Lower Duwamish Waterway Group

Port of Seattle / City of Seattle / King County / The Boeing Company

Appendix J – Detailed Evaluation of MTCA Requirements for Cleanup Actions Draft Feasibility Study

Lower Duwamish Waterway
Seattle, Washington

For submittal to

The U.S. Environmental Protection Agency
Region 10
Seattle, WA

The Washington State Department of Ecology
Northwest Field Office
Bellevue, WA

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J.1 Introduction

This appendix presents the evaluation of cleanup action alternatives under the State of Washington Model Toxics Control Act (MTCA) requirements for conducting a Feasibility Study (FS). As stated within Washington Administrative Code (WAC) 173-340-350, the purpose of an FS is to develop and evaluate cleanup action alternatives that will enable a cleanup action to be selected for the site. This is the same purpose for conducting an FS under the Comprehensive Environmental Response Conservation and Liability Act (CERCLA) of 1980. The Washington State Department of Ecology (Ecology) is responsible for actions under MTCA. Under CERCLA, the U.S. Environmental Protection Agency (EPA) is responsible for actions. Both Ecology and EPA are reviewing the FS and will select the cleanup action alternative for the LDW.

The Lower Duwamish Waterway (LDW) FS is based on the CERCLA framework for determining, evaluating, and presenting the analysis of cleanup action alternatives (referred to as remedial alternatives in the main text of the FS) for a site. This appendix evaluates the information contained within the FS sections against the MTCA requirements, which are similar to CERCLA requirements. Similarities and differences between the two regulations are described in this appendix and are cross referenced to the main body of the FS.

J.1.1 MTCA Requirements for the FS

The general content and requirements under MTCA for an FS are outlined within WAC 173-340-350 and include:

- Establishing cleanup standards
- Assembling cleanup action alternatives that protect human health and the environment by eliminating, reducing, or otherwise controlling risks posed through each exposure pathway and migration route identified for the site
- Evaluating a reasonable number and type of alternatives, taking into account the characteristics and complexity of the waterway, including current site conditions and physical constraints
- Utilizing cleanup action components that provide for on-site or off-site disposal of the hazardous substances in an engineered, lined and monitored facility; on-site isolation or containment of the hazardous substances with attendant engineering controls and institutional controls and monitoring
- Using remediation levels to define when particular cleanup action components will be used

- Evaluating the residual threats that would accompany each cleanup action alternative to determine that alternatives that are protective of human health will also be protective of ecological receptors
- Providing for reasonable restoration time frames.

The LDW FS addresses these requirements within various sections, including Sections 4 and 6 (cleanup standards and remediation levels[1]), Section 7 (technology evaluations), and Section 8 (assembly of alternatives). Section 9 presents the restoration time frames. In addition to these general FS requirements, MTCA requires specific methods be followed in evaluating the assembled cleanup action alternatives.

J.1.2 Evaluation of Cleanup Action Alternatives under MTCA

MTCA provides requirements and procedures for selecting cleanup actions in the WAC 173-340-360. Table J-1 presents the MTCA requirements for the selection of cleanup actions as specified in WAC 173-340-360, and, if applicable, the comparable CERCLA criterion under which the MTCA requirement is evaluated within Section 9 of the FS. Table J-1 presents the general headings and individual components to be used in selecting cleanup actions in the first two columns of the table. The third column indicates where the specific requirements are discussed and addressed within this FS. Where the MTCA evaluation requirements have not been fully addressed within the body of the FS, this appendix devotes subsections to those topics under the appropriate headings.

Under MTCA, cleanup action alternatives must be evaluated within the framework of threshold and other minimum requirements. As shown in Table J-1, the four requirements that must be met with any alternative can be characterized as "threshold requirements" in that any alternative must meet these criteria to be considered viable. Section J.2 presents these criteria and discusses how each of the alternatives meets these threshold requirements. In addition, this section provides a discussion of the cleanup levels used in this FS. Section J.3 presents the additional requirements and the evaluation of the alternatives within this MTCA framework. These evaluation criteria are used in Section J.4 to perform a Disproportionate Cost Analysis (DCA) of the alternatives. This DCA allows the FS to screen from further consideration an alternative for which the cost of implementation is disproportionate to the benefits achieved by that alternative. As per WAC 173-340-360(3)(e)(i), costs are considered disproportionate to benefits when the incremental costs of the alternative over those of a lower cost

[1] *Cleanup standards* as defined under MTCA will be determined by Ecology. For this FS, the preliminary remediation goals (PRGs) identified in Section 4 are used as the preliminary MTCA cleanup standards. Please see section J.2.2 for discussion of how PRGs are used as cleanup levels for evaluation in this appendix. *Remediation levels* are equivalent to the Remedial Action Levels (RALs) used in Section 6 and 8. The body of the FS utilizes the CERCLA terminology, whereas this appendix uses the MTCA terms.

alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative.[2]

J.2 MTCA Threshold Requirements

Table J-1 presents the four MTCA threshold criteria. For any alternative, these criteria must be met to be considered viable as a cleanup action alternative for the LDW.

J.2.1 Protect Human Health and the Environment

Under MTCA, an alternative's protectiveness of human health and the environment is determined by the degree to which existing site risks are reduced, the time required to reduce these risks and to attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality (WAC 173-340-360(3)(f)(i)). These measures of protectiveness are discussed below.

J2.1.1 Degree to which Existing Risks are Reduced

Within the LDW Remedial Investigation (Windward 2008), exposure pathways were determined and risks scenarios were evaluated. Section 3 of the FS presents the findings of the ecological and human health risk assessments (Windward 2007a, 2007b), and the risk-based threshold concentrations (RBTCs). Section 4 of the FS developed remedial action objectives (RAOs) to address unacceptable risk from each of the exposure pathways presented by the four risk driver chemicals (total polychlorinated biphenyls [PCBs], arsenic, carcinogenic polychlorinated aromatic hydrocarbons [cPAHs], and dioxins/furans) plus the 41 SMS risk driver chemicals, and developed the preliminary remediation goals (PRGs). For this FS, the PRGs will be considered equivalent to cleanup levels under MTCA. Section J.2.2.2 elaborates on this point.

Models were developed to analyze sediment movement and predict chemical concentrations and recovery rates, as described in Section 5. These models were used to construct alternatives (Section 8) and evaluate the protectiveness of the alternatives, as presented in Section 9 and within the DCA (Section J.4).

In Section 9, Tables 9-2 and 9-3 present the reduction in the levels of risk-driver chemical concentrations over time for human and ecological exposure scenarios addressed by RAOs 1 through 4, and Tables 9-5 and 9-6 present the resulting reductions in human health risks anticipated under each of the alternatives. The time frames over which these RAOs are achieved differ among the cleanup action alternatives.

J2.1.2 Time Required to Reduce Risks and Attain Cleanup Standards

As a portion of the determination of overall protectiveness of human health and the environment, evaluations of cleanup action alternatives include the estimated times to

[2] In this analysis, Alternatives are first ranked from most to least permanent.

achieve the cleanup standards. These standards are comprised of cleanup levels and points of compliance. For this MTCA evaluation, the PRGs developed in Section 4 of the FS are used as the preliminary cleanup levels, and the point of compliance is considered to be the biologically active zone in the LDW sediment (see Section J.2.2 for a discussion on the cleanup standards and biologically active zone).

The bed composition model (BCM) predicts the concentrations of chemicals in surface sediments under each alternative over time, as discussed in Section 9.2 and shown in Tables 9-2 and 9-3. These tables present surface sediment concentrations at times of 0, 10, and 30 years following the end of construction (i.e., recovery time). However, as different alternatives require significantly different construction time frames, the total *restoration time frame* (the combined implementation and recovery time frames) required to reduce risks so that RAOs are reached, is compared for this criterion. The restoration time frames for each cleanup action alternative are presented within the Section 9 summary tables and figures for the individual alternatives. These summary figures present the modeled concentrations of risk drivers in relationship to the total time from the issuance of the record of decision (ROD). These concentration curves are compared to the cleanup levels (PRGs) for the different exposure pathways so that the restoration time frames are indicated.

J2.1.3 On-site and Off-site Risks from Implementing Alternatives

The remedial actions performed for each alternative result in differing degrees of risks to construction workers and the community and differing degrees of environmental impacts both within the LDW and off site. Within Section 9, the "Short-term Effectiveness" headings present and discuss the on-site and off-site risks due to implementing the cleanup action alternatives.

Controls related to these risks are discussed in Section 8, and are generally considered to be effective. However, risks to workers and the community are proportional to the time required for implementation; larger-scale cleanup alternatives provide higher levels of construction-related and construction traffic-related risk.

In addition, ecological risks increase as the duration and total area of dredging or, to a lesser extent, capping increase. As these risks are due to the implementation of the cleanup action alternatives, these risks are discussed in the context of managing short-term risk.

J2.1.4 Improvement in Overall Environmental Quality

The overall improvement in environmental quality within the LDW is generally proportional to the degree to which risk-driver chemical concentrations are reduced by the cleanup action alternative, balanced with the short-term effects to the environment (e.g., habitat loss and restoration, increased fish tissue concentrations of risk driver chemicals during dredging, etc.) that result from active remedies. All cleanup action alternatives are expected to reduce risk-driver chemical concentrations over time to

achieve RAO 1 (seafood consumption/background), RAO 2 (direct contact), RAO 3 (benthic protection), and RAO 4 (seafood consumption by river otter) by achieving the respective PRGs. As discussed in Sections 9 and 10, there are some substantial differences among the alternatives in the times required to achieve some of the RAOs. However, the overall improvement to the quality of the aquatic environment of the LDW for Alternatives 2 through 5 is similar over the long term.

