2.1	-10.0
	e. Time-effectiveness	Ratio of construction time to time to achieve RAO for PCBs in sediment - time-effectiveness of treatment. Reflects potential reduction in time gained by construction time. Ratio of AnchorQEA construction period (years) and time to achieve RAOs. Use >45 as 45. Note: based upon 2012 draft FS becaue 2015/2016 did not present predicted outcomes over time.	2.00	3.00	0.1	0.8	construction years/time to achieve RAO	n/a	0.1	0.2	0.3	0.3	0.8
	Score of 0 is B, the quickest option with data; score of -10 is the highest ratio. A also given a score of -10 as it will not reach RAOs							n/a	0.0	-1.0	-2.8	-2.1	-10.0
	SOC-3 Acceptable Remedy centroid		*3.00*					3.6	3.5	2.9	2.0	2.2	-0.1

6.6.4 SOC-4: Health & Safety

The SG Value of Health & Safety seeks to address various aspects of short- and long-term human health and safety and is evaluated by considering four metrics, as summarized below.

6.6.4.1 Worker safety (SOC-4a):

This metric is scored based upon the SiteWise™ scores for Accident Risks during Construction (AECOM 2016). This metric is related to the accident risks as a result of construction. Accident risks, which are the equally weighted average of injury and fatality risks, are based on the transportation type, labor type, and construction duration calculated in SiteWise™, as described in the environmental report (AECOM 2016). This is an undesirable outcome (risk), and thus is scored negatively. A score of -10 represents highest accident risk (i.e., Alternative F), and a score of 0 represents no construction and therefore no accident risk (i.e., Alternative A).

6.6.4.2 Human Health (long-term) (SOC-4b):

This metric is scored based on the average of two metric scores, chosen to reflect risk reduction at the end of construction (T0) and longer term (T45):

- **Human Health Risk, T0 (SOC-4b1):** Based on Human Carcinogenic and Non-Cancer Risks (as in NEBA Metric 3a; AECOM 2016). Residual risk is the risk predicted to remain on-site from exposure to surface sediment containing residual concentrations of risk drivers. Four carcinogenic or non-cancer risks were averaged: carcinogenic risks from direct contact, carcinogenic risks from seafood consumption (fish and shellfish tissue), child non-cancer HQs, and nursing infant non-cancer HQs. Risk reduction is a desirable outcome (benefit) so this is scored positively. A low score of 0 represents residual risks without construction (i.e., Alternative A), and a high score of 10 represents minimal adverse human risks (i.e., acceptable risk levels for human health are $1x10^{-5}$ for multiple carcinogens and a hazard index of 1 for non-carcinogens). Fish and shellfish contaminant concentrations (and the associated seafood consumption risks) are predicted to increase during dredging activities. These calculations do not include these effects and therefore may understate risks throughout the construction period, particularly for alternatives with larger dredging disturbance during construction (AECOM 2016); but are addressed to some extent in SOC-4c.

- **Human Health Risk, T45 (SOC-4b2):** This metric seeks to address long-term reductions in human health risk, but these are not modeled in the draft FS (EPA 2015a). Thus, data from the 2012 Draft FS (AnchorQEA 2012) were used. This metric was based on Year 45 PCB SWAC, site-wide, from Table 9.3.1-1 of the 2012 Draft FS (Section 9 tables; AnchorQEA 2012). Risk reduction is a desirable outcome, so alternatives are scored positively. Alternatives are scored with a score of 0 being no risk reduction (Alternative A) and a score of 10 being background levels of 9 ppb. Alternative I was treated as Alternative E.

6.6.4.3 Fish consumption risk (short-term) (SOC-4c):

Contaminants will be mobilized during (and possibly after) construction; these will be taken up in fish tissue, and thus these increased contaminant loads pose a risk to fish consumers during the construction period. As this issue is not addressed in the draft FS (EPA 2015a), data were used from the 2012 Draft FS (AnchorQEA 2012). This metric was scored based on the total mass PCBs exiting the study area for each alternative, as described in ENV-1b. This is an undesirable impact (a risk), so it is scored negatively.

A score of 0 represents baseline (Alternative A); a score of -10 represents the maximum short-term risk from elevated fish tissue (Alternative F).

6.6.4.4 Health & Safety score

The Health & Safety score is the centroid; the relevance-weighted average of metric scores SOC-4a, SOC-4b, and SOC-4c. Table 6-15 summarizes the approach for SOC-4 scoring. Figure 6-18 shows the Health & Safety metric scores for each remedial alternative; Figure 6-19 illustrates the same results but plots the aggregated metric scores for each alternative. In this manner, it is clear how different metrics aggregate to form the net SG Value scores (with equal weighting).

6.6.4.5 Discussion: Health & Safety

Human health and safety are important community concerns, and the reduction of long-term human health risk is among the criteria that drive remedial action. However, short-term risks to human health and safety occur during construction and implementation. Given the heavy equipment required to remove, treat, and transport the millions of tons of sediment in these remedial alternatives, it is not surprising that there is a high probability of worker injury of death. This increases with increasing project size, as reflected in SOC-4a. As pointed out in other sections, as hotspots are treated in all remedial alternatives, there is no significant difference in risk reduction for the various remedial alternatives (barring Alternative A); thus, SOC-4b scores, though somewhat higher for the more extensive alternatives, are similar (though positive) for all active alternatives. Contaminants will be mobilized during (and possibly after) construction; these will be taken up in fish tissue, and thus these increased contaminant loads pose a risk to fish consumers during the construction period. This is an EJ concern; fish are disproportionately caught and consumed by Tribes, the houseless community, and some immigrant communities (Rome and Bell 2012; Sunding and Buck 2012). As this issue is not addressed in the 2016 EPA FS (EPA 2016a), data were used from the 2012 Draft FS (AnchorQEA 2012). This risk will be a function of the extent and length of construction, so the scores for this negative impact (SOC-4c) increase for the more extensive and long-lived remedies. Only SOC-4b is a focus of CERCLA criteria—human health is a threshold criterion (EPA 1998). However, these other human risks are of concern to various SGs. How these different aspects of risk affect the health risk perception or priorities of different SGs will be addressed in Section 8.

Figure 6-18. Metric scores for SOC-4 (Health & Safety), Equal weighting

Figure 6-19. Stacked Health & Safety metric scores for each remedial alternative, Equal weighting

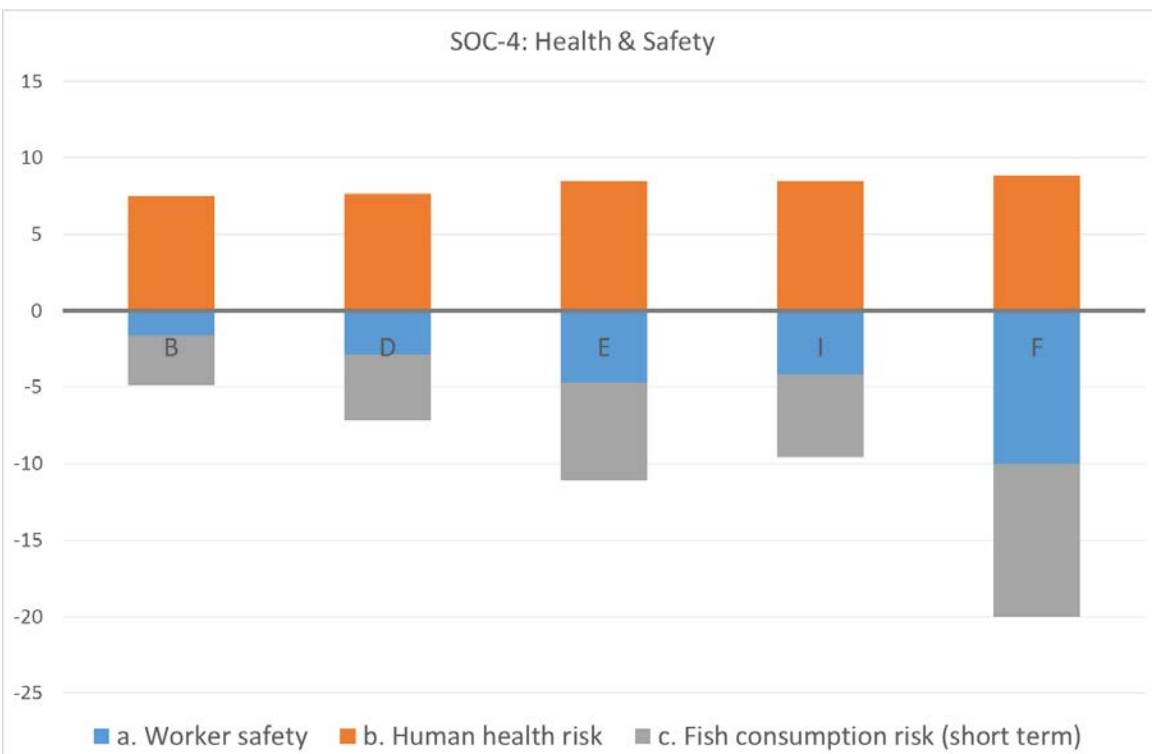


Table 6-15. Scores, weights, and approaches for SOC-4 and overall metric and SG Value scoring in the SVA tool

Evaluation Criteria			MRW	SG metric and sub-metric weighting	Risk/Benefit Scoring Basis: Minimum Impact	Risk/Benefit Scoring Basis: Maximum Impact	Units	Site-wide Remedial Alternatives: A (baseline)	B	D	E	I	F
SOC-4 Health & Safety	a. Worker safety	Accident Risk - Injury		0.50	5.16E-01	0	Risks	0.0	0.1	0.1	0.2	0.2	0.5
		Accident Risk - Fatality	3.00	3.00			Score	0.0	-1.6	-2.9	-4.7	-4.1	-10.0
	Score -0 represents accident risk predicted without construction (ie., Alt A); score -10 represents accident risk with the maximum amount of construction (ie., Alt F).				*0.0004*	*0.00001*	Risks	0.0	0.0	0.0	0.0	0.0	0.0
	b1. Human health risk, T0	RAO1: Cumulative Carcinogenic Risk - Direct Contact			2.0E-03	1.0E-05	Risks	2.00E-03	4.00E-04	3.00E-04	2.00E-04	2.00E-04	1.00E-04
		RAO 2: Cumulative Carcinogenic Risk - Subsistence Angler Consumption of contaminated fish and shellfish (site-wide)			1.4E+02	1.0E+00	HI	1.38E+02	3.80E+01	2.90E+01	2.10E+01	2.10E+01	1.20E+01
		RAO 2: Cumulative Child Non-cancer Hazard Index - Subsistence Child Consumption of contaminated fish and shellfish (site-wide)			3,333	1	HI	3333.00	810.00	619.00	446.00	454.00	268.00
		RAO 2: Nursing Infant Non-cancer Hazard Index - Consumption of contaminated fish and shellfish	3.00				Score	0.00	7.97	8.60	9.06	9.06	9.49
	Score 0 represents human risk predicted without construction (ie., Alt A); score 10 represents minimal adverse human risks F).		2.50		*35*	*9*	SWAC	35.0	17.0	18.0	15.0	15.0	14.0
	b2. Human health, T45	Based on Year 45 PCB SWAC, site-wide, from Table 9.3.1-1 2012 Draft FS (Section 9 tables) Notes: Based on the 2012 Draft FS; goal set to a Background level of 9					Score	0.0	6.9	6.5	7.7	7.7	8.1
	Score of 0 represents baseline (A); Score of 10 represents maximum SWAc reduction		*2.75*	*3*			Score	0.0	7.5	7.7	8.4	8.4	8.8
	b. Human health centroid value		2.50	3.00	92.857143	0	Total PCB kg (adj.)	0.0	30.0	40.0	59.6	50.4	92.9
	c. Fish consumption risk (short term)	Total Mass Exiting the Study Area for Each Alternative (Total PCB kg), adjusted for AECOM years.Note: this metric is based on 2012 FS as the 2015 FS does not address					Score	0	-3	-4	-6	-5	-10
	Score 0 represents baseline; -10 represents maximum short-term risk from elevated fish tissue						Score	0.0	-3.2	-4.3	-6.4	-5.4	-10.0
	SOC-4 Health & Safety centroid score		*3.00*					0.0	0.9	0.2	-0.8	-0.3	-3.7

7. Trade-off Evaluation; Equal Weighting

This section discusses project results by aggregating metrics to generate SG Value scores, and by aggregating SG Value scores to generate overall pillar scores (Section 7.1). Results are graphically presented in Section 7.2 and discussed in Section 7.3. In this section, all metrics and SG Values are weighted by their relevance weights (Section 6.2); all SG Values and metrics are given equal weight in aggregation (unless it was stated otherwise in metric descriptions in Section 6). A sensitivity analysis by weighting based upon SG priorities will be addressed in Section 8.

7.1 Metric aggregation: SG Value and pillar scores and trade-offs; equal weighting (relevance weighted)

The SG Value scores are calculated as the relevance-weighted centroid (V_r), which is the weighted average of the metric relevance scores for a given SG Value:

$$V_r = (\sum(M_i{*}MRW_i))/ \sum W_i),$$

where M_i is the score assigned for each metric and MRW_i is the MRW assigned to that metric (see Section 6.3). The centroid is used to ensure that the most relevant, quantitative, and standard metrics are given more weight than those less quantitative, relevant, or clearly linked to the SG Value.

The pillar (i.e., Environmental Quality, Economic Viability, and Social Equity) scores are calculated as the average of the SG Value scores for a given pillar:

$$P_r = (\sum(V_{ri})/ 4),$$

where V_{ri} is the score assigned for each SG Value. Table 7-1 illustrates scores for the SG Values and pillars, with only relevance weighting (i.e., giving all metrics and SG Values equal stakeholder weight). SG Values in red are negative scores; those in green are positive scores.

Table 7-1. Aggregated SG Value and pillar scores, equal weighting (relevance weighted)

Equal Weighting		A (baseline)	B	D	E	I	F
ENV	Environmental Quality	0.0	-1.2	-1.6	-1.9	-1.7	-2.7
ECON	Economic Viability	0.0	-0.6	-2.3	-3.7	-3.3	-7.5
SOC	Social Equity	0.9	0.4	-0.2	-1.1	-0.7	-3.5
Mean Sustainability Score		0.3	-0.5	-1.4	-2.2	-1.9	-4.6
Label	**Value**	A (baseline)	B	D	E	I	F
ENV-1	Fish & Wildlife	0.0	3.2	3.3	3.4	3.4	3.0
ENV-2	Habitat	0.0	-3.9	-5.3	-6.7	-6.0	-10.0
ENV-3	Resilience	0.0	0.4	1.1	2.3	1.9	6.1
ENV-4	Low Impact Remedy	0.0	-4.5	-5.4	-6.6	-6.2	-10.0
ECON-1	Economic Vitality	0.0	-2.7	-4.0	-5.6	-5.2	-10.0
ECON-2	Jobs	0.0	-2.6	-3.9	-5.5	-5.0	-10.0
ECON-3	Infrastructure	0.0	-2.1	-3.8	-4.9	-4.7	-7.9
ECON-4	Cost-Effectiveness	0.0	4.8	2.5	1.1	1.5	-2.1
SOC-1	Quality of Life & Recreation	0.0	-2.9	-4.3	-5.9	-5.1	-10.0
SOC-2	Community Values	0.1	0.1	0.2	0.2	0.2	0.0
SOC-3	Acceptable Remedy	3.6	3.5	2.9	2.0	2.2	-0.1
SOC-4	Health & Safety	0.0	0.9	0.2	-0.8	-0.3	-3.7

7.2 Graphic results

7.2.1 SG Value aggregation

A number of ways exist to graphically present these results. Discussions with stakeholders have shown that the clearest approach differs greatly between individuals, so data are presented a few different ways below. Figure 7-1 shows an “SG Value radar” graph. In this format, each of the 12 axes of the figure represents one SG Value and SG Values from each pillar are clustered together. SG Value scores closer to the center of the figure are higher negative scores (risks); scores near the outer edge are higher positive scores (benefits). The dashed black line represents Alternative A, the baseline alternative. For any given SG Value and alternative, scores closer to the outer edge of the radar represent the most sustainable alternative (in terms of that SG Value); the largest overall size or surface area suggests the most desirable or sustainable alternative overall. Trade-offs can be seen. For instance, for SG Values such as Economic Vitality and Low Impact Remedy, all active alternatives have lower scores than does Alternative A, with the more extensive alternatives having the lowest SG Value scores. On the other hand, Alternative B has a higher Health & Safety score than does Alternative A, Alternative D’s score is positive but closer to baseline, and Alternatives E and F have scores much lower than baseline. For Resilience, the most aggressive alternatives have the highest scores. Community Values, on the other hand, has similar aggregated values for all alternatives. The basis for each of these scores, and the metrics that were aggregated to generate them, can be found in Section 6. Overall, the relative size of an alternative’s shape indicates relative sustainability. Clearly, there are economic, environmental, and social impacts for all active alternatives relative to the baseline of no action (Alternative A), and the overall magnitude of those impacts is much greater for the more extensive alternatives. Even the issues driving remediation (Fish & Wildlife and Health & Safety) do not provide a compelling argument for extensive remediation when both the short- and long-term impacts are considered together. Active remedies score higher than the baseline, though only for Resilience do the more extensive remedies score higher than the less extensive remedies. Figure 7-2 illustrates the same data, but as stacked columns. Here, it can be seen that the net benefits (positive SG Value scores) for each alternative are progressively offset by increasing costs (negative SG Value scores) as one moves to the more extensive, costly, and time-consuming alternatives, though the high Resilience score for F offsets this trend to some extent by having a slightly higher benefit score (but also a much higher risk score) than its closest alternative. Alternative I, with its slightly shorter construction times, scores better than does the closely related Alternative E. That very large construction projects should have substantial environmental, economic, and social impacts is not in itself surprising, given the magnitude of the proposed alternatives. However, what is important to note about the Portland Harbor remedial alternatives is that there is minimal risk reduction pay-off for that incremental increase in cost.

Figure 7-1. SG Values-based sustainability scores for each remedial alternative, Equal weighting (relevance weighted)

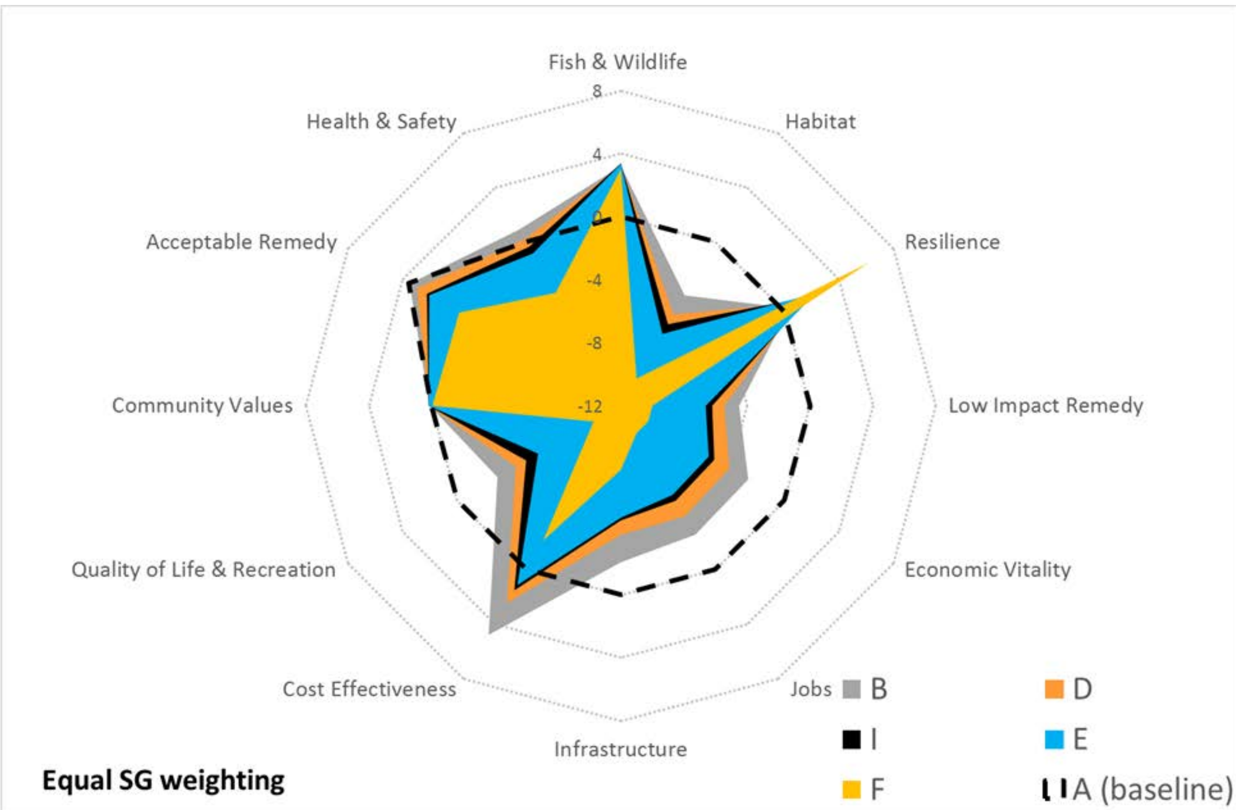
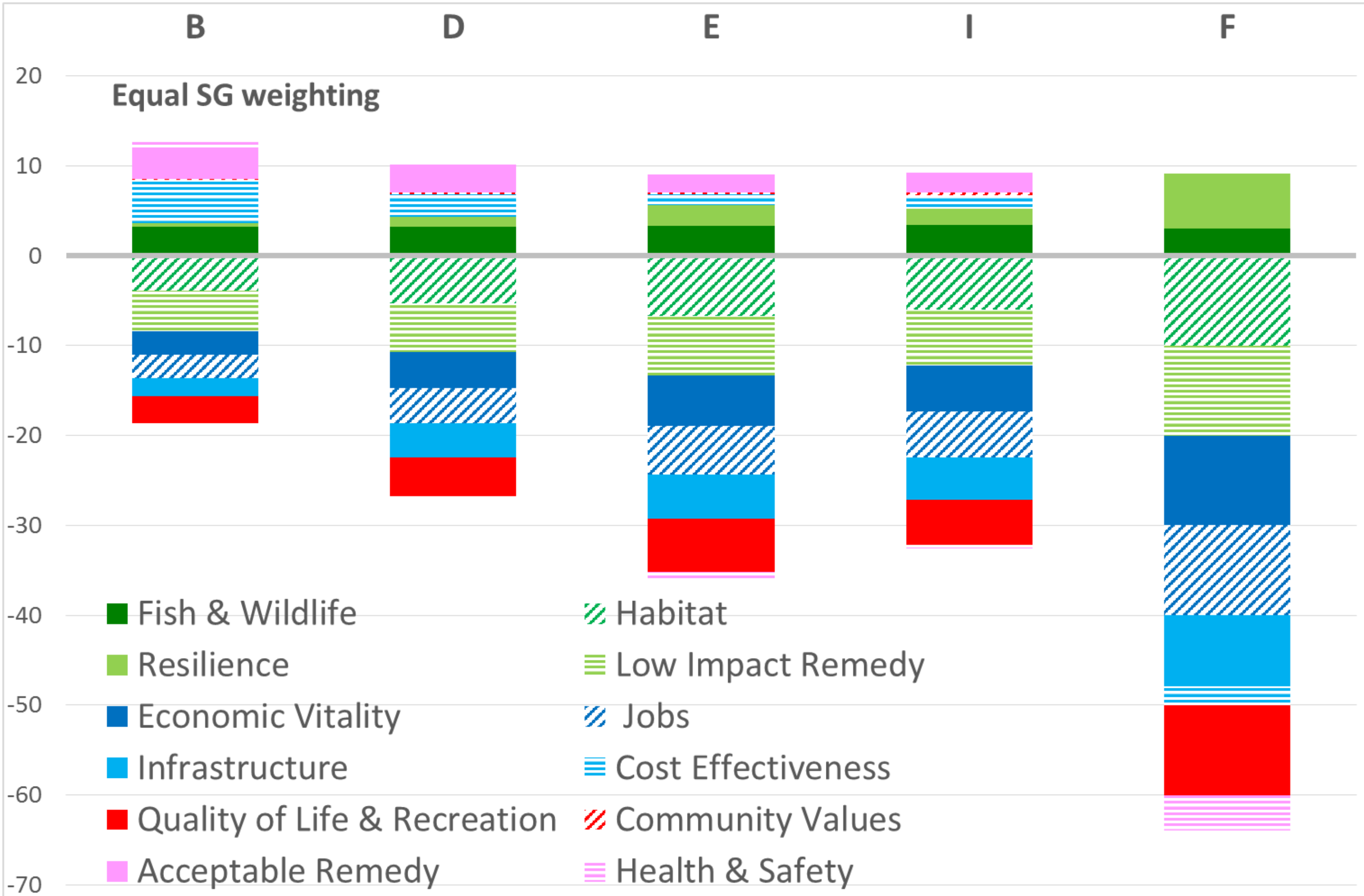


Figure 7-2. Stacked SG Values-based sustainability scores for each remedial alternative, Equal weighting (relevance weighted)



7.2.2 Pillar aggregation

Figure 7-3 and Table 7-1 illustrate the aggregated SG Value-based pillar scores, for all alternatives, with equal weighting (relevance weighted). For Environmental Quality, Economic Viability, and Social Equity, the sustainability of all active alternatives is lower than that of the baseline Alternative A.

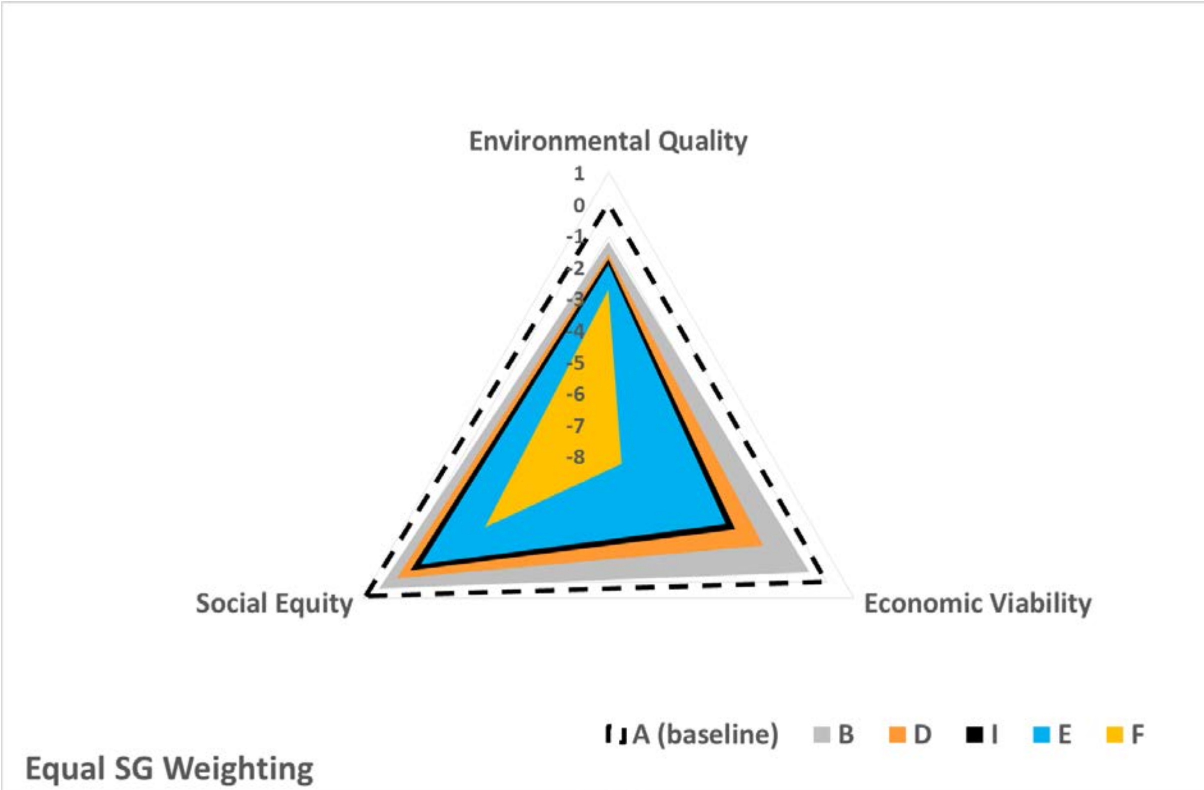
It should be noted that all relative sustainability scores depend upon the definition of baseline. All CERCLA FSs compare remedial alternatives against the No Action Alternative (in this case, Alternative A). However, this does not suggest that, if overall sustainability scores are lower than baseline, there is no argument for remediation. There are regulatory and risk drivers that drive remedial decisions. The sustainability assessment considers a full range of impacts of remedial options but does not, due to the manner in which it is framed, address the impacts or benefits that accrued before the baseline condition. To return to a less contaminated state will inevitably require energy, time, and disturbance. This framework allows stakeholders to consider what levels of disturbance result from various levels of cleanup.

7.3 Discussion: Assessment of alternative sustainability, equal weighting

Although there are trade-offs, Alternative F is by far the least sustainable alternative among those evaluated by a clear margin when considering the aggregate of SG Values. Alternatives E, I, D, and B are increasingly more sustainable, respectively, than Alternative F when considering the aggregated SG Value-based scoring.

It should be noted that, in this section, all metrics that aggregate to an SG Value and all SG Values that aggregate to a pillar are given equal importance (barring their relevance weight). Clearly, different SGs will have very different priorities when it comes to the SG Values and metrics that feed into these scores. However, stakeholder mapping (Section 3) illustrated that the >280 SGs identified in the Portland Harbor region were very diverse. Value mapping (Section 4) further illustrated that their priorities were also diverse, and demonstrated that any attempt to speak for the Portland community as a whole by suggesting one voice or one set of SG priorities has the potential to introduce bias. This poses a strong argument for considering trade-offs by weighting all SG Values equally, as is done in this section. Such an approach does not favor one SG’s set of priorities over those of another, but addresses how various aspects of sustainability affect its overall assessment. However, the sensitivity and robustness of the above conclusions to diverse stakeholder priorities will be addressed in Section 8.

Figure 7-3. SG Values-based pillar sustainability scores for each remedial alternative, Equal weighting (relevance weighted)



8. Sensitivity Analysis: Stakeholder Group Weighting

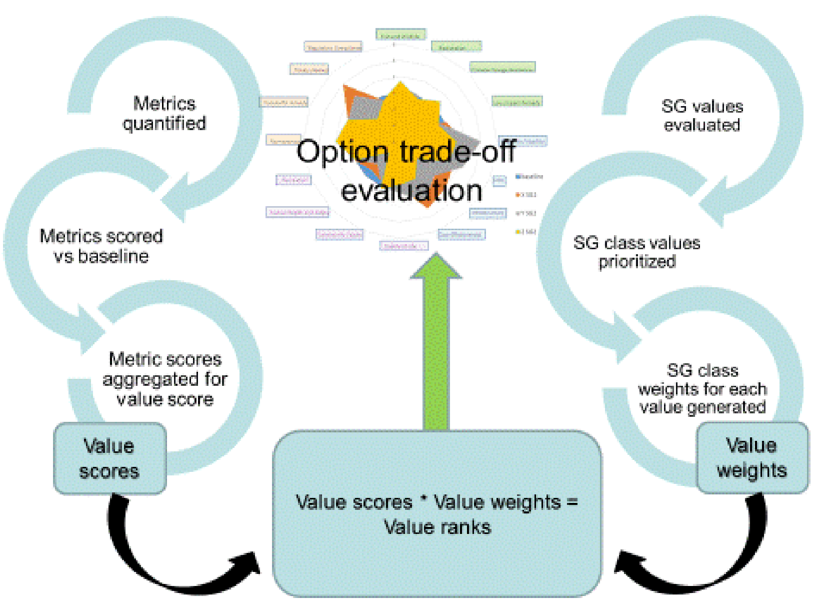
Section 7 aggregates metrics to SG Values and SG Value to pillars, treating all metrics and SG Values as equally important to the overall sustainability. However, not all SGs prioritize these SG Values and metrics equally. For instance, for some SGs, permanence is the primary metric for their evaluation of an acceptable remedy; others value time-effectiveness, implementability, etc. to differing degrees. For Health & Safety, not all stakeholders consider risk to workers a relevant metric, and they may have differing opinions on the relative importance of long-term vs. short-term human health risk. The relative importance of the SG Values that feed into the pillars may differ as a function of SG priorities as well. Thus, in this section, metric and SG Value scores are weighted to reflect the inferred priorities of different representative SGs. This will affect the aggregation of metrics to SG Value scores and SG Values to overall pillar sustainability scores. This is being carried out to address two objectives:

1. To demonstrate the use of the SVA tool to address SG-specific priorities and communicate trade-offs in terms of these priorities, and
2. To evaluate the sensitivity and robustness of SVA-based assessment of the relative sustainability of remedial alternatives to differing SG priorities.

8.1 Stakeholder group weighting

Figure 8-1 illustrates a simplified version of the approach to generating SG-weighted SG Value ranks; the approach for aggregating these SG Values to pillars is the same. The left side of the figure illustrates how metrics and SG Values are scored. This process was described in Sections 6 and 7. The right side addresses how SG Value weights are developed; this will be described in Section 8.3. Once SG Value scores and SG Value weights are developed, SG Value ranks can be calculated. It should be noted, however, that within the SVA tool, if enough is known about SG priorities, it is also possible to weight the metrics that aggregate into SG Values as well as the SG Values that aggregate into pillars. This approach is illustrated in this section.

Figure 8-1. Conceptual approach for weighting SG Values using SG priority weights



8.1.1 Approach – SG weighting for metric and SG Value aggregation

Value mapping, meeting notes, surveys, discussions, and reviews provided evidence for the priorities of a range of SGs. For an SG-specific weighting, metrics and SG Values for which there was evidence that an SG considered it very important were given a higher relative weight; those that an SG distrusted or considered unimportant were given a lower relative weight. For the representative SGs listed above, weights could be assigned to some metrics and values. The following scheme was used to assign weights (with the exception of the City Survey SG, the approach for which is described below):

Based upon a review of available information, SG weights were assigned a score from 0 to 5 using the following scale:

- Metric or value is unimportant (or evidence is seen as not relevant or believable): 0
- Metric or value is marginally important: 1
- Metric or value is somewhat important: 2
- Metric or value is important: 3
- Metric or value is very important: 4
- Metric or value is critically important: 5
- If no statement or evidence of an SG view was found, the metric or value is weighted as 2.

It is important to note that most representative SG weightings were based on limited evidence of SG priorities (as described below). Ideally, SGs could be asked their opinions to elicit information on the relative importance of all metrics and SG Values considered; they could then provide complete information. However, for the evidence bases used for the inferred priorities described below, not all metrics and values are addressed at the same level. It was concluded, however, that the lack of evidence of importance (or unimportance) of an unaddressed metric or SG Value did not provide evidence of its lack of importance to that SG. Instead, as SGs were all subsets of the overall Portland community, it was assumed that all values not addressed could be assumed to be *somewhat* important (a weight of 2), as the Stakeholder Value Map provided evidence that all SG Values were of some importance to some sectors of the community. As a result, the SG weight tables (see Appendix D) have very few 0's or 1's, as there was more of a tendency in the evidence base for SGs to state positive values (i.e., something is important) than negative values (i.e., something is unimportant). It is possible that, if all weights were elicited, there would be more negative value statements by some SGs, and the differences between SG weights would be greater, but this could not be tested in the context of this project.

For the "equal weighting" scenario, all values and metrics were scored as important, or 3. For the City Survey SG (CS), the survey report (DHM Research 2016) provided numerical results for a range of questions. As much as possible, these questions were mapped to specific values or metrics. Metrics and values were then scored based on the following scheme:

- 0–15% of survey respondents strongly or somewhat agree with the relevant statement: 0
- 16–25% of survey respondents strongly or somewhat agree with the relevant statement: 1
- 26–45% of survey respondents strongly or somewhat agree with the relevant statement: 2
- 45–65% of survey respondents strongly or somewhat agree with the relevant statement: 3
- 66–85% of survey respondents strongly or somewhat agree with the relevant statement: 4
- >85% of survey respondents strongly or somewhat agree with the relevant statement: 5
- If no statement or evidence of an SG view was found, the metric or value is weighted as 2

Tables presented in Appendix D illustrate the value and metric weights that were assigned for the representative SGs, and their basis.

It should be noted that, when aggregated, metrics were also still weighted in terms of their MRWs.

8.1.2 Representative stakeholder groups

Stakeholder mapping (Section 3 and Appendix B) and the "value map" database (Section 4.2) demonstrate that there is a diversity of voices in Portland. SG Value metrics can be weighted based upon the priorities of different SGs. This can be done using a variety of tools to elicit values from stakeholders, but broad representation is always a challenge; as is including a diversity of opinions (rather than just the most vocal groups or individuals). As described above, the diversity of priorities in Portland is an argument for weighting all SG Values and metrics equally, as was done in Section 7. However, another approach is to weight SG Values and metrics considering the priorities of specific SGs. To address this issue, one approach is to identify an illustrative set of "Representative SGs" for which there is sufficient documentation on their priorities and concerns to develop a representative set of metric and SG Value weightings. This approach is used here.

It is important to note that the intent is not to represent all stakeholders, but to illustrate how trade-offs are affected when differing priorities are considered. Nor is the intent to speak for the selected representative SGs. Rather, the intent is to apply a diverse set of plausible SG Value and metric priorities for SGs for which we have documentation on their inferred values. Five representative SGs were identified for this purpose, as described below.

8.1.2.1 Representative SG: Community Forum (CF)

The first representative SG considered is based upon a pair of illustrations developed by an EPA-sponsored graphic facilitator at a Portland Harbor Superfund Site community outreach meeting called "St John's Community Café", in July 2015 (EPA 2015b). Community members were encouraged to discuss their values, aspirations, and concerns for Portland Harbor and ask: "What do we want the river to be and do?" This resulted in a draft and final illustration, with text (Appendix D). These graphics, and the text within them, were mapped in the value map, and a set of SG Values was inferred. Based upon this, a set of SG weights was developed (see Section 8.1.1 for the approach), using this information and professional judgment. This SG had relatively balanced priorities; the graphic, among other themes, emphasized the "Triple Bottom Line," suggesting a balance. Concerns expressed were local jobs, equity, disaster resilience, and fish consumption.

8.1.2.2 Representative SG: Community Comments (CC)

SG Value ranks for this representative SG are based upon notes and transcriptions of public statements, presentations, comments, and questions made by community groups and members of the public at public meetings, seminars, and webinars on the Site cleanup plans (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c, and others). These meetings have been sponsored by a range of groups, and have been held at a range of venues, encompassing many neighborhoods and stakeholder and interest groups. Most had open question, answer, and comment periods, and all of these were transcribed. However, it should be noted that some groups and individuals were present and vocal at most meetings, so their viewpoints may be over-represented relative to other stakeholders. Not surprisingly, some of the more involved individuals have strong positions, often on a narrow number of issues. Thus, this SG's priorities differ in some respects from those represented in the St John's Community Café, with its focus on the triple bottom line, but some overlap. SG Value weights were developed using professional judgment based upon the value maps of these meeting notes (Appendix C). As one purpose of this exercise was to test the model's sensitivity to diverse priority sets, an attempt was made to emphasize these differences in SG priority weights, while still remaining consistent with the value map for this group.

The main issues of concern raised in these meetings include:

- Long-term risk reduction, and risk from fish consumption are concerns; worker health and safety is of less concern
- Permanence and certainty are major concerns
- Time is an important issue
- Impacts on the community are of concern (though it is expected that these can be mitigated)
- Cost is not a major concern, but the expectation is that large companies will carry the costs
- Jobs are a concern, but the expectation is that jobs will be gained

8.1.2.3 Representative SG: Business Groups (BG)

SG Value ranks for this representative SG were inferred using professional judgment based on documents commenting on the 2015 EPA FS (LWG 2015), interviews (e.g., NERA 2016) and discussions at project and other meetings, and business group statements and presentations at public meetings (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c; and others). Business groups include PRPs and other local businesses, which may also be affected by the Site and its cleanup. As one purpose of this exercise was to test the model’s sensitivity to diverse priorities, an attempt was made to emphasize these differences in SG priority weights, while still remaining consistent with the value map for this group. The main issues of concern include:

- Costs, time, uncertainty, and impacts on business viability
- Cost-effectiveness
- Impacts on business and infrastructure
- Implementability is important to remedy effectiveness
- Health and safety of worker is an issue of concern, as are reduction of human health risks in the short and long term

8.1.2.4 Representative SG: Tribal Groups (TG)

This is an important SG to consider due to the important role Tribal groups play in the region. Because of their historical sovereignty in the region, regional Tribes retain treaty rights in conditionally ceded and usual and accustomed lands (with historical use). Responsibility for protecting the natural resources is shared among federal and state agencies and Tribes who own, manage, or have an interest in the resources and who are named as Trustees of the resources on behalf of the public; many Tribes play a role on the Natural Resource Trustee Board. Tribal members have been active in having Portland Harbor listed as a Superfund site, and continue to play an active role in the outreach, commenting, and decision process (e.g., CAG 2015; Fricano et al. 2015; ODEQ 2015; Ward 2015). The Yakama Nation has been particularly active at public meetings, and other stakeholders and community members frequently comment on or inquire regarding Tribal viewpoints (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c; Ward 2015). Tribal groups have a significant stake in the health of the Willamette and Columbia Rivers. The Yakama Nation, and their representative, Rose Longoria, have been very active in public outreach and comment on the Site cleanup. The Tribes were very active in commenting on the 2015 EPA FS and attending public meetings about the remedial alternatives. It should be noted that The Confederated Tribes and Bands of the Yakama Nation, although a trustee for Portland Harbor, has withdrawn from the Trustee Council and is no longer participating with the Natural Resource Trustee Council in their restoration planning efforts, as they felt that all their concerns were not being addressed in that effort. SG Value weights for this representative SG are based upon notes and transcriptions of public statements, presentations, comments, and questions answered by Yakama Nation representatives at public meetings and seminars on the Site cleanup plans (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c; Ward 2015; and others; mapped in Appendix C). As one purpose of this exercise was to test the model's sensitivity to diverse priorities, an attempt was made to emphasize these differences in SG priority weights, while still remaining consistent with the value map for this group. Key issues include:

- Treaty rights and the protection of fish in the Columbia River are foci
- Remedy should be permanent and extensive
- Cost and short-term impacts are not of concern (except for fish tissue impacts)
- Fish consumption is important
- Focus is on the timescale of generations

8.1.2.5 Representative SG: City Survey (CS)

The City of Portland's Bureau of Environmental Services, in partnership with OKT, conducted an online consultation with Portland residents in March 2016 to better understand their opinions and values regarding cleanup of the Site in the Willamette River north of downtown Portland (DHM Research 2016). A total of 2,704 residents (including 67 via paper) responded to the survey. The raw data for both the paper and online versions were provided by OKT to DHM Research for processing and analysis. An analysis by DHM Research includes a summary of results as well as findings and examples of responses to open-ended questions (DHM Research 2016). Open-ended questions were not fully included in the report. Although the report states that all responses to open-ended questions are available upon request from OKT, requests to the City and OKT did not yield these, nor requested raw results. However, the data reported by DHM Research can be used to determine the SG priorities for the values addressed by the survey. Main points of the survey (DHM Research 2016) are the following:

- 98% of respondents agree that the river should be safe for fish and wildlife
- 95% of respondents agree that the river should be as clean as possible
- 93% of respondents agree that the cleanup plan should allow Portlanders to swim, boat, and play in the river
- 81% of respondents say it is important the cleanup minimizes cost to households in Portland
- 69% of residents agree that the river should be cleaned to as safe as possible for people, fish, and wildlife, even if some of the costs are passed on to Portland households
- 39% of respondents say it is important to them that cleanup occur more quickly, even if it means that the cost increases
- 72% of residents agree it is important that the plan considers potential positive and/or negative impacts on jobs
- 60% of residents agree that Portlanders should be able to eat an increased amount of resident fish, even if it means spending more for cleanup

8.2 Results, SG-weighted SG Value and pillar scores

When SG metric weights are determined, the SG-weighted SG Value scores are calculated as the MRW- and SG-weighted centroid ($V_{SG,r}$); the weighted average of the metric scores for a given SG Value:

$$V_{SG,r} = (\sum(M_i*MRW_i*W_{mSGi}))/ \sum MRW_i*\sum W_{mSGi}),$$

where M_i is the score assigned for each metric, MRW_i is the MRW assigned to that metric (see Section 6.2), and W_{mSGi} is the SG weighting for that metric. The centroid is used to ensure that the most relevant, quantitative, and standard metrics are given more weight than those less quantitative, relevant, or clearly linked to the SG Value, and to those more important to an SG.

Similarly, pillar (i.e., Environmental Quality, Economic Viability and Social Equity) scores are calculated as the SG-weighted centroid ($P_{SG,r}$); the weighted average of the SG Value scores for a given pillar:

$$P_{SG,r} = (\sum(V_i*W_{vSGi}))/ \sum W_{vSGi}),$$

where V_i is the score assigned for each SG Value, and W_{vSGi} is the SG weighting for that SG Value.

It is important to note that the value scores above take into account SG weights for the metrics that go into them, but not the specific value weight (which is not taken into account until the values are aggregated to generate pillar scores). For radar graphs in which the SG-relevant value scores are compared, without SG Value weights, the relative importance of metrics, but not values, is reflected in the graphs. To compare SG Value scores taking into account both SG Value and metric weights, value scores are multiplied by the SG Value weight:

$$V_{SG,r}\text{ (value weighted)}= (\sum(M_i*MRW_i*W_{mSGi}))/ \sum MRW_i*\sum W_{mSGi}) * W_{vSGi}$$

These scores are then SG metric and value weighted.

8.2.1 SG: Community Forum; results

Tables and figures supporting results are presented in Appendix D. Table D-21 shows the SG-weighted SG Value and pillar scores for the Community Forum; Figure D-4 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). A preference for permanence and effectiveness over other metrics of acceptable remedy results in higher scores for more extensive remedies (Figure D-4) when compared to equal weighting (Figure 7-1). Concerns about flooding risk and long-term stability results in higher relative scores for Resilience. Other than that, the relative scores of the different alternatives does not differ greatly for this SG, which was selected to represent a (somewhat) balanced set of priorities, compared to when all values are equally weighted. It should be noted that the SG Values illustrated in Figure D-4 are generated from metrics weighted based upon SG priorities (Tables D-2 through D-4).

However, different SGs also have different preference weights for different SG Values (Table D-1); these are taken into account when the SG Values are aggregated to pillar scores, but are not used to generate the numbers in Figure D-4. Figure D-5a, on the other hand, illustrates the SG Values, multiplied by their SG weights as a radar diagram; Figure D-5b illustrates the same data as stacked bars to illustrate how various values add up.

These weighted SG Values are then aggregated for the pillar scores. It should be noted that all approaches to multi-criteria assessment using scoring and weighting schemes, which seek to integrate and balance dissimilar data, have strengths, weaknesses, and artifacts. Different approaches provide different views of the information and may provide insights into how strong preferences for specific issues, metrics, or SG Values may drive a perception of optimal or more sustainable remedial strategies.

The pillar scores are illustrated in Figure D-6. When compared to equal value weighting (Figure 7-2), the concerns expressed in this forum for long-term risks over short-term ones, the low concern with cost-effectiveness, and the focus on permanence and effectiveness results in higher relative pillar scores for Alternative F in Figure D-6 than when all metrics and values are equally weighted (Figure 7-2). Nonetheless, the relative overall sustainability, for all three pillars, does not change, with the less aggressive options having higher scores than the more aggressive options, due to the short- and long-term environmental, economic, and social impacts of large-scale remediation.

8.2.2 SG: Community Comments, results

Table D-22 shows the SG-weighted SG Value and pillar scores for Community Comments. Figure D-7 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). A strong preference for permanence and effectiveness over other metrics of acceptable remedy results in a preference for more extensive remedies, when compared to equal weighting (Figure 7-1). In the Environmental Quality pillar, Resilience was given a higher weight than the other SG Values. Air Emissions were of greater concern than other issues for the SG Value of low-impact remedy. Long-term risk reduction (human and to fish and wildlife) was more important than short-term reduction. Jobs and infrastructure (primarily road traffic) were more important than other economic impacts. All social SG Values which were addressed were weighted as relatively important.

Figure D-8a, on the other hand, illustrates the SG Values, multiplied by their SG weights as a radar diagram; Figure D-8b illustrates the same data, as stacked bars, to illustrate how the values add up for each alternative. These weighted SG Values are then aggregated for the pillar scores. The pillar scores are illustrated in Figure D-9.

Given the heavy emphasis on social SG Values and permanence, the overall sustainability (Figure D-9) scores for more aggressive remedies (i.e., Alternatives E and F) are higher than they are for equal weighting (Figure 7-2), similar to the Community Forum (Figure D-6). This reflects the strong representation of a few individuals and SGs at community meetings, either as presenters or as questioners or commenters in the audience. Although questions and comments reflected a broad range of issues, the preponderance of comments on issues of permanence, and thus alternatives that remove the most sediment, in preference to other alternatives, are heavily weighted here. Nonetheless, if all SG Values are considered, the less aggressive alternatives (B and D) still score better overall, in the SG Value and pillar aggregations, if by a smaller margin. In a discussion of trade-offs, however, the focus can be on those issues where no alternative is a clear-cut “winner”—optimizing sustainability will require a focus on such issues.

8.2.3 SG: Business Groups, results

Table D-23 shows the SG-weighted SG Value and pillar scores for Business Groups. Figure D-10 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). A stronger preference for implementability and time-effectiveness over permanence and effectiveness as metrics of acceptable remedy results in a preference for less extensive remedies, when compared to equal weighting (Figure 7-1).

Figure D-11a, on the other hand, illustrates the SG Values, multiplied by their SG weights, plotted as radar diagrams; Figure D-11b illustrates the same data plotted as stacked bars to illustrate how the values add up for each alternative. These weighted SG Values are then aggregated for the pillar scores. The pillar scores, using the two weighting schemes, are illustrated in Figure D-12.

Although some values are the same as those of other community groups, this SG sets a high priority on Economic Vitality and Cost-Effectiveness. Resilience and Low Impact Remedies are the drivers of concern for Environmental Quality, and this SG, unlike the others, puts a priority on Worker Safety as a metric for the value of Human Health & Safety. Acceptable Remedy is an important value for this SG, but the metrics of importance for this value differ; this SG puts a much heavier emphasis on Implementability and Time-Effectiveness, and a lower emphasis on Permanence (and mass removal). Metrics of importance in the Social Equity pillar are Communication of Uncertainty and Amenability to Re-Use.

In aggregate, these values and priorities lead to a stronger differentiation between alternatives (Figure D-12) than for CF (Figure D-6) and CC (Figure D-9), with the less extensive alternatives (B and D) scoring much better than the more extensive ones (E and F) for most metrics. However, the relative overall ranking remains the same.

8.2.4 SG: Tribal Groups, results

Table D-24 lists the SG Value and pillar scores for the remedial alternatives, using the Tribal Groups SG weightings. Figure D-13 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). An extreme preference for permanence and effectiveness over other metrics of acceptable remedy results in a preference for more extensive remedies, when compared to equal weighting (Figure 7-1), to the extent that the Acceptable Remedy SG Value scores increase with increasingly aggressive options (unlike the scores for any other SG).

Figure D-14a illustrates the SG Values, multiplied by their SG weights, plotted as radar diagrams; Figure D-14b illustrates the same data as stacked bars, so that the sum of the values for each alternative can be seen. The fact that this SG has a strong preference for long-term removal and risk reduction, and little to no concern for short-term impacts (due to a stated focus on generations rather than decades), the differences between less and more extensive options, which are largely driven by short-term regional impacts, are greatly reduced when values are weighted by this SG's priorities. As some metrics are still of concern for most SG Values, most SG Value scores for the alternatives are still higher for Alternatives B and D than they are for Alternatives I, E, and F, but the differences are much smaller. This illustrates the importance of shorter-term regional impacts in the overall sustainability assessment, but also demonstrates the robustness of the overall assessment.

This SG has a strong stated preference for permanence of remedy. The focus is on the long term, on the scale of generations, not years. Value statements suggest that cost is not an issue, and that most short-term social, economic, and environmental (barring elevated fish tissue) impacts are not of concern, so any metric reflecting these has been weighted very low. These weighted SG Values are then aggregated for the pillar scores. The pillar scores are illustrated in Figure D-15. As noted, the strong preference for removal-linked metrics and the low priority given to many regional impacts, increases the social sustainability score of all active alternatives, but increases the score of Alternative F relative to the others, suggesting that the aggregated priorities of this SG are the most consistent with their stated objective—removal over all other concerns. Although it would be possible to collapse all metrics to a single point, there is some evidence of other metrics and values, and some short-term impacts, of concern to this representative SG. Because of this, the Environmental Quality and Economic Viability Scores remain higher for less extensive remedial options, which may result in less construction-induced contaminant mobility, habitat, and economic impact. This is because, although economic SG Values were not a stated priority for this SG, all their weights were not set to zero, and thus the aggregated scores are dominated by the metrics and SG Values that are not set to zero or low.

8.2.5 SG: City Survey, results

Table D-25 lists the SG Value and pillar scores for the remedial alternatives, using the City Survey SG weightings. Figure D-16 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). A strong preference for permanence and effectiveness over other metrics of acceptable remedy results in a preference for more extensive remedies, when compared to equal weighting (Figure 7-1). While overall cost was not a concern, some preference was stated for cost-effectiveness, job protection, and, to a lesser extent, local business. This results in a clearer differentiation between the economic SG Value scores for this SG than for the other community SGs CF (Figure D-5) and CC (Figure D-8). Fish and wildlife are a major concern, with stated concerns for both short- and long-term impacts to wildlife and habitats.

Figure D-17a, illustrates the SG Values, multiplied by their SG weights, plotted as radar diagrams; Figure D-17b illustrates the same data as stacked bars to demonstrate how value scores add up for each alternative. These weighted SG Values are then aggregated for the pillar scores. The pillar scores are illustrated in Figure D-18. Given the balance of priorities for this SG, the relative pillar scores for the different alternatives are more sharply differentiated for this SG (Figure D-17) than they are for CF (Figure D-6) or CC (Figure D-9), but are more similar to those seen when all metrics and values are weighted equally (Figure 7-2).

8.3 Uncertainty and sensitivity – comparative results, all SGs; determining community priorities

Although the SGs Business Groups and Tribal Groups can be seen as representatives of subsets of stakeholders (businesses and Tribal groups), it can be argued that equal weighting and the other three SGs—Community Forum, Community Comments, and City Survey—all seek to capture the relative priorities of the broader Portland community. As stated previously, all efforts at determining stakeholder and community priorities (whether inferred or elicited) are subject to challenges and potential bias. The four approaches to determining broad community priorities used here have the following characteristics:

- Equal weighting: This approach sought to identify the broadest possible stakeholder representation, and identified priorities by evaluating value-relevant statements in web pages, documents (on remediation, restoration, planning, and development), meetings, and interviews. This collected value evidence base suggested that community values are broad and diverse, and provided an argument for treating all values and metrics equally to ensure broad representation. This approach avoids giving specific groups undue weight. This may represent the interests of uninvolved or underrepresented groups.
- Community Forum: This approach mapped statements gathered in facilitated meetings to identified SG Values. This approach could be subject to bias in how these statements were mapped (or how they were recorded during and after the meeting), and is only representative of those who attended the forum, so this group is self-selecting. Thus, more engaged community members may have a disproportionate influence on outcomes. If certain values or metrics were not addressed in the meeting (or its notes) then they could not be reflected in the weights (if this was so, the same weights were applied to all unaddressed metrics and values).
- Community Comments: This approach mapped statements and comments made at public meetings about Portland Harbor Remediation onto SG Values. This approach could be subject to bias in how these statements were mapped. Furthermore, attendance, questions, and comments at a number of meetings were dominated by a few highly engaged individuals, so this group is self-selecting. Thus, the concerns and priorities of these individuals will be disproportionately represented by this approach. If certain values or metrics were not addressed in the meeting (or its notes) then they could not be reflected in the weights (if this was so, the same weights were applied to all unaddressed metrics and values).
- City Survey: The City survey asked a broad range of people (seeking diversity) a specific set of questions on their priorities. Some of these could be mapped easily onto SG Values or metrics used in this study. When they could, SG weights were proportional to the rate of response to relevant questions. If certain values or metrics were not addressed in the survey, then they could not be reflected in the weights (if this was so, the same weights were applied to all unaddressed metrics and values). While survey respondents are self-selecting inasmuch as they can choose whether to answer the survey, efforts were made to ensure diversity in responses. This approach developed elicited, rather than inferred, SG priorities, but only for a limited set of values and metrics.

