Columbia River Channel Improvement Project Adaptive Environmental Management Plan

prepared by

Steven M. Bartell
Shyam K. Nair

E2 Consulting Engineers, Inc.
339 Whitecrest Drive
Maryville, TN 37801

for the

U.S. Army Corps of Engineers
333 SW First Avenue
Portland, OR 97204-3495

March 2006

Acknowledgement

The development of the Columbia River Channel Improvement Project Adaptive Management Plan reflects the valued discussion, contributions, and review provided by members of the Adaptive Management Team, including K. Larson, M. Cook, L. Hicks (Corps of Engineers), C. Tortorici (NMFS), G. Smith (FWS), D. Perry (Sponsor Ports), R. Randall, C. Donoghue (Washington DOE), A. Lut (Oregon DEQ), D. Blanton (Oregon DLCD). Comments and discussions with E. Casillas (NMFS), A. Baptista (OHSU), and W. Pearson, and M. Miller (Battelle PNL) also contributed to the Plan and are sincerely appreciated. The CRCIP AEM Plan described in this report was developed under contract W9127N-05-F-0062 between the U.S. Army Corps of Engineers and E2 Consulting Engineers, Inc.

Table of Contents

List of Figures

List of Tables

Executive Summary

Adaptive Environmental Management

Part 1 of this document describes a strategic approach to adaptive environmental management (AEM) for the Lower Columbia River (LCR) and estuary. Adaptive management prescribes an iterative management process wherein management activities can be changed in relation to their efficacy in restoring and/or maintaining an ecological system in some desired range of conditions. A key component in AEM is the establishment of a feedback mechanism whereby monitoring can be used in combination with an understanding of the ecosystem to alter management actions, if necessary, to obtain future system conditions compatible with the desired conditions and/or to avoid or minimize undesired effects.

Decisions made within the context of AEM are often based on incomplete data and imperfect scientific understanding. Importantly, AEM provides a decision-making process that can adjust management actions on the basis of newly acquired science and monitored responses of performance measures to previous management actions. This iterative process can increase the likelihood that management goals and objectives (e.g., ecosystem restoration, sustainability) will be achieved.

There are three ways to conduct adaptive environmental management: (1) evolutionary (trial and error), (2) passive adaptive, and (3) active adaptive management. Evolutionary AEM attempts to achieve desired conditions through educated guesses and accumulated knowledge of system response to previous management activities. Passive AEM modifies management actions in response to changes in monitored conditions observed over the "natural" range of managed perturbations to the system. Active AEM involves purposeful manipulations of the system to increase understanding of system behavior and to achieve management goals and objectives. Active AEM can involve trade-offs between short term gains in understanding that must be weighed against the probability that manipulations might produce undesired and irreversible changes in ecosystem conditions.

Fundamental to AEM is the specification of desired conditions for valued resources in the system(s) of interest. In complex and dynamic ecological systems, it may be more realistic to define the ranges (or distributions) of acceptable values for each system attribute. AEM can then operate to create and maintain similarity between the current and desired variability in system conditions.

The strategic Plan for AEM is designed to be consistent with the guidance provided in 65 Federal Register (FR) 35242. This FR document identifies specification of alternative management actions, addressing uncertainties, and the establishment of critical feedback mechanisms between monitoring results and subsequent management actions as necessary features of AEM. Based on 65 FR 35242 and items specified in the National Oceanic and Atmospheric Administration terms and conditions [National Marine Fisheries Service

(NMFS) 2005, 2002], this proposed AEM Plan emphasizes the following components: management goals and objectives, a management and decision-making process, identification of existing and proposed monitoring actions (MA), identification of models that may prove useful in assessing outcomes of management decisions, a methodology for examining uncertainties, opportunities for stakeholder input, and overall transparency of the AEM Process.

The vision implied in the proposed Channel Improvement AEM Plan emphasizes the direct management of potential physical-chemical impacts associated with channel deepening. Importantly, the proposed AEM Process can contribute to the development of a comprehensive adaptive management effort ultimately focused on enhancing the survival, growth, and ocean entry of juvenile salmonids that utilize the LCR and estuary.

Adaptive Management for the Channel Improvement Project

Part 2 of the report addresses the specific design and implementation of an AEM Plan and Process in support of the Columbia River Channel Improvement Project (CRCIP). Provisions for implementation are primarily based on the CRCIP, Final Supplemental Integrated Feasibility Report (FSIFR) and Environmental Impact Statement (EIS) (FSIFR/EIS, January 2003), the NMFS Biological Opinion (BO) (February 2005, May 2002), and the Section 401 Water Quality Certification issued by the Oregon Department of Environmental Quality and Washington Department of Ecology (June 2003). The primary purpose of the AEM Plan and its implementation is to manage the channel improvement project in an adaptive manner to avoid or minimize physical-chemical impacts in relation to channel deepening in the LCR and estuary. Adaptive management directed at habitat, food webs, ecological production, juvenile salmonids, and other species defines a second level of management to be pursued if channel deepening results in demonstrated impacts to the physical-chemical characteristics. Importantly, the AEM Process will evaluate the effectiveness of compliance measures, MA, and research to ensure that project construction, operation, and maintenance have impacts no greater than those described in the Biological Assessment or the BO (NMFS 2005, 2002).

The recommended plan (1999 FSIFR/EIS) indicated that dredging would be limited to selected areas from Columbia River mile (CRM) 3, near the mouth of the river, to CRM 106.5, near the I-5 Bridge in Portland. The revised study area includes the bank-to-bank run of the Columbia River from Bonneville Dam to the river mouth and extending in a fan shape 12 miles into the Pacific Ocean. The study area divides the run of the river into three reach types: riverine (Bonneville Dam to CRM 40), estuarine (~CRM 40 to CRM 3), and river mouth (CRM 3 to outer boundary of the Deep Water Site). The study area also includes sites for upland disposal or dredged materials, ecosystem restoration, and wildlife mitigation.

The proposed Channel Improvement AEM Process will focus on short- and mid-term management actions and system responses. The MA will include two years of measurements prior to construction, two years during construction, and a third year following the end of construction. The periods of pre-construction and construction correspond to the near- (0–5 years) and mid-term (5–10 years) timeframes identified in the BO (NMFS 2005, 2002). Emphasis will be on near-term physical impacts of channel improvement. Mid-term management actions may include the use of monitoring and research results to establish mid-term trends in the physical aspects of the systems and potentially other resources of concern, depending on the results of the near-term system responses to channel improvements. The long-term actions include years 10 and beyond. At this scale, trend analysis could be used to assess ecosystem impacts of channel improvement.

The Adaptive Management Team

The organizational structure for the Project consists of the following: (1) the formal Adaptive Management Team (AMT), and (2) a less formal technical support group. The AMT comprises the managers, decision makers, and technical staff ultimately responsible for initiating, carrying out, and sustaining the AEM Process. The organizational structure also encourages interactions with the scientific and technical community, as well as concerned stakeholders.

The AMT technical support group serves as a primary source of technical support to the AMT. The group comprises professionals that primarily have other duties and responsibilities, but would be available as necessary to assist the AMT. The AMT can also establish subcommittees for the purposes of compiling information, performing analysis, discussing issues, and reporting to the AMT. Subcommittees would reasonably consist of physical and chemical oceanographers. Fisheries biologists, ecosystem scientists, environmental toxicologists, risk analysts, and hydrologic engineers could be consulted as needed.

To facilitate adaptive management, the AMT regularly receives information from the technical support group that describes current conditions and trends for selected Project performance measures or risk endpoints. Based on deliberations that may draw upon technical inputs of the support group, as well as advice solicited from the general scientific community and other appropriate sources, the AMT will recommend any necessary changes in the conduct of the Project in order to achieve and maintain the Project AEM goals and objectives.

Stakeholder Participation

The AEM process benefits from active participation by invested stakeholders. The AEM Plan underscores the key role played by the Corps of Engineers. The Plan also identifies federal (NMFS, USFWS) and state (Washington, Oregon) agencies, as well as the Sponsor Ports as principal partners in the AEM Process. The Tribes and interested public can also become actively involved in the Project’s adaptive management process (Appendix B). The nature of participation can be largely determined by the various responsibilities (e.g., legislative mandates), economic concerns, and public welfare interests of the stakeholders.

The important point is that the AEM Process is designed to be open and transparent in addressing the concerns of a broad base of Project stakeholders.

The risk-based decision framework for AEM provides for documentation of the management and decision-making process. The framework includes identification of the decision alternatives and criteria for selecting among management alternatives. The specific data, information, and model results used to support particular decisions will be recorded. The uncertainties associated with the sources of information entering into each decision analysis will be characterized along with an evaluation of the risks implied by each decision alternative. Documentation of the AEM Process and making this information readily available will further demonstrate the transparency of the process to stakeholders and the interested public. Documentation approved by the AMT will be posted on the CRCIP internet site (www.nwp.usace.army.mil/issues/CRCIP), which is configured to accept comments concerning various aspects of the Project.

CRCIP Adaptive Management Process

Seven steps outline the AEM Process for the Channel Improvement Project:

1. Results of the ongoing monitoring programs, ecosystem evaluation actions (EEA), and research are summarized and reported on a quarterly basis.

2. The results of monitoring programs, EEA, and relevant research are collated and analyzed by the technical support group.

3. The technical support group advises the AMT concerning any performance measures or risk endpoints that exceed the decision criteria.

4. If none of the decision criteria are exceeded, the AEM Process can simply continue with the current monitoring programs until the next evaluation is performed (i.e., Step 1).

5. If decision criteria are exceeded, the AMT requests the USACOE to develop a mitigation or management Plan intended to redress the Project impacts indicated by the monitoring results.

6. Based on the USACOE Plan, the AMT can recommend continuation of the current management practices or adaptations of current practices.

7. Following resolution of the AMT recommendations, the AEM Process continues by cycling back to step 1.

Performance Measures and Risk Endpoints

Performance measures define desirable ecosystem responses to management actions (e.g., dredging). Risk assessment endpoints define complementary undesirable ecosystem responses that might result from such actions. AEM is an iterative process that tracks changes in performance measures and risk endpoints and modifies management actions accordingly.

The principal Project performance measures or risk endpoints include changes to depth, temperature, and salinity. The underlying hypothesis is that the channel deepening will not significantly alter the physical or chemical conditions of the lower river and estuary. Potential Project impacts on sturgeon, smelt, and Dungeness crab are also of concern and are addressed in the AEM Plan.

Monitoring Actions and Decision Criteria

A credible monitoring program provides the necessary data to describe current conditions and outcomes of EEA undertaken as part of the Project. The monitoring effort is an essential component in developing the feedback between management actions and system response necessary for adaptive management. The necessary data will be provided by USACOE MA A-1 through MA-6.

Values of the performance measures/endpoints have been selected as initial decision criteria for use in implementation of the AEM Plan. (Appendix D details the development of these criteria). Comparisons of pre-project, construction, and post-construction data with the decision criteria will be used to evaluate Project impacts. Monitoring results that are at variance with the decision criteria can “trigger” adaptive management in accordance with the Plan. Importantly, the effectiveness of the decision criteria in supporting the AEM Process will be evaluated in relation to AEM goals and objectives during the Project. Criteria can be modified if they prove overly conducive to false positive or false negative assessments of Project impact.

The initial decision criteria for water depth, salinity, and temperature derive from statistical analysis of available CORIE monitoring data (1996–2004) and USACOE-sponsored MA-1. MA-1 will continue the monitoring for three CORIE stations: red26, grays, and cnbc3. The AMT will review newly collected monitoring data in relation to (1) a tabular summary of 20- and 80- percentiles of estimated monthly median values, (2) a similar table of 5- and 95-percentile values, and (3) for water temperature, plotted relationships between daily median temperatures for a reference location (woody) and the corresponding values for the three MA-1 stations.

MA-2 will provide annual dredging volumes associated with construction and operation of the 43-foot channel. Volumes will be reported for each dredging bar (~3-mile reaches). Volumes of dredged materials will be compared to projected values. This MA will continue through the Project duration. The decision criterion for dredging volume is whether or not actual volumes of dredged materials exceed the volumes proposed in development of the CRCRIP. The percent exceed will be determined by accuracy and precision associated with estimation of the volume of dredged materials. An initial exceedance value of 15% is under review by the AMT. In addition, adaptive management might be initiated if the volumes of dredged materials exceed the capacity for their disposal.

MA-3 will examine accretion and erosion in the main channel in relation to the channel deepening. Navigation channel surveys from CRM 3 to CRM 106 will be conducted annually (between December and February) for two years prior to construction, two years during construction, and three years after construction. The surveys will estimate minimum, maximum, mean and median depth across the channel, standard deviation and coefficients of variation will also be calculated. The consensus AMT decision criteria for MA-3 are defined as an "envelope" calculated as the minimum surveyed depth +1 standard deviation and the maximum depth +1 standard deviation. The envelope is defined across the channel for each survey with particular emphasis on the northern and southern boundaries of the navigation channel.

MA-4 will augment estuary habitat surveys being conducted by NMFS as part of the Anadromous Fish Evaluation Program. The surveys will be conducted three years after construction to determine if changes in habitat result from the channel deepening. The surveys will assess tidal marsh, swamp, flats, and deep-water habitats and will also address habitat complexity, connectivity, and conveyance. Habitat-specific food availability will be estimated along with the use of peripheral areas by juvenile salmonids. Threshold values that define unacceptable change (i.e., decision criteria) will be defined for each habitat type. Measured changes that exceed any of the decision criteria can trigger adaptive management.

MA-5 will review sediment chemistry data to evaluate the potential impacts of channel deepening on the exposure of aquatic organisms to toxic contaminants. MA-5 will ensure that channel construction and maintenance does not disturb undetected deposits of fine-grained material, potentially causing redistribution of contaminants that could pose a risk to species of concern. The AMT technical support group will annually review any new sediment chemistry from the LCR and estuary. The SEDQUAL database will play an important role in this continued review and evaluation. A new Sediment Evaluation Framework (SEF) is projected to be in place by September 2006. The SEF largely addresses the sediment contaminants of interest to Washington, Oregon, and Idaho. The decision criteria for MA-5 will be made based on the final SEF.

MA-6 addresses the potential impacts of channel improvements on fish stranding by commercial navigation on the lower river and estuary. The proposed decision criterion is based on a comparison of pre- and post-project numbers of stranded fish and associated estimates of the probability of fish stranding. An increase in the probability of fish stranding following channel improvements can initiate the adaptive components of the AEM Plan. In addition to potentially changing the frequency of fish stranding events, channel modifications might alter the susceptibility of different fish species to stranding. Susceptibility to stranding can also serve as decision criteria for fish stranding in the AEM Plan.

Sturgeon, Smelt, Dungeness Crab, Sediment

Decision criteria are being developed to assess potential impacts of channel modifications on sturgeon, smelt, and Dungeness crab. The decision criteria for these resources are defined mainly as administrative constraints defined by the states of Oregon and Washington. These criteria are evaluated in the AEM Process as issues of compliance rather than as flexible or adaptable criteria.

Criteria to protect sturgeon address the possible Project impacts on the mortality, movements, feeding behavior, and habitat utilization of these fish in relation to the dredging process and the disposal of dredged materials. The results of previous studies of monitored individual sturgeon suggest that the dredging process or the disposal of dredged materials does not measurably affect these fish. The derivation of decision criteria for sturgeon is continuing with the analysis of preferred habitats and the potential impacts of channel dredging on these habitats.

Decision criteria to minimize channel improvement impacts on smelt (Eulachon) take the form of depth constraints (43 ft.) on flow lane disposal for specified river miles (e.g., between CRM 35 and CRM 75). Particular attention will be paid to in-water disposal, which is not permitted between the eighth and 20th weeks of the year (out migration) throughout CRM 35-75. In-water disposal of dredged material will not occur in areas shallower than 43-feet between CRM 35 and CRM 75 along the Washington shoreline. Depths determined in the pre-construction bank-to-bank bathymetry data supplemented by additional channel bathymetry measures define these areas. If in-water disposal is essential during the period of peak out migration, then the Corps shall further study the potential for smelt losses as a result of dredged material disposal impacts. Appropriate mitigation measures shall be developed based on the study outcomes as part of the adaptive management process.

The objectives of the AEM Plan concerning Dungeness crab are to avoid or minimize crab entrainment mortality and crab burial by disposal of dredged materials. Field studies were undertaken from 2002 through 2004 to estimate the numbers of crab entrained and killed by the dredging process, and to develop a model that predicts crab distribution as a function of salinity in the estuary. Entrainment studies were performed at the mouth of the Columbia River, Desdemona Shoals, Upper Sands, Miller Sands, and Flavel Bar. Estimates of entrainment rates and projected volumes of construction dredging were used to estimate numbers of entrained crabs. These entrainment mortalities were extrapolated to an expected number of lost future adults and losses to the crab fishery. These results will be used as AEM decision criteria to assess crab entrainment in relation to channel modifications. The salinity model identifies 16 practical salinity units (psu) as the value below which crab abundance markedly decreases. Characterization of the spatial-temporal distribution of water >16 psu can be used to estimates crab abundance throughout the estuary. The salinity model can be used to estimate the implications of alterations in salinity attributed to channel modifications on the distribution of crab. The model can complement MA aimed at assessing entrainment of crabs during dredging, as well as potential burial of crabs by flowlane disposal of dredged materials.

Concerns have been expressed by the AMT about the potential for the disposal of Project dredged materials to impact valued coastal zone habitats. To address these concerns, the Corps is pursuing a regional sediment management program that encompasses the Channel Improvement Project and other Columbia River navigation projects. Consistent with this sediment management program, higher priority will be given to development of near shore sites where disposal of dredged materials can effectively contribute to the littoral zone sediment budget. Accordingly, when near shore sites are available, they will be given priority over estuarine in-water disposal and deepwater ocean disposal to minimize potential dredged material disposal impacts to coastal zone resources.

Ecosystem Evaluation Actions

The results of six EEA (EEA-1 through EEA-6) can provide useful information in support of the AEM Process. These evaluation actions were developed to further assist the Corps, NMFS, and the USFWS in advancing the basic understanding of the LCR ecosystem. In general, the evaluation actions will address indicators of the salmonid conceptual model and advance the knowledge base for conservation and recovery of salmonid species. Several actions will provide quantitative information describing habitat parameters including bathymetric information for listed evolutionary significant units. The corresponding studies will focus on tidal marsh, shallow water flats, and water column habitat. Other evaluation actions derive from concerns of sublethal effects of contaminants on fish growth, disease and resistance, for juvenile salmonids and their prey. The individual EEA include:

- EEA-1 will generate additional information on salmonid habitat distribution in the estuary. Transects will be surveyed and analyzed in a manner similar to NMFS studies currently underway to characterize salmonid habitat utilization. Data will be obtained prior to construction and three years after Project completion.

- EEA-2 will ascertain the use of tidal marsh habitat by cutthroat trout. Juveniles of this species develop in the estuary for extended periods of time compared to other anadromous fish. In addition to previous efforts, more data will be collected for one year of prior to construction and for two years of following construction.

- EEA-3 includes a bank-to-bank hydrographic survey of the estuary. The survey will provide valuable information describing the bathymetry of the estuary and shallow water-flat habitat.

- EEA-4 addresses contaminant issues in juvenile salmonids and their prey. One year of preconstruction data will be collected. Additional contaminant data will be collected during construction and three years following construction.

- EEA-5 will assess the possible sublethal impacts of contaminants on juvenile salmonid growth and survival.

- EEA-6 centers around an "Estuary Turbidity Maximum Workshop." The purpose of the workshop is to increase understanding of the estuary turbidity maximum (ETM) and develop effective management actions to conserve the ETM.

Data produced by these actions will be collated and provided to the AMT to (1) determine the possible need for alteration of the Project actions (i.e., dredging), and (2) assess the value of information provided by the actions in relation to management and decision making. Importantly, the results of these studies may assist in the analysis and interpretation of monitoring data. These studies might also provide critical information for the development and implementation of environmental/ecological models used in support of adaptive management.

Uncertainty

The proposed AEM Plan is an example of risk-based decision making or decision making under uncertainty. Risk-based decision making takes into account the uncertainties that arise from natural variability and imperfect knowledge. Uncertainty can confound the decision-making process by eroding confidence in accurately selecting among alternative management actions.

Sources of uncertainty fall into three broad categories: natural variability, knowledge uncertainty, and decision model uncertainty. Natural variability refers to the inhomogeneous properties of natural materials, such as soils and sediments, and the range and relative frequency of events, such as rainfall or stream flow. Managers can minimize the effect of uncertainty by recognizing the presence of natural variability in ecosystems and defining management objectives probabilistically, as risk endpoints. Gathering more and better information cannot reduce natural variability.

Knowledge uncertainty reflects deficiencies in understanding of ecosystems and factors that affect them. If knowledge uncertainty is high, it might not be possible to distinguish the effect of one management alternative from another with an acceptable degree of certainty. Gathering more information and better data can reduce knowledge uncertainty.

Uncertainties associated with management and decision-making should be identified and characterized. The implications of these uncertainties on projected decision outcomes and risks should be quantified. The expected effects of channel improvement on achieving desired ecosystem conditions or incurring risks of adverse impacts will be estimated using relationships between the variables manipulated through management actions and the selected performance measures and assessment endpoints. Each of the manipulated variables is a source of uncertainty. These uncertainties, along with natural variability will be described, quantified, and where possible used to estimate decision outcomes and risk.

Comprehensive Adaptive Management in the Lower Columbia River

The proposed AEM Plan is designed to focus initially on potential physical-chemical impacts of channel deepening. It is also recognized that these attributes, while of fundamental environmental importance, represent a subset of the components of a more comprehensive conceptual model of the lower river and estuary. The CRCIP AEM Plan can contribute valuably to the future development and integration of a comprehensive adaptive management plan for the LCR and estuary. Data and information generated by the MA, EEA, and research performed during the course of Project management can be shared among other agencies and stakeholder groups involved in other AEM Projects. This sharing can help in the development of a more comprehensive ecological understanding of the river and estuary ecosystem. Cooperation among ongoing (and future) AEM Projects will be required to achieve the desired goals concerning recovery and sustainability of the valued salmonid resources in the LCR and estuary.

Part 1. Strategic Plan

1-1 Introduction

Part 1 of this document describes a strategic approach to adaptive environmental management (AEM) for the Lower Columbia River (LCR) and estuary. The development of the strategic Plan for the LCR and estuary was based in part on existing AEM Plans for other major ecosystems including the Florida Everglades, the Chesapeake Bay, the Upper Mississippi River, and Glen Canyon. Part 1 begins with a brief overview of adaptive management. The discussion continues by describing the necessary components of an AEM Plan in the context of the management goals and objectives associated with Columbia River Channel Improvement Project (CRCIP). The proposed AEM Plan and Process for the LCR and estuary are developed in the context of decision analysis and risk assessment.

Part 2 of this report presents a proposed AEM Plan developed specifically to address environmental issues related to Channel Improvement Project. The AEM Plan is developed in the context of engineering control theory. Part 2 presents the details of implementing the strategic Plan outlined in Part 1. Central to the proposed Plan and process is the establishment of the necessary feedback mechanisms that inform management and decision-making through comparisons of current conditions with decision criteria for selected performance measures and risk endpoints. Part 2 also describes the proposed MA and ecosystem evaluation actions (EEA) as providing the fundamental information base for establishing the feedback that characterizes adaptive management and decision-making. Part 2 discusses possible technical and organizational barriers to adaptive management and outlines potential solutions to overcome them. Part 2 concludes by considering the contribution of the proposed Channel Improvement AEM Plan to a more comprehensive adaptive management program that could be designed for the LCR and estuary.

The AEM Plan describes a process for adaptive management regarding channel modifications performed under the CRCIP. This Plan is not a decision-making document; however, it describes a process for decision-making within an adaptive management framework. Outcomes of the adaptive management process are not intended to compromise the legislative mandates or authorities of the participating federal or state agencies; their authorities shall prevail as applicable.

Adaptive Management

As implied by the term, “adaptive management” prescribes a management process wherein management activities can be changed in relation to their efficacy in restoring and/or maintaining an ecological system in a specified desired state or ecological potential (Gunderson and Holling 2002). Desired state may specify some precisely defined structural condition or, more realistically, a range of structural conditions, desired state can also specify rates of ecological processes or some description of biotic potential (e.g., energy capture and processing or production). A key component in AEM is the establishment of a feedback mechanism wherein characterization of current conditions (monitoring) can be used in conjunction with an understanding (model) of the system dynamics to alter management actions, if necessary, to produce future system conditions compatible with the desired conditions that derive from management goals and objectives.

AEM is an iterative process for managing natural resources (Gunderson and Holling 2002, Gray 2000, Walters 1986, Holling 1978). AEM recognizes that decisions are often based on the best available, yet incomplete and imperfect, scientific data, information, and understanding. Competing interests and constraints on time and resources can further complicate the management and decision-making process. Under these circumstances, there is no best approach to decision-making (Anderson et al. 2003). Importantly, AEM provides a decision-making process that can adjust management actions based on newly acquired science and monitored responses of performance measures in relation to previous decisions. This iterative process can increase the likelihood that management goals and objectives (e.g., ecosystem restoration, sustainability) will be achieved.

Walters (1986) offers three ways to structure environmental management as an adaptive process: (1) evolutionary (trial and error), (2) passive adaptive, and (3) active adaptive. Evolutionary AEM defines a management approach that attempts to achieve desired conditions through educated guesses and accumulated knowledge of system response to previous management activities. The benefits of this largely trial and error approach include comparatively low costs in implementation. The main drawback is the potentially low effectiveness in achieving management goals and objectives. Another negative aspect of this approach is the informal and minimal investment in gaining an understanding of system dynamics as the result of management.

Passive AEM describes a management approach that uses current understanding of the system to change management actions in response to monitoring conditions that change as a result of the "natural" range of perturbations to the system. An advantage of passive AEM is learning to manage effectively by monitoring system conditions (including patterns of disturbance), undertaking management actions in light of current understanding, and determining the utility of the management actions in relation to obtaining conditions consistent with management goals and objectives. One limitation of this approach lies in developing management capabilities that are effective only within the range of disturbance regimes experienced during management. Passive AEM may provide sufficient management capability for a reasonable range of system conditions and disturbances yet preclude the development of management skills necessary to correctly respond to highly unusual circumstances) that are not likely to be encountered during the management period.

Active AEM views management actions as purposeful and scientific experimental manipulations of the system (e.g., Walters and Holling 1990) to increase understanding of system behavior in the short term and as a result, achieve management goals and objectives in the long term. Active AEM encumbers a "dual control" problem, where trade-offs between short term gains in understanding through system manipulation must be weighed against the probability that such manipulations might produce substantial and irreversible changes that reduce the likelihood of achieving the desired conditions.

System State

Fundamental to AEM is the specification of desired conditions for valued resources in the system(s) of interest. In the vernacular of systems analysis, each (e.g., reach-specific, ecosystem type, community structure) desired condition specified for the ecosystem of interest (e.g., LCR and estuary) defines a point (x^*_t) in a multidimensional space, where each specified structural and functional attribute delineates a single dimension in this space. The current system condition (x_t) can be similarly located in this space. AEM operates to move x_t through the multidimensional space towards x^*_t and maintain minimal (acceptable) deviation of x_t from x^*_t.