Implementing the cleanup actions causes construction-related environmental risks such as the potential mobilization of chemicals of concern during construction. In-water dredging activities carry a relatively higher risk of water quality issues, elevated concentrations of chemicals in fish tissue, and potential sediment recontamination, as compared to capping, monitored natural recovery (MNR), or enhanced natural recovery (ENR). These risks include the introduction of excess residuals into areas that were not contaminated above cleanup levels. Generally, while some short-term risks can be reduced through the use of best management practices during project design and construction, other short-term risks are inherent to the scale and types of remedial actions. As these impacts are related to construction of the cleanup action alternatives, they are evaluated in the context of the management of short-term risk within the DCA in Section J.4.2.

J.2.2 Compliance with Cleanup Standards

For cleanup action alternatives to be considered viable, the alternatives must comply with cleanup standards (i.e., result in the attainment of cleanup levels at the appropriate points of compliance). Setting cleanup standards also involves being able to demonstrate that they have been achieved. This involves specifying where on the site the cleanup levels must be met (points of compliance), determining how long it takes for a site to meet cleanup levels (restoration time frame), and conducting sufficient monitoring to demonstrate that the cleanup standards have been achieved and will continue to be met in the future.

J2.2.1 Points of Compliance for the FS

For the LDW, the point of compliance for sediment is considered the biologically active zone. For this FS, the biologically active zone is assumed to be 10 centimeters (cm) below the sediment surface, as described in the RI (Windward 2008).

J2.2.2 Cleanup Level Determination

MTCA addresses sediment cleanup levels by reference to the SMS. Under the SMS, the primary endpoint for sediment quality evaluations is protection of human health and the environment, specifically the benthic community and wildlife, from adverse effects associated with the risk driver chemicals. Cleanup standards derived for the LDW must consider both protection of benthic organisms and the protection of human health and ecological receptors. Part V of the SMS provides guidance on developing sediment cleanup standards, and this guidance was used to evaluate the potential cleanup levels.

As discussed in Section 4 of the FS, RAOs for the LDW describe what a proposed cleanup remedy is expected to accomplish to protect human health and the environment. A range of chemical concentrations was examined for each exposure pathway to evaluate cleanup levels that may achieve the four RAOs:

- RAO 1 – human health seafood consumption
- RAO 2 – human health direct contact
- RAO 3 – ecological health of benthic organisms
- RAO 4 – ecological health of fish and wildlife receptors

Tables J-2a through J-2d summarize the relevant, site-specific concentrations (ordered by concentration) of the four primary risk driver chemicals within the LDW that are considered for identifying preliminary cleanup levels based on risk assessments, regulations, or practicable cleanup considerations (for RAOs 1, 2, and 4).

For RAO 3, the cleanup level is to comply with the SMS in ten years following remedy completion. The analysis for determining SMS compliance is presented in Section 9.1.1.1. For the other RAOs, selection of cleanup levels considers spatial scale, practicability, protection of receptors, and background levels. For the primary risk driver chemicals, the anthropogenic background concentrations are considered to be the minimum feasible cleanup level and are identified as PRGs in Section 4 of the FS. The anthropogenic background concentrations are presented as ranges, and the upper ends of these ranges have been used to assess the alternatives. It is expected that the anthropogenic background concentrations and PRGs will be further refined in later drafts of the FS.

EPA and Ecology will ultimately define the cleanup levels in the ROD and cleanup action plan. However, this FS has utilized the PRGs developed in Section 4 as the preliminary MTCA cleanup levels, using the process outlined in Section 4.3.

J.2.3 Meeting Cleanup Standards and Compliance Monitoring

With the exception of Alternative 1, the no action alternative, all the cleanup action alternatives include compliance monitoring. The cleanup action alternatives are expected to ultimately achieve compliance with cleanup standards as previously defined. However, the estimated time required to achieve compliance varies among the alternatives.

Section 9.1 describes the requirement under MTCA for protection, performance, and confirmation monitoring. Built into Alternatives 2 through 5 is the monitoring required to determine whether cleanup standards are being achieved. The monitoring program allows for examination of the recovery rates and sufficiency of the cleanup actions in achieving cleanup standards. The program also includes monitoring of areas that rely in part on natural recovery processes. Components of the conceptual monitoring program are presented in Appendix K.

J.2.4 Compliance with Applicable State and Federal Laws

With the exception of Alternative 1, all cleanup action alternatives will comply with the applicable state and federal laws. This criterion is discussed in Section 9.1.1.2.

J.3 Other MTCA Requirements

J.3.1 MTCA Minimum Requirements

MTCA identifies three additional requirements that are used by Ecology when selecting a cleanup action alternative; these are presented on the second page of Table J-1. The selected cleanup action alternative must use permanent solutions to the maximum extent practicable, they must provide for a reasonable restoration time frame, and they must consider public concerns.

J3.1.1 Permanent to the Maximum Extent Practicable

In accordance with WAC 173-340-360(2)(b)(i), the selected cleanup action must use permanent solutions to the maximum extent practicable. To support this determination, a comparison of benefits versus costs, the DCA, is performed within this appendix. As there are no alternatives that effectively result in the large-scale destruction of contaminants, permanence is evaluated within the DCA considering factors such as the amount of contaminated sediment removed from the LDW. Section J.4 describes the DCA evaluation in detail.

J3.1.2 Provide for a Reasonable Restoration Time Frame

Section 9 presents the implementation and estimated recovery periods for each cleanup action alternative within the summary tables. The summary figures within Section 9 present the performance of the cleanup action alternatives (as measured by the modeled LDW-wide UCL95) over time. The estimated restoration time frame ranges of each alternative (and for each RAO) are charted and summarized in Section 10.

As discussed in the FS, there are uncertainties associated with the estimated restoration time frames. These uncertainties may be managed through compliance monitoring, coupled with an adaptive management approach described in Sections 7.2.5 and 8.1.3 to provide information during the implementation of cleanup actions and allow for appropriate assessments of risk and progress toward attaining the RAOs. This monitoring allows for feedback, reassessments, and adjustments to provide adequate methods and levels of protection. These adaptive management measures are included in Alternatives 2 through 5 and will allow any additional areas, including areas that may still exceed SMS compliance after 10 years, to be identified and managed as needed to complete restoration of the LDW.

J3.1.3 Public Concerns

MTCA requires solicitation and consideration of public concerns throughout the cleanup process pursuant to WAC 173-340-660. Consideration of public concerns (including individuals, community groups, local governments, tribes, and federal and

state agencies) cannot be fully assessed until after the FS is released for regulatory and public review. This criterion should, therefore, be evaluated in the ROD, which will also include a formal responsiveness summary to public comments.

However, community and stakeholder comments and concerns have and will continue to be considered by EPA and Ecology. In addition, as the State of Washington is actively involved in the project through Ecology, state acceptance of alternatives is implicit in the FS-approval process.

J.3.2 Other MTCA Requirements

MTCA also requires that a cleanup action alternative prevent or minimize present and future releases and migration of contamination (WAC 173-340-360(2)(f)). Factors that may be considered in this evaluation for the LDW FS include:

- Releases from sources to the site
- Releases during implementation, e.g., during dredging or contained aquatic disposal
- Releases associated with treatment residuals
- Potential future releases from scour in MNR areas
- Potential future releases from failure of containment remedies (e.g., caps and ENR areas).

As discussed in Section 8, control of continuing sources of contamination to the LDW is a parallel process that is being led by Ecology. This FS does not evaluate alternatives for implementing source control, but does consider how the overall effectiveness of source control may affect the performance of the alternatives.

The other factors listed above are evaluated for each alternative in Section 9 of the FS. Construction best management practices and proper residuals management will be designed into the engineering and construction management of the cleanup action alternatives to limit resuspension of contaminated sediment and recontamination of adjacent areas. Under Alternatives 2 through 5, removal or isolation under an appropriately engineered cap is generally assumed for locations subject to significant erosion from high flows or vessel traffic. This limits the potential of re-exposing contaminated subsurface material in the future.

J.4 MTCA Disproportionate Cost Analysis

J.4.1 Purpose and Analysis Methodology

As discussed in Section J.3.1, MTCA requires that cleanup actions must use permanent solutions to the maximum extent practicable. This determination is made based on the DCA process in which 1) the most practicable, permanent cleanup action alternative serves as the baseline and 2) the benefits to human health and the environment of the

cleanup action alternatives are evaluated and compared to the costs. This analysis uses the evaluation criteria listed in WAC 173-340-360(3)(f). Both quantitative measures of benefit, as well as more qualitative judgments that are by necessity reliant upon best professional judgment, are used in assessing benefits (WAC 173-340-360(3)(e)(ii)(C)).

J.4.2 Weighting of Factors Used to Assess Cleanup Action Alternatives

To determine an overall benefits rating for each cleanup action alternative, the MTCA evaluation criteria presented in WAC 173-340-360 (3)(f) are each assigned a weighting within an overall benefits score. The weightings focus on the core purpose of protecting human health and the environment and reflect site-specific considerations, such as the size, complexity, and potential time frames involved in the cleanup action alternatives.

Table J-3 presents an overview of the metrics used to rate the cleanup action alternatives against the criteria specified by MTCA. This table summarizes the framework for performing the DCA, including how the criteria are weighted to produce an overall benefits rating.

The overall protectiveness of human health and the environment represents the ultimate objective of implementing a cleanup action. Therefore, the overall protectiveness rating is assigned 30 percent in the total weighted benefits calculation.

A weighting factor of 10 percent is assigned to the "permanence" criterion. Here, MTCA focuses on the degree that toxicity, mobility, or volume of hazardous substances are reduced. The comparatively low weighting of 10 percent reflects the small differences that exist among cleanup action alternatives for this criterion.

The effectiveness of the cleanup alternatives over the long term is an important requirement for continued protection of human health and the environment. This criterion therefore has a relatively high weighting of 25 percent in the total benefit calculation.