Representing community values in a fair and representative manner is challenging, and is not an exact science. As can be seen, each of these approaches has strengths and weaknesses in terms of breadth, relevance, and representativeness. Together, they may be seen as a reasonable representation of the Portland community, but they also pose an opportunity for examining the uncertainty and sensitivity of this framework to SG diversity. When the value and metric-weighted scores for these different approaches to broad community priorities are compared (Equal weighting: Figure 7-1; CF: Figure D-5; CC: Figure D-8; CS: Figure D-17), it is noteworthy that these figures appear rather similar. In all cases, there is a clear separation between the alternative scores for most values, with the scores; the less extensive alternatives score higher than the more extensive. The largest differences are the relative differences in the SG Value “Acceptable Remedy”; the differences are driven by the degree of stated preference for permanence. These figures are also more similar to each other than they are to BG (Figure D-11) and TG (Figure D-14), both of which represent narrower SGs and represent distinct priorities, when compared to these broader community SGs. Thus, the approach, which is sensitive to the range of SG priorities (and how these priorities are determined), seems rather robust in its overall outcomes.

8.4 Uncertainty and sensitivity – adjusted vs. EPA time and cost numbers

The input tables that feed into the SVA calculations have used the adjusted time and cost numbers, as described in the environmental report (AECOM 2016). A large number of metrics in this framework, including downstream risk, contaminant mobilization, construction impacts, quality of life, recreation, socially optimal construction time, time-effectiveness, and fish consumption risk, have a time component; these affect a range of values and pillars. Similarly, costs affect economic vitality, jobs, and all aspects of cost-effectiveness.

Table 8-1 illustrates the relative difference in value and pillar scores, for equal value weighting, using the adjusted and EPA cost and time values. Green highlighted values have a higher score using the EPA values; red highlighted values have a lower score. As can be seen, a number of values that have cost-sensitive metrics are affected by the use of the EPA values. In particular, the SG Value Cost-Effectiveness, which has several cost-dependent metrics, is affected by cost differences. Fish & Wildlife, Low Impact Remedy, Infrastructure, Quality of Life & Recreation, Acceptable Remedy, and Health & Safety are all sensitive to time. Most time-sensitive metrics, which are scored relatively as a function of time, have lower scores using the EPA times. However, Acceptable Remedy has two metrics that are based on absolute times (time-effective remedy and time-effectiveness). These SG Values, not surprisingly, have higher scores using the EPA’s shorter construction times. Overall, the EPA values reduce the difference between Alternatives E and I. However, the relative alternative sustainability rankings overall remain the same. This can be seen with the evaluation of the row labeled “Average Sustainability Score” in Table 8-1. This score is the average of the three pillar scores for each alternative. As can be seen, the Pillar Average Score is lower for each alternative using the EPA costs and times, and the difference in this score for Alternatives E and I is smaller using the EPA numbers. However, the relative sustainability of the alternatives, the relative ranking of these Pillar Average Scores, remains the same.

Table 8-1. Comparison of SG-value and pillar, and overall scores, using adjusted and EPA cost and time values

Evaluation Criteria		Equal; adjusted time and cost						Equal; EPA time and cost						Equal score change from Adjusted time and cost					
		A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV	Environmental Quality	0.0	-1.5	-2.2	-2.7	-2.5	-4.3	0.0	-1.7	-2.4	-2.8	-2.6	-4.3	0.0	0.2	0.2	0.0	0.1	0.0
ECON	Economic Viability	0.0	-0.6	-2.3	-3.7	-3.3	-7.5	0.0	-0.7	-2.9	-4.2	-4.0	-7.5	0.0	0.1	0.6	0.5	0.6	0.1
SOC	Social Equity	0.9	0.4	-0.2	-1.1	-0.7	-3.5	1.4	0.3	-0.5	-1.0	-0.9	-3.5	0.5	0.1	0.2	0.1	0.1	0.0
Average Sustainability score		0.3	-0.6	-1.6	-2.5	-2.2	-5.1	0.5	-0.7	-1.9	-2.7	-2.5	-5.1	0.2	0.1	0.3	0.2	0.3	0.0
Label	**Value**	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV-1	Fish & Wildlife	0.0	3.2	3.3	3.4	3.4	3.0	0.0	2.8	2.7	3.2	3.0	3.0	0.0	0.5	0.5	0.1	0.4	0.0
ENV-2	Habitat	0.0	-3.9	-5.3	-6.7	-6.0	-10.0	0.0	-3.9	-5.3	-6.7	-6.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0
ENV-3	Resilience	0.0	-1.0	-1.3	-1.0	-1.1	-0.1	0.0	-1.0	-1.3	-1.0	-1.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
ENV-4	Low Impact Remedy	0.0	-4.5	-5.4	-6.6	-6.2	-10.0	0.0	-4.7	-5.6	-6.6	-6.3	-10.0	0.0	0.2	0.2	0.1	0.2	0.0
ECON-1	Economic Vitality	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	0.0	0.0	0.0	0.0	0.0
ECON-2	Jobs	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0
ECON-3	Infrastructure	0.0	-2.1	-3.8	-4.9	-4.7	-7.9	0.0	-2.3	-4.3	-5.0	-5.1	-7.9	0.0	0.3	0.4	0.1	0.3	0.0
ECON-4	Cost Effectiveness	0.0	4.8	2.5	1.1	1.5	-2.1	0.0	4.8	0.5	-0.9	-0.6	-1.9	0.0	0.0	2.0	2.1	2.2	0.3
SOC-1	Quality of Life & Recreation	0.0	-2.9	-4.3	-5.9	-5.1	-10.0	0.0	-3.4	-4.9	-6.1	-5.5	-10.0	0.0	0.5	0.6	0.2	0.5	0.0
SOC-2	Community Values	0.1	0.1	0.2	0.2	0.2	0.0	0.1	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOC-3	Acceptable Remedy	3.6	3.5	2.9	2.0	2.2	-0.1	5.4	4.3	3.3	2.7	2.6	-0.1	1.9	0.8	0.4	0.7	0.4	0.0
SOC-4	Health & Safety	0.0	0.9	0.2	-0.8	-0.3	-3.7	0.0	0.3	-0.4	-1.0	-0.8	-3.7	0.0	0.6	0.7	0.1	0.4	0.0

Table 8-1 notes: Change is the absolute difference between scores. When EPA costs and times result in higher scores; these cells are highlighted green; if they result in lower scores, they are highlighted in red. “Pillar Average Score” is the average of the pillar scores for an alternative.

8.5 Uncertainty and sensitivity – overall alternative scores

Figure 8-2 illustrates the stacked SG Value scores for all alternatives and SGs. Although the metrics feeding into these SG Value scores are weighted based upon SG preference, the SG Values are not. Figure 8-3 illustrates the SG Value scores with the scores weighted using both metric and SG Value weights. In theory, then, there are scenarios where a single-issue SG could weight a single (or a few) SG Values heavily and set other weights to 0. (The TG SG is the closest to such an example, although a number of metrics and values are still considered.) This would essentially collapse the sustainability assessment to a single or narrow-issue assessment not unlike a stand-alone risk assessment or economic assessment (but not, it should be pointed out, like CERCLA-linked NEBA, which is another multi-criteria approach that aggregates, scores, and weights metrics with a CERCLA, rather than a social SG Values, focus). While Section 7 sought to evaluate the effects of SG Value priorities from representative SGs with diverse priorities, no single-issue assessment was carried out, though this could easily be done using the SVA tool.

Figure 8-2, with the metric-only weighted SG Values (for all alternatives and all SGs considered), shows a clear ranking of net SG Value scores, with progressively lower net scores for the more aggressive alternatives. This trend is generally independent of SG, though SG Value weights for Resilience by the SG Community Forum and the discounting of short-term impact-related values and metrics by the SG Tribal Groups make these trends less clear-cut. However, a closer look makes clear that the difference between remedial alternatives is driven not by increased benefits for the higher-scoring alternatives, but by increasing negative impacts for the more extensive alternatives. The sum of the SG Values with positive benefits (the bars above the zero line) shows a slight decrease for the more extensive alternatives, even when individual SGs are broken out. Most of the SG Values that have generally positive scores (Fish & Wildlife, Health & Safety, Acceptable Remedy, Cost-Effectiveness and Community Values) are scored using metrics with both positive and negative values. Some metrics have higher scores and some have lower scores for the more extensive alternatives. These SG Values and metrics are among those that are most frequently reflected in SG priority differences. There are somewhat decreasing net benefits scores across the alternatives (with minor trends for some SGs) for these SG Values. On the other hand, the SG Values which have net negative scores, the environmental, economic and social impacts of a large remediation, increase as the remedial alternatives become more extensive.

This difference between the trends for risks and benefits, or for desirable and undesirable impacts, is still seen in Figure 8-3, when SG Values are weighted considering both metric and value weights. Although there is a bit more noise in the trends, net negative impacts increase clearly across SGs for the more extensive alternatives, while net benefits, though less consistent, show no clear trends. Figure 8-4 illustrates SG Values weighted considering both metric and value weights, but with scores using EPA costs and times. As can be seen, there are some differences in values with cost- or time-dependent metrics, resulting in subtle changes in the importance of SG Values such as Cost-Effectiveness between SGs, but the overall results remain largely the same.

Figure 8-5 illustrates the pillar average score (the average of the scores for each pillar) for each alternative, with each SG weighting scheme, with adjusted and EPA costs and times. As can be seen, although there is variability in overall sustainability score within an alternative, depending on the weighting scheme and the cost and time data used, the overall trends between alternatives hold. There is less of a difference in net negative impacts for Alternatives B, D, and I.

For each SG's values, the net negative impacts increase with more aggressive alternatives, and increasingly outweigh the benefits as more aggressive alternatives are considered. However, across SGs, the delineation between remedial alternatives is less clear. Given the wide range of environmental, economic, and social impacts of large-scale remediation, the trend towards greater negative sustainability scores for the most extensive alternatives holds, regardless of which metrics, values, risks, and benefits various SGs prioritize.

Thus, it is clear that the SVA assessment framework is sensitive to various stakeholder inputs—the relative SG Value and pillar scores change in response to different SG priorities, identifying trade-offs, opportunities for optimization, and sources of potential disagreement. However, the conclusions are robust—regardless of the weighting approach used, from equal weighting to absolute weighting using plausible inferred values from "endmember" representative SGs, the overall SG Values-based sustainability score of the Portland Harbor remedial alternatives can be ranked as:

Alternative B ≥ Alternative D > Alternative I > Alternative E >> Alternative F

8.6 Final note

Although inferred SG Value priorities were, for the most part, used to test this approach, the SVA tool can be used to automatically assess, score, and graph the social sustainability SG Values using a variety of inputs from surveys, workshops, or other sources; can test the implications of the SG Value priorities of a specific SG; or can be used to provide inputs into more formalized tools such as MCDA. Should such information or tools become available, the outputs of this report will be further tested and validated.

It should be noted that a few issues drive the relative rankings of these alternatives:

- All options under consideration (barring Alternative A) have targeted removal of higher concentrations as part of their design, and
- Regional background contaminant levels limit the degree to which any remedial option can reduce risk.

Thus, the net risk reduction for more extensive options is easily dwarfed by their impacts, as this assessment focused on evaluating a set of remedies in the 2016 EPA FS, after they were developed. For this tool to be more useful in optimizing sustainable options, a range of remedial options, with a broader range of potential risk reduction, could be evaluated, to identify the point where benefits are overwhelmed by impacts. Alternatively, an identification of the risks and benefits of most interest to SGs can allow for negotiation and optimization of alternatives under consideration, to collaboratively design more sustainable options.

Table 8-2. Summary of SG weighted pillar scores

Sustainability Pillar	EPA Remedial Alternative	Equal Weight	SG Weighted				
			CF	CC	BG	TG	CS
Environmental Quality (ENV)	B	-1.2	-0.6	-0.8	-1.1	-0.4	-0.4
	D	-1.6	-0.8	-1.1	-1.5	-0.8	-0.9
	E	-1.9	-0.9	-1.2	-2.0	-1.2	-1.3
	I	-1.7	-0.8	-1.1	-1.7	-1.0	-1.1
	F	-2.7	-0.9	-1.5	-3.1	-2.3	-2.4
Economic Viability (ECON)	B	-0.6	-1.8	0.1	-0.3	-2.3	0.9
	D	-2.3	-3.2	-1.5	-1.8	-3.5	-0.9
	E	-3.7	-4.6	-3.0	-3.1	-4.9	-2.5
	I	-3.3	-4.3	-2.7	-2.8	-4.6	-2.1
	F	-7.5	-8.8	-7.0	-6.8	-9.1	-6.6
Social Equity (SOC)	B	0.4	1.0	1.1	1.3	1.8	-0.1
	D	-0.2	0.6	0.6	0.7	1.7	-0.8
	E	-1.1	-0.1	-0.2	-0.2	1.6	-1.7
	I	-0.7	0.2	0.2	0.1	1.7	-1.2
	F	-3.5	-1.9	-2.1	-2.3	1.0	-4.1

CF = Community Forum
CC = Community Comments
BG = Business Groups
TG = Tribal Groups
CS = City Survey

(green)	= greater than +0.8
no color	= between +0.8 and -1.9
(gray)	= -2.0 to -3.9
(blue)	= less than -4.0

Figure 8-2. SG Value scores for all alternatives, all SGs. SG Values based upon SG-weighted metrics, SG Values unweighted

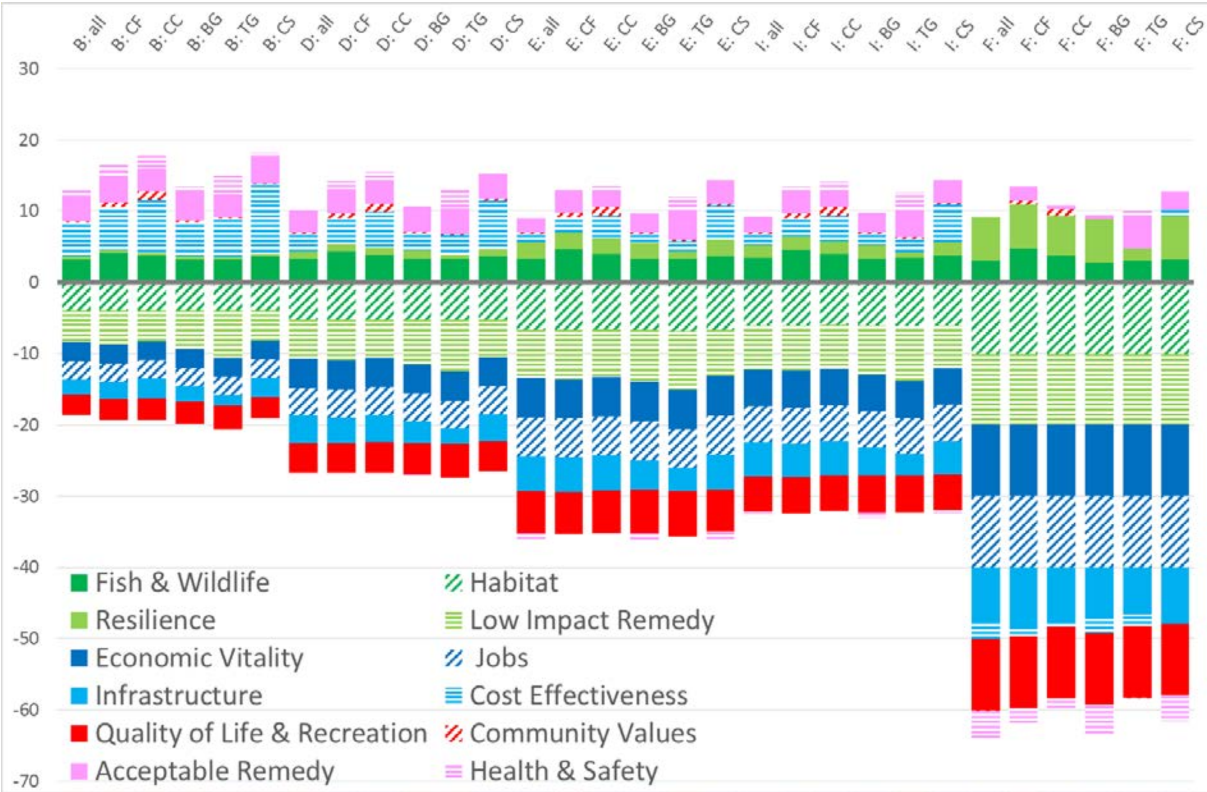


Figure 8-3. SG Value scores for all alternatives, all SGs. SG Values based upon SG-weighted metrics. SG Values weighted, Adjusted times and costs in input table

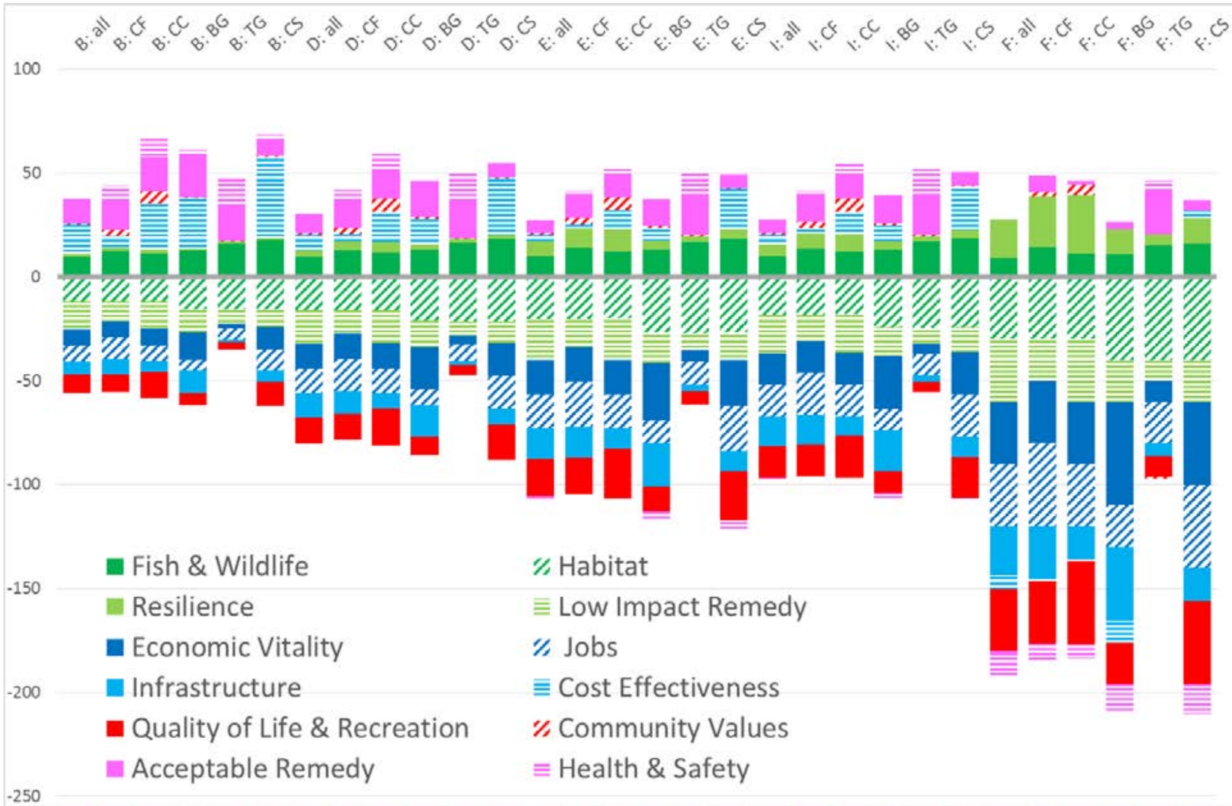


Figure 8-4. SG Value scores for all alternatives, all SGs. SG Values based upon SG-weighted metrics. SG Values weighted, EPA times and costs in input tables

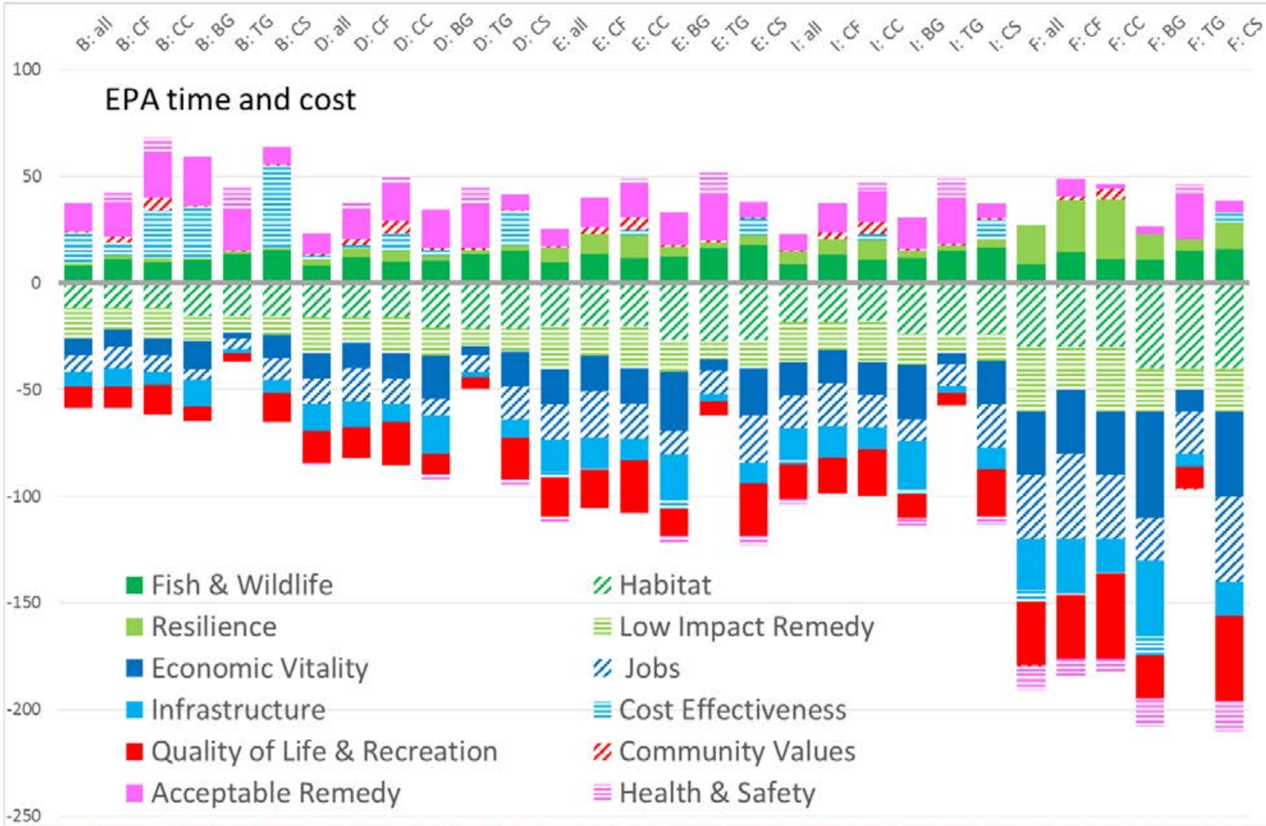
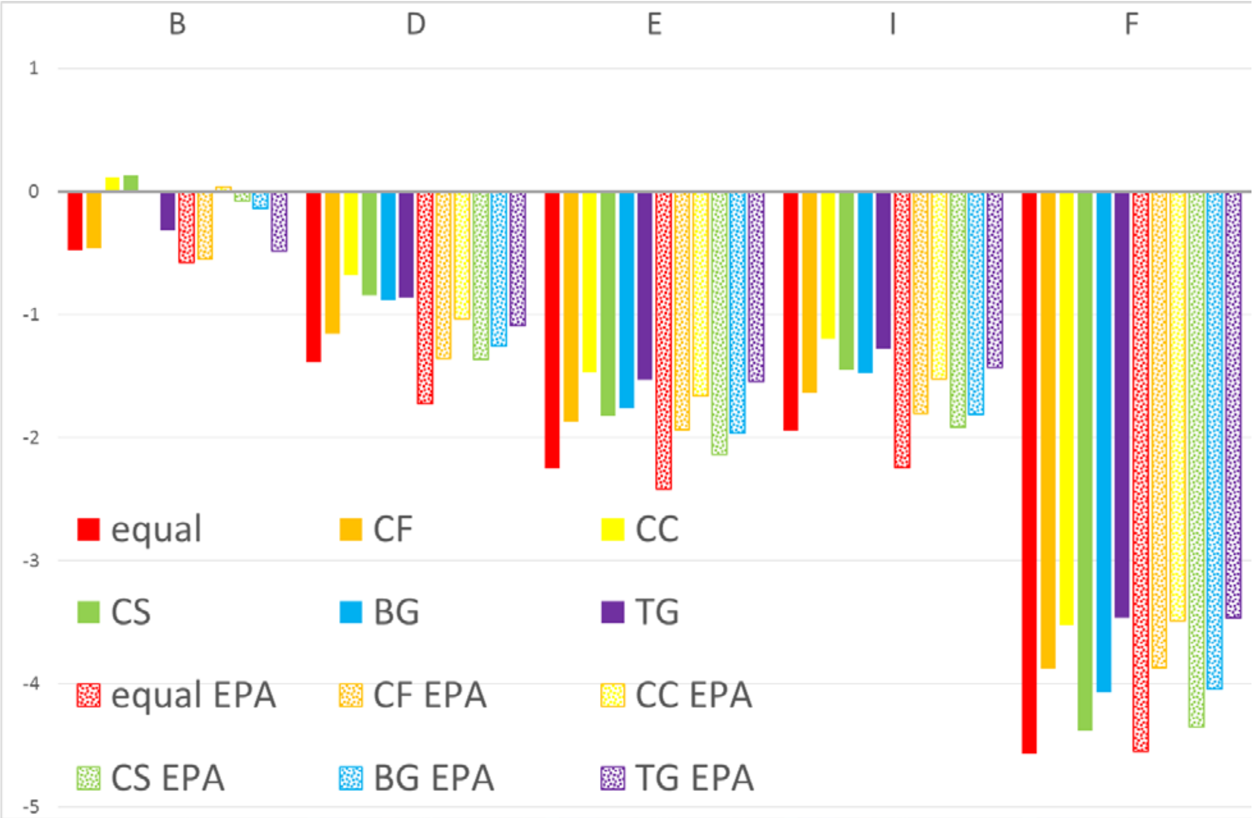


Figure 8-5. Overall sustainability score (the average of the scores for each pillar) for each alternative, with each SG weighting scheme, with adjusted and EPA costs and times



9. Closure

This report has been prepared for the sole benefit of the Portland Harbor Sustainability Project. This report may not be relied upon by any other person or entity, other than for its intended purposes, without the express written consent of SEA Environmental Decisions, Ltd., AECOM, and ExxonMobil. This report was undertaken exclusively for the purpose outlined herein and was limited to the scope and purpose specifically expressed in this report. This report cannot be used or applied under any circumstances to another location or situation or for any other purpose without further evaluation of the data and related limitations. Any use of this report by a third party, or any reliance on decisions made based upon it, are the responsibility of such third parties. SEA Environmental Decisions, Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

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This report was prepared by Sabine E. Apitz, Ph.D. If you have any questions regarding the contents of this report, or require any additional information, please do not hesitate to contact the author.

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Appendix A

Background for Methods Development

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Background for Methods Development

A.1 Tools for Evaluating Sediment Remedial Alternatives – From Presumptive Remedies to Sustainable Solutions

Internationally, sediment management issues are highly politicized and often newsworthy. Not surprisingly, given the complex environmental issues and the enormous potential costs, in some cases, the remediation/disposal decision process can be very adversarial (NRC 1997, 2001, 2007).[1] In the early 1990s, many regulators (and site owners) thought that removal and treatment of contaminated sediments, rather than any in place (in situ) management strategy, would or should be the presumptive remedy of choice. Thus, much sediment-related research and development (R&D), in North America and Europe pursued technologies to support such an approach at that time. However, based upon potential volumes, the social, environmental, and economic impacts of the indiscriminate or presumptive use of such an approach are prohibitive, and in-place management (where possible) or disposal, containment, or beneficial re-use of sediments is now pursued when possible.

There is an increasing use of (and policy requirement for) comparative risk assessments (CRA), multi-criteria analysis (MCA) or similar tools that consider all risks (and, at times, benefits) of a remedial alternative, including those of removal, residuals, treatment, transport, and disposal. Results from these provide a body of evidence that suggests that sediment removal for remedial purposes can result in uncertain or, at times, greater human health risk and ecological damage than in-place management strategies (Bridges et al. 2006; Wenning et al. 2006; Bridges et al. 2008), or, after great expense, not show measurable ecological improvement (SMWG 1999; Thibideaux et al. 1999). While there continue to be gaps in our knowledge of the fate of contaminants in place, and the effects of in place and ex situ remedial strategies, which must be filled if management strategies are to be compared and chosen wisely (Apitz et al. 2005; White and Olfenbuttel 2006; Förstner and Apitz 2007), extensive research has been carried out in the last decade or two that helps inform risk-based remedial and disposal decisions (EPA/USACE 1991; NRC 1997; PIANC 1998; USAEWES 1998; EPA/USACE 1998; Cura et al. 1999; Porebski et al. 1999; ICES 2000; IMO 2001; NRC 2001; Munns et al. 2002; PIANC 2002; USACE 2003; Cura et al. 2004a; GLC 2004a, b; Eek et al. 2006; OSPARCOM 2006; PIANC 2006a, b; NRC 2007; Osborne 2007; IMO 2009; PIANC 2009b, a).

United States (US) Environmental Protection Agency (EPA) guidelines suggest that “All remedies that may potentially meet the removal or remedial action objectives…should be evaluated prior to selecting the remedy” (EPA 2002); careful planning is necessary to ensure that sampling and analysis plans are designed to address these disparate needs in a meaningful and comparable way. While it is entirely feasible to develop decision frameworks based on goals other than risk management, within an environmental context, risk-based decision making is widely considered the most appropriate foundation

[1] *References cited in the Appendices are included in Section 10 of the main text.*

for evaluating the feasibility of contaminated sediment management strategies. Effective risk-based decision-making is informed by three fundamental principles: (1) adverse conditions are driven by site-specific factors, (2) uncertainty is always present, and (3) risks are managed, and only rarely eliminated (Bridges et al. 2006).

To some extent, the evolution of sediment decision-making can be seen as an expanding perspective on what are appropriate endpoints of a risk assessment, moving from purely ecological or human-health risks of in situ sediments, to a broader, systems-based perspective that examines pathways of ecological and human, as well as broader environmental, economic, and social risk throughout the lifetime of a remedial project, at a range of spatial and temporal scales. The scope and scale of this perspective, and the risks and endpoints considered, can significantly alter what is considered the most optimal alternative.

The use of ecological risk assessment (ERA) to determine whether sites present a risk that requires remedial action is now well established in North America, and is increasingly used in Europe and elsewhere. The use of quantitative risk assessment, as well as comparative assessment in the sediment remedy selection process, and during the design and implementation of the preferred remedy is becoming increasingly important. This approach seeks to predict net reductions in ecological and human health risks (primarily to fish consumers) as a function of various remedial approaches and to quantify post-remedial risk reduction and the overall effectiveness of the remedy itself relative to remedial action objectives (RAOs). This approach provides the balanced information necessary to make a site-specific, science-based decision about the best available approach to managing risks at a given site. The emergence of sustainability-based remediation decisions expands this paradigm, considering not just ecological risks, but also the economic and social risks and benefits of remedial alternatives.

A quantitative risk of remedy analysis compares different sediment remedial/disposal alternatives. Economic impacts, implementation risks to workers and the local community associated with transportation, construction, and operation of the remedy should be considered, as should short-term ecological risks during construction and operation such as habitat loss, water quality impact, recreational activities, and impacts on aquatic life (NRC 1997; Wenning et al. 2006; Osborne 2007). If sediments are to be managed in place, the risks of in-place exposure must be evaluated, while sediments that are removed and then treated or contained pose exposure risks during removal, transport, treatment, and during and after disposal. While dredging may remove contaminants from the aquatic system (although there are a number of concerns about residual risks that will be addressed below), simply moving risks to other regions may be inconsistent with the basin-scale and regional-scale objectives. Thus, decisions that only address a single, sectoral regulatory driver (such as a desire to remove contaminants from a water body) may result in a net detriment to the environment, and the consequences of such choices require a policy-based evaluation.

A shift from presumptive upland disposal actions to CRAs seeking to balance the net risks of all aspects of the management process in order to maximize benefits to various objectives, whether they are to human or ecological health, ecosystem services, or some combination of these, requires a regulatory and policy framework in which RAOs are based upon risk, rather than on mass removal of contaminants. If regulatory criteria are simply based upon the net removal of contaminants from a water body, or on absolute chemical criteria, rather than on minimizing pathways of contaminant exposure in the food chain (whether by removal, isolation, sequestration, or other means), then the criteria described here are moot. Clearly, the science used to inform management decisions must be relevant and appropriate to local, regional, national, and/or international policies. Otherwise, it is essential that scientists and decision makers work together to ensure that RAOs are driven by regional risk reduction with an aim towards basin-scale good ecological (and, increasingly, social and economic) status, rather than by simple chemical thresholds that may result in moving risks from one area or set of receptors to another. This will require a focused effort to ensure that decision frameworks are underlain by models and measures that clearly and explicitly link sound science to well-thought-out policy and objectives.

Palermo et al. (2008) produced a guidance document that provides approaches and models for addressing various aspects of assessing and controlling the risks of the dredging and disposal of contaminated sediments. They point out that any remedial dredging or navigational dredging of contaminated sediment is preceded and followed by a number of processes ultimately leading to sediment disposal or re-use, and that the potential risks of all these steps must be considered in an overall comparative risk assessment, as well as in the design of monitoring strategies. The principles, although applied to navigational dredging, provide useful insights for the evaluation of remedial removal as well. It is important to remember that any sediment treatment technologies may have several pre-treatment, treatment, and disposal and/or re-use steps, which may introduce various pathways of exposure to humans and the environment. Such potential exposures differ in many details as a function of the technology selected; many treatment technologies are selected because, although they may create a number of relatively short-term exposure pathways, they are generally expected to significantly reduce long-term exposure risks when compared to containment approaches, but this assumption should be examined on a project-specific basis.

NRC (1997) stated:

> Contaminated sediments can best be managed if the problem is viewed as a system composed of interrelated issues and tasks. Systems engineering and analysis are widely used in other fields but have not been applied rigorously to the management of contaminated sediments. The overall goal is to manage the system in such a way that the results are optimized. In particular, a systems approach is advisable with respect to the selection and optimization of interim and long-term controls and technologies. Although unlimited time and money would make remediation of any site feasible, resource limitations demand that trade-offs be made and that solutions be optimized. A fundamental aspect of the committee's recommended approach is the delineation of the trade-offs among risks, costs, and benefits that must be made in choosing the best course of action among multiple management alternatives. A number of decision-making tools can be used in making these trade-offs. Available tools include risk analysis, cost-benefit analysis, and decision analysis.

In this systems-based review of contaminated sediment management, NRC (1997) described an approach to balancing various competing aspects of the decision process, and taking stakeholder views into account. Case studies were presented, in which a number of parameters were converted into financial costs and benefits to inform the decision process. The interconnectedness of various aspects of the process were described; this was an early example of a comparative risk assessment for contaminated sediment management, considering processes now addressed in sustainability assessments. Some of these approaches were further described in Pavlou and Stansbury (1998).

Expressing ecological processes and resources in terms of the goods and services they provide links our scientific understanding of the environment to socioeconomic factors. Understanding how various human activities affect ecosystem functions, and how this can be integrated into decision-making is a rapidly evolving field (e.g., Apitz 2013). However, while this and other methods have been proposed in which the values of less tangible ecosystem services are translated into purely economic terms that can be balanced against the value of (sometimes less sustainable) goods, such approaches have at times been met with hostility and suspicion (e.g., Blacker 2012; Redford and Adams 2009).

Other tools, such as multi-criteria decision analysis and regional risk models, in which ecosystem services, river basin objectives, or a diverse set of ecological and socioeconomic assessment endpoints are compared, may, if well designed, allow for a more explicit or less controversial balance of these issues. How one ranks potential risks and benefits to various receptors, goods, and services is a societal and policy decision, but it is important that sound science is developed and clearly communicated to inform such decision frameworks (Apitz 2008). Green and sustainable remediation frameworks (e.g., EPA 2012) have emerged to help inform such decisions.

EPA (2005) provides guidance on factors to consider when comparing sediment remediation approaches. It states that “A risk management process should be used to select a remedy designed to reduce the key human and ecological risks effectively. Another important risk management function generally is to compare and contrast the costs and benefits of various remedies.” A number of PIANC documents (PIANC 2002, 2006b, 2009b) provide specific guidance on the assessment of the risks of various aspects of the dredged material management process, and suggest that these aspects must be taken into account in the selection, design, and monitoring of strategies. However, they do not provide a specific framework for a comparative assessment. Similarly, EPA and US Army Corps of Engineers (USACE) provide extensive guidance on the assessment of dredged material management and disposal options (USACE 1987, 2003; EPA/USACOE 2004).

Cura et al. (2004a) reviewed the status of CRA within the context of environmental decision-making and evaluated its potential application as a decision-making framework for selecting alternative technologies for dredged material management. They pointed out that comparative risk assessment, however conducted, is an inherently subjective, value-laden process. Although this raises objections by some, due to its perceived lack of scientific objectivity, it is important to remember that sediment management frameworks are not purely scientific tools, but rather, when properly designed, are tools for using science to inform decisions within a policy-based structure. Thus, the fact that the application of comparative risk assessment in the decision-making process at sediment management facilities has an element of value and professional judgment in the process is not a failing. Rather, it is a tool that can be used to balance science and judgement in a systematic and transparent manner. They recommended that those who wish to apply CRA for sediment management should develop a method that is logically consistent and allows for uncertainty by comparing risks on the basis of more than one set of criteria, more than one set of categories, and more than one set of experts. It should incorporate a probabilistic approach where necessary and possible, based on management goals.

Driscoll et al. (2002) applied these principles to the evaluation of contaminated sediment disposal options in case studies. Management alternatives included aquatic containment facilities, upland containment, and treatment with beneficial re-use. As an important consideration in the selection of an appropriate alternative is the evaluation of potential risks to ecological and human receptors, their studies applied frameworks for a screening-level ecological and human health risk assessment that compared risks associated with management alternatives for contaminated dredged materials. The major objectives of the work were to identify exposure routes that show the potential for risk and develop a framework that can be used to compare relative potential risks among eight management alternatives. They suggested that managers could use these CRA frameworks to:

- identify characteristics of the placement/treatment alternatives that contribute to potential risk,
- choose one alternative over another for sediments with high concentrations of contaminants,
- implement controls that mitigate risk, or
- identify the need for a more comprehensive site-specific risk assessment.

The CRA they carried out used modeled exposure and effects; no bioassays were carried out. Ecological risks were ranked based upon the number of complete exposure pathways, and modeled hazard quotients for a number of exposure pathways. Food chain, cancer, and acute risk were estimated using models and a number of assumptions about exposure extent and routes. To carry out such detailed comparisons, there was the need for detailed ecological and human health conceptual models identifying all potential exposure pathways for the entire dredging and disposal process. Based upon these conceptual models, the chosen criteria were evaluated for each alternative, and compared. While this approach provided a systematic manner in which to compare disparate disposal options, it is important to note that a number of simplifying assumptions are embedded in the calculation of each parameter. While providing bases for addressing disparate parameters across dissimilar disposal options, this paper did not provide a basis for weighting and balancing the different parameters, as had been done based upon cost in previous approaches.

These and related case studies were taken further when Linkov et al. *(*2006) and Yatsalo et al. (2007) applied multi-criteria decision analysis (MCDA). MCDA methods are tools that help evaluate and choose among alternatives based on multiple criteria using systematic analysis that overcomes the limitations of unstructured individual or group decision making (Yatsalo et al. 2007). They tested different MCDA methods on two case studies involving contaminated sediment management, and showed that different MCDA tools pointed to similar management solutions no matter which tool is applied, although each method had strengths and weaknesses.

These and a number of subsequent related papers coming from same group (Cura et al. 2004b; Hunter and Ghosh 2004; Bridges et al. 2005; Linkov et al. 2005; Kiker et al. 2006; Linkov et al. 2006; Kiker et al. 2007; Linkov et al. 2007; Kiker et al. 2008) have discussed the role of CRA and MCDA in the selection of remedial and disposal options. However, the focus of these papers has been on the decision process and how the priorities of various stakeholders or decision makers can be taken into account in the decision process. There has often been a careful assessment of the ranking procedure; but there is less critical review of the selection and derivation of the criteria, metrics, or indicators that are to be ranked. As these papers continued to focus on the MCDA process, the basis of criterion selection and derivation was increasingly lost. In fact, many of these papers only address it peripherally in referring to one of a network of interrelated papers, leading back to the first. However, Driscoll et al. (2002) does not purport to critically assess the appropriateness of the criteria used, but rather to provide a case study for discussion. Thus, while this approach has been a promising and much-invoked one for making sediment management decisions, there is still a need to critically assess the selection and development of criteria, and whether they are appropriate to the scientific and policy objectives of a given program.

Recently, the application of broader assessments has fallen under the mantle of sustainability assessment. EPA (2012, 2013) is promoting Green Remediation, which focuses on reducing the “footprint” (e.g., energy and water use, emissions, materials use, waste production, and impacts on ecosystem services) of remediation practices, but the focus is on best management practices to improve remediation after remedy selection. Sustainability assessment should consider the balance between environmental, social, and economic factors. Considering all these factors goes beyond the “footprint” of approaches to examine the broader trade-offs. In general, sustainability issues will not supersede those of risk and cost; but will deepen the analysis for broader, more informed decisions.

To that end, Bardos et al. (2012) reviewed approaches to sustainability assessment for sustainable remediation. They identified three categories:

- Qualitative appraisal
  - A simple assessment of the sustainability aspects of options
- Multi-criteria analysis
  - A more formal approach in which indicators of sustainability are scored, possibly weighted, and ranked
- Monetized cost-benefit analysis

- o The application of monetary values to all impacts and benefits to generate a single, monetary indicator

SuRF-UK (2010) provided a framework for the assessment of sustainability in soil and groundwater remediation. This was modified for sediments (in particular, for dredged material management) in Vivian et al. (2011). Recent papers update the MCDA approach to sediment decision-making by applying sustainability principles to indicator selection (SMOCS 2013; Linkov 2014; Sparrevik et al. 2011); a review of the indicators used can be found in Section 2.2.1 of this report.

A.2 Weight of Evidence Approaches to Integrating Lines of Evidence

While most, but not all, sediment management decision frameworks are risk-based and built upon our scientific understanding of ecological risks of various processes, they are tools for implementing policy. Many aspects of these frameworks, such as how lines of evidence (LOEs) will be combined, and what decisions they lead to, are quite clearly policy decisions. What is less clear is that even more seemingly scientific aspects, such as the development of toxic risk standards and the selection of bioassays, are permeated with policy choices. Wagner (1995) has stated that "…contemporary science can provide only partial answers to pressing environmental problems, (but that) this limitation is esoteric and often escapes the lay observer." Thus, the development of standards and tools, intentionally or inadvertently, fall victim to a "science charade" in which "the capabilities of science (are) susceptible to …overstatement," and the role of science, trans-science (questions that can be asked of science and yet cannot be answered by science, and are thus addressed by policy) and policy can be unclear (Wagner 1995). Although this mix may be appropriately applied as tools and frameworks are being developed for a specific application, when the lines between the science and policy choices are blurred, we lose our ability to be adaptive, and this poses risks as tools are applied to different management decisions, regulatory frameworks, and policy priorities.

As various countries are developing and refining their decision frameworks in light of changing policy and emerging science, there is a need to critically assess the science and policy embedded in various choices, including chemical action levels; how various chemical data are combined; the selection of biotests; how tests and decisions are combined and/or tiered; and how emerging chemicals, endpoints, and changing priorities will be addressed. While there are no inherently right or wrong answers to these questions, it is important to be clear about how these choices affect our ability to implement desired policy in a scientifically defensible way. The implications of such choices in a dredged material disposal framework are much different than they would be in, for example, a basin-scale sediment risk assessment or a remedial study.

A.2.1 Multiple Lines of Evidence

Whereas there is strong evidence of anthropogenic impacts on benthic communities at many sediment sites, the degree of toxicity (or even its presence or absence) cannot be predicted by contaminant concentrations alone. According to Wenning et al. (2005), a sediment ERA should include lines of evidence derived from several different investigations. One common approach to developing several of these lines of evidence in a decision framework is the triad approach. Triad-based assessment frameworks require evidence of hazard and exposure (generally based on sediment chemistry, toxicity, benthic community structure, and, sometimes, evidence of bioaccumulation) to designate sediment as toxic or requiring management (Chapman et al. 1996). However, the three lines of evidence do not always agree; thus, there are various ways to interpret LOE results in a weight of evidence (WOE) approach. One of the simplest is a decision matrix, such as the one laid out in Chapman (2007) and various other papers.

While decision matrices are seemingly simple, how one arrives at the decision of “pass” or “fail” for each LOE is in itself a complex, and often unaddressed, mix of science, trans-science, and policy. The complexity and implications of various approaches to interpreting the chemical LOE are reviewed in Apitz (2008a).

In some guidance for sediments (e.g., Chapman 2008), the objective is to determine whether there is a WOE to justify management actions for contaminants causing impacts in sediments. Thus, the LOEs are interpreted to determine whether there is a need to manage sediment or to carry out further investigations. In comparative assessments as the one in this study, on the other hand, is a different question: What is the most sustainable management strategy? This poses a more precautionary question, as it does not look for sufficient information to initiate a cleanup action, with all its inherent risks and uncertainties, but rather seeks to ensure that a proposed action does not result in disproportional risk or cost for the desired risk reduction. The lines of evidence and, perhaps, the standard of proof are different for these two management questions.

Chapman and Hollert (2006) pointed out that toxicity alone does not drive risk in sediments. Rather, a broad range of stressors can impact benthic, pelagic, and other communities. How risk should be assessed depends on details of its application and interpretation, but it is important to note that, as the risk of sediments to be moved, rather than the risk of sediments in place, is to be examined, each issue must be carefully considered.

Clearly, various LOEs can provide conflicting evidence on the degree of potential impact from sediments, as well as from actions to manage sediments. Furthermore, due to differences in scientific basis, study design, and method sensitivity, different methods have different degrees of uncertainty, and differing degrees of relevance to a given value. To integrate various LOEs in a systematic and transparent way, it is important to take these differences into account. For example, in characterizing ecological risks, considerable consensus building and professional judgments are required to develop conclusions about risk. This is because the approaches used to evaluate all the factors that determine ecological risk are often not well defined and are subject to interpretation (Johnston et al. 2002).

A.2.2 Weight of Evidence

WOE is the process by which multiple measurement endpoints are related to an assessment endpoint to evaluate whether significant risk of harm is posed to the environment (or to evaluate how multiple LOEs apply to some other endpoint). There have been a number of efforts in recent years to develop methodologies for reconciling or balancing multiple lines of evidence pertaining to an assessment endpoint. The Massachusetts Weight of Evidence Workgroup (Workgroup 1995) developed a scoring system to account for several measurement endpoints within a single assessment endpoint. Several aspects were examined, and weighed based on the risk estimate; these aspects are split into three categories, i.e. the weight of the assessment endpoint, the magnitude of the response, and concurrence among measurement endpoints. First, the weight of a LOE was evaluated based upon 10 to 11 attributes grouped into three categories: relationship to the assessment endpoint, data quality, and study design. These attributes were given a scaling value, acknowledging that some attributes are more important than others. Finally, the weight of a LOE was expressed as a score, scaled from 1 to 5, based upon the scaled rankings for all attributes. Then, the magnitude of response of a LOE in an assessment was evaluated based upon two questions: “is there harm?”, and “is it low/high?” This may involve the use of metrics, but can also be qualitative, using discrete values such as low, medium, or high. The third component, concurrence, reflects whether measurement endpoints agree or diverge.

One of the main goals of this approach was to provide a structured way to include the uncertainty (here called weight) within the risk estimate. Johnston et al. (2002) further refined this approach by developing a weighting procedure that consisted of scoring the attributes of each measure as low (1), medium (2), or high (3), depending on how well the measurement data related to the assessment of stressor levels or ecological damage. For each assessment endpoint with multiple LOEs, a centroid was calculated so that both the magnitude (is there evidence of harm?) and the uncertainty (weight) of each measure could be brought together in a systematic way that provides a transparent synthesis of all LOEs for that assessment endpoint. This centroid (X_w) was the weighted average of the exposure or effect LOEs:

$$X_w = (\sum(M_i \cdot W_i))/ \sum W_i),$$

where M_i is the magnitude assigned for each LOE and W_i is the weight assigned to that LOE. The centroid was used to aid in interpreting the balance of exposure and effects information suggested by the data. Measures with higher weight would tend to draw the centroid in their direction. They then determined risk evidence by combining the centroids of exposure and effect assessments using a matrix table. The primary advantage of this approach is that it provides a formal procedure for risk and uncertainty characterization. The weighting process is less complex than the approach in Workgroup (1995); this may be due to the effort to standardize the procedure (Babut et al. 2007).

For some LOEs, the quantitative WOE approach described above may be unwarranted, such as when measurement endpoints for a single assessment endpoint do not contradict one another, or when a contradiction exists but there is a clear difference in the scientific defensibility of the endpoints. In these cases, the WOE approach may be substantially simplified. A qualitative adaptation of the WOE approach also involves three main steps; only the first step differs substantially from that applied under the quantitative method. First, each measurement endpoint is assigned a qualitative score of high, medium, or low for each of the three principal attributes. The numbers of high, medium, and low scores for each measurement endpoint are counted and the measurement endpoint is assigned an overall score based on the majority of attribute specific scores. Second, the risk assessor evaluates the outcome of each measurement endpoint with respect to indication of risk of harm (e.g., positive, negative, or undetermined) and magnitude of the outcome (e.g., high or low). Third, the risk assessor integrates the measurement endpoint weight and magnitude of response on a matrix, in order to determine whether the overall evidence indicates a risk of harm. While this qualitative adaptation is clearly simpler to apply than the quantitative approach, it introduces greater subjectivity and may require less deliberate justification for conclusions regarding the potential risk of harm to the environment.

The methods described above can be used to integrate disparate LOEs for a specific site, or they can be used to integrate a suite of tests that are used to inform one part of a multi-criteria comparative assessment. For instance, if a range of biotests are used to inform the biological branch of an assessment, these approaches can be adapted to provide decision rules for pass or fail for a biotest suite, as well as for the integration of this suite with other LOEs.

A.2.3 WOE to evaluate management alternatives

WOE tools can, as described above, be used to evaluate whether sediments pose a risk in place or at a proposed disposal site. However, there is also a need to monitor or forecast the consequences of various management actions. The sections above discuss aspects of the use of CRA and MCDA to evaluate sediment management and remedial actions. Other approaches and issues for ranking and comparing risks and benefits of management actions over space or time are described below.

To use WOE methods not to only evaluate risks of contaminants in sediments but also risks and benefits of various sediment management alternatives over time, Apitz (2008d) adapted various aspects of these methodologies (e.g., Babut et al. 2007; Johnston et al. 2002; Workgroup 1995). For this study, LOEs of both risk (e.g., contaminant impact on the benthic community) and benefit (e.g., enhanced primary producer activity) were evaluated. The approach used is summarized in Table A-1.

Table A-1. WOE methodology for determining the overall risks and benefits of remedial actions/disposal approaches using a systematic WOE approach to integrate disparate measures of differing relevance and uncertainty to multiple assessment endpoints

Step	Objective	Approach
1	Define assessment endpoints (AEs) and measures (AMs)	•Define what is to be protected or enhanced (Assessment Endpoints, AEs) •AEs can also be ecosystem service providing units (SPUs) •Determine what AMs represent AEs (AMs are indicators of AEs)
2	Establish weights/uncertainty for AMs	•Evaluate AMs based upon attributes •Score the attribute for each AM of each AE (1-3) •Mean score for each AM is its weight •Mean AM weight for each AE is its uncertainty
3	Determine the degree of exposure or effect, based on each AM	•For a site, time point, treatment, etc., assign a score to the AMs •Score both desirable (-1 to -3) and undesirable (1 to 3) effects for each AM
4	WOE determination for each AE	•Calculate the centroid for each AE, based on all relevant AMs •Centroid = $AE_w = (\Sigma(M_i \cdot W_i)) / \Sigma W_i$, where M_i is the magnitude assigned for each AM and W_i is the weight assigned to that AM •AE scores corrected for more intuitive graphical presentation: $AE_{corr} = -(AE_W-1)$ •AE score confidence is the mean weight of its AMs
5a	EcoResA risk/benefit assessement for each AE	•If both exposure and effects evaluated for AE, overall effects can be estimated using the impact decision table •If only exposure or effect available for AE, then score for AE is based on that
5b	EcoResA interpretation for SPUs	•If study is along stressor gradients, in space or time, interpret AE response in terms of resistance and resilience
6	Risk/benefit comparison for all AEs	•Compare impacts or status to all AEs as a function of time, replicate, stressor, etc •These can be weighted to reflect priorities

Table A-1 Notes: AE= assessment endpoint; AM=assessment measure. SPU=(ecosystem) service providing unit. From Apitz (2008d)

To examine the WOE of harm to various assessment endpoints, the magnitude of impacts indicated by each LOE for sediments was assessed. Magnitude was assessed from -1 (no evidence of risk) to -3 (strong evidence of risk). For benefits to assessment endpoints (e.g., enhanced community structure, reduced turbidity), magnitudes were assessed from +1 to +3. Scores were assigned in 0.5 point increments. These scores were a semi-quantitative assessment of the quantitative results of each LOE.

For each assessment endpoint (e.g., benthic exposure, benthic effects, etc.), the centroid of the LOEs was calculated (as a weighted average of LOE magnitude and uncertainty or weight, as described above). These centroids for an assessment endpoint then represent an integrated estimate of the degree of impact (positive or negative), taking into account all the relevant LOEs and their uncertainty. The range of outcomes for various LOEs for an assessment endpoint can then be reported, along with the overall weight. Because measures with higher certainty have higher weights in the centroid calculation, this value provides a balanced integration of the seemingly conflicting LOEs. This approach gives decision-makers both an indication of the most likely data interpretation and the degree of uncertainty around that estimate. The centroid approach provides a clear method of balancing this uncertainty in a transparent manner.

The next step estimates the overall risk or benefit to a given assessment endpoint by combining centroid measures of exposure and effect using a risk matrix (e.g., Table A-2, for a case study). For example, a management action that causes a moderate decrease in turbidity and increase in production rate may appear to result in high benefit. However, if sediment is highly impacted, this increase in production rate could also result in increased toxicity to ecological receptors.