In open, complex, and dynamic ecological systems, it may be more realistic to describe the desired condition as a set of points or a region in a multidimensional space. Integration of the range (or distribution) of acceptable values for each dimension (system attribute) will define the desired region in this space. Importantly, natural spatial-temporal variation in each attribute combined with imperfect measurement (sampling, data analysis) will determine how precisely the desired conditions can be specified, as well as how precisely the current system condition can be described. In this sense, AEM operates to create and maintain as much overlap as possible between the current region and desired region in this space.

Environmental (e.g., seasonality) or ecological (e.g., competition, predation) factors can introduce dynamics to the system condition that are not necessarily manageable. Such dynamics may cause the desired condition to be more accurately described as a trajectory or set of trajectories in this multidimensional space. AEM can then operate to create and maintain as much similarity (overlap) between the current and desired system trajectory or sets of trajectories.

This multidimensional description of system state might be used to assist in defining desired river and floodplain conditions (or configurations, as in Walker et al. 2002). The desired system configuration can be described in tabular or spreadsheet form, where each row corresponds to one of the structural/functional attributes of the desired configuration. One column of values (or ranges, distributions) would be defined for each location for which desired conditions were specified. A matrix of described desired configurations would result from the inclusion of additional locations. Depending on the selected scale and resolution of management actions, a matrix could be constructed for each river reach, ecosystem type, or habitat. Companion matrices that quantified current conditions could be constructed in a parallel effort to specifying desired system configurations.

1-2 Components of the AEM Plan

The strategic Plan for AEM is designed to be consistent with the guidance provided in 65 FR 35242. This Federal Register document identifies specification of alternative management actions, addressing uncertainties, and the establishment of critical feedback mechanisms between monitoring results and subsequent management actions as necessary features of AEM. Based on 65 FR 35242 and items specified in the National Oceanic and Atmospheric Administration (NOAA) terms and conditions [National Marine Fisheries Service (NMFS) 2002], this proposed AEM Plan emphasizes the following components:

- statement of management goals and objectives,
- delineation of the management and decision-making process,
- identification of existing and proposed MA that will quantify the specified performance measures and assessment endpoints,
- identification of models that may prove useful in assessing outcomes of management decisions,
- a methodology for examining uncertainties to determine the value of new information in supporting the AEM decision-making process, and
- consideration of opportunities for stakeholder input and overall transparency of the AEM Process.

1-3 Management Goals and Objectives

A useful and effective AEM program requires the specification of desired resource conditions. The statements of vision, principles, and goals are vitally important components in developing an AEM program.

Vision and Mission

Vision and mission statements provide the necessary strategic cultural and technological context in defining overarching goals and objectives for specific AEM Projects (e.g., Everglade's restoration, Glen Canyon Dam Project). If carefully crafted, these statements can also serve to generate support and enthusiasm and more importantly, galvanize management actions towards realization of the strategic goals and objectives.

As an example, the following are selected excerpts from the combined vision and mission statement for the Glen Canyon AEM Project:

> "The Grand Canyon is a homeland for some, sacred to many, and a national treasure for all. In honor of past generations, and on behalf of those of the present and future, we envision an ecosystem where the resources and natural processes are in harmony under a stewardship worthy of the Grand Canyon. This will be accomplished through our long-term partnership utilizing the best available scientific and other information through an adaptive ecosystem management process."

While it might be presumptuous to offer such statements as part of this AEM Plan development, the above example identifies several key aspects of a vision or mission statement relevant to the Channel Improvement Project: an envisioned ecosystem, harmony between resource utilization and natural processes, recognition of responsibility for stewardship, long-term partnerships, and use of best scientific and other information. Even in the absence of an explicit vision or mission, these aspects were addressed in the development and are hopefully evident in the description of the AEM Plan and Process described in Part 2 of this document.

The mission and vision implied in the proposed Channel Improvement AEM Plan emphasize the direct management of potential physical-chemical impacts associated with channel deepening. Importantly, the proposed AEM Process can contribute to the development of a more comprehensive adaptive management effort ultimately focused on enhancing the survival, growth, and ocean entry of juvenile salmonids that utilize the LCR and estuary.

Principles

The following principles are offered in support of the LCR Adaptive Management Program. These principles derive in part from similar considerations developed in relation to the Glen Canyon, Upper Mississippi River, Chesapeake Bay, and Florida Everglades AEM programs tailored to the specific needs of the LCR and estuary:

1. The programmatic goals define a set of desired management outcomes that can ensure achievement of the stated vision concerning valued resources in the LCR and estuary.

2. The historical human modifications of the Columbia River watershed have dramatically and perhaps irreversibly impacted the distribution and abundance of valued habitat and ecological resources both in the river and within the watershed.

3. The LCR and estuary remains imperfectly understood from an ecosystem perspective. Inadequate ecosystem understanding and incomplete data will impact the success of an AEM program.

4. The stated ecological complexity of the river and estuary requires an ecosystem management approach. Management efforts should be designed to prevent local extinctions of native species as the result of further human modifications to the Columbia River watershed.

5. An adaptive management approach will be designed and implemented to achieve the AEM program goals. This approach will emphasize passive adaptive management through monitoring the impacts of channel improvements on valued habitat and resources.

6. Management actions that benefit multiple resources in relation to the stated desired conditions will be pursued first. If this is not possible due to conflicting resource requirements, management actions will be implemented that have neutral or minimal negative impacts on resources that fail to benefit from these actions.

7. Particular management goals will be reevaluated if they prove to be inappropriate, unrealistic, or unattainable in the course of implementation of the AEM Plan.

Importantly, it must be emphasized that the primary management principles for the Channel Improvement AEM Plan focus on the historical physical, hydrodynamic, and selected water quality characteristics of the river and estuary. These principles pertain to the dynamics of bathymetry, flows, salinity, and temperature in relation to management goals and objectives. Adaptive management directed at ecosystem resources (e.g., habitat, food webs, ecological production, juvenile salmonids, other species), as previously outlined, practically refer to a second level of management. This management level might be pursued if channel deepening results in demonstrated impacts in relation to the primary physical-chemical management principles.

Goals

One of the major goals of the AEM Process in the LCR is to evaluate the effectiveness of compliance measures, monitoring program, and research to ensure that Project construction, operation, and maintenance have impacts no greater than those predicted in the Biological Assessment (BA) or the Biological Opinion (BO) (NMFS 2005, 2002).

While the primary AEM emphasis remains on physical impacts of the channel deepening, secondary goals and objectives underlying the main ecosystem management activities include:

- provision of additional shallow water and intertidal marsh habitat,
- increased connectivity among habitat types and habitat complexity,
- additional rearing habitat for ocean-type salmonids,
- increased detrital export,
- sustaining native tidal marsh plant communities,
- increased benthic invertebrate productivity,

- increases access/egress for ocean-type salmonids, and
- improved access to headwaters for spawning salmonids.

The above objectives more directly refer to the long-term recovery and sustainability of listed salmonids (Bottom et al. 2001, Kareiva et al. 2000). Specific management actions directed at these objectives may become increasingly important in the proposed Channel Improvement AEM Process if it is determined that channel deepening has demonstrable negative impacts in relation to salmonid utilization of the LCR.

1-4 Management and Decision-making Process

Perfect information may be of little use if managers undertake an *ad hoc* decision-making process. Thus, perhaps the most critical component in implementing the management framework is the specification of how the performance measures or assessment endpoints will be used to make decisions in relation to the management goals and objectives.

The description of the decision process should clearly state the management actions that can be taken to achieve the desired goals and objectives. The Process should also describe how management actions will be selected or developed in relation to expected outcomes of specific decisions. The value of information (i.e., utilities) to be used in directing the decision process should also be articulated in specification of the decision process.

Decision Framework

In general, making a decision involves identifying and evaluating a set of management alternative actions and choosing those actions that will best achieve the desired goals and objectives. The overall effectiveness of the framework in supporting management needs will depend critically on the precise delineation of the decision-making process in relation to the channel improvement Project. Regardless of the details of any specific decision, a decision making process can be structurally decomposed into the fundamental components outlined in Table 1.1.

Table 1.1. Components of a decision-making process (Rubenstein 1975).

Goals and Objectives	What the decision maker desires to achieve.
Alternatives	Alternative actions that the decision maker controls and selects among, actions taken by the decision maker.
States of nature	The broader environmental context where the selected alternatives or management actions manifest themselves.
Outcome	The combination of a management alternative or management action and states of nature.
Utility	The value of an outcome in relation to the goals and objectives.

Figure 1.1 illustrates the interrelations among goals and objectives, decision-making, and the modeling and monitoring activities that support the AEM Process. Figure 1.1 also identifies risk and uncertainty as key components inherent to managing complex environmental systems. The components and their interrelations define an overall AEM management framework. The framework links the activities for assembling information about the ecosystem, formulating ecological forecasts, and assessing risks and uncertainties. The framework adopts the paradigm of AEM as the overall context for decision-making. This contributes to defining the types of information that must be assembled through monitoring and modeling activities. The framework uses risk analysis to account for uncertainty in the process of evaluating and comparing alternative actions. The risk-based approach influences how management goals are translated into decision-making, and this approach also sets the objectives for data analysis and predictive modeling in support of the decision process.

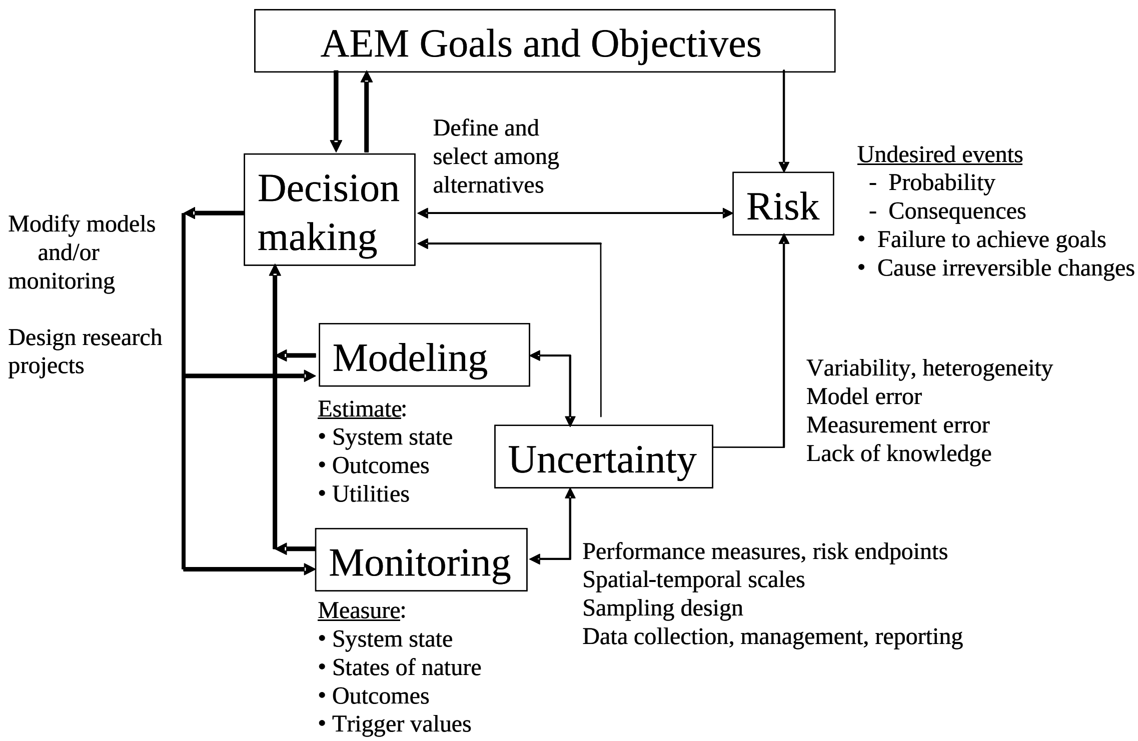

Figure 1.1. General framework for AEM in the context of risk-based decision-making and decision making under uncertainty.1

The adaptive nature of the framework links directly to setting priorities for research, and this provides an operational connection between the goals for resource management and the funding of necessary research to support the AEM Process. A key aspect of implementing the framework will be to establish feedback mechanisms to modify monitoring programs and models as needed during the course of management and decision-making—such feedback mechanisms are central to AEM. Within the framework, these technical support "tools" can be used to define a baseline for performance measures (e.g., historical conditions, desired future conditions), project the expected effects of alternative management actions, periodically track and assess performance, and provide managers with updated information on the effectiveness of management actions (i.e., current conditions) in achieving the desired goals and objectives.

It is recognized that managing complex ecological systems cannot always be conveniently put into the precise framework of decision analysis. Therefore, the decision process might be more loosely defined in some cases. A good test of the specified decision process, however derived, is whether independent teams of similarly skilled managers, given the same goals/objectives and information, would arrive at similar decisions (i.e., coherency). If not, the decision process should be revised until such coherency obtains. The decision process should also be "transparent"—that is, all of the data limitations, model assumptions, input values, and analyses are laid out plainly for review and evaluation (Reinert et al. 1998).

Goals and Objectives

Initially, goals and objectives are established outside of or before the advent of the decision-making process. Resource management goals are established either directly by legislated mandates or through a strategic planning exercise to determine requirements for operating within the United States Army Corps of Engineers (USACOE) mandate. Importantly, the decision-making process may result in subsequent evaluation and modification of goals and objectives, depending in part on the success of management actions in achieving them.

Goals and objectives influence the choice of ecosystem characteristics that are important and how these characteristics will be evaluated. In turn, these choices influence what ecological information must be assembled from studies and monitoring and how this information is applied to evaluate the management alternatives.

Goals and objectives orient the decision-making process. They influence the selection of what information is needed to describe the behavior of the ecosystem in response to management activities, what data must be gathered and how these data are interpreted. In a risk-based approach, goals and objectives contribute to identifying the specific events or conditions for which risk is determined. Goals and objectives influence derivation of the decision criteria in relation to the selected ecosystem characteristics.

Decision Alternatives

The decision alternatives constitute the actions that are under the control of the managers and decision-makers. At the level of ecosystem management, the decision alternatives consist of the specific actions (e.g., collect additional data, perform critical experiments, restore or create habitat) that can be undertaken by decision-makers to protect, restore, and otherwise manage the resources entrusted to their care. The decision framework provides an organized process for assembling and analyzing information to determine appropriate actions aimed at achieving desired ecosystem conditions consistent with AEM goals and objectives.

Development of the decision-support system will be successful in direct proportion to the close collaboration among the adaptive management team (AMT) members to develop and understand their decision-making processes and to identify the necessary and sufficient sets of decision alternatives for managing a complex ecosystem in relation to stated goals and objectives.

States of Nature

Environmental factors not directly related to the proposed AEM Process that can influence the outcome of a decision and that are not controlled by the decision-maker define the environmental context (states of nature) of the decision-making process. For example, climate change, periodic drought conditions, floods, and toxic chemicals (e.g., polychlorinated biphenyls, herbicides, and pesticides) might realistically affect the expected success of the USACOE' projects in achieving management goals. Similarly, the population dynamics of predators or exotic species not directly influenced by the USACOE' projects might nonetheless determine the project effectiveness. Functional relationships can be developed and incorporated into the decision-support model in an attempt to characterize the effects of these other factors on the expected outcomes of the channel-deepening project.

Modeling studies can be performed for different scenarios of these factors, the scenarios can be developed using existing information and understanding of these factors (e.g., periodicity of drought cycles, distributions of contaminants, distribution and abundance of predators on juvenile salmonids). To the extent possible as dictated by available data and understanding, the spatial-temporal variability in these kinds of factors can be quantified and included as part of the overall structure of the decision-support model for AEM. The expected outcomes of alternative decisions or management actions concerning the USACOE' Projects can be estimated in probabilistic terms with the associated capability for performing sensitivity and uncertainty analyses.

Outcomes

In decision analysis, an outcome is the result of a particular decision as influenced by the states of nature. In this framework (i.e., Figure 1.1), outcomes are the values of ecological indicators or performance measures projected in relation to expected impacts of alterations to channel bathymetry, for example, and in relation to probable states of nature.

Ecological and environmental (e.g., hydrodynamic) models developed to support the AEM management framework can be used to estimate outcomes of management actions. The models can translate potential environmental changes in flows, water levels, or salinities into estimates of decision outcomes for the selected ecological resources (indicators or performance measures). The projected outcomes based on model results can then be evaluated in terms of their utility in informing the decision-making process.

Utility

The utility of an alternative management action under consideration prior to making a decision is defined by its effectiveness in either reducing risk or increasing benefits in the ecosystem. The goals and objectives of the project help define the particular risk endpoints or performance measures to be used. For example, the utilities of proposed management alternatives with respect to the resulting habitat changes (e.g., tidal marsh, swamp, flats) can be defined by the impacts of these habitat changes on juvenile salmonid foraging habitat, growth, survival, and subsequent ocean entry. Utility is often expressed in monetary terms, either as economic benefits or as avoided costs. In the present framework for juvenile salmonids, utility might be expressed as increases in habitat opportunity, increased growth, higher rates of survival, and increased numbers of juvenile salmon entering the ocean phase of their life cycle.

The evaluation of a management action's effectiveness must take into account the various sources of uncertainty in forecasting, planning, and monitoring the ecosystem's response after the management action is initiated. An important aspect of the decision-making framework described in the previous section is that it is designed to be applied within an overall management approach that incorporates uncertainties and embraces AEM (Walters 1986, Walters and Hilborn 1978).

Ecological Risk Assessment

An ecological risk is the probability that an undesired ecological impact will occur in relation to one or more environmental stressors [Bartell et al. 1992, United States Environmental Protection Agency (USEPA) 1992, Bartell 1996]. In engineering analysis, the definition of risk is sometimes expanded to include the product of the probability of an undesired event and the costs or losses associated with the event (Kaplan and Garrick 1981). Ecological impacts of concern to natural resource managers might include the local extinction of an ecologically important species, reduced population size in a commercial fishery, or reduced species diversity. Impacts of concern might also include the increase in population of undesired species, such as blue-green algae that are responsible for noxious blooms in coastal water bodies.

Ecological risk assessment provides a conceptual and operational framework for characterizing the responses of complex ecological systems to natural and human-induced disturbances. Ecological risk assessment, through quantification and evaluation of uncertainty in estimating probably impacts, can serve as the basis for informed and adaptive management of natural resources.

The risk component of the adaptive management and decision framework (Figure 1.1) refers to two kinds of risk in implementation. The first category corresponds to more traditional considerations of the probability of obtaining (or failing to obtain) the desired conditions as the outcomes of management and decision-making. To address these risks, the available data and models will focus on estimating the expected (i.e., average, modal, median) values for each of the assessment endpoints or performance measures as a function of the alternative management activities. Ideally, the desired decision is made in terms of the management action that will likely result in the highest expected value of ecosystem performance and/or the lowest risk of an undesired impact. Realistically, the decision may reflect some compromise between increased ecosystem performance and reducing the risk of undesired impacts.

The second category of risk addresses the probability of driving the ecosystem (perhaps irreversibly) to an undesired condition as an unintended consequence of management. The same data and tools might be used to estimate the unanticipated consequences of management alternatives. However, these methods would emphasize estimating the probability of extreme outcomes or surprise ecosystem responses, or those events that characterize the tails of the distribution of expected outcomes. Qualitatively different outcomes not described by the distributions resulting from current models, data, and understanding would have to be addressed using other approaches developed expressly for analyzing extreme events. Considerations of these unexpected results of management actions might reasonably include assessments of the consequences of management actions on ecosystem resources not currently part of the assessment. For example, use of dredged materials potentially contaminated by agrochemicals or industrial pollutants to help restore or create habitat might have a beneficial effects on those organisms directly and positively affected (e.g., salmonids), yet pose unacceptable risks of decreased production of benthic invertebrates or associated food web transfers and bioaccumulation of toxic chemicals by juvenile salmonids. The key to a risk-based approach is formulating ecosystem management objectives as risk assessment endpoints.

The process of assessing risk to ecosystems organizes and presents scientific information in a way that is consistent with the context established by adaptive ecological management that also accounts for uncertainty. The USEPA guidelines divide this process into three phases: problem formulation, exposure and effects analysis, and risk characterization. When these are applied to a particular ecosystem, resources managers can use the risk assessment process to identify vulnerable and valued resources, determine important data needs, and investigate the potential effects of various management actions.

Generally, the three phases of risk assessment identified by the USEPA guidelines have direct parallels in elements of the decision-making framework described here. The problem formulation phase includes a characterization of the ecosystem, identifying performance measures and the development of a conceptual model that describes its response to management interventions, i.e., stressors. The analysis phase corresponds to the processes of collecting survey and monitoring data and formulating predictive models to link management activities with response of the chosen ecological performance measures. The risk characterization phase corresponds to application of the predictive models to forecast and evaluate ecological impacts associated with each management alternative under consideration.

Table 1.2 attempts to compare the implementation of the decision framework schematically outlined in Figure 1.1 with the generalized implementation of an AEM Plan for the LCR and estuary. Part 2 of this report presents a more detailed AEM Plan specific to the Channel Improvement Project.

Table 1.2. Comparison of the decision framework to the LCR AEM Plan.

Implementing the Decision Framework	**Implement the LCR AEM Plan**
Identify goals and objectives.	Specify problems and opportunities. Goals and objectives: • manage physical attributes of channel and estuary, • manage river flows and velocities, and • manage salinity and temperature.
Define the decision-making procedures.	Formulate desired conditions: • goals and objectives, • decision criteria. Identify performance measures. Identify risk endpoints. Compare current conditions to desired conditions. Evaluate decision criteria. Continue current management or adapt management actions.
Identify and apply models.	Inventory and understand current conditions. Forecast future conditions. Project outcomes of management alternatives.
Establish monitoring program.	Baseline data collection and analysis. Effects of channel deepening. Identify data gaps and data needs.
Assess risks.	Risk analysis: • monitoring data, and • model forecasts.
Identify and describe uncertainties.	Focus on uncertainties: • Project construction, • monitoring results, • model bias and imprecision, and • states of nature.

Part 2. Channel Improvement AEM Plan

2-1 Introduction

The preceding discussion addressed the development and composition of a strategic AEM Plan and the process for managing complex ecosystems. The remainder of the report addresses the specific design and implementation of an AEM Plan and Process in support of the CRCIP. Provisions for implementation are primarily based on information contained in the CRCIP, Final Supplemental Integrated Feasibility Report (FSIFR) and Environmental Impact Statement (EIS) (January 2003), and the NMFS BO (May 2002, February 2005). These primary sources were augmented by additional data and information obtained through electronic searches concerning the LCR ecosystem.

History of AEM in the Lower Columbia River

In August 2000, the NMFS withdrew their 1999 BO of "No Jeopardy" concerning the expected impacts of the Channel Improvement Project on listed salmonids. This withdrawal resulted in part from the availability of new information regarding the anticipated effects of the Project on bathymetry, flows, estuarine habitat, and suspension of chemical contaminants. The USACOE and NMFS consulted to resolve the issues of concern. A new BA was prepared by the USACOE following a series of technical reviews, expert panel workshops, ad hoc meetings, and a survey - activities facilitated by the Sustainable Ecosystems Institute during 2001. The new BA (USACOE 2001), submitted in January 2002, specified compliance measures to minimize the incidental take of listed species, monitoring to ensure minimal impacts of dredging and deepening on listed fish and their habitats, and adaptive management to respond to impacts observed during monitoring.

In May 2002, NMFS and the United States Fish and Wildlife Service (USFWS) concluded "no jeopardy" as the result of the Federal Endangered Species Act (ESA) consultations in relation to the recommended plan. The NMFS reiterated their conclusion of no jeopardy in a more recent BO (February 2005). The USEPA, as a cooperating agency, also supported the recommended Plan developed by the USACOE.

On June 23, 2003, the Oregon Department of Environmental Quality (ODEQ) and the Washington Department of Ecology (WDOE) issued Section 401 Water Quality Certification that outlined conditions (findings) associated with permitting the proposed channel modifications. Amendments to both certifications were issued on June 23, 2005. The certifications expire in June of 2008 and the Corps will have to re-apply for certification.

On January 9, 2004, a record of decision (ROD) was released that approved the Columbia River Navigation Improvement Project. Importantly, the ROD included provisions for MA, EEA, and adaptive management.

Study Area

The recommended Plan described in the 1999 FSIFR and EIS indicated that dredging would be limited to selected areas from Columbia River mile (CRM) 3, near the mouth of the river, to CRM 106.5, near the I-5 Bridge in Portland. The revised study area includes the bank-to-bank run of the Columbia River from Bonneville Dam to the river mouth and extending in a fan shape 12 miles into the Pacific Ocean. The study area divides the run of the river into three reach types: riverine (Bonneville Dam to CRM 40), estuarine (~CRM 40 to CRM 3), and river mouth (CRM 3 to outer boundary of the Deep Water Site). The study area also includes sites for upland disposal or dredged materials, ecosystem restoration, and wildlife mitigation.

Time Scales

The proposed Channel Improvement AEM Process will focus on short- and mid-term management actions and system responses. As indicated in the ROD, the MA will include two years of measurements prior to construction, two years during construction, and a third year following the end of construction. The periods of pre-construction and construction correspond to the near- (0–5 years) and mid-term (5–10 years) timeframes identified in the BO (NMFS 2005, 2002). Emphasis will be on near-term physical impacts of channel improvement.

Mid-term management actions may include the use of monitoring and research results to establish mid-term trends in the physical aspects of the systems and potentially other resources of concern, depending on the results of the near-term system responses to channel improvements.

The long-term actions include years 10 and beyond. At this scale, trend analysis could be used to assess ecosystem impacts of channel improvement. However, longer-term time scales appear more relevant to other AEM Processes being developed in the Columbia River Basin. The Channel Improvement AEM may contribute to some aspects of longer-term AEM planning, but the focus emphasizes the detection and characterization of potential impacts of channel improvement on depth, temperature, and salinity in the near-term.

Time scales also refer to the frequency of sample collection or obtaining measurements in the monitoring program that supports the AEM Process. Time scales for measurement should be determined by considering: (1) the scales of natural variability inherent to the measurement, (2) the scales that characterize the management actions, and (3) the frequency of measurement permitted by available resources. Similarly, the number and location of measurements is influenced by the same three scale considerations in the spatial domain (Gardner et al. 2001). The success of the monitoring program in usefully informing the decision-making process will be proportional to the congruency among these three scales in time (and space).

Scope

The primary purpose or scope of the proposed AEM Plan and implementation process are to manage the Channel Improvement Project in an adaptive manner to avoid or minimize physical-chemical impacts in relation to channel deepening in the LCR and estuary. Although the Channel Improvement AEM Plan is purposefully limited in scope to managing the selected physical-chemical performance measures, one underlying reason for this proposed AEM Process is to ensure compliance with the BO in relation to recovery and sustainability of valued salmonids that utilize the estuary. Table 2.1 lists the salmonid evolutionary significant units (ESU) that are important subjects of more comprehensive management and assessment. Achieving these management goals will realistically require the participation of additional stakeholders and the integration of the Channel Improvement AEM Process with other adaptive management programs underway or planned for the LCR and estuary.

Table 2.1 Federal Register notices for final rules that list species, designate critical habitat, or apply protective regulations to ESU considered in this consultation.