Short-term risk management at this site is weighted relatively high at 25 percent. This weighting is based partially upon the relatively long durations of most of the LDW cleanup action alternatives, including time frames for both construction and natural recovery processes. Because of the extended implementation times of many of the alternatives, short-term risks associated with the cleanup action can extend for many years. Additionally, this criterion is weighted comparatively high as a result of the potential severity of the risks to human health, particularly to the community and construction workers, though generally, these short-term risks are actively monitored during the period the risks exist.

The weighting factor assigned for the technical and administrative implementability criterion is 10%. Although an important consideration, this lesser weighting reflects the fact that implementability is less associated with environmental concerns than the relative difficulty and uncertainty of implementing the project. It includes technical

factors and the administrative factors associated with permitting and completing the cleanup.

These weightings and ratings represent LDWG's best effort to account for and capture the positive benefits as well as the impacts to the environment and human health as a direct result of the cleanup action.[3]

J.4.3 DCA Evaluation of Cleanup Alternatives

Table J-4a provides a summary of how well the cleanup action alternatives rate on a scale from 1 to 10 for each of the following MTCA criteria (1 = lowest possible rank and 10 = highest possible rank) assigned weighting factors in the previous section:

- Overall protection of human health and the environment
- Permanence
- Long-term effectiveness
- Management of short term risks
- Technical and administrative implementability.

The following evaluations provide the basis for the numerical ratings in Table J-4a. These ratings are then weighted and summed to yield an overall measure of benefits, which are presented in Table J-4b along with the cost estimates (as net present worth) for each cleanup action alternative.

J4.3.1 Overall Protectiveness of Human Health and the Environment

The overall protectiveness of human health and the environment is determined equally by (1) the degree to which existing site risks are reduced, (2) the time required to reduce these risks and to attain cleanup standards, and (3) on-site and off-site risks resulting from implementing the alternative. As described in Section J.2.1.4, the fourth criterion of the *Improvement to overall environmental quality* is similar among the alternatives that meet the threshold criteria (Alternatives 2 through 5). The differences in ratings for the *Improvement to environmental quality* are primarily because of the short-term risks and impacts. Therefore these risks are evaluated under the *Management of short-term risk*, in Section J.4.2.4.

J4.3.1.1 Reduction in the Degree of LDW-wide Residual Risk

The reduction in the degree of LDW-wide residual risk is based on the ability of a cleanup alternative to achieve all four RAOs. All cleanup alternatives perform similarly over the long term in that they achieve RAOs 1, 2, and 4 established for human and

[3] *Consideration of Public Concerns* and *Costs* were not directly included in the MTCA weighting of benefits. Consideration of public concerns is in small part captured under implementability and will also be evaluated by EPA and Ecology after release of the FS and will be included on the ROD. Costs are considered alongside the weighted benefits in the cost/benefit analysis.

ecological receptors.[4] However, the alternatives rely upon natural recovery processes and time to widely differing degrees. Additionally, the percent of the site area that still has SQS and cleanup screening level (CSL) point exceedances (a measure of residual risk to benthic community) decreases slightly with increasing areas of active cleanup actions. Therefore, the cleanup action alternatives with larger active remediation footprints generally rate slightly higher for this factor. Table 9-2b presents these areal percentages for all alternatives. Although Alternative 1 would significantly reduce the remaining area of contamination with some adverse effects at the end of construction, this alternative also results in relatively high percentage of the site with some adverse effects remaining after 10 years and so it rates poorest for this metric. The other alternatives have increasingly higher ratings because of the decreasing area of contamination with minor adverse effects expected under the respective alternatives.

J4.3.1.2 Time Required to Reduce Risk

For protectiveness, the time required to reduce risk (by achieving RAOs) is measured from the issuance of the ROD to the attainment of the RAOs. The full restoration time frame[5] for each RAO is summarized by alternative in Table J-4b. For rating this metric, the attainment of each RAO is considered equally important. Alternative 5 rates poorly because the extended construction time results in the longest times to achieve all RAOs. Alternative 1 also rates poorly in this metric as it relies heavily on natural recovery and so requires long periods to attain RAOs 1, 2, and 3. Alternatives 2, 4c and 4d rate moderately for the longer time to attain RAOs 2 and 4. Alternatives 4a and 4b result in restoration time frames of 25 years or less for all RAOs. Alternatives 3a through 3d rate the highest due the shortest overall restoration time frame (20 years or less).

J4.3.1.3 On-site and Off-site Risks from Implementation

On-site and off-site risks from alternative implementation are directly related to the quantity of contaminated material dredged, transported, and disposed of by the cleanup action alternative. A semi-quantitative determination of the risks produced by the alternatives was performed by scaling the relative volumes of dredging and disposal among the alternatives. Though the dredge volume for Alternative 1 is the smallest of any alternative, the rating has been qualitatively reduced because of the additional uncertainty resulting from not monitoring remaining areas of known contamination. Dredged volumes are presented in the summary tables within Section 9 for each of the alternatives, and these volumes provide a basis for rating the risks resulting from the removal and management of the sediment. With the exception of

[4] The alternatives perform similarly for residual risk in that the calculated risk due to the primary risk drivers is in the range of 10^{-5} after achieving RAOs. Further reductions of the residual risks are unlikely due to anthropogenic background levels (see Section 9 for more detail.)

[5] The full restoration time frame includes the time to implement the remedy, the recovery time after remedy construction to meet the PRG, plus an additional five years after the ROD and before construction to allow for remedial design, baseline monitoring, and permitting needs.

Alternative 1, the smaller the amount of dredging required, the higher the alternative was rated.

J4.3.2 Permanence

The permanence of a cleanup action alternative is measured by the relative reduction in toxicity, mobility, or volume of hazardous substances, including both the original contaminated media, and to a lesser degree the residuals generated by the cleanup action as the latter is included in short-term risk management (WAC 173-340-360(3)(f)(ii)). Only one alternative explicitly includes treatment (Alternative 4d), but this process option could be incorporated into other alternatives. As discussed in Section 9, the benefits of this treatment are marginal, and the contaminants themselves are not destroyed. Additionally, each of the alternatives could include treatment in the form of reactive caps; however this would be determined in design. Overall, the alternatives are not greatly distinguished with regard to this criterion.

Although removal and disposal is not treatment, this evaluation does assign somewhat higher scores under permanence for increasing removal and disposal. The ratings reflect the permanence benefit of increased sediment removal and upland disposal using the product of two metrics: the volume of dredged material removed and the RAL driving that volume. These ratings thereby account for the decreased marginal benefit of increasing volumes removed. The ratings also reflect the possible reuse benefit and the reduction in disposal volume for the sediment washing technology included in Alternative 4d but also consider the associated treatment residuals that must be managed.

The ratings of the permanence criterion show the increasing benefit resulting from the higher volumes of sediment removed in Alternative 4 (4a through 4d) and Alternative 5 cleanup actions. However, the differences within Alternative 3 and even Alternative 2 are relatively small, due to the decreasing marginal benefit of utilizing increasingly lower RALs for the cleanup action alternatives. The rate at which the human health risks decrease with increasing sediment removed diminishes, as is indicated in Figures 10-1 and 10-2.

The expected destruction of organic contamination from natural processes (i.e., biotransformations) that may be a component of ENR and MNR or the reduction in mobility and toxicity that would result from any potential use of carbon amendment in capping or ENR are not accounted for within these ratings.

J4.3.3 Long-term Effectiveness

The effectiveness of the cleanup action over the long term is determined by averaging the score of the following components:

- Degree of certainty that the remedy will be successful

- Reliability of the alternative during the period during which risk-driver chemicals remain at concentrations higher than cleanup levels
- Reliability of institutional and engineering controls used to manage risks
- Cleanup and disposal methods hierarchy listed in WAC 173-340-360(3)(f)(iv).

These evaluation components are summarized in Table J-4a.

A fifth evaluation criterion of the long-term effectiveness is the magnitude of residual risk with the alternative in place. As discussed in Section J.4.3.1.1, the alternatives vary little in this regard, and the magnitude of the residual risks is driven largely by background levels of primary risk drivers. See Appendix B for additional discussion of this topic.

J4.3.3.1 Degree of Certainty in the Success of Cleanup Alternatives

The ratings for the degree of certainty in the success of the cleanup action balance the benefits from removing contaminants from the LDW environment (and isolating them in an upland landfill), and the certainty that the cleanup levels can be achieved. Because Alternative 1 does not include adequate monitoring or address large areas with moderate to high concentrations of the risk driver chemicals, the certainty in that alternative is poor. Alternatives 2 and 3a through 3d address increasingly larger active footprints, and Alternatives 4a through 5 (removal focus) utilize increasingly larger removal activities, resulting in higher amounts of certainty of success. The increments of certainty provided by the alternatives, however, diminish due to the increasing impact of dredging residuals at lower RALs. The success of the sediment washing component of Alternative 4d is somewhat in question (e.g., the amount of extractable fine grain fractions and beneficial reuse of the treated material) , and so does not impact the rating.

J4.3.3.2 Reliability of the Cleanup Alternatives

The evaluation of the reliability of the alternative, during the period in which risk driver concentrations remain higher than cleanup levels, uses the likelihood that areas do not require any further action after implementation in the rating. Capping and dredging are reliable in the long term. Areas that utilize ENR may require maintenance, and areas relying heavily on monitoring and MNR are rated lower. Alternative 1 does not employ an adequate strategy for reliability in that large areas of the LDW would remain unmonitored and unaddressed; therefore, it rates low. The potential for the need for additional cleanup actions or future maintenance activities, respectively, results in middle ratings for Alternative 2 and the improved ratings for Alternative 3a and 3b. In actively addressing increasing volumes of contaminated sediment, Alternatives 3c, 3d, 4a, and 4c rate moderately high. Due to the increased reliance on removal actions, Alternatives 4 and 5 are ranked high and highest, respectively.