Table A-2. Overall risk/benefit can be evaluated using a decision matrix using the centroid values of exposure and effect for each assessment endpoint. a) relative to reference or time 0

			Evidence of Exposure[a] (and score)						
			Stong decrease	**Moderate decrease**	**Slight decrease**	**none**	**Slight increase**	**moderate increase**	**Strong increase**
		Range of possible scores	+1.5 to +3	+0.5 to +1.5	0 to +0.5	0	0 to -0.5	- 0.5 to - 1.5	-1.5 to -3
Evidence of Effect[a]	**Strong positive**	+1.5 to +3	very high benefit (3)	high benefit (2.5)	moderate benefit (2)	no link			
	Moderate positive	+0.5 to +1.5	moderate benefit (2)	moderate benefit (2)	slight benefit (1)	no link			
	Slight positive	0 to +0.5	slight benefit (1)	negligible (0.5)	negligible (0.5)	no link			
	none	0	negligible (0.5)	negligible (0.5)	negligible (0.5)	none	negligible (-0.5)	negligible (-0.5)	negligible (-0.5)
	Slight negative	0 to -0.5				no link	negligible (-0.5)	negligible (-0.5)	slight risk (-1)
	Moderate negative	- 0.5 to -1.5				no link	slight risk (-1)	moderate risk (-2)	moderate risk (-2)
	Strong negative	-1.5 to -3				no link	moderate risk (-2)	high risk (-2.5)	very high risk (-3)

Table A-2 Notes**:** From Apitz (2008d)

An overall decision must be based upon a risk/benefit comparison for all assessment endpoints. Such risks and benefits can be integrated over time, or they can be evaluated at various time points. As some disposal options may be expected to cause higher-level transient risks, but lower risks or even benefits over time, the resilience of communities to disturbance may be part of such an evaluation. For example, while benthic communities may initially exhibit impacts during dredged material disposal due to smothering and release of ammonia and sulfides, they generally recover over time. If sediments are being used beneficially, these impacts may be offset over time by benefits.

As described in this appendix, multi-criteria assessment approaches for the evaluation of sediment management options are rapidly evolving. The above example illustrates a WOE approach to compare the risks and benefits of potential dredged sediment management options. This approach was adapted to develop the framework for evaluating the value-linked risks and benefits of sediment remedial options described in this report.

Appendix B
Stakeholder Map

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
anglers	Oregon Council Trout Unlimited	http://www.tuoregon.org/	Gabe Parr		communications@tuoregon.org	Trout Unlimited (TU) Vision: By the next generation, Trout Unlimited will ensure that robust populations of native and wild coldwater fish once again thrive within their North American range, so that our children can enjoy healthy fisheries in their home waters. TU Mission: To conserve, protect, and restore North America's coldwater fisheries and their watersheds.
anglers	Oregon Bass	http://www.oregonbassfederation.org/	Lonnie Johnson, conservation and legislative director		damaro@oigp.net	
anglers	Coastal Conservation Association (CCA) Oregon	http://www.ccaoregon.org/pageview.aspx?id=40111	Chris Cone, executive director	541-213-1464 or 503-496-5496	jzell@zephyr.net; chapter at portland@ccapnw.org	The stated purpose of CCA is to advise and educate the public on conservation of marine resources. The objective of CCA is to conserve, promote and enhance the present and future availability of these coastal resources for the benefit and enjoyment of the general public.
anglers	Sustainable Fisheries Foundation	http://sustainablefisheriesfoundation.org/	Cleveland R. Steward (American Office, Snohomish WA)	(360) 862-1255	http://sustainablefisheriesfoundation.org/contact-us/	The Sustainable Fisheries Foundation is a non-profit organization dedicated to the protection, enhancement, and wise use of fisheries resources and their habitats. Our mission is to promote a balanced approach to fisheries management – one based on sound ecological and economic principles – to ensure that fish populations, and the ecosystems they depend on, remain viable, productive, and accessible to future generations.
anglers	PanFish (Oregon Bass and Panfish Club)	http://obpc0.tripod.com/			oregonbassandpanfish@gmail.com	Come join the fun, meet new friends, learn about fishing for bass, walleye, yellow perch, crappie, and sunfish (bluegill, pumpkinseed, and warmouth), learn new techniques for catching and new places to fish, and share your knowledge with us. Bring the whole family!

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anglers	Association of Northwest Steelheaders	http://nwsteelheaders.org/about-us/mission/	Bob Rees, director	503-653-4176	office@anws.org	One of the oldest and most-cherished conservation organizations in the Pacific Northwest, the Association of Northwest Steelheaders was founded in 1960. The Steelheaders mission is "anglers dedicated to enhancing and protecting fisheries and their habitats for today and the future." Our vision is "responsible and enjoyable sport angling with good access to healthy, abundant and sustainable fisheries in Northwest's healthy watersheds." ANWS serves all residents of the Pacific Northwest who value strong salmon and steelhead runs and clean water. ANWS became the Oregon affiliate of the National Wildlife Federation (one of the oldest and largest conservation nonprofits in the United States) in 2007. Northwest Steelheaders programs and services include advocacy for fish, their habitats, and fishing opportunity at local, state and federal levels; environmental education of youth, anglers, and veterans; and protecting public access to waterways. Volunteerism is one of the Steelheaders greatest strengths, with members contributing thousands of volunteer hours annually in education, propagation, habitat restoration and monitoring.
salmon	Salmon Safe	http://www.salmonsafe.org/	http://www.salmonsafe.org/about/contact	503.232.3750		Welcome to Salmon-Safe. More than a decade after first certifying farms in Oregon's Willamette Valley, Salmon-Safe has become one of the nation's leading regional eco labels with more than 95,000 acres of farm and urban lands certified in Oregon, Washington, California, and British Columbia. The Salmon-Safe retail campaign has been featured in 300 supermarkets and natural food stores, delivering important marketplace benefits to participating landowners. Founded by Pacific Rivers Council, Salmon-Safe is now an independent 501(c)3 nonprofit based in Portland Oregon. Our mission is to transform land management practices so Pacific salmon can thrive in West Coast watersheds. Salmon-Safe works across the West Coast through our Partner Network. Established at our Salmon-Safe Summit in 2007, the Partner Network consists of place-based conservation organizations as well as collaborating certification organizations. Founding organizations Stewardship Partners, Oregon Tilth, and LIVE have been joined by Pacific Salmon Foundation, Fraser Basin Council, Demeter, Vinea and Trout Unlimited. Salmon-Safe seeks to extend the range of the Network in key agricultural and urban watersheds throughout the West Coast range of Pacific salmon.

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river recreation	Human Access Project	http://www.humanaccessproject.com/	Willie Levenson, project ringleader		http://www.humanaccessproject.com/Contact	VISION A city in love with its river. MISSION Transform Portland's relationship with the Willamette River. PATH OF OBJECTIVES Build it: create more public spaces, beaches and access points to the Willamette River in downtown Portland. Use it: inspire Portlanders and visitors to connect with the Willamette River. Love it: support conservation, education and stewardship of the Willamette River and Watershed.
Boaters	Portland Marine Dealers Association			(503) 380-5223		
Boaters small craft	RiversWest Small Craft Center	http://www.riverswest.org/	Education Coordinator Randy Torgerson		education@riverswest.org	Since 1983, RiversWest Small Craft Center has been promoting the use of sustainable, beautiful boats built to operate on the human scale. For some of our members, that means restoring historically correct wooden boats. For others, it is a chance to design and build with the support and input of a like-minded group. Many enjoy the camaraderie of "messing about" on the water. We all benefit from the chance to learn from one another. We are often inspired to get our hands busy building, paddling, rowing, motoring or sailing small craft. To do this, we maintain a shop with some building bays available for members, and woodworking tools available for use . We get together informally every couple of week
Paddlers	Dragon Sports, USA	http://www.portlanddragonboats.com/	Anissa Lofti, Board Secretary		events@dragonsports.org	DragonSports USA is a non-profit dragon boat paddling club located in Portland, Oregon. Our Vision: Promoting fitness and friendship through paddle sports. Our Mission: DragonSports is a driving force in developing paddlers of all abilities and ages through a responsive, well-coordinated program of boat and equipment rental, and of sponsoring (at least one) local races
Yachting	Columbia River Yachting Association	http://crya.us/index.html	Andy Meyer, CRYA Executive VP	503.201.5045	exec-vp@crya.us	CRYA was founded in 1933 to "encourage sailing and racing yachts on the Columbia River and its tributaries

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Rowers	Oregon Rowing Unlimited	http://oregonrowing.org/	Frank Zagunis, Director	503-419-7222	frankzagunis@gmail.com	Oregon Rowing Unlimited (ORU) is a non-profit 501c(3) rowing club based in Portland, Oregon. It was established in 1988 to promote the sport of rowing in a team and goal oriented atmosphere. Since its inception, ORU has helped launch many careers and has been a source of origin and inspiration for other local rowing clubs. Boasting a competitive junior team, and a recreational and competitive masters team, we welcome anyone ages 11 and older to experience the joy of rowing. If you're looking for a fun team atmosphere filled with camaraderie, where you can experience a challenging program under the leadership of caring and committed coaches, then ORU is the place for YOU! We believe that the skills learned in rowing support success both on and off the water, and our goal is to teach you as much as we can about the sport and encourage your growth as an athlete. Come on down to ORU, and give rowing a try!
whitewater boating	Oregon Kayak & Canoe Club	http://www.okcc.org/	Russ Pascoe		info@okcc.org	The OKCC is a group of boaters in the Portland area who have joined together to pursue a common interest in whitewater boating. Our primary focus is to organize river trips at various skill levels. Safety, as well as enjoyment, is considered important on all club-sponsored trips. We are also involved in ocean kayaking and surfing, slalom races, instruction, and river conservation.
hikers/bikers	Friends of the North Portland Greenway Trail (npGREENWAY)	http://npgreenway.org/	Shamus Lynsky	503-314-3336	shamus@npgreenway.org	npGREENWAY envisions a trail system providing access to and along the Willamette River enveloping the north riverfront from the Steel Bridge in downtown Portland to Cathedral Park near the St. Johns Bridge and extending through Baltimore Woods to Kelley Point Park. Our goal is to link North Portland neighborhoods with the Willamette River for recreation and access to jobs. This expansion of the Willamette River Greenway will include a network of trails used for activities such as walking, running, cycling, skating, skateboarding, fishing, boating and wildlife viewing. The North Portland Greenway trails will connect with the existing Willamette River trail system serving residents and visitors throughout the region. npGREENWAY is working collaboratively with community stakeholders to realize this goal.
Hikers	Trailkeepers of Oregon	http://www.trailkeepersoforegon.org/	Tom Kloster, Board Chair; http://www.trailkeepersoforegon.org/contact/		volunteers@trailkeepersoforegon.com	Trailkeepers of Oregon (TKO) is a non-profit organization whose mission is to protect and enhance the Oregon hiking experience through advocacy, stewardship, outreach and education.

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Hikers	The Mazamas	http://mazamas.org/	Adam Baylor, Stewardship & Advocacy Manager; Sarah Bradham, Marketing & Publications Manager	503-227-2345	adam@mazamas.org; sarah@mazamas.org	A nonprofit Mountaineering Education Organization based in Portland, Oregon. The Mazamas, founded in 1894 on the summit of Mt. Hood, is a nonprofit mountaineering education organization located in Portland, Oregon. Mazamas offers over 700 hikes and 350 climbs annually. A variety of classes and activities are offered for every skill and fitness level and are open to both members and non-members
bicycle	Bicycle Transportation Alliance	https://btaoregon.org/	Carl Larson, engagement manager	503.226.0676 x16	Carl Larson <carl@btaoregon.org>	In Oregon, we know the joy of riding a bike to work, to school, and around the neighborhood. Wherever you go, the Bicycle Transportation Alliance works to make your ride safe, convenient, and fun.
Near Water (bicyclists, dog walkers, etc.)	Portland Bike Club	http://portlandbikeclub.com/		503.939.0023		Our membership is made up of people who love biking, cycling or whatever you want to call it. It doesn't matter what kind of bike you ride, we are open to everyone and all types. We ride all over the city, exploring the amazing infrastructure our city has to offer. We are a welcoming casual bike club that makes it easy to have fun on your bike, and meet other cool people.
urban nature	The Intertwine Alliance	http://theintertwine.org/about	Tara Wilkinson, communications coordinator		list of many other potential stakeholder groups at http://theintertwine.org/partners	The Intertwine Alliance is a coalition of 140+ public, private and nonprofit organizations working to integrate nature more deeply into the Portland-Vancouver metropolitan region.

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urban nature	Friends of Baltimore Woods	http://www.friendsofbaltimorewoods.org/about/mission/	Amira El-Cherbini, vol coord FOBW	cell phone: 971-207-3989; work phone: 503-681-4432	amira.elcherbini@yahoo.com	The 30-acre Baltimore Woods Connectivity Corridor fills a critical gap in the Willamette Greenway and regional 40-Mile Loop bicycling and walking trails, situated between Cathedral and Pier Parks in North Portland. This unique urban greenway, recognized for its special habitat value to plants and wildlife, faces threats from invasive species and development pressures that could eventually spoil its natural value. The Friends of Baltimore Woods is dedicated to preserving and restoring this corridor, and we encourage you to join us. This remnant native woods features such trees as Oregon white oak, madrone, and broad-leaf maple and provides food and shelter for a variety of birds, mammals, and other species. Restoring Baltimore Woods will: Improve the Willamette River watershed's health by filtering storm runoff so pollutants are not carried into the river Keep a natural buffer between residential and industrial neighbors Provide excellent views of the Willamette River, St. Johns Bridge, Forest Park and the vibrant working harbour Enhance native habitat Offer trail users opportunities for recreation, education, and a natural experience for walkers and bicyclists, away from auto traffic
River protection	Willamette River Keeper	http://www.willamette-riverkeeper.org/WRK/index.html	Marci Krass, Restoration Coordinator	503.223.6418	marci@willametteriverkeeper.org	Willamette Riverkeeper is a non-profit organization, whose sole mission is to protect and restore the Willamette River. We believe that a river with good water quality and abundant natural habitat is a basic public right. The Willamette River belongs to all of us, and should be protected as such
River Protection	Columbia Riverkeeper	http://columbiariverkeeper.org/	For inquires related to our Citizen Outreach Program, contact Rob Cochran	541.399.7284	rob@columbiariverkeeper.org	Columbia Riverkeeper's mission is to protect and restore the water quality of the Columbia River and all life connected to it, from the headwaters to the Pacific Ocean. Our strategy for protecting the Columbia includes working in river communities and protecting the people, fish and wildlife that depend on the Columbia River.

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River Protection	Tualatin Riverkeepers	http://tualatinriverkeepers.org/		503-218-2580	info@tualatinriverkeepers.org	Tualatin Riverkeepers is a non-profit organization dedicated to holistic watershed management for the benefit of our communities. TRK takes a proactive approach to advocacy for clean waters, empowers the diversity of stakeholders in the Tualatin river basin to care for our unique river, and educates youth and future activists with creative curriculum inspired by local ecological traditions. We seek partnerships with agencies and landowners throughout the watershed to conserve the lands and biodiversity found within the broader landscape and analyze watershed issues from the floodplain's perspective. As such, we find strength from farmer to ecologist's viewpoints and believe bringing multiple parties together based on shared common ground will enhance sustainable management of the Tualatin watershed
River Protection	Willamette River Initiative	http://willametteinitiative.org/home	http://willametteinitiative.org/meet-our-team			The purpose of the Willamette River Initiative is to achieve meaningful, measurable improvements in the health of the Willamette River and selected tributaries by 2018 and to create a national model for effective philanthropic involvement in the restoration of large, complex ecological systems. The Meyer Memorial Trust established the Willamette River Initiative in July 2008. Through WRI, the Trust makes grants to groups working to improve the health of the river and its tributaries and invests in the development of research and planning tools to help identify restoration priorities. In 2009, MMT entered into a partnership with the Tides Center, a national fiscal sponsor organization, to support administration of WRI program activities. Through this partnership, grants associated with WRI are administered directly by MMT, while program management and communication activities are administered as a project of the Tides Center. We work with key partners to improve coordination of Willamette restoration efforts through shared goals, common measures of success, and joint learning and networking opportunities. Our closest working partnerships are with the Oregon Watershed Enhancement Board, the Bonneville Environmental Foundation, the University of Oregon's Environmental Sustainability Lab, and the Oregon Department of Fish and Wildlife. Our 20+ grantees are also important partners, as are many other public agencies and non-governmental organizations.

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nature	Environmental Defense Fund (San Francisco office)	https://www.edf.org/offices/san-francisco	Julie Benson	(415) 293-6050 (general); (415) 293-6069 (office); (310) 699-6959 (cell)	https://www.edf.org/email/node/5371/field_email/136	Clean air and water. Abundant fish and wildlife. A stable climate. Our work protects nature and helps people thrive. What sets us apart is how we make this happen: By creating solutions that also carry economic benefits.
nature	Audubon Society (Portland)	http://audubonportland.org/; http://audubonportland.org/issues/habitat/urban/superfund/?searchterm=superfund	Bob Sallinger?	503.292.6855	general@audubonportland.org	The Audubon Society of Portland promotes the understanding, enjoyment, and protection of native birds, other wildlife and their habitats.
nature	Oregon Environmental Council	http://oeconline.org/about/	Andrea Durbin? http://oeconline.org/about/contact/	(503) 222-1963		Oregon Environmental Council advances innovative, collaborative solutions to Oregon’s environmental challenges for today and future generations. Founded in 1968, Oregon Environmental Council is a nonprofit, non-partisan, membership-based organization. We protect the health of every Oregonian and the place we call home by working for clean air and water, a healthy climate, an unpolluted landscape and sustainable food and farms.
nature	Sierra Club Oregon Chapter	http://oregon2.sierraclub.org/chapter	Hilary Shohoney, outreach and development	(503) 238-0442 x300	hilary.shohoney@sierraclub.org	The Oregon Sierra Club is a non-profit member-supported, public interest organization that promotes conservation of the Oregon natural environment by influencing public policy decisions—legislative, administrative, legal, and electoral.
nature	Columbia Slough Watershed Council	http://www.columbiaslough.org/	http://columbiaslough.org/index.php/about_the_council/contact_us/	(503) 281-1132	info@columbiaslough.org	To foster action to protect, enhance, restore, and revitalize the Slough and its watershed; Council, C.S.W. (2013) Columbia Slough Watershed Projects And Programs 2003-2013. Columbia Slough Watershed Council, Portland, OR, p. 48.

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nature	Friends of Columbia Gorge	http://gorgefriends.org/section.php?id=9	http://gorgefriends.org/section.php?id=16	503-241-3762	info@gorgefriends.org	Friends of the Columbia Gorge shall vigorously protect the scenic, natural, cultural, and recreational resources of the Columbia River Gorge. We fulfill this mission by ensuring strict implementation of the Columbia River Gorge National Scenic Area Act and other laws protecting the region of the Columbia River Gorge; promoting responsible stewardship of Gorge land, air, and waters; encouraging public ownership of sensitive areas; educating the public about the unique natural values of the Columbia River Gorge and the importance of preserving those values; and working with groups and individuals to accomplish mutual preservation goals
nature	Friends of Trees	http://www.friendsoftrees.org/	Scott Fogarty?	503-282-8846	fot@FriendsofTrees.org	Friends of Trees is a 501(c)3 nonprofit whose mission is to bring people together to plant and care for city trees and green spaces in Pacific Northwest communities. Through our Neighborhood Trees program, homeowners buy discounted trees to plant with their neighbors at weekend plantings. Through our Green Space Initiative, trained crew leaders guide volunteers at weekend events to restore green spaces
wildlife	Defenders of Wildlife, West Coast Office	http://www.defenders.org/northwest/our-top-priorities; http://www.defenders.org/		503/697-3222		Defenders of Wildlife's Northwest office works to restore and protect imperiled wildlife and habitats in Washington, Oregon and Idaho. The region's diverse landscapes range from the marine waters of the coast and Puget Sound, to the old growth forests of the Cascade Mountains, to the arid high desert of the interior basins and plateaus.
nature wetlands	The Wetlands Conservancy	http://wetlandsconservancy.org/		503-227-0778	info@wetlandsconservancy.org	The Wetlands Conservancy (TWC) is the only organization in Oregon dedicated to promoting community and private partnerships to permanently protect and conserve Oregon's greatest wetlands – our most biologically rich and diverse lands. For more than 30 years, The Wetlands Conservancy has educated and assisted landowners, neighborhood groups, land trusts, and watershed councils on local stewardship to support fish and wildlife, clean water, open space and people's appreciation of nature. Wetlands are vital to our community's health and the health of our environment. They clean and recharge our water supply, provide critical fish and wildlife habitat, and protect our communities from floods. Today The Wetlands Conservancy owns and manages 32 preserves and more than 1,500 acres across Oregon. Join us in conserving and restoring Oregon's greatest wetlands today! Mission: To partner with communities across our state in conserving, enhancing and restoring the physical and ecological values of Oregon's greatest wetlands for current and future generations

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climate change	Rising Tide North America Portland	https://portlandrisingtide.org/			info@portlandrisingtide.org	Rising Tide is an international, all-volunteer, grassroots network of groups and individuals who organize locally, promote community-based solutions to the climate crisis and take direct action to confront the root causes of climate change. Portland Rising Tide does combine long-term strategic campaigning with educational events to raise awareness and build capacity in our community to stop the plunge into climate chaos. The Portland chapter of Rising Tide has existed for about six years, and in that time we have been instrumental in the battle to keep LNG out of Mount Hood. We have teamed up with student groups to expose banks that fund mountaintop removal coal mining. We have joined with groups such as Columbia Riverkeeper, The Indigenous Environmental Network and the American Indian Movement to protect the Columbia river from becoming another industrial highway to ship tarsands equipment. We have held teach-ins, movie screenings and workshops ranging from urban bee keeping to road blockades.
climate change	350PDX	http://350oregon.org/	http://350oregon.org/index.php/contact-us/			350 Oregon is made up of the local chapters of 350.org, an international group dedicated to growing the grassroots climate movement. We are working to in our local communities to fight fossil fuel export projects, put a statewide price on fossil pollution to hold polluters accountable, and divest our state, communities, and institutions from the fossil fuel industry.
environmental action	SOLVE It's Our Nature to Volunteer	http://solveoregon.org/		503-844-9571	info@solveoregon.org	SOLVE is a state-wide non-profit organization that takes action every day to keep Oregon clean and green. We mobilize over 35,000 volunteers and organize over 1,000 cleanup and restoration projects throughout the state. Our mission: Bring Oregonians together to improve our environment and build a legacy of stewardship.

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environmental justice	Indigenous Environmental Network	http://www.ienearth.org/	http://www.ienearth.org/contact-us/			Established in 1990 within the United States, IEN was formed by grassroots Indigenous peoples and individuals to address environmental and economic justice issues (EJ). IEN's activities include building the capacity of Indigenous communities and tribal governments to develop mechanisms to protect our sacred sites, land, water, air, natural resources, health of both our people and all living things, and to build economically sustainable communities.IEN accomplishes this by maintaining an informational clearinghouse, organizing campaigns, direct actions and public awareness, building the capacity of community and tribes to address EJ issues, development of initiatives to impact policy, and building alliances among Indigenous communities, tribes, inter-tribal and Indigenous organizations, people-of-color/ethnic organizations, faith-based and women groups, youth, labor, environmental organizations and others. IEN convenes local, regional and national meetings on environmental and economic justice issues, and provides support, resources and referral to Indigenous communities and youth throughout primarily North America – and in recent years – globally.
environmental education	Rewild Portland	http://www.rewildportland.com/	http://www.rewildportland.com/about/contact/	503-863-8462		Rewild Portland is an environmental education focused non-profit organization serving Portland, Oregon and the surrounding wild and rural communities. Our mission is to create cultural and environmental resilience through the education of earth-based arts, traditions, and technologies. This mission comes to life in the form of educational workshops and programs, community-building events, and ecological restoration.
trail heritage	Lewis and Clark Trail Heritage Foundation; Oregon State Chapter	http://www.lewisandclark.org/chapters/oregon/index.php	Mark Johnson	(503) 614-1821		We are dedicated to the promotion of an accurate and interesting telling of all stories of the Expedition and the time and context in which they occured. Our programs encourage cultural awareness, protection of sacred sites, and preservation of the natural and historical resource along the trail.
historic and cultural resources	Oregon State Historic Preservation Office (SHPO)	http://www.oregon.gov/oprd/HCD/SHPO/Pages/index.aspx	http://www.oregon.gov/oprd/HCD/Pages/contact_us.aspx	503-986-0690		The Oregon State Historic Preservation Office (SHPO) was established in 1967 to manage and administer programs for the protection of the state's historic and cultural resources. When these resources disappear communities can lose tangible and educational assets that contribute directly to Oregon's heritage, and also opportunities for local economic development. SHPO staff is here to assist city planners and other officials, property owners, and preservation groups to find forward-thinking solutions to protect and preserve our past.

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historic and cultural resources	The Oregon Historical Society	http://www.ohs.org/	Kerry Tymchuk?			The Oregon Historical Society is dedicated to making Oregon's long, rich history visible and accessible to all. For more than a century, we have served as the state's collective memory, gathering and preserving a vast collection of artifacts, photographs, films, manuscripts, books, and oral histories. Researchers from around the world travel to our library, unearthing information that challenges conventional thinking. Curious individuals come to us to explore their family trees or discover the history of their homes or neighborhoods. Archaeologists, environmentalists, filmmakers, architects, novelists, artists, and others all find their way to us, asking questions, making discoveries, creating knowledge. We share our vast collection through thought-provoking museum exhibits and robust digital platforms. We bring history directly to Oregon's students in ways that bridge gaps of time and perspective, and we support lifelong learning through our many public lectures and events. We advance critical inquiry through the Oregon Historical Quarterly, a journal that has sparked conversations throughout our community for over a century
maritime heritage	Maritime Heritage Coalition	PHP presented to but no web presence				
environment	Northwest Earth Institute	http://www.nwei.org/support-nwei/partner-with-nwei/	http://www.nwei.org/about-nwei/contact-us/	503.227.2807	Media Inquiry: kerry@nwei.org	NWEI has formed partnerships with individuals and organizations across North America to actively inspire others to change for good. We are proud of our strong history of collaboration. - See more at: http://www.nwei.org/support-nwei/partner-with-nwei/#sthash.ouUFzrhH.dpuf
market-based conservation	Willamette Partnership	http://willamettepartnership.org/about/history/	Bobby Cochran?	(503) 946-8350	info@willamettepartnership.org	Willamette Partnership is a non-profit organization dedicated to helping build collaborative solutions to complex conservation problems using market-based and incentive programs. Our mission is to increase the pace, scope, and effectiveness of conservation.
mitigation banking	Wildlands, Inc	http://www.wildlandsinc.com/about/company-overview/	http://www.wildlandsinc.com/contact/	503.241.4895	oregon@lewisandclark.org	Wildlands is a habitat development and land management company with projects throughout the Western United States. Established in 1991, Wildlands is a national leader in establishing mitigation banks and conservation banks that enhance water quality and protect wildlife habitat in perpetuity. - See more at: http://www.wildlandsinc.com/about/company-overview/#sthash.x58kd4lz.dpuf

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natural capital	ecotrust	http://www.ecotrust.org/about-us/	http://www.ecotrust.org/join-us/visit-us/	503.227.6225		In everything we do, we work to create systemic responses to systemic challenges — a culture of resilience. A culture that adapts to the ever-changing world around us, inspiring innovation, seeking diversity, and sharing ideas and resources equitably. At Ecotrust, we see the many faces of change — in our climate, in our culture, in our connections to one another. And, we believe resilience — the capacity to influence and adapt to change — is essential to meeting these changes and the challenges they present.
community air quality	The NWDA Air Quality Committee	http://www.northwestdistrictassociation.org/?cat=5	Sharon Genasci chairs the Committee	503.823.4288	contact@northwestdistrictassociation.org	The NWDA Air Quality Committee, known as the Health and Environment Committee until a name change in February 2012, strives to monitor and improve the quality of the air in the Northwest neighborhood with the goal of creating a healthy environment for everyone living, working in, and visiting the neighborhood
community air quality	Neighbors for Clean Air	http://www.whatsinourair.org/	Outreach and Volunteer Coordinator: Linda Nakashima linda@whatsinour.org President, Mary Peveto		mary@whatsinourair.org	To educate, motivate and activate citizens in efforts to improve air quality in Portland and Oregon. To collaborate with our elected officials to promote regulations and policies that best protect public health, including children. To work with businesses subject to air quality regulation and provide opportunities for dialogue about their efforts to reduce emissions and the results of those efforts. To continue to build a coalition of likeminded individuals and organizations to strengthen our public voice.
community	Portland Harbor Community Coalition	http://ourfutureriver.org/		(503) 662-2590	ourfutureriver@gmail.com	The Portland Harbor Community Coalition (PHCC) is a group of individual community members, community of color organizations, conservation organizations, environmental justice organizations, higher educational institutions, and Native organizations, all invested in the outcome of the Willamette River's Superfund site cleanup.
community	Portland Harbor Community Advisory Group (CAG)	http://www.portlandharborcag.info/	Mr Jim Robison; Portland CAG	(971) 303-9742	chair@portlandharborcag.info	CAG Mission Statement: To ensure a Portland Harbor Cleanup that restores, enriches, and protects the environment for fish, wildlife, human health, and recreation, through community participation. The Portland Harbor CAG is comprised of individuals from neighborhood associations, environmental, health, recreation, and business groups, and concerned citizens. We have worked closely with the community, the Environmental Protection Agency (EPA), Oregon's Dept. of Environmental Quality (DEQ), the Lower Willamette Group (LWG), the City of Portland, the Port of Portland, and the Tribes affected by the Superfund site

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public space	The City Repair Project	http://www.cityrepair.org/mission/		503.583.8532	info@cityrepair.org	The City Repair Project fosters thriving, inclusive and sustainable communities through the creative reclamation of public space; City Repair facilitates artistic and ecologically-oriented placemaking through projects that honor the interconnection of human communities and the natural world. We are an organized group action that educates and inspires communities and individuals to creatively transform the places where they live. The many projects of City Repair have been accomplished by a mostly volunteer staff and thousands of volunteer citizen activists.
Homeless	Right 2 Survive	http://www.right2survive.net/ https://right2survive.wordpress.com/contact/	Ibrahim Mubarak	(503)839-9992	i_tpop@hotmail.com	Educates both houseless and housed people on their civil, human, and constitutional rights empowers houseless people to stand up for themselves when their rights are violated. They bridge the gap between housed and un-housed people by clearing away misconceptions and stigmas associated with houselessness.
Homeless	Home Forward	http://www.homeforward.org/		503.802.8300	info@homeforward.org	The mission of Home Forward is to assure that the people of the community are sheltered. Home Forward has a special responsibility to those who encounter barriers to housing because of income, disability or special need. Home Forward will continue to promote, operate and develop affordable housing that engenders stability, self-sufficiency, self-respect and pride in its residents and represents a long-term community asset. Home Forward will be a community leader to create public commitment, policy and funding to preserve and develop affordable housing. - more housing than advocacy
Homeless	streetroots	http://streetroots.org/	http://streetroots.org/contact	503-228-5657		Street Roots — published weekly in Portland, Oregon — has been Portland's flagship publication addressing homelessness and poverty since 1998.
Homeless youth	JOIN	http://joinpdx.org/about/	http://joinpdx.org/contact/			Founded in 1992 by Rob Justus, JOIN began as an educational organization offering experiential “immersions” into the experience of homelessness for youth. As the homeless people that we worked with began to share their wisdom and experiences with us, we shifted our organizational mission to direct housing services.JOIN exists to support the efforts of homeless individuals and families to transition out of homelessness into permanent housing. Our efforts are directed at individuals sleeping outside or in their car in the Portland Metro area. Our service provision is not dependent on age, gender, ethnicity, sexual identity, specific diagnosis, or identifiable issue.
Housing	Portland Housing Authority	http://www.porthouse.org/section8/index.html		(207) 773-4753	infodesk@porthouse.org	Together with its community partners, the PHA provides and expands affordable housing and services that improve quality of life, build community, enhance safety and promote personal success for the people we serve and the neighborhoods in which they reside.

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affordable housing	Hacienda Community Development Corporation	http://www.haciendacdc.org/find-us/	http://www.haciendacdc.org/contacted/			Hacienda CDC is a Latino Community Development Corporation that strengthens families by providing affordable housing, homeownership support, economic advancement and educational opportunities
public health	Oregon Physicians for Social Responsibility	http://www.psr.org/chapters/oregon/about.html		503-274-2720	info@oregonpsr.org	Guided by the values and expertise of medicine and public health, Oregon Physicians for Social Responsibility (PSR) works to protect human life from the gravest threats to health and survival by striving to end the nuclear threat, advance environmental health, protect our climate and promote peace. Oregon PSR is an organization of health professionals and concerned individuals working collaboratively with community partners to educate and advocate for societal and policy change that protects human health at the local, state, national and international level. We seek a healthy, just and peaceful world for present and future generations.
public health	Coalition of Community Health Clinics	http://www.coalitionclinics.org/article/who-we-are	Julie Scholz, Development Director		julie.scholz@coalition-clinics.org	The Coalition of Community Health Clinics (CCHC) is a non-profit network of 14 safety-net health centers in the Portland, Oregon area. Our clinics provide high quality, culturally appropriate care to low-income patients who are uninsured, under-served, or members of the Oregon Health Plan. CCHC operates joint programs for member clinics; provides health insurance enrollment and literacy, as well as clinic and resources referrals; and facilitates meetings and communications so that clinics can more easily work together to improve quality and lower costs, share best practices, and coordinate care for patients. - See more at: http://www.coalitionclinics.org/article/who-we-are#sthash.hyNY39Mk.dpuf
public health	Oregon Center for Environmental Health (OCEH)	can't make this link work from here: http://www.oregon-health.org/		503-233-1510		OCEH is a non-profit, member-based organization, dedicated to reducing and eliminating toxic chemicals that are long lasting and build up in living tissues, threatening the health and reproductive viability of humans and wildlife. OCEH's mission is to protect public health and the environment by promoting alternatives to the use, manufacture, release and disposal of toxic chemicals.
social justice	Oregon State Public Interest Research Group (OSPIRG)	http://www.ospirg.org/home	David Rosenfeld executive director	503-231-4181 x311	http://www.ospirg.org/staff	OSPIRG is a consumer group that stands up to powerful interests whenever they threaten our health and safety, our financial security or our right to fully participate in our democratic society. For decades, we've stood up for consumers, countering the influence of big banks, insurers, chemical manufacturers and other powerful special interests.
social justice	Resolutions Northwest	http://resolutionsnorthwest.org/the-movement/mission-vision-values/		503.595.4890	info@resolutionsnorthwest.org	facilitates honest dialogue to resolve conflict and advance racial and social justice. We envision inclusive and just communities in which people connect across differences and equitably share opportunities to thrive.

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public health; at risk communities	Josiah Hill III Clinic	www.jhillclinic.org		503- 415-9694		The Josiah Hill III Clinic provides education, testing, and resources to families and communities at risk for environmental health hazards in order to promote and improve early childhood health and development. At our clinics we conduct free blood lead testing, provide results on-site within minutes, offer one-to-one blood lead level consultation and link families to community resources.
environmental justice	Environmental Justice Action Group Portland, Oregon	Joined OPAL in 2008	First Unitarian Church of Portland		economicjustice.actiongroup@gmail.com	Joined OPAL A community that educates and speaks out for itself can best protect itself," is the mission of the Environmental Justice Action Group (EJAG) of Portland, Oregon. EJAG is a community-based, membership-driven organization founded in 1996 by a group of north and northeast Portland residents to address significant environmental health hazards faced by residents of those communities
environmental justice	Organizing People/Activating Leaders (OPAL)	http://www.opalpdx.org/		(503) 342-8910	info@opalpdx.org	OPAL Environmental Justice Oregon has been on the front lines of Portland's movement for environmental and social justice since our founding in 2006. We fight for greater self-determination within our most impacted communities. We have built a powerful and inclusive movement at the intersection of transportation, housing and health, lifting up the voices of people of color, low-income residents, women, immigrants, people with disabilities, youth and seniors to speak for themselves and make change. We're the hub of the city's movement for transportation, housing, employment and climate justice. We convene partners across sectors, and build capacity to advance justice for historically-marginalized communities
environmental justice	Northwest Toxics Community Coalition	http://nwtoxiccommunities.org/members/oregon	http://nwtoxiccommunities.org/contact-info			Some of the toxic sites our members organizations are fighting to clean up are polluted with pesticides, coal-tar, PCB's, mercury and DDT. The sites are in regions such as, the Columbia River, Willamette River, Portland Harbor, and old Union Pacific Rail yards.
environmental justice	Southeast Uplift Land Use & Transportation Committee	http://www.seuplift.org/se-uplift-land-use-transportation-committee/	Ashe Urban; Outreach and Communications Program Manager	503-232-0010 x 313	ashe@seuplift.org	To assist the citizens and neighborhood associations of Southeast Portland* to create communities that are livable, socially diverse, safe and vital. Southeast Uplift provides an organizational structure and forum to empower citizens to effectively resolve issues of livability and community development. SE Uplift also joyfully supports Northeast neighborhoods south of I-84
Community engagement and outreach	Voice Public Involvement	http://voicepublicinvolvement.com/	Francesca Patricolo, Principal of Voice Public Involvement			Voice Public Involvement helps communities facilitate improvement to public quality of life through effective communication and creative community engagement for planning and public policy decision-making. Projects at http://voicepublicinvolvement.com/projects/

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equity maps	Coalition for a Livable Future	http://clfuture.org/home	Mara Gross and Kathy Hammock will be working on the transition through September 2015, and will still be available by email.		info@clfuture.org	Mission. The purpose of the Coalition for a Livable Future is to protect, restore, and maintain healthy, equitable, and sustainable communities, both human and natural, for the benefit of present and future residents of the greater metropolitan region. Creating a Livable Future. The Coalition for a Livable Future is a diverse partnership of organizations supporting just and sustainable communities in the Portland-Vancouver region. We were founded in 1994 by a group of civic and nonprofit leaders to encourage collaboration among organizations that had not traditionally worked together. CLF uses research, policy analysis, and convening to catalyze action for equitable development, prosperous and livable communities, and a healthy environment. By working together, CLF members have been able to provide integrated solutions for vibrant neighborhoods, housing affordability, transportation options, economic prosperity, healthy ecosystems, and accountable government. Our signature project, the Regional Equity Atlas, uses maps to document disparities and promote greater equity. By illuminating the geography of opportunity, the Equity Atlas is a powerful tool to shape public policies, plans, community development projects, and investment decisions.
youth	Multnomah Youth Commission	https://multco.us/multnomah-youth-commission		503.823.4000		The Multnomah Youth Commission (MYC), the official youth policy body for both Multnomah County and the City of Portland, is a group of young people, ages 13-21, that strives to provide a voice for youth in the County & City's work. In addition to its advisory role within local government, the MYC provides youth input to its parent organization the Commission on Children, Families & Community and also works to improve the community through service projects. The MYC works to change policy affecting young people, as well as stereotypical community perceptions
quality of life	1000 Friends of Oregon	https://www.friends.org/about/our-focus	https://www.friends.org/regional/portlandmetro	*(503) 497-1000 x124*	*alyson@friends.org*	Working with Oregonians to enhance our quality of life by building livable urban and rural communities, protecting family farms and forests, and conserving natural areas.
energy	Community Energy Project	http://www.communityenergyproject.org/	http://www.communityenergyproject.org/about-cep/contact-us/	*(503) 284-6827*		Community Energy Project, Inc., empowers people to maintain healthier, more livable homes, control their utility costs, and conserve natural resources. We do this through education, hands-on training, and distribution of weatherization, water conservation, and lead poisoning prevention materials. We also provide direct weatherization and water conservation services to seniors and people with disabilities. We deliver these services in partnership with community members and service organizations, utilities, corporations, foundations, and government agencies

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voters	League of Women Voters of Portland	http://www.lwvpdx.org/	http://www.lwvpdx.org/about/contact	503-228-1675	info@lwvpdx.org	The League of Women Voters of Portland is a nonpartisan political organization that promotes informed and active participation in government. Membership is open to all, men and women, who are interested in learning how the government operates and have a desire to make a difference.
community public affairs	City Club of Portland	http://www.pdxcityclub.org/about		503-228-7231	info@pdxcityclub.org	City Club of Portland is a nonprofit, nonpartisan education and research based civic organization dedicated to community service, public affairs and leadership development. Through weekly Friday Forums, community-based research and advocacy, and after-hours civic programs, City Club examines issues of importance to the Portland metropolitan region, the state and society as a whole
community; immigrant and refugee	Immigrant and Refugee Community Organization (IRCO)	http://www.irco.org/who-we-are/mission-history.html; http://www.irco.org/what-we-do/community-development/	Sophorn Cheang, Civic Engagement	971-271-6501	sophornc@irco.org	IRCO's mission is to promote the integration of refugees, immigrants and the community at large into a self-sufficient, healthy and inclusive multi-ethnic society. Founded in 1976 by refugees for refugees, IRCO has nearly 40 years of history and experience working with Portland's refugee and immigrant communities. Following the 1970s political upheavals in Southeast Asia, Oregon and Washington were two of the first states to offer new opportunities and homes to refugees. A group of Vietnamese, Laotian and Cambodian refugees in Portland formed the Indochinese Cultural and Service Center (ICSC) to help newly arrived families adjust to American society and find jobs. By the mid-'80s, ICSC joined forces with another community-based organization, Southeast Asian Refugee Federation (SEARF). The newly formed International Refugee Center of Oregon (IRCO) became the sole service provider of employment services and job training for all newly arrived refugees, a role IRCO has retained ever since. We became the Immigrant and Refugee Community Organization in 2001. In 1994, IRCO founded the Asian Family Center, the first of our culturally and linguistically specific one stop service locations, followed by the establishment of Africa House in 2006.

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community; African American	Urban League of Portland	https://ulpdx.org/	Zev Nicholson, Community Director, Advocacy and Civic Engagement Program	503-280-2600	znicholson@ulpdx.org	Established in 1945, the Urban League of Portland is one of the oldest African American service, civil rights and advocacy organizations in the area. We are part of a network of over 90 National Urban League Affiliates across the country and are recognized as one of the leading voices for African Americans and other people of color in the region. We are a key coalition-builder amongst other African American organizations, and work extensively with both traditional and emerging African American groups, the faith-based community, minority businesses, and other organizations of color, including immigrants and refugees. The Urban League of Portland's mission is to empower African Americans and others to achieve equality in education, employment, health, economic security and quality of life. Our programs include a distinctive blend of direct services, organizing, outreach, and advocacy. We offer workforce services, community health services, summer youth programming, senior services, meaningful civic engagement opportunities, and powerful advocacy
community	Impact NW	http://impactnw.org/main-navigation/about-impact-nw/mission-history/	Katie Riley	503-349-2965	katie@katieriley.org	By working with schools, businesses, faith communities, other community-based organizations and governmental agencies we create a safety net and springboard for community members to improve their quality of life and achieve independence.
community	Latino Network	http://www.latnet.org/		503.283.6881	info@latnet.org	Latino Network provides transformative opportunities, services, and advocacy for the education, leadership and civic engagement of our youth, families and communities
community	Occupy St John's	https://occupystjohns.wordpress.com/	https://www.facebook.com/Occupy-St-Johns-Portland-Oregon-261788043864015/		occupystjohns@gmail.com	The Occupy community of St. Johns OR can communicate here regarding political and social actions in our village.
community	Czech School of Portland	http://czechschoolportland.org/			info@czechschoolportland.org	Czech culture
community	East European Coalition	http://eecnorthamerica.org/	http://eecnorthamerica.org/contact			The purpose of this non-profit corporation is to unite the Eastern European Communities in Oregon and promote Eastern European culture

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community	Green Anchors Partners	http://www.greenanchorspdx.com/	http://www.greenanchorspdx.com/contact-us-green-anchors-pdx/	(541) 390-5167		a 7 acre eco-industrial park with green and creative tendencies, situated on the north shore of the Willamette River, just downstream of the St Johns Bridge.
community	Groundwork Portland	http://www.groundworkportland.org/	Edward B. Hill; Executive Director	(503) 662-2590	edward@groundworkportland.org	Brings about sustainable, community-led improvement of the physical environment in low-income areas, while promoting environmental and social justice.
community	Iraqui Society of Portland	http://iraqisocietyoforegon.org/				Helps integrate Iraqi residents into Portland life by providing basic skills and a sense of community
community	Lideres Verde	http://ourfutureriver.org/coalition-partners/	http://ourfutureriver.org/	*(503) 662-2590*	*ourfutureriver@gmail.com*	Cully neighborhood Latino residents in leadership training on environmental and social justice issues
community	Hmong American Community of Oregon	https://www.bigtent.com/groups/haco			*chia.cha@hotmail.com*	Hmong American Community of Oregon provides various activities of common interests for those of the Hmong ancestry and other interested persons, particularly in the fields of family, education, vocations, culture and recreation. We strive to build among the Hmong individuals, families, community and interest groups, a sense of solidarity and friendship. Through our outreach program we share with other communities our Hmong language, culture and traditions. Thus, preserving what it means to be Hmong for future generations. We represent the Hmong community in Oregon and make known the needs of the Hmong community to government, other agencies, community groups and the public in general
neighborhood	Portland Office of Neighborhood Involvement	http://www.portlandoregon.gov/oni/		*503-823-4519*		Promoting a culture of civic engagement by connecting and supporting all Portlanders working together and with government to build inclusive, safe and livable neighborhoods and communities.
community involvement	Portland Public Involvement Advisory Council (PIAC)	http://www.portlandoregon.gov/oni/48951	Ashley Horne, Program Coordinator	*503-823-5202*	*greg.greenway@portlandoregon.gov*	The purpose of the Public Involvement Advisory Council (PIAC) is to: Develop guidelines and policy recommendations for citywide public involvement, to be presented to City Council for approval, Provide support and advice to City Council and City bureaus with implementation of shared public involvement guidelines and best practices, Encourage ongoing collaboration between the community, City bureaus and City Council in the development of shared public involvement guidelines

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District Coalition Offices & Neighborhood Offices	Central Northeast Neighbors (CNN)	http://cnncoalition.org/		*(503) 823-3156*	*sandral@cnncoalition.org*	Central Northeast Neighbors (CNN) is a community-based non-profit coalition of eight neighborhoods East of NE 33rd to I-205 and North of I-84 to the Columbia River. The CNN Board of Directors is made up of volunteer representatives living and/or working in the Beaumont-Wilshire, Cully, Hollywood, Madison South, Rose City Park, Roseway, and Sumner neighborhoods. We provide support and technical assistance to the volunteer-based neighborhood associations, community groups, individuals, and business associations. The coalition acts as a forum to strengthen communities to take action on issues identified by those communities. The coalition supports community-driven activities that contribute to livability, diversity, safety, vitality and sustainability.
District Coalition Offices & Neighborhood Offices	East Portland Neighborhood Office	http://eastportland.org/	http://www.nwnw.org/contact-us/	*503-823-4550*	*http://eastportland.org/contact-epno*	Represents: Argay, Centennial, Glenfair, Hazelwood, Lents, Mill Park, Parkrose Neighborhood Association, Parkrose Heights, Pleasant Valley, Powellhurst-Gillbert, Russell, Wilkes, Woodland Park; A coalition representing 13 of Portland's easternmost neighborhoods, we are home to diverse communities, unique neighborhoods, and a quarter of Portland's population! - See more at: http://eastportland.org/#sthash.woZDhF5u.dpuf
District Coalition Offices & Neighborhood Offices	Neighbors West/Northwest (W/NW)	www.nwnw.org			*coalition@nwnw.org*	Represents: Arlington Heights, Forest Park, Goose Hollow, Hillside, Linnton, Northwest District Association, Northwest Industrial, Northwest Heights, PearlDistrict, Sylvan-Highlands; Neighbors West-Northwest (NWNW) grew out of the 1960s organizing efforts of the Northwest District Association, a strong voice for livability issues in Portland. At that time our work involved supporting Northwest Portland neighborhood volunteers as they advocated to halt construction of a proposed I-405 extension. We also worked to secure a historic good neighbor agreement with Legacy Good Samaritan while they were in the early stages of expansion. Today we provide support to neighbors in twelve vibrant Neighborhood Associations in northwest and inner southwest Portland. Together, these diverse associations contribute to the efforts of our city's active citizen volunteers who provide input and direct involvement with issues that effect livability in our communities.
District Coalition Offices & Neighborhood Offices	Northeast Coalition of Neighborhoods (NECN)	http://necoalition.org/		*503.388.5004*	info@necoalition.org	Represents: Alameda, Boise, Concordia, Eliot, Grant Park, Humboldt, Irvington, King, Sabin, Sullivan's Gulch, Vernon, Woodlawn

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District Coalition Offices & Neighborhood Offices	Southeast Uplift (SEUL)	http://www.seuplift.org/		*(503) 232-0010*	*southeastuplift.org*	Represents: Ardenwald-Johnson Creek, Brentwood-Darlington, Brooklyn, Buckman, CENTER, Creston-Kenilworth, Eastmoreland, Foster-Powell, Hosford-Abernethy, Kerns, Laurelhurst, Montavilla, Mt. Scott-Arleta, Mt. Tabor, Reed, Richmond, Sellwood-Moreland, South Tabor, Sunnyside, Woodstock; Our Mission: To assist the citizens and neighborhood associations of Southeast Portland* to create communities that are livable, socially diverse, safe and vital. Southeast Uplift provides an organizational structure and forum to empower citizens to effectively resolve issues of livability and community development. * SE Uplift also joyfully supports Northeast neighborhoods south of I-84. We Believe: Relationship-Building: Personal connections and networks strengthen our communities. Community Involvement: Organized neighbors can shape the future of our communities, including envisioning and enacting positive change. Through collaboration, we co-create the communities we want to inhabit. Grassroots Democracy: We all have a role in determining the character and future of our city through grassroots, bottom-to-top participation. Sharing, Teaching and Learning: With tools, support, and opportunities to connect, we can effect positive change. Diversity and Inclusiveness: In an inclusive, multicultural environment, through which we can explore our differences and come together around common interests and goals. Building Capacity: We strengthen our communities as we strengthen our neighborhood associations, community based organizations and business districts
District Coalition Offices & Neighborhood Offices	Southwest Neighborhoods, Inc.	http://swni.org/		*(503) 823-4592*	*swni123@teleport.com*	Represents: Arnold Creek, Ashcreek, Bridlemile, CollinsView, Corbett-Terwilliger-Lair Hill, Crestwood, Far Southwest, Hayhurst, Hillsdale, Homestead, Maplewood, Markham, Marshall Park, Multnomah, South Burlingame, Southwest Hilles, West Portland Park.; Empower citizen action to improve and maintain the livability of Southwest neighborhoods.
District Coalition Offices & Neighborhood Offices	North Portland Neighborhood Services (NPNS)	http://npnscommunity.org/	http://npnscommunity.org/contact/	*(503) 823-4524*	*info@npnscommunity.org*	Serves: Arbor Lodge, Bridgeton, Community Association of Portsmouth, East Columbia Friends of Cathedral Park, Hayden Island, Kenton, Overlook,Piedmont, St. Johns, University Park; North Portland Neighborhood Services: Working with neighbors in North and Northeast Portland to engage community participation, build community assets, and foster community partnerships.

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neighborhood	City Neighborhood association web page	https://www.portlandoregon.gov/oni/28385	do we contact all 95 neighborhood associations? Entered two but can contact all?			contains links to associations, contacts and CENSUS DATA
neighborhood	Friends of Cathedral Park	https://www.portlandoregon.gov/oni/47225	https://www.facebook.com/CathedralParkNeighborhood/info/?tab=page_info	503-823-4519		Cathedral Park is a beautiful and historic neighborhood in North Portland, known for its nature areas and vibrant community.
neighborhood	Bridlemile Neighborhood Association/Bridlemile Creek Stewards	http://swni.org/bridlemile/about	SWNI Parks & Watershed Committee; Steve Mullinax,	(503) 823-4592	BridlemileNAParks@swni.org	The rain that falls onto every home, park, and openspace in Bridlemile eventually drains into one of Bridlemile's many creeks, which are tributaries of Fanno Creek, which is a branch of the Tualatin River, which flows into the Willamette River.
neighborhood activism	North Portland Neighborhood Services	http://npnscommunity.org/%20http:/piedmontneighborhood.com/		(503) 823-4524	info@npnscommunity.org	North Portland Neighborhood Services (NPNS) staff work with grassroots organizations and community building projects that engage residents in the 11 NPNS neighborhoods. NPNS is one of seven regional neighborhood offices funded by the City of Portland Office of Neighborhood Involvement. NPNS staff work at the direction of the community and without charge providing organizational, technical, material, and financial assistance and support. North Portland Neighborhood Services doesn't solve problems or initiate ideas, but rather works with you and your neighbors to move community ideas forward and solve issues that often don't receive the attention they should. North Portland Neighborhood Services' small staff has over 50 years of combined service working for neighborhoods This experience has produced a unique knowledge of North Portland, an effective record at community building and important access to City Hall.
neighborhood (unaffiliated)	Old Town/ Chinatown Community Association	http://oldtownchinatown.org/			chair@oldtownchinatown.com	The Old Town Chinatown Community Associationoperates as a Portland neighborhood association as recognized by the City's Office of Neighborhood Involvement. Membership in the OTCTCA is open to anyone who lives, owns property, or operates a business or non-profit organization in Old Town Chinatown.
neighborhood	Southwest Hills Residential League	http://swni.org/swhrl	http://swni.org/contact_us	503-823-4592	swhrl@yahoo.com	Empower citizen action to improve and maintain the livability of Southwest neighborhoods.

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neighborhood	Cully Association of Neighbors	http://www.cullyneighbors.org/	Erwin Bergman, livibility	503.288.8573	http://www.cullyneighbors.org/contactus.asp	The Cully Association of Neighbors is a non-profit volunteer organization whose members strive to enhance the livability of the neighborhood. We meet to make Cully a better place to live by working together on issues and activities, connecting with neighbors, businesses and governmental agencies. The Cully Association of Neighbors takes pride in its neighborhood involvement and the achievements that have resulted
neighborhood	Portsmouth Neighborhood Association	http://portsmouthneighborhood.com/	Mary-Margaret Wheeler-Weber	503-240-3344	portsmouthchair@gmail.com	Portsmouth is a neighborhood on the North Portland peninsula. Its boundaries are the railroad cut on the west, Lombard on the south, Chautauqua on the east and Columbia Boulevard on the north. The Portsmouth Neighbothood Assocation is one of the 95 officially recognized neighborhood associations in Portland. Neighborhood associations are a powerful resource that draws together a diversity of people who are concerned with issues affecting the quality of life in their neighborhoods. Participation is voluntary and open to all residents who live, own property or a business, organization, church or government agency within its boundaries. Your neighborhood association does the following: Advocates: Represents neighborhood interests to local government, participates on policy committees, develops grassroots campaigns and advocates for community priorities. Communicates Activities and Ideas: Organizes forums, writes and distributes neighborhood communications. Organizes Community Events: Plans block parties, festivals, clean-ups, tree plantings and other events
neighborhood	Overlook Neighborhood Association (OKNA)	http://www.overlookneighborhood.org/	– Leslee Lewis	503-703-3702	kgllport@aol.com	The Overlook Neighborhood Association welcomes everyone! Our neighborhood includes approximately 3,800 homes, 5,800 people, a thriving industrial area and several business associations. Everyone who lives, owns property or who works within the boundaries of Overlook is part of OKNA. Please attend a meeting and get involved
neighborhood	Arbor Lodge Neighborhood Association	http://www.arborlodgeneighborhood.com/	Nate Young, board member		arborlodgepdx@gmail.com	Welcome to the Arbor Lodge Neighborhood Association! We're glad you're here. We're convinced that Arbor Lodge is the best neighborhood in Portland— maybe even the whole entire universe
neighborhood	Eliot Neighborhood Association	http://eliotneighborhood.org/	Alan Rudwick; Land Use Chair	5037033910	arudwick@gmail.com	The Eliot Neighborhood Association is a nonprofit corporation whose members are the residents and business owners of the Eliot Neighborhood. Its purpose is to inform Eliot residents about issues affecting the neighborhood through meetings, newsletters, this website and other activities.
neighborhood	Forest Park Neighborhood Association	http://www.forestparkneighbors.org/		503.823.4288	board@forestparkneighbors.org	The Neighbors West-Northwest District Coalition provides support to neighborhood associations in the northwest and inner southwest of Portland.