Species ESU	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon (Oncorhynchus tshawytscha)			
LCR	T 3/24/99, 64 FR 14308; P 6/28/05, 70 FR 37160	9/2/05, 70 FR 52630	6/28/05, 70 FR 37160
Upper Columbia River spring-run	E 3/27/99, 64 FR 14308; P 6/28/05, 70 FR 37160	9/2/05, 70 FR 52630	ESA Section 9 applies
Snake River spring/summer-run	T 4/22/92, 57 FR 14653; P 6/28/05, 70 FR 37160	10/25/99, 64 FR 57399	6/28/05, 70 FR 37160
Snake River fall-run	T 6/3/92, 57 FR 23458; P 6/28/05, 70 FR 37160	12/28/93, 58 FR 68543	6/28/05, 70 FR 37160
Chum salmon (O. keta)			
Columbia River	T 3/25/99, 64 FR 14508; P 6/28/05, 70 FR 37160	9/2/05, 70 FR 52630	6/28/05, 70 FR 37160
Coho salmon (O. kisutch)			
LCR	P 6/28/05, 70 FR 37160	Not applicable	6/28/05, 70 FR 37160
Sockeye salmon (O. nerka)			
Snake River	E 11/20/91, 56 FR 58619; P 6/28/05, 70 FR 37160	12/28/93, 58 FR 68543	ESA Section 9 applies
Steelhead (O. mykiss)			
LCR	T 3/19/98, 63 FR 13347; D 6/28/05, 70 FR 37160	9/2/05, 70 FR 52630	7/10/00, 65 FR 42422
Middle Columbia River	T 3/25/99, 64 FR 14517; D 6/28/05, 70 FR 37160	9/2/05, 70 FR 52630	7/10/00, 65 FR 42422
Upper Columbia River	E 8/18/97, 62 FR 43937; D 6/28/05, 70 FR 37160	9/2/05, 70 FR 52630	ESA Section 9 applies
Snake River Basin	T 8/18/97, 62 FR 43937; D 6/28/05, 70 FR 37160	9/2/05, 70 FR 52630	7/10/00, 65 FR 42422

Listing status: “T” means listed as threatened under the ESA, “E” means listed as endangered, “P” means proposed for listing, proposed for designation as critical habitat, or proposed as protective regulations, and “D" means that the final listing determination is deferred until December 28, 2005. The designation of critical habitat for LCR Chinook salmon, UWR spring-run Chinook salmon, UCR spring-run Chinook salmon, LCR steelhead, UWR steelhead, MCR steelhead, UCR steelhead and SRB steelhead is not effective until January 2, 2006.

2-2 Control Theory Model

AEM parallels earlier applications of engineering control theory to the management of ecological systems. Figure 2.1 illustrates an AEM model for the Channel Improvement Project as a problem in control theory. Key components of the control theoretic model include the controller, the controlled system, and a desired system configuration. These components correspond to the manager(s), the managed ecosystem, and the management goals, respectively. Importantly, the control theory model can serve as a template for designing a corresponding AEM Process for the Channel Improvement Project.

In its basic form, the control model includes relevant input information important in determining the state (or condition) of the managed system. The decision-makers implement selected management actions with the objective of changing the current state of the managed system to match the desired conditions. In the Channel Improvement AEM model, the decision-makers are the members and consultants of the AMT. The specification of desired conditions might focus on ensuring that impacts do not exceed those projected for the Project. Specification of desired conditions might: (1) derive from consideration of historical accounts of the lower river and estuary; (2) reflect current conditions consistent with management objectives; or (3) be based on diverse management objectives, such as sustaining salmonid ESU, minimizing risks posed by dredging, or restoring critical habitats and ecosystems

In the control model, the decision-makers have information that describes selected aspects of system structure and function. These inputs can be used to characterize the current condition of the managed system. The inputs of initial primary concern include bathymetry, salinity, temperature, turbidity, and contaminants.

Outputs (or outcomes) that describe system response to management actions are used to compare the effects of management actions in relation to management goals and objectives (i.e., desired conditions). Outputs can include selected performance indicators (i.e., measures to be achieved) or risk endpoints (i.e., impacts to be avoided or minimized). The proposed Channel Improvement AEM focuses initially on possible Project effects on channel bathymetry (accretion/erosion), salinity, temperature, and turbidity as system outputs of interest. Note that in this case the set of primary system outputs is identical to the set of inputs. In a real sense, the control model uses management actions to translate values of inputs to resulting values of outputs, which are then compared to the desired values or decision criteria.

Consistent with the conceptual model (Appendix A), future additional outputs of interest might also include the growth, survival, and ocean entry of juvenile salmonids. Measures of habitat, productivity, and food web dynamics are also of eventual concern, as are possible Project impacts on crab, sturgeon, and smelt. Clearly, the outputs should be selected to provide comprehensive, quantitative measures of system state, including both the current state and desired conditions.

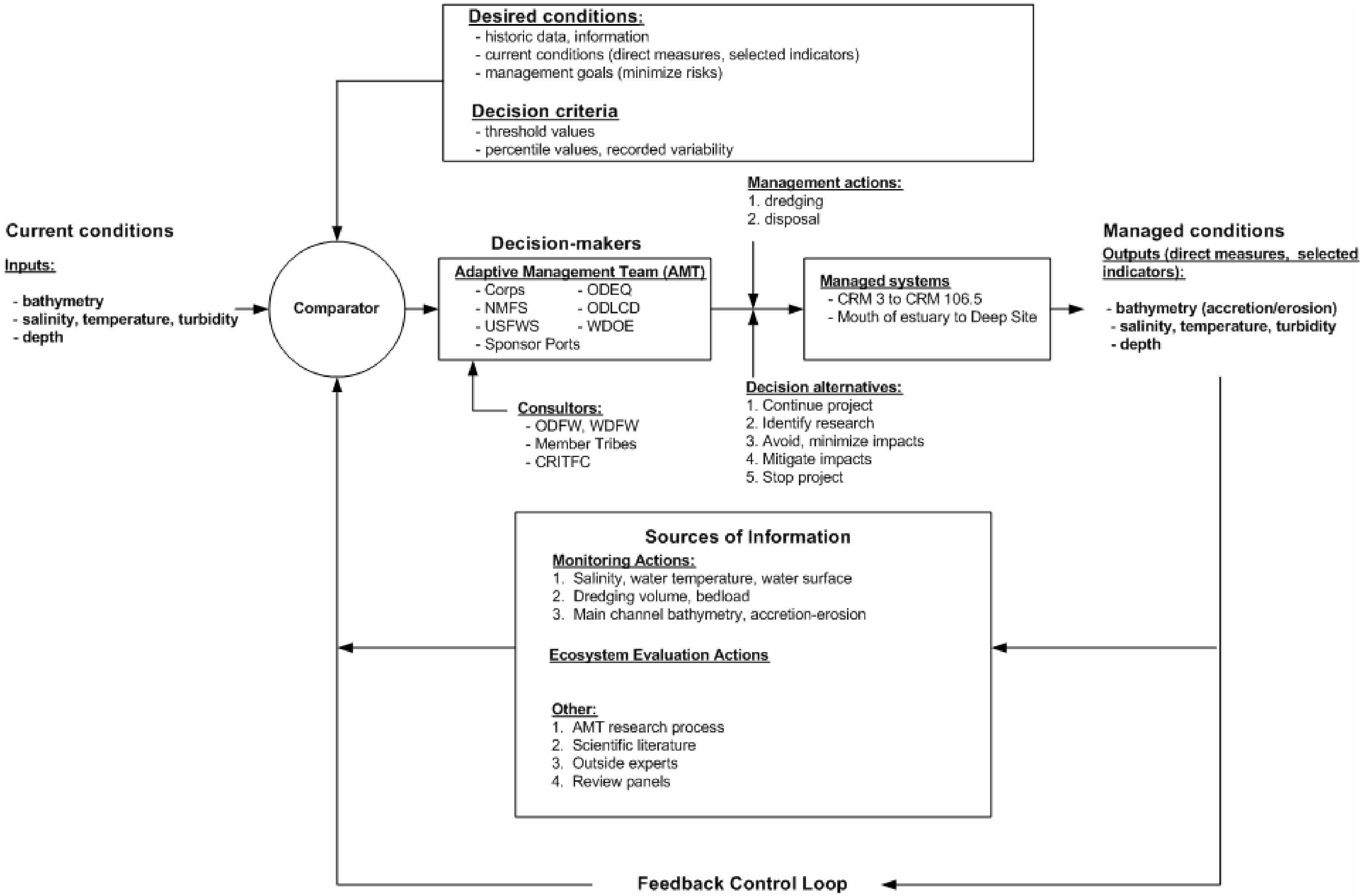

Figure 2.1. AEM model formulated in terms of control theory.

The comparison (comparator) between current and desired system conditions sets up a critical feedback mechanism between management actions and subsequent system response. Each output defines a dimension in a multi-dimensional space. The current conditions define a point in this decision space, inclusion of uncertainties redefines this point as a bounded region in this space. The desired conditions also define a point or region in this space. At any moment, the "distance" between the current and desired states provides a measure of the effectiveness of current management actions. The objective is to manage the system to achieve and maintain desired conditions (i.e., minimize distance between desired and measured system state) or be compatible within specified decision criteria (i.e., acceptable overlap of desired and measured regions) developed in relation to the desired conditions.

Dictated by the selected scale of decision making (e.g., monthly, annually), the decision makers, in this case the AMT, compare the current conditions to the desired conditions. If the current conditions are acceptably similar to the desired conditions, the decision makers may elect to continue the current management actions and wait until the next management opportunity. Alternatively, if the current conditions and trends in performance measures or risk endpoints are sufficiently dissimilar to the desired conditions, the decision makers can select from available management actions and implement changes in an attempt to improve the comparison between existing and desired conditions.

Critical to successful management in the control theory model is a quantitative understanding of the system response to different management actions. As indicated in Figure 2.1, various sources of information, including monitoring, EEA, and other scientific studies may provide or improve the necessary understanding that underpins the adaptive management effort. Empirical and process-level models might also be developed and used to project the results (outputs, outcomes) of management and decision alternatives. Models are particularly useful in estimating the expected response of system outputs to different management actions.

Clearly, future increases in understanding to improve management capabilities and decision-making skills require an investment in the various sources of information indicated in Figure 2.1. Thus, concepts and measures of sensitivity and uncertainty, as well as the value of added information become relevant to the adaptive management process. Investments should be made in data and information that provide the greatest improvement in management and decision-making.

To summarize, in the context of the control theory model, AEM is the continued process of comparing system state (management outcomes) to desired conditions using a feedback mechanism established between management actions and observed system response. New information (i.e., monitoring data, research results, and model calculations) can further develop a mechanistic understanding of the relationship between management actions (inputs) and system responses to management (outputs). Management can become more effective as a result of improvements in understanding the feedback mechanism.

The manager collects information about the desired state of the ecosystem, external processes that drive the ecosystem, and the state of the controlled ecosystem itself. These correspond to the management objectives, factors that make up "states of nature" in decision analysis terms, such as the drivers of climate and sea level for estuarine ecosystems, and monitoring data that measure the current and past condition of the ecosystem.

Based on information received, the manager takes actions to direct the conditions in the ecosystem toward the desired state. The management actions act in combination with the factors outside of the manager's control, i.e., the "states of nature." In addition, the resulting changes in the performance measures, outputs from the controlled system feed back information into the next decision-making cycle. These outputs are compared with the desired system configuration to determine future management actions or decisions as necessary. This process continues until the configuration of the managed system is sufficiently (acceptably) similar to the desired conditions. Management actions (inputs) continue indefinitely to maintain the desired configuration.

In each iteration, the manager (controller) chooses from a set of alternative actions. The information inputs defined in Figure 2.1, i.e., data on past and present conditions in the ecosystem and states of nature and the desired condition for the ecosystem, provide only part of the information that is needed. The utility assigned to each alternative depends on the manager's evaluation of how closely the estimated outcome corresponds to the desired condition for the ecosystem. To make this evaluation, the manager must be able to forecast the condition of the ecosystem that will occur if any alternative is chosen. The ability to forecast conditions in the ecosystem represents another source of information to the decision-making process, i.e., the information contained in a predictive model. As part of each iteration of the process, resources can be expended to obtain more information, perform research (i.e., increase utility), monitor, and improve the models.

2-3 Organizational Structure and Management Interactions

The proposed organizational structure for AEM in relation to the Channel Improvement Project consists of the following: (1) the formal AMT, and (2) a less formal technical support group. The organizational structure would also identify and encourage interactions with the scientific and technical community, as well as concerned stakeholders.

Adaptive Management Team

The proposed AEM Plan will be administered mainly through the actions of an AMT. Appendix B describes the composition, organization, and the operations Plan for the AMT. The AMT comprises the managers, decision makers, and technical staff ultimately responsible for initiating, implementing, and sustaining the AEM Process.

It is envisioned that the exact composition and participation of these AMT constituents will vary in relation to issues raised by the technical support group. This comprehensive organizational approach ensures the appropriate entities are informed of potential variances with the decision criteria. At the same time, depending on the specific nature of any variances (i.e., ESA concerns, state water quality mandates), the AMT provides for flexibility in organizational participation to effectively address such variances. This organizational flexibility within the operation of the AMT will undoubtedly include some overlap in participation, again depending on the nature of any variances with the decision criteria (i.e., "trigger values").

Regardless of the specific composition, the role of the various participating organizations is to identify the appropriate and effective course of actions to be undertaken by the USACOE in responding to any variances with the decision criteria. In the absence of variances with the AEM decision criteria, the technical support group would ensure that current conditions and trends were summarized and reported to all constituents of the AMT.

Importantly, the AMT receives information from the technical support group that describes current conditions and trends for selected performance measures or risk endpoints. Based on deliberations that may draw upon technical inputs of the support group, as well as advice solicited from the general scientific community and other sources deemed appropriate by the AMT, the AMT would recommend any necessary changes in the conduct of the Channel Improvement Project in order to achieve and maintain the AEM goals and objectives developed for the LCR. In this context, the AMT would evaluate the effectiveness of compliance measures, monitoring program, and research to ensure that Project construction and operation have impacts no greater than those predicted in the BA (USACOE 2001) or the BO (NMFS 2005, 2002).

Adaptive Management Technical Support

A proposed Adaptive Management technical support group can serve as a primary source of technical support for the AEM Process and the AMT. The group is envisioned as a less formal organization constituted by professionals that primarily have other duties and responsibilities, but would be available as necessary to assist the AMT. As explained in Appendix B, the AMT would establish subgroups or subcommittees as deemed necessary for the purposes of compiling information, performing analysis, discussing issues, and reporting back to the AMT. Such a group would reasonably consist of professional physical and chemical oceanographers. Fisheries biologists, ecosystem scientists, environmental toxicologists, risk analysts, and hydrologic engineers could be consulted as needed if unacceptable physical-chemical impacts are observed in relation to channel improvement. The principle functions of the technical group might include:

- assisting the AMT in review and evaluation of the monitoring results in relation to specification and modification of the AEM decision criteria;

- advising the AMT in the derivation of alternative management actions;

- interfacing with the USACOE' monitoring activities (MA-1 through MA-6) to facilitate the timely compilation, analysis, and communication of the monitoring results to the AMT;

- coordinating with other monitoring programs ongoing in the LCR [e.g., CORIE, Lower Columbia River Estuary Partnership (LCREP)] and estuary to introduce additional relevant information to the AMT;

- estimating the likely outcomes of modifications to management actions in the context of the performance measures and risk endpoints;

- overseeing the use of operational models used to forecast expected results of management actions;

- consulting with the AMT to identify critical research needs or coordinate peer review of proposals; and

- other duties as designated by the AMT.

2-4 Performance Measures and Risk Endpoints

Performance measures define those attributes of the ecosystem that provide the manager with information on the response of the ecosystem in relation to the desired conditions (i.e., goals, objectives). Risk assessment endpoints define complementary ecosystem attributes that indicate the likely occurrence of undesired, adverse impacts associated with the Project or produced by management actions.

To be useful as a performance measure or an assessment endpoint, an ecosystem attribute exhibits several specific requirements. First, the attribute should be an integrative indicator of overall ecosystem structure or function, and not one that narrowly measures a peripheral component or secondary process. Second, the measure must be responsive, that is it should be possible to measure quantifiable changes over time periods relevant to management. Third, the patterns of spatial-temporal response of the attribute should be consistent with current quantitative ecosystem understanding. Finally, it should be possible to predict quantitatively how the attribute will respond to management action as distinct from other sources of variation. AEM can be succinctly described as the continued process of tracking performance measures and risk endpoints in response to management actions over the course of the Project.

The underlying hypothesis is that the channel deepening will not significantly alter the fundamental physical or chemical conditions of the LCR and estuary. If these conditions are not substantially altered as the result of additional dredging, it is further postulated that the habitat conditions that influence the growth, survival, and ocean entry of the listed ESU will not be significantly altered. These hypotheses can be used to identify performance measures and risk endpoints and to establish priorities among these measures in the design and implementation of MA central to AEM.

Initially, the performance measures or risk endpoints include changes to depth, temperature, and salinity in the LCR and estuary in relation to channel deepening.

2-5 Decision Criteria

Selected values or conditions of the performance measures or risk endpoints will be used as criteria for implementing the adaptive management process. The criteria enter into the AEM process in several ways. Comparisons of pre- and post-construction data with the decision criteria can be used to evaluate Project impacts for some performance measures (e.g., habitat alterations). Comparisons of pre-construction data with observations made during construction can be used for physical-chemical parameters, including water temperature, salinity, depth, and fish stranding. The results of such comparisons can "trigger" adaptive management actions. Decision criteria for valued resources may derive from studies performed in association with the Project (e.g., Dungeness crab, sturgeon) or from legislative mandates (e.g., smelt).

Several alternative approaches were used to derive decision criteria (Appendix D). For example, statistical analyses of existing data, which define historical patterns of spatial and/or temporal variability were used for depth, temperature, and salinity endpoints. These historical variance structures were used to define decision criteria ("trigger values") as selected percentile values based on the historical record. Evaluations of previously conducted studies were discussed within a consensus-building process, as another approach, to define criteria for crab entrainment, crab burial and dredging-related impacts on sturgeon. In some cases, compliance measures provided by NMFS, Washington, and Oregon (Appendix E) defined decision criteria.

The CRCIP decision criteria are described briefly in this section. Appendix D provides a detailed discussion of the development of initial decision criteria for the AEM Plan. Much of the data used to develop criteria are provided by Project monitoring actions (e.g., MA-1 through MA-6). The decision criteria for water elevation, salinity, and temperature were empirically derived as selected percentiles from the analysis of CORIE monitoring data and MA-1 results obtained for three CORIE locations. MA-2 provides the annual dredging volumes associated with construction and operation of the 43-foot channel. AEM actions can be triggered if the actual volumes of dredged materials exceed the projected values by a specified amount. MA-3 will address decision criteria for side-slope changes caused by channel modifications. The criteria are defined statistically as ranges of historical depths associated with selected cross-line surveys between CRM 3 and CRM 106. Threshold values of habitat change (yet to be developed) will serve as the decision criteria for the evaluation of habitat change as a result of channel deepening. These criteria will be determined from estuary habitat surveys conducted by MA-4. Habitat complexity, connectivity, and conveyance, as well as food availability, are also addressed by MA-4. MA-5 will update and maintain a sediment contaminant data base (SEDQUAL). Toxicity benchmark data will be used as decision criteria to evaluate new data that describe potential exposure of salmonids and their prey to contaminants remobilized as the result of channel deepening. Pre- and post-Project comparisons of fish stranding at selected locations will result from studies that constitute MA-6. An increase in the number of stranded fish following channel deepening could trigger the adaptive components of the AEM Plan. Changes in susceptibility of different species to stranding can also initiate adaptive management.

Appendix E presents information used by Washington and Oregon to evaluate potential Project impacts on crab, sturgeon, and smelt. This information has been discussed by the AMT within a consensus framework to determine how to best incorporate states' concerns into the development of decision criteria. Decision criteria for these resources largely take the form of continued studies (e.g., crab entrainment, impacts on sturgeon, fish stranding) and compliance monitoring (e.g., turbidity).

Regardless of the approach used in their derivation, it is important to recognize that the initial decision criteria are subject to review, evaluation, and modification throughout the AEM process.

2-6 Proposed AEM Process

The following steps outline a process for adaptively managing the environmental resources of concern in relation to the Channel Improvement Project:

1. Results of the ongoing monitoring programs, EEA, and research are periodically (i.e., quarterly) summarized and reported.[1] This reporting might be primarily event-driven, where new observations or data suggest possible violations of existing decision criteria for one or more of the performance measures or risk endpoints. Annual (January) reporting of research results might also occasion the review of the data and information generated by the monitoring and evaluation actions and initiate the AEM Process.

2. The results of monitoring programs (MA-1 through MA-6), the EEA (EEA-1 through EEA-6), and relevant research are collated and analyzed by an informal technical support group. The technical support group would summarize current conditions and examine short-term trends.

3. The Technical Support Group would review the summaries and analyses, monitoring results and advise the AMT concerning any performance measures or risk endpoints that exceed the decision criteria. The technical group would also advise the AMT if none of the measures or endpoint criteria have been exceeded.

4. If none of the decision criteria are exceeded, the AEM Process can simply continue with the current monitoring programs until the next evaluation is performed (i.e., Step 1). Under these circumstances, the AMT might consider research needed to address key gaps in existing data, especially in relation to the AEM control model (i.e., Figure 2.1).

[1] It is recognized that some performance measures or risk endpoints are monitored almost continuously (e.g., temperature, salinity). Provisions might reasonably be made for data analysis, summarization, and reporting on time scales more commensurate with continuous monitoring. In particular, if significant fluctuations or a trend in deviations from historical values are measured, such anomalous conditions should be readily detectable by the monitoring procedures and deviations of this kind should enter on a timely basis into the AEM process. Real time data analysis and decision models, perhaps involving methods of artificial intelligence, may prove useful for performance measures or risk endpoints that are continuously monitored.

5. If any decision criteria are exceeded, the AMT requests the USACOE to develop a mitigation or management plan intended to redress the Project impacts indicated by the monitoring results. If requested by the AMT, the USACOE will provide alternative management actions to address the impacts of the Project on the performance measures or risk endpoints that exceed the decision criteria. The USACOE will provide the alternative management plan within 30 days of the request by the AMT.

6. Based on an evaluation of the USACOE' Plan, the AMT can determine that there is no justification for adapting the current management practices, or recommend adaptations to current management practices. If the AMT concludes that there is no need for adapting the current management actions given the USACOE' plan, the current management actions and supporting monitoring and evaluation actions continue until the next technical group summary and analysis. Alternatively, if the AMT decides that adaptations to the current management actions are warranted, further deliberations would initiate concerning the management changes, revisions to monitoring/ecosystem evaluation, and review of the decision criteria.

7. Following resolution of the proposed adaptive management actions and possible revisions to monitoring and research recommended by the AMT, the AEM Process continues by cycling back to review and analysis of new data and information by the technical support group (Step 1).

The steps in the above-described AEM Process are schematically illustrated in the following AEM Plan flowchart (Figure 2.2). As listed or implied by the AEM control model Figure 2.1), the AEM Process will focus initially on specific physical and chemical effects potentially impacted by the Channel Improvement Project.

2-7 Stakeholder Involvement, Documentation, and Transparency

The AEM process can benefit from the active participation of invested stakeholders (Walker et al. 2002). The AEM Plan identifies the key role played by the USACOE and underscores the initial focus on managing channel improvements to minimize potential impacts on the basic physical-chemical attributes of the LCR and estuary. Concurrently, the Plan identifies important federal and state agencies, Tribes, and the Sponsor Ports as active participants in the AEM process (see Appendix B). The roles and responsibilities of the federal and state agencies may be determined in part by their respective mandates and interests. For example, the NMFS and the USFWS are entrusted with enforcement of the Endangered Species Act. Washington and Oregon are responsible for Section 401 provisions of the Clean Water Act. The Sponsor Ports are interested in the economic aspects of channel improvement. State resource agencies are undoubtedly concerned with wetlands and water quality issues, while the Tribes focus on access to a valued salmon fishery.

The AEM Plan recommends the documentation of the adaptive management process. The risk-based decision framework (Figure 1.1) provides an organizational structure to document the management and decision-making process implementation of the Plan:

- Goals and objectives should be clearly delineated.

- The decision process should be described in detail, including identification of the decision alternatives and criteria for selecting among the alternatives.

- The specific data, information, and model results used to support particular decisions should be recorded.

- The uncertainties associated with the sources of information entering into each decision analysis should be characterized along with an evaluation of the risks implied by each decision alternative.

In each analysis, the components of the general decision model serve as templates for describing any management actions undertaken by the AMT, including the decision to continue the process (i.e., monitoring, assessment, evaluation) without any adaptive changes. The goals and objectives, decision alternatives, states of nature, expected or observed outcomes, and the value (i.e., utility) of the management actions in relation to achieving the stated goals can be described and discussed for each iteration of the AEM process. A standardized format should be developed to facilitate such reporting.

Documentation of the AEM process and making this information readily available will demonstrate the transparency of the process to stakeholders and the interested public. One convenient mechanism for making AEM information available would be to publish the information on the CRCIP internet site (www.nwp.usace.army.mil/issues/CRCIP). The site is configured to accept comments concerning various aspects of the Project. More costly and time-consuming ways to share information include formal presentations or workshops where stakeholders and the public are invited to participate.

The documentation of the AEM process will also generate coherency and credibility. Coherency, in this case, refers to the desirable aspect of the AEM process wherein independent decision-makers, given a particular decision objective and the same information, would arrive at a similar decision. Documentation and transparency of the AEM process will normally contribute to credibility among stakeholders and the public, even if there is disagreement in relation to specific management actions. Credibility is essential for effective adaptive management.

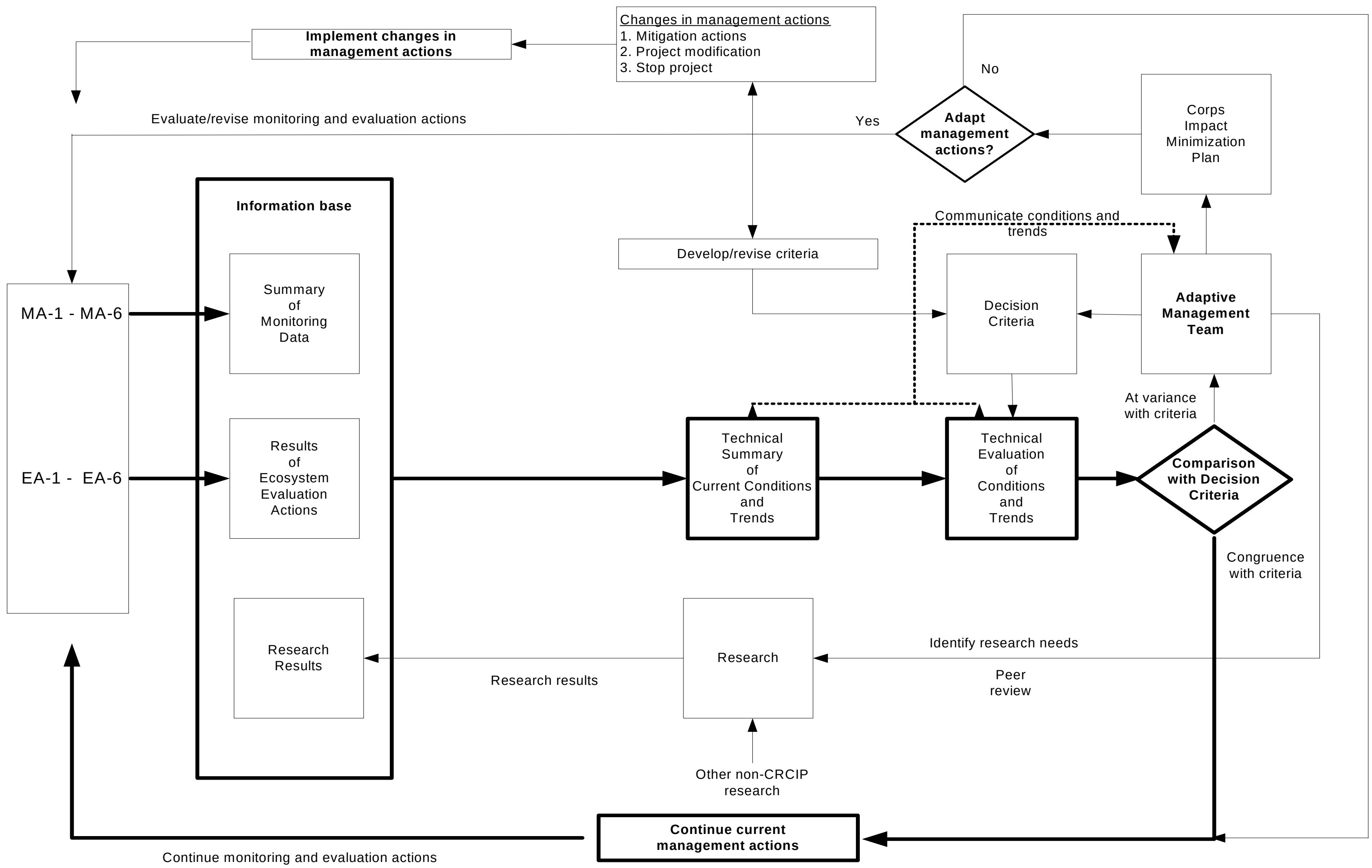

Figure 2.2. Flow chart describing the proposed AEM Process in support of the Channel Improvement Project.