J4.3.3.3 Reliability of Controls Used for Cleanup Alternatives

Similarly, the ratings for the reliability of institutional and engineering controls are based on the alternatives' reliance on these controls for their overall effectiveness. All the alternatives require active monitoring and institutional controls due to long implementation and restoration time frames. Alternatives that include a higher degree of removal, such as Alternatives 4d and 5, require fewer engineering and institutional controls once the active cleanup is completed; however, the implementation time frames span decades, so all the alternatives are considered equivalent in this category.

J4.3.3.4 Hierarchy of Cleanup Alternatives Technologies Used

The hierarchy of cleanup and disposal methods is listed in WAC 173-340-360(3)(f)(iv) and can be used as a guide for evaluating effectiveness over the long term. Within this hierarchy, technologies are ranked (in descending order):

- Reuse (used to limited degree within Alternative 4d)
- Destruction or detoxification (not evaluated)
- Immobilization or solidification (not evaluated)
- Removal/upland disposal
- On-site containment (which includes contained aquatic disposal, capping, and ENR)
- Institutional controls and monitoring.

MNR is not explicitly listed in the MTCA hierarchy; for this FS, MNR is considered to rank below on-site containment.

Because Alternative 1 does not cleanup or monitor significant areas of impacted sediment in the LDW, it is rated poorly. Alternative 2 utilizes some removal and aquatic (or upland) disposal, it rates relatively poorly because it relies heavily on MNR and institutional controls within its remediation footprint. Alternatives 3a and 3b use on-site containment in the form of isolation capping and ENR, but still rely on MNR for a significant portion of the managed area, so these alternatives rate moderately. Alternatives 3c and 3d use larger areas of removal and upland disposal than Alternative 3a and 3b, as well as increased areas of capping or ENR (as opposed to relying on monitoring). Alternatives 3c and 3d rate slightly above average. Alternatives 4a, 4b and 4c rely upon removal and upland disposal, as opposed to capping. However, Alternative 4a and 4b use MNR in larger areas than Alternatives 3c and 3d, and as such, Alternatives 4a and 4b are also considered to rate slightly above average. Alternative 4c uses removal and disposal for a larger area while using fewer acres of MNR and so rates moderately high. Alternative 4d includes the assumed ability to reuse some of the washed sediment, in addition to dredging all of the managed areas and not using MNR. Alternative 4d rates high in this category. Alternative 5 uses removal and upland

disposal for all managed areas. This alternative also rates comparatively high within the regulatory hierarchy.

J4.3.4 Management of Short-term Risk

In addition to the risks posed by contaminated sediments in the LDW prior to RAOs being achieved, the implementation of cleanup actions for LDW will result in short-term risks to communities, construction workers, and the environment. This criterion uses two components: the risks presented by the implementation of the cleanup action alternative and the effectiveness of the protective measures to be utilized during the time required to achieve the RAOs during and after completion of cleanup actions.

J4.3.4.1 Implementation Risks

The first criterion component is generally a quantitative metric, based on such measures as:

- Estimated quantities of transportation miles for sediment and capping materials (community risks)
- Estimated construction time required for each alternative and associated increased risks to people who consume resident seafood during that period (community risks)
- Magnitude of construction scope and nationwide rates of injuries (construction worker risks)
- Quantitative impacts to the environment from air pollution generated and depletable resources consumed, as well as the expected short-term increases of contaminant concentrations within fish tissue and potential disruptions to aquatic habitat (environmental risks).

The implementation risks to the community are largely due to the increased construction-related traffic through local communities, along with risks to those people who choose to consume resident seafood during the construction period. The latter can be reduced by seafood consumption advisories; however these advisories are informational devices only.

Safety risks to construction workers are always present, typical to large construction projects. The risks can be estimated based on tabulated statistics of injuries and fatalities from the number of hours worked.

The evaluation of environmental risks includes the quantitative impacts to the environment from air pollution generated by construction activities and depletable resources consumed, as well as the expected short-term increases of contaminant concentrations within fish tissue and potential disruptions to aquatic habitat. Increased resuspension of sediment due to dredging is anticipated to result in higher fish tissue concentrations for an estimated period of three years following construction activities (see Appendix F). In addition, the recovery time of habitat in areas may be heavily

affected by the degree to which the existing sediment habitat is disrupted, the total area disrupted, and to what degree the impacted habitats are contiguous.

Alternative 1 rates very well for this criterion because of the limited amount of time, materials, traffic, and impacted habitat that would result from its implementation. All other alternatives build on the quantities within Alternative 1, with the ratings decreasing proportionally to the volumes of ecological disturbance and air pollution impacting the environment, traffic and materials increasing risks to the community, and construction hours required for workers. Alternative 5 results in roughly twice the risks and impacts as Alternative 4d.

J4.3.4.2 Effectiveness of Protective Measures during time to achieve RAOs

The second criterion component rates the effectiveness of protective measures such as institutional controls and best management practices that would be used to mitigate the risks presented under the cleanup action alternatives. These qualitative ratings include the anticipated effectiveness of the measures throughout the time frame of implementation and recovery estimated for the alternatives.

The lack of protective measures used and lack of monitoring included within Alternative 1 result in a poor rating for its effectiveness. Alternative 2 requires additional monitoring, engineering controls, and ICs for both the SMAs and the contained aquatic disposal facilities, although the controls would not fully mitigate the risks present in the areas. In addition to best management practices, Alternatives 3, 4, and 5 include extensive monitoring components that provide good reliability in identifying and managing risks. As the alternatives require increasing amounts of time (and risk) for implementation, the effectiveness of the protective measures is rated lower for the increasing amount of time required for the cleanup actions and the concomitant protective measures. Larger dredging projects require more on-site coordination with ongoing vessel traffic, berthing operations, recreational vessels, fish window limitations, and shore-side activities; more coordination efforts typically result in less effective protective measures.

Alternatives 3a and 3b rate high because of the relatively small amount of intensive removal and disposal activities included and the short implementation time frame. Alternatives 3c and 3d remove and dispose of 25% to 50% more sediment volume than Alternatives 3a and 3b, resulting in more implementation time and risk. These alternatives rate moderately high. However, Alternatives 4a-4d require two to three times the amount of time to implement as Alternatives 2 and 3a, and so these alternatives rate average. Because Alternative 5 requires more than twice the time to implement than 4d, it has a lower rating than Alternatives 4a-4d.

J4.3.5 Technical and Administrative Implementability

Implementability includes technical factors such as the availability of experienced contractors and logistics required to accomplish the cleanup work. However, the

criterion also incorporates the administrative factors associated with permitting and completing the cleanup, including potential property restrictions and requirements for property access during long-term monitoring. These two factors tend to work in opposite directions. For instance, Alternative 5 is the most technically complex alternative due to the areas and volumes of sediment that must be removed and includes a large amount of complicating overwater structures (rated low); however, very little long-term monitoring or property restrictions would be required under this alternative. The rating for Alternative 1 reflects the relatively small volumes and areas of impacted sediment to be managed within this alternative. Between the corresponding Alternatives 3a through 3d and Alternatives 4a through 4d, the Alternatives 4a-4d generally rate slightly lower due to their increased technical complexity and requirements for property access. Alternative 2 rates lower because of the increased difficulty in administrative implementability related to permitting and monitoring requirements of the contained aquatic disposal facility. Alternative 4d rates lower as well because of extensive permitting and property requirements for the soil washing facility.

The ratings reflect a balancing of the technical difficulty of implementing increasingly complex remedies, with the decreasing administrative difficulty expected from fewer years of property restrictions and institutional controls. Administrative implementability ratings also decrease with increasingly larger active areas managed because of reduced requirements for long-term property access, monitoring, and reporting after the completion of the cleanup action. Engineering design considerations are often of importance in this category and are often refined during the development of the engineering and design report. Again, technical and administrative implementability is less important in selecting an alternative for this site, because each alternative can be modified to improve implementability, but the same is not true for, for example, protectiveness, and permanence.

J4.3.6 Consideration of Public Concerns

The public involvement process under MTCA and CERCLA is used to identify public preferences and concerns regarding the alternatives. This includes concerns raised by individuals, community groups, local governments, local businesses, tribes, federal and state agencies, and other organizations that may have an interest in or knowledge of the site. The extent to which an alternative addresses the concerns identified by the public is considered as part of the remedy selection process that occurs after the FS is completed.

This issuance of this FS and Proposed Plan will provide an opportunity for identifying public comments, concerns, and feedback. This criterion will ultimately be evaluated by the agencies (EPA and Ecology) in the selection of the preferred alternative with the issuance of the ROD (and Corrective Action Plan). Therefore, this criterion cannot be adequately rated at this time and is not used within this evaluation.

J4.3.7 Costs

Costs are evaluated on a net present value basis. The derivation of the cost estimates is presented in Appendix I. Within this DCA, these present value cost estimates are used, in combination with the total benefits to determine whether or not an alternative's costs are disproportionate to the benefits provided by the alternative. The costs are presented in Table J-4b and are shown with the total benefits ratings on Figure J-1a and Figure J-2.

J.4.4 Summary of DCA Results

The individual criteria and ratings are presented in Table J-4a. This table shows the averaged ratings for each benefit category based on the arithmetic average of its component rating metrics.