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neighborhood	Northwest District Association	http://www.northwestdistrictassociation.org/?page_id=4		503.823.4288	contact@northwestdistrictassociation.org	The NWDA is open to residents, representatives of businesses, and property owners in the Northwest Neighborhood. We encourage everyone to participate to help make "Northwest" a great place to live, work, and visit
neighborhood	St. Johns Neighborhood Association	http://stjohnspdx.org/			info@stjohnspdx.org	The purpose for which SJNA is organized is to enhance the livability of the area by: Establishing and maintaining an open line of communication and liaison between the neighborhood, government agencies, and other neighborhoods; Providing an open process by which all members of the neighborhood may involve themselves in the affairs of the neighborhood; Organizing community members, both individuals and groups
neighborhood	East Columbia neighborhood association	http://www.ecnapdx.com/	http://www.ecnapdx.com/contact			East Columbia is a very unique neighborhood due to its wetlands, open space and drainage wasy combined with residential, industrial and agricultural uses
neighborhood (unaffiliated)	Portland Downtown Neighborhood Association	http://portlanddowntownna.com/		503-823-4288	info@portlanddowntownna.com	The PDNA is one of the primary sources of public input for city bureaus and officials as they make decisions about downtown development. The city seeks the PDNA's input by sending staff to attend PDNA meetings, inviting PDNA representatives to serve on planning committees, and mailing notices to the Board about proposed construction. Through position statements, public testimony, and participation in citizen advisory groups, PDNA and its members weigh-in on critical decisions that shape the future of life in downtown Portland. Lobbied to reduce impact of Ladd Tower on the South Park Blocks. Presented testimony at Design Commission, City Council. Wrote op-ed articles. Petitioned to prevent reduction in Fareless Square service. Presented testimony at TriMet Hearings. Joined coalition promoting statewide legislation to enhance renters' rights and regulate condo conversion. Advocated reinstatement of on-street parking ban along the South Park Blocks. Sent presentation to Parks & Recreation, Department of Transportation, City Council. Helped negotiate Good Neighbor Agreements, including the accord that prevented eviction of Peterson's Convenience Store. Presented testimony at City Council. Worked with Development Commission to ensure that expiring Section Eight housing would be funded through the Urban Renewal Area budget. Gave presentation to Central City URA Committee. Created website, wrote editorials to promote retail freeway caps as possible mechanism to reconnect Downtown with Goose Hollow across I-405.
neighborhood	Kerns Neighborhood Association	http://www.kernspdx.org/resources/	http://www.kernspdx.org/contact/			

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neighborhood	Kenton Neighborhood Association	http://historickenton.com/	http://historickenton.com/contact-us/			Our mission is to support our community by advocating for diversity, sustainability and promoting the propensity and livability of all neighbors. - See more at: http://historickenton.com/about/general-information/#sthash.1JCaP1Wi.dpuf
neighborhood (unaffiliated)	Lloyd district Community Association	http://lloyddistrict.org/	http://lloyddistrict.org/contactus/			The Lloyd District Community Association is a group of business leaders and residents working together to make our community a better place to live, work, and play. Members enjoy benefits of networking with other leaders in the community and a loud voice for concerns regarding City issues. Join us to make the Lloyd District the place you want to be in.
community	Verde	http://www.verdenw.org/	Pedro Moreno, outreach worker	503.980.5261	pedromoreno@verdenw.org	Verde serves communities by building environmental wealth through Social Enterprise, Outreach and Advocacy. Since 2005, Verde has brought new environmental investments to Portland's neighborhoods, involved community members in the planning and building of these investments, and ensured that low-income people and people of color directly benefited from the investments: Greenspaces, Habitat, Energy Efficiency and Renewable Energy, Green Streets, Stormwater Management Facilities, Environmental Education, Green Jobs, Green Businesses...
neighborhood	SW Neighborhoods, Inc (SWIN)	http://swni.org/	Sharon Keast, communications	503-823-4592	sharon@swni.org	Empower citizen action to improve and maintain the livability of Southwest neighborhoods.
neighborhood / community	Neighbors West-Northwest Coalition	http://www.nwnw.org/			coalition@nwnw.org	NWNW supports neighborhood volunteers as they govern their own affairs, advocate for community interests, and promote public involvement in the development of public policy. We assist with research, land use expertise, fiscal management, an array of communications efforts, membership recruitment, leadership trainings – and more. Neighborhoods are a volunteer driven training ground for aspiring citizen activists. Coalition staff provide resources to help develop these future leaders. NWNW may also act as a liaison between citizens and public agencies.
neighborhood	University Park Neighborhood Association	https://www.portlandoregon.gov/oni/48655	Mike Salvo, chair; Pam Daily, secretary	503-823-4519	UPNA.chair@gmail.com; UPNA.secretary@gmail.com	UPNA is organized exclusively for charitable and educational purposes. a To establish and maintain communication and liaisons between the neighborhood, the City of Portland, and the N. Portland Community (i.e. government agencies, institutions, businesses, organizations, and other neighborhoods) regarding the livability and planning for the neighborhood. b To provide a forum and encourage open processes by which members may become informed about neighborhood issues and express their ideas and recommendations concerning the neighborhood

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neighborhood	Cathedral Park Neighborhood Association (NPNS)	http://www.portlandoregon.gov/oni/search/index.cfm?event=search.neighborhood&neighborhood_id=31&submit=Search	Doug Larson	503-823-4519	larson.dg@gmail.com	
neighborhood	Linnton Neighborhood Association Environmental Committee	http://nwtoxiccommunities.org/members/oregon/linnton-neighborhood-association		503-309-2458	LinntonLRG@gmail.com	
community	Asian Pacific American Network of Oregon (APANO)	http://www.apano.org/		(971) 340-4861	info@apano.org	The core of APANO's work is building a powerful base of members who co-create and co-lead campaigns that address real issues in their community. Our community organizing results in concrete change through policy, public investments, political influence, and greater solidarity with other communities of color and allies. APANO members and leaders drive all aspects of our work, through informing and identifying the issues we prioritize, to developing and implementing campaign plans with our staff and coalition partners.
community/ Tribes	Confederated Tribes of Siletz Indians (CTSI)	http://ctsi.nsn.us/	Portland Area office	503) 238-1512		The Confederated Tribes of Siletz is a federally recognized confederation of 27 bands, originating from Northern California to Southern Washington. Termination was imposed upon the Siletz by the United States government in 1955. In November of 1977, we were the first tribe in the state of Oregon and second in the United States to be fully restored to federal recognition. In 1992, our tribe achieved self governance, which allows us to compact directly with the US Government. This gives us control and accountability over our tribal programs and funding. We occupy and manage a 3,666 acre reservation located in Lincoln County, Oregon. We manage several resources, including water, timber and fish

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community/ Tribes	Portland Youth and Elders Council	http://nayapdx.org/community/community-engagement-advocacy/portland-youth-elders-council/		503.288.8177	info@nayapdx.org	Portland Youth and Elders Council is a grassroots advocacy group housed at NAYA Family Center and is open to everyone interested in building a strong civic connection with the local Native American community.
community/ Tribes	Wiconi International	http://www.wiconi.com/?cid=595		360-546-1867 (vancouver, Washington)	office@wiconi.com	Provides education, encouragement and offer practical support to Native American families and communities in creating a preferred future.
community/ Tribes	Wisdom of the Elders	http://wisdomoftheelders.org/	http://www.wisdomoftheelders.org/contact-us/	503-775-4014	raven@wisdomoftheelders.org	Records and preserves the oral history, cultural arts, language concepts, and traditional ecological knowledge of exemplary American Indian historians, cultural leaders and environmentalists in collaboration with arts and cultural organizations and educational institutions. They especially seek to correct misconceptions, end prejudice, bring health and wellness to Native people, and demonstrate how Indian culture has and is continuing to enrich our worlds

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community/ Tribes	American Indian Movement (Portland Chapter)	http://www.aimovement.org/			AIMGGC@att.net	Things will never be same again and that is what the American Indian Movement is about ... They are respected by many, hated by some, but they are never ignored ... They are the catalyst for Indian Sovereignty ... They intend to raise questions in the minds of all, questions that have gone to sleep in the minds of Indians and non-Indian alike ... From the outside, AIM people are tough people, they had to be ... AIM was born out of the dark violence of police brutality and voiceless despair of Indian people in the courts of Minneapolis, Minnesota ... AIM was born because a few knew that it was enough, enough to endure for themselves and all others like them who were people without power or rights ... AIM people have known the insides of jails; the long wait; the no appeal of the courts for Indians, because many of them were there ... From the inside AIM people are cleansing themselves; many have returned to the old traditional religions of their tribes, away from the confused notions of a society that has made them slaves of their own unguided lives ... AIM is first, a spiritual movement, a religious re-birth, and then the re-birth of dignity and pride in a people ... AIM succeeds because they have beliefs to act upon ... The American Indian Movement is attempting to connect the realities of the past with the promise of tomorrow ... They are people in a hurry, because they know that the dignity of a person can be snuffed by despair and a belt in a cell of a city jail ... They know that the deepest hopes of the old people could die with them ... They know that the Indian way is not tolerated in White America, because it is not acknowledged as a decent way to be ... Sovereignty, Land, and Culture cannot endure if a people is not left in peace ... The American Indian Movement is then, the Warriors Class of this century, who are bound to the bond of the Drum, who vote with their bodies instead of their mouths ... THEIR BUSINESS IS HOPE
community/ Tribes	Confederated Tribes of the Warm Springs Reservation of Oregon	http://www.warmsprings.com/	http://www.warmsprings.com/warmsprings/Contact_Us/	(541) 553-1161		Welcome to Warm Springs, a nation where the sun shines most every day, and time turns to the pace of a culture thousands of years in the making. It is the land of the Warm Springs, Wasco and Paiute Native American Tribes, stretching from the snowcapped summit of the Cascade Mountains to the palisaded cliffs of the Deschutes River in Central Oregon. We invite you to visit Warm Springs. We invite you to escape to another nation

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community/ Tribes	Confederated Tribes of the Umatilla Indian Reservation	http://ctuir.org/	http://ctuir.org/about-us/contact-us	541-276-3165		Day-to-day business of the tribal government is carried out by a staff of about 520 employees in departments and programs such as natural resources, health, police, fire, education, social services, public works, economic development, and dozens more. In 1855 the three tribes signed a treaty with the US government, in which it ceded over 6.4 million acres to the United States. In the treaty, the tribes reserved rights to fish, hunt, and gather foods and medicines within the ceded lands, which today is northeastern Oregon and southeastern Washington. Tribal members still exercise and protect those rights today
community/ Tribes	Confederated Tribes of the Grand Ronde Community of Oregon	http://www.grandronde.org/	Siobhan Taylor?	(503)-235-4230	portland@grandronde.org	The mission of the Confederated Tribes of Grand Ronde staff is to improve the quality of life for Tribal people by providing opportunities and services that will build and embrace a community rich in healthy families and capable people with strong cultural values. Through collective decision making, meaningful partnerships and responsible stewardship of natural and economic resources, we will plan and provide for a sustainable economic foundation for future generations..
community/ Tribes	Nez Perce Tribe	http://www.nezperce.org/	http://www.nezperce.org/Official/mainpages/contactus.htm	208-843-2253		To implement effective and efficient services through existing and potential programs that promote, protect, and perpetuate the utilization and sustain ability of the tribe's invaluable treaty rights and resources. To improve management of all Tribal and individual-Indian lands in a manner that preserves long-term productivity, protects cultural properties, and maximizes revenue. To protect the health of the Tribal public through sound land management practices and protection of all environmental resources. Above all, to protect, preserve, and perpetuate all cultural resources necessary to Nez Perce way of life
community/ Tribes	Yakama Nation Fisheries	http://yakamafish-nsn.gov/	Bob Rose	509-945-0141	rosb@yakamafish-nsn.gov	Yakama Nation Fisheries is a program of the Confederated Tribes and Bands of the Yakama Nation. From its inception in 1983, Yakama Nation Fisheries has employed scientific expertise in concert with traditional ecological knowledge to develop innovative projects and partnerships credited with restoring culturally important fish runs in the Columbia River. Yakama Nation Fisheries is headquartered on the Yakama Reservation. We maintain field offices in Portland, Husum, Goldendale, Wahkiacus, Glenwood, Prosser, Yakima, Ellensburg, Cle Elum, Peshastin, Wenatchee, Winthrop, Piney Wood, and Twisp. Yakama Nation Fisheries consists of over 200 employees that manage numerous projects across the Columbia River mainstem and sub-basins (White Salmon, Little White Salmon, Wind, Klickitat, Rockcreek, Yakima, Wenatchee, Entiat, Chelan, and Methow). Yakama Nation Fisheries focuses on culturally important fish, including: Chinook, sockeye, steelhead, coho, Pacific lamprey, and White sturgeon. Yakama Nation Fisheries honors, protects, and restores the Columbia River.

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community/ Tribes	Confederated Tribes and Bands of the Yakama Nation	http://www.yakamanation-nsn.gov/		(509) 865-5121; (509) 865-5121 Ext. 4648 (Department of Natural resources)		Mission: The Department of Natural Resources was established to manage, co-manage and protect the Yakama Nation's Ancestral, Cultural, and Treaty Natural Resources on Reservation, in the Ceded Area and at Usual and Accustomed Sites, to meet the tribal culture, protecting tribal sensitive areas and sites and restoring diminished damaged resources.
community/ Tribes	Native American Youth Association (NAYA)	http://nayapdx.org/		503.288.8177	INFO@NAYAPDX.ORG	The Portland region has a large, growing proud Native community grounded in our traditional worldview. Our united and connected community celebrates our multicultural and multi-tribal heritage as a source of strength. Our healthy community understands the connection between our environment, our culture, our spirituality and our wellness. Our economically secure families thrive and live in homes that provide stability and a place to practice culture and connection to community. Our successful businesses support the entire Native community and its prosperity.
planning; land use	Citywide Land Use Group	https://www.portlandoregon.gov/oni/	Bonny McKnight, Citywide Land Use group chair (mentioned as contact for CWLU meetings and sponsored activities on http://www.portlandonline.com/Fritz/index.cfm?a=240868&c=49247		bonnymck@comcast.net	mentioned repeatedly for meeting sites but no independent web presence I could find
planning; river plan	River Plan Committee	https://www.portlandoregon.gov/bps/42556	Try the bureau and ask about river plan committee current leaders	503-823-7700		The River Plan Committee is a voluntary group comprised of seven Portlanders and chaired by a member of the Portland Planning Commission. Its role is to provide guidance to the City on an update of the Willamette Greenway Plan for the North Reach of the Willamette River.
port	Port of Portland (as PRP listed below)	http://www2.portofportland.com/	Community Outreach	503.415.6056		Podcasts: https://www2.portofportland.com/Inside/PortlandHarborSuperfund;

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transportation	Department of Transportation	http://www.oregon.gov/ODOT/Pages/index.aspx	Matthew Garrett, Director	(888) 275-6368		The Oregon Department of Transportation began life in 1913 when the Oregon Legislature created the Oregon Highway Commission to "get Oregon out of the mud." Today, the Oregon Department of Transportation works to provide a safe, efficient transportation system that supports economic opportunity and livable communities for Oregonians. We develop programs related to Oregon's system of highways, roads, and bridges; railways; public transportation services; transportation safety programs; driver and vehicle licensing; and motor carrier regulation.
freight	City of Portland Freight Advisory Committee	https://www.portlandoregon.gov/transportation/54899				Support and enhance the economy of the City of Portland by advancing a balanced and well-managed multi-modal freight network.
biking	City of Portland Bicycle Advisory Committee	https://www.portlandoregon.gov/transportation/37435	Roger Geller		roger.geller@portlandoregon.gov	The twenty-member volunteer Bicycle Advisory Committee (BAC) meets monthly to review projects of interest to cyclists and discuss bike issues. The committee advises City Council and bureaus on all bicycle-related matters.
pedestrians	City of Portland Pedestrian Advisory Committee	https://www.portlandoregon.gov/transportation/34964	Sara Schooley, Pedestrian Coodinator	503-823-4589	sara.schooley@portlandoregon.gov	The PAC advises the City of Portland – particularly the Bureau of Transportation – on matters that encourage and enhance walking as a means of transportation, recreation, wellness and environmental enhancement. The PAC is a 9- to 15-person committee that represents a cross-section of Portlanders, including walking and mobility advocates, neighborhood activists, environmental design professionals and citizens-at-large
Willamette	Willamette Technical Advisory Committee	https://www.portlandoregon.gov/bps/42564		503-823-7700		The purpose of the Willamette Technical Advisory Committee is to act as a forum where City staff can share information about the progress of projects along the Willamette River whose geographic scope or impacts overlap with other government agencies working in the same area. By building a foundation of understanding about the parallel efforts, Willamette TAC members will help draw connections between the projects and with their own work. This coordination will lead to greater efficiencies and connections in project planning and implementation between the various local, state and federal agencies represented on the committee.
Metro	Metropolitan Service District (District 5 - Sam Chase)	http://www.oregonmetro.gov/metro-news/councilor-chase-news/about	Sam Chase	Nikolai Ursin; Policy coordinator; 503-797-1939; nikolai.ursin@oregonmetro.gov	sam.chase@oregonmetro.gov	Metro works with communities, businesses and residents in the Portland metropolitan area to chart a wise course for the future while protecting the things we love about this place.

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equity	Metro equity	http://www.oregonmetro.gov/regional-leadership/access-metro/equity	Juan Carlos Ocaña-Chíu	503-797-1774	juan.carlos.ocana-chiu@oregonmetro.gov	Our region is stronger when individuals and communities benefit from quality jobs, living wages, a strong economy, stable and affordable housing, safe and reliable transportation, clean air and water, a healthy environment, and sustainable resources that enhance our quality of life. We share a responsibility as individuals within a community and communities within a region. Our future depends on the success of all, but avoidable inequities in the utilization of resources and opportunities prevent us from realizing our full potential. Our region's population is growing and changing. Metro is committed with its programs, policies and services to create conditions which allow everyone to participate and enjoy the benefits of making this a great place today and for generations to come. In 2010, the Metro Council adopted equity as one of the region's six desired outcomes. The equity strategy program is an organizing framework initiated by the Metro Council in 2012 to incorporate and apply equity more consistently across its program, policies and services – in collaboration with community, city and county partners
development	Portland Development Commission	http://www.pdc.us/welcome.aspx	Shawn Uhlman	503-823-3200; 503-823-7994	uhlmans@pdc.us	PDC's mission is to create one of the world's most desirable and equitable cities by investing in job creation, innovation and economic opportunity throughout Portland.
planning and sustainability	Portland Bureau of Planning and Sustainability (BPS)	https://www.portlandoregon.gov/bps/		503-823-7700	bps@portlandoregon.gov	The Portland Bureau of Planning and Sustainability (BPS) develops creative and practical solutions to enhance Portland's livability, preserve distinctive places and plan for a resilient future. BPS collaborates with community partners to provide: Comprehensive land use, neighborhood, district, economic, historic and environmental planning, and urban design. Research, policy and technical services to advance green building, energy efficiency and the use of solar and renewable energy, waste prevention, composting and recycling, and a sustainable food system. Policy and actions to address climate change

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sustainable development	Portland/Multnomah Sustainable Development Commission	http://www.portlandoregon.gov/oni/article/84819	City: Michele Crim, 503-823-5638; Multnomah County, Molly Chidsey, 503-988-5015 ext 27365			The Sustainable Development Commission (SDC) is a 11-member citizen advisory panel appointed by the Mayor of Portland and the Multnomah County Board of Commissioners. Reporting directly to Portland City Council and the Multnomah County Board of Commissioners, SDC promotes programs and policies in three main areas related to sustainable development: 1) Help the City and County identify specific resource conservation goals and environmental practices within government to reduce costs and support sustainability. 2) Create and maintain a Sustainable Community Report Card to inform residents and businesses about community progress related to a specific set of sustainability indicators. 3) Guide strategies to enhance sustainable economic development by increasing Portland's visibility as an international center for green business development and professional training on sustainability.
urban forestry	Urban Forestry Commission	https://www.portlandoregon.gov/parks/41487				The Commission reviews development plans and assesses the impact on the urban forest. It also acts as an appeal board for right-of-way street tree permits, sponsors the Heritage Tree Program, and educates the community about urban forestry issues.
environmental services	Bureau of Environmental Services	https://www.portlandoregon.gov/bes/	Linc Mann	503-823-5328		Portland is a leader in restoring urban waterways, using natural approaches to manage stormwater, and working to recover endangered species. Environmental Services is committed to protecting and restoring our watersheds for clean water, lower infrastructure costs, and making our city more livable and healthy.
Municipal Employees	Oregon American Federation of State, County and Municipal Employees (AFSCME)	http://www.oregonafscme.com/index.cfm	could not get staff link to work	(503) 239-9858		Oregon AFSCME Council 75 represents some 25,000 workers in Oregon. Most are public employees who work for either the State of Oregon or an Oregon city, county or special district. Oregon AFSCME does represent some private sector employees as well; most of those are employed by non-profit agencies that provide some form of public service
public transport	Tri-Met	http://trimet.org/	T. Allen Bethel, vice president board of directors			Vision: To do our part in making our community the best place to live in the country. Mission: To provide valued transit service that is safe, dependable and easy to use. Values: Do the right thing, by being responsive, inclusive and accountable
Metro	Oregon Metro	http://www.oregonmetro.gov/	Tom Hughes and Andy Shaw?	503-797-1700	http://www.oregonmetro.gov/metropedia/regional-leadership/contact-metro	Whether your roots in the region run generations deep or you moved to Oregon last week, you have your own reasons for loving this place – and Metro wants to keep it that way. Help shape the future of the greater Portland region and discover tools, services and places that make life better today.

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City	City of Portland	http://www.portlandoregon.gov/	Marty Stockton, Portland Bureau of Sustainability and Portland Public Involvement	503-823-2041	marty.stockton@portlandoregon.gov	
County	Multnomah County	https://multco.us/	Brenda Morgan, Program Manager, Community Outreach	503-988-3450	citizen.involvement@multco.us	
vector control	Multnomah County vector control	https://multco.us/health/staying-healthy/pest-prevention-and-control/vector-control-code-enforcement		**503-988-3464**		Vector Control protects health and enhances livability through control of the rat and mosquito populations, and serves as a resource for addressing public health vector problems. Programs include Rodent Control, Mosquito Control and Code Enforcement, which enforces some specific county and city municipal codes
soil and water conservation	East Multnomah Soil and Water Conservation District (EMSWCD)	http://emswcd.org/	Allison Hensey, Associate Director	503-222-SOIL (7645)	allisonh@emswcd.org	The East Multnomah Soil and Water Conservation District (EMSWCD) is a unit of local government serving Northwest Oregon's Multnomah County east of the Willamette River. We work entirely on a voluntary, non-regulatory basis. All of our work is geared toward keeping water clean, conserving water and keeping soil healthy!
drainage, flood control	Multnomah County Drainage District	http://www.mcdd.org/				The Multnomah County Drainage District protects lives, property and the environment through innovative, proactive flood plain management.
soil and water conservation	West Multnomah Soil & Water Conservation District	http://www.wmswcd.org/	Carol Myers Lindberg, Communications Coordinator	503-238-4775 ext. 101	carolyn@wmscd.orf	We're here to serve West Multnomah County and Sauvie Island residents with information and assistance on conservation planning, invasive weeds, native plants, livestock management, grant funding, wildlife, healthy woods, habitat restoration, school gardens and other projects for which they need assistance. We look forward to hearing from you!
State Elected Officials	Oregon State Senate District 18	https://www.oregonlegislature.gov/burdick	Senate Majority Leader Ginny Burdick	503-986-1718	sen.ginnyburdick@state.or.us	

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State Elected Officials	Oregon State House District 36	http://www.oregonlegislature.gov/williamson	House Majority Leader Jennifer Williamson	503-986-1436	Rep.JenniferWilliamson@state.or.us	
State Elected Officials	Governor	http://www.oregon.gov/gov/pages/index.aspx	Kate Brown	(503) 378-4582	contact form: http://www.oregon.gov/gov/Pages/share-your-opinion.aspx	
State Elected Officials - comms	Governor	http://www.oregon.gov/gov/pages/index.aspx	Kristen Grainger, Communications Director	503-378-5965	kristen.grainger@oregon.gov	
Universities	University of Portland	http://www.up.edu/pac/default.aspx?cid=7651&pid=2936	Andre Hutchinson, Chair, Presidential Advisory Committee on Sustainability	503-943-7306	hutchina@up.edu	
Universities	Lewis & Clark University Law	https://www.lclark.edu/offices/public_affairs_and_communications/	Joe Becker, Executive Director of Public Affairs	503-768-7971	jbecker@lclark.edu	
Universities	Portland State University	http://www.pdx.edu/university-communications/contact	Chelsea Kastelnik, Marketing & Communications Manager	503-725-8575	ckast@pdx.edu	
Universities	Portland Community College	http://www.pcc.edu/	Abe Proctor, Manager of Community Relations	971-722-5227	abraham.proctor@pcc.edu	
Universities	Oregon State University	http://oregonstate.edu/	Patrick Proden, Outreach and Engagement Regional Administrator	503-821-1150	patrick.proden@oregonstate.edu	

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Universities	Reed College	http://www.reed.edu/	Mandy Heaton, Executive Director of Communications and Public Affairs	503-777-7289	heatonm@reed.edu	
Universities	Washington State University, Vancouver	http://www.vancouver.wsu.edu/	Maureen Keller, Office of Marketing and Communications	360-546-9599	mareen_keller@wsu.edu	
Universities; environmental exposure and health	Pediatric Environmental Health Specialty Unit (PEHSU); University of Washington	http://depts.washington.edu/pehsu/		206- 744-9380		The University of Washington PEHSU has assembled a team of experts including pediatricians, emergency medicine physicians, toxicologists, and other environmental health specialists to provide health care providers, government officials, educators, and families with telephone consultation on health risks associated with environmental exposures. In addition, these experts are available to train health care providers and others, and can provide pediatric clinical services on a case-by-case basis at the University of Washington Pediatric Clinic and at the Harborview Medical Center.
Universities	Center for Research on Occupational and Environmental Toxicology; Oregon Health & Science University	http://www.ohsu.edu/croet/		503-494-4273		CROET's mission is to promote health, and prevent disease and disability among working Oregonians and their families, through basic and applied research, outreach, and education.
State; public health	Oregon Health Authority	http://www.oregon.gov/OHA/Pages/index.aspx	ask for communications and web operations contact	health.webmaster@state.or.us	971-673-1222	The Oregon Health Authority is at the forefront of lowering and containing costs, improving quality and increasing access to health care in order to improve the lifelong health of Oregonians. The organizational chart shows the top-level organization of the Oregon Health Authority. OHA is overseen by the nine-member citizen Oregon Health Policy Board working towards comprehensive health reform in our state.
human and occupational health	Oregon Department of Human Services, Environmental and Occupational Epidemiology	http://www.dhs.state.or.us/publichealth/eoe/index.cfm			503-731-4025	EOE conducts surveillance on reportable environmental illnesses and targeted occupational injuries and diseases, and provides public information and education on preventive strategies about environmental health risks. Our mission is to improve the safety and health of all Oregonians

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State; Environmental Quality	Oregon Department of Environmental Quality (ODEQ)	http://www.deq.state.or.us/lq/cu/nwr/portlandharbor/	Matt McClincy	503-229-5538	mcclincy.matt@deq.state.or.us	http://www.deq.state.or.us/lq/cu/nwr/PortlandHarbor/understanding.htm
State; boating	Oregon State Marine Board	http://www.oregon.gov/osmb/pages/access/access.aspx	http://www.oregon.gov/OSMB/pages/contact_us_directory.aspx#Environmental_Section	503-378-8587	marine.board@state.or.us	boating access information. The Oregon State Marine Board's mission is: "Serving Oregon's recreational boating public through education, enforcement, access, and environmental stewardship for a safe and enjoyable experience. It's the vision of the Marine Board to create: "A collaborative community providing opportunities for all boaters to safely and respectfully experience Oregon's waterways."
State; parks	Oregon Parks and Recreation	http://www.oregonstateparks.org/		800-551-6949	park.info@oregon.gov	The mission of the Parks and Recreation Department is to provide and protect outstanding natural, scenic, cultural, historic and recreational sites for the enjoyment and education of present and future generations.
State; lands	Oregon Department of State Lands	http://www.oregon.gov/dsl/pages/index.aspx		503-986-5200	dsl@dsl.state.or.us	The mission of the Department of State Lands is to ensure a legacy for Oregonians and their public schools through sound stewardship of lands, wetlands, waterways, unclaimed property, estates and the Common School Fund. The Department of State Lands is the administrative agency of the State Land Board, handling the day-to-day work of the board in managing the land and other resources dedicated to the Common School Fund.
State; conservation	Oregon Department of Land Conservation and Development	http://www.oregon.gov/lcd/Pages/index.aspx	Anne Debaut		anne.debbaut@state.or.us	To help communities and citizens plan for, protect and improve the built and natural systems that provide a high quality of life. In partnership with citizens and local governments, we foster sustainable and vibrant communities and protect our natural resources legacy.
State; transportation	Oregon Department of Transportation	http://www.oregon.gov/odot/pages/index.aspx	http://www.oregon.gov/ODOT/Pages/contact_us.aspx			The Oregon Department of Transportation began life in 1913 when the Oregon Legislature created the Oregon Highway Commission to "get Oregon out of the mud." Today, the Oregon Department of Transportation works to provide a safe, efficient transportation system that supports economic opportunity and livable communities for Oregonians. We develop programs related to Oregon’s system of highways, roads, and bridges; railways; public transportation services; transportation safety programs; driver and vehicle licensing; and motor carrier regulation

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
State; business	Oregon Economic Development Department (Business Oregon)	http://www.oregon4biz.com/	http://www.oregon4biz.com/About-Us/Contact-Us/			Mission: Business Oregon works to create, retain, expand and attract businesses that provide sustainable, living-wage jobs for Oregonians through public-private partnerships, leveraged funding and support of economic opportunities for Oregon companies and entrepreneurs; Vision: A globally-competitive economy based on innovation, sustainable production and world-class talent that creates family-wage jobs and preserves and enhances the quality of life for Oregonians; The Greater Portland region offers an ideal combination of urban activities and outdoor adventures. The city of Portland is compact and walkable, with a renowned culinery scene and great views of nearby Mt. Hood. Within a few minutes' drive are farms and Pinot-producing wineries (most with year-round tasting rooms), kayak-friendly waterways, historic cities and museums.
EJ	Oregon Environmental Justice Task Force	http://www.oregon.gov/gov/policy/environment/environmental_justice/Pages/default.aspx	Gabriela Goldfarb, Natural Resources Policy Advisor		gabriela.goldfarb@oregon.gov	Environmental justice is equal protection from environmental and health hazards, and meaningful public participation in decisions that affect the environment in which people live, work, learn, practice spirituality and play. "Environmental justice communities" include minority and low-income communities, tribal communities, and other communities traditionally underrepresented in public processes. When state agencies make decisions that affect our environment it is critical that low-income and minority populations are not disproportionately affected. The Environmental Justice Task Force (EJTF) was created by the Legislature to help protect Oregonians from disproportionate environmental impacts on minority and low-income populations. The EJTF encourages state agencies to give all people knowledge and access to improve decisions that affect environment and the health of all Oregonians.
State; fish and wildlife	Oregon Department of Fish and Wildlife	http://www.dfw.state.or.us/	Jessica Sall, Fish Communication Coordinator	Main Phone (503) 947-6000 or (800) 720-ODFW [6339]; 503-947-6023	odfw.info@state.or.us; jessica.sall@state.or.us	Our mission is to protect and enhance Oregon's fish and wildlife and their habitats for use and enjoyment by present and future generations
Federal elected officials	US Senators	http://www.merkley.senate.gov/	Senator Jeff Merkley			
Federal elected officials - comms	US Senators, com	http://www.merkley.senate.gov/	Courtney Warner Crowell, State Communications Director	202-224-3753	courtney_crowell@merkley.senate.gov	

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
Federal elected officials	US Senators	https://www.wyden.senate.gov/	Senator Ron Wyden			
Federal elected officials - comms	US Senators, com	https://www.wyden.senate.gov/	Charles A. Pope, Senior Communications Advisor for Health and Human Services	202-224-5244	charles_pope@wyden.senate.gov	
Federal elected officials	US H of R	http://bonamici.house.gov/	Representative Suzanne Bonamici			
Federal elected officials - comms	US H of R, com	http://bonamici.house.gov/	Ryan M. Mann, Outreach Director	202-225-0855	Ryan.Mann@mail.house.gov	
Federal elected officials	US H of R; Oregon 3rd District	http://blumenauer.house.gov/	Representative Earl Blumenauer			
Federal elected officials - comms	US H of R; Oregon 3rd District, com	http://blumenauer.house.gov/	Nicole A L'Esperance, Communicatios Director	202-225-4811	nicole.lesperance@mail.house.gov	
Federal elected officials	US H of R	http://schrader.house.gov/	Representative Kurt Schrader			
Federal elected officials - comms	US H of R, com	http://blumenauer.house.gov/	Elizabeth M Margolis, Communications Director	202-225-5711	liz.margolis@mail.house.gov	
Federal agency;	USACE Portland District	http://www.nwp.usace.army.mil/Missions/Environment/DMM.aspx	James McMillan, Lead, Portland Sediment Evaluation Team, Portland District, Corps of Engineers	503-808-4510	rset.lead@usace.army.mil	Manages and regulates dredging in Portland Harbor and other navigable waters of the U.S.

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Environmental protection	USEPA Region 10	http://yosemite.epa.gov/R10/EXTAFF.NSF	Oregon Operations Office; Kristine Koch, Portland Harbor Remedial Project Manager	503-326-3250; 206-553-6705	koch.kristine@epa.gov	superfund site health assessment reports; many uses
NRD Trustees	NOAA	https://darrp.noaa.gov/hazardous-waste/portland-harbor	Rob Neely; NOAA Office of Response and Restoration	(206) 553-2101	Robert.Neely@noaa.gov	NOAA and the other trustees are currently conducting an injury assessment. The final assessment report is scheduled for release in 2015.
Fish and wildlife	U.S. Fish and Wildlife Service	http://www.fws.gov/offices/Directory/OfficeDetail.cfm?OrgCode=13420	Dr. J. Frederick Caslick, Wildlife and Sport Fish Restoration Program Division Chief	503-231-6257	fred_caslick@fws.gov	Our Objectives: Assist in the development and application of an environmental stewardship ethic for our society, based on ecological principles, scientific knowledge of fish and wildlife, and a sense of moral responsibility. Guide the conservation, development, and management of the Nation's fish and wildlife resources. Administer a national program to provide the public opportunities to understand, appreciate, and wisely use fish and wildlife resources. Functions. Here are a few of the ways we try to meet our mission: Enforce federal wildlife laws, Protect endangered species, Manage migratory birds, Restore nationally significant fisheries, Conserve and restore wildlife habitat such as wetlands, Help foreign governments with their international conservation efforts, and Distribute hundreds of millions of dollars, through our Wildlife Sport Fish and Restoration program, in excise taxes on fishing and hunting equipment to State fish and wildlife agencies
Media	Oregon Business Magazine	http://www.oregonbusiness.com/	Linda Baker, editor	lindab@oregonbusiness.com	503.445.8805	Oregon Business is an award-winning magazine founded in 1981. The magazine reaches more than 20,000 business, political and civic leaders across the state. It reports on a wide range of big-tent business topics
Media	in Oregon Business Magazine					Jacklet, B. (2010) Portland Harbor sinks under Superfund stigma, Oregon Business.

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Media	KBOO Radio Station	https://kboo.fm/	Cris Andreae, Host, Air Cascadia Local News	503 231 8032	KBOO does not list email addresses, a contact form can be filled out here: https://kboo.fm/user/87/contact	We are Volunteer-Powered, Non-Commercial, Listener-Sponsored, Full-Strength Community Radio for Portland, Oregon, Cascadia & the World!
Media	Portland Tribune	http://www.pamplinmedia.com/portland-tribune-contact-us	Joseph Gallivan, Reporter	503-580-5132	jgallivan@portlandtribune.com	
Media	The Portland Observer	http://portlandobserver.com/	Michael Leighton, Editor	503-288-0033	mleighton@portlandobserver.com	The Portland Observer is the oldest continuous African-American owned publication in the State of Oregon. Our website portlandobserver.com and our weekly newspaper are committed to cultural diversity. Our focus is to bring stories focusing on education, health, politics, and law and justice to our readers.
Media	The Oregonian	http://www.oregonianmediagroup.com/reader-services/	Rob Davis, Watchdog Environment Reporter	503-294-7657	rdavis@oregonian.com	Oregonian Media Group publishes The Oregonian and OREGONLIVE, our online hub for breaking news, information and community engagement. Our family of print publications also provides hyper-local news to Portland Metro and Southwest Washington. Together, their coverage is unmatched in the region. We bring readers the stories they care about, when and where they want it, across digital platforms and in print. That unmatched reach – combined with powerful marketing tools – means we're better positioned to help businesses tell their stories, too
Media	Oregon Public Broadcasting	http://www.opb.org/	Sarah Jane Rothenfluch, Executive Editor of News	503-244-9900	srothenfluch@opb.org	
Media	The Portland Mercury	http://www.portlandmercury.com/	Dirk VanderHart, City News Reporter	503-294-0844	dirk@portlandmercury.com	
Media	Willamette Week	http://www.wweek.com/homepage/	Aaron Mesh, News Editor	503-243-2122	amesh@wweek.com	
Media	The Skanner	http://www.theskanner.com/	Christen McCurdy, News Editor	503-285-5555	christen@theskanner.com	

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Media	The Catholic Sentinel	http://www.catholicsentinel.org/main.asp?SectionID=15&SubSectionID=60&ArticleID=11773	Jose Ortiz-Valladares, Managing Editor	503-281-1191	sentinel@catholicsentinel.org	The Catholic Sentinel is published twice monthly by Oregon Catholic Press, and is the official newspaper of the Archdiocese of Portland
Media	El Latino de Hoy	http://www.ellatinodehoy.com/	Rodrigo J. Aguillar, Editor	503-493-1106	contact@ellatinedehoy.com	Spanish-English newspaper serving the latin American community in Oregon and Washington
Media	The Portland State Vanguard	http://psuvanguard.com/	Collen Leary, News Editor	503-725-3883	news@psuvanguard.com	A weekly newspaper seving Portland State University, the largest campus in the Oregon University System
Media	The Reed College Quest	http://www.reedquest.org/	Quest Editorial Board		Quest@reed.edu	
Marinas	Rocky Pointe Marina and Boatyard	http://www.rpmarina.com/	Stan and Jen Tonneson, Owners	503-543-7003	stan@rpmarina.com	
Marinas	Big Island Marina	http://bigislandmarina.net/aboutus.html	George A. Lyngheim, Manager	503-987-1025	bigislandmarina@westcoastmhp.com	
Marinas	Fred's Marina	http://www.fredsmarina.com/		503-286-5537	webadmin@fredsmarina.com	
Marinas	McCuddy's Marina	http://mccuddysmarina.com/		503-289-7879	info@mccuddysmarina.com	
Marinas	Big Eddy Marina	http://bigeddymarina.com/		503-666-3515	jack@bigeddymarina.com	
Marinas	Columbia Crossings Marinas	http://columbiacrossings.com/		503-286-2444	riverplace@columbiacrossings.com	
Marinas	The Portland Yacht Club	http://portlandyc.com/	Commodore Larry Justice	503-283-4960	office@portlandyc.com	
Marinas	Willamette Sailing Club	http://willamettesailingclub.com/	David Valentine, Club Manager	503-246-5345	office@willamettesailingclub.com	
Union	International Longshore and Warehouse Union (ILWU) Local 8	https://www.ilwu.org/		503.224.9310	ilwu8@integra.ne	

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
Industry	ESCO Corp Portland	http://www.escocorp.com	http://www.escocorp.com/EN/company/Pages/Contact-Us.aspx; James Heaukulani	Phone: +1 503-228-2141; Toll Free: 800-523-3795	epinfo@escocorp.com and corpinfo@escocorp.com; james.heaukulani@escocorp.com	ESCO Portland, Oregon, USA; 2141 NW 25th Ave; Portland OR 97210 USA
Industry	Siltronic Corporation	http://www.siltronic.com/int/en/aboutus/sites/portland/portland.jsp	Chris Reive; http://www.siltronic.com/int/en/aboutus/sites/portland/portland.jsp	+1 503 243-2020	chris.reive@jordanramis.com	right on the river: We set up our first production facility outside Germany in Portland, Oregon, USA, back in 1979. In 1995/96, we expanded our production capabilities. Portland produces wafers with diameters of 200 mm. The high-purity silicon crystals come from Burghausen. Portland primarily serves the American market.
Industry	T&G Trucking			+1 503-283-9550		
Industry	Union Pacific Railroad	Mike Eliason, director, public affairs	https://www.up.com/aboutup/community/community_contacts/index.htm	503-249-3079		
Industry	Schnitzer Steel	http://www.schnitzersteel.com/company_locations.aspx?View=Detail&ID=167	Colin Kelly, public affairs	781-873-1665	ckelly@schn.com	Three sites near river
Industry	Owens Corning	http://www.owenscorning.com/	http://www.owenscorning.com/contact-us/		Chuck.Hartlage@owenscorning.com	
Industry	participation and common intersest (PCI)					
Industry	Lower Willamette Group (LWG)	http://lwgportlandharbor.org/				The Lower Willamette Group (LWG) is composed of the ten parties who signed agreements with EPA to conduct the remedial investigation and feasibility study of the Site and four other parties who have contributed financially to the project. The LWG, a small subset of potentially responsible parties identified by EPA, has been working with EPA to complete the RI/FS of the site for more than 14 years.
Industry	Arkema		Fred Wolf		frederick.wolf@total.com	

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Industry	Chevron USA, Inc		Gerald (Jerry) George		GeraldGeorge@dwt.com	
City as PRP	City of Portland		Kim Cox		Kim.Cox@portlandoregon.gov	
Industry	Gunderson LLC (The Greenbrier Companies)		David Harvey	503-598-3805	David.Harvey@gbrx.com	
Industry	Kinder Morgan Liquids Terminals		Priscilla (Polly) Hampton		PHampton@perkinscoie.com	
Industry	NW Natural		Patty Dost		pdost@pearllegalgroup.com	
Port	Port of Portland		Kelly Madalinski		Kelly.Madalinski@PortofPortland.com	

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Industry	BAE Marine Group		Karen Reed	cc Karen Reed on all correspondence. The primary contact for Portland Harbor is: J.W. Ring -Ring Bender McKown & Castillo LLLP-Attorneys for The Marine Group LLC, BAE Systems San Diego Ship Repair Inc. and Summit Properties, Inc.-(503) 964-6730 The attorney assigned to remedial sustainability issues is: Phillip M. Bender, Ring Bender, Pittsburgh, PA 15222, (412) 360-8002 (direct) (412) 770-7721 (mobile)	kreed@ringbenderlaw.com	
Industry	Shell Oil		Carol Campagna		carol.campagna@shell.com	
Industry	Ashland and Hercules		Andy Zabel; Richmond Williams		andy@houlihan-law.com; rlwilliams@ashland.com	

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Industry	Bayer Crop Sciences, Inc	http://www.cropscience.bayer.com/	Jim Benedict	https://secure.cropscience.bayer.com/en/global-portal/contact.aspx	jbenedict@cablehuston.com	Beautiful fields of healthy, high-yielding crops. Abundant harvests of golden grains, white cotton and succulent produce – plentiful enough to nourish and clothe the world. Healthy environments in which we safely and comfortably live, work and play. At Bayer CropScience, these ideals drive us every day. Our singular purpose is to propel farming's future, harnessing cutting-edge agricultural and environmental innovations to deliver on Bayer's mission: Science For A Better Life.
Industry	BNSF Railway Company, Inc	http://www.bnsf.com/communities/contact-us/	Ross Lane, public affairs; John Ashworth		jashworth@kelrun.com	
Industry	Phillips 66 Company	http://www.phillips66.com/EN/Pages/index.aspx	Brandi Sablatura	http://www.phillips66.com/EN/susdev/Pages/Contact-Us.aspx	brandi.c.sablatura@p66.com	
Industry	TOC Holdings Company		Patty Dost		pdost@pearllegalgroup.com	
Industry	UPRR		Robert Bylsma		rcbylsma@up.com	
Industry	BP		John Frankenthal		john.frankenthal@bp.com	
Industry	Cargill		William (Bill) Ford	816 460-5817	wford@lathropgage.com	
Industry	Evraz Oregon Steel		Debbie Silva		debbie.silva@evrazna.com	
Industry	Portland General Electric (PGE)		Chris Bozzini		Christopher.Bozzini@PGN.com	
Industry	Schnitzer		Matthew Cusma		mcusma@schn.com	
Industry	Vigor		Alan Sprott		Asprott@vigorindustrial.com	
Industry	Calbag Metals		No contact			
Industry	FMC		David Heineck		davidh@summitlaw.com	
Industry	Geosyntec		Keith Kroeger Jeff Ring		KKroeger@Geosyntec.com JWRing@ringbenderlaw.com	

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Industry	NuStar/Shore Terminals		Gregory Jacoby		GAJ@mcgavick.com	
PRPs	Portland Harbor Partnership	http://www.portlandharborpartnership.com/	http://www.portlandharborpartnership.com/contact-us/	503-517-3758	info[at]portlandharborpartnership[dot]com	The Portland Harbor Partnership is a public-private partnership made up of public entities and local businesses working in cooperation with Portland State University and Oregon State University to support a broad community outreach effort. The purpose of this outreach is to raise awareness about the Superfund Site and to encourage everyone to have a voice in the future of Portland Harbor and the river overall. The Portland Harbor Partners include the Port of Portland, the Oregon Department of State Lands, Calbag Metals, EVRAZ Portland, Gunderson LLC, NW Natural, Schnitzer Steel, Vigor Industrial and PGE. The Partners are a small subset of the Potentially Responsible Parties (PRPs) for the Portland Harbor Superfund Site. A potentially responsible party is any person, company or public entity that owns property in a contaminated site or may have had some part in polluting a site. There are over 100 PRPs at the Portland Harbor Superfund Site. The Partners came together to make sure their community has a voice in the clean-up.
Businesses near river	Portland Business Alliance	http://portlandalliance.com/	http://portlandalliance.com/about/staff-members.html	503.224.8684		Advocating for commerce, building community and supporting regional prosperity. The Portland Business Alliance is Greater Portland's Chamber of Commerce and is the voice of business in the region. As the voice of business, the Alliance advocates for issues that support commerce, community health and the region's overall prosperity. With more than 1,850 member companies, representing 375,000 business people in Multnomah, Washington and Clackamas counties in Oregon and Clark County in Washington, the Alliance is the region's leading business organization. The Alliance's mission to promote and foster an environment in the Portland region that attracts, supports and retains private-sector jobs, spurs economic vitality and enables quality educational opportunities for the region's residents. In pursuit of that mission, the Alliance advocates for business at all levels of government and also offer a variety of networking events and professional development opportunities to connect and foster growth in our region's business community

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	Oregon Business Association	http://www.oba-online.org/about/vision-and-goals/	http://www.oba-online.org/contact/	503-641-0959	oba@oba-online.org	Members of the Oregon Business Association share a commitment to the well-being of the state's economy as a whole. The First Goal – The Economy; A healthy business climate supports economic growth and prosperity in Oregon consistent with the values of environmental stewardship and sustainability. The business community has a good reputation and the community recognizes the importance of quality jobs to quality of life. Oregon fosters the development of emerging new business opportunities while creating policies and institutions that support traditional industries and the agriculture and forestry sectors; The Second Goal – State Finance; A sustainable revenue structure reduces volatility and is sufficient to adequately invest in and maintain Oregon's infrastructure and social services. Current rainy day and education funds are maintained and become significant reserves. The personal and corporate kickers have been eliminated or altered in such a way that they are not an impediment to stable and adequate funding of essential services. Salaries and benefits for public employees are not excessive comparable to other states and the private sector; The Third Goal – The Environment; Oregon has protected its natural environment, sustained an environment of vital communities, built a system of renewable energy and created a business climate that rewards stewardship and sustainability. Sustainable practices and the new energy economy have contributed to the vitality of our agricultural and forest business sector and led to the creation of many new companies, the expansions of existing ones, and increased profitability. Environmental policies balance the needs of the new economies and traditional sectors, and are sensitive to both rural Oregonians and to those who live in cities. Manufacturers, traditional service industries, and producers of power have been supported and encouraged as they adopted sustainable practices; The Fourth Goal – Public Education - Public education in Oregon provides students with the essential knowledge and skills to get a good job, to lead a good life and to contribute to the future. Public education is an integrated system of pre-K through higher education, including an emphasis on community colleges and workforce training as well as four-year degrees. General and health-related research at Oregon's public universities contributes to economic growth as well as general quality of life. In order to attract good teachers at every level, salaries and benefits are competitive. There is a focus on consistent and adequate funding as well as an equal focus on accountability, and the influence of the various stakeholders is balanced and constructive; The Fifth Goal – Public Health and Healthcare - Basic preventive and catastrophic healthcare is provided to all citizens of

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Industry	Ross Island Sand & Gravel Co.	http://www.rossisland.co/	contact page on website			Ross Island leads in environmentally responsible methods for production and transportation of all aggregates for our manufactured construction products.Use of barges for aggregates transport reduces CO2 Greenhouse Gas Emissions by 73% when compared to the 70 standard truckloads one barge replaces. All aggregate based manufactured products including ready mixed concrete, asphalt and bagged products are not moved by truck until they are loaded as finished products for delivery. All Ross Island delivery vehicles use biodiesel fuel. Ross Island has an ongoing reclamation program to manage the lagoon created during 75 years of in water mining that ended in 2001. This is in cooperation with State and Federal Agencies. Ross Island efforts insure that additional upland forest, riparian/emergent wetland habitat and shallow water habitat are being created
Industry	Working Waterfront Coalition	http://www.workingwaterfrontportland.org/	Ellen Wax	503-220-2064	ellen.wax@comcast.net; contactus@workingwaterfrontportland.org	Established in 2005, the Working Waterfront Coalition (WWC) is an organization of businesses concerned about the environmental health and economic vitality of the Portland harbor. The WWC advocates for sound public policy that promotes environmental, social and economic sustainability. Portland's Harbor is a vital employment area; home to thousands of valuable high-wage, high-benefit jobs. The WWC, with its extensive knowledge of harbor industry needs, active industry participation and record of effective advocacy, is dedicated to working with its partners to ensure an appropriate balance between environmental concerns and the needs of river related employers. The coalition's activities include: Advocating with local, state and federal officials and agencies on behalf of marine-dependent and river-related businesses. Working to broaden community understanding of: the importance of the Portland Harbor as one of the most impactful employment areas in the region, and the harbor industries' dependence on a limited land supply suitable for business needs. Providing up-to-date information and advice to coalition members regarding developments in the public policy and regulatory arena. WWC members are conscientious stewards of the environment. They make significant investments in the harbor, consistent with state and federal laws and regulations, to reduce the impacts of human activity in the harbor. After completing many diligent studies and commissioning numerous reports, the WWC has concluded that increased job development and environmental enhancement efforts in the harbor will be impeded by unnecessarily burdensome and duplicative regulation and government-imposed costs

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Industry	Associated Oregon Industries	http://www.aoi.org/	http://www.aoi.org/main/contact-us/	503.227.5636	aoi@aoi.org	AOI is Oregon's largest and most influential comprehensive business association advocating for a vigorous business climate in Oregon. Our membership is comprised of large and small companies from all business classifications in Oregon. Since 1895, AOI has been a powerful voice listened to by legislators and regulatory agencies. As a member you are able to participate with other business leaders committed to growing Oregon's economy, quality jobs for our citizens, and healthy communities. You're also able to take advantage of money-saving services. The AOI Mission: To grow Oregon's economy, quality jobs for our citizens, and healthy communities through strong advocacy of Oregon's businesses. Advocating for your Business's Concerns: As the state's premier non-partisan business advocate, AOI represents its members before the legislature and state agencies for issues that pertain to: Education & Workforce Development; Employment Practices; Environment & Energy; Health Care; Oregon Retail Council; Fiscal Policy; Transportation & Distribution; Core Principles: AOI's guiding principles are to support: A free-market economy; A well-educated, trained, and employable citizenry; Justifiable, cooperative, appropriate, fact-based regulation; Private property rights; Efficient, effective and accountable public policies that encourage private sector job creation and business prosperity; A mutually supportive, vigorous economy and high-quality environment
Industry; manufacturing	Manufacturing 21 Coalition	http://manufacturing21.com/mission/	Norm Eder?			Manufacturing 21 Coalition is a private-public partnership created to support and advocate for Oregon's and Washington's manufacturing economy. Its members include business, labor, education and training providers, local workforce development boards, economic development organizations and government agencies. MFG 21 Coalition provides leadership to assure manufacturing remains a strong contributor to our region's economy and to the health of our communities. It is a practical and expert voice for manufacturing and is organized, led and supported by the private sector. MFG 21 Coalition educates and informs public and community leaders about the role manufacturing plays in the region. The coalition works to identify and satisfy manufacturers' needs for a skilled workforce, research and development. MFG 21 Coalition fosters seamless delivery of workforce development services through knowledgeable engagement with public agencies, education institutions and community-based private organizations. MFG 21 Coalition expands and builds upon the existing capacity of our colleges and universities to meet the needs of our regions manufacturing sector for applied research and development by securing investment and supporting technology collaborations..

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Industry	Columbia Corridor Association	http://www.columbiacorridor.org/	Corky Collier?			The Columbia Corridor Association is Working For You. CCA is actively helping Corridor businesses by advocating for business and development interests with local, regional, state and federal jurisdictions. Our mission is to enhance economic prosperity in the Columbia Corridor. Our vision is to be the voice and resource for business in the Columbia Corridor. The Columbia Boulevard East-End Connector transportation project we obtained $19.78 million in funding for is well underway. Pushed for economic and environmental balance on Wellfield regulations. Our active participation in the formation of this ordinance gave voice to affected businesses. Gave BALANCE to the Metro Goal 5 Project's Economic Technical Advisory Committee, where economic values needed to be counted along with environmental protection. CCA's opposition led to the downfall of the proposed business income tax and business license fees restructuring which seriously threatened corridor businesses. $6 MILLION in transportation improvement monies for corridor projects. Sponsoring BUSINESS AFTER HOURS functions for networking and displaying local businesses. Delivering informative and educational MONTHLY FORUMS on hot topics. Protecting BUSINESSES who must monitor and protect stormwater management rights during continuing regulatory revisions.
business	Venture Portland	http://ventureportland.org/		503.477.9648	info@ventureportland.org	Venture Portland means business. Since 1986 Venture Portland has invested in the smart, strategic growth of Portland's unique neighborhood business districts. These dynamic districts, which together make up a majority of the city's businesses and nearly half of its jobs, play a vital role in Portland's economic prosperity and collectively represent local, regional, national and international demand for goods and services.