Important physical-chemical effects addressed by the Channel Improvement AEM Process include:

- possible shifts in location or changes in ecological function of the estuarine turbidity maximum;
- deleterious changes in current velocity in shallow water habitats and refugia;
- undesired changes in accretion/erosion rates along the main channel and side-channels;
- undesired changes in temperature, salinity and depth that impact habitat opportunity; and
- undesired changes in bathymetry, bedload sediments, rate of suspended sediment transport, and water levels in the estuary.

Some of the longer-term benefits that should be achieved as the result of a successful AEM Process for the LCR and estuary include:

- provision of additional shallow water and intertidal marsh habitat,
- increased habitat connectivity and complexity,
- creation of additional rearing habitat for ocean-type salmonids,
- increases in detrital export,
- maintaining native tidal marsh plant communities,
- increased benthic invertebrate productivity,
- increased access/egress for ocean-type salmonids, and
- improved access for adult salmonids to headwaters for spawning.

Part 3. Technical Support of the AEM Plan

3-1 Monitoring Actions

A scientifically based and informative monitoring program is central to effective AEM. The monitoring program provides the necessary data to describe previous and current conditions. Monitoring can also characterize the outcomes of the ecosystem management actions undertaken as part of the Channel Improvement Project. Importantly, the results of monitoring quantify the response of the performance measures and risk endpoints to management actions. The measured degree of success (or failure) can be used to adapt subsequent management actions if necessary. The monitoring effort is an essential component in developing the feedback between management and system response in relation to the desired condition (i.e., goals and objectives). Thus, the importance of a well-designed monitoring program cannot be overstated in the implementation of the overall AEM Process.

The degree of accuracy and precision required for each measured parameter should be specified as part of implementing the monitoring program. The data quality required for each monitored parameter can be determined in part from knowledge concerning the sensitivity of the decision-making process to the measured value. The required data quality also relates back to specification of the decision process. For example, if the management goal is an increasing population of an ESU, the corresponding monitoring program may prove less intensive (and costly) than if the goal was a population increasing at a specific desired rate (e.g., 10% per year). Conversely, a decision process will not be feasible if it critically relies on a degree of data quality that surpasses current technical capabilities or is prohibitively expensive (e.g., cost of acquiring the data exceeds funds available for management or in some cases the value of the managed resource).

USACOE' Monitoring Actions

The USACOE is implementing six monitoring actions that will help to assess the possible impacts of the Channel Improvement Project on selected physical and chemical attributes of the LCR and estuary. The USACOE has worked with the NMFS, FWS, and the states of Oregon and Washington to achieve consensus concerning the implementation of the monitoring actions, including the derivation of initial decision criteria ("trigger values") for use in adaptive management. In addition to the endpoints addressed by MA-1 through MA-6, studies are also being performed to assess the potential impacts of channel modifications on sturgeon, smelt, and Dungeness crab. Appendix D provides a detailed account of the development of the initial decision criteria for use in the AEM Process. The following paragraphs briefly describe the six USACOE' monitoring actions.

<u>MA-1</u>

The USACOE will maintain three hydraulic monitoring stations on the lower river. Their locations will be downstream from Astoria, Grays Bay, and Cathlamet Bay. The measured parameters include salinity, water depth, and water temperature. Physical changes resulting from channel deepening are expected to be minor and occur in proximity to the navigation channel. The proposed monitoring duration includes two years before channel deepening, two years during the construction, and three years following construction.

The MA-1 data will be analyzed to establish pre- and post-project relationships between the channel deepening and values of flow, salinity, water surface elevation, and water temperature. The purpose of MA-1 in the context of the AEM Plan is to verify levels of impact, MA-1 is essentially compliance monitoring. However, the results of MA-1 might be used to assess habitat complexity, connectivity, conveyance, and habitat opportunity.

<u>MA-2</u>

MA-2 will provide annual dredging volumes associated with construction and operation of the 43-foot channel. Volumes will be reported for each dredging bar (~3-mile reaches). Volumes of dredged materials will be compared to projected values.

Evaluation of dredged materials disposal in relation to projections of contract dredging volumes and disposal site capacities can contribute decision-making in relation to the AEM Plan. If dredging volumes exceed the capacity of the disposal plan, management actions might be triggered in relation to the AEM Process. This monitoring action will continue through the Project duration.

<u>MA-3</u>

The MA-3 will examine accretion/erosion and changes in bathymetry of the main channel in relation to the channel deepening. Surveys will be conducted annually for two years prior to construction, two years during construction, and three years after construction. Crossline surveys will be conducted within a December-February time period to coincide with the end of the dredging season. Surveys will be conducted along the navigation channel from CRM 3 to CRM 106.

MA-3 will provide information to assess physical alterations to habitat opportunity due to side-slope impacts of dredging. Adjustments to dredging are expected to occur intermittently adjacent to the navigation channel.

<u>MA-4</u>

MA-4 will augment estuary habitat surveys previously conducted by NMFS as part of the Anadromous Fish Evaluation Program (AFEP). The objective is to determine if changes in habitat result from the channel deepening. The surveys will assess a variety of habitat types important to juvenile salmonids (e.g., tidal marsh, swamp, flats, deep water). The survey will also address habitat complexity, connectivity, and conveyance. Habitat-specific food availability will be quantified. The use of peripheral areas by juvenile salmonids will be measured. The survey will be conducted three years after construction.

Threshold values of change (i.e., decision criteria) will be defined for each habitat type. Measures that exceed any of the decision criteria may result in adaptation to current management actions.

MA-5

The AEM Process will include the review of sediment chemistry data to evaluate the potential impacts of channel deepening on the exposure of aquatic organisms to toxic contaminants. Such reviews may be largely initiated by the observation of suspected toxicological events associated with channel improvement.

MA-6

MA-6 will provide for field surveys (April–August) to assess any Project related changes in fish stranding during outmigration. Surveys will be conducted one year before and one year after channel deepening.

If the number of stranded fish increases in relation to channel deepening, management actions might change as a result of implementing the AEM Process. Note that stranding is also being considered in relation to Section 401 Water Quality Certification requirements for the states of Oregon and Washington.

Coordinated and Integrated Monitoring Program

The scale and complexity of the lower river and estuary all but preclude the operation of a comprehensive monitoring program by any single public or private entity. Other programs that have historically collected data and information relevant to the AEM management goals and objectives can contribute to the effectiveness of monitoring in the conduct of AEM. Presumably, the data collected by the USACOE will be useful in addressing other management needs expressed for the estuary (e.g., LCREP). Thus, the implementation of the AEM Plan should provide a mechanism to share information among the various monitoring programs active in the river and estuary.

The following monitoring programs might be able to provide data and information of value to the Channel Improvement AEM Process:

CORIE

The Oregon Graduate Institute at the Oregon Health and Science University operates the CORIE, an environmental observation and forecasting system. The CORIE network (www.ccalmr.ogi.edu/CORIE/network/) includes a set of monitoring stations located throughout the Columbia River estuary. Most stations monitor water temperature, salinity, and water level. Typical sampling intervals range from 1 to 15 minutes. Most stations real-time permit access to recent data, other stations allow access only to verified archived data.

The LCR Estuary Partnership

The LCREP has developed an integrated monitoring program based largely on concerns associated with conventional pollutants, toxic contaminants, habitat degradation, and exotic species introductions.

Oregon Department of Environmental Quality

The Oregon DEQ maintains ambient water quality monitoring sites on many of the tributaries of the LCR. The program collects data describing several physical and chemical factors that appear relevant to the Channel Improvement AEM Plan, including total suspended solids, chlorophyll, color, and turbidity.

Washington Department of Ecology

The WDOE currently operates ambient water quality sites on the Washington side of the LCR. Monitoring data include total suspended solids, and certain toxic chemicals that are analyzed at irregular time intervals.

United States Geological Survey

The United States Geological Survey (USGS) operates four ambient water quality-monitoring sites on the Columbia River. These sites have provided data for long term-trend analysis for the lower river. Future monitoring may emphasize measures of primary productivity. The USGS in cooperation with the Estuary Program will monitor the concentrations of lipid-soluble organic contaminants throughout the Columbia Basin, including the lower river. The USGS Biological Resources Division is conducting an analysis of the occurrence and distribution of contaminants in biota.

United States Environmental Protection Agency

The USEPA is conducting a study of water temperatures above the Bonneville Dam. The resulting forecasting model may prove useful in understanding the sources of elevated temperatures in both the upper and lower regions of the Columbia River. The USEPA has also collected information describing the contaminants in fish flesh from samples collected above the Bonneville Dam. These results might prove useful in directing the sampling of fish tissues in the lower river.

United States Army Corps of Engineers

In addition to MA-1 through MA-6 that directly support the Channel Improvement AEM Plan, the USACOE also performs other routine and compliance monitoring (e.g., water temperature, dissolved gas), including sediment sampling for toxic contaminants.

Coordination and Integration

While recognizing the need and importance of an integrated monitoring approach to effectively managing the LCR in broader terms, the Channel Improvement AEM Plan is more narrowly focused on the potential impacts of channel improvement on the physical nature of the river and estuary. Nevertheless, the AMT could informally contribute to the coordination and integration across the various monitoring programs. Alternatively, the participating organizations could establish a centralized data management system that provides for more formal sharing and archiving of the products of the diverse monitoring activities currently underway. A centralized data management system offers the advantage of accessing various sources of data from a single location, even though the actual data might be distributed among a variety of locations. However, development of such a data management system lies currently beyond the scope of the Channel Improvement AEM Plan.

3-2 Ecosystem Evaluation Actions

The results of six proposed ecosystem evaluation actions (EEA-1 through EEA-6) can usefully serve as part of the information base that enters into the AEM Process (Figure 2.2). These evaluation actions were developed to further assist the USACOE, NMFS, and the USFWS in advancing the basic understanding of the LCR ecosystem.

In general, the evaluation actions will address indicators of the salmonid conceptual model (Appendix A)[2] and advance the knowledge base for conservation and recovery of salmonid species (e.g., Bottom et al. 2001). Several actions will provide quantitative information describing habitat parameters including bathymetric information for listed ESU, the corresponding studies will focus on tidal marsh, shallow water flats, and water column habitat. Other evaluation actions derive from concerns of sublethal effects of contaminants on growth, and survival of juvenile salmonids and their prey (e.g. Arkoosh et al. 1998).

The following paragraphs briefly outline the six EEA. Associated costs of each action could be used to characterize the value of new information produced by these studies in increasing the likely success of the proposed LCR and estuary AEM Plan.

EEA-1

EEA-1 will obtain additional data and information that describe salmonid habitats and

[2] The juvenile salmonid conceptual model developed for the Channel Improvement Project has been further elaborated into the more comprehensive Columbia River Conceptual Model (www.nwp.usace.army.mil/Pm/LCR/docs/CREConceptualmodel/START.htm).

distribution of these habitats in the estuary. This action will provide additional transects in different habitat types similar to those being conducted as part of the NOAA Fisheries AFEP. One of these transects is prescribed for Cathlamet Bay because numerical modeling completed for the CRCIP identified Cathlamet Bay as an important area to evaluate regarding potential changes in habitat availability and utilization by juvenile salmonids.

It is anticipated that these transect data would be obtained prior to construction and for an additional three years following project completion. The data will contribute to decisions regarding possible project modification if adverse impacts to the listed ESU are determined. Additionally, the data could be used to help plan future ecosystem restoration and enhance the environmental benefits associated with individual restoration projects.

EEA-2

EEA-2 will characterize coastal cutthroat trout use of tidal marsh habitat in the Columbia River estuary. Juveniles of cutthroat rear in the estuary for an extended period of time compared to other anadromous fish species. One year of data for this evaluation action has been previously collected. An additional year of pre-construction data and two years of construction period data will be collected. These data will contribute to decisions regarding possible project modification if adverse impacts to the listed ESU are determined.

EEA-3

EEA-3 includes a bank-to-bank hydrographic survey of the Columbia River estuary. This survey will provide valuable information describing the bathymetry of the estuary and shallow water-flat habitat. These kinds of data have not been collected since the mid-1980s. The results of the survey can contribute to the development and construction of future ecosystem restoration features.

EEA-4

EEA-4 addresses contaminant issues in juvenile salmonids and their prey. EEA-4 focuses on possible bioaccumulation of chemical contaminants. EEA-4 will characterize possible risks of chemical exposure associated with the potential resuspension of toxic chemicals associated with Project dredging. Pre-construction data were collected in 2002. Additional data will be collected during construction and for three years post-construction.

EEA-5

EEA-5 compliments and extends EEA-4 by examining the potential sub-lethal effects of contaminants on juvenile salmonid growth and survival. Information will be assembled to describe potential effects of accumulated chemical contaminants on physiological processes that contribute to growth. The combination of EEA-4 and EEA-5 can develop a comprehensive description of ecological risks posed by the possible mobilization of chemical contaminants as a result of CRCIP dredging.

EEA-6

EA-6, a term and condition of the NOAA Fisheries and USFWS BO, will take the form of an "Estuary Turbidity Maximum Workshop." The purpose of the workshop is to better understand the spatial and temporal variability in the location of the ETM, as well as to propose effective management actions to conserve the ETM on the basis of this understanding.

These ecosystem evaluation actions are consistent with Corps' Environmental Operating Principles and actively consider the possible environmental consequences of the Channel Improvement Project. These evaluation actions demonstrate an attempt to seek a balance between the proposed channel improvement project and the environmental integrity of the Columbia River estuary through designing mutually beneficial economic and environmental solutions. These ecosystem evaluation actions reflect an effort by the Corps Portland District, the Sponsor Ports, NOAA Fisheries, and the USFWS to develop an integrated scientific, economic and social knowledge base that supports a greater understanding of the environment, particularly as it relates to juvenile salmonids of listed ESUs, and the CRCIP. The national importance of these ESUs justifies the evaluation actions described for this project. Management emphasis on recovery of these ESUs is shifting from above Bonneville Dam to the lower Columbia River and estuary.

Data produced by these actions will be collated and provided to the AMT to (1) determine the possible need for alteration of the Project actions (i.e., dredging); and (2) assess the value of information provided by the actions in relation to management and decision-making. Importantly, the results of these studies may assist in the analysis and interpretation of monitoring data. These studies might also provide critical information for the development and implementation of environmental/ecological models used in support of the AEM Process.

3-3 Identification of Models

Both conceptual and operational models will be necessary for successful management within an AEM framework. Conceptual models can importantly assist in the design of the AEM Plan. Operational models can provide quantitative forecasts of the likely impacts of channel deepening in terms of the selected performance measures and risk endpoints. Operational models can also estimate the expected effects of ecosystem management on juvenile salmonid habitat, habitat opportunity, and associated salmonid growth, survival, and ocean entry.

Conceptual Models

Within the AEM and risk-based framework, conceptual models should be developed in relation to proposed management objectives as an initial step in making the decision-support framework operational. A conceptual model essentially describes in schematic shorthand the nature and content of the management process. The model attempts to reduce ecological complexity by focusing on selected ecosystem attributes that are essential in addressing a specific management challenge. This feature of the model helps to define the information that must be obtained and organized to describe the general characteristics and desired conditions of the managed ecosystem. The model also attempts to identify key cause-effect relationships that provide a basis for implementing models used forecast the outcomes of management actions. This aspect of the model depicts a qualitative understanding of interactions among system components that are vital to understanding and management. The conceptual model thereby assists in identifying the necessary and appropriate data (e.g., monitoring) and tools (e.g., models) needed to examine the proposed Project within the AEM decision framework i.e., Figures 1.1 and 2.2). Appendix A presents conceptual models developed to support the LCR and estuary AEM Process. Table 3.1 indicates how the proposed management actions may provide information for various aspects of the conceptual models.

Operational and Forecasting Models

Management challenges in the LCR and estuary involve complex, imperfectly understood ecological systems described by incomplete data. These circumstances suggest that environmental models will be increasingly relied upon to assist management and decision-making. As indicated in the overall management framework (Figure 1.1), environmental models can be used to (1) describe and understand the current conditions of the resources of concern, (2) explain historical trends, and (3) forecast the outcomes of management actions. Implementing the AEM framework requires the identification of specific environmental models (e.g., hydrologic, ecological, meteorological, chemical) that can be used to address the resources of concern in the context of the goals, objectives, and the decision process. Key criteria for selecting models are the operational (i.e., mathematical, statistical) relationships between factors affected by management decisions, for example, salinity changes and the assessment endpoints or performance measures selected to evaluate resources in relation to the desired conditions. The models must be capable of translating management actions into the expected corresponding changes in the values of the endpoints and measures used in decision-making (Pastorok et al. 2002).

The first step is to comprehensively search among existing models to identify those that are currently used or that can be either directly applied or that might be relevant following an acceptable level of effort in adapting the models. In some instances, new models might have to be developed. If so, the schedule for implementing the overall AEM framework must accommodate the time required for model development, testing, and application.

Application of the models clearly requires values of all the model input parameters. Ideally, the values would be derived using site-specific data and information. In practice, the parameter values will likely include site-specific data, estimates derived for similar applications, and in some instances, values based on best professional judgment. In all cases, the sources and estimation of the parameter values should be documented. Uncertainties (e.g., bias, imprecision) associated with each parameter should also be quantified or otherwise described as part of the process.

Table 3.1. Integration of LCR ecosystem conceptual model, monitoring, and ecosystem evaluation actions

	Conceptual Model Pathway and Indicators Addressed					
AEM Feature	**Habitat Processes**	**Habitat Types**	**Primary Productivity**	**Food Web**	**Growth**	**Survival**
MA-1	Salinity				Habitat connectivity, conveyance, habitat opportunity	Salinity, temperature
MA-2	Suspended sediments, bedload					Suspended solids
MA-3	Bathymetry (main channel)					
MA-4	Suspended sediments, turbidity	Tidal marsh, tidal flats, swamp	Benthic algae	Macroinvertebrates, insects, suspension/deposit feeders, resident macrodetritus	Habitat complexity, feeding opportunity, food availability, refugia	Suspended solids, turbidity, predation
MA-5						Contaminants
MA-6						Stranding
EEA-1		Tidal marsh, swamp, flats, main channel				
EEA-2		Tidal marsh, tidal flats, swamp, main channel				
EEA-3	Bathymetry	Shallow water- flats habitat				
EEA-4						Contaminants
EEA-5						Contaminants
EEA-6	Salinity		Phytoplankton			Salinity, turbidity

The results of model calculations should be evaluated to ensure that they are of proper format (e.g., units) to contribute directly to the management and decision-making process. The model outputs should correspond as closely as possible to the selected assessment endpoints or performance measures used to define the desired conditions (system state).

3-4 Identifying, Characterizing, and Addressing Uncertainties

As formulated, the proposed AEM Plan for the Channel Improvement Project is an example of risk-based decision-making or decision making under uncertainty. Risk-based decision-making takes into account the uncertainties that arise from natural variability and imperfect knowledge. Uncertainty can confound the decision-making process by eroding confidence in accurately selecting among alternative management actions. Managers can minimize the effect of uncertainty by recognizing the presence of natural variability in ecosystems and defining management objectives probabilistically, as risk endpoints. Analysis of risk based on ecological forecasting and the errors inherent in these forecasts establishes bounds on uncertainty and provides additional information that can be incorporated into decisions. This introduces a set of probabilistic tools for characterizing uncertainty, describing confidence bounds, and applying this information in decision-making.

Application of a risk-based approach to ecosystem management draws on experience in two related areas. First, concepts of uncertainty and risk and the probabilistic tools for their analysis have deep roots in engineering practice. The application of these tools to water management by the USACOE (National Research Council 2000) translates directly to the management of the channel deepening. Second, concepts of mapping the response of organisms and ecosystems to environmental stressors form the basis for evaluating risks of toxic substances released into the environment (USEPA 1998). The approach developed to direct the cleanup of Superfund hazardous waste sites provides a model for applying conceptual models, performance measures and environmental monitoring to the more general problem of ecosystem management. Although the proposed AEM Process does not emphasize risks posed by toxic chemicals, the overall USEPA framework for risk assessment has been usefully adapted to management challenges involving physical degradation of large river ecosystems [e.g., Upper Mississippi River Navigation Feasibility Study (UMRNFS)].

Various sources of uncertainty will influence management and decision-making in this complex river and estuary. Sources of uncertainty fall into three broadly recognized categories: natural variability, knowledge uncertainty, and decision model uncertainty. Uncertainty associated with each of these categories has different implications for decision-making.

Natural variability refers to the inhomogeneous properties of natural materials, such as soils and sediments, and the range and relative frequency of events, such as rainfall or stream flow. This source of uncertainty relates to the unknown “states of nature” that must be taken into account in decision-making under uncertainty. Often, stochastic models provide descriptions of these variable characteristics for decision-making purposes. Gathering additional better information cannot reduce natural variability, although the accuracy of the related stochastic models might be improved

Knowledge uncertainty reflects deficiencies in understanding of ecosystems and factors that affect them. If knowledge uncertainty is high, either because the data are poor or because the models are inaccurate, then it may not be possible to distinguish the effect of one management alternative from another with an acceptable degree of certainty. In principle, gathering more information and better data can reduce this uncertainty. Knowledge uncertainty also reflects errors in the data available to describe ecosystem structures and processes. Bias and imprecision can result from poorly designed or improperly executed monitoring programs. Sample collection, data analysis, data management and reporting can all introduce errors. Importantly, uncertainties introduced as part of monitoring can impair the decision-making process. Conversely, the management and decision-making process can result in the refinement of monitoring programs to reduce knowledge uncertainties and improve the overall effectiveness of the decision-making process.

Knowledge uncertainty can also introduce errors in the models used to interpret data and make predictions. Hydrologic and ecological models can be used extensively to project the expected outcomes of channel improvement on estuarine resources and performance measures. To the extent that the models are simplified and imperfect representations of complex hydrologic and ecological processes, bias and imprecision can enter into decision-making based on results from these models. Assumptions concerning basic model structure, as well as the quantification of initial conditions and estimation of model parameter values, can also introduce uncertainties into the use of models within the general decision-making framework (Figure 1.1).

Uncertainties associated with management and decision-making should be identified and characterized. The implications of these uncertainties on projected decision outcomes and risks should be quantified. The expected effects of channel improvement on achieving desired ecosystem conditions or incurring risks of adverse impacts will be estimated using quantitative (qualitative where necessary) relationships (stress-response functions) between the variables manipulated through management actions (e.g., water levels, salinities) and the selected performance measures and assessment endpoints. Each of the manipulated variables is a source of uncertainty, each of the functional relationships, whether a regression model or a complex process-based simulation, can also introduce uncertainty. These uncertainties, along with natural variability should be described, quantified, and where possible, propagated through the calculations used to estimate decision outcomes and risk.

Numerical methods are available for relating uncertain outcomes to uncertain input values as part of the risk estimation process. Results of these uncertainty analyses can be used to identify critical new data needed to refine the assessment and increase the effectiveness of the decision-making process. These analyses should be performed for the functional relationships used to estimate risk and include as many of the input and outcomes as practical and permitted by the assessment models and data.

Part 4. Broader Considerations in AEM Planning

4-1 Discussion

Challenges to Implementing an AEM Process

The goals and objectives of the CRCIP have been formulated in the context of economic and environmental sustainability. These goals and objectives will be translated into management actions applied to a large and complex environmental system–the lower river and estuary. This combination of desired sustainability, large scales, and system complexity justifies the use of an AEM approach to management and decision-making. In fact, it is difficult to think of an alternative management approach for this large-scale river and estuary ecosystem. However, practical barriers to making the AEM Process operational have emerged in previous applications of this approach, especially active AEM (Walters 1997). Hopefully, these barriers might not arise in management and decision-making regarding channel improvement. However, plans should be developed in anticipation of these potential pitfalls to effectively executing AEM.

Walters (1997) identified the following four challenges in putting an AEM Process into practice:

- Modeling in support of AEM is often replaced by never-ending model development and modeling exercises with the presumption that detailed modeling replace field experimentation in defining best management practices. There are also technical issues (e.g., accuracy, reliability) associated with the development and use of models in AEM. The most difficult technical issue may be the cross-scale linkages between physical (hydrodynamic), chemical (water quality), and ecological models that are necessary in using the models to design and evaluate management alternatives.

- Using active AEM (i.e., system manipulations as large-scale experiments) has been often viewed as excessively expensive or ecologically risky, compared to traditional management approaches. Costly modeling studies may be needed to design the management manipulation. Follow-on monitoring programs add to the costs of active AEM. Manipulations may result in economic losses to economic interests (e.g., lost revenues from reduced navigation). The management manipulation might result in unanticipated effects on non-target populations or resources with unacceptable consequences.

- People in management bureaucracies often oppose experimental management policies (e.g., AEM) in order to protect self-interests and retain the status quo. Complex institutional settings involving multiple agencies with sometimes-overlapping responsibilities and legal mandates can lead to interference in operations and resistance to proposed changes in management policy.

- There are value conflicts within the community of ecological (e.g., preservation) and environmental (e.g., conservation) management interests. In some cases, these conflicts can run deeper than more traditional conflicts between ecological and industrial (e.g., power production, navigation) values.

In addition to the challenges identified by Walters (1997), the current planning and guidance procedures (USACOE 1990) that have directed USACOE's activities in the past may require modifications that facilitate the practice of AEM. For example, identification of a "best" management Plan (i.e., National Economic Development Plan) seems to run counter to the basic philosophy of AEM, wherein the best current Plan might well change in the future. Identifying a best Plan might have to be replaced by identifying or describing the most effective process for performing AEM. Yet in the context of AEM, even the best AEM Process defined *a priori* as the result of a feasibility study might change during the course of managing. Therefore, the potential incompatibility of current planning and guidance with directives to embrace sustainability and practice AEM might require modifications to such guidance (Martin and Stakhiv 1999).