Table J-4b presents the summary of the alternatives' overall performances within the DCA. This table also reiterates the restoration time frame and costs for the alternatives. Alternatives 2 through 5 meet the MTCA threshold requirements, while Alternative 1 does not comply with the cleanup standards in that the CSL is not achieved within 10 years after implementation, nor does it include adequate compliance monitoring. Considering all of the rating criteria, Alternative 3a provides the highest weighted benefit score. Alternatives 3b through 3c score similarly high. Alternatives 3d, 4a-4c have incrementally lower overall scores. Among the cleanup action alternatives that meet the threshold requirements, Alternatives 2 and 5 have the lowest total weighted benefits. For informational purposes, Table J-4b also includes calculated cost-benefit ratios, which is another metric that can be used to identify alternatives with disproportionate costs.

Figure J-1a presents the alternatives ranked in order from highest to lowest permanence ratings, and presents the total weighted benefits versus costs. Alternative 5 shows a clear disproportionality between the costs and benefits. Alternative 1 shows a lower benefit (and lower cost) compared to the other alternatives. Figure J-1b graphically shows the individual contributions of the criteria to the total benefits ratings.

Figure J-2 presents a cost/benefit quadrant plot of the alternatives. Alternatives 3 and 4 have higher benefits than Alternatives 1 and 2. The eight subalternatives among Alternatives 3 and 4, tend to show decreasing benefit with increasing costs. Alternatives 2 and 5 have lower benefits than Alternatives 3 and 4. Alternative 1 has been included for comparison, but it does not meet the threshold requirements and is not considered a viable alternative under MTCA. Figure J-2 clearly shows that Alternative 5 does not have the greatest overall benefits, and has a substantial and disproportionally high cost to the total benefits. This figure also indicates that Alternative 4d has substantial costs, compared with the overall benefits rating.

Additionally, Figure J-3 graphically presents the total weighted benefits as compared to the ranges of implementation times required for the alternatives. The figure shows there is not necessarily added overall benefit from alternatives that require more time to

implement. Indeed Alternative 3a, with the highest total benefit points, requires one of the shortest times to implement.

The incremental costs of Alternative 5, compared to the other, lower cost alternatives, combined with the lower total benefits provided by Alternative 5, clearly exceed the incremental degree of benefit achieved by this alternative's higher permanence rating over that of the other alternatives. Because of this disproportionality, Alternative 5 is removed from further consideration and was not evaluated in the comparative analysis (Section 10), consistent with WAC 173-340-350(8)(c)(ii)(B).

It is possible that costs may be determined to be disproportionate to benefits for other alternatives in addition to Alternative 5. The final identification of the alternative that uses "permanent solutions to the maximum extent practicable" will be made by EPA and Ecology after the FS is finalized and will consider public comment[6].

Finally, Table J-5 presents the MTCA analysis of the cleanup action alternatives side-by-side with the evaluation of the alternatives within the CERCLA framework. The CERCLA ranking is non-numeric, but nevertheless, the alternatives rank similarly between the two frameworks.

[6] The DCA is one of the three MTCA Other requirements, as stated in WAC 173-340-360(2)(b), and so Ecology will select the cleanup action alternative based on an evaluation of a reasonable restoration time frame and the consideration of public concerns, in addition to the results from the DCA.

Table J-1 Cross Reference of MTCA Threshold and Other Requirements to Sections of the FS

MTCA Minimum Requirements for Cleanup Actions: Threshold Requirement WAC 173-340-360 (2)(a)	*FS Evaluation Factors*	*FS Section in which Requirement is Evaluated*
i Protect human health and the environment WAC 173-340-360(3(f)(i)	• Degree to which existing risks are reduced • Time required to reduce risks and attain cleanup standards • On-site and off-site risks from implementing alternative • Improvement in overall environmental quality	• Tables 9-2 through 9-6 and alternative summary tables and figures in Section 9 provide the predicted numerical reductions in risk driver concentrations for each alternative over time. • The ”Short Term Effectiveness” headings in Section 9 contain evaluations of on site and off site risks, as well as time to achieve RAOs • Section J.2.1.4
ii. Comply with cleanup standards WAC 173-340-760	• Cleanup objective 173-204-570 (2): o No adverse effects on biological resources (173-204-320 (2)) o No significant health risk to humans (site specific) (173-340-320 (4)) • Minimum Cleanup Level (173-204-570(3)) • Remediation levels (WAC 173-340-355)	• RAOs and PRGs are presented and discussed in Section 4. Sediment cleanup objective is the SQS (RAO 3), discussed in Section 4.3.1. Tables J-2a through J-2d present relevant, potential site-specific cleanup levels. • See Section J.2.2.3 – cleanup standard requirements and PRGs • RALs developed in Section 6 are used to define alternatives in Section 8.
iii. Comply with applicable state and federal laws. WAC 173-340-710	• Chemical-specific • Action-specific • Location-specific	Discussed in Section 9.1.1.2
iv. Provide for compliance monitoring WAC 173-340-410 and 173-340-760	• Protection Monitoring • Performance Monitoring • Confirmational Monitoring	Discussed in Section 9.1.1.3 Compliance monitoring is a component of each alternative as discussed in Section 8. Appendix K contains an example framework for a monitoring plan.
i. Use permanent solutions to the maximum extent practicable	Disproportionate Cost Analysis 173-340-360(3)(e)	See Section J.4. “Practicability” determined through the Disproportionate Cost Analysis (DCA).

Table J-1 Cross Reference of MTCA Threshold and Other Requirements to Sections of the FS

MTCA Minimum Requirements for Cleanup Actions: Threshold Requirement WAC 173-340-360 (2)(a)	*FS Evaluation Factors*	*FS Section in which Requirement is Evaluated*
ii Provide for a reasonable restoration time frame	173-340-360(4)(b) • Potential risks posed by the site • Practicability of achieving a shorter restoration time frame • Uses & resources that are or may be affected by releases from the site • Effectiveness & reliability of institutional controls • Ability to control and monitor migration • Toxicity of the hazardous substances at the site • Natural processes that reduce concentration and have been documented to occur at the site or under similar site conditions • Area background (173-360-340(3(d)	• Potential site risks examined in Section 3. • Discussion of increased transloading capacity and shorter construction timeframes in Section 8.3.1 and Appendix I. • The potential for elevated fish tissue concentrations during and following construction activities are discussed in "Short-term Effectiveness" headings in Section 9. • Discussed in Section 8 for each alternative • Section 8.3.3 discusses monitoring and adaptive management • Risk Assessment findings discussed in Section 3 • Time to achieve RAOs for alternatives that rely on MNR under "Long Term Effectiveness" headings for each alternative in Section 9. STM (Section 5) used to explore recovery potential • Discussed in Section 4.3 and Appendix B
iii Consider public concerns	Not evaluated at this stage of the FS	Discussed in Section 9.1.3

Note:

DCA = disproportionate cost analysis; MNR = monitored natural recovery; MTCA = model toxics control act; PRG = preliminary remediation goal; RAL = remedial action levels; RAO = remedial action objectives; SQS = sediment quality standards; STM = sediment transport model; WAC = Washington Administrative Code

Table J-2a Relevant Site-Specific Risk-Based, Regulatory or Practicable Cleanup Levels for PCBs

Parameter	Surface Sediment Arsenic Concentration (mg/kg dw)	Measurement Basis	Basis
Natural background	2.3-10.4	UCL95 individual natural background (reference area) datasets	RI
Practical quantitation level	5		RI QAPP RLs[a]
Range of anthropogenic background	10-15	UCL95 LDW-wide	PRGs (Table 4-29)
Lowest technically achievable concentration	13	UCL95 LDW-wide	Best professional judgment, Dredge residual analysis, BCM mid bed replacement value
Direct contact (tribal clamming 1 x 10^{-5})	13	UCL95 Tribal Clamming areas	Human health risk assessment
Direct contact (beach play 1 x 10^{-5})	28	UCL95 Tribal Clamming areas	Human health risk assessment
Netfishing direct contact (1 x 10^{-5})	37	UCL95 LDW-wide	Human health risk assessment
Sediment quality standard	57	Point	SMS
Minimum cleanup level achieved in 10 years	93	Point	SMS

Notes:

Shading indicates the practical considerations for the MTCA cleanup level. For the evaluation of the cleanup action alternatives within the FS, the PRGs are used.

Other values within the table presented provide the potentially relevant levels for comparison.

[a] Reporting limits from Table A-1, Round 3 Surface Sediment QAPP Addendum (Windward 2006) in dry weight on non-transformed data.

BCM = bed composition model; LDW = Lower Duwamish Waterway; PRG = preliminary remediation goal; QAPP = quality assurance project plan; RAL = remedial action levels; RI = remedial investigation; RL = reporting limit; SMS = sediment management standards; STM = sediment transport model; UCL95 = 95th upper confidence limit of the mean concentration

Table J-2b Relevant Site-Specific Risk-Based, Regulatory or Practicable Cleanup Levels for Arsenic

Parameter	Sediment PCB Concentration (µg/kg dw)	Measurement Basis	Basis
Natural Background	2-20	UCL95 LDW-wide	RI
Tulalip Adult RME (1×10^{-4})	6	UCL95 LDW-wide	FWM
Practical Quantitation level	4[b]	n/a	RI QAPP RLs[a]
API RME (5×10^{-5})	37	UCL95 LDW-wide	FWM
Range of anthropogenic background	50-100	UCL95 LDW-wide	PRGs (Table 4-29)
Lowest technically achievable concentration	75	UCL95 LDW-wide	Best professional judgment, Dredge residual analysis, BCM mid bed replacement value
API RME (1×10^{-4})	100	UCL95 LDW-wide	FWM
Wildlife Risks (Otter HQ=1)	128-159	UCL95 LDW-wide	Ecological risk assessment
Apparent Effects Threshold	130	Point	SMS
Crab 1 meal/month (1×10^{-5})	218	UCL95 LDW-wide	FWM
Sediment quality standard (normalized to 2% oc)	240	Point	SMS
Direct contact (clamming 1×10^{-6})	500	UCL95 clamming areas	Human health risk assessment
Netfishing direct contact (1×10^{-6})	1,300	UCL95 LDW-wide	Human health risk assessment
Minimum cleanup level in 10 years (normalized to 2% oc)	1,300	Point	SMS
Direct contact (beach play 1×10^{-6})	1,700	UCL95 clamming areas	Human health risk assessment

Notes:

Shading indicates the practical considerations for the MTCA cleanup level. For the evaluation of the cleanup action alternatives within the FS, the PRGs are used.