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
business (environmental)	Northwest Environmental Business Council (NEBC)	www.nebc.org	Robert Grott, Executive Director	503-227-6361 or 800-985-6322 Cell 503-984-7144	robert@nebc.org	The Environment is Our Business. Representing the Northwest's leading service & technology providers working to protect, restore & sustain the natural and built environment. Since 1996. As a non-profit trade association, NEBC represents the interests of its members, while promoting the health of the industry and the environment as a whole. Formed as a regional organization in 1996, NEBC is the recognized voice of the industry - advocating for science-based regulation, supportive policies and tax structures, the dissemination of knowledge, and the adoption of best practices. All Sectors. As a cross-sector organization, NEBC fosters transfer of knowledge and learning, builds synergies among members, and expands business opportunities. NEBC members provide product and service support in: Environmental Protection & Cleanup; Energy & Efficiency; Sustainable Development; Water & Waste Water; Waste & Recycling; Business Support Services. All Disciplines. Members cover an ever-widening spectrum, including engineers, consultants, contractors, scientists, lawyers, product and technology providers, insurers, project developers, financers, architects, business support professionals, plus a host of other disciplines and organizations supportive of NEBC's goals
business and neighborhood	Swan Island Business Association (SIBA)	http://www.swanislandba.org/about-siba/	http://www.swanislandba.org/about-siba/staff/	816 460-5817	sarah.angell@swanislandba.org	The Swan Island Business Association (SIBA) is dedicated to the success and vitality of Swan Island and our members. We identify opportunities for improvement and then partner with members, other businesses, city and governmental agencies to plan, fund and ultimately implement the desired changes. Our efforts focus on facilitating economic development on Swan Island, moving people and goods on and off the Island efficiently, safely and conveniently and strengthening ties to adjacent neighborhoods by connecting residents to jobs on Swan Island and promoting employees' awareness of nearby community resources
business	Oregon Business Council	http://orbusinesscouncil.org/	http://orbusinesscouncil.org/contact/	(503) 595-7616	obc@orbusinesscouncil.org	The Oregon Business Council is an association of more than 40 business community leaders focused on public issues that affect Oregon's life and future. Founded in 1985, we are patterned after the national Business Roundtable and affiliate organizations in a number of other states.
business and neighborhood	St Johns Main Street	http://www.stjohnsmainstreet.org/				St. Johns Main Street is working to create a thriving and sustainable local economy for the St. Johns neighborhood. As part of the national Main Street movement, we promote local prosperity and livability by serving as a resource hub for community and local business.

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
business and neighborhood	Westside Economic Alliance	http://westsidealliance.org/		503.968.3100	tdunham@westside-alliance.org	We are a non-profit, member-based organization that advocates for a healthy economic environment on the Westside of the Portland, Oregon metropolitan region. Westside Economic Alliance provides its members with a common voice on local, regional and state issues, and operates as a problem solver and a "one-stop-shop" for the entire Westside business community. Issues of concern include land use regulations, urban growth boundary expansion, transportation funding, and other Westside infrastructure issues vital to economic development. Westside Economic Alliance members are strategically located on local, county and state public policy-making committees to advocate for our members' positions regarding these issues
business and neighborhood	Sauvie Island Community Association	http://sauvieisland.org/	Ed Gibson	cell 971 263 9203; Home 503 621 3078	edg@metapower.com	Join the Sauvie Island Community Association to interact with your neighbors, keep up with what's going on and have a say in the future of our island. Everyone who lives or owns residential or business property on the island can join, and there is no cost to do so. Houseboat owners from the moorages on both sides of the Multnomah Channel can be members, too.
home and property owners	Oregonians in Action	http://www.oia.org/	http://www.oia.org/contact/	503.620.0258	oia@oia.org	Oregonians In Action is a non-partisan, non-profit organization representing Oregon home and property owners. As Oregon's largest property owners association, our mission is to defend the right of private property owners to make use of their property. At the legislature, through the courts and at the ballot box, working with the media and through our many educational efforts, OIA works to change Oregon's broken land-use system, a system unlike any in the United States.
commercial real estate	Commercial Real Estate Economic Coalition	http://www.manta.com/c/mb5q59b/commercial-real-estate-economic-coalition	Bob Lefeber	(503) 241-2423		

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
engineers	Professional Engineers of Oregon	http://www.oregonengineers.org/index.php?option=com_content&view=article&id=31&Itemid=230				The Professional Engineers of Oregon (PEO) exists to unify engineering professionals under a code of conduct, ethics, professionalism, a standard of technical excellence and public safety. We are the voice of Oregon's engineers to promote and protect licensure. PEO represents the profession in development of public policy and provides opportunities for professional development, fellowship and local and global public service. Vision: The Professional Engineers of Oregon (PEO) is Oregon's professional association providing leadership in all engineering disciplines. We promote the professional engineer as a recognized voice in society through legislative advocacy, public education and adherence to engineering principles and standards. Values: Protection of the public welfare above all other considerations; Ethical and competent practice of engineering Innovation through the creative application of math, science, and engineering; The PE license as the highest standard of professionalism in engineering; Growth in the number of licensed professional engineers; Teamwork, unity, and fellowship of all PEs across all disciplines; Commitment to the future of the licensed professional engineer.
general contractors	Associated General Contractors; Oregon Columbia Chapter	http://www.agc-oregon.org/	http://www.agc-oregon.org/about/contact/			
Commercial Fishing	Pacific Fishery Management Council	http://www.pcouncil.org/		503-820-2280	pfmc.comments@noaa.gov	With jurisdiction over the 317,690 square mile exclusive economic zone off Washington, Oregon and California, the Council manages fisheries for about 119 species of salmon, groundfish, coastal pelagic species (sardines, anchovies, and mackerel), and highly migratory species (tunas, sharks, and swordfish). The Council is also active in international fishery management organizations that manage fish stocks that migrate through the Council’s area of jurisdiction, including the International Pacific Halibut Commission (for Pacific halibut), the Western and Central Pacific Fisheries Commission (for albacore tuna and other highly migratory species), and the Inter-American Tropical Tuna Commission (for yellowfin tuna and other high migratory species).

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
Tribal fishing	Columbia River Inter-Tribal Fish Commission	http://www.critfc.org/		(503) 238-0667	fdsk@critfc.org	The Columbia River Inter-Tribal Fish Commission coordinates management policy and provides fisheries technical services for the Yakama, Warm Springs, Umatilla, and Nez Perce tribes. CRITFC's mission is "to ensure a unified voice in the overall management of the fishery resources, and as managers, to protect reserved treaty rights through the exercise of the inherent sovereign powers of the tribes." This mission is accomplished with four primary goals: 1. Put Fish Back in the Rivers and Protect Watersheds Where Fish Live. CRITFC provides our four member tribes and the region with invaluable biological research, fisheries management, hydrology, and other science to support the protection and restoration of Columbia River Basin salmon, lamprey, and sturgeon. The vision of this goal is to reverse the decline of salmon, lamprey, and sturgeon and rebuild their numbers to full productivity. This work is guided by the holistic principles outlined in Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon), the tribal salmon plan that addresses recommended restoration actions in every phase of the salmon's lifecycle from stream to ocean and back.; 2. Protect Tribal Treaty Fishing Rights. CRITFC employs lawyers, policy analysts, and fisheries enforcement officers who work to ensure that tribal treaty rights are protected. All of these activities are done in careful coordination with and under the direction of member tribes. The commission works closely with state and federal agencies to ensure fair harvest sharing between tribal and non-tribal fisheries. 3. Share Salmon Culture. CRITFC shares news, information, and the tribal perspective on a variety of issues. Common topics include salmon and lamprey restoration, the nature of treaty fishing rights, and tribal culture. This effort ranges from school children to policy makers. By educating the general public on these topics, the tribes hope to increase interest for productive partnerships and support in the effort to restore Columbia River Basin salmon and lamprey. 4. Provide Fisher Services. CRITFC provides a variety of services directly to fishers from its member tribes. The Salmon Marketing program provides fishers from the four member tribes with resources to help them carry on the tradition of making a living from fishing, whether that be from commercial, over-the-bank, or value-added fish sales. The organization also operates and maintains 31 fishing access sites along the Columbia River for the exclusive or near-exclusive use of the fishers from all the member tribes.
freight mobility	Portland Freight Committee	https://www.portlandoregon.gov/transportation/54899		503-823-5185		The Portland Freight Committee (PFC) serves as an advisory group to the Bureau of Transportation and City Council on issues related to freight mobility. The PFC was formed in February 2003 and includes both citizen volunteers and public agency representatives at the local, state, and federal level. Support and enhance the economy of the City of Portland by advancing a balanced and well-managed multi-modal freight network.

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
power	Bonneville Power Administration	https://www.bpa.gov/news/AboutUs/Pages/default.aspx	http://www.efw.bpa.gov/IntegratedFWP/contact.aspx	503-230-5136	efwweb@bpa.gov	The Bonneville Power Administration is a federal nonprofit agency based in the Pacific Northwest. Although BPA is part of the U.S. Department of Energy, it is self-funding and covers its costs by selling its products and services. BPA markets wholesale electrical power from 31 federal hydro projects in the Columbia River Basin, one nonfederal nuclear plant and several other small nonfederal power plants. The dams are operated by the U.S. Army Corps of Engineers and the Bureau of Reclamation. About one-third of the electric power used in the Northwest comes from BPA. BPA also operates and maintains about three-fourths of the high-voltage transmission in its service territory. BPA's service territory includes Idaho, Oregon, Washington, western Montana and small parts of eastern Montana, California, Nevada, Utah and Wyoming. As part of its responsibilities, BPA promotes energy efficiency, renewable resources and new technologies. The agency also funds regional efforts to protect and rebuild fish and wildlife populations affected by hydroelectric power development in the Columbia River Basin. BPA is committed to providing public service and seeks to make its decisions in a manner that provides opportunities for input from all stakeholders. In its vision statement, BPA dedicates itself to providing high system reliability, low rates consistent with sound business principles, environmental stewardship and accountability
power	Northwest Power and Conservation Council	https://www.nwcouncil.org/	Karl Weist; Fish and Wildlife Policy Analyst	503-229-5171	kweist@nwcouncil.org	Our mission is to ensure, with public participation, an affordable and reliable energy system while enhancing fish and wildlife in the Columbia River Basin. Core Values: We take the long view. We work for the wellbeing of future generations, not just our own; We have a regional perspective. We address the interests of the region as a whole; We serve the public. We listen to their concerns and we strive to bring insight to the issues affecting them; We are independent. We tell people what they need to know because trust is the basis of partnership and the key to progress; We embrace learning. We're open to change and diverse views because it sparks opportunity
Tourism (business)	Travel Portland	http://www.travelportland.com/	http://www.travelportland.com/about-us/contact-us/		info@travelportland.com; communityrelations@travelportland.com	The mission of Travel Portland is to strengthen the region's economy by marketing the metropolitan Portland region as a preferred destination for meetings, conventions and leisure travel. A private non-profit destination marketing organization with more than 750 partner businesses, Travel Portland operates a busy visitor information center, supports a climate of year-round hospitality, and helps our city, state and region reap the rewards of a thriving visitor industry

Focus	Organization(s)	Web page	Contact	Phone	Email	Organization role/vision (largely from web pages)
business and neighborhood	Central Eastside Industrial Council (CIEC)	http://ceic.cc/	http://ceic.cc/index.php/contact			The Central Eastside Industrial Council is a non-profit, volunteer organization, responsible for representing businesses and property owners residing in the Central Eastside Industrial District (CEID) in Portland, Oregon.
business and neighborhood	Waterfront Organizations Of Oregon (WOOO)	http://waterfrontoregon.com/	Stan Tonneson, board of directors	503 329-0298	stan@rpmarina.com	To encourage and promote educational programs aimed at all users of waterways in order to increase public access to the river as a gathering place for a wide range of waterway activities. To foster stewardship of Oregon's waterways with an eye toward environmental responsibility and recreational use; making our organization available for projects that benefit Oregon's waterways. To monitor and communicate with governmental agencies to ensure that members are fully informed of waterway and waterfront regulations and policy changes that potentially impact the members of the waterfront community. To network and associate with other groups as a resource for the common interests and benefits of all waterway users.
business and neighborhood	NW Industrial Neighborhood Association (NINA)	http://nwindustrial.org/	http://nwindustrial.org/contacts/			The Northwest Industrial Neighborhood Association (NINA) represents Portland's northwest industrial sanctuary. As a neighborhood association, we are unique. Comprised almost entirely of manufacturing, commercial and artisanal industries, wholesalers, warehouses, and the occasional retail business, NINA's boundaries extend from the Willamette River to US 30, and I-405 to St. Johns Bridge.
Regional; economic development	Columbia River Economic Development Council (CREDC)	http://www.credc.org/initiatives/	http://www.credc.org/contact/	(360) 694-5006	info@credc.org	CREDC is a private-public partnership of over 130 investors and strategic partners working together to advance the economic vitality of Clark County through business relocation, growth, and innovation. Serving as your first point of contact to leverage 20 years of community connections and 80+ local and state resources
environmental services	Freshwater Trust	http://www.thefreshwatertrust.org/about-us/	Alan Horton?	(503) 222-9091	info@thefreshwatertrust.org	The Freshwater Trust protects and restores freshwater ecosystems. Using science, technology and incentive-based solutions, we're changing the course of conservation on a timeline that matters

Appendix C
Stakeholder Value Map
(Included on CD)

Appendix D

Stakeholder Sensitivity Analysis

Appendix D

Stakeholder Sensitivity Analysis: Stakeholder Group Weighting

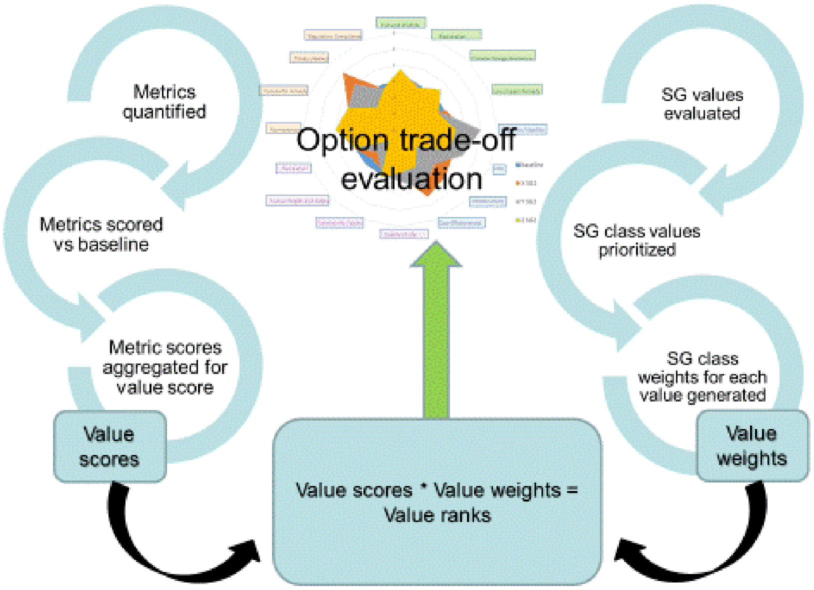
Section 7 of the Social Analysis Report aggregates metrics to Stakeholder Group (SG) Values and SG Value to pillars, treating all metrics and SG Values as equally important to the overall sustainability. However, not all SGs prioritize these SG Values and metrics equally. For instance, for some SGs, permanence is the primary metric for their evaluation of an acceptable remedy; others value time-effectiveness, implementability, etc. to differing degrees. For Health & Safety, not all stakeholders consider risk to workers a relevant metric, and they may have differing opinions on the relative importance of long-term vs. short-term human health risk. The relative importance of the SG Values that feed into the pillars may differ as a function of SG priorities as well. Thus, in this appendix, metric and SG Value scores are weighted to reflect the inferred priorities of different SGs. This will affect the aggregation of metrics to SG Value scores and SG Values to overall pillar sustainability scores. This is being carried out to address two objectives:

1. To demonstrate the use of the Sustainable Values Assessment (SVA) tool to address SG-specific priorities and communicate trade-offs in terms of these priorities, and
2. To evaluate the sensitivity and robustness of SVA-based assessment of the relative sustainability of remedial alternatives to differing SG priorities.

D.1 Approach

Figure D-1 illustrates a simplified version of the approach to generating SG-weighted SG Value ranks; the approach for aggregating these SG Values to pillars is the same. The left side of the figure illustrates how metrics and SG Values are scored. This process was described in Sections 6 and 7. The right side addresses how SG Value weights are developed; this will be described in Section D1.1. Once SG Value scores and SG Value weights are developed, SG Value ranks can be calculated. It should be noted, however, that within the SVA tool, if enough is known about SG priorities, it is also possible to weight the metrics that aggregate into SG Values as well as the SG Values that aggregate into pillars. This approach is illustrated in this appendix.

Figure D-1. Conceptual approach for weighting SG Values using SG priority weights



D.1.1 Metric weighting for SG Value aggregation

Value mapping, meeting notes, surveys, discussions, and reviews provided evidence for the priorities of a range of SGs. For an SG-specific weighting, metrics for which there was evidence that an SG considered it very important were given a higher relative weight; those that a SG distrusted or considered unimportant were given a lower relative weight. For the representative SGs listed in Section 8.1.2, weights could be assigned to some metrics and values. The following scheme was used to assign weights (with the exception of the City Survey SG, the approach for which is described below):

Based upon a review of available information, SG weights were assigned a score from 0 to 5 using the following scale:

- Metric or value is unimportant (or evidence is seen as not relevant or believable): 0
- Metric or value is marginally important: 1
- Metric or value is somewhat important: 2
- Metric or value is important: 3
- Metric or value is very important: 4
- Metric or value is critically important: 5
- If no statement or evidence of a SG view was found, the metric or value is weighted as 2.

It is important to note that most representative SG weightings were based on limited evidence of SG priorities (as described below). Ideally, SGs could be asked their opinions to elicit information on the relative importance of all metrics and SG Values considered; they could then provide complete information. However, for the evidence bases used for the inferred priorities described below, not all metrics and values are addressed at the same level. It was concluded, however, that the lack of evidence of importance (or unimportance) of an unaddressed metric or SG Value did not provide evidence of its lack of importance to that SG. Instead, as SGs were all subsets of the overall Portland community, it was assumed that all values not addressed could be assumed to be somewhat important (a weight of 2), as the Stakeholder Value Map provided evidence that all SG Values were of some importance to some sectors of the community. As a result, the SG weight tables (see Tables D-1 to D-20 below) have very few 0's or 1's, as there was more of a tendency in the evidence base for SGs to state positive values (i.e., something is important) than negative values (i.e., something is unimportant). It is possible that, if all weights were elicited, there would be more negative value statements by some SGs, and the differences between SG weights would be greater, but this could not be tested in the context of this project.

For the "equal weighting" scenario, all values and metrics were scored as important, or 3. For the City Survey SG (CS), the survey report (DHM Research 2016) provided numerical results for a range of questions. As much as possible, these questions were mapped to specific values or metrics. Metrics and values were then scored based on the following scheme:

- 0–15% of survey respondents strongly or somewhat agree with the relevant statement: 0
- 16–25% of survey respondents strongly or somewhat agree with the relevant statement: 1
- 26–45% of survey respondents strongly or somewhat agree with the relevant statement: 2
- 45–65% of survey respondents strongly or somewhat agree with the relevant statement: 3
- 66–85% of survey respondents strongly or somewhat agree with the relevant statement: 4
- >85% of survey respondents strongly or somewhat agree with the relevant statement: 5
- If no statement or evidence of a SG view was found, the metric or value is weighted as 2

Tables presented in throughout this appendix illustrate the value and metric weights that were assigned for the representative SGs, and their basis.

It should be noted that, when aggregated, metrics were also still weighted in terms of their Metric Relevance Weightings (MRWs).

D.2 Representative stakeholder groups

Stakeholder mapping (Section 3) and the "value map" database (Section 4.2) demonstrate that there is a diversity of voices in Portland. SG Values and metrics can be weighted based upon the priorities of different SGs. This can be done using a variety of tools to elicit values from stakeholders, but broad representation is always a challenge; as is including a diversity of opinions (rather than just the most vocal groups or individuals). As described above, the diversity of priorities in Portland is an argument for weighting all SG Values and metrics equally, as was done in Section 7. However, another approach is to weight SG Values and metrics considering the priorities of specific SGs. To address this issue, one approach is to identify an illustrative set of "Representative SGs" for which there is sufficient documentation on their priorities and concerns. This approach is used here.

It is important to note that the intent is not to represent all stakeholders, but to illustrate how trade-offs are affected when differing priorities are considered. Nor is the intent to speak for the selected SGs. Rather, the intent is to apply a diverse set of plausible SG Value and metric priorities for SGs for which we have significant documentation on their inferred values. Five representative SGs were identified for this purpose, as described below.

D.2.1 Representative SG: Community Forum (CF)

The first representative SG considered is based upon a pair of illustrations developed by a United States (US) Environmental Protection Agency (EPA)-sponsored graphic facilitator at a Portland Harbor Superfund Site (Site) community outreach meeting, St John's Community Café, in July 2015 (EPA 2015b).[1] Community members were encouraged to discuss their values, aspirations, and concerns for Portland Harbor and ask: "What do we want the river to be and do?" This resulted in a draft and final

[1] *References in Appendices are included in Section 10 of the main text.*

illustration, with text (see Figures D-2 and D-3). These graphics, and the text within them, were mapped in the value map, and a set of SG Values was inferred. Based upon this, a set of SG weights was developed (see Section D1.1 for the approach), using this information and professional judgment; these are in Tables D1-D4. This SG had relatively balanced priorities; the graphic, among other themes, emphasized the "Triple Bottom Line," suggesting a balance. Concerns expressed were local jobs, equity, resilience, and fish consumption.

Figure D-2. Draft facilitated graphic, St John's Community Café

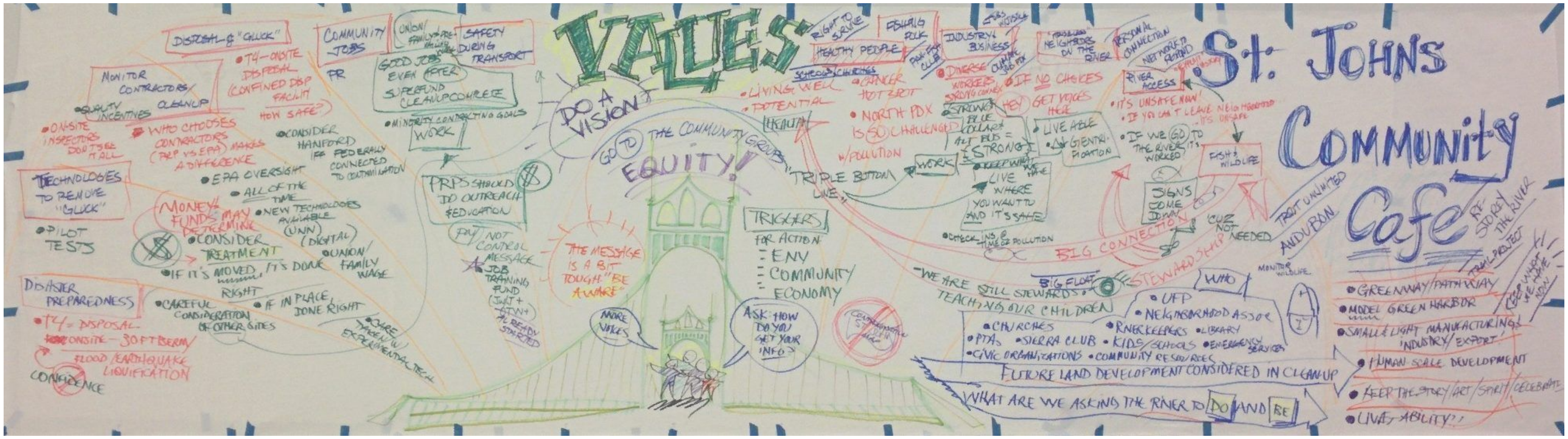


Figure D-3. Final facilitated graphic, St John's Community Café

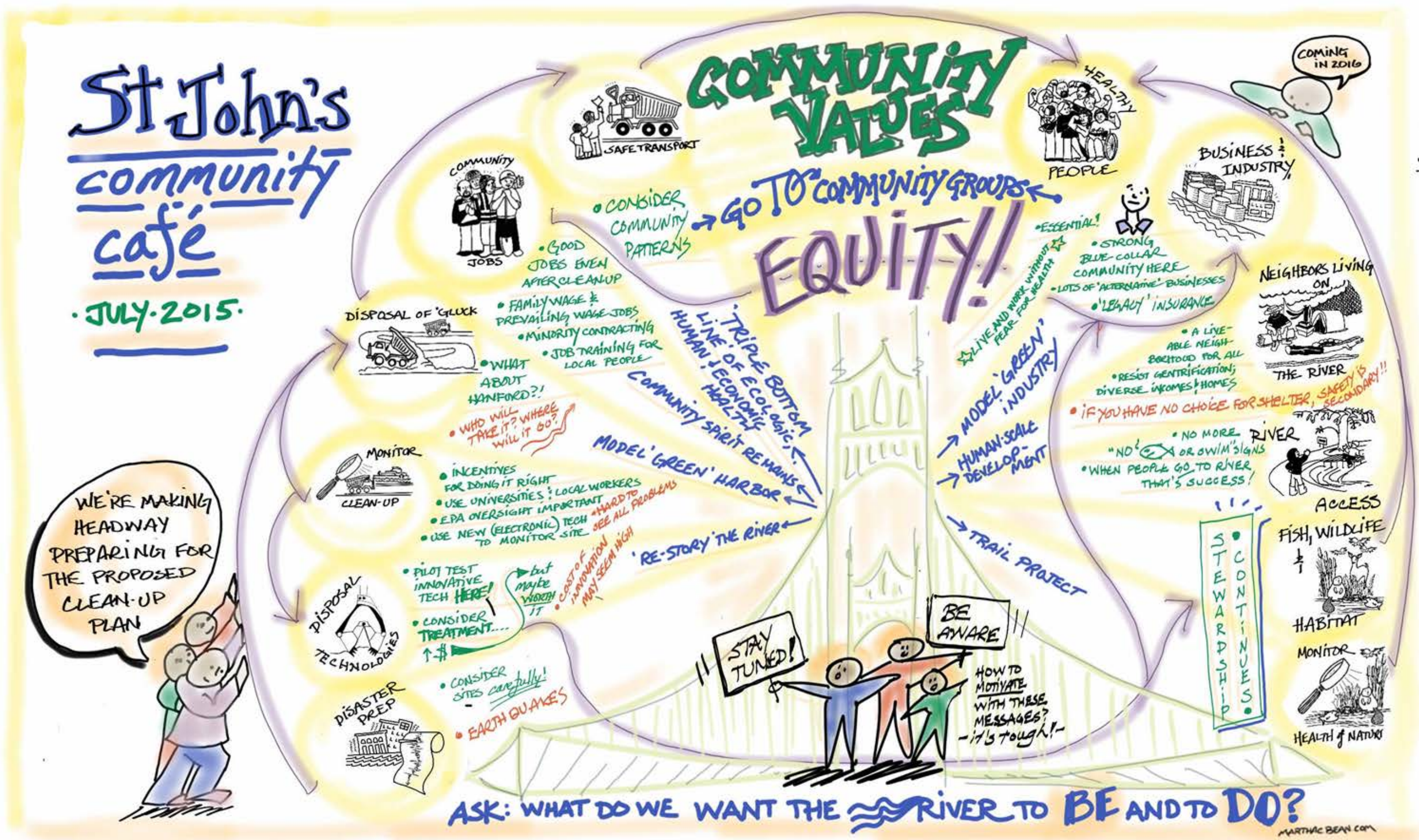


Table D-1. SG Value weights and their basis for SG Community Forum (CF)

Label	Value	Community Forum (CF)	Basis: Comments from Faciltated Graphics
ENV-1	Fish & Wildlife	3	Monitor health of nature; Fish, wildlife & habitat; stewardship continues
ENV-2	Habitat	3	Fish, wildlife & habitat; stewardship continues
ENV-3	Resilience	4	Disaster prep; Earthquakes; Consider sites carefully; Flood/earthquake liquifaction
ENV-4	Low Impact Remedy	2	Triple bottom line of ecologic, human, and economic health
ECON-1	Economic Vitality	3	Business and industry; Strong blue collar community here; Model 'green' industry; Lots of 'alternative' business; 'Legacy' insurance
ECON-2	Jobs	4	Community jobs; Good jobs even after cleanup; community spirit remains; Family wage & prevailing wage jobs; Minority contracting; Job training for local people
ECON-3	Infrastructure	3	Safe transport; consider community patterns
ECON-4	Cost-Effectiveness	1	High cost - but maybe worth it
SOC-1	Quality of Life/ Recreation	3	Human-scale development; Community values; Equity; go to community groups
SOC-2	Community Values	4	Do a vision - go to the community groups; the message is a bit tough - be aware; PRPs should do outreach education $$$; But not control the message; Neighbors living on the river; If you have no choice for shelter, safety is secondary; A livable neighborhood for all; Resist gentrification; Diverse incomes and homes; Community values; equity; go to community groups; Equity; More voices; Ask: how do you get your info?; Triggers for action; Environment; Community; Economy
SOC-3	Acceptable Remedy	4	Disposal of "gluck"; Who will take it? Where will it go? What about Hanford? Model "Green" harbor; Disposal technologies; cost of innovation may seem high; Pilot test innovative tech here!; Consider treatment; Pilot tests; Consider treatment; If it's moved, it's done; If in place, done right; Care taken with experimental technology
SOC-4	Health & Safety	4	Healthy people; Essential; Live and work without fear for health; safe transport; consider community patterns

Table D- 2. SG ENV metric weights and their basis for SG Community Forum (CF)

Label	Metric	Community Forum (CF)	Basis: Comments from Facilitated Graphics
ENV-1a	a. Residual risk, T0	4	
ENV-1b	b. Downstream risk	2	
ENV-1c	c. Reliance on controls	4	
ENV-1d	d. Construction risk	0	not used
ENV-1e	e. Residual risk, T45	4	
ENV-2a	a. Nearshore habitat	3	
ENV-2b	b. Benthic habitat	3	
ENV-2c	c. Shoreline habitat	3	
ENV-3a	a. Flood risk	4	Disaster prep; Earthquakes; Consider sites carefully; Flood/earthquake liquefaction
ENV-3b	b. Vulnerability in place	4	Disaster prep; Earthquakes; Consider sites carefully; Flood/earthquake liquefaction
ENV-4a	a. Air emissions	2	
ENV-4b	b. Energy consumption	2	
ENV-4c	c. Water consumption	2	
ENV-4d	d. Hazardous landfill use	3	
ENV-4e	e. Non-hazardous landfill use	2	
ENV-4f	f. Volume of sediment treated	2	
ENV-4g	g. Contaminant mobilization	3	Monitor health of nature

Table D- 3. SG ECON metric weights and their basis for SG Community Forum (CF)

Label	Metric	Community Forum (CF)	Basis: Comments from Faciltated Graphics
ECON-1a	a. Economic (long-term)	4	Business and industry; Strong blue collar community here; Model 'green' industry; Lots of 'alternative' business; 'Legacy' insurance
ECON-1b	b. Economic (short-term)	0	(not used)
ECON-1c	c. Tourism	0	(not used)
ECON-1d	a. Real estate stigma removal	0	Resist gentrification (not used)
ECON-2a	a. Employment (local)	4	Community jobs; Good jobs even after cleanup; Community spirit remains; Family wage & prevailing wage jobs; Minority contracting; Job training for local people
ECON-3a	a. Road traffic	4	Safe transport; consider community patterns
ECON-3b	b. Construction time	2	Safe transport; consider community patterns
ECON-3c	c. Utilities	2	
ECON-3d	d. River infrastructure	2	
ECON-3e	e. Navigational channel	0	not used
ECON-4a	a. Capital cost	2	
ECON-4b	b. Long-term cost	2	
ECON-4c	c. Cost-effectiveness (T0)	3	High cost - but maybe worth it
ECON-4d	d. Cost-effectiveness (T45)	3	High cost - but maybe worth it
ECON-4e	e. Net environmental benefit	3	High cost - but maybe worth it

Table D-4. SG SOC metric weights and their basis for SG Community Forum (CF)

Label	Metric	Community Forum (CF)	Basis: Comments from Facilitated Graphics
SOC-1a	a. Quality of life	4	Human-scale development; Community values; equity; go to community groups; safe transport; consider community patterns
SOC-1b	b. Recreation: water quality	4	No more fish or swim signs; When people go to river that's success!
SOC-1c	c. Other water recreation	3	River access; No more fish or swim signs; When people go to river that's success!
SOC-1d	d. Access to river	4	River access; No more fish or swim signs; When people go to river that's success!
SOC-2a	a. Stakeholder involvement	4	Do a vision - go TO the community groups; the message is a bit tough - be aware; PRPs should do outreach education $$$; But not control the message
SOC-2b	b. Re-use	2	
SOC-2c	c. Communication of uncertainty	4	Equity; More voices; Ask: how do you get your info?
SOC-2d	d. Archaeological sites	2	
SOC-3a	a. Permanence	4	Disposal technologies; cost of innovation may seem high; Pilot test innovative tech here!; Consider treatment; Pilot tests; Consider treatment; If it's moved, it's done; If in place, done right; Care taken with experimental technology
SOC-3b	b. Effectiveness	4	If it's moved, it's done; If in place, done right; Care taken with experimental technology
SOC-3c	c. Implementability	2	
SOC-3d	d. Socially optimal construction time	2	
SOC-3e	e. Time-effectiveness	2	
SOC-4a	a. Worker safety	4	Healthy people; Essential; Live and work without fear for health
SOC-4b	b. Human health risk	5	Healthy people; Essential; Live and work without fear for health
SOC-4c	c. Fish consumption risk (short-term)	3	Neighbors living on the river; If you have no choice for shelter, safety is secondary

D.2.2 Representative SG: Community Comments (CC)

SG Value ranks for this representative SG are based upon notes and transcriptions of public statements, presentations, comments, and questions made by community groups and members of the public at public meetings, seminars, and webinars on the Site cleanup plans (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c, and others). These meetings have been sponsored by a range of groups and have been held at a range of venues, encompassing many neighborhoods and stakeholder and interest groups. Most had open question, answer, and comment periods, and all of these were transcribed. However, it should be noted that some groups and individuals were present and vocal at most meetings, so their viewpoints may be over-represented relative to other SGs. Not surprisingly, some of the more involved individuals have strong positions, often on a narrow number of issues. Thus, this SG's priorities differ in some respects from those represented in the St John's Community Café, with its focus on the triple bottom line, but some overlap. SG Value weights were developed using professional judgement based upon the value maps of these meeting notes. As one purpose of this exercise was to test the model's sensitivity to diverse priority sets, an attempt was made to emphasize these differences in SG priority weights, while still remaining consistent with the value map for this group.

The main issues of concern raised in these meetings include:

- Long-term risk reduction, and risk from fish consumption are concerns; worker health and safety is of less concern
- Permanence and certainty are major concerns
- Time is an important issue
- Impacts on the community are of concern (though it is expected that these can be mitigated)
- Cost is not a major concern, but the expectation is that large companies will carry the costs
- Jobs are a concern, but the expectation is that jobs will be gained

Table D-5 illustrates the SG Value weights assigned for this SG. Tables D-6 through D-8 illustrate the SG metric weights assigned for this SG.

Table D-5. SG Value weights and their basis for SG Community Comments (CC)

Label	Value	Community Comments (CC)	Basis - summary of notes (evidence in Value Map)
ENV-1	Fish & Wildlife	3	Ecological receptors, food chain effects, and benthic organisms mentioned on occasion
ENV-2	Habitat	3	Some concern about accountability for habitat restoration promises
ENV-3	Resilience	5	Significant concern about flooding, earthquake and extreme weather resilience, almost solely in the context of CDFs, but to a small extent also in terms of in situ management
ENV-4	Low Impact Remedy	3	Significant concerns about contaminant remobilization, air emissions. Minor concern about other impacts
ECON-1	Economic Vitality	3	Major concerns about who is bearing the cost; minor concerns about taxpayer/ratepayer impacts
ECON-2	Jobs	3	Jobs mentioned frequently, but on the assumption that cleanup will bring long-term jobs
ECON-3	Infrastructure	2	Minor mention of traffic impact, but very little concern or awareness, based on public meetings
ECON-4	Cost-Effectiveness	3	Concern that cost is not the main driver of the decision
SOC-1	Quality of Life/ Recreation	4	Mentioned at meetings, but mostly by EPA, not community questioners. Some concern about smells and neighborhood impact but minor. Concern about impacts to recreation and river access were major
SOC-2	Community Values	5	Significant comments on the need for communities to be heard, consulted, and considered
SOC-3	Acceptable Remedy	5	Aspects of this value dominated most public meetings.
SOC-4	Health & Safety	5	Major concern, in terms of EJ (homeless and subsistence fisherpersons) and also a fear of impacts when using or being near river.

Table D-6. SG ENV metric weights and their basis for SG Community Comments (CC)

Label	Metric	Community Comments (CC)	Basis - summary of notes (evidence in Value Map)
ENV-1a	a. Residual risk, T0	4	Many comments, but mostly in terms of human health
ENV-1b	b. Downstream risk	3	Many comments, but mostly in terms of human health
ENV-1c	c. Reliance on controls	2	not addressed directly
ENV-1d	d. Construction risk	0	not used
ENV-1e	e. Residual risk, T45	3	no clear awareness of risk reduction over time vs right after construction
ENV-2a	a. Nearshore habitat	2	
ENV-2b	b. Benthic habitat	3	mentioned once
ENV-2c	c. Shoreline habitat	2	
ENV-3a	a. Flood risk	4	some concern in some meetings
ENV-3b	b. Vulnerability in place	5	significant concern in some meetings
ENV-4a	a. Air emissions	4	some concern in some meetings
ENV-4b	b. Energy consumption	3	mentioned rarely
ENV-4c	c. Water consumption	2	not mentioned
ENV-4d	d. Hazardous landfill use	2	not mentioned
ENV-4e	e. Non-hazardous landfill use	2	not mentioned
ENV-4f	f. Volume of sediment treated	3	treatment mentioned a couple of times
ENV-4g	g. Contaminant mobilization	4	significant concern in some meetings

Table D-7. SG ECON metric weights and their basis for SG Community Comments (CC)

Label	Metric	Community Comments (CC)	Basis - summary of notes (evidence in Value Map)
ECON-1a	a. Economic (long-term)	4	addressed but main concern is the equity - making business pay
ECON-1b	b. Economic (short-term)	0	not mentioned (not used)
ECON-1c	c.Tourism	0	not mentioned (not used)
ECON-1d	d. Real estate stigma removal	0	not mentioned (not used)
ECON-2a	a. Employment (local)	4	a concern in some meetings but assumption is that jobs are gained
ECON-3a	a. Road traffic	2	not mentioned
ECON-3b	b. Construction time	2	not mentioned
ECON-3c	c. Utilities	2	not mentioned
ECON-3d	d. River infrastructure	2	not mentioned
ECON-3e	e. Navigational channel	0	not used
ECON-4a	a. Capital cost	1	only concern is how costs will be distributed
ECON-4b	b. Long-term cost	1	only concern is how costs will be distributed
ECON-4c	c. Cost-effectiveness (T0)	3	some concerns about whether gain will justify cost
ECON-4d	d. Cost effectiveness (T45)	2	no real awareness of long-term vs post-construction
ECON-4e	e. Net environmental benefit	3	some concerns about whether gain will justify cost

Table D- 8. SG SOC metric weights and their basis for SG Community Comments (CC)

Label	Metric	Community Comments (CC)	Basis - summary of notes (evidence in Value Map)
SOC-1a	a. Quality of life	2	not much awareness of this issue
SOC-1b	b. Recreation: water quality	4	great concerns over water quality
SOC-1c	c. Other water recreation	4	great concerns over river use
SOC-1d	d. Access to river	3	Some concerns raised in some meetings
SOC-2a	a. Stakeholder involvement	5	This was critical point in comments on community values
SOC-2b	b. Re-use	3	Some comments
SOC-2c	c. Communication of uncertainty	3	Numerous comments in community values addressed a desire for more clarity; frustration at vagueness
SOC-2d	d. Archaeological sites	2	Mentioned in one meetings
SOC-3a	a. Permanence	5	Significant concern in many meetings.
SOC-3b	b. Effectiveness	4	A major concern in meetings
SOC-3c	c. Implementability	3	Numerous comments about track record and effectiveness of technologies
SOC-3d	d. Socially optimal construction time	5	Time to completion is a major concern
SOC-3e	e. Time-effectiveness	2	not mentioned
SOC-4a	a. Worker safety	2	not mentioned
SOC-4b	b. Human health risk	5	major concern
SOC-4c	c. Fish consumption risk (short- term)	4	significant concern in some meetings

D.2.3 Representative SG: Business Groups (BG)

SG Value ranks for this representative SG were inferred using professional judgment based on documents commenting on the 2015 EPA Draft Final Feasibility Study (FS) (LWG 2015), interviews (e.g., NERA 2016) and discussions at project and other meetings, and business group statements and presentations at public meetings (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick, 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c; and others). Business groups include potentially responsible parties and other local businesses, which may also be affected by the Site and its cleanup. As one purpose of this exercise was to test the model's sensitivity to diverse priorities, an attempt was made to emphasize these differences in SG priority weights, while still remaining consistent with the value map for this group. The main issues of concern include:

- Costs, time, uncertainty, and impacts on business viability
- Cost-effectiveness
- Impacts on business and infrastructure
- Implementability is important to remedy effectiveness
- Health and safety of worker is an issue of concern, as are reduction of human health risks in the short and long term

Table D-9 illustrates the SG Value weights assigned for this SG. Tables D-10 through D-12 illustrate the SG metric weights assigned for this SG.

Table D-9. SG Value weights and their basis for SG Business Groups (BG)

Label	Value	Business Groups (BG)	Basis - summary of notes (evidence in Value Map)
ENV-1	Fish and Wildlife	4	As a driver of cleanup and site closure, of great concern to businesses who are PRPs
ENV-2	Habitat	4	Impacts to habitat may drive cleanup options and may drive restoration and NRDA so are of concern
ENV-3	Resilience	2	Not raised as a concern in most sources used (meetings, documents, interviews)
ENV-4	Low Impact Remedy	2	Not raised as a concern in most sources used (meetings, documents, interviews)
ECON-1	Economic Vitality	5	Business groups have expressed significant concerns about economic impacts of expenditures
ECON-2	Jobs	2	While jobs are affected by business viability, they are an effect, not a major driver of concern.
ECON-3	Infrastructure	5	Great concern over impacts to infrastructure and traffic
ECON-4	Cost Effectiveness	5	Of particular concern to businesses who are PRPs
SOC-1	Quality of Life/ Recreation	2	Not raised as a concern in most sources used (meetings, documents, interviews)
SOC-2	Community Values	3	Some concerns raised
SOC-3	Acceptable Remedy	5	Aspects of this value critical to business community
SOC-4	Health & Safety	3	As a regulatory driver and due to protection of workers a significant concern

Table D-10. SG ENV metric weights and their basis for SG Business Groups (BG)

Label	Metric	Business Groups (BG)	Basis - summary of notes (evidence in Value Map)
ENV-1a	a.Residual risk, T0	4	A regulatory driver and a metric of completion
ENV-1b	b. Downstream risk	4	Will affect project rates and long-term success and liability
ENV-1c	c. Reliance on controls	2	Not raised as a concern in most sources used (meetings, documents, interviews)
ENV-1d	d. Construction risk	0	not used
ENV-1e	e. Residual Risk, T45	3	A major concern, but awareness that goals are not achievable
ENV-2a	a. Nearshore habitat	4	Impacts to habitat may drive cleanup options and may drive restoration and NRDA so are of concern
ENV-2b	b. Benthic habitat	2	Not raised as a concern in most sources used (meetings, documents, interviews)
ENV-2c	c. Shoreline habitat	2	Not raised as a concern in most sources used (meetings, documents, interviews)
ENV-3a	a. Flood risk	2	Not raised as a concern in most sources used (meetings, documents, interviews)
ENV-3b	b Vlunerability in place	2	Not raised as a concern in most sources used (meetings, documents, interviews)
ENV-4a	a. Air Emissions	2	Not raised as a concern in most sources used (meetings, documents, interviews)
ENV-4b	b. Energy consumption	3	A cost item for PRPs
ENV-4c	c. Water consumption	2	Not raised as a concern in most sources used (meetings, documents, interviews)
ENV-4d	d. Hazardous landfill use	4	A cost item for PRPs
ENV-4e	e. Non-hazardous landfill use	3	A cost item for PRPs
ENV-4f	f. Volume of sediment treated	5	A cost item for PRPs
ENV-4g	g. Contaminant mobilization	3	Will affect project rates and long-term success and liability

Table D-11. SG ECON metric weights and their basis for SG Business Groups (BG)

Label	Metric	Business Groups (BG)	Basis - summary of notes (evidence in Value Map)
ECON-1a	a. Economic (long-term)	5	A critical issue for PRPs and local businesses
ECON-1b	b. Economic (short-term)	0	Raised as a significant concern in NERA interviews with business (not used)
ECON-1c	c.Tourism	0	No evidence of business impact couod be found (not used)
ECON-1d	d. Real Estate stigma removal	0	Some suggestion that cleanup could benefit business in the long run by allowing re-development (not used)
ECON-2a	a. Employment (local)	3	While jobs are affected by business viability, they are an effect, not a major driver of concern.
ECON-3a	a. Road traffic	3	Businesses have expressed some concern about impacts increased traffic will have on business
ECON-3b	b. Construction time	4	Business groups have suggested that the longer the construction, the more severe the potential impact on business viability
ECON-3c	c. Utilities	2	No concerns expressed
ECON-3d	d.River infrastructure	5	Business groups have expressed significant concerns imapcts to river access and infrastructure
ECON-3e	e. Navigational channel	0	not used
ECON-4a	a. Capital cost	5	Of major concern to PRPs
ECON-4b	b. Long-term cost	5	Of major concern to PRPs
ECON-4c	c. Cost-effectiveness (T0)	5	Of significant concern to PRPs
ECON-4d	d. Cost effectiveness (T45)	5	Of significant concern to PRPs
ECON-4e	e. Net environmental benefit	5	Of significant concern to PRPs

Table D-12. SG SOC metric weights and their basis for SG Business Groups (BG)

Label	Metric	Business Groups (BG)	Basis - summary of notes (evidence in Value Map)
SOC-1a	a. Quality of life	2	No business-specific concerns expressed; though there was an awareness of this issue and its impact on the community
SOC-1b	b. Recreation: water quality	2	No business-specific concerns expressed; though there was an awareness of this issue and its impact on the community
SOC-1c	c. Other water recreation	2	No business-specific concerns expressed; though there was an awareness of this issue and its impact on the community
SOC-1d	d. Access to river	3	Of some concern to business groups
SOC-2a	a. Stakeholder involvement	3	Some business groups would like to see community engaged
SOC-2b	b.Re-use	3	Some re-use options have business impacts
SOC-2c	c. Communication of uncertainty	4	Significant concern that communication to the community is too black and white, without clear articulation of broader issues and uncertainty
SOC-2d	d. Archaeological sites	2	Not mentioned as an issue
SOC-3a	a. Permanence	3	Fewer concerns in the business community
SOC-3b	b. Effectiveness	4	A major concern in meetings and discussions
SOC-3c	c. Implementability	5	Buinesses who must finance the cleanup have significant concern for this issue
SOC-3d	d. Socially optimal construction time	2	Not mentioned as an issue
SOC-3e	e. Time-effectiveness	4	The question of whether longer construction times reach cleanup faster is a major issue for PRPs
SOC-4a	a. Worker safety	4	A liability issue for businesses
SOC-4b	b. Human health risk	3	A regulatory driver and a metric of completion
SOC-4c	c. Fish consumption risk (short term)	3	Sometimes mentioned in meetings

D.2.4 Representative SG: Tribal Groups (TG)

This is an important SG to consider due to the significant role Tribal groups play in the region. Because of their historical sovereignty in the region, regional Tribes retain treaty rights in conditionally ceded and usual and accustomed lands (with historical use). Responsibility for protecting the natural resources is shared among federal and state agencies and Tribes who own, manage, or have an interest in the resources and who are named as Trustees of the resources on behalf of the public; many Tribes play a role on the Natural Resource Trustee Board. Tribal members have been active in having Portland Harbor listed as a Superfund site, and continue to play an active role in the outreach, commenting, and decision process (e.g., CAG 2015; Fricano et al. 2015; ODEQ 2015; Ward 2015). The Yakama Nation has been particularly active at public meetings, and other stakeholders and community members frequently comment on or inquire regarding Tribal viewpoints (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c; Ward 2015). Tribal groups have a significant stake in the health of the Willamette and Columbia Rivers. The Yakama Nation, and their representative, Rose Longoria, have been very active in public outreach and comment on the Site cleanup. The Tribes were very active in commenting on the 2015 EPA Draft Final FS and attending public meetings about the remedial alternatives. It should be noted that The Confederated Tribes and Bands of the Yakama Nation, although a trustee for Portland Harbor, has withdrawn from the Trustee Council and is no longer participating with the Natural Resource Trustee Council in their restoration planning efforts, as they felt that all their concerns were not being addressed in that effort. SG Value weights for this representative SG are based upon notes and transcriptions of public statements, presentations, comments, and questions answered by Yakama Nation representatives at public meetings and seminars on the Site cleanup plans (e.g., Apitz 2016a, b, c, d; Apitz and Fitzpatrick 2016a, b; Apitz and McNally 2016; Fitzpatrick 2016; Garland 2016a, b, c; Ward 2015; and others). As one purpose of this exercise was to test the model's sensitivity to diverse priorities, an attempt was made to emphasize these differences in SG priority weights, while still remaining consistent with the value map for this group. Key issues include:

- Treaty rights and the protection of fish in the Columbia River are foci
- Remedy should be permanent and extensive
- Cost and short-term impacts are not of concern (except for fish tissue and contaminant transport impacts)
- Fish consumption is important
- Focus in on the timescale of generations

Table D-13 illustrates the SG Value weights assigned for this SG. Tables D-14 through D-16 illustrate the SG metric weights assigned for this SG.

Table D-13. SG Value weights and their basis for SG Tribal Groups (TG)

Label	Value	Tribal Groups (TG)	Basis - summary of notes (evidence in Value Map)
ENV-1	Fish and Wildlife	5	Major concerns about fish and wildlife as major cultural and treaty-guaranteed values
ENV-2	Habitat	4	Significant concerns about some habitat to support fish and wildlfe
ENV-3	Resilience	3	Some concerns raised in documents and commentaries
ENV-4	Low Impact Remedy	1	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
ECON-1	Economic Vitality	1	Specific comments suggested that economic impacts were minor and not relevant
ECON-2	Jobs	2	Some minor comments on the need for jobs
ECON-3	Infrastructure	1	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
ECON-4	Cost Effectiveness	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
SOC-1	Quality of Life/ Recreation	1	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
SOC-2	Community Values	5	Major concern that community values considered, but a feeling that tribal values, due to treaty commitments, trump other values
SOC-3	Acceptable Remedy	5	Aspects of this value are major concerns in documents
SOC-4	Health & Safety	3	The ability eat fish, in the long term, and to a lesser extent, in the short term, are major concerns.

Table D- 14. SG ENV metric weights and their basis for SG Tribal Groups (TG)

Label	Metric	Tribal Groups (TG)	Basis - summary of notes (evidence in Value Map)
ENV-1a	a.Residual risk, T0	5	Reduction of contaminant loads a major concern
ENV-1b	b. Downstream risk	5	downstream risks, and the transport of contaminants from the Willamette to the downstream sites including the Colombia River, are major concerns
ENV-1c	c. Reliance on controls	5	Tribes want full removal without reliance on O&M and controls.
ENV-1d	d. Construction risk	0	not used
ENV-1e	e. Residual Risk, T45	5	Risk reduction in the long term is a major concern
ENV-2a	a. Nearshore habitat	3	Some mention of habitats as they are essential for valued fish
ENV-2b	b. Benthic habitat	2	not mentioned
ENV-2c	c. Shoreline habitat	3	Some mention of habitats as they are essential for valued fish
ENV-3a	a. Flood risk	0	Not mentioned, but short term risks stated to not be a priority
ENV-3b	b Vlunerability in place	3	Mentioned in some documents
ENV-4a	a. Air Emissions	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
ENV-4b	b. Energy consumption	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
ENV-4c	c. Water consumption	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
ENV-4d	d. Hazardous landfill use	2	Where this links to permanence, somewhat of an issue
ENV-4e	e. Non-hazardous landfill use	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
ENV-4f	f. Volume of sediment treated	2	Where this links to permanence, somewhat of an issue
ENV-4g	g. Contaminant mobilization	5	A major concern as it impacts on tribal fishing

Table D-15. SG ECON metric weights and their basis for SG Tribal Groups (TG)

Label	Metric	Tribal Groups (TG)	Basis - summary of notes (evidence in Value Map)
ECON-1a	a. Economic (long-term)	1	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
ECON-1b	b. Economic (short-term)	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant (not used)
ECON-1c	c.Tourism	0	A minor concern (not used)
ECON-1d	d. Real Estate stigma removal	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant (not used)
ECON-2a	a. Employment (local)	2	Mentioned occasionally
ECON-3a	a. Road traffic	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
ECON-3b	b. Construction time	2	Where this affects river use, may be an issue
ECON-3c	c. Utilities	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
ECON-3d	d.River infrastructure	2	Where this affects river use, may be an issue
ECON-3e	e. Navigational channel	0	not used
ECON-4a	a. Capital cost	1	Costs have been stated to be irrelevant to the decision, except inasmuch as they should be paid by companies
ECON-4b	b. Long-term cost	1	Costs have been stated to be irrelevant to the decision, except inasmuch as they should be paid by companies
ECON-4c	c. Cost-effectiveness (T0)	1	Indirectly addressed as an issue
ECON-4d	d. Cost effectiveness (T45)	2	Indirectly addressed as an issue; long term effectiveness a priority
ECON-4e	e. Net environmental benefit	1	Indirectly addressed as an issue

Table D-16. SG SOC metric weights and their basis for SG Tribal Groups (TG)

Label	Metric	Tribal Groups (TG)	Basis - summary of notes (evidence in Value Map)
SOC-1a	a. Quality of life	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
SOC-1b	b. Recreation: water quality	3	Where this affects river use, may be an issue
SOC-1c	c. Other water recreation	3	Where this affects river use, may be an issue
SOC-1d	d. Access to river	3	Where this affects river use, may be an issue
SOC-2a	a. Stakeholder involvement	3	Tribal groups have stated that the community should be consulted but think their treaty rights trump other SGs
SOC-2b	b.Re-use	4	Some re-uses of tribal importance
SOC-2c	c. Communication of uncertainty	2	Some concern that communication to the community is too black and white, without clear articulation of broader issues and uncertainty
SOC-2d	d. Archaeological sites	4	Potential risk to cultural sites of concern.
SOC-3a	a. Permanence	5	A major concern to tribal groups
SOC-3b	b. Effectiveness	5	A significant concern to tribal groups
SOC-3c	c. Implementability	0	This has been stated as of no concern - the problem of PRPs
SOC-3d	d. Socially optimal construction time	2	Faster remediation of some concern, but very long term goals are the focus
SOC-3e	e. Time-effectiveness	0	Generational timescales are the focus
SOC-4a	a. Worker safety	0	Many comments made (primarily by YN) that the focus was on generations; impacts in the short-term were said to be irrelevant and unimportant
SOC-4b	b. Human health risk	5	Fish consumption in the long term a major concern
SOC-4c	c. Fish consumption risk (short term)	4	Fish consumption in the mid term a significant concern

D.2.5 Representative SG: City Survey (CS)

The City of Portland's Bureau of Environmental Services, in partnership with Oregon's Kitchen Table (OKT), conducted an online consultation with Portland residents in March 2016 to better understand their opinions and values regarding cleanup of the Site in the Willamette River north of downtown Portland (DHM Research 2016). A total of 2,704 residents (including 67 via paper) responded to the survey. The raw data for both the paper and online versions were provided by OKT to DHM Research for processing and analysis. An analysis by DHM Research includes a summary of results as well as findings and examples of responses to open-ended questions (DHM Research 2016). Open-ended questions were not fully included in the report. Although the report states that all responses to open-ended questions are available upon request from OKT, requests to the City and OKT did not yield these, nor requested raw results. However, the data reported by DHM Research can be used to determine the SG priorities for the values addressed by the survey. Main points of the survey (DHM Research 2016) are the following:

- 98% of respondents agree that the river should be safe for fish and wildlife
- 95% of respondents agree that the river should be as clean as possible
- 93% of respondents agree that the cleanup plan should allow Portlanders to swim, boat, and play in the river
- 81% of respondents say it is important the cleanup minimizes cost to households in Portland
- 69% of residents agree that the river should be cleaned to as safe as possible for people, fish, and wildlife, even if some of the costs are passed on to Portland households
- 39% of respondents say it is important to them that cleanup occur more quickly, even if it means that the cost increases
- 72% of residents agree it is important that the plan considers potential positive and/or negative impacts on jobs
- 60% of residents agree that Portlanders should be able to eat an increased amount of resident fish, even if it means spending more for cleanup

Table D-17 illustrates the SG Value weights assigned for this SG. Tables D-18 through D-20 illustrate the SG metric weights assigned for this SG.