Surmounting Barriers to AEM

It is not easy to anticipate the extent to which the previously described barriers will influence the implementation of AEM in the context of the Channel Improvement Project. Several important steps have been undertaken that might surmount these barriers and facilitate the effective use of AEM in managing the lower river and estuary:

A comprehensive conceptual environmental model relevant to managing salmonids in the lower river and estuary has been developed. The model has been reviewed and shared with the community of stakeholders. The model has been used to guide the identification and selection of management goals and objectives consistent with the adaptive management directives that continue to shape the Channel Improvement Project.

A long-standing and continuing relationship between the USACOE and key partners provides a mechanism for sharing information, exchanging ideas, identifying concerns, and creating solutions in the context of AEM and sustainability for the Project.

Extensive peer review can be established to evaluate the technical aspects of sustainability goals and objectives, as well as the available models, data, and other tools needed to practice AEM in the context of the lower river and estuary.

Experience can accumulate in the use of complex hydrodynamic and ecological models in assessing ecological risks posed by channel deepening. The important cross-linkages among these models have been worked through in other applications (e.g., UMRNFS) and the models appear amenable for applications in AEM, as well as for continued evaluation of risks posed by physical, chemical, and biological alterations to complex lotic systems, including the LCR.

4-2 A Comprehensive, Integrated AEM Plan

The proposed AEM Plan to support the Channel Improvement Project was designed to focus initially on potential physical-chemical impacts of channel deepening. At the same time, it is recognized that these attributes, while of fundamental environmental importance, represent a subset of the components of a more comprehensive conceptual model of the lower river and estuary (Appendix A). This conceptual model conveys a direct sense of the ecological and environmental complexity in describing, understanding, and managing salmonid survival, growth and ocean entry. It appears unlikely that any single AEM Process undertaken by an individual resource agency or stakeholder could meaningfully progress towards realization of these challenging objectives. It seems more realistic that cooperation among ongoing (and future) AEM Projects (e.g., LCREP) will be required to achieve the desired goals concerning recovery and sustainability of the valued salmonid resources in the LCR and estuary.

The proposed Channel Improvement AEM Plan can contribute valuably to the future development and integration of a comprehensive adaptive management plan for the LCR and estuary. Data and information generated by the EEA, as well as research results developed during the course of Project management, can be shared among other agencies and stakeholder groups involved in other AEM Projects. The Channel Improvement Project AEM monitoring results, when integrated with other adaptive management programs, can help construct a more comprehensive picture concerning the structure and dynamics of the river and estuary ecosystem.

Data developed as a result of the Channel Improvement AEM Process may prove useful in facilitating the implementation of programs directed at recovery of listed salmonids in the estuary. For example, the research, monitoring, and evaluation Plan for the Columbia River estuary and plume (EP-RME Plan), currently under development, also emphasizes an adaptive management framework in relation to salmon habitat restoration (Johnson et al. 2004). Overlap in performance measures (e.g., accretion rates, water velocity, water elevation, water quality) between the EP-RME Plan and the Channel Improvement AEM Plan indicate an opportunity for useful collaboration towards achieving goals and objectives consistent with a comprehensive management Plan for the estuary.

References

Anderson, J.L., R.W. Hilburn, R.T. Lackey, and D. Ludwig. 2003. Watershed restoration–adaptive decision making in the face of uncertainty, pp. 203–232. In: Wissmar, R.C. and P.A. Bisson (Eds.), Strategies for restoring river ecosystems: sources of variability and uncertainty in natural and managed systems. American Fisheries Society, Bethesda, MD. p 276.

Arkoosh, M.R., E. Casillas, P. Huffman, E. Clemons, J. Evered, J.E. Stein, and U. Varanasi. 1998. Increased susceptibility of juvenile chinook salmon from a contaminated estuary to *Vibrio anguillarum*. Transactions of the American Fisheries Society 127:360–374.

Bartell, S.M., R.H. Gardner, and R.V. O'Neill. 1992. Ecological Risk Estimation. Lewis Publishers, Inc., Chelsea, MI. p 233.

Bartell, S.M. 1996. Ecological/environmental risk assessment: principles and practices. In: Risk Assessment and Management Handbook for Environmental, Health, and Safety Professionals, Kolluru, R., S.M. Bartell, S. Stricoff, and R. Pitblado (Eds.). McGraw-Hill.

Bottom, D.L., C.A. Simenstad, A.M. Baptista, D.A. Jay, J. Burke, K. Jones, E. Casillas, and M.H. Schiewe. 2001. Salmon at river's end: the role of the estuary in the decline and recovery of Columbia River salmon. U.S. National Marine Fisheries Service, Seattle, WA. p 271.

Gardner, R.H., W.M. Kemp, V.S. Kennedy, and J.E. Petersen (eds.). 2001. Scaling relations in experimental ecology. Complexity in ecological systems. Columbia University Press, N.Y.

Gray, A.N. 2000. Adaptive ecosystem management in the Pacific Northwest: a case study from coastal Oregon. Conservation Ecology 492): 6. [online] URL: http://www.consecol.org/vol4/iss2/art6.

Gunderson, L.H. and C.S. Holling (eds.). 2002. Panarchy–understanding transformations in human and natural systems. Island Press, Washington, D.C.

Holling, C.S. 1978. Adaptive environmental assessment and management. John Wiley, N.Y.

Johnson, G.E., H. Diefenderfer, T. Berquam, B.D. Ebberts, and J.D. Wilcox. 2004. Research, monitoring, and evaluation plan for listed salmon of the Columbia River estuary and plume. Draft report prepared for NMFS. March 18, 2004.

Kaplan, S. and B.J. Garrick. 1981. On the quantitative definition of risk. Risk Analysis 1:11–27.

Kareiva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer chinnok salmon in the Columbia River Basin. Science 290:977–979.
Martin, L.R. and E.Z. Stakhiv. 1999. Sustainable development: concepts, goals, and relevance to the civil works program. IWR Report 99-PS-1. Water Resources Support Center, U.S. Army Corps of Engineers, Alexandria, VA.

National Research Council. 2000. Risk analysis and uncertainty in flood damage reduction studies. The National Academy Press, Washington, D.C. p 202.

Pastorok, R.A., S.M. Bartell, S. Ferson, and L.R. Ginzburg. 2002. Ecological modeling in risk assessment: chemical effects on populations, ecosystems, and landscapes. Lewis Publishers, Boca Raton, FL.

Reinert, K.H., S.M. Bartell, and G.R. Biddinger (eds.). 1998. Ecological risk assessment decision-support system: a conceptual design. Proceedings from SETAC Ecological Risk Assessment Modeling Workshop, 1994 August 23–28, Pellston, MI. Pensacola, FL: Society of Environmental Toxicology and Chemistry. p 120.

Rubenstein, M.F. 1975. Patterns in problem solving. Prentice-Hall, Englewood Cliffs, N.J.

U.S. Army Corps of Engineers (USACOE). 1990. Engineering Regulation 1105-2-100, Guidance for conducting civil works planning studies (Planning Guidance Notebook, PGN). CECW-P, HQUSACE, Washington, D.C.

USACOE. 2001. Biological assessment. Columbia River Channel Improvements Project USACOE, Portland District, Portland, OR. (www.nwp.usace.army.mil/issues/CRCIP/Bioassessment2001/assessment.pdf).

United States Environmental Protection Agency (USEPA). 1998. Guidelines for ecological risk assessment PA/630/R-95/002F. USEPA, Risk Assessment Forum, Washington, D.C.

Walker, B., S. Carpenter, J. Anderies, N. Abel, G.S. Cumming, M. Janssen, L. Lebel, J. Norberg, G.D. Peterson, and R. Pritchard. 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. Conservation Ecology 6(1):14. http://www.consecol.org/vol6/iss1/art14.

Walters, C.J. 1986. Adaptive management of renewable resources. Mcgraw-Hill, New York, N.Y.

Walters, C.J. 1997. Challenges in adaptive management of riparian and coastal ecosystems. Conservation Ecology 1(2):1. http://www.consecol.org/vol1/iss2/art1.

Walters, C.J. and R. Hilborn. 1978. Ecological optimization and adaptive management. Annual Review of Ecology and Systematics 8:157–188.

Walters, C.J. and C.S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology 71:2060–2068.

LIST OF ACRONYMS & ABBREVIATIONS

AEL	adult equivalent losses
AEM	Adaptive Environmental Management
AFEP	Anadromous Fish Evaluation Program
AMT	Adaptive Management Team
BA	biological assessment
BO	biological opinion
CRCIP	Columbia River Channel Improvement Project
CRITFC	Columbia River Inter-tribal Fish Commission
CRM	Columbia River mile
CWA	Clean Water Act
cy	cubic yards
DLCD	Department of Land Conservation and Development
EEA	ecosystem evaluation actions
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ESU	evolutionary significant units
ETM	estuary turbidity maximum
FR	Federal Register
FSIFR	Final Supplemental Integrated Feasibility Report
LCR	Lower Columbia River
LCREP	Lower Columbia River Estuary Partnership
MA	monitoring actions
NMFS	National Marine Fishery Service
NOAA	National Oceanic and Atmospheric Administration
ODEQ	Oregon Department of Environmental Quality
psu	practical salinity units
ROD	record of decision
SEF	Sediment Evaluation Framework
USACOE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WDOE	Washington Department of Ecology

Appendix A

Salmonid Conceptual Models

Columbia River Channel Improvement Project
Adaptive Environmental Management Plan

March 2006

A.1 Introduction to the Conceptual Model

Within the broader Adaptive Environmental Management (AEM) and risk-based framework, conceptual models should be developed in relation to proposed management actions as an initial step in making the decision-support framework operational. A conceptual model essentially describes in schematic shorthand the nature and content of the assessment. The model attempts to reduce ecological complexity by focusing on selected ecosystem attributes that are essential in addressing a specific management challenge; this process includes the identification of risk assessment endpoints and performance measures. This feature of the model helps to define the information that must be obtained and organized to describe the general characteristics and desired conditions of the managed ecosystem. The model also attempts to identify key cause-effect relationships that provide a basis for implementing models used to forecast the outcomes of management actions. This aspect of the model depicts a qualitative understanding of interactions among system components that are vital to understanding and management. The conceptual model thereby assists in identifying the necessary and appropriate data (e.g., monitoring) and tools (e.g., models) needed to examine the proposed project within the broader AEM decision framework.

In applying the overall framework, it is important to remember that conceptual models, as with other models, are simplifications and to some degree arbitrary representations of complex environmental systems: there is no "best" conceptual model. Within the AEM framework, the initial conceptual model might be modified during the course of management and decision-making. Stressors initially thought important may prove to be less so; additional stressors, initially not addressed, may need to be added to the model. Similarly, certain endpoints or performance measures might be added, deleted, or modified as the result of experience gained through application of the conceptual model to specific management questions. Functional relationships between stressors and endpoints might be reformulated based on new information. Successive refinements of the conceptual model can eventually produce a relatively stable model structure that accurately and concisely depicts the nature and scope of effective management and decision-making in relation to channel improvement. For example, the Columbia River Conceptual Model (www.nwp.usace.army.mil/Pm/LCR/docs/CREConceptmodel/Start.htm) has been developed as a more comprehensive model that derives from the channel deepening conceptual model described in this Appendix. This effort continues to evolve and both conceptual models can be usefully referenced in evaluations of the potential impacts of channel modifications on Columbia River salmonids.

The conceptual model developed as part of the Final Supplemental Integrated Feasibility Report/Environmental Impact Statement can play a central role in implementing the AEM Plan for the Lower Columbia River (LCR) and estuary. The overall conceptual model identifies ocean and river processes, habitat forming processes, habitat type, primary productivity associated with each habitat, food web dynamics, growth, and survival as key determinants of juvenile salmon entry into the ocean (Figure A.1). Each of these major contributors to salmon entry has been further decomposed into corresponding indicators (i.e., performance measures, and risk endpoints) in further elaboration of the overall conceptual model.

The conceptual models are reproduced in this Appendix mainly to emphasize the need to ensure that the AEM Plan addresses key indicators in these models. The conceptual models can also guide the identification and selection of operational models to be included as part of the management and decision-making process. Importantly, the identification, selection, and application of models (both conceptual and operational) can proceed in a hierarchical manner, with an initial emphasis placed on models that focus on changes in bathymetry (accretion/erosion), temperature, and salinity in relation to channel deepening. If substantial alterations (i.e., exceed decision criteria) in these physical and chemical characteristics of the lower river and estuary are not demonstrable project impacts, consideration of additional models for the remaining habitat and ecological indicators might not be necessary to support the Channel Improvement AEM Plan.

Conceptual Model for Juvenile Salmonids in the Lower Columbia River
(From Figure S6-1 in FSEIS)

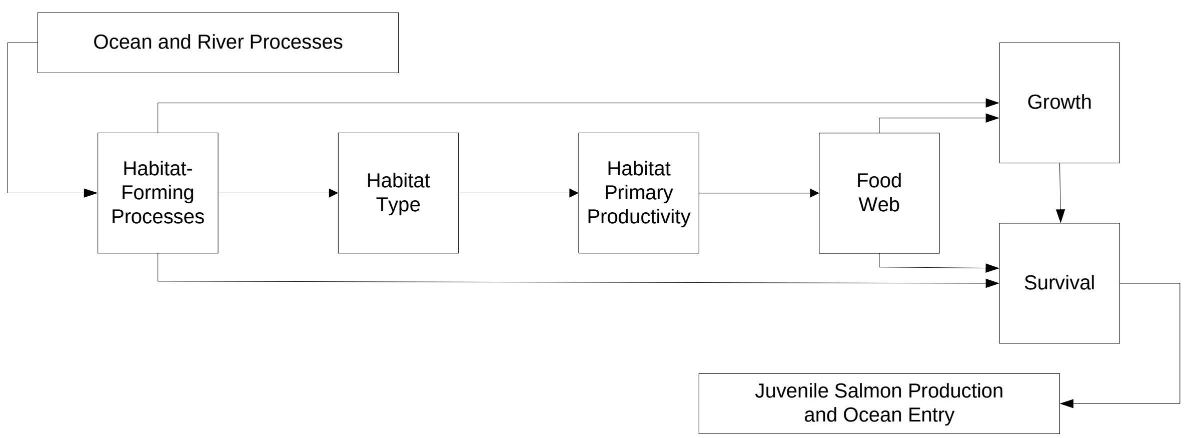

Figure A.1. Overall conceptual model used in support of the LCR and the estuary AEM Plan.

A.2 Habitat Forming Processes

Dredging required for channel improvement might effect changes in selected indicators of habitat forming processes (Figure A.2):

- short-term, localized increases in suspended sediment concentrations in the vicinity of dredging and disposal;
- shifts in the direction of bedload sediment movement that might impact the quantity and quality of shallow waters and flats habitat;
- the amount and distribution of woody debris that can provide valuable habitat for salmonids and their prey;
- increases in local turbidity as well as upstream shifts in the estuary turbidity maximum;
- salinity changes in shallow embayments (e.g., Cathlamet Bay, Grays Bay) and the bottom of the navigation channel;
- accretion and erosion associated with dredging and disposal of dredged materials; and
- changes in bathymetry that result from channel deepening that could influence depths and flow velocity in water column habitat.

Previous modeling and analysis during the Endangered Species Act consultation process suggested minimal changes in the above indicators in relation to channel deepening. However, these indicators could become components of a compliance-monitoring program as part of the AEM Plan implementation.

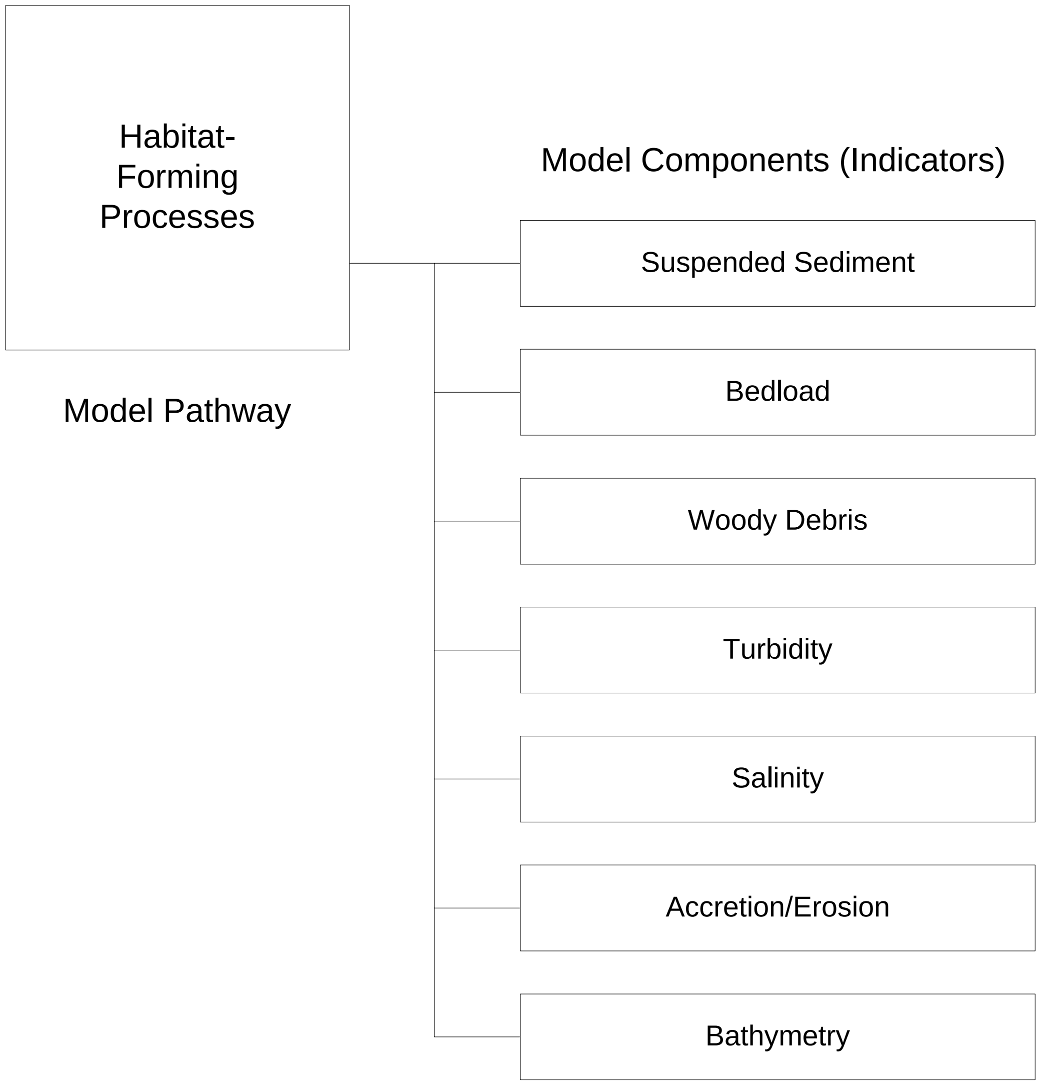

Figure A.2. Conceptual model indicators developed for habitat forming processes.

A.3 Estuarine Habitats

Figure A.3 identifies the important types of estuarine habitat that can influence the successful entry of juvenile salmonids into the ocean:

- tidal marsh and swamp,
- shallow water and flats, and
- water column.

The distribution and extent of each of these habitat types should be included as indicators of the adverse impacts of channel deepening (i.e., risk endpoints) or the benefits of ecosystem restoration actions (i.e., performance measures).

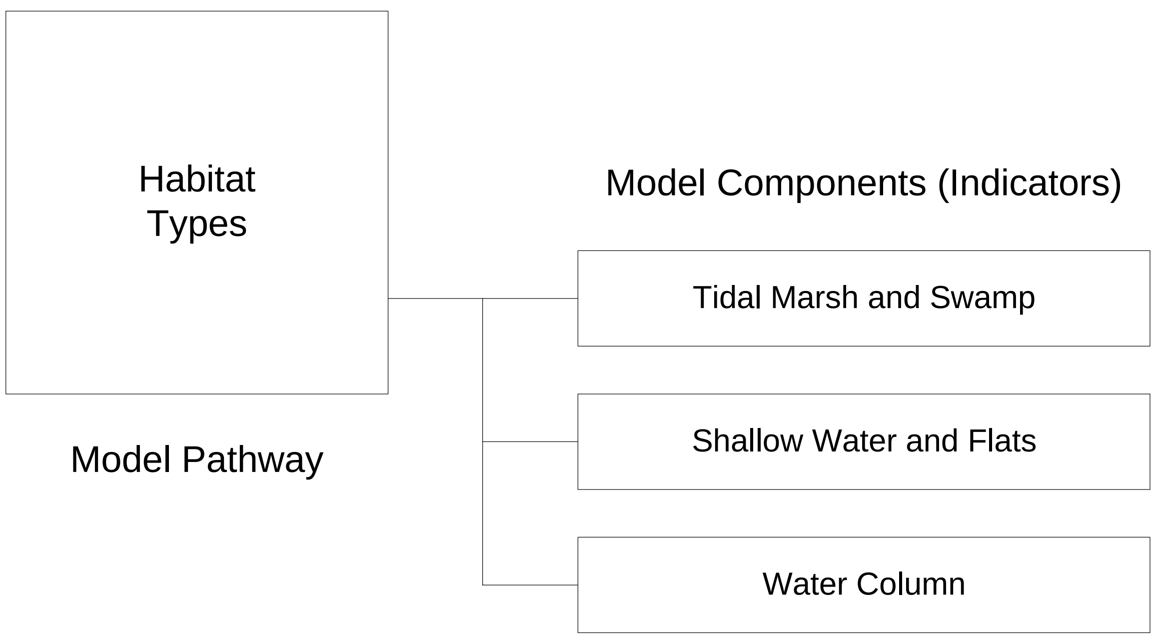

Figure A.3. Three important estuarine habitat types to be included as indicators in the LCR and the estuary AEM Plan.

A.4 Habitat Primary Productivity

Primary productivity in each of the above important habitat types provides a key contribution to the overall energy budget and influences the availability of food to juvenile salmonids that develop in the estuary before entering the ocean (Figure A.4). The proposed indicators of primary productivity include light and nutrients that can determine rates of photosynthesis and plant growth. Additional direct measures of primary production are included as indicators in the conceptual model:

- production of imported phytoplankton and resident phytoplankton,
- production by benthic algae, and
- production measured in tidal marsh and swamp habitats.

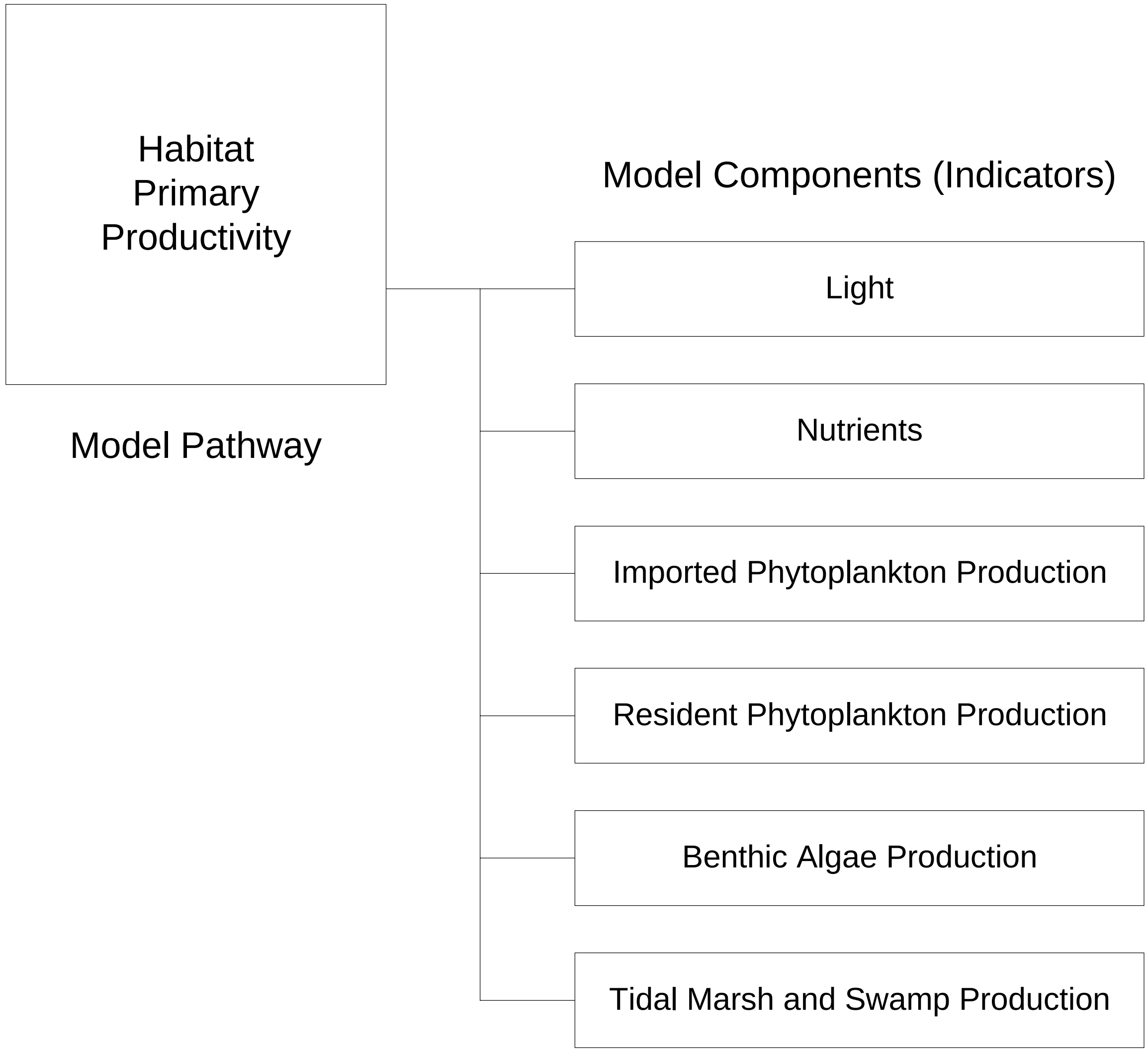

Figure A.4. Indicators of primary productivity for three important habitats in the conceptual model for the AEM in the Columbia River estuary.

A.5 Food Web

The conceptual model identifies food web components that constitute indicators of potential project effects on the overall production dynamics in the LCR (Figure A.5): They are

- deposit feeders, suspension/deposit feeders, and suspension feeders can suffer short-term impacts due to removal and burial associated with dredging and disposal activities,

- dredging and disposal can also impact the distribution and abundance of mobile macroinvertebrates and insects that serve as important food sources for salmonids in the estuary, and.

- the overall ecosystem energetics important in determining the growth of salmonids within the estuary are also influenced by the production and availability of resident microdetritus, imported microdetritus, and macrodetritus produced mainly in the tidal marshes.