Other values within the table presented provide the potentially relevant levels for comparison.

[a] Reporting limits from Table A-1, Round 3 Surface Sediment QAPP Addendum (Windward 2006) in dry weight on non-transformed data.

[b] PCB RLs reported in the QAPP are for individual Aroclors. Range of RLs for undetected values were queried from the RI database and represent RLs for undetected calculated total PCBs, not undetected values of individual Aroclors. Individual undetected Aroclors were not reported because they are not included in the calculation of total PCBs when other Aroclors are detected in the sample.

Table J-2c Relevant Site-Specific Risk-Based, Regulatory or Practicable Cleanup Levels for cPAH

Parameter	Sediment cPAH Concentration (µg/kg TEQ dw)	Measurement Basis	Basis
Natural background	15-155	UCL95 LDW-wide	RI
Practical quantitation level	6.3 – 20[b]	NA	RI QAPP RLs[a]
Range of anthropogenic background	100 – 300	UCL95 LDW-wide	PRGs (Table 4-29)
Lowest technically achievable concentration	200	UCL95 LDW-wide	Best professional judgment, Dredge residual analysis, BCM mid bed replacement value
Netfishing direct contact (1×10^{-6})	380	UCL95 LDW-wide	Human health risk assessment
Direct contact (beach play 1×10^{-5})	900	UCL95 tribal clamming areas	Human health risk assessment
Apparent Effects Threshold (Benzo(a)pyrene only)	1,600	Point	SMS
Direct contact (tribal clamming 1×10^{-5})	1,500	UCL95 tribal clamming areas	Human health risk assessment
Sediment quality standard (normalized to 2% oc as benzo(a)pyrene only)	1,980	Point	SMS
Minimum Cleanup Level in 10 years (normalized to 2% oc as benzo(a)pyrene only)	4,200	Point	SMS

Notes:

Shading indicates the practical considerations for the MTCA cleanup level. For the evaluation of the cleanup action alternatives within the FS, the PRGs are used.

Other values within the table presented provide the potentially relevant levels for comparison.

[a] Reporting limits from Table A-1, Round 3 Surface Sediment QAPP Addendum (Windward 2006) in dry weight on non-transformed data.

[b] All individual PAH compounds used in the cPAH calculation have an RL of 20 except for dibenzo[a,h]anthracene, which has an RL of 6.3. RLs reported for undetected values are based on calculated cPAHs and can be found in Table 4-26 of the RI.

BCM = bed composition model; LDW = Lower Duwamish Waterway; PRG = preliminary remediation goal; QAPP = quality assurance project plan; RME = risk management endpoint; RI = remedial investigation; RL = reporting limit; SMS = sediment management standards; UCL95 = 95th upper confidence limit of the mean concentration

Table J-2d Relevant Site-Specific Risk-Based, Regulatory or Practicable Cleanup Levels for Dioxins

Parameter	Sediment Dioxin Concentration (ng/kg TEQ dw)	Measurement Basis	Basis
Natural background	Not Yet Available	Reference Areas	RI
Practical quantitation level	1 – 10[b]	NA	RI QAPP RLs[a]
Range of anthropogenic background	5 – 10	UCL95 LDW-wide	PRGs (Table 4-29)
Lowest technically achievable concentration	7.5	Mean LDW-wide	Best professional judgment, Dredge residual analysis, BCM mid bed replacement value
DMMP interim interpretative criteria for open water disposal	8.7 – 12.2	Sample mean	EPA comments on SMAs 9/11/08
Direct contact (tribal clamming 1 x 10^{-6})	13	Mean tribal clamming areas	Human health risk assessment
Direct contact (beach play 1 x 10^{-6})	28	Mean beach areas	Human health risk assessment
Netfishing direct contact (1 x 10^{-6})	37	Mean LDW-wide	Human health risk assessment

Notes:

Shading indicates the practical considerations for the MTCA cleanup level. For the evaluation of the cleanup action alternatives within the FS, the PRGs are used.

Other values within the table presented provide the potentially relevant levels for comparison.

[a] Reporting limits from Table A-1, Round 3 Surface Sediment QAPP Addendum (Windward 2006) in dry weight on non-transformed data.

[b] Dioxins/furans TEQ RLs are based on those for the individual congeners used in the TEQ calculation. RLs for undetected values are in Table 4-30 of the Remedial Investigation.

BCM = bed composition model; LDW = Lower Duwamish Waterway; PRG = preliminary remediation goal; QAPP = quality assurance project plan; RME = risk management endpoint; RI = remedial investigation; RL = reporting limit; SMS = sediment management standards; STM = sediment transport model; UCL95 = 95th upper confidence limit of the mean concentration

Table J-3 Framework and Weighting of Factors in the MTCA Disproportionate Cost Analysis

Evaluation Criterion and WAC Citation	Benefit Weighting Percentages and Rationale	Rating Metrics Used
Protectiveness: WAC 173-340-360(3)(f)(i)	**30%:** Protectiveness has a high weighting because it represents the ultimate goal of the cleanup.	• Reduction in LDW-wide residual risk. • Time required to reduce risk from the issuance of the ROD. • On-site and off-site risks from alternative implementation. • Improvement of overall environmental quality.
Permanence WAC 173-340-360(3)(f)(ii)	**10%:** Permanence receives a low weighting value because of the limitations of treatment options for contaminated sediments. Treatment is not a major component of most alternatives; it offers only limited potential for volume reduction, does not destroy contaminants, and it generates additional waste streams.	Contaminant volume and concentration removal is the dominant metric for permanence. The potential contaminated sediment volume reduction through treatment is also considered.
Long-term Effectiveness: WAC 173-340-360(3)(f)(iv)	**25%:** This category receives a high weighting value because it addresses how well the remedy reduces risks and whether controls are adequate to maintain protection against exposures to contamination left in place in the long term.	• Reliability of the alternative during the period in which contaminants remain higher than cleanup levels. • Potential for exceeding PRGs after implementation. • Reliability of institutional and engineering controls. • Hierarchy of cleanup types.
Management of short-term risk: WAC 173-340-360(3)(f)(v)	**25%:** This category receives a relatively high weighting value because impacts to both human health and the environment are predictable and are of significant magnitude. While short-term risks are generally considered manageable, they may be significantly elevated compared to baseline risks over the duration of the construction period.	• Risks to the community. • Risks to construction workers. • Impacts to the environment. • Effectiveness of protective measures used to mitigate the risks.
Technical and Administrative Implementability: WAC 173-340-360(3)(f)(vi)	**10%:** This category receives a relatively low weighting value because it is not directly related to the goals of the environmental cleanup. Further, the alternatives are all considered to be implementable.	• Number of SMAs remediated. • Dredge footprint. • Cap or ENR area. • Reliability of achieving RAL. • Degree of complexity. • Level of monitoring required.
Consideration of Public Concerns: WAC 173-340-360(3)(f)(vii)	A weighting value will be assigned to this category in the ROD or CAP.	Will be evaluated in the ROD and/or CAP.
Costs (see Appendix I): WAC 173-340-360(3)(f)(iii)	This criterion is not weighted for the analysis of benefits, but is used to compare against the benefits in Figure J-1a.	Net present value; see Appendix I.

Notes:

CAP = corrective action plan; ROD = record of decision; SMA = sediment management area

Table J-4a MTCA Disproportionate Cost Analysis – Alternative Benefits Scorecard

Alternative Performance											Benefit Metric, Weighting Factor, and Descriptions of Sub-criteria Scored	
1	2	3a	3b	3c	3d	4a	4b	4c	4d	5		
4.7	**7.3**	**8.3**	**8.3**	**8.0**	**8.0**	**7.0**	**7.0**	**6.7**	**5.7**	**4.7**	**Overall Protectiveness of Human Health and the Environment**	**30%**
4	6	7	7	8	8	8	9	9	9	10	Reduction in degree of site-wide residual risk	
4	6	8	8	8	9	7	7	7	5	2	Time required to reduce risk/achieve RAO (as measured from the issuance of the ROD)	
6	10	10	10	8	7	6	5	4	3	2	On-site and off-site risks from alternative implementation	
4	**5**	**5**	**5**	**5**	**5**	**6**	**6**	**7**	**8**	**8**	**Permanence**	**10%**
4	5	5	5	5	5	6	6	7	8	8	Degree to which alternative permanently reduces toxicity, mobility, volume; reflecting the permenance benefit of increased sediment removal and disposal	
2.0	**4.5**	**5.5**	**5.5**	**6.3**	**6.3**	**7.3**	**7.3**	**7.8**	**8.0**	**8.8**	**Long-term Effectiveness**	**25%**
3	5	6	6	7	7	7	7	8	8	9	Degree of certainty that remedy will be successful	
2	6	6	6	6	6	8	8	8	8	9	Reliability of the alternative during the period in which contaminants remain higher than cleanup levels	
2	5	6	6	6	6	8	8	8	8	9	Reliability of institutional and engineering controls	
1	2	4	4	6	6	6	6	7	8	8	Hierarchy of cleanup and disposal methods	
5.0	**6.0**	**8.0**	**8.0**	**7.0**	**6.5**	**5.5**	**5.5**	**5.0**	**5.0**	**3.5**	**Management of Short-Term Risk**	**25%**
9	8	8	8	7	6	5	5	4	4	2	Implementation risks to community, workers, and the environment (based on quantities and transportation of sediment and materials and areas of disturbance)	
1	4	8	8	7	7	6	6	6	6	5	Effectiveness of protective measures during time to achieve RAOs	
9	**4**	**8**	**7**	**6**	**6**	**6**	**5**	**4**	**3**	**2**	**Technical and Administrative Implementability**	**10%**
9	4	8	7	6	6	6	5	4	3	2	Degree of technical complexity and administrative (legal, regulatory, and monitoring) requirements	

Notes:

1 = lowest; 10 = highest

Ratings shown are used for rankings in figures and total weighted benefit points (Table J-4b).