Table D-17. SG Value weights and their basis for SG City Survey (CS)

Label	Value	City Survey (CS)	Basis: if a survey question could be mapped to value; then scored: 0: 0-15% strongly or somewhat agree; 1: 16-25%; 2: 26-45% OR not addressed; 3: 46-65%; 4:66-85%; 5: 86-100%
ENV-1	Fish and Wildlife	5	98% of respondents agree that the river should be safe for fish and wildlife
ENV-2	Habitat	4	Wildlife health and habitat ranked top in question 7
ENV-3	Resilience	2	not addressed
ENV-4	Low Impact Remedy	2	not addressed
ECON-1	Economic Vitality	4	68% of respondents agree that industries that rely on the river are important to the region's economy and jobs, and we should consider their needs in the cleanup plan, but only 22% say they strongly agree.
ECON-2	Jobs	4	72% of residents agree it is important that the plan considers potential positive and/or negative impacts on jobs
ECON-3	Infrastructure	2	not addressed
ECON-4	Cost Effectiveness	4	69% of residents agree that the river should be cleaned to as safe as possible for people, fish, and wildlife, even if some of the costs are passed on to Portland households
SOC-1	Quality of Life/ Recreation	4	It is important to me that the plan considers cleanup construction impacts (such as lights, noise, and air pollution) on the neighborhoods surrounding the Harbor during the cleanup.
SOC-2	Community Values	2	not addressed
SOC-3	Acceptable Remedy	2	not addressed

Table D-18. SG ENV metric weights and their basis for SG City Survey (CS)

Label	Metric	City Survey (CS)	Basis: if a survey question could be mapped to value; then scored: 0: 0-15% strongly or somewhat agree; 1: 16-25%; 2: 26-45% OR not addressed; 3: 46-65%; 4:66-85%; 5: 86-100%
ENV-1a	a.Residual risk, T0	4	69% of residents agree that the river should be cleaned to as safe as possible for people, fish, and wildlife, even if some of the costs are passed on to Portland households
ENV-1b	b. Downstream risk	4	69% of residents agree that the river should be cleaned to as safe as possible for people, fish, and wildlife, even if some of the costs are passed on to Portland households
ENV-1c	c. Reliance on controls	2	not addressed
ENV-1d	d. Construction risk	0	not used
ENV-1e	e. Residual Risk, T45	4	69% of residents agree that the river should be cleaned to as safe as possible for people, fish, and wildlife, even if some of the costs are passed on to Portland households
ENV-2a	a. Nearshore habitat	4	Wildlife health and habitat ranked top in question 7
ENV-2b	b. Benthic habitat	4	Wildlife health and habitat ranked top in question 7
ENV-2c	c. Shoreline habitat	4	Wildlife health and habitat ranked top in question 7
ENV-3a	a. Flood risk	2	not addressed
ENV-3b	b Vlunerability in place	2	not addressed
ENV-4a	a. Air Emissions	4	It is important to me that the plan considers cleanup construction impacts (such as lights, noise, and air pollution) on the neighborhoods surrounding the Harbor during the cleanup.
ENV-4b	b. Energy consumption	2	not addressed
ENV-4c	c. Water consumption	2	not addressed
ENV-4d	d. Hazardous landfill use	2	not addressed
ENV-4e	e. Non-hazardous landfill use	2	not addressed
ENV-4f	f. Volume of sediment treated	2	not addressed
ENV-4g	g. Contaminant mobilization	2	not addressed

Table D-19. SG ECON metric weights and their basis for SG City Survey (CS)

Label	Metric	City Survey (CS)	Basis: if a survey question could be mapped to value; then scored: 0: 0-15% strongly or somewhat agree; 1: 16-25%; 2: 26-45% OR not addressed; 3: 46-65%; 4:66-85%; 5: 86-100%
ECON-1a	a. Economic (long-term)	4	81% of respondents say it is important the cleanup minimizes cost to households in Portland.
ECON-1b	b. Economic (short-term)	0	68% of respondents agree that industries that rely on the river are important to the region's economy and jobs, and we should consider their needs in the cleanup plan, but only 22% say they strongly agree. (not used)
ECON-1c	c.Tourism	0	not addressed (not used)
ECON-1d	d. Real Estate stigma removal	0	not addressed (not used)
ECON-2a	a. Employment (local)	4	72% of residents agree it is important that the plan considers potential positive and/or negative impacts on jobs
ECON-3a	a. Road traffic	2	not addressed
ECON-3b	b. Construction time	2	not addressed
ECON-3c	c. Utilities	2	not addressed
ECON-3d	d.River infrastructure	2	not addressed
ECON-3e	e. Navigational channel	0	not used
ECON-4a	a. Capital cost	0	94% of respondents agree that industries contaminated the river and it is their responsibility to clean it up. (interpreted as an inverse cost preference)
ECON-4b	b. Long-term cost	0	94% of respondents agree that industries contaminated the river and it is their responsibility to clean it up. (interpreted as an inverse cost preference)
ECON-4c	c. Cost-effectiveness (T0)	4	69% of residents agree that the river should be cleaned to as safe as possible for people, fish, and wildlife, even if some of the costs are passed on to Portland households
ECON-4d	d. Cost effectiveness (T45)	4	69% of residents agree that the river should be cleaned to as safe as possible for people, fish, and wildlife, even if some of the costs are passed on to Portland households
ECON-4e	e. Net environmental benefit	4	69% of residents agree that the river should be cleaned to as safe as possible for people, fish, and wildlife, even if some of the costs are passed on to Portland households

Table D-20. SG SOC metric weights and their basis for SG City Survey (CS)

Label	Metric	City Survey (CS)	Basis: if a survey question could be mapped to value; then scored: 0: 0-15% strongly or somewhat agree; 1: 16-25%; 2: 26-45% OR not addressed; 3: 46-65%; 4:66-85%; 5: 86-100%
SOC-1a	a. Quality of life	4	It is important to me that the plan considers cleanup construction impacts (such as lights, noise, and air pollution) on the neighborhoods surrounding the Harbor during the cleanup.
SOC-1b	b. Recreation: water quality	5	93% of respondents agree that the cleanup plan should allow Portlanders to swim, boat, and play in the river
SOC-1c	c. Other water recreation	5	93% of respondents agree that the cleanup plan should allow Portlanders to swim, boat, and play in the river
SOC-1d	d. Access to river	4	Beach access and recreation other than swimming or fishing scored 66% in question 7
SOC-2a	a. Stakeholder involvement	2	not addressed
SOC-2b	b.Re-use	2	not addressed
SOC-2c	c. Communication of uncertainty	2	not addressed
SOC-2d	d. Archaeological sites	2	not addressed
SOC-3a	a. Permanence	5	95% of respondents agree that the river should be as clean as possible
SOC-3b	b. Effectiveness	5	95% of respondents agree that the river should be as clean as possible
SOC-3c	c. Implementability	2	not addressed
SOC-3d	d. Socially optimal construction time	2	39% of respondents say it is important to them that cleanup occur more quickly, even if it means that the cost increases
SOC-3e	e. Time-effectiveness	2	not addressed
SOC-4a	a. Worker safety	2	not addressed
SOC-4b	b. Human health risk	3	60% of residents agree that Portlanders should be able to eat an increased amount of resident fish, even if it means spending more for cleanup.
SOC-4c	c. Fish consumption risk (short term)	4	It is important to me that the cleanup plan protects those who rely on eating resident fish from the river for food.

D.3 Results, SG-weighted SG Value and pillar scores

As was illustrated in Figure D-1, when SG metric weights are determined, the SG-weighted SG Value scores are calculated as the MRW- and SG-weighted centroid ($V_{SG,r}$); the weighted average of the metric scores for a given SG Value:

$$V_{SG,r} = (\sum(M_i * MRW_i * W_{mSGi}))/ \sum MRW_i * \sum W_{mSGi}),$$

where M_i is the score assigned for each metric, MRW_i is the MRW assigned to that metric (see Section 6.2), and W_{mSGi} is the SG weighting for that metric. The centroid is used to ensure that the most relevant, quantitative, and standard metrics are given more weight than those less quantitative, relevant, or clearly linked to the SG Value, and to those more important to an SG.

Similarly, pillar (i.e., Environmental Quality, Economic Viability and Social Equity) scores are calculated as the SG-weighted centroid ($P_{SG,r}$); the weighted average of the SG Value scores for a given pillar:

$$P_{SG,r} = (\sum(V_i * W_{vSGi}))/ \sum W_{vSGi}),$$

where V_i is the score assigned for each SG Value, and W_{vSGi} is the SG weighting for that SG Value.

It is important to note that the value scores above take into account SG weights for the metrics that go into them, but not the specific value weight (which is not taken into account until the values are aggregated to generate pillar scores). For radar graphs in which the SG-relevant value scores are compared, without SG Value weights, the relative importance of metrics, but not values, is reflected in the graphs. To compare SG Value scores taking into account both SG Value and metric weights, value scores are multiplied by the SG Value weight:

$$V_{SG,r} \text{ (value weighted)} = (\sum(M_i * MRW_i * W_{mSGi}))/ \sum MRW_i * \sum W_{mSGi}) * W_{vSGi}$$

These scores are then SG metric and value weighted.

D.3.1 SG: Community Forum; results

Table D-21 shows the SG-weighted SG Value and pillar scores for the Community Forum; Figure D-4 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). A preference for permanence and effectiveness over other metrics of acceptable remedy results in higher scores for more extensive remedies (Figure D-4) when compared to equal weighting (Figure 7-1). Concerns about flooding risk and long-term stability over greenhouse gases results in higher relative scores for Resilience. Other than that, the relative scores of the different alternatives does not differ greatly for this SG, which was selected to represent a (somewhat) balanced set of priorities, compared to when all values are equally weighted. It should be noted that the SG Values illustrated in Figure D-4 are generated from metrics weighted based upon SG priorities (Tables D-2 through D-4).

However, different SGs also have different preference weights for different SG Values (Table D-1); these are taken into account when the SG Values are aggregated to pillar scores, but are not used to generate the numbers in Figure D-4. Figure D-5a, on the other hand, illustrates the SG Values, multiplied by their SG weights as a radar diagram; Figure D-5b illustrates the same data as stacked bars to illustrate how various values add up.

These weighted SG Values are then aggregated for the pillar scores. It should be noted that all approaches to multi-criteria assessment using scoring and weighting schemes, which seek to integrate and balance dissimilar data, have strengths, weaknesses, and artifacts. Different approaches provide different views of the information and may provide insights into how strong preferences for specific issues, metrics, or SG Values may drive a perception of optimal or more sustainable remedial strategies.

The pillar scores are illustrated in Figure D-6. When compared to equal value weighting (Figure 7-2), the concerns expressed in this forum for long-term risks over short-term ones, the low concern with cost-effectiveness, and the focus on permanence and effectiveness results in higher relative pillar scores for Alternative F in Figure D-6 than when all metrics and values are equally weighted (Figure 7-2). Nonetheless, the relative overall sustainability, for all three pillars, does not change, with the less aggressive options having higher scores than the more aggressive options, due to the short- and long-term environmental, economic and social impacts of large-scale remediation.

Table D-21. SG-Value and pillar scores, metric, and value and metric weighted; Community Forum

Community Forum (CF)								**Value and metric weighted**					
Aggregating values								A (baseline)	B	D	E	I	F
ENV	Environmental Quality							0.0	-0.6	-0.8	-0.9	-0.8	-0.9
ECON	Economic Viability							0.0	-1.8	-3.2	-4.6	-4.3	-8.8
SOC	Social Equity							0.8	1.0	0.6	-0.1	0.2	-1.9
Average Sustainability Score								0.3	-0.5	-1.2	-1.9	-1.6	-3.9
		Metric weighted only						Value and metric weighted					
Label	**Value**	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV-1	Fish & Wildlife	0.0	4.1	4.3	4.7	4.6	4.8	0.0	12.3	12.9	14.0	13.8	14.4
ENV-2	Habitat	0.0	-3.9	-5.3	-6.7	-6.0	-10.0	0.0	-11.7	-15.9	-20.2	-18.1	-30.0
ENV-3	Resilience	0.0	0.4	1.1	2.3	1.9	6.1	0.0	1.5	4.3	9.2	7.4	24.4
ENV-4	Low Impact Remedy	0.0	-4.8	-5.7	-6.8	-6.4	-10.0	0.0	-9.6	-11.3	-13.7	-12.8	-20.0
ECON-1	Economic Vitality	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	-8.0	-12.1	-16.7	-15.5	-30.0
ECON-2	Jobs	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	-10.2	-15.6	-21.8	-20.2	-40.0
ECON-3	Infrastructure	0.0	-2.5	-3.6	-4.9	-4.7	-8.4	0.0	-7.5	-10.9	-14.6	-14.2	-25.1
ECON-4	Cost Effectiveness	0.0	6.1	3.6	2.1	2.5	-1.3	0.0	6.1	3.6	2.1	2.5	-1.3
SOC-1	Quality of Life & Recreation	0.0	-2.9	-4.2	-5.9	-5.0	-10.0	0.0	-8.6	-12.6	-17.6	-15.1	-30.0
SOC-2	Community Values	0.6	0.7	0.7	0.7	0.7	0.5	2.4	2.7	2.8	2.9	2.9	2.2
SOC-3	Acceptable Remedy	2.4	3.5	3.4	3.0	3.0	2.0	9.8	14.1	13.6	12.0	12.1	7.8
SOC-4	Health & Safety	0.0	1.8	1.2	0.4	0.8	-2.2	0.0	7.1	4.6	1.4	3.1	-8.8

Figure D-4. SG-weighted value radar, Community Forum. Values based on SG-weighted metric aggregation; values not weighted

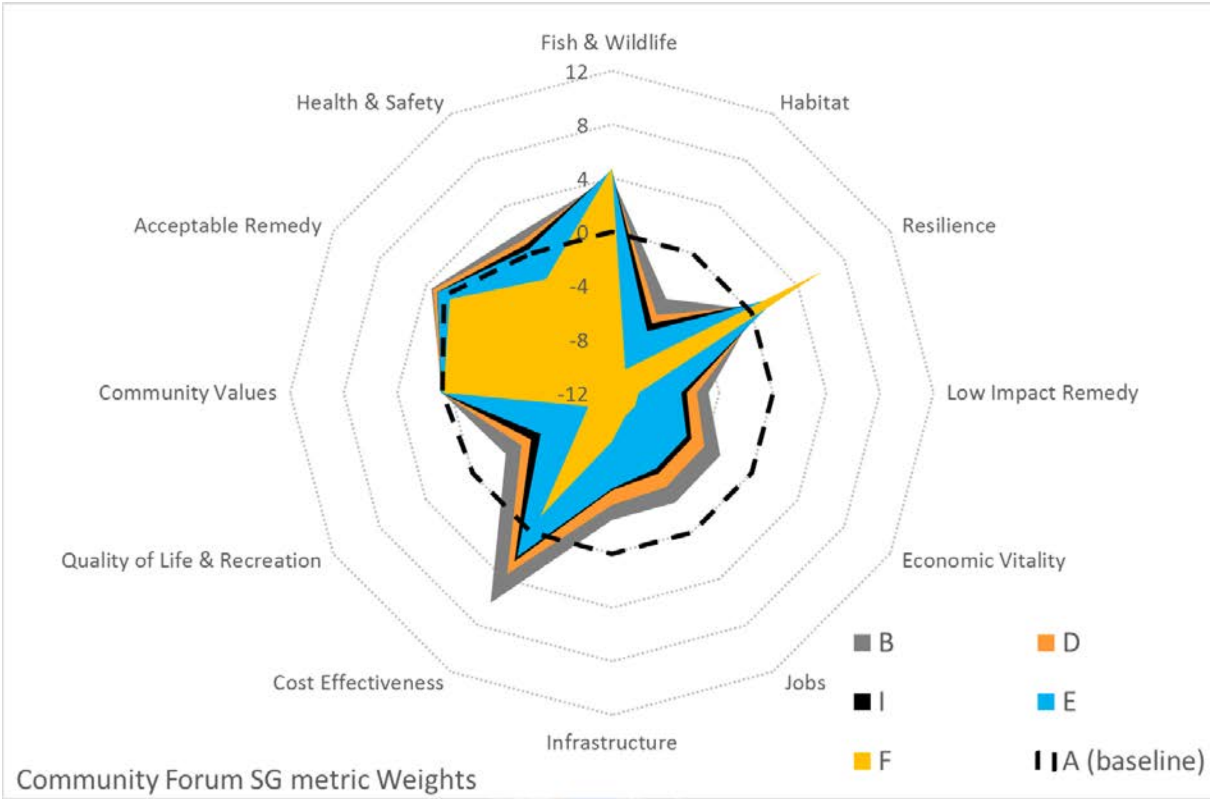


Figure D-5a. SG-weighted value radar, Community Forum. Values based on SG-weighted metric aggregation; SG Value weighted; radar diagram

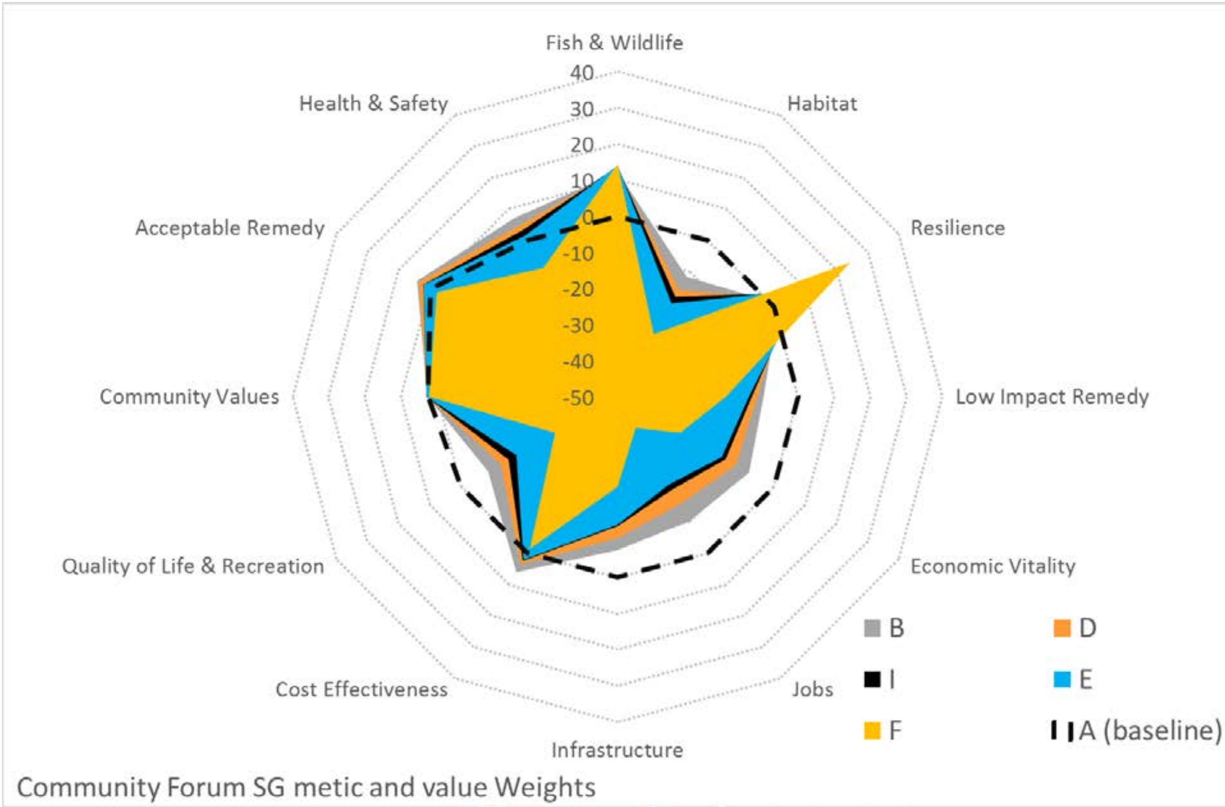


Figure D-5b. SG-weighted value radar, Community Forum. Values based on SG-weighted metric aggregation; SG Value weighted; Stacked bars

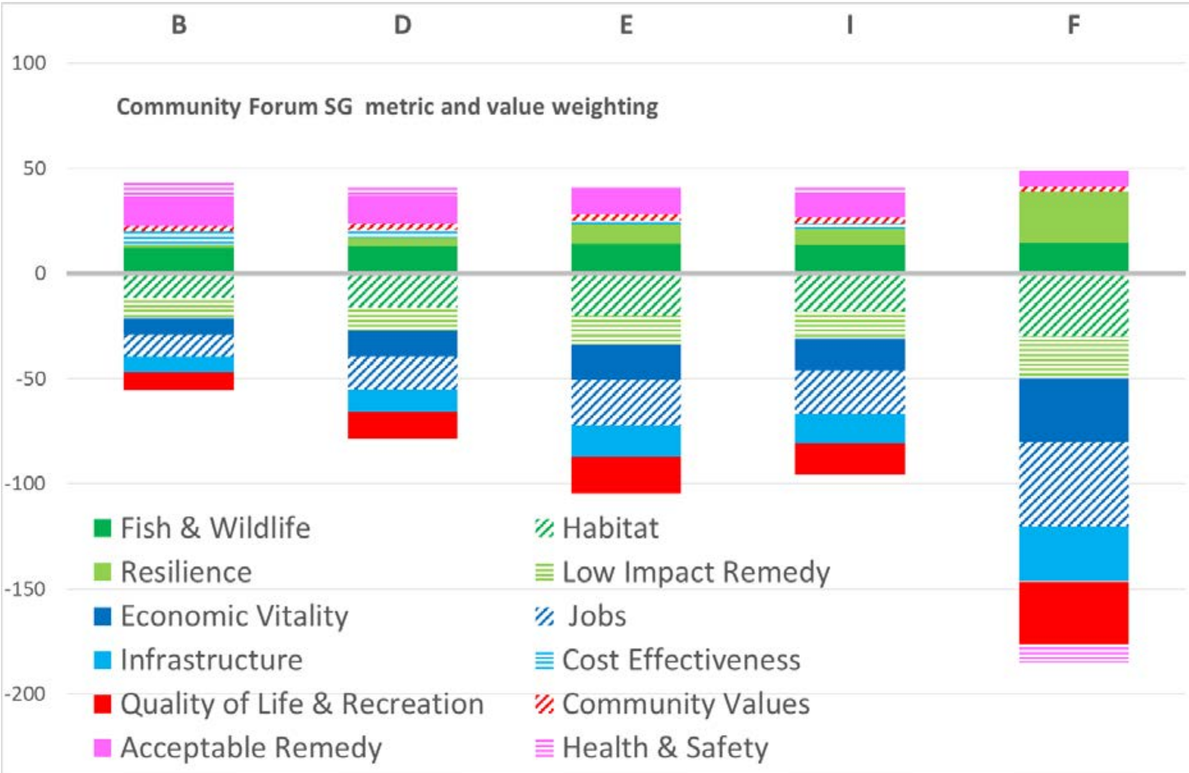
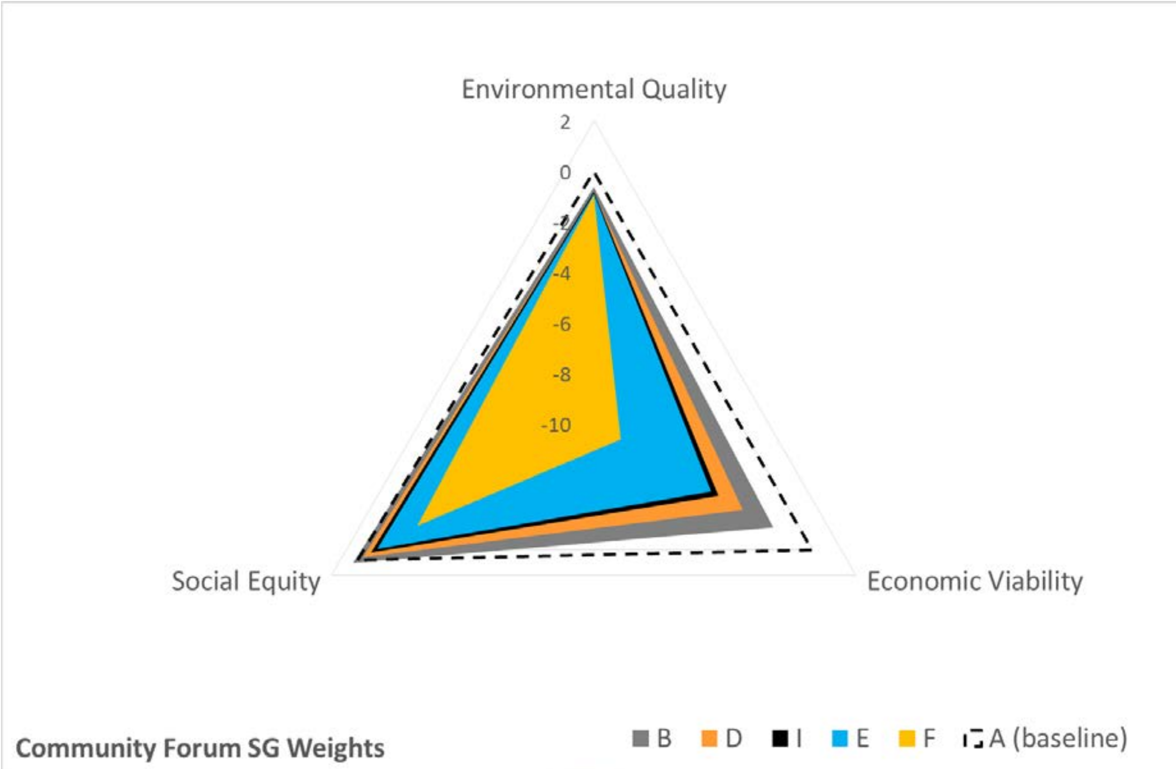


Figure D-6. SG-weighted values-based sustainability pillar scores. Community Forum



D.3.2 SG: Community Comments, results

Table D-22 shows the SG-weighted SG Value and pillar scores for Community Comments. Figure D-7 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). A strong preference for permanence and effectiveness over other metrics of acceptable remedy results in a preference for more extensive remedies, when compared to equal weighting (Figure 7-1). In the Environmental Quality pillar, Resilience was given a higher weight than the other SG Values. Air Emissions were of greater concern than other issues for the SG Value of low-impact remedy. Long-term risk reduction (human and to fish and wildlife) was more important than short-term reduction. Jobs and then infrastructure (primarily road traffic) were more important than other economic impacts. All social SG Values which were addressed were weighted as relatively important. Figure D-8a, on the other hand, illustrates the SG Values, multiplied by their SG weights as a radar diagram; Figure D-8b illustrates the same data, as stacked bars, to illustrate how the values add up for each alternative. These weighted SG Values are then aggregated for the pillar scores. The pillar scores are illustrated in Figure D-9.

Given the heavy emphasis on social SG Values and permanence, the overall sustainability (Figure D-9) scores for more aggressive remedies (i.e., Alternatives E and F) are higher than they are for equal weighting (Figure 7-2), similar to the Community Forum (Figure D-6). This reflects the strong representation of a few individuals and SGs at community meetings, either as presenters or as questioners or commenters in the audience. Although questions and comments reflected a broad range of issues, the preponderance of comments on issues of permanence, and thus alternatives that remove the most sediment, in preference to other alternatives, are heavily weighted here. Nonetheless, if all SG Values are considered, the less aggressive alternatives (B and D) still score better overall, in the SG Value and pillar aggregations, if by a smaller margin. In a discussion of trade-offs, however, the focus can be on those issues where no alternative is a clear-cut “winner”—optimizing sustainability will require a focus on such issues.

Table D-22. SG Value and pillar scores, metric, and value and metric weighted; Community Comments

Community Comments (CC)								Value and metric weighted					
Aggregating values								A (baseline)	B	D	E	I	F
ENV	Environmental Quality							0.0	-0.8	-1.1	-1.2	-1.1	-1.5
ECON	Economic Viability							0.0	0.1	-1.5	-3.0	-2.7	-7.0
SOC	Social Equity							1.0	1.1	0.6	-0.2	0.2	-2.1
Average Sustainability Score								0.3	0.1	-0.7	-1.5	-1.2	-3.5
		Metric weighted only						Value and metric weighted					
Label	**Value**	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV-1	Fish & Wildlife	0.0	3.8	3.9	4.0	4.0	3.7	0.0	11.3	11.7	12.1	12.1	11.1
ENV-2	Habitat	0.0	-3.9	-5.3	-6.6	-5.9	-10.0	0.0	-11.7	-15.8	-19.9	-17.8	-30.0
ENV-3	Resilience	0.0	0.4	1.0	2.2	1.7	5.7	0.0	1.9	5.1	10.8	8.7	28.3
ENV-4	Low Impact Remedy	0.0	-4.4	-5.4	-6.6	-6.2	-10.0	0.0	-13.2	-16.2	-19.9	-18.5	-30.0
ECON-1	Economic Vitality	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	-8.0	-12.1	-16.7	-15.5	-30.0
ECON-2	Jobs	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	-7.7	-11.7	-16.4	-15.1	-30.0
ECON-3	Infrastructure	0.0	-2.7	-3.8	-4.9	-4.7	-7.9	0.0	-5.4	-7.6	-9.8	-9.5	-15.9
ECON-4	Cost Effectiveness	0.0	7.4	4.9	3.2	3.6	-0.4	0.0	22.3	14.8	9.6	10.8	-1.3
SOC-1	Quality of Life & Recreation	0.0	-3.0	-4.4	-6.0	-5.1	-10.0	0.0	-12.2	-17.5	-24.0	-20.2	-40.0
SOC-2	Community Values	0.9	1.1	1.2	1.2	1.2	1.0	4.4	5.7	5.9	6.0	6.0	4.9
SOC-3	Acceptable Remedy	3.0	3.3	2.9	2.2	2.3	0.4	14.9	16.6	14.6	10.9	11.7	2.0
SOC-4	Health & Safety	0.0	2.0	1.5	0.8	1.2	-1.3	0.0	10.2	7.6	4.0	6.2	-6.4

Figure D-7. SG-weighted value radar, Community Comments. Values based on SG-weighted metric aggregation; values not weighted

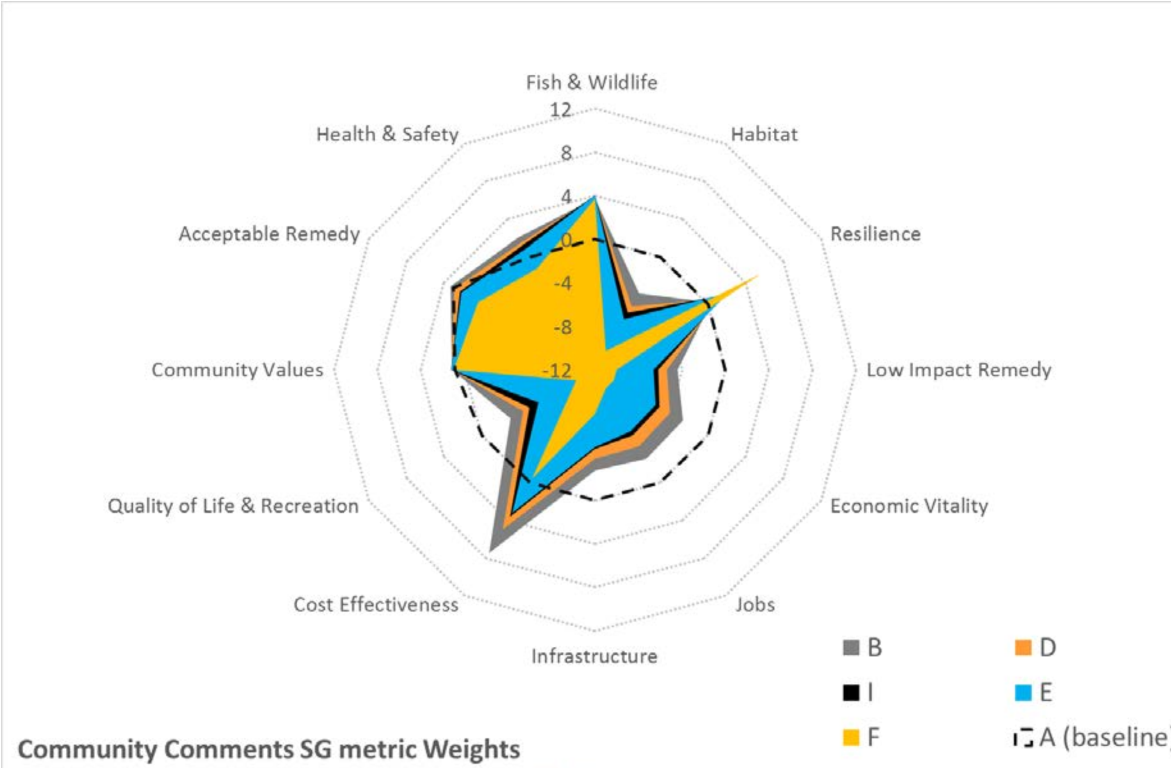


Figure D-8a. SG-weighted value radar, Community Comments. Values based on SG-weighted metric aggregation; SG Value weighted; radar diagram

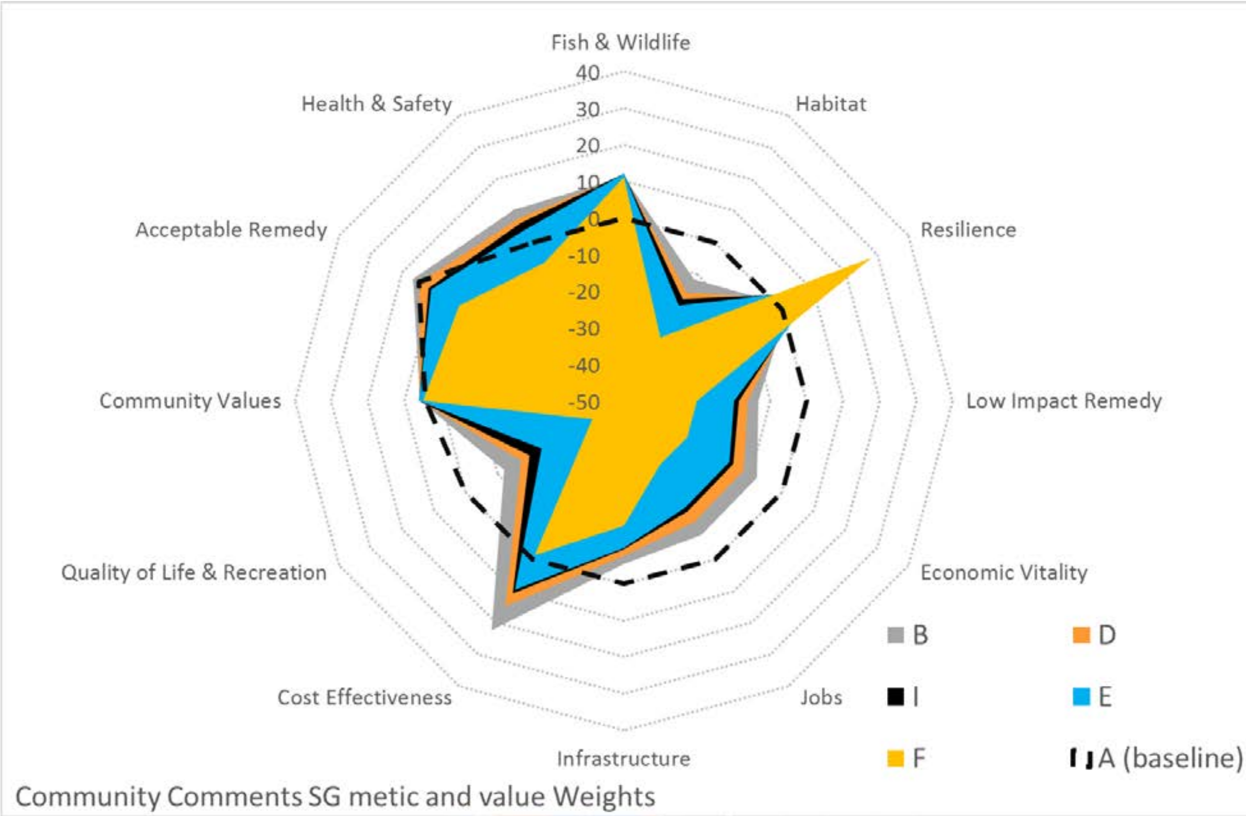


Figure D-8b. SG-weighted value radar, Community Comments. Values based on SG-weighted metric aggregation; SG Value weighted; stacked bars

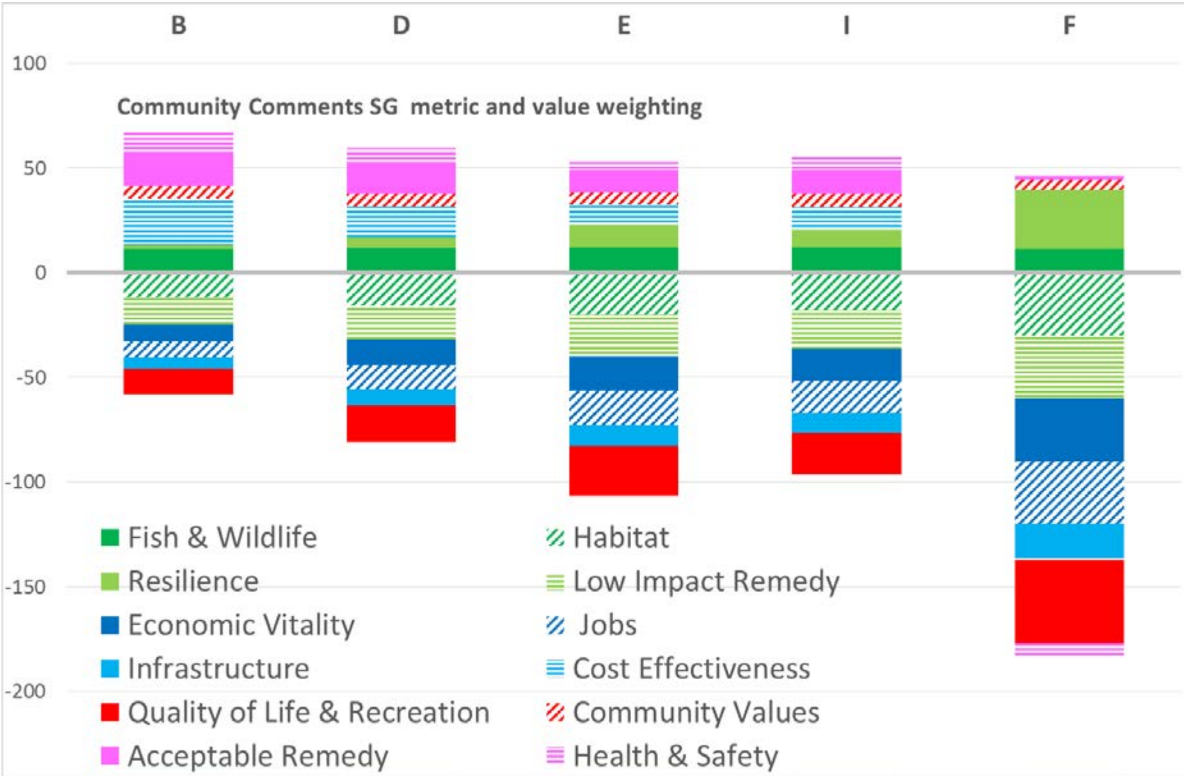
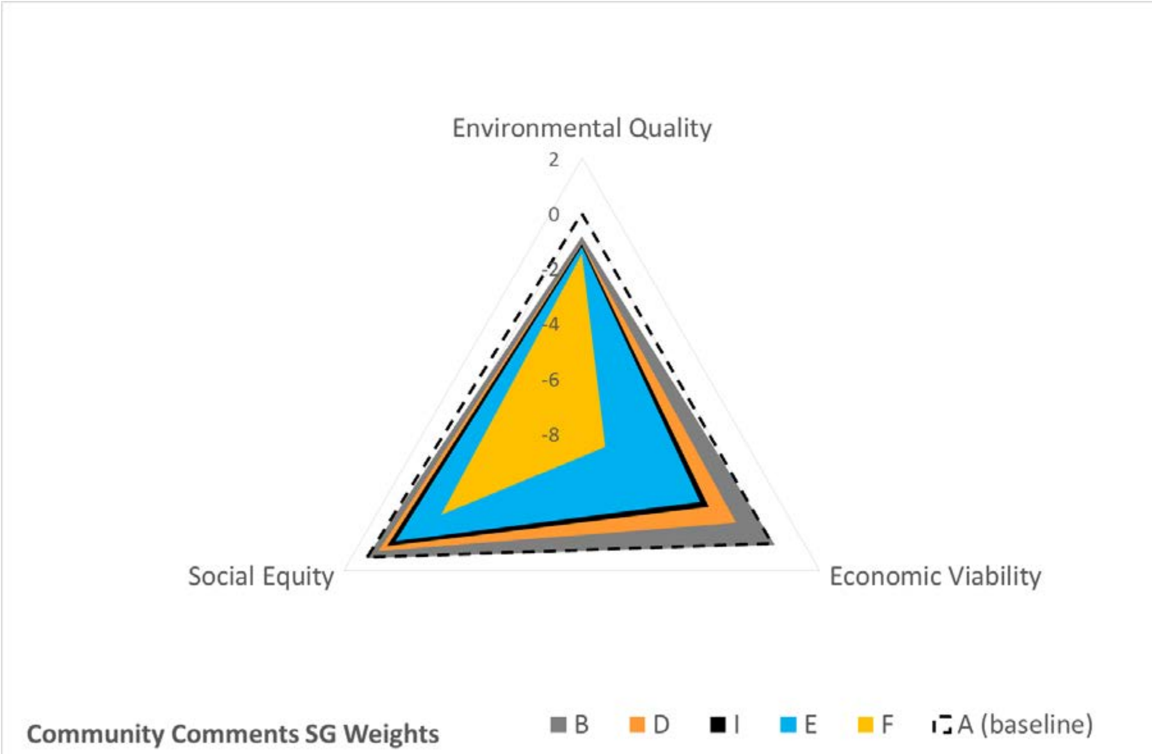


Figure D-9. SG-weighted values-based sustainability pillar scores. Community Comments



D.3.3 SG: Business Groups, results

Table D-23 shows the SG-weighted SG Value and pillar scores for Business Groups. Figure D-10 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). A stronger preference for implementability and time-effectiveness over permanence and effectiveness as metrics of acceptable remedy results in a preference for less extensive remedies, when compared to equal weighting (Figure 7-1).

Figure D-11a, on the other hand, illustrates the SG Values, multiplied by their SG weights, plotted as radar diagrams; Figure D-11b illustrates the same data plotted as stacked bars to illustrate how the values add up for each alternative. These weighted SG Values are then aggregated for the pillar scores. The pillar scores, using the two weighting schemes, are illustrated in Figure D-12.

Although some values are the same as those of other community groups, this SG sets a high priority on Economic Vitality and Cost-Effectiveness. Resilience and Low Impact Remedies are the drivers of concern for Environmental Quality, and this SG, unlike the others, puts a priority on Worker Safety as a metric for the value of Human Health & Safety. Acceptable Remedy is an important value for this SG, but the metrics of importance for this value differ; this SG puts a much heavier emphasis on Implementability and Time-Effectiveness, and a lower emphasis on Permanence (and mass removal). Metrics of importance in the Social Equity pillar are Communication of Uncertainty and Amenability to Re-Use.

In aggregate, these values and priorities lead to a stronger differentiation between alternatives (Figure D-12) than for CF (Figure D-6) and CC (Figure D-9), with the less extensive alternatives (B and D) scoring much better than the more extensive ones (E and F) for most metrics. However, the relative overall ranking remains the same.

Table D-23. SG Value and pillar scores, metric only and metric and value weighted; Business Groups

Business Groups (BG)								Value and metric weighted					
Aggregating values								A (baseline)	B	D	E	I	F
ENV	Environmental Quality							0.0	-1.1	-1.5	-2.0	-1.7	-3.1
ECON	Economic Viability							0.0	-0.3	-1.8	-3.1	-2.8	-6.8
SOC	Social Equity							1.6	1.3	0.7	-0.2	0.1	-2.3
Average Sustainability Score								0.5	0.0	-0.9	-1.8	-1.5	-4.1
		Metric weighted only						Value and metric weighted					
Label	**Value**	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV-1	Fish & Wildlife	0.0	3.3	3.3	3.3	3.3	2.7	0.0	13.0	13.2	13.1	13.4	10.9
ENV-2	Habitat	0.0	-3.9	-5.3	-6.7	-6.1	-10.0	0.0	-15.6	-21.0	-26.8	-24.2	-40.0
ENV-3	Resilience	0.0	0.4	1.1	2.3	1.9	6.1	0.0	0.8	2.2	4.6	3.7	12.2
ENV-4	Low Impact Remedy	0.0	-5.5	-6.3	-7.3	-6.9	-10.0	0.0	-11.0	-12.6	-14.5	-13.8	-20.0
ECON-1	Economic Vitality	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	-13.3	-20.2	-27.8	-25.8	-50.0
ECON-2	Jobs	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	-5.1	-7.8	-10.9	-10.1	-20.0
ECON-3	Infrastructure	0.0	-2.1	-3.1	-4.1	-4.0	-7.2	0.0	-10.7	-15.3	-20.7	-19.8	-35.8
ECON-4	Cost Effectiveness	0.0	4.8	2.5	1.2	1.6	-2.1	0.0	24.2	12.6	6.0	7.9	-10.3
SOC-1	Quality of Life & Recreation	0.0	-3.1	-4.4	-6.1	-5.2	-10.0	0.0	-6.1	-8.9	-12.2	-10.4	-20.0
SOC-2	Community Values	-0.1	0.2	0.2	0.2	0.2	0.0	-0.4	0.5	0.7	0.7	0.7	0.0
SOC-3	Acceptable Remedy	4.2	4.1	3.5	2.6	2.7	0.6	21.1	20.6	17.5	13.1	13.6	3.2
SOC-4	Health & Safety	0.0	0.6	-0.1	-1.3	-0.8	-4.4	0.0	1.9	-0.4	-3.8	-2.3	-13.2

Figure D-10. SG-weighted value radar, Business Groups. Values based on SG-weighted metric aggregation; values not weighted

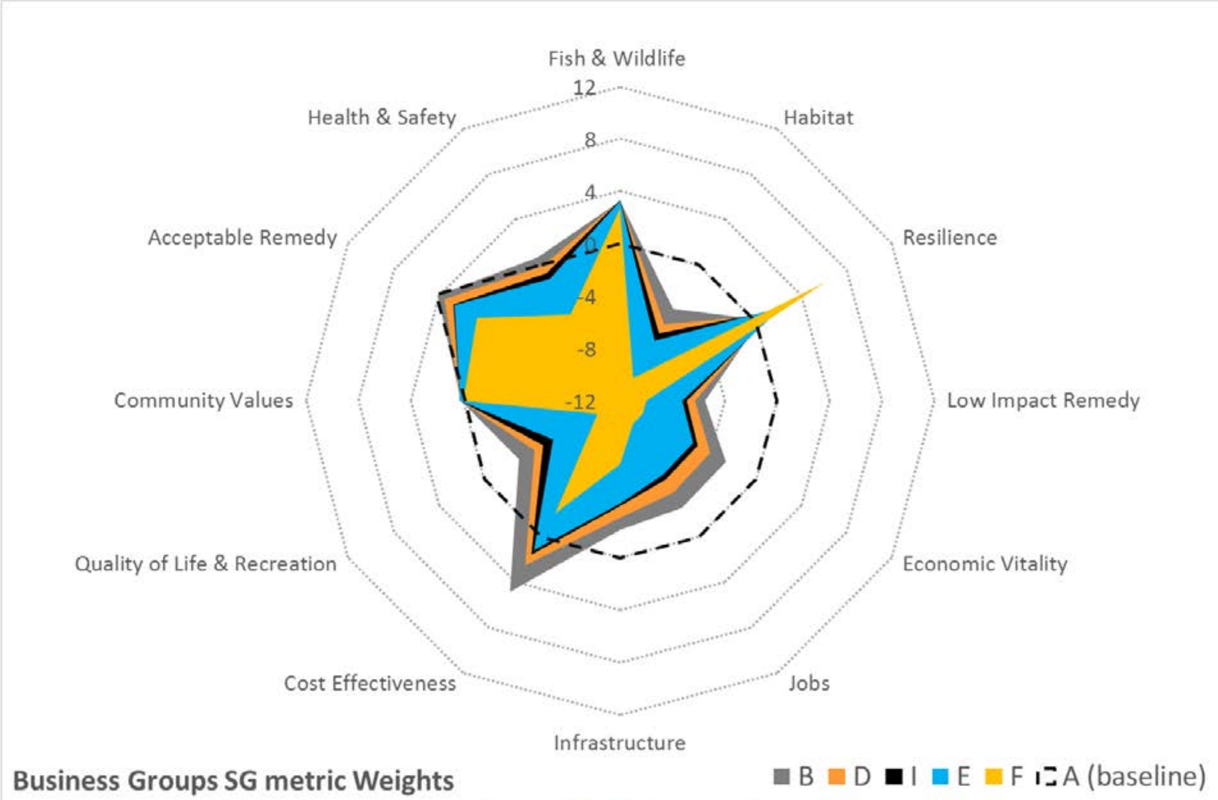


Figure D-11a. SG-weighted value radar, Business Groups. Values based on SG-weighted metric aggregation; SG Value weighted; radar diagram

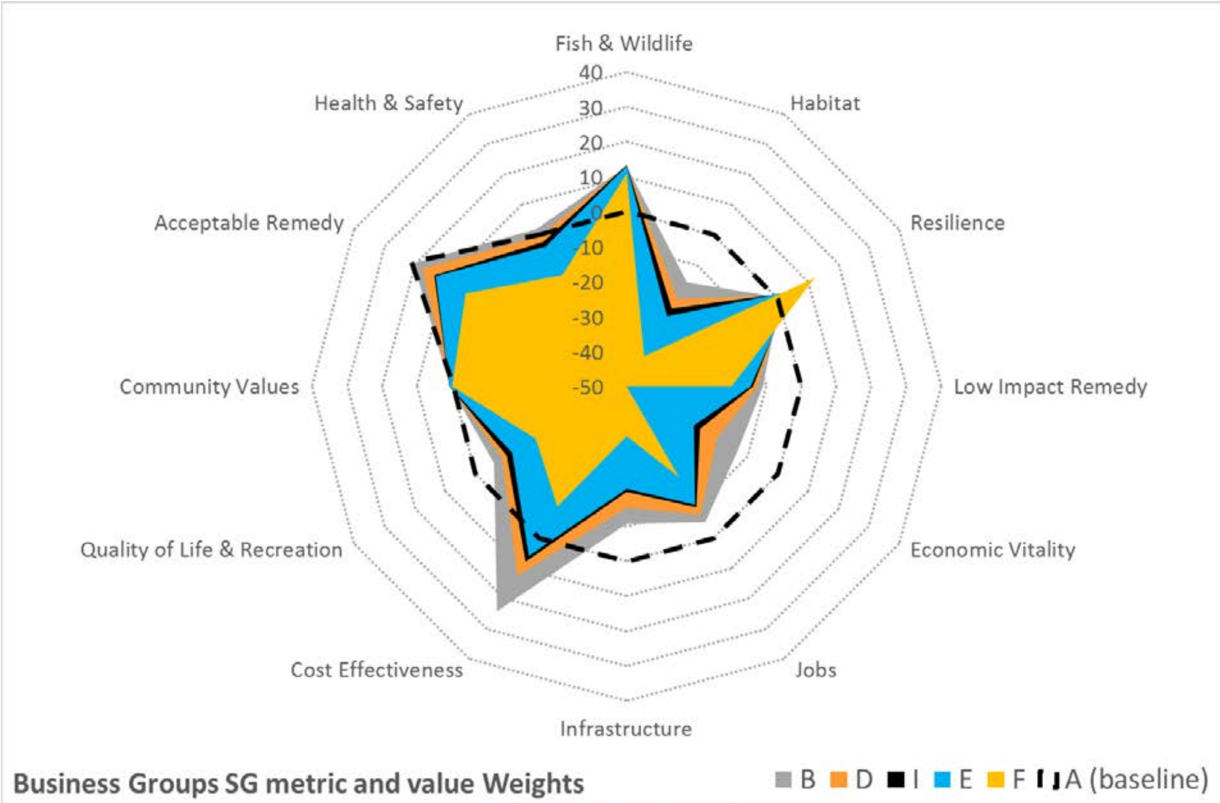


Figure D-11b. SG-weighted value radar, Business Groups. Values based on SG-weighted metric aggregation; SG Value weighted; stacked bars

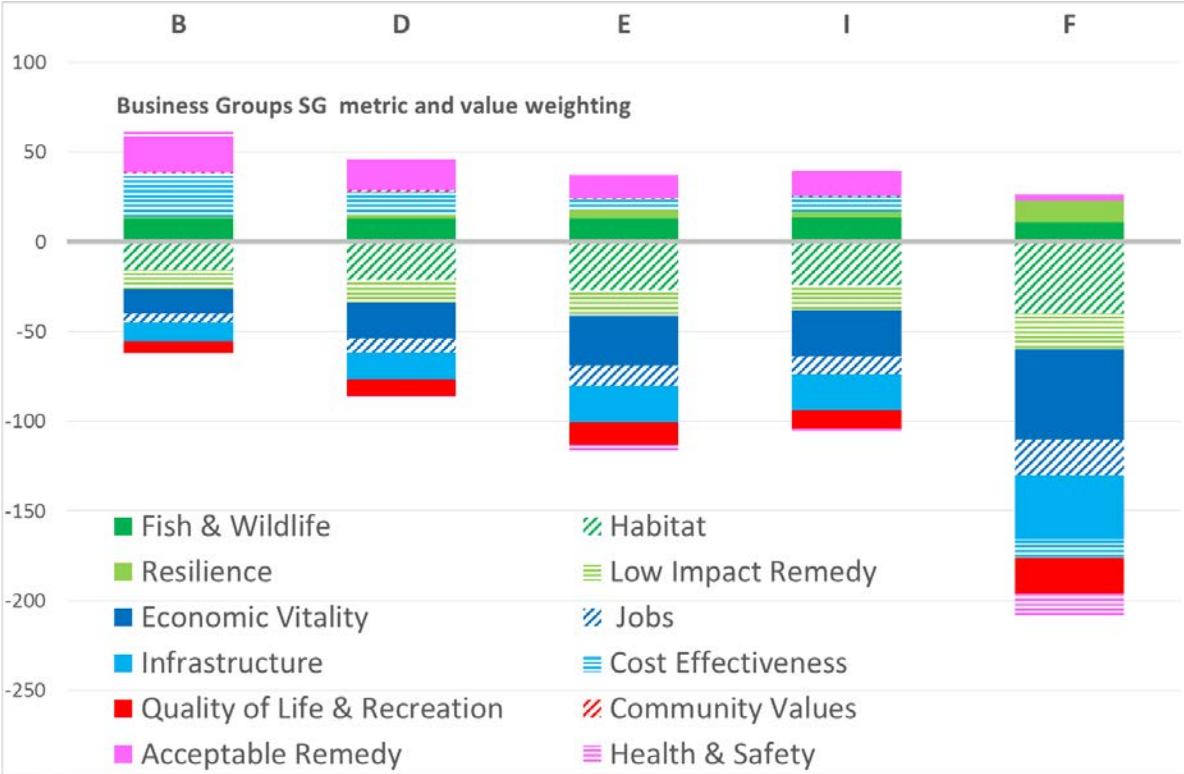
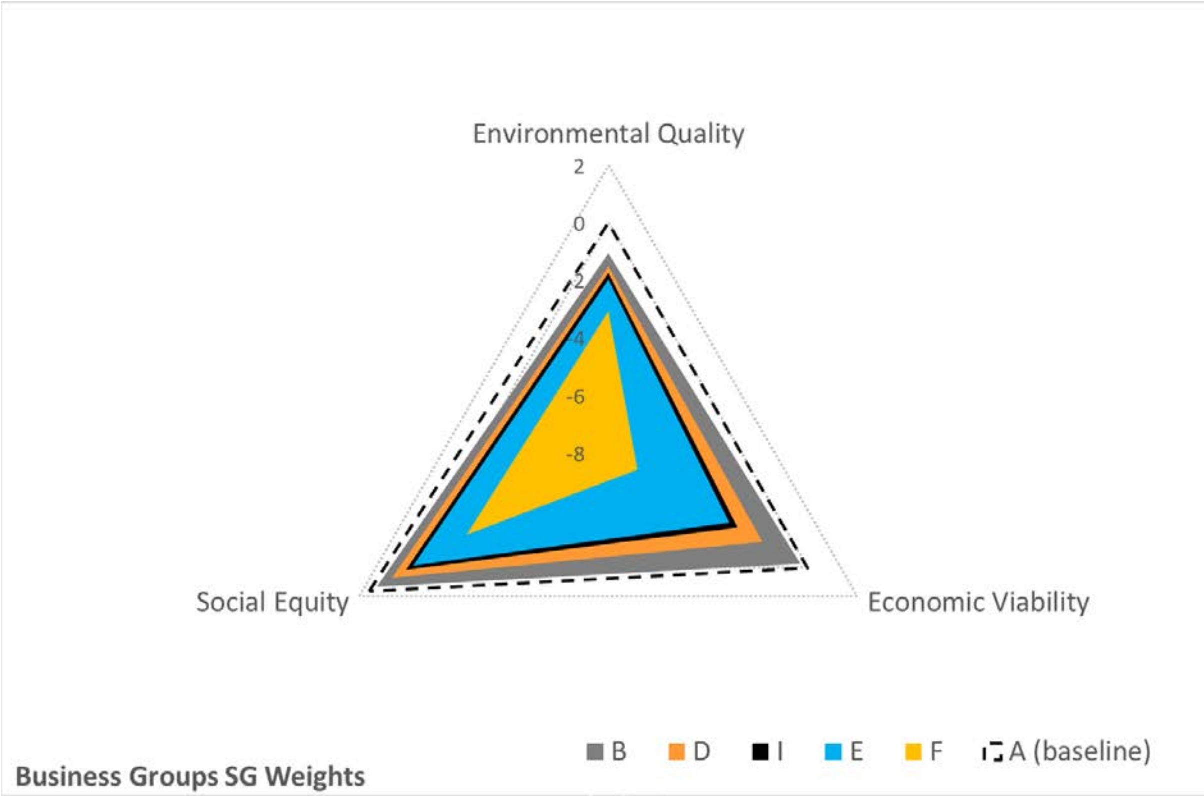


Figure D-12. SG-weighted values-based sustainability pillar scores. Business Groups



D.3.4 SG: Tribal Groups, results

Table D-24 lists the SG Value and pillar scores for the remedial alternatives, using the Tribal Groups SG weightings. Figure D-13 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). An extreme preference for permanence and effectiveness over other metrics of acceptable remedy results in a preference for more extensive remedies, when compared to equal weighting (Figure 7-1), to the extent that the Acceptable Remedy SG Value scores increase with increasingly aggressive options (unlike the scores for any other SG).