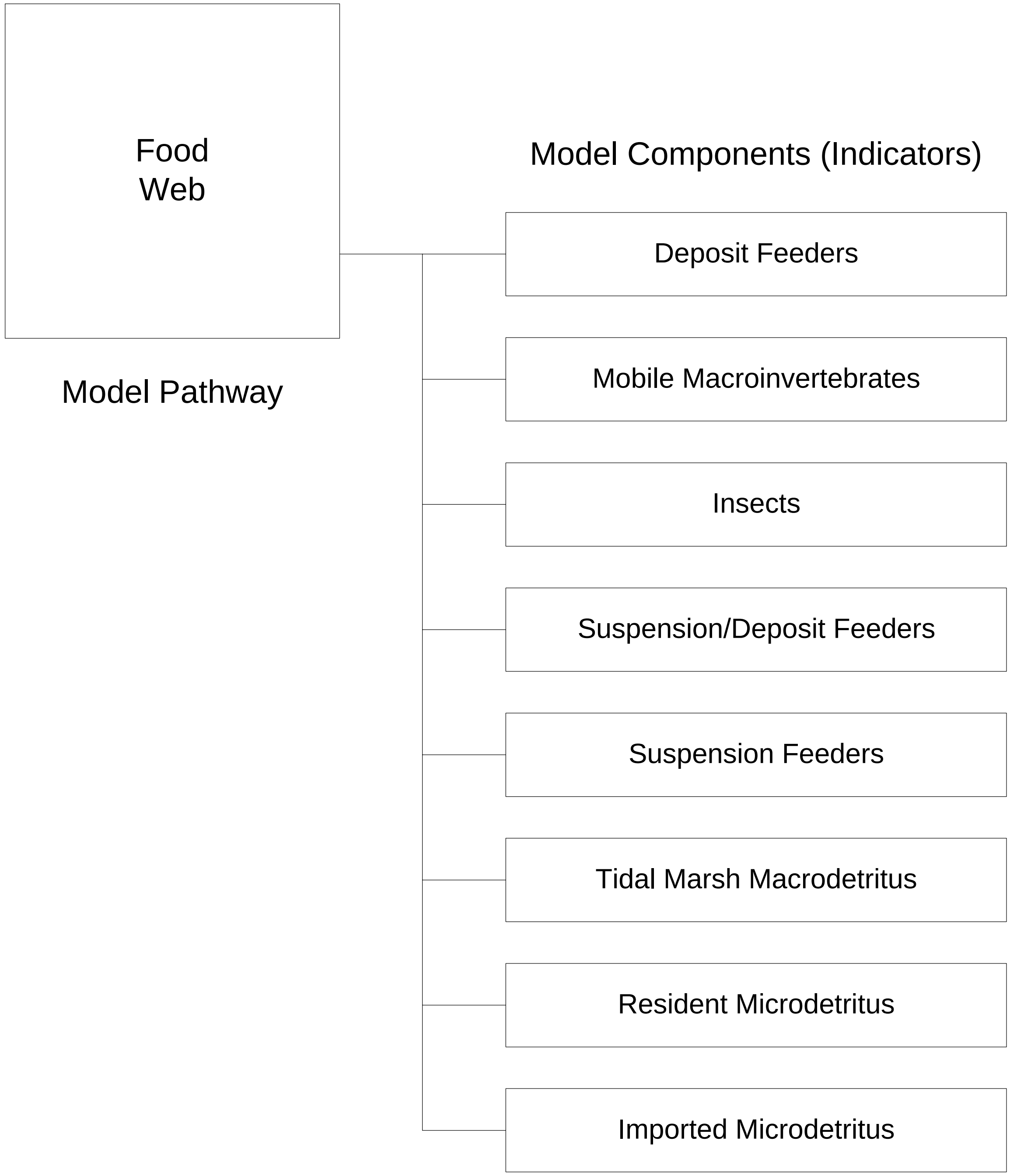

Figure A.5. Food web indicators identified in the conceptual model for the AEM of the LCR and estuary.

A.6 Salmonid Growth

Figure A.6 identifies components of the conceptual model that influence the growth of juvenile salmonids in the lower river and estuary. Habitat complexity, connectivity, and conveyance can determine the availability of foraging opportunities and physical routes for safe passage to the open ocean for juvenile salmonids. Spatial and temporal patterns in current velocities can impact growth. Higher than preferred current velocities can make greater energetic demands on smaller fish and reduce growth. Areas of slower velocity can provide energetic refugia for migrating fish. Modifications to bathymetry in the main channel and shallow water habitats can alter the extent of important habitat available for juvenile fishes. Turbidity can correlate with the location of a concentrated food source (e.g., turbidity maximum), as well as impede the visually-oriented feeding behavior of juvenile salmonids. The previous model components determine, in part, the habitat opportunity for juvenile salmonid feeding. Feeding opportunity is also influenced by the availability of prey in specific foraging habitats.

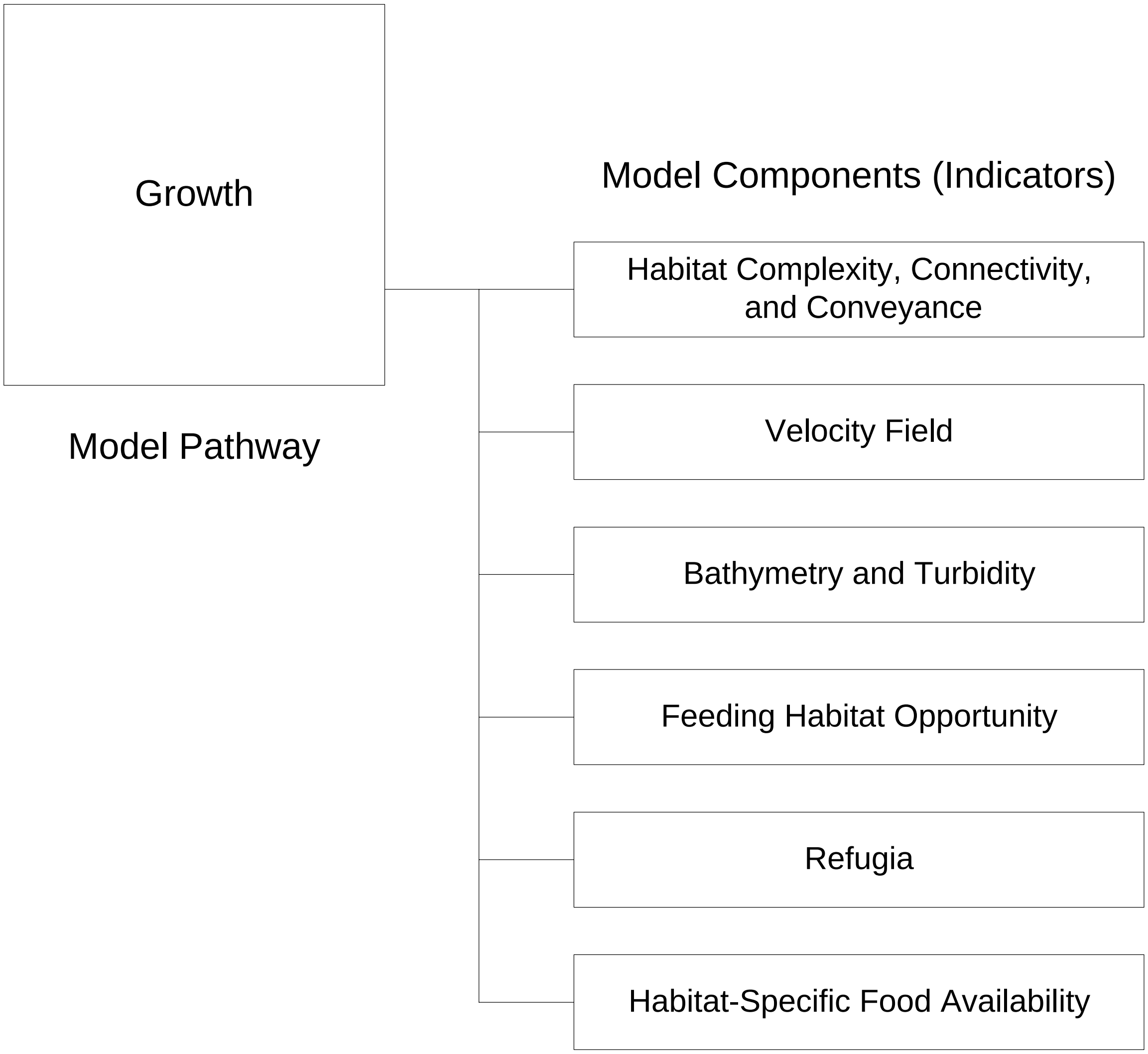

Figure A.6. Components and indicators of the growth pathway in the overall the LCR and estuary conceptual model.

A.7 Salmonid Survival

The conceptual model components recognized as important to the survival of juvenile salmonids are provided in Figure A.7. The indicators of survival include physical, chemical, and biological/ecological factors that can determine the probability that a juvenile fish will successfully enter the open ocean. Channel modifications suggest a low probability of fish experiencing extreme values of temperature and salinity. Channel dredging can also alter the concentrations of suspended solids, influence local turbidity, and potentially expose fish to sediment contaminants. Increased commercial navigation can entrain and strand smaller fish. The susceptibility of smaller fish to predation and disease also impacts the likelihood that these fish will survive to enter the open ocean component of their life cycle.

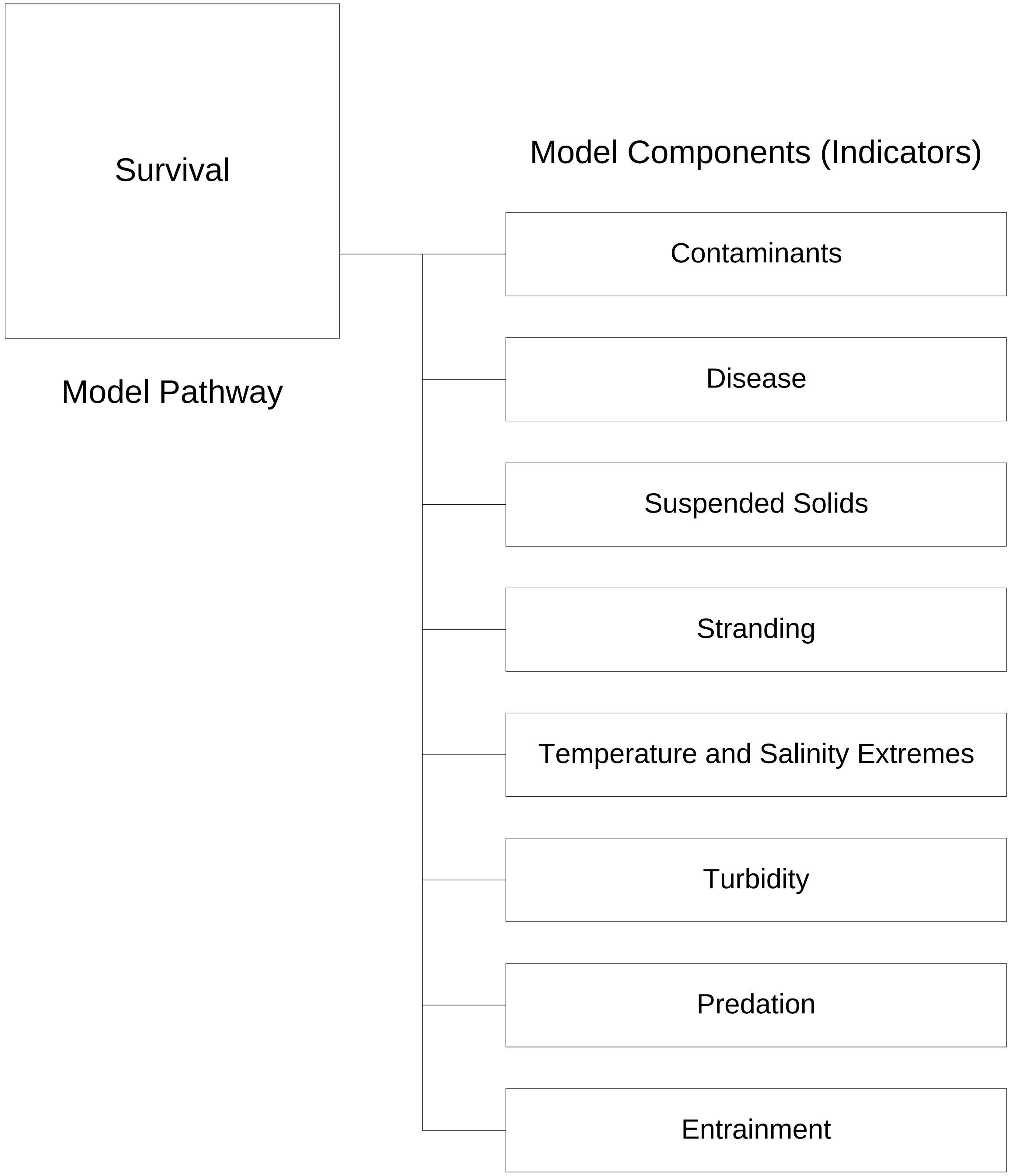

Figure A.7. Components and indicators of the survival pathway in the overall the LCR and estuary conceptual model.

The pathways and indicators presented in the conceptual models can be used to organize information that will be generated as the result of the monitoring programs and planned ecosystem evaluation actions.

Again, it must be remembered that the initial AEM Plan emphasizes the examination and evaluation of channel deepening in relation to possible changes in bathymetry, patterns of water circulation, and associated impacts on salinity, temperature, and depth. If such impacts cannot be demonstrated in relation to channel improvement, many of the more detailed ecological pathways and indicators will likely not be pursued.

Appendix B

Adaptive Management Team
Organization & Plan of Operation

Columbia River Channel Improvement Project
Adaptive Environmental Management Plan

March 2006

B.1 Authority

An adaptive management program was specified for the Columbia River Channel Improvement Project (CRCIP) in the Final Supplemental Integrated Feasibility Report and Environmental Impact Statement (January 2003), and by the terms and conditions specified in the National Marine Fisheries Service (NMFS) Biological Opinion (BO) (February 2005). Additionally, the water quality certifications and coastal zone management decisions issued by the States of Oregon and Washington require an Adaptive Management Team (AMT) to be established in relation to the channel modifications.

B.2 Composition of the AMT

The AMT comprises the managers, decision-makers, and Technical Staff ultimately responsible for implementing the CRCIP Adaptive Environmental Management (AEM) Plan (Table B.1). The primary federally oriented composition of the AMT includes representatives from

- the U.S. Army Corps of Engineers together with the Sponsor Ports for the CRCIP,
- the NMFS, and
- the U.S. Fish and Wildlife Service (USFWS)

In addition to the federal components, the AMT also includes state representation from

- the Oregon Department of Environmental Quality,
- the Oregon Department of Land Conservation and Development, and
- the Washington Department of Ecology.

Columbia River Channel Improvement Project
Adaptive Management Team

	Federal orientation	State orientation
Dispute Resolution Team	Corps of Engineers, Colonel Portland District NMFS, Assistant Regional Administrator, Habitat Conservation Division USFWS, State Supervisor, OR State Office	Water Quality Administrator, Oregon DEQ Director, Oregon DLCD Director, Washington DOE
Management Team	Corps of Engineers, Deputy District Engineer NMFS, State Director, OR State Habitat Office USFWS, State Supervisor, OR State Office Port of Vancouver, Executive Director	Watershed Assessment Manager, Oregon DEQ Coastal Program Manager, Oregon DLCD Program Manager, Washington DOE
Technical Team	Project Manager, CRCIP, COE NMFS US Fish and Wildlife Sponsor Ports	Columbia River Coordinator, Oregon DEQ CZMA Technical Lead, Oregon DLCD 401 Technical Lead, Washington DOE CZMA Technical Lead, Washington DOE

Table B.1. Composition of CRCIP AMT.

The AMT consists of a Technical Team, a Management Team, and a Dispute Resolution Team (Table B.1). The Technical Team is responsible for conducting the regularly scheduled activities required to implement the CRCIP AEM Plan and Process. The Technical Team consists of individuals who represent federal [e.g., Endangered Species Act (ESA)] and state [e.g., Section 401 of the Clean Water Act (CWA), and the Coastal Zone Management Act (CZMA)] regulatory interests in relation to channel modifications. The Technical Team will execute the AEM Process through an informal, yet scientifically rigorous, process based on collaboration and consensus building.

The Management Team consists of more senior-level managers representing their respective federal and state agencies. In the event that consensus cannot be reached by the Technical Team concerning adaptive management, the Management Team can be consulted to assist in the AEM Process. In addition, the Technical Team might consider specific adaptive management issues to be of sufficient importance to be communicated to the Management Team, even though a consensus opinion might exist among the Technical Team. As specified in the AEM Plan, the Technical Team will inform the Management Team at least annually concerning the status of adaptive management in relation to the CRCIP.

The Dispute Resolution Team includes those top-level managers and decision makers who are ultimately responsible to ensure that the implementation of the CRCIP AEM Plan ensures compliance with their respective federal and state mandates. The Dispute Resolution Team will address those AEM issues and concerns that cannot be resolved by the Management Team. The Dispute Resolution Team will have the same opportunity as the Management Team to be informed annually about the status of the CRCIP Adaptive Management Project.

To be eligible for appointment to the AMT, a candidate must (1) work for an agency with regulatory responsibility in relation to the actions the Corps will be undertaking or be a cost sharing partner with the Corps, (2) have the ability to work productively in a group setting towards common objectives in support of the AEM Plan, and (3) represent their constituent organization.

Each participating agency shall be responsible for appointing one or more representatives to the AMT. It is the responsibility of each agency to designate alternate representatives as necessary. Terms of service on the AMT are indefinite, but may be determined separately by each agency.

B.3 Scope and Objectives

The AMT is responsible for implementing the AEM Plan for the CRCIP. As outlined in Table B.1, the AMT reflects both federal concerns regarding threatened or endangered species throughout the river and estuary, and state interests concerning water quality standards and beneficial uses related to coastal zone management and river conditions.

The AMT will consider monitoring, research, and other information obtained during project implementation and make decisions concerning modifications to the project if such information indicates that the decision criteria (i.e., “trigger values”) established by the AMT have been exceeded. The AMT will regularly evaluate the effectiveness of the CRCIP monitoring program and related research, to ensure that project construction and operation have impacts no greater than those used in the derivation of the decision criteria.

The AMT will conduct adaptive management within the framework described in the CRCIP AEM Plan document. Adaptive management will (1) mitigate for any impacts that exceed the decision criteria, (2) modify the project to maintain consistency with the decision criteria, and (3) possibly stop the project. The AMT will carry out the AEM Process in a manner consistent with the ESA incidental take provisions stated the BO, as well as the ecological resource and water quality compliance issues associated with Section 401 of the CWA and the CZMA as implemented by the states of Oregon and Washington.

It is envisioned that the AMT will act primarily through consensus, where consensus is obtained when no person of the AMT formally opposes the particular issue in question. Formal opposition shall be provided in writing to the AMT.

B.4 Description of Duties

The duties of the AMT focus on the continuing implementation of the CRCIP AEM Plan and include the following activities:

- establish and revise as necessary AMT operating procedures;
- execute the CRCIP AEM Plan and Process;
- define and recommend resource management objectives (decision criteria or "trigger values") for environmental and ecological components of the CRCIP AEM Plan;
- implement the relevant provisions of the BO, Section 401 of the CWA, and the CZMA;
- obtain and review summaries of monitoring activities (MA-1 through MA-6) and other AEM-relevant information concerning channel improvements from the Technical Work Group;
- define and solicit additional information that needs to be provided by the Technical Work Group to the AMT;
- recommend management actions (i.e., continue the current CRCIP, or undertake adaptive management) in relation to the monitoring data, other supporting information, and the agreed upon decision criteria; and
- provide for transparency and documentation of the AEM Plan and Process.

B.5 Tribal Involvement in the AMT Process

The federal government agencies that comprise the AMT have a “government to government” relationship with the Tribes that have been acknowledged in the development and implementation of the CRCIP. As part of it’s work to implement the ESA**;** NMFS and the USFWS will address Tribal issues associated with the ESA via Secretarial Order 3206 (American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the ESA). This Order clarifies the responsibilities of the component agencies, bureaus, and offices of the Department of the Interior and the Department of Commerce, when actions taken under authority of the ESA affect, or may affect, Indian lands, tribal trust resources, or the exercise of American Indian tribal rights. This Order further acknowledges the trust responsibility and treaty obligations of the United States toward Indian Tribes and tribal members and its “government to government” relationship in dealing with Tribes.

The Tribes and the Columbia River Inter-tribal Fish Commission (CRITFC) have a continuing interest in the CRCIP. In order to acknowledge the unique role that the Tribes have in the AMT Process and to support the “government to government” relationship that the federal government has with the Tribes, including compliance with Secretarial Order 3206, the Tribes have agreed to participate in the AMT Process in the following manner:

- Individual tribal governments may request “government to government” consultation at the Management Team and/or Dispute Resolution Team levels with the USFWS and NMFS in accordance with Secretarial Order 3206 to address specific issues associated with the findings of the CRCIP AEM Process.

- The Management and Technical Teams will provide briefings to the CRITFC and USFWS Committee on the status and findings of the AMT as requested. AMT participants will be available to respond to questions from CRITFC and/or individual Tribe’s questions about the project. This may involve follow-up discussions via e-mail, regular mail, phone or visits to the CRITFC office and/or to the individual Tribe’s reservation.

- CRITFC Technical Staff and Technical Staff from individual member Tribes will be invited to the annual Anadromous Fish Evaluation Program meeting that addresses estuary issues, including the monitoring and research resulting from implementation of the CRCIP.

B.6 Sub-groups

The AMT may establish such work groups or subcommittees as it deems necessary for the purposes of compiling information, performing analyses, discussing issues, and reporting back to the AMT. Examples of an AMT Work Group could be Dungeness Crab Team, or Sturgeon Support Team, etc.

The Technical Work Group described in the CRCIP AEM Plan will serve as a standing sub-group of the AMT.

B.7 Estimated Number and Frequency of Meetings

The Technical Team of the AMT will meet at least quarterly. The Technical Team and its support group(s) can, however, meet more frequently, for example, as determined by the availability of monitoring summaries or the occurrence of CRCIP-related events not anticipated in the design and/or implementation of the AEM Plan. The Technical Work Group will meet as needed, and any member of the Technical Work Group can call a meeting. The entire AMT is expected to meet annually. Individual participating agencies may call additional meetings of the AMT as deemed appropriate.

B.8 Duration

It is the intent that the AMT shall continue throughout the construction and monitoring phase of the CRCIP.

B.9 Agency Responsibility

Each agency represented on the AMT is responsible for ensuring that the AEM Process is meeting agency needs. The AMT as a group does not intentionally make decisions that would reduce the ability of any participating agency to realize its mission or meet its regulatory responsibilities.

Appendix C

Adaptive Management
Section 401 Water Quality Certification

Columbia River Channel Improvement Project
Adaptive Environmental Management Plan

March 2006

C.1 Oregon Department of Environmental Quality

Adaptive management was also addressed in the Water Quality Certification issued 23 June 2003, by the Oregon Department of Environmental Quality (ODEQ). Specific text from the ODEQ 401 Certification concerning adaptive management is contained in this appendix.

Adaptive Management

Where conditions of this order require adaptive management, an Adaptive Management Team (AMT) will be used to review and/or develop data, information, or issues, and to arrive at a consensus regarding how to respond. The AMT will consist of three teams: a technical Team, a Management Team, and a Dispute Resolution Team.

The Technical Team will review research, monitoring and other data, information and issues relevant to the adaptive management conditions, and determine actions to be taken in response to such data, information and issues. In addition, the technical team will coordinate with the federal adaptive management process created under the Biological and conference opinions.

The Technical Team will act by consensus. In the event that the team is unable to achieve a consensus within a reasonable time under the circumstances, any member of the team may refer the matter to the Management Team.

The Management Team will review matters referred by the Technical Team and provide oversight to the Technical Team and the Corps in order to help coordinate the requirements of the state and federal agencies related to the project. The Management Team will act by consensus. In the event that the team is unable to achieve a consensus within a reasonable time under the circumstances, any member of the team may refer the matter to the Dispute Resolution Team.

The Dispute Resolution Team will review matters referred by the Management Team. The Dispute Resolution Team will act by consensus. In the event that the team is unable to achieve a consensus within a reasonable time under the circumstances, the matter in question shall be resolved by the federal or state agency or agencies with regulatory jurisdiction.

Each team will include one or more members from Department of Land Conservation and Development (DLCD), ODEQ, Washington Department of Ecology (WDOE), and the Corps. The members of the Dispute Resolution Team will be the Directors of the state agencies, and the Commander of the Portland District of the Corps. The members of the other teams will be designees of the state agencies and the Commander of the Portland District of the Corps. The state agencies will designate one person to coordinate the activities of the teams, which responsibility will be rotated between the two states over time. The teams will consult with local governments, Indian Tribes, other state and federal agencies, and involve the public, as appropriate under applicable state and federal laws and policies.

A group may act by consensus where no member of the group formally opposes the particular action in question.

No provision of this condition is intended to or does alter or supercede the authorities or duties of the ODEQ, the DLCD, or the WDOE relating to the project. In addition, this condition is not intended to, and does not alter, limit, or repeal any authorities of ODEQ, DLCD or WDOE to revoke, suspend, or modify their respective § 401 Water Quality Certifications or coastal zone decisions, or to request remedial action, seek mediation, or to request supplemental coordination with respect to the construction and continued operation of the Project.

Appendix D

Decision Criteria

Columbia River Channel Improvement Project
Adaptive Environmental Management Plan

March 2006

D.1 Introduction

Bartell and Nair (2005) presented an Adaptive Environmental Management (AEM) Plan that was developed to support the Columbia River Channel Improvement Project (CRCIP). The proposed AEM Plan includes seven steps for adaptively managing the environmental resources of concern in relation to channel deepening. These steps are briefly described as:

1. Results of the ongoing monitoring programs, ecosystem evaluation actions (EEA), and research are periodically summarized and reported. This reporting might be primarily event-driven, where new observations or data suggest possible violations of existing decision criteria for one or more of the performance measures or risk endpoints.

2. The results of monitoring actions (MA)-1 through MA-6, EEA-1 through EEA-6, and relevant research are collated and analyzed by an informal Technical Support Group.

3. The Technical Support Group would review the monitoring results and advise the Adaptive Management Team (AMT) concerning any performance measures or risk endpoints that exceed the management decision criteria.

4. If none of the decision criteria is exceeded, the AEM Process can continue with the current monitoring programs until the next evaluation (i.e., Step 1).

5. If any decision criteria are exceeded, the AMT can request the United States Army Corps of Engineers (USACOE) to develop a mitigation or management plan. If requested by the AMT, the USACOE will also suggest alternative management actions to address the performance measures or risk endpoints that exceed the decision criteria.

6. Upon evaluating the USACOE mitigation or management plan, the AMT may determine that there is no need to change current CRCIP management practices. Alternatively, the AMT may recommend modifications to current practices. If current practices remain unchanged, the corresponding monitoring and evaluation actions would continue unchanged until the next Technical Group summary and analysis. However, if changes to the current management practices are recommended, the AMT would develop the necessary changes and address potential revisions to monitoring, ecosystem evaluation actions, and decision criteria.

7. Following resolution of the proposed adaptive management actions and possible revisions to monitoring and research recommended by the AMT, the AEM Process continues by cycling back to review and analysis of new data and information by the Technical Support Group.

The steps in the above-described AEM Process are schematically illustrated in the AEM Plan flowchart (Figure 2.3 in AEM Plan).