Categorical ratings for each alternative are averaged scores from each of the sub-criteria listed underneath the shaded headings.

MTCA = Model Toxics Control Act; RAO = remedial action objective; ROD = Record of Decision

Table J-4b Summary Findings of MTCA Disproportionate Cost Analysis

Analysis Parameters		Weighting Factor	Remedial Alternative 1	2	3a	3b	3c	3d	4a	4b	4c	4d	5
Net Present Value ($Million)			50	220	250	270	310	340	420	480	530	650	1280
Restoration Time Frames (RTF) For Implementation and MTCA and SMS Compliance													
Construction Period (years)			5	5	5	6	7	8	10	12	14	17	38
Implementation Time from Issuance of the ROD			5	10	10	11	12	13	15	17	19	22	43
RAO 1	RTF - Seafood Consumption 10^{-4} risk range[a]		13	12	13	14	15	16	18	20	22	25	46
	RTF - Background [b]		30-35	20 - 25	15-20	15-20	15-20	15-20	20-25	20-25	25-30	25-30	45-50
RAO 2	RTF - Cumulative Direct Contact 10^{-5} risk range		5	5	5	5	5	5	5	5	5	5	5
	RTF- Direct Contact - all PRGs [c]		35-40	20-25	10-15	10-15	10-15	10-15	15-20	15-20	15-20	20-25	35-40
RAO 3	% of Original SQS Point Exceedances Managed After 10 Years of Recovery[d]		87%	93%	95%	97%	99%	100%	95%	97%	99%	100%	100%
	RTF - SMS		>30	20-30	10-20	10-20	10-20	10-15	15-25	15-25	15-25	20-25	>30
RAO 4	RTF - Ecological (years) [e]		15-20	15-20	10-15	10-15	15-20	15-20	20-25	20-25	20-25	25-30	45-50
Compliance w/ MTCA Threshold Criteria			No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Relative Benefits Ranking for MTCA Disproportionate Cost Analysis		**Weighting Factor**			(See Scoring on Table J-4a)								
Overall protectiveness		30%	5	7	8	8	8	8	7	7	7	6	5
Permanence		10%	4	5	5	5	5	5	6	6	7	8	8
Long Term Effectiveness		25%	2	5	6	6	6	6	7	7	8	8	9
Short Term Risk Management		25%	5	6	8	8	7	7	6	6	5	5	4
Implementability		10%	9	4	8	7	6	6	6	5	4	3	2
Consideration of Public Concerns[f]		—	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Costs[g]		—	10	8	8	8	7	7	6	6	5	4	2
Weighted Benefit Points[h]			4.5	5.7	7.2	7.1	6.8	6.7	6.5	6.4	6.3	6.1	5.5
Cost/benefit (normalized)			0.5	1.6	1.5	1.6	1.9	2.2	2.8	3.2	3.6	4.6	10.0

Notes:

[1] Estimated times required to achieve RAOs combine construction time frames and BCM predicted times to reach RAO-associated preliminary remediation goals (in years after issuance of ROD).

[a] Time to reach a seafood consumption risk of 10^{-4} for the Adult Tulalip RME scenario for total PCBs includes 3 years after active remedation to accommodate tissue recovery following the acute impacts of dredging. Risk

[b] Approximate time frame for sediment concentrations (total PCBs UCL95) to reach the upper end of the background range, as modeled using the mid-range BCM input parameter values.

[c] The cumulative direct contact risk applies to the site-wide (netfishing) exposure scenario as well as potential tribal clamming areas and individual beaches. Alternative 2 is above the background PRG for cPAHs for beach 6 after remedy construction.

[d] See Table 9-2b for numbers of points and associated areas managed after 10 and 30 years. Some recontamination may occur, and is not included in this analysis.

[e] Time to reach a total PCBs concentration in surface sediments in the range of 128 to 159 µg/kg total PCBs, which is protective of river otters and other ecological receptors.

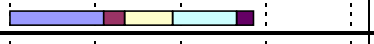
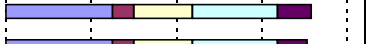
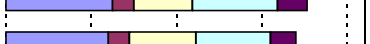
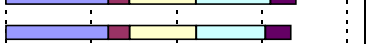
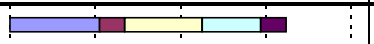
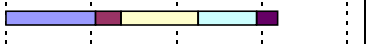
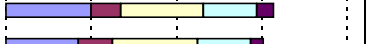
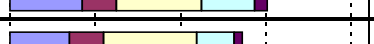
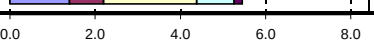
[f] Consideration of public concerns is not specifically evaluated in the FS. It will be evaluated for the ROD.

[g] Costs are not included in benefits points or ranking. They are used for the cost/benefit ratio and determination of disproportionate cost only.

[h] Total weighted benefit points is the sum of the weighted totals of each category.

MTCA = Model Toxics Control Act; NE = not evaluated; PRGs = preliminary remediation goals; ROD = record of decision; RTF = restoration time frame; SMS = sediment management standards
SQS = sediment quality standards

Table J-5 Cleanup Action Alternative Analysis: MTCA Ratings Compared with CERCLA Evaluations

Alternative	Costs (Present Value)	Weighted Ratings Under MTCA	CERCLA Evaluation of Alternatives[b]							
		Total Benefits by Criteria[a]	Overall Protection of Human Health and the Environment	Compliance with ARARs	Reduction in Toxicity, Mobility & Volume through Treatment [c]	Long-Term Effectiveness	Short-Term Effectiveness	Implementability	Cost	State/Tribal and Community Acceptance
1	$50 M		●	●	●	●	◒	◎	◎	TBE
2	$220 M		○	◎	●	○	○	◒	◎	TBE
3a	$250 M		◎	◎	●	◒	◎	◎	◎	TBE
3b	$270 M		◎	◎	●	◒	◎	◎	◎	TBE
3c	$310 M		◒	◎	●	◒	◒	◒	◒	TBE
3d	$340 M		◒	◎	●	◒	◒	◒	◒	TBE
4a	$420 M		◒	◎	●	◎	○	◒	○	TBE
4b	$480 M		◒	◎	●	◎	○	○	○	TBE
4c	$530 M		○	◎	●	◎	◒	○	◒	TBE
4d	$650 M		○	◒	◒	◎	◒	◒	◒	TBE
5	$1280M		◒	◒	●	◎	●	●	●	TBE

Notes:

[a] See Figure J-1b for detail.

[b] Ratings based on rankings shown in Table 10-1.

[c] Treatment is only a component of Alternative 4d, which uses soil washing technology.

◎ - Ranks very high compared to other Alternatives
◒ - Ranks relatively high compared to other Alternatives
○ - Ranks average compared to other Alternatives
◒ - Ranks low-moderate compared to other Alternatives
● - Ranks low compared to other Alternatives

ARARs = Applicable or Relevant and Appropriate Requirements; CERCLA = Comprehensive Environmental Response Conservation and Liability Act
MTCA = Model Toxics Control Act; TBE = To be evaluated later in the FS, ROD and CAP process

Figure J-1a Disproportionate Cost Analysis: Cleanup Alternatives Total Benefits and Costs