Figure D-14a illustrates the SG Values, multiplied by their SG weights, plotted as radar diagrams; Figure D-14b illustrates the same data as stacked bars, so that the sum of the values for each alternative can be seen. The fact that this SG has a strong preference for long-term removal and risk reduction, and little to no concern for short-term impacts (due to a stated focus on generations rather than decades), the differences between less and more extensive options, which are largely driven by short-term regional impacts, are greatly reduced when values are weighted by this SG's priorities. As some metrics are still of concern for most SG Values, most SG Value scores for the alternatives are still higher for Alternatives B and D than they are for Alternatives I, E and F, but the differences are much smaller. This illustrates the importance of shorter-term regional impacts in the overall sustainability assessment, but also demonstrates the robustness of the overall assessment.

This SG has a strong stated preference for permanence of remedy. The focus is on the long term, on the scale of generations, not years. Value statements suggest that cost is not an issue, and that most short-term social, economic, and environmental (barring elevated fish tissue) impacts are not of concern, so any metric reflecting these has been weighted very low. These weighted SG Values are then aggregated for the pillar scores. The pillar scores are illustrated in Figure D-15. As noted, the strong preference for removal-linked metrics, and the low priority given to many regional impacts, increases the social sustainability score of all active alternatives, but increases the score of Alternative F relative to the others, suggesting that the aggregated priorities of this SG are the most consistent with their stated objective—removal over all other concerns. Although it would be possible to collapse all metrics to a single point, there is some evidence of other metrics and values, and some short-term impacts, of concern to this representative SG. Because of this, the Environmental Quality and Economic Viability Scores remain higher for less extensive remedial options which may result in less construction-induced contaminant mobility, habitat and economic impact. This is because, although economic SG Values were not a stated priority for this SG, all their weights were not set to zero, and thus the aggregated scores are dominated by the metrics and SG Values that are not set to zero or low.

Table D-24. SG Value and pillar scores, metric only and metric and value weighted; Tribal Groups

Tribal Groups (TG)								Value and metric weighted					
Aggregating values								A (baseline)	B	D	E	I	F
ENV	Environmental Quality							0.0	-0.4	-0.8	-1.2	-1.0	-2.3
ECON	Economic Viability							0.0	-2.3	-3.5	-4.9	-4.6	-9.1
SOC	Social Equity							0.2	1.8	1.7	1.6	1.7	1.0
Average Sustainability Score								0.1	-0.3	-0.9	-1.5	-1.3	-3.5
		Metric weighted only						Value and metric weighted					
Label	**Value**	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV-1	Fish & Wildlife	0.0	3.2	3.3	3.4	3.4	3.0	0.0	16.1	16.3	16.8	17.0	15.1
ENV-2	Habitat	0.0	-3.9	-5.3	-6.8	-6.1	-10.0	0.0	-15.6	-21.2	-27.1	-24.4	-40.0
ENV-3	Resilience	0.0	0.3	0.6	0.9	0.8	1.8	0.0	1.0	1.8	2.8	2.3	5.4
ENV-4	Low Impact Remedy	0.0	-6.7	-7.2	-8.3	-7.8	-10.0	0.0	-6.7	-7.2	-8.3	-7.8	-10.0
ECON-1	Economic Vitality	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	-2.7	-4.0	-5.6	-5.2	-10.0
ECON-2	Jobs	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	-5.1	-7.8	-10.9	-10.1	-20.0
ECON-3	Infrastructure	0.0	-1.5	-2.2	-3.3	-3.0	-6.3	0.0	-1.5	-2.2	-3.3	-3.0	-6.3
ECON-4	Cost Effectiveness	0.0	5.5	2.8	1.5	1.9	-2.0	0.0	0.0	0.0	0.0	0.0	0.0
SOC-1	Quality of Life & Recreation	0.0	-3.4	-4.7	-6.3	-5.3	-10.0	0.0	-3.4	-4.7	-6.3	-5.3	-10.0
SOC-2	Community Values	0.0	0.1	0.1	0.2	0.2	-0.1	-0.1	0.4	0.7	0.8	0.8	-0.6
SOC-3	Acceptable Remedy	0.8	3.2	3.7	3.9	3.8	4.2	4.0	16.1	18.4	19.6	19.0	21.2
SOC-4	Health & Safety	0.0	3.0	2.6	2.2	2.6	0.9	0.0	14.9	13.1	10.9	13.0	4.6

Figure D-13. SG-weighted value radar, Tribal Groups. Values based on SG-weighted metric aggregation; values not weighted

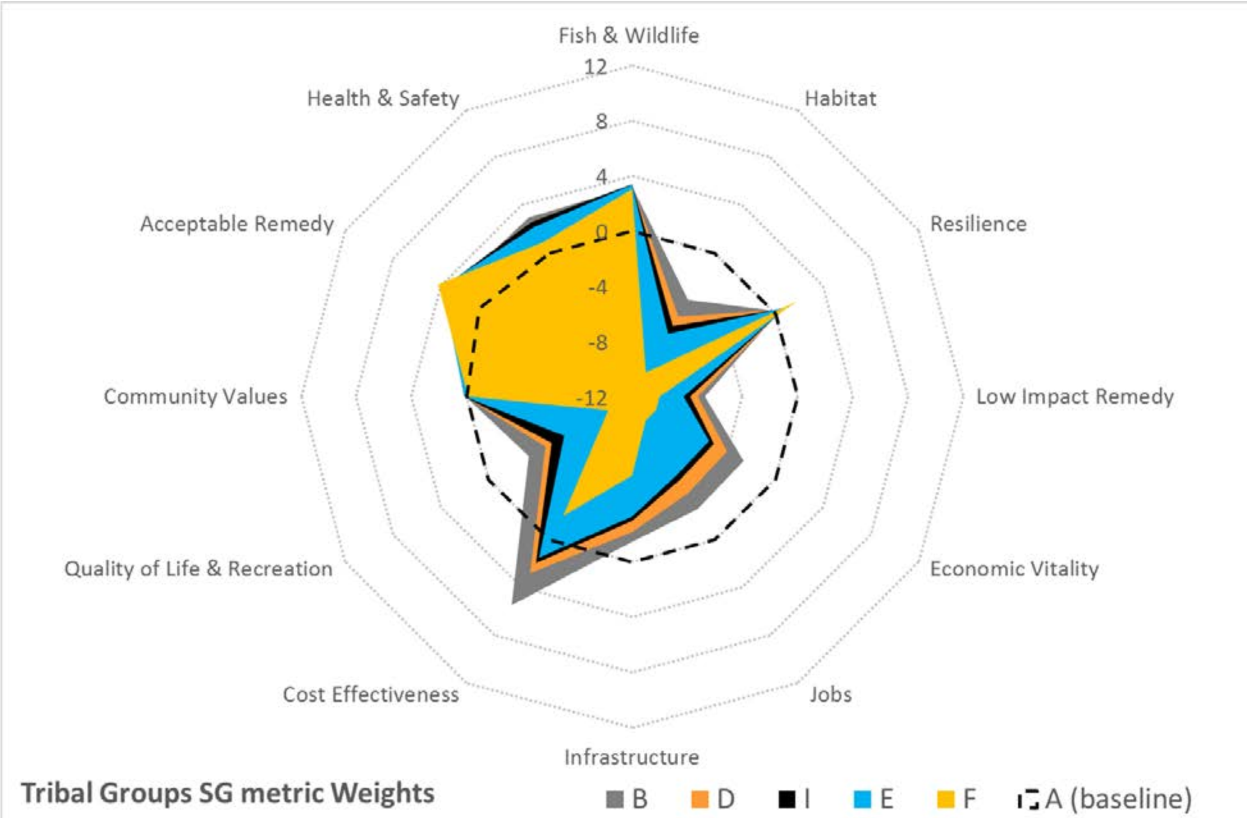


Figure D-14a. SG-weighted value radar, Tribal Groups. Values based on SG-weighted metric aggregation; SG Value weighted

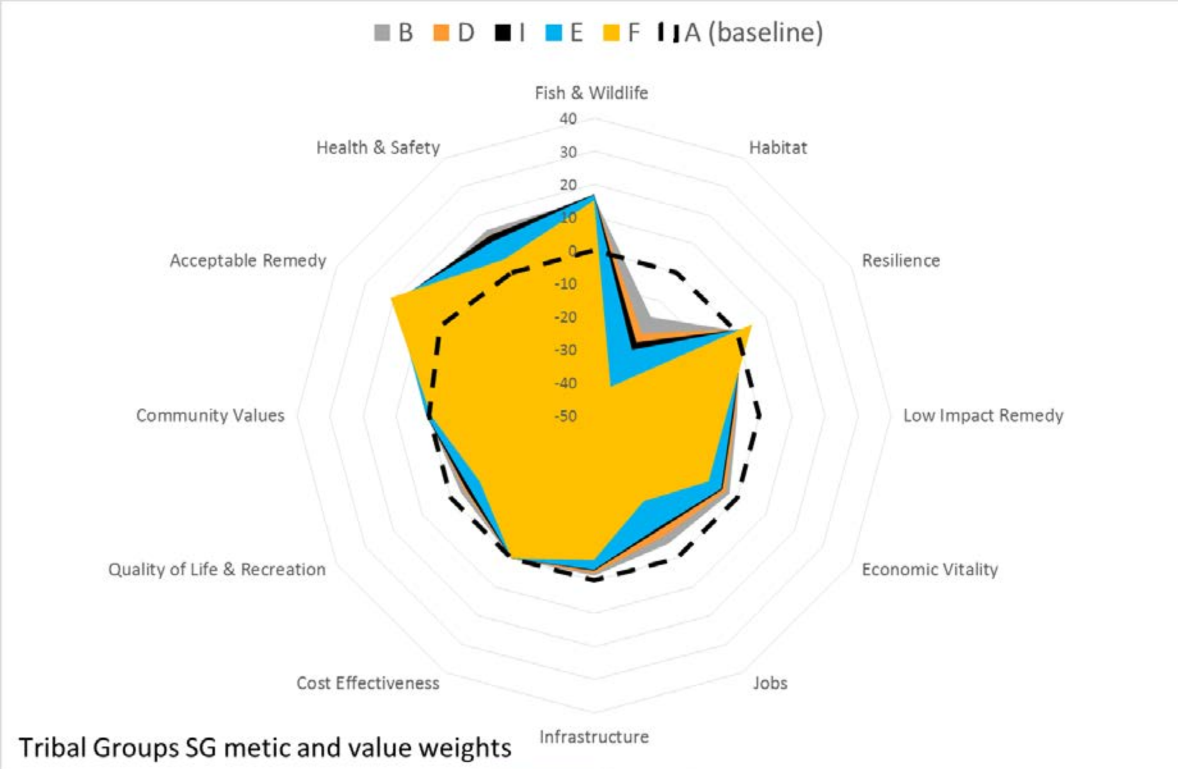


Figure D-14b. SG-weighted value radar, Tribal Groups. Values based on SG-weighted metric aggregation; SG Value weighted

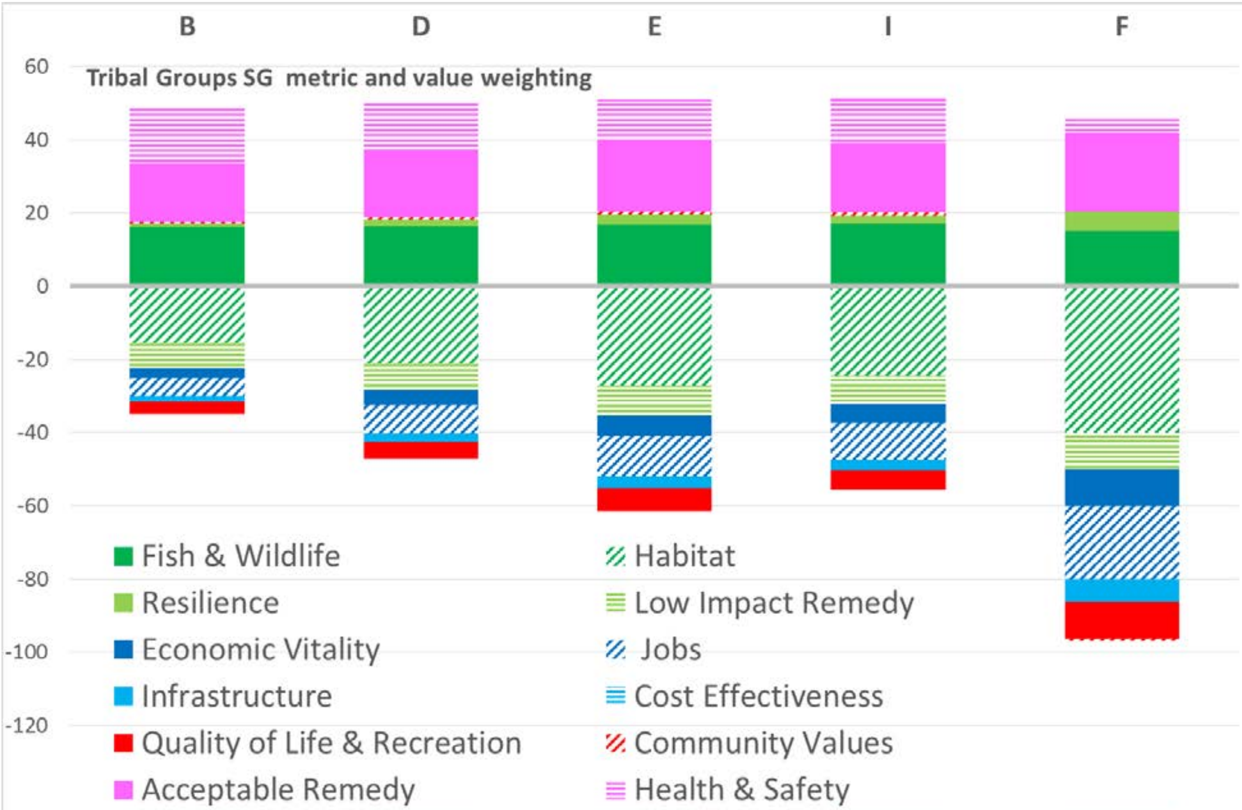
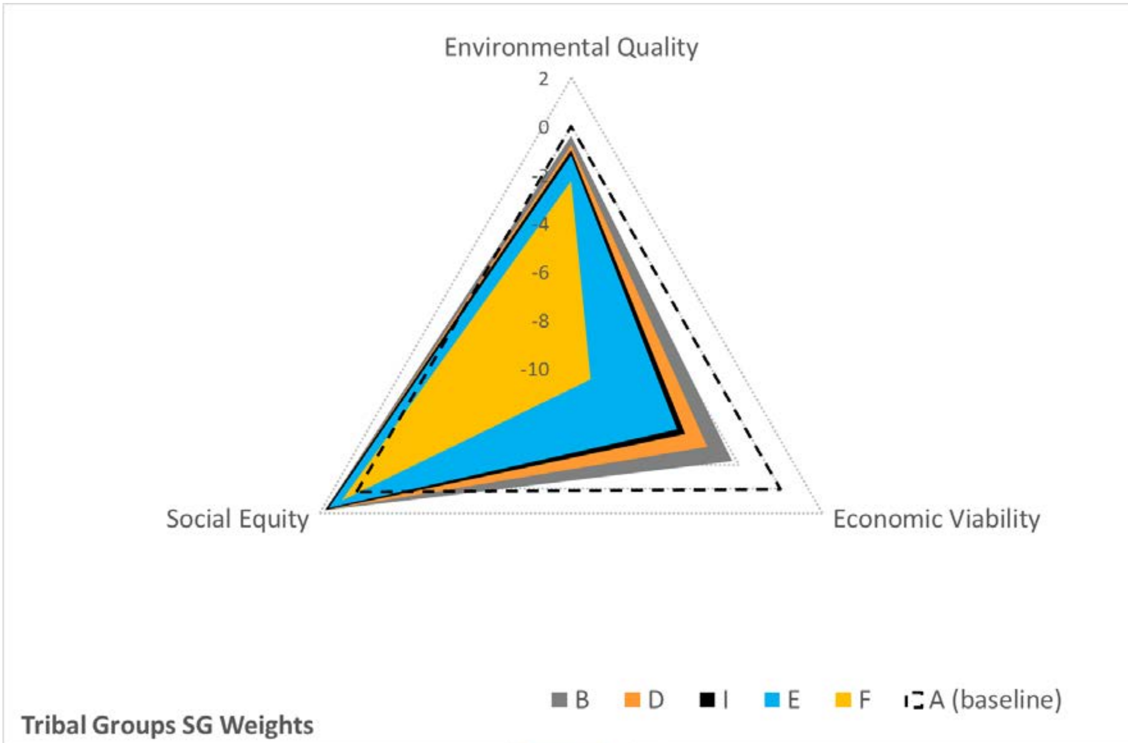


Figure D-15. SG-weighted values-based sustainability pillar scores. Tribal Groups



D.3.5 SG: City Survey, results

Table D-25 lists the SG Value and pillar scores for the remedial alternatives, using the City Survey SG weightings. Figure D-16 compares the SG Value scores, based on metrics weighted for the representative SG. These can be compared to the results with equal weighting (Figure 7-1). A strong preference for permanence and effectiveness over other metrics of acceptable remedy results in a preference for more extensive remedies, when compared to equal weighting (Figure 7-1). While overall cost was not a concern, some preference was stated for cost-effectiveness, job protection and, to a lesser extent, local business. This results in a clearer differentiation between the economic SG Value scores for this SG than for the other community SGs CF (Figure D-5) and CC (Figure D-8). Fish and wildlife is a major concern, with stated concerns for both short- and long-term impacts to wildlife and habitats.

Figure D-17a, illustrates the SG Values, multiplied by their SG weights, plotted as radar diagrams; Figure D-17b illustrates the same data as stacked bars to demonstrate how value scores add up for each alternative. These weighted SG Values are then aggregated for the pillar scores. The pillar scores are illustrated in Figure D-18. Given the balance of priorities for this SG, the relative pillar scores for the different alternatives are more sharply differentiated for this SG (Figure D-17a and b) than they are for CF (Figure D-6) or CC (Figure D-9), but are more similar to those seen when all metrics and values are weighted equally (Figure 7-2).

Table D-25. SG Value and pillar scores, metric only and metric and value weighted; City Survey

City Survey (CS)		Value and metric weighted					
Aggregating values		A (baseline)	B	D	E	I	F
ENV	Environmental Quality	0.0	-0.4	-0.9	-1.3	-1.1	-2.4
ECON	Economic Viability	0.0	0.9	-0.9	-2.5	-2.1	-6.6
SOC	Social Equity	0.4	-0.1	-0.8	-1.7	-1.2	-4.1
Average Sustainability Score		0.1	0.1	-0.8	-1.8	-1.5	-4.4

		Metric weighted only						Value and metric weighted					
Label	**Value**	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV-1	Fish & Wildlife	0.0	3.6	3.6	3.7	3.8	3.2	0.0	18.1	18.1	18.5	18.8	16.1
ENV-2	Habitat	0.0	-3.9	-5.3	-6.7	-6.0	-10.0	0.0	-15.6	-21.2	-26.9	-24.1	-40.0
ENV-3	Resilience	0.0	0.4	1.1	2.3	1.9	6.1	0.0	0.8	2.2	4.6	3.7	12.2
ENV-4	Low Impact Remedy	0.0	-4.2	-5.2	-6.5	-6.0	-10.0	0.0	-8.5	-10.5	-12.9	-12.1	-20.0
ECON-1	Economic Vitality	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	-10.6	-16.2	-22.2	-20.6	-40.0
ECON-2	Jobs	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	-10.2	-15.6	-21.8	-20.2	-40.0
ECON-3	Infrastructure	0.0	-2.7	-3.8	-4.9	-4.7	-7.9	0.0	-5.4	-7.6	-9.8	-9.5	-15.9
ECON-4	Cost Effectiveness	0.0	9.7	6.8	4.8	5.3	0.9	0.0	39.0	27.1	19.3	21.2	3.4
SOC-1	Quality of Life & Recreation	0.0	-3.0	-4.3	-5.9	-5.0	-10.0	0.0	-11.8	-17.1	-23.7	-20.1	-40.0
SOC-2	Community Values	0.1	0.1	0.2	0.2	0.2	0.0	0.1	0.3	0.4	0.4	0.4	-0.1
SOC-3	Acceptable Remedy	2.1	3.5	3.5	3.3	3.3	2.6	4.2	7.1	7.1	6.6	6.5	5.2
SOC-4	Health & Safety	0.0	0.8	0.1	-0.9	-0.4	-3.6	0.0	3.2	0.5	-3.7	-1.6	-14.4

Figure D-16. SG-weighted value radar, City Survey. Values based on SG-weighted metric aggregation; values not weighted

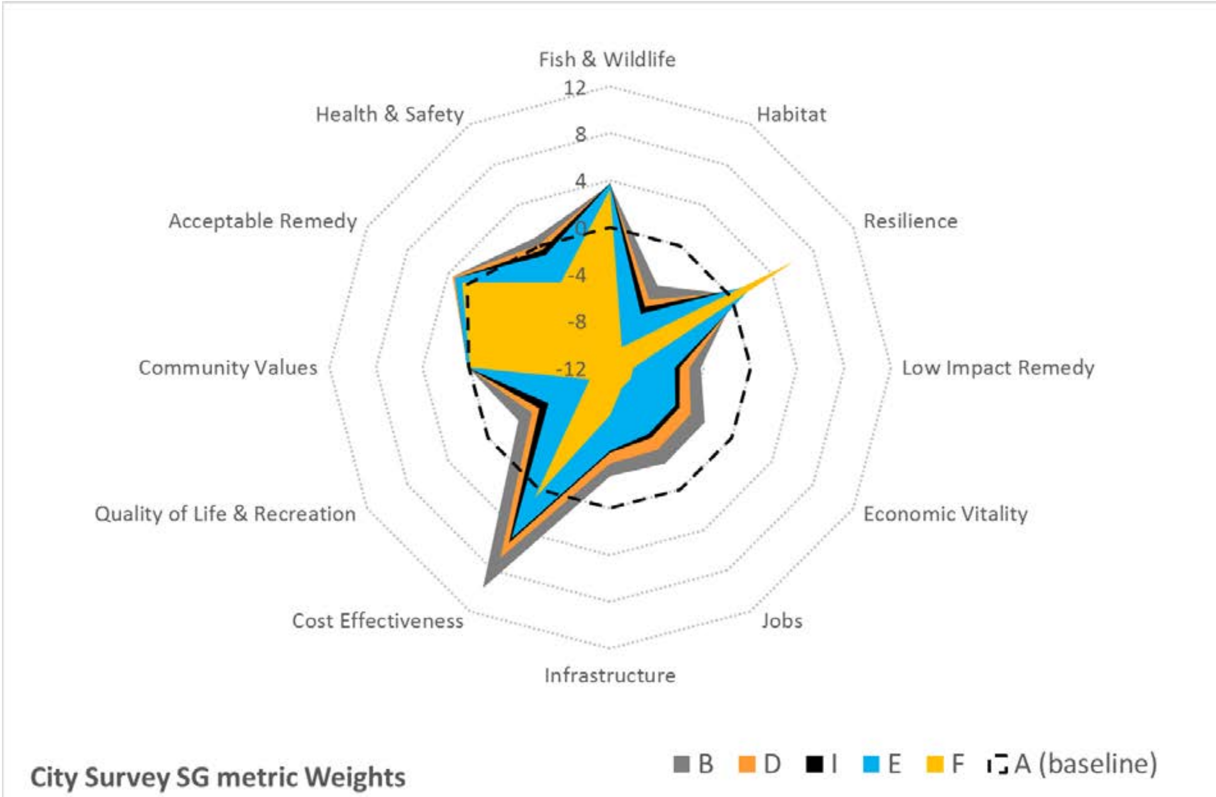


Figure D-17a. SG-weighted value radar, City Survey. Values based on SG-weighted metric aggregation; SG Value weighted; radar diagram

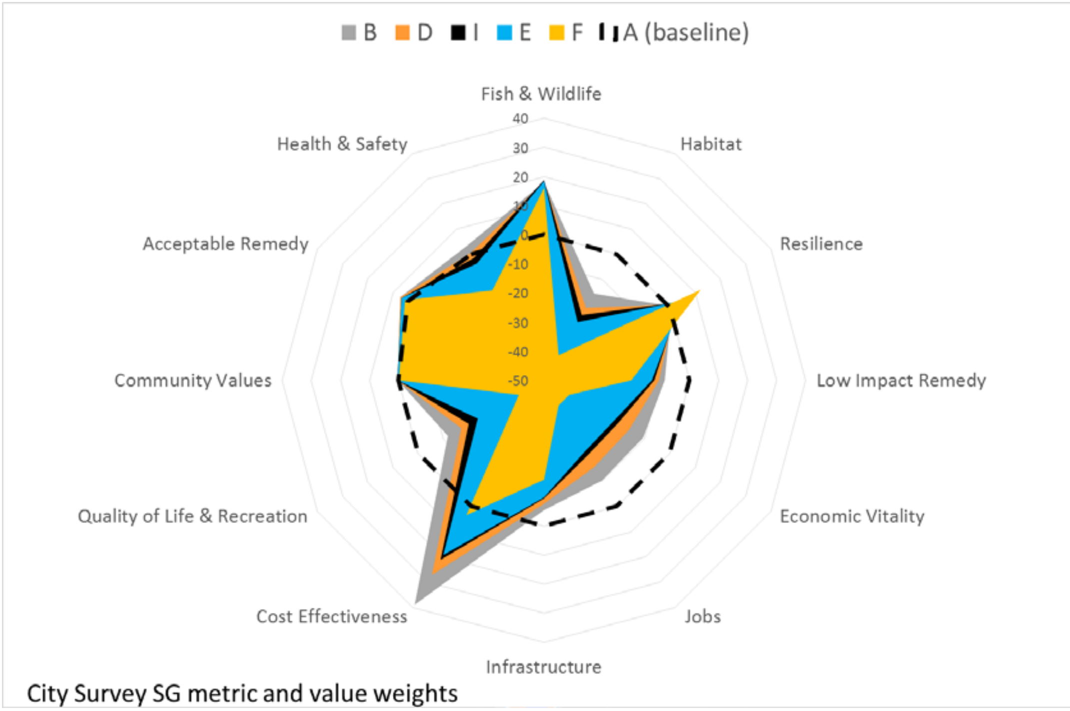


Figure D-17b. SG-weighted value radar, City Survey. Values based on SG-weighted metric aggregation; SG Value weighted; stacked bars

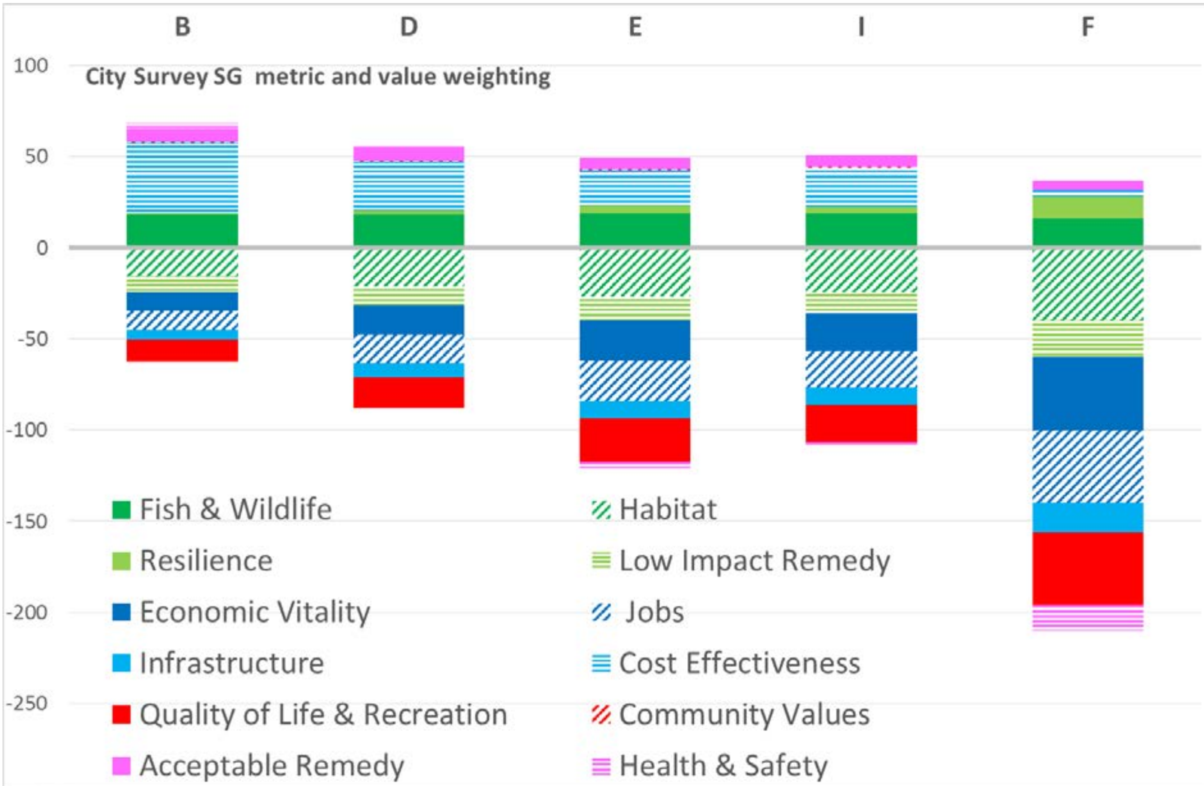
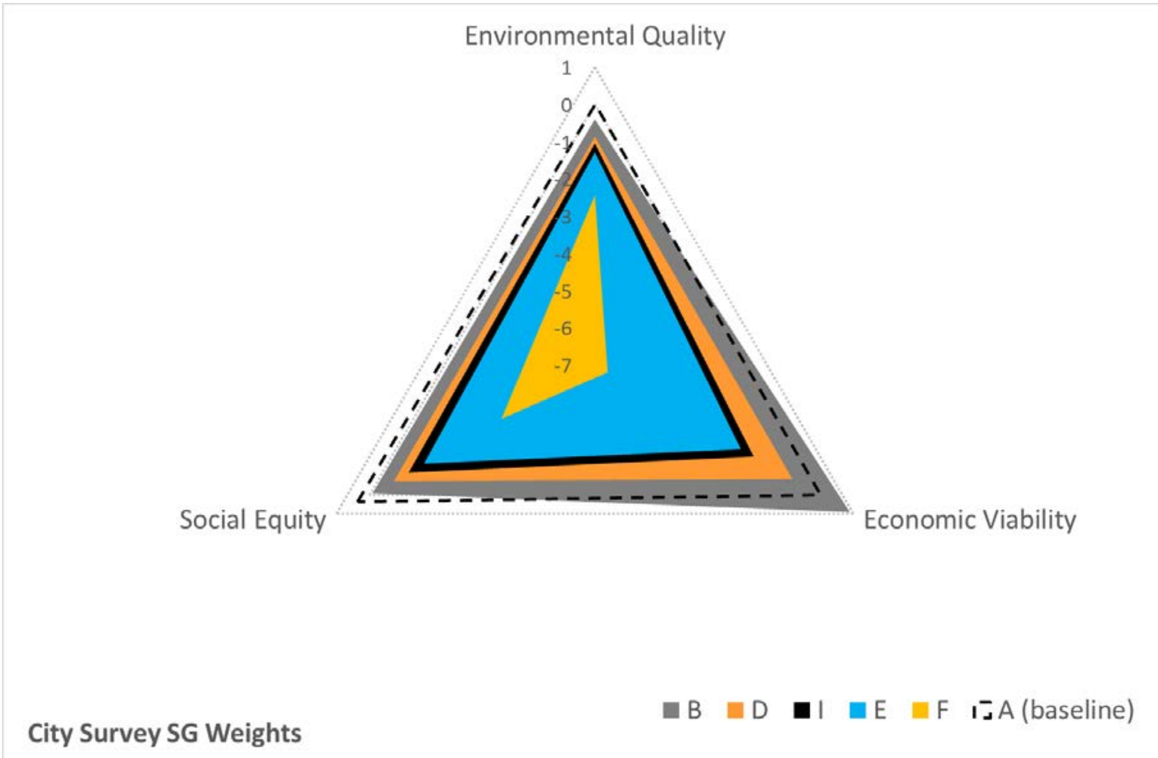


Figure D-18. SG-weighted values-based sustainability pillar scores. City Survey



D.3.6 SG: Equal Weighting; Value-weighted results

For comparison, Table D-26 shows the SG-weighted SG Value and pillar scores for equal weighting of metrics and pillars. In this example, all metrics and values were given equal SG weighting scores, a score of 3. Figure 7-1 compares the SG Value scores, based on metrics weighted for the representative SG.

Figure D-19a, illustrates the SG Values, multiplied by the SG weight of 3 as a radar diagram; Figure D-19b illustrates the same data as stacked bars to illustrate how various values add up. The pillar scores were illustrated in Figure 7-2.

Table D-26. SG Value and pillar scores, metric, and value and metric weighted; Equal Weighting

Equal Weighting		Value and metric weighted					
Aggregating values		A (baseline)	B	D	E	I	F
ENV	Environmental Quality	0.0	-1.2	-1.6	-1.9	-1.7	-2.7
ECON	Economic Viability	0.0	-0.6	-2.3	-3.7	-3.3	-7.5
SOC	Social Equity	0.9	0.4	-0.2	-1.1	-0.7	-3.5
Average Sustainability Score		0.3	-0.5	-1.4	-2.2	-1.9	-4.6

		Metric weighted only						Value and metric weighted					
Label	**Value**	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV-1	Fish & Wildlife	0.0	3.2	3.3	3.4	3.4	3.0	0.0	9.7	9.8	10.1	10.2	9.1
ENV-2	Habitat	0.0	-3.9	-5.3	-6.7	-6.0	-10.0	0.0	-11.7	-15.9	-20.2	-18.1	-30.0
ENV-3	Resilience	0.0	0.4	1.1	2.3	1.9	6.1	0.0	1.2	3.2	6.9	5.6	18.3
ENV-4	Low Impact Remedy	0.0	-4.5	-5.4	-6.6	-6.2	-10.0	0.0	-13.5	-16.3	-19.9	-18.6	-30.0
ECON-1	Economic Vitality	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	-8.0	-12.1	-16.7	-15.5	-30.0
ECON-2	Jobs	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	-7.7	-11.7	-16.4	-15.1	-30.0
ECON-3	Infrastructure	0.0	-2.1	-3.8	-4.9	-4.7	-7.9	0.0	-6.2	-11.4	-14.7	-14.2	-23.8
ECON-4	Cost Effectiveness	0.0	4.8	2.5	1.1	1.5	-2.1	0.0	14.3	7.4	3.4	4.6	-6.4
SOC-1	Quality of Life & Recreation	0.0	-2.9	-4.3	-5.9	-5.1	-10.0	0.0	-8.8	-12.9	-17.8	-15.2	-30.0
SOC-2	Community Values	0.1	0.1	0.2	0.2	0.2	0.0	0.2	0.4	0.6	0.6	0.6	-0.1
SOC-3	Acceptable Remedy	3.6	3.5	2.9	2.0	2.2	-0.1	10.7	10.5	8.8	6.1	6.7	-0.4
SOC-4	Health & Safety	0.0	0.9	0.2	-0.8	-0.3	-3.7	0.0	2.8	0.6	-2.5	-1.0	-11.2

Figure D-19a. SG-weighted value radar, Equal Weighting. Values based on SG-weighted metric aggregation; SG Value weighted; radar diagram

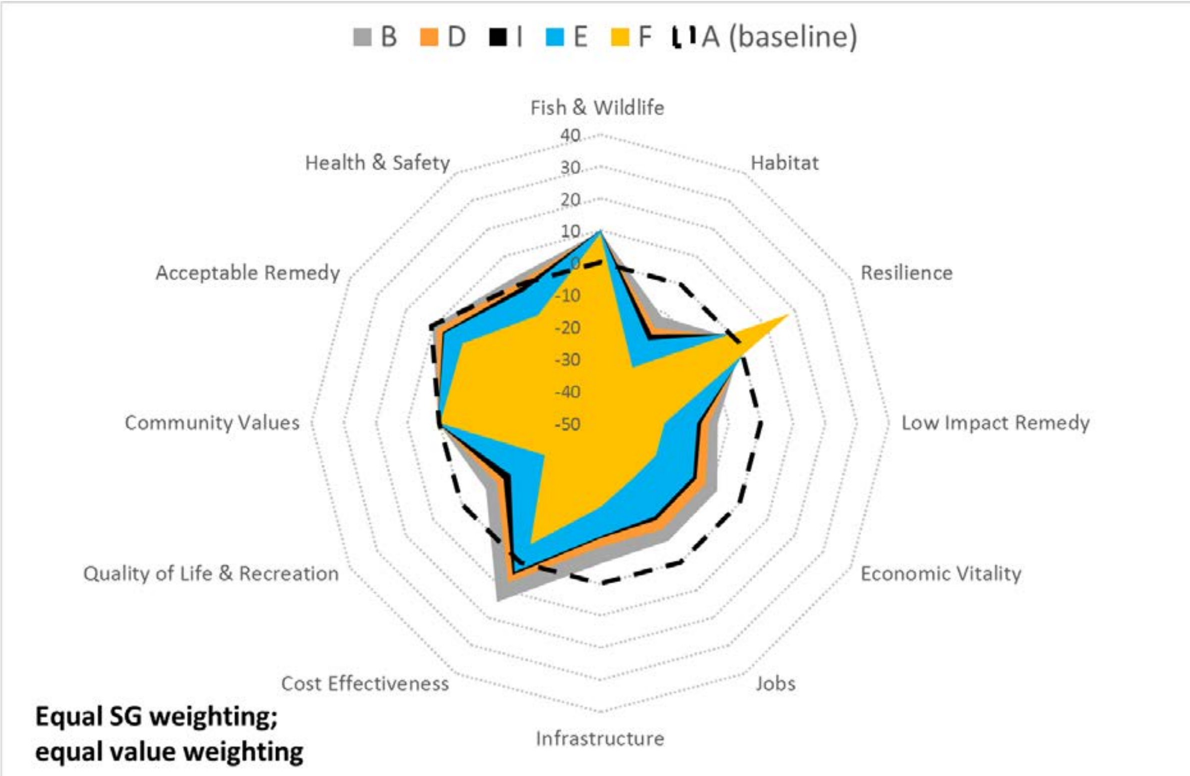
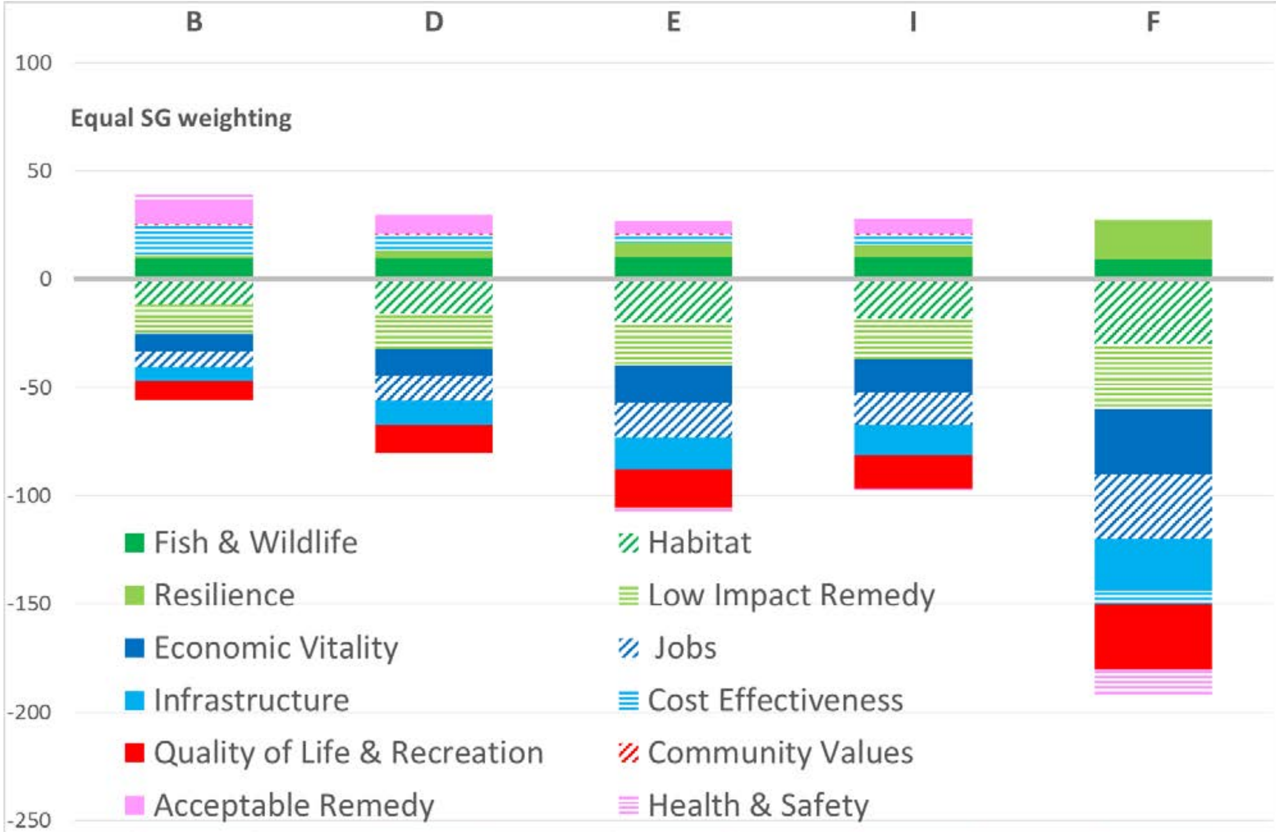


Figure D-19b. SG-weighted value radar, Equal Weighting. Values based on SG-weighted metric aggregation; SG Value weighted; Stacked bars



D.4 Uncertainty and Sensitivity – determining community priorities

Although the SGs Business Groups and Tribal Groups can be seen as representatives of subsets of stakeholders (businesses and tribal groups), it can be argued that equal weighting and the other three SGs—Community Forum, Community Comments and City Survey all seek to capture the relative priorities of the broader Portland community. As stated previously, all efforts at determining stakeholder and community priorities (whether inferred or elicited) are subject to challenges and potential bias. The four approaches to determining broad community priorities used here have the following characteristics:

- Equal weighting: This approach sought to identify the broadest possible stakeholder representation, and identified priorities by evaluating value-relevant statements in web pages, documents (on remediation, restoration, planning and development), meetings and interviews. This collected value evidence base suggested that community values are broad and diverse, and provided an argument for treating all values and metrics equally to ensure broad representation. This approach avoids giving specific groups undue weight. This may represent the interests of uninvolved or underrepresented groups.
- Community Forum: This approach mapped statements gathered in facilitated meetings to identified SG Values. This approach could be subject to bias in how these statements were mapped (or how they were recorded during and after the meeting), and is only representative of those who attended the forum, so this group is self-selecting. Thus, more engaged community members may have a disproportionate influence on outcomes. If certain values or metrics were not addressed in the meeting (or its notes) then they could not be reflected in the weights (if this was so, the same weights were applied to all unaddressed metrics and values).
- Community Comments: This approach mapped statements and comments made at public meetings about Portland Harbor Remediation onto SG Values. This approach could be subject to bias in how these statements were mapped. Furthermore, attendance, questions and comments at a number of meetings were dominated by a few highly engaged individuals, so this group is self-selecting. Thus, the concerns and priorities of these individuals will be disproportionately represented by this approach. If certain values or metrics were not addressed in the meeting (or its notes) then they could not be reflected in the weights (if this was so, the same weights were applied to all unaddressed metrics and values).
- City Survey: The City survey asked a broad range of people (seeking diversity) a specific set of questions on their priorities. Some of these could be mapped easily onto SG Values or metrics used in this study. When they could, SG weights were proportional to the rate of response to relevant questions. If certain values or metrics were not addressed in the survey then they could not be reflected in the weights (if this was so, the same weights were applied to all unaddressed metrics and values). While survey respondents are self-selecting inasmuch as they can choose whether to answer the survey, efforts were made to ensure diversity in responses. This approach developed elicited, rather than inferred, SG priorities, but only for a limited set of values and metrics.

Representing community values in a fair and representative manner is challenging, and is not an exact science. As can be seen, each of these approaches has strengths and weaknesses in terms of breadth, relevance and representativeness. Together, they may be seen as a reasonable representation of the Portland community, but they also pose an opportunity for examining the uncertainty and sensitivity of this framework to SG diversity. When the value and metric-weighted scores for these different approaches to broad community priorities are compared (Equal: Figure 7-1; CF: Figure D-5; CC: Figure D-8; CS: Figure D-17), it is noteworthy that these figures appear rather similar. In all cases, there is a clear separation between the alternative scores for most values, with the scores; the less extensive alternatives score higher than the more extensive. The most significant difference is the relative differences in the SG Value "Acceptable Remedy"; the differences are driven by the degree of stated preference for permanence. These figures are also more similar to each other than they are to BG (Figure D-11) and TG (Figure D-14), both of which represent narrower SGs and represent distinct priorities, when compared to these broader community SGs. Thus, the approach, which is sensitive to the range of SG priorities (and how these priorities are determined), seems rather robust in its overall outcomes.

D.5 Uncertainty and sensitivity – adjusted vs EPA time and cost numbers

The input tables that feed into the SVA calculations have used the adjusted time and cost numbers, as described in AECOM (2016). A large number of metrics in this framework, including downstream risk, contaminant mobilization, construction impacts, quality of life, recreation, socially optimal construction time, time-effectiveness and fish consumption risk, have a time component; these affect a range of values and pillars. Similarly, costs affect economic vitality, jobs, and all aspects of cost-effectiveness.

Table D-27 illustrates the relative difference in value and pillar scores, for equal value weighting, using the adjusted and EPA cost and time values. Green highlighted values have a higher score using the EPA values; red highlighted values have a lower score. As can be seen, a number of values that have cost-sensitive metrics, are affected by the use of the EPA values. In particular, the SG Value Cost Effectiveness, which has several cost-dependent metrics is affected by cost differences. . Fish & Wildlife, Low Impact Remedy, Infrastructure, Quality of Life & Recreation, Acceptable Remedy, and Health & Safety y are all sensitive to time. Most time-sensitive metrics, which are scored relatively as a function of time, have lower scores using the EPA times. However, Acceptable remedy has two metrics that are based on absolute times (time-effective remedy and time-effectiveness). These SG Values, not surprisingly, have higher scores using the EPA's shorter construction times. Overall, the EPA values reduce the difference between Alternatives E and I. However, the relative alternative sustainability rankings overall remain the same. This can be seen with the evaluation of the row labeled "Average Sustainability Score" in Table D-27. This score is the average of the three pillar scores for each alternative. As can be seen, the Pillar Average score is lower for each alternative using the EPA costs and times, and the difference in this score for Alternatives E and I is smaller using the EPA numbers. However, the relative sustainability of the alternatives, the relative ranking of these Pillar Average Scores, remains the same. The relative ranking of alternatives is further discussed in Section D-7, below.

Table D-27. Comparison of SG-value and pillar, and overall scores, using Adjusted and EPA cost and time values.

Evaluation Criteria		Equal; adjusted time and cost						Equal; EPA time and cost						Equal score change from Adjusted time and cost					
		A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV	Environmental Quality	0.0	-1.5	-2.2	-2.7	-2.5	-4.3	0.0	-1.7	-2.4	-2.8	-2.6	-4.3	0.0	0.2	0.2	0.0	0.1	0.0
ECON	Economic Viability	0.0	-0.6	-2.3	-3.7	-3.3	-7.5	0.0	-0.7	-2.9	-4.2	-4.0	-7.5	0.0	0.1	0.6	0.5	0.6	0.1
SOC	Social Equity	0.9	0.4	-0.2	-1.1	-0.7	-3.5	1.4	0.3	-0.5	-1.0	-0.9	-3.5	0.5	0.1	0.2	0.1	0.1	0.0
Average Sustainability score		0.3	-0.6	-1.6	-2.5	-2.2	-5.1	0.5	-0.7	-1.9	-2.7	-2.5	-5.1	0.2	0.1	0.3	0.2	0.3	0.0
Label	**Value**	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F	A (baseline)	B	D	E	I	F
ENV-1	Fish & Wildlife	0.0	3.2	3.3	3.4	3.4	3.0	0.0	2.8	2.7	3.2	3.0	3.0	0.0	0.5	0.5	0.1	0.4	0.0
ENV-2	Habitat	0.0	-3.9	-5.3	-6.7	-6.0	-10.0	0.0	-3.9	-5.3	-6.7	-6.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0
ENV-3	Resilience	0.0	-1.0	-1.3	-1.0	-1.1	-0.1	0.0	-1.0	-1.3	-1.0	-1.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
ENV-4	Low Impact Remedy	0.0	-4.5	-5.4	-6.6	-6.2	-10.0	0.0	-4.7	-5.6	-6.6	-6.3	-10.0	0.0	0.2	0.2	0.1	0.2	0.0
ECON-1	Economic Vitality	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	-2.7	-4.0	-5.6	-5.2	-10.0	0.0	0.0	0.0	0.0	0.0	0.0
ECON-2	Jobs	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	-2.6	-3.9	-5.5	-5.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0
ECON-3	Infrastructure	0.0	-2.1	-3.8	-4.9	-4.7	-7.9	0.0	-2.3	-4.3	-5.0	-5.1	-7.9	0.0	0.3	0.4	0.1	0.3	0.0
ECON-4	Cost Effectiveness	0.0	4.8	2.5	1.1	1.5	-2.1	0.0	4.8	0.5	-0.9	-0.6	-1.9	0.0	0.0	2.0	2.1	2.2	0.3
SOC-1	Quality of Life & Recreation	0.0	-2.9	-4.3	-5.9	-5.1	-10.0	0.0	-3.4	-4.9	-6.1	-5.5	-10.0	0.0	0.5	0.6	0.2	0.5	0.0
SOC-2	Community Values	0.1	0.1	0.2	0.2	0.2	0.0	0.1	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOC-3	Acceptable Remedy	3.6	3.5	2.9	2.0	2.2	-0.1	5.4	4.3	3.3	2.7	2.6	-0.1	1.9	0.8	0.4	0.7	0.4	0.0
SOC-4	Health & Safety	0.0	0.9	0.2	-0.8	-0.3	-3.7	0.0	0.3	-0.4	-1.0	-0.8	-3.7	0.0	0.6	0.7	0.1	0.4	0.0

Note: Change is the absolute difference between scores. When EPA costs and times result in higher scores; these cells are highlighted green; if they result in lower scores, they are highlighted in red. “Pillar Average Score” is the average of the pillar scores for an alternative

D.6 Uncertainty and sensitivity – overall alternative scores

Figure D-20 illustrates the stacked SG Value scores for all alternatives and SGs. Although the metrics feeding into these SG Value scores are weighted based upon SG preference, the SG Values are not. Figure D-21 illustrates the SG Value scores with the scores weighted using both metric and SG Value weights. In theory, then, there are scenarios where a single-issue SG could weight a single (or a few) SG Values heavily and set other weights to 0 (The TG SG is the closest to such an example, although a number of metrics and values are still considered). This would essentially collapse the sustainability assessment to a single or narrow-issue assessment not unlike a stand-alone risk assessment or economic assessment (but not, it should be pointed out, like Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-linked Net Environmental Benefit Analysis, which is another multi-criteria approach which aggregates, scores and weights metrics with a CERCLA, rather than a social SG Values, focus). While Section D-1 sought to evaluate the effects of SG Value priorities from representative SGs with diverse priorities, no single-issue assessment was carried out, though this could easily be done using the SVA tool.

Figure D-20, with the metric-only weighted SG Values (for all alternatives and all SGs considered), shows a clear ranking of net SG Value scores, with progressively lower net scores for the more aggressive alternatives. This trend is generally independent of SG, though SG Value weights for Resilience by the

SG Community Forum and the discounting of short-term impact-related values and metrics by the SG Tribal Groups make these trends less clear-cut.

However, a closer look makes clear that the difference between remedial alternatives is driven not by increased benefits for the higher-scoring alternatives, but by increasing negative impacts for the more extensive alternatives. The sum of the SG Values with positive benefits (the bars above the zero line) shows a slight decrease for the more extensive alternatives, even when individual SGs are broken out. Most of the SG Values that have generally positive scores (Fish & Wildlife, Health & Safety, Acceptable Remedy, Cost-Effectiveness and Community Values) are scored using metrics with both positive and negative values. Some metrics have higher scores and some have lower scores for the more extensive alternatives. These SG Values and metrics are among those that are most frequently reflected in SG priority differences. There are somewhat decreasing net benefits scores across the alternatives (with minor trends for some SGs) for these SG Values. On the other hand, the SG Values which have net negative scores, the environmental, economic and social impacts of a large remediation, increase significantly as the remedial alternatives become more extensive.