The implicit hypothesis underlying the AEM Plan is that the channel deepening will not significantly alter the physical or chemical conditions characteristic of the Lower Columbia River (LCR) and estuary. Failure in rejecting this hypothesis further suggests that the corresponding habitat factors that influence the growth, survival, and ocean entry of salmonids will not be significantly altered by the CRCIP. Therefore, the AEM Process will focus initially on specific physical and chemical effects potentially impacted by channel deepening (Bartell and Nair 2005).

Consensus agreement among the AMT identified the following important physical-chemical effects to be addressed by the Channel Improvement AEM Process:

- possible shifts in location or changes in ecological function of the estuarine turbidity maximum;
- deleterious changes in current velocity in shallow water habitats and refugia;
- undesired changes in accretion/erosion rates along the main channels and side-slopes;
- undesired changes in temperature, salinity, and water depth; and
- concerns with predicted dredge volumes as it relates to disposal capacity.

Some of the longer-term benefits that should be achieved as the result of a successful AEM Process for the LCR and estuary include:

- provision of additional shallow water and intertidal marsh habitat;
- increased habitat connectivity and complexity;
- creation of additional rearing habitat for ocean-type salmonids;
- increases in detrital export;
- maintaining native tidal marsh plant communities;
- increased benthic invertebrate productivity;
- sustainability of sturgeon, smelt, and Dungeness crab populations;
- increased access/egress for ocean-type salmonids; and
- improved access for adult salmonids to headwaters for spawning.

The remainder of this Appendix outlines the development of decision criteria that will be used to implement the AEM Process. Following a brief discussion concerning the general nature and desired attributes of such criteria, several methods are presented for deriving their values. These methods are used subsequently to determine initial values of decision criteria. These proposed values can then focus future and continued efforts in arriving at consensus criteria ("trigger values") for the CRCIP Adaptive Management Process.

D.2 Decision Criteria

A scientifically based and informative monitoring program is central to AEM. Importantly, the results of monitoring quantify the response of the performance measures and risk endpoints to channel improvement. Performance measures define those attributes of the ecosystem that provide the manager with information on the response of the ecosystem in relation to the desired conditions (i.e., goals, objectives). Risk assessment endpoints define complementary ecosystem attributes that indicate the likely occurrence of undesired, adverse impacts associated with the project

To be useful as a performance measure or an assessment endpoint, a monitored attribute should serve as an indicator of an integrated ecosystem structure or function. Patterns of spatial-temporal responses of the attribute to management should be consistent with current quantitative ecosystem understanding. The measures should be capable of responding to management actions specific to channel improvements. It should be possible to determine how the attribute might change in response to channel dredging as distinct from other sources of variation. Thus, in developing decision criteria, efforts should be made to

- characterize values of pre-project indicators in relation to historical values and trends;
- analyze values in relation to natural variability in space and time; and
- develop functional relationships between management actions (e.g., dredging) and indicators, including uncertainty.

Importantly, certain values of the performance measures or risk endpoints will be used as criteria for deciding to continue current management actions or to adapt management by undertaking new or different actions. The remainder of this Appendix describes the derivation of selected decision criteria ("trigger values") for the CRCIP AEM Process. Where data are lacking, methods are proposed for development of the corresponding criteria.

2-1 Derivation of Decision Criteria

One of the key activities in implementing the proposed AEM Plan was to explore alternative approaches with the purpose of deriving meaningful and justifiable decision criteria. There are several approaches for deriving values of performance measures or risk endpoints that will serve as decision criteria in the AEM Process. These approaches include: (1) legislative mandates, (2) consensus among stakeholders, (3) pre- and post-project comparisons, (4) empirical derivation, and (5) modeling.

Legislative Mandates

Federal and/or state laws may specify values used as decision criteria for selected water quality parameters. For example, concentrations of nutrients, chemical pollutants, and dissolved oxygen can be specified to meet designated uses in relation to the Clean Water Act. It is assumed that ordinances related to federal, Oregon, and Washington water quality criteria will be complied with during the CRCIP Adaptive Management Process.

Consensus

In the absence of legal requirements, values of decision criteria might be derived as the result of consensus building among project stakeholders. It is desirable that criteria developed through consensus are supported by science. However, the consensus process might well result in compromises among participating stakeholders. Such compromise might produce criteria that reflect socioeconomic and political interests, as well as scientific understanding (e.g., the 10 parts per billion phosphorus criterion for agricultural runoff in South Florida). Depending on the nature and degree of compromise, the consensus process can nevertheless produce useful and defensible decision criteria. This derivation process needs to be carefully documented in order that the resulting criteria are understood within the context of the overall negotiations.

Consensus building among the USACOE, the National Oceanic and Atmospheric Administration Fisheries, the U.S. Fish and Wildlife Service (USFWS), Oregon, Washington and other project principals will likely continue during the CRCIP Adaptive Management Process (Appendix B). Importantly, the proposed AEM Plan (Bartell and Nair 2005) includes provisions for review and evaluation of the decision criteria by the principal participants.

Pre- and Post-Project Comparisons

Comparisons of pre- and post-construction data can be used to evaluate project impacts for certain performance measures, including salinity, current velocity, surface elevations, and fish stranding. The results of the comparisons can “trigger” adaptive management. The pre- and post-construction comparisons require only an adequate characterization of system conditions prior to project implementation and a similar characterization following construction. Perhaps the greatest technical and management challenges to using this approach lies in identifying the appropriate spatial-temporal scales of measurement that define “pre-project” and “post-project” conditions. The identification of appropriate scales may require some consensus building among CRCIP principals. There is current agreement supporting a two-year pre-construction monitoring effort, followed by a post-construction monitoring period of one or more years for several of the performance measures and risk endpoints included in the AEM Process for the CRCIP.

Empirical Derivation

Conceptually, perhaps the most compelling method for determining the decision criteria lies in analysis of historical patterns and trends for the performance measures and risk endpoints. Analyses of existing data can define historical patterns of spatial and/or temporal statistics (e.g., mean, median, variance, maximum, minimum) in selected performance measures. These statistics can be used to estimate decision criteria ("trigger values") for the corresponding performance measures based on historical observations.

More complex methods of statistical time series analyses including, for example, trend analysis (Kukulka and Jay 2003), spectral analyses (e.g., Platt and Denman 1975), and autoregressive integrated moving average models (Shugart 1978) may be necessary to define decision criteria, depending on the quality and quality of available data. Analogous spatial statistics (e.g., two-dimensional spectral analysis, spatial autocorrelation, and kriging) may prove useful in defining the spatial attributes of the decision criteria (Ripley 1981).

Statistical analyses can also be used to evaluate the statistical power (or performance characteristics) of monitoring (e.g., MA-1) in discriminating the potential impacts of channel improvement from historical patterns of variability. Depending on the amount of historical data underlying the decision criteria and the number of samples obtained during monitoring, evaluation of the monitoring data can be undertaken as hypothesis testing. The null hypothesis is that the monitoring data are samples from the same distribution underlying the decision criteria. Clearly, the greater the variability in the data used to develop the decision criteria, the larger the number of monitoring samples that will be required to statistically demonstrate departure from historical conditions as the possible result of channel deepening. Estimates of historical variability can be used to rather straightforwardly determine the number of future samples required for statistical comparisons at a specified level of power (Dixon and Massey 1969).

Modeling

Existing data may prove insufficient for estimating certain performance measures or risk endpoints. Under these circumstances, statistical or process-oriented models might provide recourse for deriving values of decision criteria. Detailed hydrodynamic models (e.g., CORIE estuary circulation model) might be used to determine dredging-induced changes in bathymetry that increase the risks of alterations in the spatial-temporal patterns of salinity, temperature, and water depth.

The initial emphasis of the CRCIP AEM Plan focuses on potential physical-chemical impacts associated with channel improvements in the lower river and estuary. At the same time, however, the ecological importance of significant deviations from historical patterns in the decision criteria resides in the possible implications on the survival, growth, and ocean entry of salmonids. Such implications can be addressed using models of habitat opportunity (e.g., Bottom et al. 2001). It would be possible to use the habitat opportunity models to derive decision criteria for the physical-chemical parameters based on conditions favorable to salmon.

Wherever possible, the uncertainties associated with derivation of criteria using these models should be described and quantified. Bias and imprecision can result from uncertainties associated with model structure, estimates of model parameter values, and specification of initial conditions. Methods of numerical sensitivity and uncertainty analyses can be used to examine the implications of uncertainties in parameter estimation and initial conditions. Comparisons of model predictions with observations can be used to evaluate overall model structure.

2-2 Scale and Decision Criteria

The spatial complexity of the estuary and temporal dynamics of hydrology (tides, river flows, and tributary inputs) and salmonid utilization of the estuary require careful considerations of scale in developing an effective monitoring plan and establishing decision criteria to support adaptive management. Two important aspects of ecological scale are "grain" and "extent" (Gardner and O'Neill 1991, Allen and Starr 1982). Grain refers to the level of resolution (in time or space) of measurement. For example, Landsat imagery has a grain (pixel) size of 30 m x 30 m; AVHRR[1] data have a grain size of 1 km x 1 km (Gardner and O'Neill 1991). Information is gained with increasing grain, given the same extent. Extent defines the sampling universe: spatial size or temporal duration. Increasing extent, while maintaining constant grain, also increases information. Gardner (1998) defines scale as the combination of grain, extent, and number of samples that minimizes the statistical variance (in space and/or time) estimated for the indicator of interest.

Spatial scale has been considered in the monitoring and analysis of the Columbia River estuary (extent). For example, Bottom et al. (2001) divided the estuary into six comparatively distinct regions (grain) defined by topology, bathymetry, and proximity to the river mouth. These six regions are (1) Baker Bay, (2) lower mainstem of the estuary, (3) Youngs Bay, (4) Cathlamet Bay, (5) Grays Bay, and (6) the upper mainstem of the estuary. Figure D.1 illustrates the location of sampling stations that map onto this spatial scheme. (Table D.1 lists the complete names of these sampling locations and monitoring depths.) Several of these stations constitute a major portion of a continuous monitoring program, CORIE (http://www.ccalmr.ogi.edu/CORIE/). Other spatial aggregations within the estuary are, of course, possible. The important point is to recognize the scale-dependence of measurements used to describe the condition of the estuary and its potential response to channel improvement.

Spatial and temporal river-estuarine variations important to scale considerations are readily apparent for the LCR and estuary. Seasonal variations in river discharge and regional meteorology, as well as temporal shifts in timing and magnitude of spring freshets should be examined from the perspective of defining relevant temporal scales in deriving decision criteria. These hydrologic processes in combination with tides and bathymetry largely

[1] Advanced Very High Resolution Radiometer

determine water circulation within and through the estuary. Perhaps overly simplistic, the ever-varying pattern of water circulation defines critical habitat features for juvenile salmon that utilize the estuary. These features can be described as somewhat distinct volumes of water within the estuary that are shallow and warm, deeper and cooler, nearly freshwater or higher in salinity, as well as higher and lower velocity volumes. The spatial-temporal distribution and extent of these water volumes can determine the successful conveyance of salmon to the ocean. This dynamic “landscape” can also define connectivity (contagion) of habitats necessary for salmon growth and survival (e.g., predator avoidance). From a LaGrangian perspective, the challenge in characterizing habitat opportunity and habitat capacity lies in accurately describing the changing shape, location, and extent of these critical volumes, as well as understanding the juxtaposition of these volumes with habitat types (i.e., wetlands marshes, intertidal flats, side channels) necessary for salmon to complete their complex life cycles. The implicit hypothesis is that channel deepening will not significantly alter the current patterns of circulation within the estuary. Examination of this hypothesis through continued monitoring will be influenced by the spatial-temporal scaling of measurements and selected decision criteria.

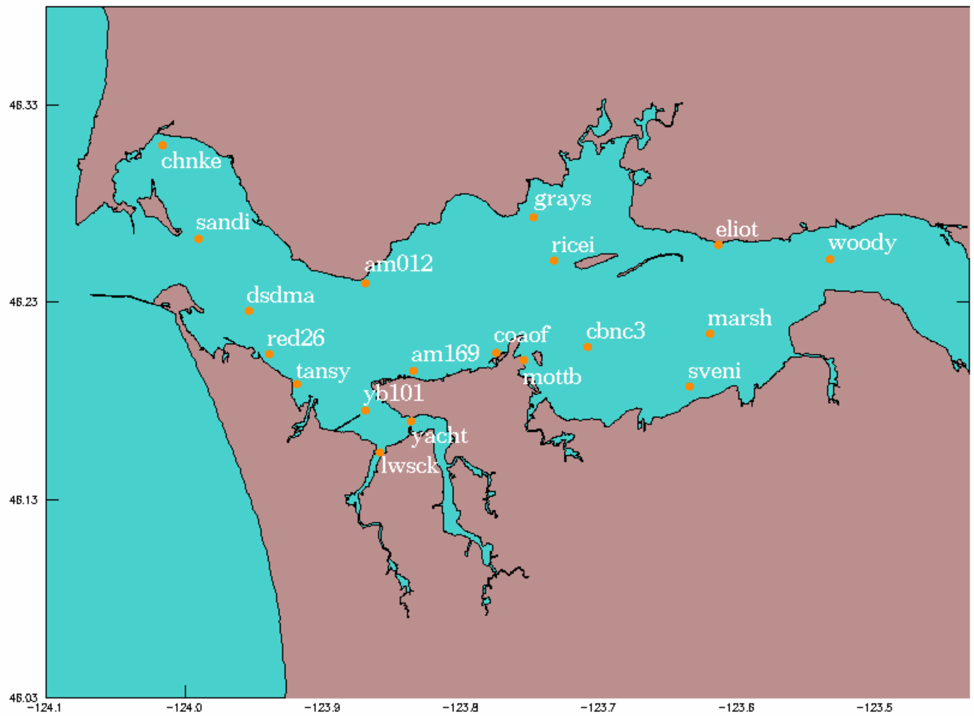

Figure D.1. Map showing locations of CORIE monitoring stations. MA-1 uses red26, grays and cbnc3 locations (http://www.ccalmr.ogi.edu/CORIE/).

Station	Full Station Name	Measurement Depth (m below datum at NGVD29)
chnke	Chinook River - Estuary	2.6
sandi	Lower Sand Island light (USCG day mark green 5)	7.9
dsdma	Desdemona Sands light (USCG day mark)	7.5
red26	Fort Stevens Wharf (USCG day mark)	7.5
tansy	Tansy Point (USCG front range board)	8.4
yb101	New Youngs Bay Bridge (ODOT highway 101)	
lwsck	Lewis and Clark Bridge (ODOT old highway 101)	
yacht	Yacht Club (City of Astoria)	
am169	Astoria Meglar Bridge South Channel (ODOT pier 169)	11.3
am012	Astoria Meglar Bridge North Channel (ODOT pier 12)	
grays	Grays Point (USCG day mark green 13)	1.6
ricei	Rice Island (Division of State Lands)	
eliot	Elliott Point	13.9
woody	Woody Island (USCG Pillar Rock back range board)	2.4
marsh	Marsh Island (USCG day mark green 21)	5.4
sveni	Svenson Island (USCG day mark 12A)	10.8
cbnc3	Cathlamet Bay North Channel (USCG day mark green 3)	6.5
mottb	Mott Basin (Tongue Point Job Corp pier 6)	8.6
coaof	Waste water outfall (City of Astoria)	3.2

These stations can be mapped onto five of the six regions delineated by Bottom et al. (2001) in their assessment of habitat opportunity. Stations chnke and sandi may represent Region 1 (Baker Bay). Region 2 (Lower Columbia mainstem) includes stations: dsdma, red26, tansy, am102, and am169. Stations yb101, lwsck, and yacht appear relevant to Region 3 (Youngs Bay). Region 4 (Cathlamet Bay) includes stations: marsh, sveni, cbnc3, and mottb. Stations grays and ricei can represent Region 5 (Grays Bay). Stations eliot and woody might be included in the mainstem. Region 6 (Upper Columbia mainstem) is not represented.

Table D.1. Names of sampling stations shown in Figure D.1.

Stations closest to the navigation channel include dsdma, red26, tansy, am169, ricei, eliot, woody, and possibly coaof. While decision criteria for physical and chemical parameters monitored through MA-1 have been developed for all stations, only cbnc3, red26, and grays would be the focus during the implementation phase of the AEM Process. Decision criteria for other stations would be used as and when required. For example, if an anomaly were discovered in the post-dredging monitoring data at one of the three stations focus, available data from additional stations would be analyzed to determine whether natural variability or channel deepening was likely the source of the anomaly.

D.3 Criteria for Corps CRCIP Monitoring Actions

3-1 MA-1 Continuous Monitoring Stations

The USACOE maintains three hydraulic monitoring stations on the lower river. Their locations are downstream from Astoria (red26), Grays Bay (grays), and Cathlamet Bay (cbnc3). The measured parameters include salinity, water depth, and water temperature. Physical changes resulting from channel deepening are expected to be minor and occur in proximity to the navigation channel. The proposed monitoring duration includes two years before channel deepening, two years during the construction, and three years following construction.

The MA-1 data have been analyzed to establish pre- and post-project relationships between the channel deepening and values of flow, salinity, water surface elevation, and water temperature. The purpose of MA-1 in the context of the AEM Plan is to verify levels of impact of channel modifications on these physical parameters. Additionally, the results of MA-1 might be used to assess habitat complexity, connectivity, conveyance, and habitat opportunity.

Proposed values of selected physical-chemical decision criteria have been derived through analysis of the CORIE data. Emphasis has been placed on an empirical approach for those performance measures characterized by substantial existing data. CORIE data are publicly available at 1- or 5-minute intervals for years 1996 to the present. Given that the criteria would enter into an annual review and evaluation according to the AEM Plan, it was decided to summarize the available data on a monthly time scale. The data were used to estimate monthly minimum, mean, median, standard deviation, and maximum values for water depth, salinity, and water temperature. Selection of this level of resolution permits examination of possible dredging effects on spatial/temporal patterns of variability in these assessment endpoints. This level of resolution appears further justified by temporal variability in dredging activities. (Note that CORIE data are not available for all months or stations.)

One important consideration in deriving empirical decision criteria is the quality of the data. The detection limits of the CORIE instrumentation contribute in part to the overall data quality. The detection limit of the CORIE instruments used for monitoring salinity is 0.1 practical salinity units (psu), that for monitoring temperature is 0.1˚C, and that for monitoring water depth is 3–10 cm. The temperature and salinity detection limits appear sufficient for purposes of the AEM Plan. That is, it would prove exceptionally challenging to demonstrate differences detected on the order of 0.1 psu or 0.1˚C as unequivocally resulting from channel dredging. The detection limits (sensitivity) of these measures also define the precision for specifying the decision criteria for these parameters. In contrast, the less sensitive 10-cm detection limits for water depth might produce situations where dredging associated changes in water depth (e.g., shallow water habitats) are not reliably measured. At the same time, it is anticipated that changes in depth, apart from the locations of dredging, will not be measurably altered by the Project. So, in practice, the 10-cm detection may prove acceptable for deriving MA-1 decision criteria for water depth.

As the result of previous discussion and analysis of the CORIE data, the AMT has reached consensus on three components of decision criteria for depth, water temperature, and salinity. The AMT will review newly collected monitoring data (MA-1) in relation to (1) a tabular summary of 20- and 80-percentiles of estimated monthly median values; (2) a similar table of 5- and 95-percentile values; and (3) for water temperature, plotted relationships between daily median temperatures for a reference location (woody) and the corresponding values for the three MA-1 stations. The following sections present these decision criteria.

Water Depth

Perhaps the most direct potential impacts of channel deepening are alterations in water depth as the result of dredging throughout the lower river and estuary. Table D.2 summarizes the 20- and 80- percentile values of water elevations referenced to the North Geodetic Vertical Datum of 1929 as determined from analyses of available CORIE data. The corresponding 5- and 95- percentile values are listed in Table D.3. The values indicate the relevance of the various sampling stations in characterizing habitats of different depths throughout the estuary. The depths clearly define the shallower and deeper monitoring stations. The values do not appear particularly sensitive to monthly changes in flows (i.e., river discharge), yet the months of typical low flow (July–September) are evident in corresponding seasonally lower water elevations. The monthly values can be used as decision criteria for selected stations because of the comparative stability of these values. Significant departures from the monthly values following dredging can "trigger" the adaptive components of the AEM Process. Clearly, any deviations from these values would have to be evaluated in relation to patterns of river discharge, as well as local and regional hydrology (e.g., precipitation events, tributary inputs, and watershed alterations). The major challenge resides in determining what defines a significant departure from the recent historical depth values.

Table D.2. Decision criteria for water depth (m) based on 20- and 80-percentile values calculated from available CORIE data between 1996 and 2004.

	January		February		March		April		May		June	
Station	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**
chnke	0.9	2.3	0.9	2.3	0.8	2.2	0.7	2.0	0.7	2.1	0.7	2.0
sandi	7.1	8.8	7.4	8.7	7.2	8.6	7.0	8.6	7.1	8.5	7.1	8.9
dsdma	6.9	8.6	6.8	8.5	6.3	8.1	6.7	8.3	6.6	8.2	6.6	8.1
red26	6.7	8.3	6.6	8.3	6.8	8.4	6.8	8.3	6.9	8.4	6.8	8.2
tansy	7.9	9.6	7.9	9.6	7.8	9.4	7.7	9.3	7.7	9.3	7.7	9.2
yb101												
lwsck												
yacht												
am169	10.7	12.2	10.5	12.3	10.6	12.2	10.5	12.1				
am012												
grays	1.3	2.8	1.2	2.8	1.1	2.7	1.1	2.6	1.0	2.6	1.0	2.5
ricei												
eliot	13.9	15.5	13.8	15.4	13.8	15.3	13.7	15.2	13.5	15.0	13.4	14.9
woody	2.1	3.6	2.1	3.6	2.0	3.5	2.0	3.4	2.0	3.4	2.0	3.4
marsh	5.2	6.7	5.0	6.5	5.0	6.5	5.0	6.4	5.0	6.5	5.0	6.5
sveni	10.6	12.1	10.5	12.0	10.4	12.0	10.4	12.0	10.4	11.9	10.4	11.9
cbnc3			5.6	6.4	5.7	7.1	5.7	7.2	5.5	6.7	5.5	6.4
mottb	8.2	9.8	8.1	9.6	8.1	9.6	8.1	9.6	7.9	9.4	7.9	9.5
coaof	2.9	4.4	2.7	4.3	2.7	4.3	2.7	4.3	2.7	4.2	2.7	4.2

	July		August		September		October		November		December	
Station	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**	**20-%ile**	**80-%ile**
chnke	0.7	2.0	0.7	2.1	0.7	2.1	0.8	2.2	0.7	2.2	0.9	2.3
sandi	7.3	8.7							7.3	8.6	7.1	8.6
dsdma	6.6	8.1	6.6	8.0	6.4	8.0	6.5	7.9	6.7	7.9	6.7	8.3
red26	6.7	8.1	6.7	8.1	6.8	8.1	6.6	8.3	6.6	8.2	6.7	8.2
tansy	7.6	9.2	7.6	9.2	7.6	9.2	7.6	9.3	7.8	9.4	7.8	9.4
yb101												
lwsck												
yacht												
am169					10.3	12.1	10.5	12.1	10.7	12.0	10.4	11.0
am012												
grays	0.9	2.5	0.9	2.5	0.9	2.5	0.9	2.5	1.1	2.7	1.2	2.8
ricei												
eliot	13.2	14.7	13.2	14.7	13.2	14.7	13.4	14.8	13.6	15.1	13.8	15.3
woody	1.9	3.3	1.8	3.3	1.8	3.3	1.8	3.3	2.0	3.5	2.2	3.6
marsh	4.8	6.4	4.8	6.4	4.8	6.3	4.9	6.4	4.9	6.5	5.1	6.6
sveni	10.4	11.9	10.3	11.9	10.3	11.9	10.3	11.9	10.3	11.9	10.6	12.1
cbnc3	5.4	6.3										
mottb	7.8	9.4	7.9	9.4	7.9	9.5	7.8	9.4	8.1	9.7	8.2	9.8
coaof	2.6	4.1	2.5	4.1	2.5	4.1	2.5	4.1	2.6	4.2	2.8	4.4

Table D.3. Decision criteria for water depth (m) based on 5- and 95-percentile values calculated from available CORIE data between 1996 and 2004.

	January		February		March		April		May		June	
Station	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile
chnke	0.4	2.8	0.5	2.8	0.3	2.6	0.3	2.5	0.2	2.6	0.3	2.5
sandi	6.4	9.3	6.9	9.0	6.6	9.1	6.4	9.0	6.5	9.0	6.3	9.4
dsdma	6.1	9.2	6.1	8.9	5.9	8.6	6.1	8.7	5.9	8.7	6.0	8.6
red26	6.0	8.8	5.9	8.8	6.2	8.9	6.2	8.8	6.3	8.7	6.1	8.6
tansy	7.3	10.1	7.3	10.1	7.2	9.9	7.1	9.7	7.1	9.8	7.0	9.8
yb101												
lwsck												
yacht												
am169	10.2	12.7	10.0	12.8	10.0	12.7	9.9	12.5				
am012												
grays	0.6	3.4	0.5	3.3	0.5	3.2	0.5	3.1	0.4	3.1	0.3	3.1
ricei												
eliot	13.3	16.0	13.3	15.9	13.2	15.8	13.1	15.7	13.0	15.5	12.9	15.4
woody	1.6	4.2	1.6	4.0	1.6	4.0	1.6	3.9	1.6	3.9	1.5	4.0
marsh	4.5	7.2	4.5	7.0	4.5	7.0	4.4	6.9	4.5	7.0	4.4	7.0
sveni	9.9	12.6	9.9	12.5	9.9	12.5	9.9	12.5	9.8	12.4	9.8	12.4
cbnc3			5.3	6.5	5.2	7.8	5.2	7.8	5.1	7.4	5.0	6.8
mottb	7.5	10.3	7.5	10.1	7.5	10.1	7.5	10.1	7.3	9.9	7.3	10.0
coaof	2.2	5.0	2.1	4.9	2.1	4.7	2.1	4.7	2.0	4.7	2.0	4.7

	July		August		September		October		November		December	
Station	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile
chnke	0.2	2.6	0.2	2.6	0.2	2.6	0.3	2.7	0.3	2.7	0.4	2.9
sandi	6.4	9.3							6.6	9.1	6.4	9.1
dsdma	6.1	8.5	6.0	8.5	5.9	8.4	5.9	8.4	6.1	8.4	5.7	9.0
red26	6.1	8.6	6.0	8.6	6.0	8.4	5.9	8.8	5.9	8.7	5.9	8.7
tansy	6.9	9.7	7.0	9.8	7.0	9.7	7.0	9.8	7.2	10.0	7.2	10.0
yb101												
lwsck												
yacht												
am169					9.8	12.6	9.9	12.6	10.1	12.4	10.2	11.2
am012												
grays	0.2	3.0	0.2	3.0	0.3	3.0	0.3	3.0	0.4	3.3	0.5	3.3
ricei												
eliot	12.7	15.2	12.6	15.2	12.7	15.2	12.8	15.3	13.0	15.6	13.2	15.9
woody	1.3	3.9	1.3	3.8	1.3	3.7	1.3	3.8	1.5	4.1	1.6	4.2
marsh	4.2	6.9	4.2	6.9	4.2	6.8	4.3	6.9	4.3	7.0	4.5	7.2
sveni	9.7	12.4	9.7	12.4	9.8	12.4	9.7	12.4	9.7	12.4	9.9	12.6
cbnc3	4.9	6.5										
mottb	7.1	9.9	7.3	9.9	7.3	9.9	7.3	9.8	7.4	10.2	7.5	10.4
coaof	1.9	4.7	1.9	4.6	1.9	4.5	1.9	4.6	2.0	4.7	2.1	4.9

The values in the preceding tables describe variation in the recent historical record of water elevations for each sampling station. Monitoring data associated with dredging activities that lie outside the 20- and 80-percentile values could serve as decision criteria. The corresponding monthly values defined by the mean +/- two standard deviations (i.e., 5- and 95-percentiles) might provide even more compelling decision criteria. Values in Table D.3 reflect a more conservative or risk-averse approach to selecting the decision criteria, given that there is a larger probability that values measured outside these limits are still within the historical variability. This probability decreases, of course, as higher and lower percentile values are used as decision criteria. In other words, using the values in Table D.3 as decision criteria for the CRCIP impacts on water elevation produces a greater likelihood that false positives would result than in using percentiles calculated for two (or more) standard deviations.