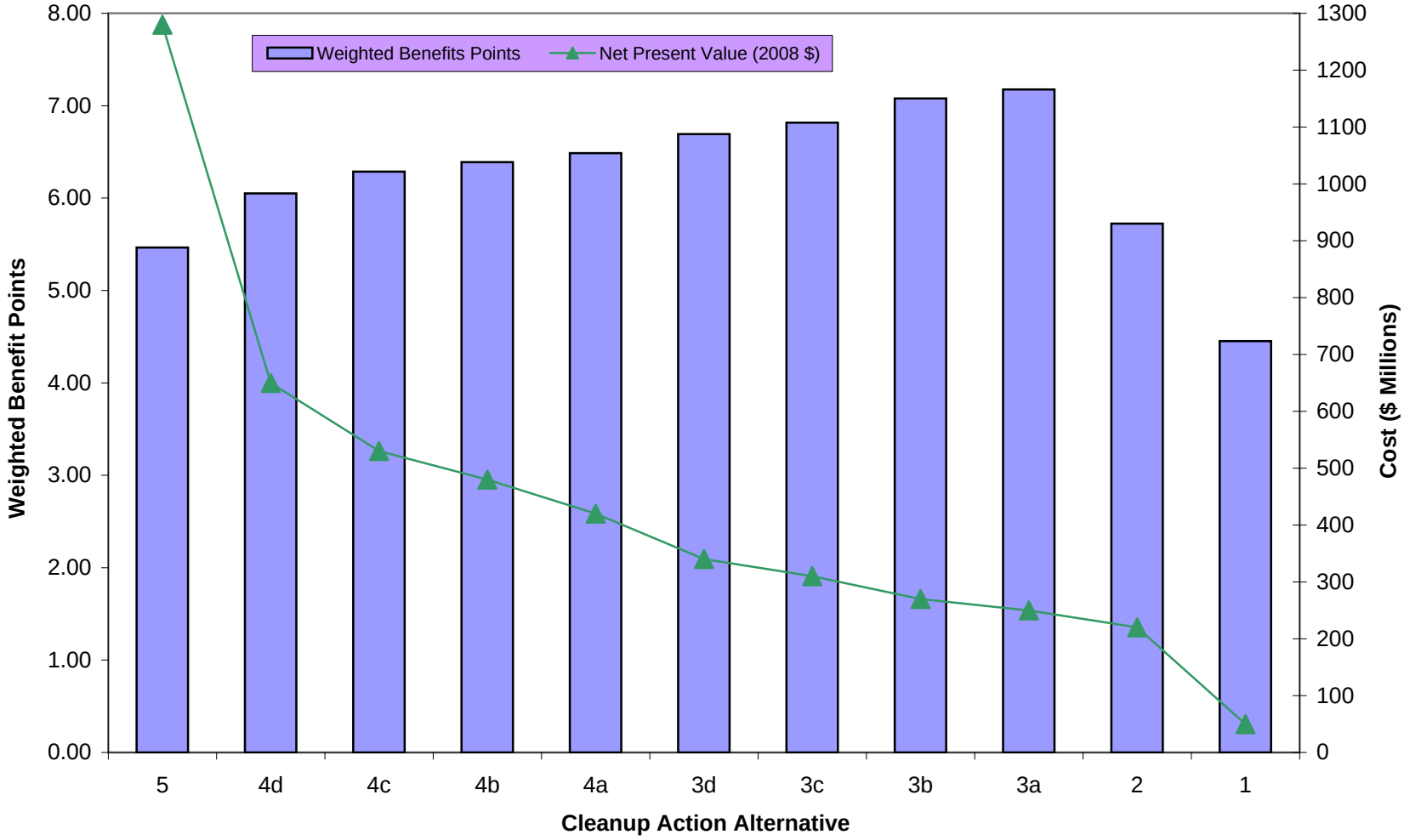


Figure J-1b Disproportionate Cost Analysis: Weighted Benefits by Criteria

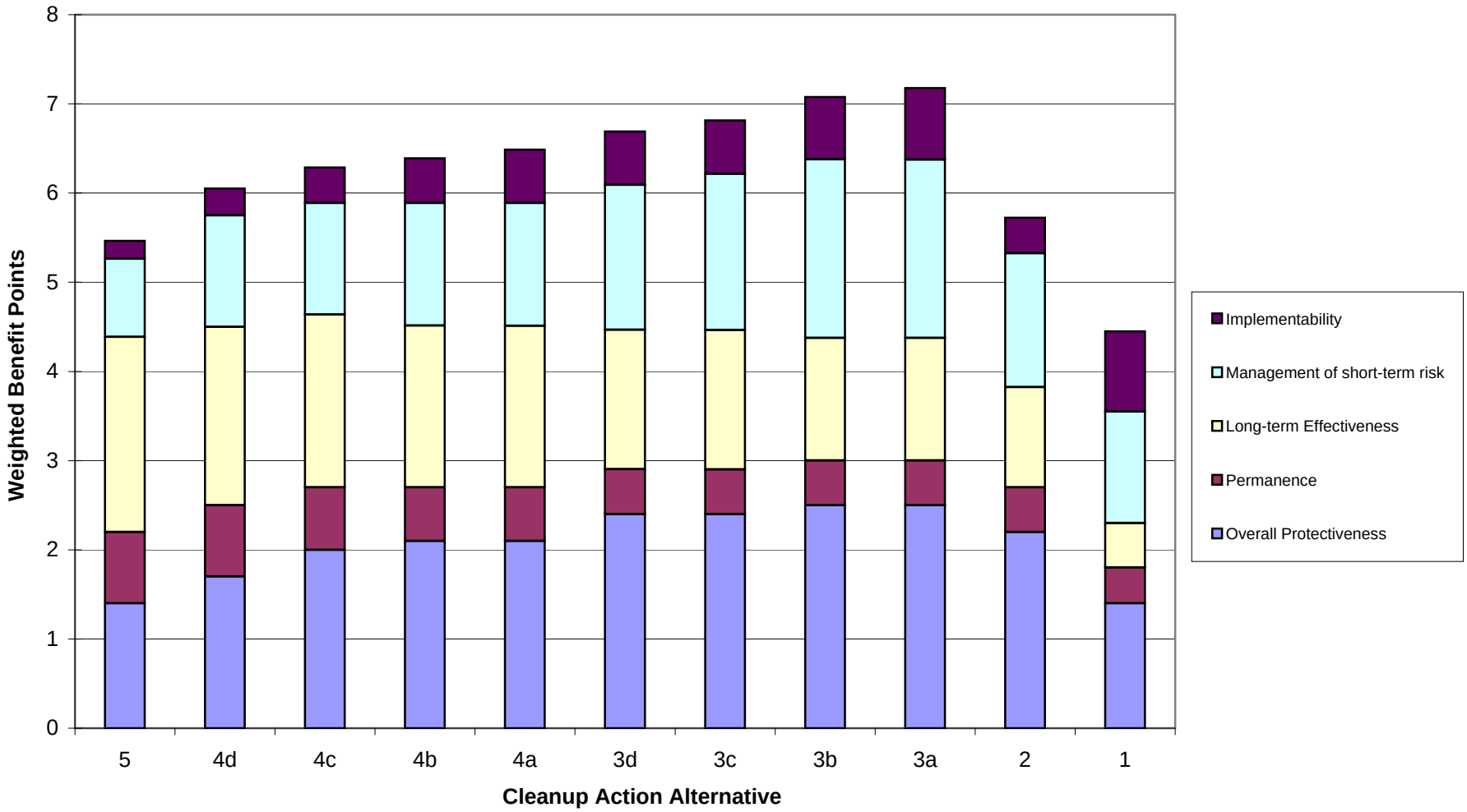


Figure J-2 DCA: Costs/Benefits of Alternatives and Disproportionality of Alternative 5

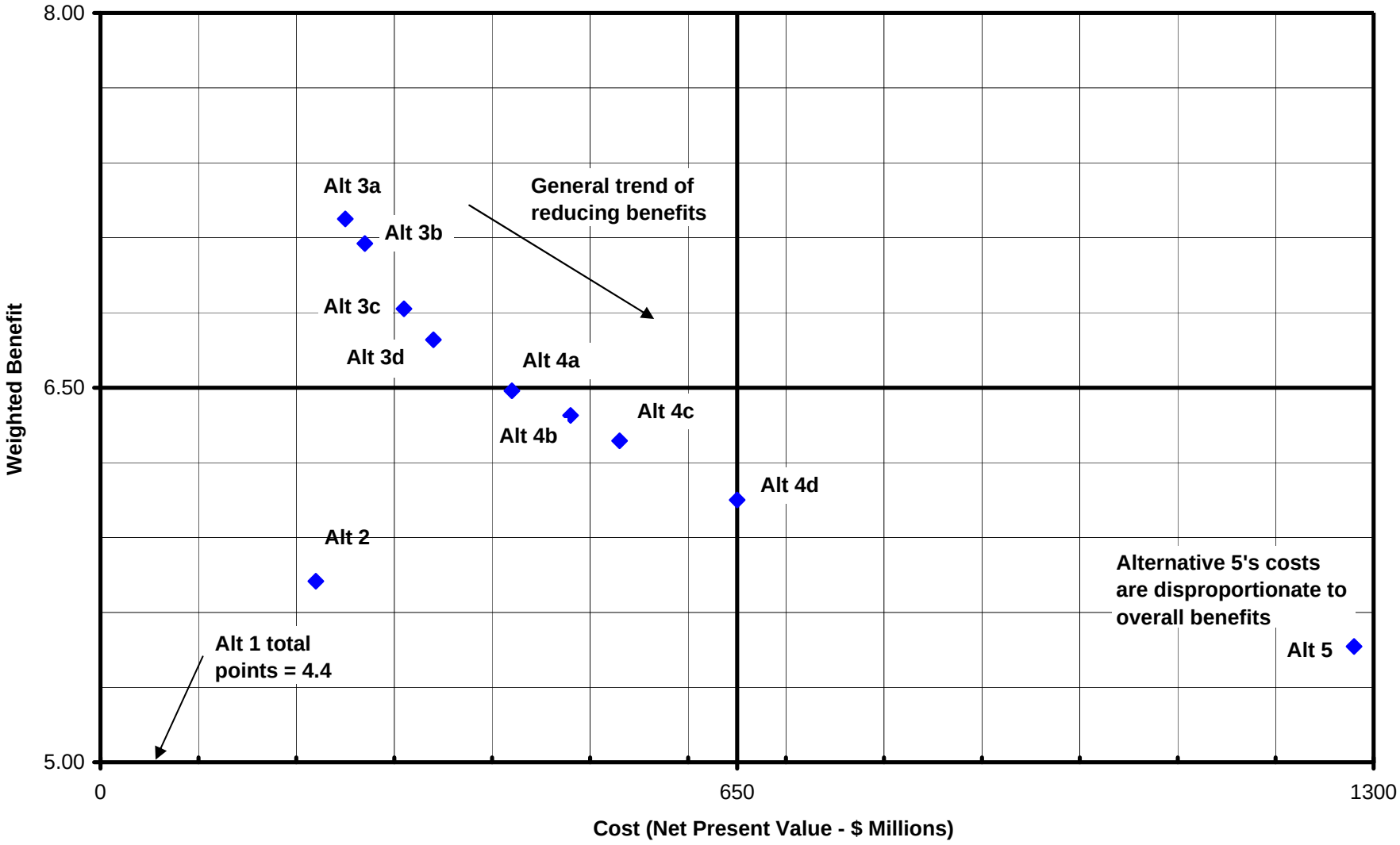


Figure J-3 DCA: Years Required for Implementation Are Not Proportional to the Benefits