This difference between the trends for risks and benefits, or for desirable and undesirable impacts, is still seen in Figure D-21, when SG Values are weighted considering both metric and value weights. Although there is a bit more noise in the trends, net negative impacts increase clearly across SGs for the more extensive alternatives, while net benefits, though less consistent, show no clear trends. Figure D-22 illustrates SG Values weighted considering both metric and value weights, but with scores using EPA costs and times. As can be seen, there are some differences in values with cost- or time-dependent metrics, resulting in subtle changes in the importance of SG Values such as Cost-Effectiveness between SGs, but the overall results remain largely the same.

Figure D-23 illustrates the pillar average score (the average of the scores for each pillar) for each alternative, with each SG weighting scheme, with adjusted and EPA costs and times. As can be seen, although there is variability in overall sustainability score within an alternative, depending on the weighting scheme and the cost and time data used, the overall trends between alternatives hold. The differences are in net sustainability scores between alternatives. There is less of a difference in net negative impacts for Alternatives B, D, and I.

For each SG's values, the net negative impacts increase with more aggressive alternatives, and increasingly outweigh the benefits as more aggressive alternatives are considered. However, across SGs, the delineation between remedial alternatives is less clear. Given the wide range of environmental, economic, and social impacts of large-scale remediation, the trend towards greater negative sustainability scores for the most extensive alternatives holds, regardless of which metrics, values, risk, and benefits various SGs prioritize.

Thus, it is clear that the SVA assessment framework is sensitive to various stakeholder inputs – the relative SG Value and pillar scores change in response to different SG priorities, identifying trade-offs, opportunities for optimization, and sources of potential disagreement. However, the conclusions are robust - regardless of the weighting approach used, from equal weighting to absolute weighting using plausible inferred values from "endmember" representative SGs, the overall SG Values-based sustainability score of the Portland Harbor remedial alternatives can be ranked as:

Alternative B ≥ Alternative D > Alternative I > Alternative E >> Alternative F

D.7 Final note

Although inferred SG Value priorities were, for the most part, used to test this approach, the SVA tool can be used to automatically assess, score and graph the social sustainability SG Values using a variety of inputs from surveys, workshops or other sources; can test the implications of the SG Value priorities of a specific SG; or can be used to provide inputs into more formalized tools such as MCDA. Should such information or tools become available, the outputs of this report will be further tested and validated.

It should be noted that a few issues drive the relative rankings of these alternatives:

- All options under consideration (barring Alternative A) have hotspot removal as part of their design,
- Regional background contaminant levels limit the degree to which any remedial option can reduce risk

Thus, the net risk reduction for more extensive options is easily dwarfed by their impacts, as this assessment focused on evaluating a set of remedies in the 2016 EPA FS (EPA 2016a), after they were developed. For this tool to be more useful in optimizing sustainable options, a range of remedial options, with a broader range of potential risk reduction, could be evaluated, to identify the point where benefits are overwhelmed by impacts. Alternatively, an identification of the risks and benefits of most interest to SGs can allow for negotiation and optimization of alternatives under consideration, to collaboratively design more sustainable options.

Figure D-20. SG Value scores for all alternatives, all SGs. SG Values based upon SG-weighted metrics. SG Values unweighted

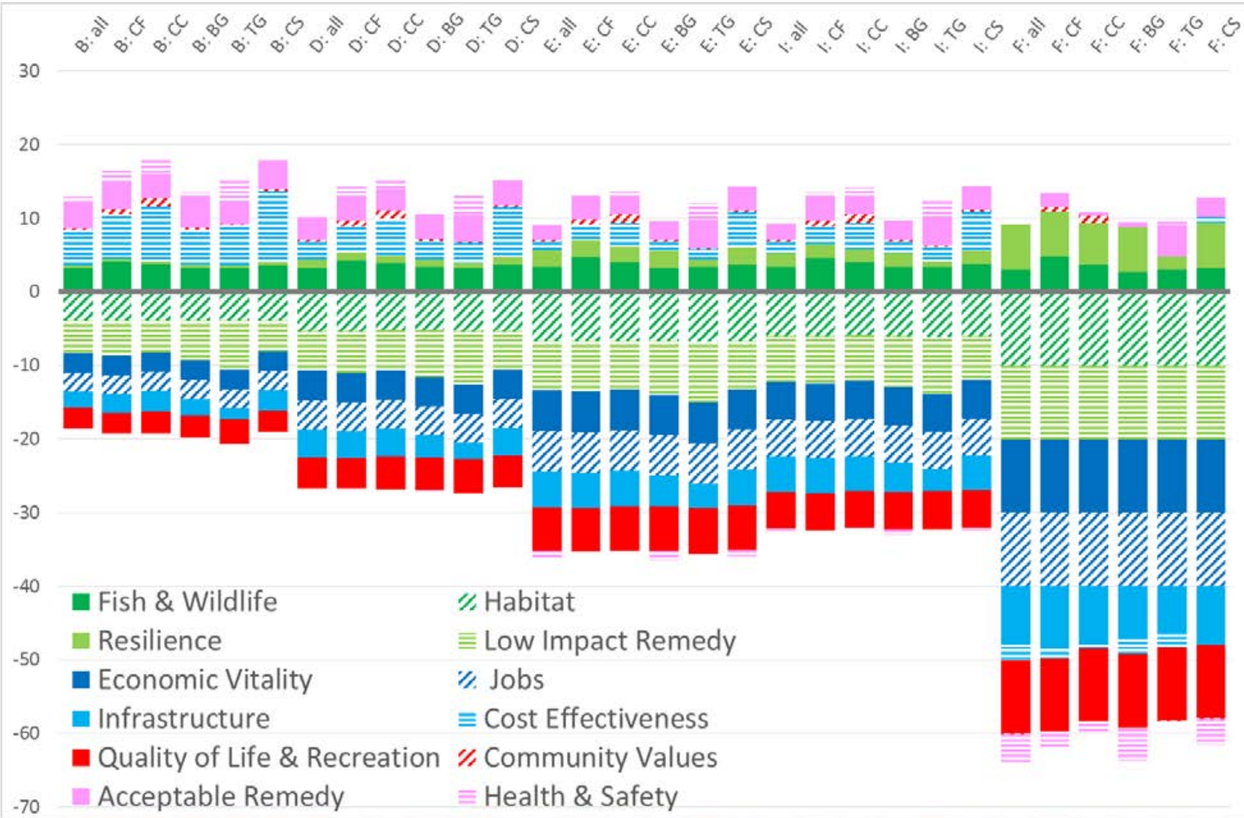


Figure D-21. SG Value scores for all alternatives, all SGs. SG Values based upon SG-weighted metrics. SG Values weighted. Adjusted times and costs in input table

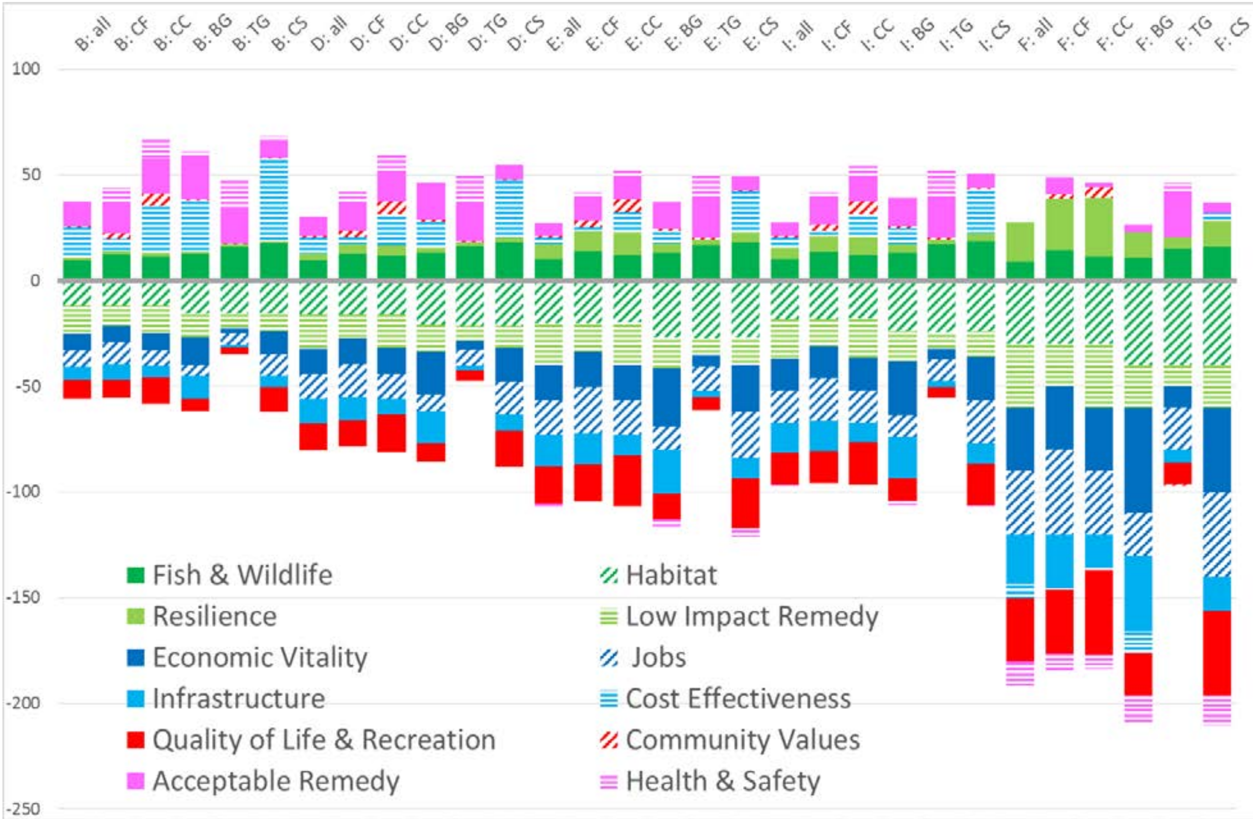


Figure D-22. SG Value scores for all alternatives, all SGs. SG Values based upon SG-weighted metrics. SG Values weighted. EPA times and costs in input tables

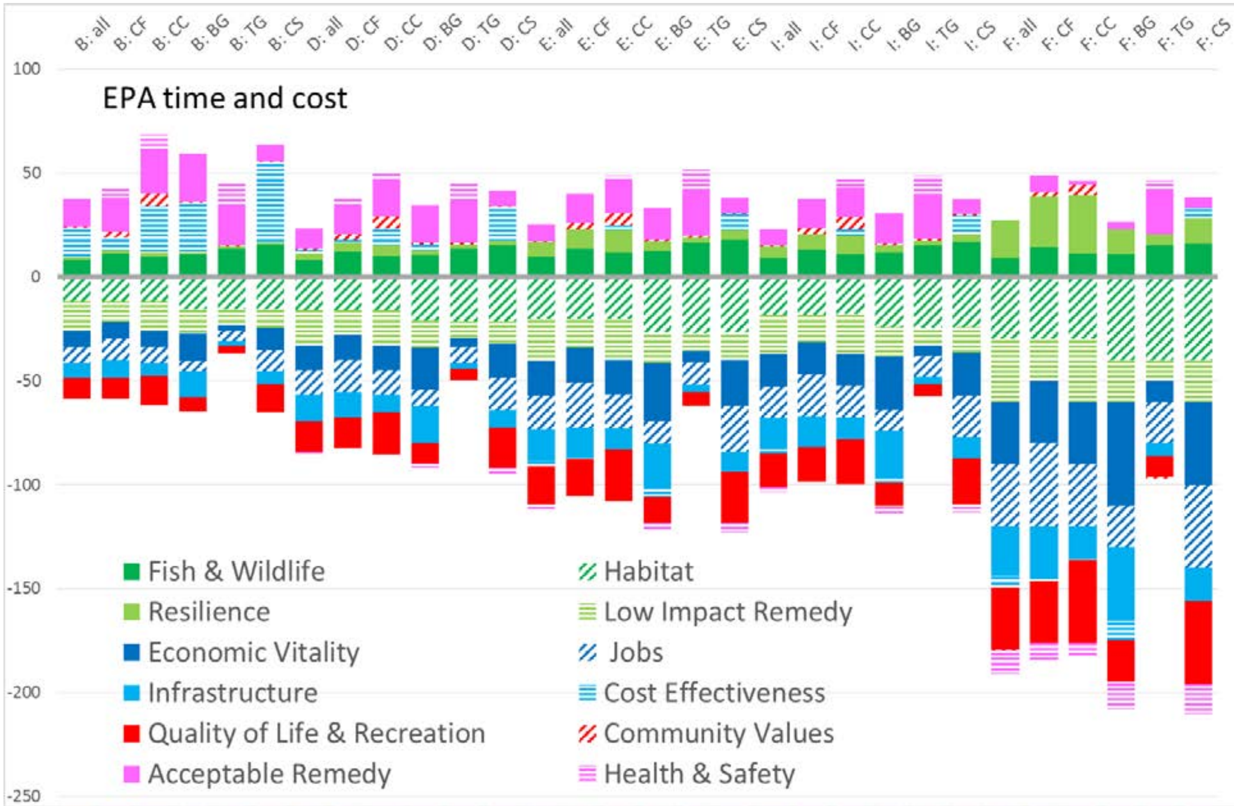


Figure D-23. Overall sustainability score (the average of the scores for each pillar) for each alternative, with each SG weighting scheme, with adjusted and EPA costs and times

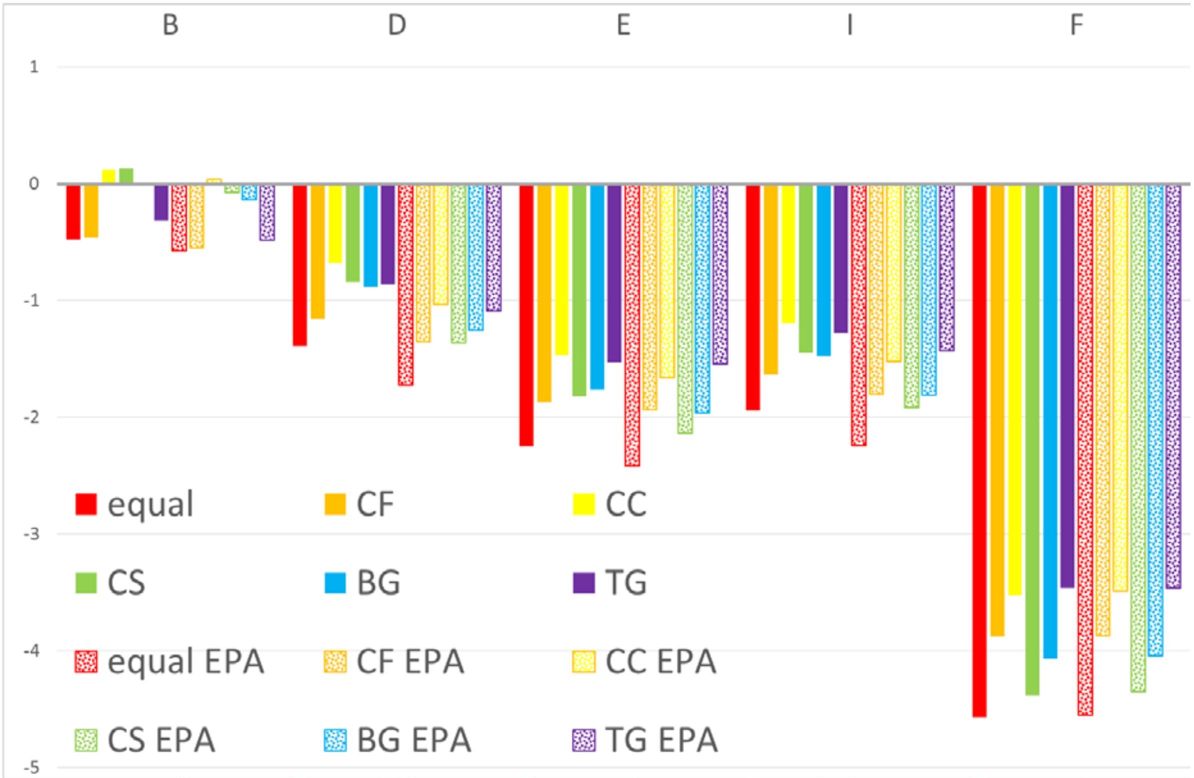


Figure D-23 note: Equal = equal weighting; CF = Community Forum; CC = Community Comments; CS = City Survey; BG = Business Groups; TG = Tribal Groups; EPA = using EPA cost and time values.

Appendix E
Qualitative Equity Assessment

Appendix E
Qualitative Equity Assessment

For the social sustainability assessment, indicators of sustainability for the three pillars (environmental, economic, and social) were mapped in terms of Stakeholder Group (SG) Values (informed by the stakeholder mapping; in support of ranking, outreach, and communication) and evaluated. In this appendix, a qualitative assessment of equity related to stakeholder values is examined. Equity is generally defined as the quality of being fair and just. Social equity is defined as all people and communities have full and equal access to opportunities that enable them to attain their full potential. Health equity is achieved when every person has the opportunity to attain his or her full health potential and no one is disadvantaged from achieving this potential because of social position or other socially determined circumstances (definition from the Center for Disease Control).

The spatial, temporal, and demographic equity and distributional aspects of project risks and benefits associated with the Portland Harbor Superfund Site were examined, and potential strategies to balance these were identified. Table E-1 below (adapted from Favara et al. 2009)[1] illustrates that many sustainable remediation practices and objectives (whether environmental, economic, or social) have environmental equity implications. For any action, costs, risks, and benefits are not evenly distributed; Table E-2 lists the equity issues for potential SG Value indicator categories (based on SuRF-UK). Exposure to risks or access to benefits may be functions of demographics, location, time, or other factors. For instance, dietary exposure to contaminants may be higher for subsistence fisherpersons, access to new parks may require transport, access to jobs may depend on education, and exposure to remedial impacts may depend upon where residents and/or businesses are located. Figure E-1 illustrates a tiered approach to addressing these issues. In this report, the first tier, a qualitative/narrative approach, was developed with an eye to informing the development of higher tiered approaches (subject to future analyses, not included in this report).

For Portland Harbor, as with other contaminated sites, risks and benefits are not borne equally, in terms of time, space, or demographics. These issues should be kept in mind when the trade-offs described in this report are considered—it is important to consider the needs of a diverse population. It is primarily for this reason that the equal SG Value weighting scheme was developed—although some SGs are very active and vocal, there is evidence of diverse values and priorities throughout the region; these disparate priorities should be considered, even if not all stakeholders are fully engaged in the decision-making.

Although this equity assessment is only qualitative, it provides an opportunity to develop strategies to optimize the equity of selected remedial alternatives, or to consider the equity impacts of various remedial alternatives. Spatial and demographic equity issues can, to some extent, be minimized using best management practices, considering community needs in design, and minimizing footprints. In general, it can be concluded that longer-lasting alternatives (long construction times) pose greater concerns for temporal equity—the short- to mid-term impacts associated with construction are borne by a different population, temporally, than those who will reap the benefits of a cleaner river.

[1] *References cited in appendices are included in Section 10 of the main text.*

Table E-1. Many environmental, economic, and social sustainability practices have equity implications. Adapted from Favara et al. 2009

Sustainable Remediation Practices and Objectives	Environmental	Economic	Social	Water Resources	Land and Ecosystems	Materials/Waste Minimization	Long-Term Stewardship	Atmospheric Emissions	Energy Efficiency	Life-Cycle Costs	Environmental Justice	Human Health and Safety
Minimize fresh water consumption				x							x	
Maximize water reuse				x		x				x		
Conserve groundwater resources				x			x				x	
Prevent runoff and negative impacts to surface water				x	x						x	x
Use native vegetation requiring little or no irrigation				x	x							
Minimize bioavailability of contaminants through source and plume control					x							
Maximize biodiversity					x		x					
Minimize soil and habitat disturbance					x		x					
Favor minimally invasive in situ technologies					x							
Favor low-energy technologies (e.g., bioremediation, phytoremediation) where possible and effective					x			x	x			
Protect native ecosystem and avoid introduction of non-native species					x		x					
Minimize risk to ecological receptors					x		x					
Adapted from Favara et al 2009												

Sustainable Remediation Practices and Objectives	Environmental	Economic	Social	Water Resources	Land and Ecosystems	Materials/Waste Minimization	Long-Term Stewardship	Atmospheric Emissions	Energy Efficiency	Life-Cycle Costs	Environmental Justice	Human Health and Safety
Preserve natural resources				x	x		x					
Use telemetry or remote data collection when possible						x			x			
Use passive sampling devices where feasible						x		x	x			
Use or generate renewable energy to the extent possible							x	x	x			
Reduce emissions of greenhouse gases							x	x				
Reduce emissions of criteria pollutants								x				
Prevent offsite migration of contamination							x					
Integrate flexibility into long-term controls to allow for future efficiency and technology improvements							x			x		
Ensure project is resilient to disasters					x		x				x	x
Invest in carbon offsets										x		
Minimize material extraction and use						x				x		
Minimize waste						x				x		
Maximize materials reuse						x				x		
Recycle or reuse project waste streams						x				x		

Sustainable Remediation Practices and Objectives	Environmental	Economic	Social	Water Resources	Land and Ecosystems	Materials/Waste Minimization	Long-Term Stewardship	Atmospheric Emissions	Energy Efficiency	Life-Cycle Costs	Environmental Justice	Human Health and Safety
Use operations data to continually optimize and improve the remedy									x	x		
Consider the net economic result										x		
Consider cost of the "sustainability delta," if any										x		
Improve the tax base/economic value of the property/local community					x		x			x	x	
Maximize employment and educational opportunities							x				x	
Minimize O&M cost and effort							x			x		x
Minimize health and safety risk during remedy implementation							x			x	x	x
Maximize acres of a site available for reuse							x				x	
Maximize acres of a site available for reuse							x				x	
Use locally sourced materials						x					x	

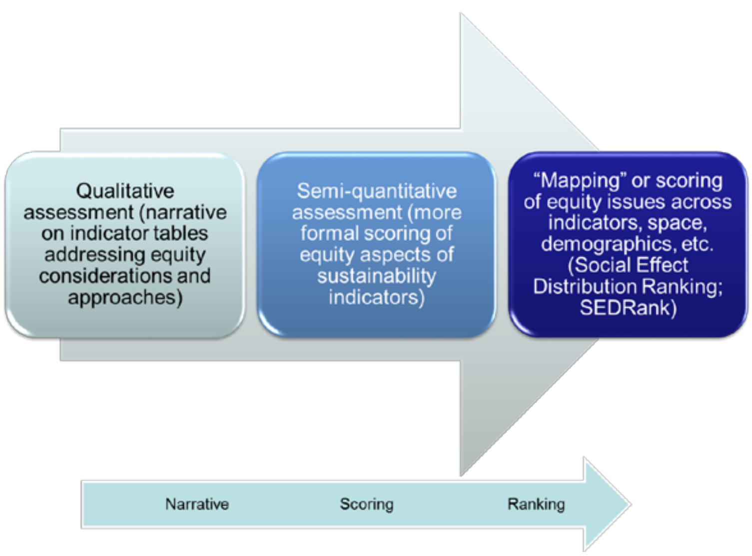
Sustainable Remediation Practices and Objectives	Environmental	Economic	Social	Water Resources	Land and Ecosystems	Materials/Waste Minimization	Long-Term Stewardship	Atmospheric Emissions	Energy Efficiency	Life-Cycle Costs	Environmental Justice	Human Health and Safety
Minimize noise, odor, and lighting disturbance							x				x	x
Favor technologies that permanently destroy contaminants					x		x					x
Avoid environmental and human health impacts in already disproportionately impacted communities					x		x				x	x
Consider net positive/negative impact of the remedy on local community							x				x	x
Assess current, potential, and perceived risks to human health, including contractors and public, over the remedy life cycle							x				x	x
Prevent cultural resource losses							x				x	
Integrate stakeholders into decision-making process							x				x	
Solicit community involvement to increase public acceptance and awareness of long-term activities and restrictions							x				x	
Maintain or improve public access to open space							x				x	
Create goodwill in the community through public outreach and open access to project information							x				x	
Consider future land uses during remedy selection and choose remedy appropriately							x			x	x	
Link remediation to restoration/enhancement goals					x	x	x		x	x	x	x
Incorporate community values in remediation/restoration design					x		x				x	

Table E-1 notes: Grey indicates aspects of the environmental pillar; black indicates aspects of the economic pillar; medium blue indicates aspects of the social pillar; light blue indicates additions (this report) to the Favara et al. tables.

Table E-2. Equity questions linked to economic, environmental, and social indicators

SuRF category	Equity/EJ questions
Environment 1: Impacts on air	Distribution of emissions/transport impacts equitable? GHG offsets?
Environment 2: Impacts on sediment, soil, porewater and ground conditions	Impacts on long-term use options equitable? Effects on resilience?
Environment 3: Impacts on groundwater and surface waters	Impacts on long-term use options equitable?
Environment 4: Impacts on ecology	Disproportionate exposure to ecosytem impacts? Ecosystem service providing unit (SPUs) of community value protected? Remediation endpoints in line with restoration/enhancement goals?
Environment 5: Use of natural resources and generation of wastes	Equitable distribution of waste sites? Local access to resources impacted? Unintended consequences of alternative fuels (e.g., biofuels)
Environment 6: Intrusiveness	Consideration of vulnerable populations?
Economic 1: Direct economic costs and benefits	Who bears costs? Who reaps benefits? Balanced?
Economic 2: Indirect economic costs and benefits	Who bears costs? Who reaps benefits? Balanced?
Economic 3: Employment and employment capital	Jobs and education; buisiness opportunities equitably balanced?
Economic 4: Induced economic benefit	Who bears costs? Who reaps benefits? Balanced? Reflecting and considering community values? Gentrification risk?
Economic 5: Life span and project risks	Properly balanced against other concerns? All exposures considered (issues differ for sediments)
Econimic 6: Project flexibility	Effects/ communication with local community and vulnerable populations?
Social 1: Human health and safety	Classical EJ questions - how are risks balanced, in space, time and demographically?
Social 2: Ethical and equity considerations	Embraces all questions here
Social 3: Impacts on neighbourhoods or regions	Classical EJ questions - how are impacts balanced, in space, time and demographically?
Social 4: Community involvement and satisfaction	Are all stakeholders' needs considered? How are they balanced? Equitable distribution of benefits/ access?
Social 5: Compliance with policy objectives and strategies	How are regulatory and sustainability drivers balanced to meet stakeholder needs; ensure equity?
Social 6: Uncertainty and evidence	Are data and decisions transparent and accessible to all stakeholders?

Figure E-1. Tiered approach to equity evaluation



For each SG Value being evaluated in this project and its key indicators, equity issues and approaches were identified. This table will address the parameters that affect the distributional nature of alternative impacts and includes the spatial, temporal, and demographic aspects of the cost/risk or benefit; aspects that affect exposure or access; and strategies to improve equity for a given indicator. Tables E-3 through E-12 summarize these equity issues, for all SG Values.

For Portland Harbor, as with other contaminated sites, risks and benefits are not borne equally, in terms of time, space, or demographics. These issues should be kept in mind when the trade-offs described in this report are considered—it is important to consider the needs of a diverse population. It is primarily for this reason that the equal SG Value weighting scheme was developed—although some SGs are very active and vocal, there is evidence of diverse values and priorities throughout the region, and these disparate priorities should be considered, even if not all stakeholders are fully engaged in the decision-making.

Although this equity assessment is only qualitative, it provides an opportunity to develop strategies to optimize the equity of selected remedial alternatives, or to consider the equity impacts of various alternatives. Spatial and demographic equity issues can, to some extent, be minimized using best management practices, considering community needs in design, and minimizing footprints. In general, it can be concluded that longer-lasting alternatives pose greater concerns for temporal equity—the short- to mid-term impacts of the remedial options are borne by a different population, temporally, than those who will reap the benefits of a cleaner river.

Table E-3. Equity considerations for ENV-1: Fish & Wildlife

Environmental Quality								
Value	**Metric**	Positive or negative impact?	Spatial equity considerations	Spatial equity strategies	Temporal equity considerations	Temporal equity strategies	Demographic equity considerations	Demographic equity strategies
Fish & Wildlife	Residual Risk reduction	+	Active risk reduction will be focused on areas of high contamination; regional background levels and inputs limit the achievability of this goal	ODEQ is addressing source control; catchment-based source control needed	Risk reduction will take decades; Benficiaries temporally distinct	Early actions on areas of elevated concentrations should provide benefits sooner; time-effecitve actions should be favored	Risk reduction benefits those who use river and eat fish the most; subsistence fisherman, tribal groups, the houseless and some immigrant communities will benetif; recreational fishermen and others benefit from healthy fish population	For recreational benefits, access to river increases benefit
	Risk from contaminant mobilization	-	Mobilized contamination impacts downstream sites (including the Colombia River)	Prevent offsite migration of contamination using BMPs	Risks during (and some time after) construction		Increased contaminants in fish tissues can disproportionately impact subsistence fisherman, tribal groups, the houseless and some immigrant communities	Education, communication, Institutional Controls
	Use of/need for institutional controls	+	All options leave some contaminated sediment in river	Risk-based management ensures controls are optimized	Seafood consumption advisories would remain in effect for all remedial alternatives	Source control will help long-term; monitoring will ensure efficacy of in-place management	Contaminants in fish tissues can disproportionately impact subsistence fisherman, tribal groups, the houseless and some immigrant communities	Education, communication, Institutional Controls
Habitat	Impact on in-water habitat (high value and benthic)	-	Habitat impacts will be focused on remedial footprint	Minimize active footprint where possible; mitgate and restore	Most impacts will be short-term, habitats may recover	Use substrates to enhance recovery; mitigate and restore	Damaged habitat may impact cultural and recreational value, disproportionately impacting some communities	Mitigation, replacement and restoration. For improved habitat; access may increase equity of benefit, but different communities have different expectations of the river and shoreline
	Impact on Shoreline habitat	-	Habitat impacts will be focused on remedial footprint	Minimize active footprint where possible; mitgate and restore	Some impacts will be short-term, some shoreline may recover	Use substrates to enhance recovery; mitigate and restore	Damaged habitat may impact cultural and recreational value, disproportionately impacting some communities	Mitigation, replacement and restoration. For improved habitat; access may increase equity of benefit, but different communities have different expectations of the river and shoreline

Table E-4. Equity considerations for ENV-2: Habitat and ENV-3: Resilience

Environmental Quality								
Value	**Metric**	**Positive or negative impact?**	**Spatial equity considerations**	**Spatial equity strategies**	**Temporal equity considerations**	**Temporal equity strategies**	**Demographic equity considerations**	**Demographic equity strategies**
Habitat	Impact on in-water habitat (high value and benthic)	-	Habitat impacts will be focused on remedial footprint	Minimize active footprint where possible; mitgate and restore	Most impacts will be short-term, habitats may recover	Use substrates to enhance recovery; mitigate and restore	Damaged habitat may impact cultural and recreational value, disproportionately impacting some communities	Mitigation, replacement and restoration. For improved habitat; access may increase equity of benefit, but different communities have different expectations of the river and shoreline
	Impact on Shoreline habitat	-	Habitat impacts will be focused on remedial footprint	Minimize active footprint where possible; mitgate and restore	Some impacts will be short-term, some shoreline may recover	Use substrates to enhance recovery; mitigate and restore	Damaged habitat may impact cultural and recreational value, disproportionately impacting some communities	Mitigation, replacement and restoration. For improved habitat; access may increase equity of benefit, but different communities have different expectations of the river and shoreline
Resilience	Resilience of Contaminant Containment	+	Failed containment will have localized impact, mobilized contaminants will affect downstream endpoints	Resilient design, monitoring and source control	Contaminants left in place or in containment may pose long-term risks and costs for monitoring, control and restoration in case of failure	Resilient design, permanent management; Indemnity provision for future loss	Failed containment will disproportionately impact subsistence fisherman, tribal groups, the houseless and some immigrant communities	Monitoring, communication

Table E-5. Equity considerations for ENV-4: Low Impact Remedy

Environmental Quality								
Value	**Metric**	**Positive or negative impact?**	**Spatial equity considerations**	**Spatial equity strategies**	**Temporal equity considerations**	**Temporal equity strategies**	**Demographic equity considerations**	**Demographic equity strategies**
Low Impact Remedy	Air Emissions	-	Air emissions will disproportionately impact those living, working and recreating near river	Monitoring; Use passive sampling devices where feasible; Reduce and control air emissions	Air emissions will be during construction time; impacting current residents; GHG emissions will affect generations	Use or generate renewable energy to the extent possible; Reduce emissions of greenhouse gases;	-	-
	Energy consumption	-	Energy use can affect local to global markets; relative impact should be minimal	-	GHG emissions will affect generations	Energy efficiency; Use or generate renewable energy to the extent possible; Reduce emissions of greenhouse gases ;	-	-
	Water consumption	-	Local burden for water provision and treatment	Miminize water use; use reclaimed water, treat water before disposal	-	-	-	-
	Landfill use (hazardous and non-hazardous)	-	No evidence of limited short-term landfill capacity	Minimize use	Landfill capacity may be limited over the very long term	Minimize use	-	-
	Sediment treatment	-	Treatment requires a land footprint; Any emissions or impacts to quality of life from treatment will disproportionately impact those living, traveling through or working near site	Use brownfields if available; high throughput technologies; BMPs	Treatment impacts are short-term	BMPs to minimize community impacts during treatment	-	-
	Contaminant mobilization	-	Mobilized contamination impacts downstream sites (including the Colombia River); contaminants released on land will have very localized effects	Prevent offsite migration of contamination using BMPs; minimize contaminant mobilization	Risks during (and some time after) construction		Increased contaminants in fish tissues can disproportionately impact subsistence fisherman, tribal groups, the houseless and some immigrant communities	Education, communication, Institutional Controls

Table E-6. Equity considerations for ECON-1: Economic Vitality and ECON-2: Jobs

Economic Viability								
Value	**Metric**	**Positive or negative impact?**	**Spatial equity considerations**	**Spatial equity strategies**	**Temporal equity considerations**	**Temporal equity strategies**	**Demographic equity considerations**	**Demographic equity strategies**
Economic Vitality	Impacts on Economic Viability (long-term)	-	Significant negative regional economic impacts; if non-local financing, also non-local impacts	Minimize costs	Costs are borne during the life of the remedy, monitoring and maintenance- a generation	-	Negative impacts to GRP affect all sectors	Minimize cost
	Disruption Impacts on Economic Viability (short-term)	-	Disruption will affect businesses working on river or requiring affected transport corridors	Smaller footprints	Dsiruption will be for the lie of the construction; up to decades	Shorter-term remedies	Impacts will affect the local economy	-
	Impacts onTourism	-	Impacts on tourism should be limited as remediation in an industrialized area, but could affect river access; and cause aesthetic and noise impacts near sites	-	Disruption will be for the life of the construction; up to decades; any restoration after will provide future tourism benefit (to a temporally distinct population)	Shorter-term remedies; faster restoration	-	-
Jobs	Impacts on Employment (local)	-	Significant negative regional impact on jobs	Minimize costs	Job losses are borne during the life of the remedy, monitoring and maintenance- a generation; not clear if jobs return	Minimize costs	Job losses affect all sectors; high-wage jobs disproportionately negatively impacted	Education and training can ensure that the jobs which are generated are more widely available

Table E-7. Equity considerations for ECON-3: Infrastructure and ECON-4: Cost-Effectiveness

Economic Viability									
Value	**Metric**	**Positive or negative impact?**	**Spatial equity considerations**	**Spatial equity strategies**	**Temporal equity considerations**	**Temporal equity strategies**	**Demographic equity considerations**	**Demographic equity strategies**
Infrastructure	Real Estate stigma removal	+	Stigma removal will be focused on areas on or adjacent to cleaned up sites	Larger remedies	Benefit will be realized after remedy; decades from now.	Faster remedies	Stigma removal can also cause gentrification, a social equity issue, but will mostly happen in industrialized areas	Planning and zoning can address some gentrification issues
Infrastructure	Road traffic	-	Traffic impact will be focused on the sediment transloading, transport and disposal sites	Barging, trains; volume minimization	Traffic impacts will be for the life of the remedy; decades	Faster remedies	Traffic impacts will disproportionatley impact those living, working and commuting along transport corridors	Sediment trans-loading and transport should be planned with community needs in mind.
Infrastructure	Impacts on Utilities	-	Utility impacts will be localized; focused on overlap between remedial footprint and cables; effect of disruption could be broader, depending on what is disrupted	Map use, avoidance; communication	Any disruptions will be very short-term	-	-	-
Infrastructure	Impact on Navigational channel	-	None found	-	-	-	-	-
Infrastructure	Impacts on Berthing areas	-	Impacts on berthing areas will be localized to remedial footprint, but over the life of the remedy they could be extensive; up to 45% of in-water infrastructure in the Superfund area could be disrupted	Much disruption will be unavoidable, particularly in hotspot areas; capping can be done if necessary	Disruption should be on the order of 1-5 years; areas of disruption should move over the life of the project	-	-	-
Cost Effectiveness	Capital cost	-	Significant negative regional economic impacts; if non-local financing, also non-local impacts	Minimize costs	Costs are borne during the life of the remedy, decades	-	Negative impacts to GRP affect all sectors	Minimize cost
Cost Effectiveness	Long-term cost	-	Significant negative regional economic impacts; if non-local financing, also non-local impacts	Minimize costs	Costs are borne during the life of the remedy, monitoring and maintenance- a generation ro more	-	Negative impacts to GRP affect all sectors	Minimize cost

Table E-8. Equity considerations for SOC-1: Quality of Life & Recreation

Social Equity									
Value	**Metric**	**Positive or negative impact?**	**Spatial equity considerations**	**Spatial equity strategies**	**Temporal equity considerations**	**Temporal equity strategies**	**Demographic equity considerations**	**Demographic equity strategies**
Quality of Life/ Recreation	Impacts on Quality of life	-	Impacts on quality of life will be highly localized to those living, commuting through or working in areas near the superfund site or transportation routes	Sediment trans-loading and transport should be planned with community needs in mind.	Impacts will be during the life of the remediation, up to a generation	Careful planning so no area is impacted for too long	-	-
	Impacts on recreation	-	Some recreation impacts will be focused on remedial footprint; others will be affected by contaminant mobilization and thus affect all water users	Minimize active footprint where possible; mitgate and restore; minimize contaminant releases	Most impacts will be short-term, recreation will be available after management unless there is long-term access control; restoration may improve future recreation; impacts will disproportionately impact real-time populations, for benefits which may be realized by a temporally distinct population, potentially decades away	Shorter-term projects; early restoration; preservation of access routes	Damaged habitat may impact cultural and recreational value, disproportionately impacting some communities	Mitigation, replacement and restoration. For improved habitat; access may increase equity of benefit, but different communities have different expectations of the river and shoreline
	Impacts on ccess to river	-	Access impacts will be focused on remedial footprint; others will be affected by contaminant mobilization and thus affect all water users	Minimize active footprint where possible; mitgate and restore;	Most impacts will be short-term, access may be available after management unless there is long-term access control; restoration may improve future access impacts will disproportionately impact real-time populations, for benefits which may be realized by a temporally distinct population, potentially decades away	Shorter-term projects; early restoration; preservation of access routes	Loss of access may impact cultural and recreational value, disproportionately impacting some communities; access benefits those who have the resources and time to get to the river; access is desirable to many in the houseless community	Mitigation, replacement and restoration. Improved access may increase equity of benefit, but different communities have different expectations of the river and shoreline; public transport, safe and well-signed access routes

Table E-9. Equity considerations for SOC-2: Community Values (part 1)

Social Equity									
Value	**Metric**	**Positive or negative impact?**	**Spatial equity considerations**	**Spatial equity strategies**	**Temporal equity considerations**	**Temporal equity strategies**	**Demographic equity considerations**	**Demographic equity strategies**
Community Values	Stakeholder involvement	+	Stakeholder involvement should be focused on affected parties, so should have a significant local component	Local outreach and accessible communication	Stakeholders who are affected (positively and negatively) span timescales and generations	Both short-term and long-term risks and benefits need to be considered in stakeholder outreach and communication	Stakeholder participation often disproportionatlely involves selected key players and those with the time and financial resources to take part	Involvement of broad-based community, ensuring that the affected become affecting, changing from subjects to key players; consideration of SGs not participating, data access and meetings to reach diverse communities; multi-lingual outreach and communication; participation of NGOs who represent the under-represented; balance decision making
	Amenability to re-use	+/-	Re-use impacts will be focused on remedial footprin and access areast; others will be affected by contaminant mobilization and thus affect all water users. Re-use plans not part of remedial plan selection; re-use benefits those who live and work near river more than those further away	Remediation, restoration and planning should be better linked; impacts on re-use should be considered	Re-use benefits are only realized after remediation complete, benefitting a termporally distinct population	Faster remediation; phased restoration and re-development; offset of use loss; re-use, restoration and redevelopment planning as part of decision making	Different stakeholders have different expectations of the re-use of the river and its shoreline. Benefits primarily realized by those with transport and access	Balanced decision-making; multi-use planning, access and public transport

Table E-10. Equity considerations for SOC-2: Community Values (part 2)

Social Equity									
Value	**Metric**	**Positive or negative impact?**	**Spatial equity considerations**	**Spatial equity strategies**	**Temporal equity considerations**	**Temporal equity strategies**	**Demographic equity considerations**	**Demographic equity strategies**
Community Values	Communication of uncertainty	+/-	-	-	-	-	Information provided to public can be confusing, or misleading; lack of experience, access to technical support, language issues or education may limit ability to fully understand or engage in the decision process	Clear and simple communication of uncertainty; avoidance of scare-mongering, lobbying and single-issue communication, resources to the community to understand and engage in the decison process; Involvement of broad-based community, ensuring that the affected become affecting, changing from subjects to key players; consideration of SGs not participating, data access and meetings to reach diverse communities; multi-lingual outreach and communication; participation of NGOs who represent the under-represented; balanced decision making
	Impacts on Archaeological sites	-	Impacts will be focused on overlap between remedial footprint and any archaeological or cultural resources	Careful planning and surveys (at this time, no evidence of impact has been found)	Damage, if any, could have long-term negative imapct on resources	Protect and avoid	Cultural and spiritual values differ among demographic groups;	Broad-based communicaiton and decision making; respect for cultural values and diversity; community outreach
	Tribal acceptance	+/-	Impacts will be both in the remedial footprint and, potentially, downstream if contaminants are mobilized	Minimize footprint, control contaminant releases	Tribal groups (e.g., Yakama Nation statements) have made clear that their focus is on generational goals; long-term restoration to near-pristine levels take precedence over short-term impacts (and costs)	More extensive and permanent remedies support tribal priorities; watershed-level management essential for meeting goals over the long term. In the short term (decades); more extensive remedies will impact fish tissue and downstream endpoints	Tribal treaty rights have a significant status and role in the region	Balance tribal needs and priorities; balanced, inclusive and transparent decision making.

Table E-11. Equity considerations for SOC-3: Acceptable Remedy

Social Equity								
Value	**Metric**	**Positive or negative impact?**	**Spatial equity considerations**	**Spatial equity strategies**	**Temporal equity considerations**	**Temporal equity strategies**	**Demographic equity considerations**	**Demographic equity strategies**
Acceptable Remedy	Permanence	+	More permanent removal of contaminants in the river may reduce long-term risk and monitoring costs, but contaminants which are not destroyed are moved to other locations	Balance risk and exposure pathway considerations	More extensive options may somewhat reduce long-term residual risks (although at this site benefit is minor), but at the cost of higher short-term risks; thus risks/costs and benefits are borne by temporally distinct populations	Balance risk and exposure, cost and benefit considerations	Populations subject to short and long-term risks may be demographically distinct; exposure pathways differ;	Balance risk and exposure pathway considerations; protect vulnerable populations; balanced decision making, engaging affected populations in a full consideration of trade-offs
	Effectiveness	+	More effective removal or containment of contaminants in the river may reduce long-term risk and monitoring costs, but contaminants which are not destroyed are moved to other locations	Balance risk and exposure pathway considerations	More extensive options may somewhat reduce long-term residual risks (although at this site benefit is minor), but at the cost of higher short-term risks; thus risks/costs and benefits are borne by temporally distinct populations	Balance risk and exposure, cost and benefit considerations	Populations subject to short and long-term risks may be demographically distinct; exposure pathways differ;	Balance risk and exposure pathway considerations; protect vulnerable populations; balanced decision making, engaging affected populations in a full consideration of trade-offs
	Implementability	+/-	Unplanned challeges may reduce project effectiveness or release more contaminants	Careful planning, experience contractors, ensuring feasability during project design and planning	Projects which posed unanticipated implementation issues may be delayed, increasing temporal inequity by extending project time	Careful planning, experience contractors, ensuring feasability during project design and planning	-	-
	Socially optimal construction time	+/-	-	-	Surveys show that a significant majority of the community support projects which are under 7 years; after that support drops quickly (although a small percentage show firm support for long projects if needed)	Shorter-term projects, unless public benefits from longer projects are clearly demonstrated	-	-
	Time-effectiveness	+/-	-	-	Longer-term projects that do not yield earlier risk reduction (and have greater interim impacts) disproportionately impact real-time populations, for benefits which may be realized by a temporally distinct population, potentially decades away	Time-effective projects should be favored - longer construction times should yield proportionately faster recovery	-	-

Table E-12. Equity considerations for SOC-4: Health & Safety

Social Equity								
Value	**Metric**	**Positive or negative impact?**	**Spatial equity considerations**	**Spatial equity strategies**	**Temporal equity considerations**	**Temporal equity strategies**	**Demographic equity considerations**	**Demographic equity strategies**
Health & Safety	Worker safety	-	Worker safety risk will be confined to remedial, treatment, transloading, tranport and disposal areas.	Perimeter control, minimizing footprint, careful planning of locations of trans-loading, treatment, transport and disposal locations and routes; lower volume projects	Safety issues will be during the lifetime of the project, potentially decades	Shorter-term projects (but not rushed work); careful scheduling to avoid weather and/or darkness-induced risks;	Safety risks can be disproportionately focused on lower wage, lower skilled jobs; potential safety risk to the public who access sites or live, work and/or travel near trans-loading, transport and disposal areas; houseless who are in areas may be disproportionately at risk	Safety training; good practice; perimeter control; minimizing footprint, careful planning of locations of trans-loading, treatment, transport and disposal locations and routes; lower volume projects
	Human health risk	+	Active risk reduction will be focused on areas of high contamination; regional background levels and inputs limit the achievability of this goal	ODEQ is addressing source control; catchment-based source control needed	Risk reduction will take decades; Benficiaries temporally distinct	Early actions on areas of elevated contamination should provide benefits sooner; time-effecitve actions should be favored	Risk reduction provides the greatest benefit to those who use river and eat fish the most; subsistence fishermen and margninalized communities will benefit	
	Fish consumption risk (short term)	-	Mobilized contamination impacts downstream sites (including the Colombia River)	Prevent offsite migration of contamination using BMPs	Risks during (and some time after) construction		Increased contaminants in fish tissues can disproportionately impact subsistence fisherman, tribal groups, the houseless and some immigrant communities	Education, communication, Institutional Controls

Appendix F
SG Metric Indicator Input Table

	Indicator	Unit	Remedial Alternative						Goal	Basis
			A (baseline)	B	D	E	I	F		
Alt summary	Years (EPA)	years	0	4	6	7	7	13	min	2016 FS
	Years (adj)	years	0	5	8	13	11	26	min	AECOM est.
	Costs (EPA, 0%)	$M NPV	0	642	953	1240	1173	1371	min	2016 FS
	Costs (alt, 0%)	$M NPV	0	1051	1355	1758	1644	2969	min	AECOM est.
	Total capital costs	$M NPV	0	394	562	783	720	1448	min	AECOM adjusted; 2016 FS
	Dredge area	acres	0	67	121	188	150	355	min	2016 FS
	Dredge volume	CY	0	659000	1266000	2204000	1885000	5100000	min	2016 FS
	Dredge/cap	acres	0	6	11	15	17	32	min	2016 FS
	Capping	acres	0	23	45	66	64	118	min	2016 FS
	ENR	acres	0	100	87	60	60	28	min	2016 FS
	In-Situ Treatment	acres	0	7	3	0	0	0	min	2016 FS
	Ex-Situ Thermal Treatment Volume	cy, high estimate	0	208000	208000	208000	208000	208000		2016 FS
	MNR	acres	2167	1966	1900	1838	1876	1634		2016 FS
	Total volume handled	Mcy	0	1.84	3.12	4.99	5.01	10.65		2016 FS (includes riverbank areas)
	Implementability	points	10	8	6	4	4	2		Table 15; EPA proposed plan - 2 points per quartile in scoring circle
Risk, T=0	Average reduction in SWACs on a site-wide basis following construction for the focused COCs (PCBs, total PAHs, 1,2,3,7,8-PeCDD, 2,3,4,7,8-PeCDF, 2,3,7,8-TCDD, and DDx) SWAC reductions from MNR are not considered. Each alternative has a different construction time.	% SWAC reduction	0	55.83	63.17	68.67	65.33	76.17	max	AECOM synthesis of 2016 FS; NEBA 1a value (Env Report, App D)
NEBA inputs	Mass of PCBs removed	kg PCB	0	72221	112698	165148	147343	289305	max	AECOM synthesis of 2016 FS; NEBA 2a value (Env Report App D)
	Net Environmental Benefit	NEBA total weighted benefits	4.30	5.60	5.60	5.40	5.40	4.50		NEBA net weighted benefit score (Env Report, App D)
Human carcinogenic and non-cancer risks	RAO1: Cumulative Carcinogenic Risk - Direct Contact	Risks	4.0E-04	5.0E-05	2.0E-05	1.0E-05	1.0E-05	1.0E-05	1.00E-05	2016 FS
	RAO 2: Cumulative Carcinogenic Risk - Subsistence Angler Consumption of contaminated fish and shellfish (site-wide)	Risks	2.0E-03	4.0E-04	3.0E-04	2.0E-04	2.0E-04	1.0E-04	1.00E-05	2016 FS
	RAO 2: Cumulative Child Non-cancer Hazard Index - Subsistence Child Consumption of contaminated fish and shellfish (site-wide)	HI	138	38	29	21	21	12	1	2016 FS
	RAO 2: Nursing Infant Non-cancer Hazard Index - Consumption of contaminated fish and shellfish	HI	3,333	810	619	446	454	268	1	2016 FS
Ecological risks	RAO 5:Acres where unacceptable benthic risks continues - Direct Contact	acres	1289	670	464	348	464	168	0	2016 FS/AECOM eval
	RAO 6: Maximum Hazard Quotient - Consumption, equal to the max HQ of 4,4-DDE, PCBs, HxCDF, PeCDF, TCDD, and TCDF (river-mile)	max HQ	138	34	19	15	19	15	1	2016 FS/AECOM eval
2012 FS inputs	Total Mass Exiting the Study Area for Each Alternative	Total PCB kg	0	30	35	55	55	100		Taken from Figure 9.5.3-1, 2012 FS
	AnchorQEA Construction Period	years	0	5	7	12	12	28		2012 FS
	Year adjusted mass	Total PCB kg	0	30	40	60	50	93	min	Normalized to years (alt)
	Year 45 PCB SWAC, site-wide	ppb	35	17	18	15	15	14	min	Table 9.3.1-1 2012 Draft FS (Section 9 tables)
	AVERAGE Mid Estimated Time to Attain RAO related to PCBs in Sediments (years)	years	N/A	45	45	44	44	34		Information on Time to Attain RAOs found in AnchorQEA FS 2012, Table 9.0-1 and Table 9.5.5-1; >45 for B and D treated as 45

	Indicator	Unit	Remedial Alternative						Goal	Basis
			A (baseline)	B	D	E	I	F		
GIS overlap analysis	% overlap of active remedial footprint (dredge, cap, treatment, ENR) with potential nearshore habitat from +13 ft to -15 ft NAVD88	%	0	15	20	26	24	39	min	AECOM GIS Overlap Analysis; Nearshore Habitat Table (Env Report App C)
	Active remedial footprint overlap with potential nearshore habitat from +13 ft to -15 ft NAVD88	SF	0	3137532	4163325	5422712	4911893	8129329		AECOM GIS Overlap Analysis; Nearshore Habitat Table (Env Report App C)
	Total Active Footprint (dredging, capping, treatment, ENR) for benthic habitat	SF	0	8712355	11518090	14209605	12666837	22997499	min	Either the 2015 or 2016 EPA FS GIS files
	Active shoreline is the shoreline that is adjacent to the active remedial footprint (dredge, cap, treatment and ENR) for shoreline habitat	LF	0	27430	38881	49364	43050	67311	min	AECOM GIS Overlap Analysis; Shoreline
	Overlap of active remedial footprint (dredge cap, treatment and ENR)with recreational areas (beach/park/public access)	LF	0	3963	5237	6365	4979	9407	min	AECOM GIS Overlap Analysis; recreational areas (Env Report App C)
	Potential overlap on utilities/cables	SF	0	347000	438000	438000	438000	438000	min	AECOM GIS Utility map (Env Report App C)
	% Overlap of Overwater Structures Area	%	0	10	12	14	16	22	min	AECOM GIS Overlap Analysis; Structures
	% Disturbance of Navigational channel	%	0	0	0	0	0	0	min	GIS available from FS but overlap is very small; insensitive.
	Fraction Infrastructure shoreline impact (GIS)	fraction	0	0.22	0.29	0.38	0.35	0.54		
SiteWise Results	GHG Emissions	metric ton	0	345844	545209	652318	613022	1055495	min	SiteWise
	Total energy Used	MMBTU	0	2303796	3591636	4488367	4190923	7557125	min	SiteWise
	Water Consumption	gallons	0	3352	6437	11213	9611	25956	min	SiteWise
	Total NO_x Emissions	metric ton	0	603	912	1346	1236	2541	min	SiteWise
	Total SO_x Emissions	metric ton	0	252	344	474	439	840	min	SiteWise
	Total PM_{10} Emissions	metric ton	0	256	440	716	630	1544	min	SiteWise
	Accident Risk Fatality		0	0.08	0.14	0.24	0.21	0.52	min	SiteWise
	Accident Risk Injury		0	10.81	18.45	29.69	26.49	62.03	min	SiteWise
	Non-Hazardous Waste Landfill Space	tons	0	693843	1599182	2975613	2534454	7149152	min	SiteWise
	Hazardous Waste Landfill Space	tons	0	358888	358888	358888	358888	358888	min	SiteWise
	Net volume removed (flood risk)	cy	0	131569	453697	1065947	855407	3019537	min	Portland Harbor RI/FS; Appendix P: Flood Rise Evaluation; Table P-15; 2016 FS
REMI outputs; interviews	GRP, mixed; average annual, upper	$M 2016	0	-18	-28	-39	-36	-71	min	NERA REMI
	GRP, mixed, average annual lower	$M 2016	0	-49	-74	-99	-93	-178	min	NERA REMI
	GRP, mixed; cumulative upper	$M 2016	0	-381	-575	-821	-747	-1432	min	NERA REMI
	GRP, mixed; cumulative lower	$M 2016	0	-815	-1233	-1648	-1544	-3030	min	NERA REMI
	Impacts of business disruption	qualitative score	0.0	-3.5	-4.2	-6.6	-6.6	-10.0	0.0	Qualitative; based upon interviews of businesses by NERA
	Jobs, annual average mixed; upper	jobs	0	-110	-170	-250	-230	-460	min	NERA REMI
	Jobs, annual average, mixed lower	jobs	0	-340	-510	-680	-640	-1250	min	NERA REMI
	Jobs, cumulative upper	job years	0	-3430	-5290	-7800	-7020	-14150	min	NERA REMI
	Jobs, cumulative upper	job years	0	-10430	-15780	-21180	-19810	-38860	min	NERA REMI
	Impacts of real estate stigma removal	qualitative score	0.0	7.7	8.5	8.8	8.8	8.2		Qualitative; based upon interviews of businesses by NERA