Another reason for using the percentile values in the above tables originates from the anticipated statistical power of the monitoring program. The AEM Process will be implemented in the form of statistical hypothesis testing. Therefore, the sample size of the monitoring data and the variability of water depths will determine the performance characteristics in testing the hypothesis that the monitored water depth (per station and month) is statistically the same as the historical depth. Small sample sizes in monitoring compared to the larger historical data record can decrease the probability of rejecting the null hypothesis, especially for significance values associated with higher percentiles of the corresponding distributions.

Temperature

Percentile Values

Table D.4 summarizes the analysis of the CORIE station temperature data and presents the monthly 20- and 80-percentile values proposed as criteria for the AEM Plan. Table D.5 lists the corresponding 5- and 95-percentile values. The results clearly delineate the seasonal pattern of temperature change. The data also indicate the comparatively warmer, shallower stations, as well as the cooler, deeper stations.

The monthly percentile values were used to derive decision criteria for water temperature in the same manner as discussed for water elevation. Again, the main issue is determining the magnitude of deviation from the monthly values that would initiate adaptations to the channel improvement activities.

Table D.4. Decision criteria for water temperature (˚C) based on 20- and 80-percentile values calculated from available CORIE data between 1996 and 2004.

	January		February		March		April		May		June	
Station	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile
chnke	6.3	8.3	6.5	8.5	8.5	11.7	10.6	13.3	13.1	16.9	16.7	21.0
sandi	5.7	8.8	6.4	9.2	7.3	9.4	9.2	11.0	10.6	12.9	10.5	15.0
dsdma	5.8	8.9	6.2	8.8	7.1	9.3	9.3	11.0	10.6	13.3	11.4	15.4
red26	6.2	9.2	6.4	8.9	7.4	9.7	9.3	11.2	10.6	13.4	10.9	15.6
tansy	5.7	8.6	5.7	8.4	6.9	9.1	8.9	11.0	10.7	13.6	11.6	15.8
yb101												
lwsck												
yacht												
am169	5.7	8.1	5.7	7.9	6.5	8.7	8.9	10.9	11.0	14.0	12.5	16.0
am012												
grays	4.7	6.6	4.7	6.5	6.0	8.4	9.0	11.4	11.6	14.8	15.2	17.6
ricei												
eliot	4.2	6.7	4.9	6.5	5.9	8.2	8.9	11.2	11.7	14.4	15.1	17.5
woody	4.2	6.0	4.3	6.1	5.7	8.1	8.6	11.2	11.5	14.5	14.8	17.5
marsh	5.1	6.9	5.1	6.9	5.7	8.2	9.2	11.6	11.9	14.8	15.8	18.0
sveni	4.5	6.8	5.2	6.8	6.1	8.6	9.3	11.7	12.1	15.0	15.6	17.9
cbnc3	4.1	6.4	4.8	6.5	6.0	8.3	8.9	11.2	12.1	15.0	15.6	17.7
mottb	4.5	7.2	5.4	7.2	6.3	8.8	9.4	11.9	12.1	14.8	15.1	17.5
coaof	4.5	7.4	5.8	7.4	7.0	9.1	9.9	12.1	12.9	15.3	15.5	17.6

	July		August		September		October		November		December	
Station	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile
chnke	18.4	21.7	17.9	20.8	15.1	17.4	11.7	14.3	8.0	10.5	6.8	8.7
sandi	10.6	16.6	11.1	17.3	12.0	16.6	10.2	14.1	9.4	11.3	7.9	10.1
dsdma	11.0	16.7	11.2	17.4	10.9	15.7	10.5	13.4	9.5	11.3	7.6	9.7
red26	10.8	16.9	11.0	17.4	11.0	16.1	11.1	13.9	9.4	11.6	7.6	9.9
tansy	11.2	17.5	11.9	18.3	11.6	16.9	11.1	14.2	9.5	11.6	7.2	9.6
yb101												
lwsck												
yacht												
am169	12.3	17.6	12.7	17.8	12.8	16.8	11.8	14.4	9.0	11.3	6.6	8.8
am012												
grays	18.0	20.6	19.3	21.1	17.3	19.5	12.9	15.9	9.0	11.3	6.2	8.0
ricei												
eliot	18.6	21.3	20.0	21.8	17.8	20.3	13.8	17.4	9.3	11.4	6.3	8.0
woody	18.6	21.0	20.1	21.7	18.1	19.9	13.6	16.8	9.3	11.4	6.2	8.1
marsh	19.0	21.6	20.3	22.0	18.1	20.2	14.0	17.3	9.1	11.0	6.3	7.9
sveni	19.0	21.8	20.3	22.0	18.0	20.2	13.7	17.0	9.1	11.1	6.4	8.0
cbnc3	18.4	21.1	19.5	21.5	17.1	19.5	13.4	16.7	9.0	10.9	6.1	7.8
mottb	15.9	19.5	16.6	20.0	15.0	18.6	12.5	15.5	9.1	10.9	6.5	8.5
coaof	18.2	20.6	18.6	20.9	16.7	18.8	13.3	16.3	9.2	11.0	6.7	8.4

Table D.5. Decision criteria for water temperature (˚C) based on 5- and 95-percentile values calculated from available CORIE data between 1996 and 2004.

	January		February		March		April		May		June	
Station	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile
chnke	5.1	9.1	5.6	9.6	7.3	13.3	9.7	16.1	12.1	19.0	15.2	23.1
sandi	4.7	9.9	5.4	10.1	6.2	9.8	8.4	11.8	9.2	14.2	9.0	16.0
dsdma	4.7	10.2	5.3	9.7	6.1	9.8	8.4	11.8	9.3	14.6	9.6	16.6
red26	4.9	10.3	5.3	9.9	6.3	10.8	8.4	12.0	9.2	14.5	9.4	16.8
tansy	4.5	9.8	4.6	9.7	6.0	9.9	8.0	11.9	9.5	14.9	9.8	16.9
yb101												
lwsck												
yacht												
am169	4.7	9.1	4.6	8.9	5.5	9.6	8.2	11.8	9.4	14.7	10.7	17.0
am012												
grays	4.0	7.7	4.1	7.3	5.2	9.4	8.0	12.6	10.5	15.9	14.1	18.8
ricei												
eliot	3.0	7.6	4.2	7.3	5.1	8.9	8.1	12.4	10.6	14.8	14.2	18.7
woody	3.4	6.8	3.5	6.9	5.0	9.1	7.6	12.4	10.5	15.6	13.7	18.6
marsh	4.1	7.7	4.3	7.7	5.1	9.2	8.3	12.8	10.9	15.7	15.0	19.1
sveni	3.2	7.7	4.4	7.5	5.2	9.6	8.3	12.9	11.0	15.8	14.7	19.0
cbnc3	3.2	7.3	4.2	7.2	5.1	9.0	8.1	12.6	11.1	16.0	14.9	18.8
mottb	3.2	8.2	4.6	8.1	5.4	9.7	8.4	12.9	11.1	16.3	13.9	18.4
coaof	3.2	8.0	5.2	8.0	6.1	9.8	8.7	13.1	11.7	15.8	14.6	18.6

	July		August		September		October		November		December	
Station	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile
chnke	17.1	23.7	16.6	22.2	14.1	18.8	10.5	15.6	6.5	11.4	6.1	9.5
sandi	9.1	18.2	9.2	18.9	9.5	18.1	8.6	15.5	8.3	12.0	6.7	10.9
dsdma	9.3	18.0	9.5	18.8	9.4	17.0	9.2	14.7	8.5	11.9	6.7	10.6
red26	9.4	18.9	9.3	19.3	9.4	17.7	9.3	15.1	8.3	12.5	6.5	10.8
tansy	9.4	19.3	10.1	19.9	9.8	18.5	9.4	15.8	8.3	12.5	6.0	10.6
yb101												
lwsck												
yacht												
am169	10.7	19.2	10.4	19.5	10.8	18.2	10.5	15.8	7.9	12.3	5.6	9.6
am012												
grays	16.6	21.8	18.3	21.9	16.3	20.5	11.8	17.3	7.4	12.3	5.2	8.8
ricei												
eliot	17.5	22.4	19.0	22.6	16.1	21.4	12.4	18.4	8.1	12.5	5.4	8.7
woody	17.8	22.1	19.3	22.5	17.2	20.9	12.4	18.2	8.0	12.3	5.2	8.8
marsh	18.0	22.7	19.5	22.8	17.2	21.3	12.4	18.4	7.8	12.1	5.5	8.7
sveni	18.0	22.9	19.4	22.7	17.1	21.3	12.3	18.0	7.8	12.3	5.6	8.7
cbnc3	17.4	22.3	18.4	22.3	16.0	20.6	11.9	17.8	7.7	12.0	5.2	8.6
mottb	13.9	20.8	14.5	21.0	13.1	19.9	11.3	16.8	8.0	12.0	5.8	9.4
coaof	17.1	21.5	17.2	21.8	15.5	19.8	12.1	17.3	8.0	12.2	6.1	9.0

Normalized Temperature Plots

Spatial-temporal variations in water temperature within the lower river and estuary reflect complex mixing patterns determined by river flows and tidal circulation. These sources of variation in water temperatures can be evaluated by comparing temperatures at locations not influenced by tidal mixing to temperatures at other stations, including similarly river-dominated stations and those more strongly influenced by tidal mixing. For example, CORIE stations closer to the mouth of the estuary are expected to be less influenced by fresh water or riverine conditions and more by tidal conditions in contrast to the stations located at a greater distance from the river mouth. Median daily temperatures from two CORIE locations strongly influenced by river flows should be strongly correlated. To examine these kinds of relationships, the median daily temperatures from Woody Island, the CORIE station farthest from the mouth of the river, were plotted against corresponding median daily temperatures from the USGS station at Beaver Army Terminal near Quincy, Oregon. Figure D.2 indicates an extremely strong correlation in water temperature between the two stations. Deviations from this relationship that are suggested by future monitoring data a second level of decision criteria for the AEM Plan.

Median daily temperature data from Woody Island were also plotted against corresponding data from other CORIE stations. Figures D.3, D.4, and D.5 present these plots for the CORIE stations at Cathlamet Bay North Channel, Grays Point, and Fort Stevens Wharf. It is evident from these figures that the CORIE station at Stevens Wharf is dominated by tidal influences and the other two stations are more dominated by the river flows. While it is not expected that channel deepening would alter the ocean-dominated pattern at Stephens Wharf, the potential for an alteration of the river-dominated patterns at Grays Point and Cathlamet Bay North Channel cannot be completely ruled out. Therefore, the AMT includes these kinds of analyses as part of the decision criteria. Data obtained during and after channel deepening will be added to these pre-project data plots. This will allow a visual determination of whether the new data are consistent with the pre-project patterns in temperature or if the data indicate a modification of the relative importance of tidal versus river flows for the monitored locations.

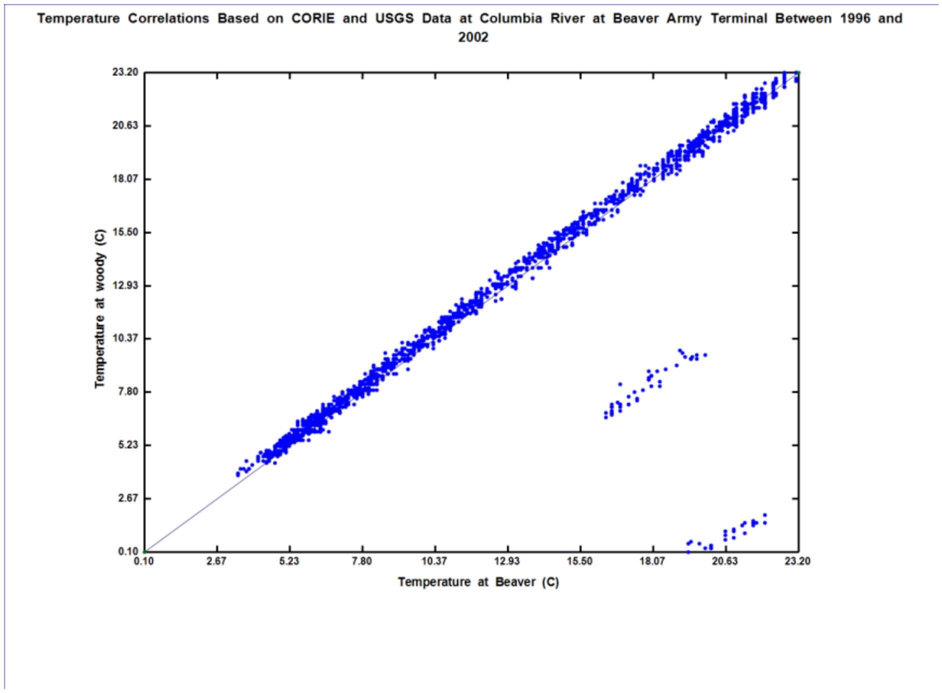

Figure D.2. Median daily temperatures (˚C) from CORIE station at Woody Island and Beaver Army Station at Quincy, Oregon.

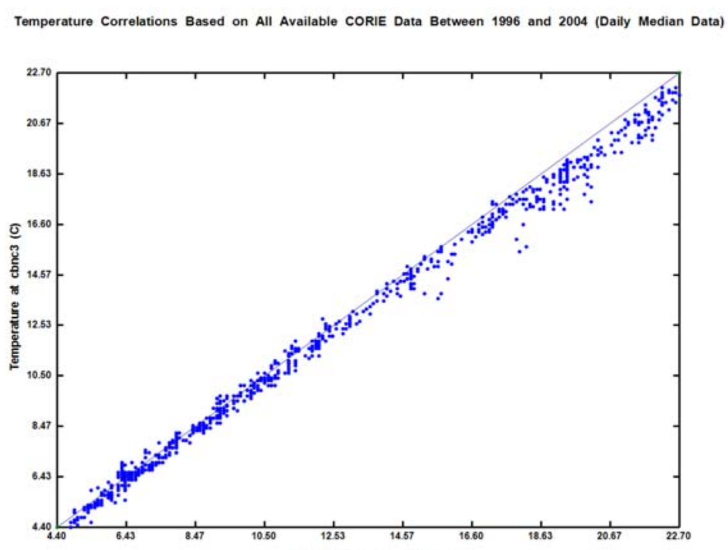

Figure D.3. Median daily temperatures (˚C) from CORIE stations at Woody Island Cathlamet Bay North Channel.

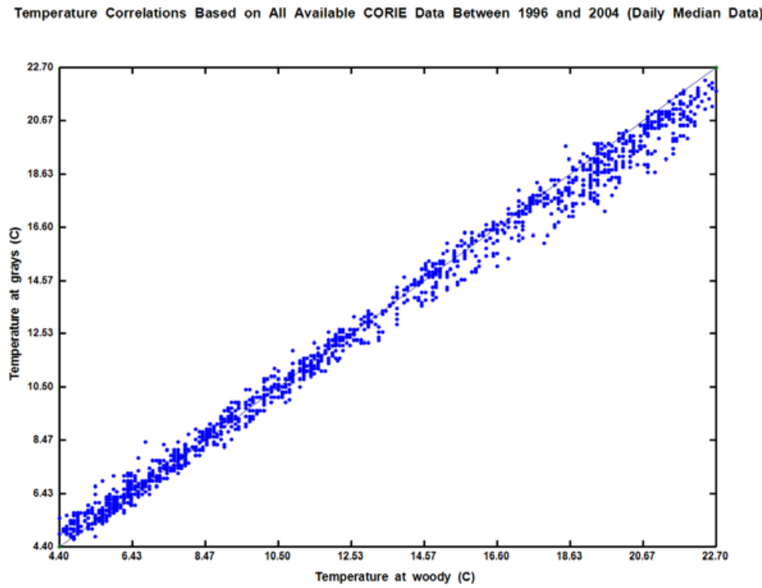

Figure D.4. Median daily temperatures (˚C) from CORIE stations at Woody Island and Grays Point.

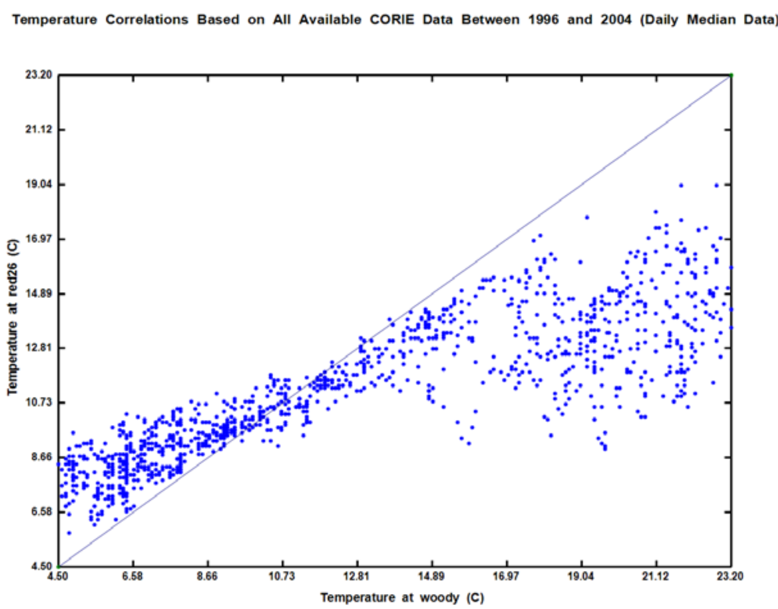

Figure D.5. Median daily temperatures (˚C) from CORIE stations at Woody Island and Stevens Wharf.

Salinity

Tables D.6 and D.7 list the salinity percentile estimates that correspond with the decision criteria developed for depth and temperature. The salinity values in these CORIE summaries are consistent with expectations. The stations nearer the mouth of the river (e.g., sandi, dsdma, red26, and tansy) show elevated salinities compared to stations less influenced by tidal circulation (e.g., grays, eliot, sveni, cbnc3). Salinities are higher in general for July–November period when river flows are lower and tidal influences are stronger. Deviations from these values in association with channel improvements will be used to justify an adaptation of the project in accordance with the proposed AEM Process.

Table D.6. Decision criteria for salinity measured as psu based on 20- and 80-percentile values calculated from available CORIE data between 1996 and 2004.

	January		February		March		April		May		June	
Station	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile
chnke	2.3	11.0	0.7	8.1	1.0	7.0	1.2	6.3	2.6	7.7	4.3	9.6
sandi			9.8	27.8	7.6	26.4	6.0	27.0	7.0	26.6	7.2	27.2
dsdma	10.1	26.9	6.1	25.0	5.2	24.4	5.0	24.5	4.6	23.2	4.2	24.9
red26	5.3	25.5	5.8	26.1	5.1	24.9	4.5	25.3	4.3	25.0	4.4	26.5
tansy	4.2	23.9	3.7	23.4	3.4	21.5	3.0	23.0	2.7	22.9	1.7	22.9
yb101												
lwsck												
yacht												
am169	0.9	17.9	1.0	19.1	0.5	17.2	0.5	17.8	1.0	17.0	0.3	16.4
am012												
grays	0.3	1.2	0.3	0.8	0.3	0.8	0.3	0.7	0.3	0.7	0.3	0.7
ricei												
eliot	0.3	0.7	0.2	0.7	0.2	0.7	0.3	0.6	0.3	0.6	0.2	0.6
woody									0.0	0.6	0.0	0.6
marsh	0.2	0.6	0.2	0.6	0.0	0.6	0.0	0.6	0.0	0.6	0.0	0.6
sveni	0.0	0.7	0.0	0.6	0.0	0.6	0.0	0.6	0.0	0.6	0.0	0.6
cbnc3	0.2	0.7	0.2	0.7	0.2	0.7	0.2	0.7	0.2	0.7	0.0	0.7
mottb	0.0	0.8	0.0	1.8	0.0	0.8	0.2	5.7			0.0	0.6
coaof	0.0	2.1	0.2	2.9								

	July		August		September		October		November		December	
Station	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile	20-%ile	80-%ile
chnke	6.9	11.0	6.7	10.9	9.1	14.1	7.8	14.3	5.1	12.6	3.1	15.1
sandi	12.0	29.2	13.4	28.5	14.2	28.9	14.9	29.5	14.3	29.9	15.5	29.9
dsdma	8.1	27.3	9.7	27.8	12.8	27.8	13.2	27.4	11.6	27.3	5.4	24.2
red26	12.8	28.1	10.5	28.0	12.5	27.9	12.8	27.6	11.1	26.7	7.2	26.3
tansy	3.8	25.1	8.7	26.3	10.4	26.0	10.7	26.0	6.8	23.9	5.9	24.6
yb101												
lwsck												
yacht												
am169	7.5	23.0	6.3	23.4	7.6	22.2	8.2	22.3	7.0	22.1	1.7	21.2
am012												
grays	0.3	2.4	0.5	2.4	0.8	4.4	0.7	3.7	0.5	2.7	0.3	0.8
ricei												
eliot	0.7	0.7	1.0	0.7	0.3	1.1	0.3	0.8	0.2	0.7	0.2	0.7
woody	0.0	0.6	0.0	0.6								
marsh	0.0	0.6	0.0	0.6	0.0	0.6	0.0	0.6	0.0	0.6	0.0	0.6
sveni	0.0	0.6	0.0	0.7	0.0	0.7	0.0	0.7	0.0	0.7	0.0	0.7
cbnc3	0.2	1.7	0.2	2.5	0.4	3.5	0.2	7.0	0.2	2.2	0.2	0.7
mottb	0.7	12.8	1.0	12.2	3.2	14.8	1.8	15.0	1.5	12.8	0.0	11.2
coaof	1.0	4.7	1.2	6.2	1.2	7.9	0.7	4.5	1.0	5.4	0.5	3.7

Table D.7. Decision criteria for salinity measured as psu based on 5- and 95-percentile values calculated from available CORIE data between 1996 and 2004.

	January		February		March		April		May		June	
Station	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile
chnke	0.8	13.0	0.2	13.0	0.2	8.7	0.2	8.6	0.5	9.5	2.2	13.7
sandi			5.0	29.9	4.1	29.1	3.0	29.3	3.8	29.6	3.8	30.3
dsdma	6.0	28.6	1.0	27.7	2.8	27.5	2.6	27.5	2.0	26.0	1.6	28.2
red26	2.3	28.5	2.4	28.6	2.0	27.8	1.6	27.9	2.0	27.9	1.5	29.3
tansy	1.2	27.3	1.2	26.7	1.2	25.5	1.2	26.6	1.2	26.5	0.7	27.2
yb101												
lwsck												
yacht												
am169	0.2	23.2	0.2	24.5	0.2	23.0	0.2	23.8	0.2	22.9	0.2	23.5
am012												
grays	0.2	3.1	0.2	2.7	0.2	2.0	0.2	1.4	0.0	0.8	0.2	1.3
ricei												
eliot	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.3	0.2	0.3
woody									0.0	0.0	0.0	0.2
marsh	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.2
sveni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cbnc3	0.2	2.3	0.2	2.1	0.2	3.3	0.2	1.7	0.2	0.9	0.2	1.5
mottb	0.0	8.4	0.0	10.4	0.0	10.0	0.0	10.9			0.0	0.0
coaof	0.0	4.7	0.0	5.9								

	July		August		September		October		November		December	
Station	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile	5-%ile	95-%ile
chnke	5.5	12.5	3.2	13.6	5.3	16.2	2.9	17.0	1.0	16.0	0.9	19.6
sandi	7.9	30.9	10.0	30.2	9.9	30.7	9.9	30.9	10.1	31.1	9.8	30.9
dsdma	4.4	29.8	5.7	30.1	8.6	29.8	9.1	29.1	6.8	29.4	2.1	27.6
red26	6.9	29.9	6.2	30.0	8.1	30.0	8.1	29.4	6.2	29.0	3.1	28.7
tansy	1.6	28.4	3.5	28.9	4.8	28.6	5.0	28.2	3.3	26.9	2.4	27.6
yb101												
lwsck												
yacht												
am169	3.1	26.0	2.2	27.1	3.3	26.6	3.3	26.3	2.5	25.6	0.3	25.0
am012												
grays	0.3	5.5	0.3	4.4	0.5	6.9	0.4	6.2	0.3	4.8	0.3	2.2
ricei												
eliot	0.2	0.9	0.3	6.4	0.3	10.3	0.3	9.5	0.2	1.9	0.2	0.3
woody	0.0	0.0	0.0	0.2								
marsh	0.0	0.3	0.0	0.4	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3
sveni	0.0	0.3	0.0	0.3	0.0	1.9	0.0	1.6	0.0	0.2	0.0	0.7
cbnc3	0.2	4.5	0.2	6.3	0.2	9.3	0.2	12.3	0.2	5.3	0.2	2.0
mottb	0.3	18.3	0.3	19.1	0.5	20.5	0.3	19.7	0.3	16.8	0.0	16.7
coaof	0.4	8.7	0.5	10.1	0.5	11.6	0.4	8.2	0.4	8.9	0.2	6.9

Numbers of Samples

The quality and quantity of the available data influence the estimation of the empirically derived decision criteria. The continuous nature of the CORIE monitoring effort provides a large number of measurements for use in estimating the percentile values selected as decision criteria for MA-1. Tables D.8 through D.10 list the number of measurements that were used to estimate the criteria for depth, temperature, and salinity for each month. Values of zero identify gaps in the data record for each station and parameter. Gaps in the data occur for various reasons, including instrument failure and biofouling. To address potential problems associated with data quality in producing biased estimates of the decision criteria, the CORIE measurements undergo a rigorous quality assurance/quality control evaluation before the data are made available for analysis (see http://www.ccalmr.ogi.edu/CORIE). This evaluation includes the analysis of reported measurements to identify likely extreme values (perhaps resulting from biofouling). Potentially erroneous values are removed from the data made publicly available for analysis.

Table D.8. Number of reported CORIE measurements of water depth between 1996 and 2004.

Station ID	January	February	March	April	May	June	July	August	September	October	November	December
chnke	5,031	4,266	5,636	6,721	4,527	3,435	10,616	13,444	12,041	11,521	9,473	4,970
sandi	45,408	9,179	35,686	72,556	13,967	1,484	2,127	0	0	0	10,957	28,269
dsdma	43,843	24,015	8,270	69,497	119,075	78,743	56,950	33,180	44,435	36,421	5,692	8,919
red26	37,913	26,384	79,426	79,227	47,206	50,725	41,155	35,444	5,557	26,566	40,807	41,480
tansy	236,375	250,328	247,127	268,164	239,353	174,112	179,712	202,392	198,763	216,240	168,468	159,412
am169	5,311	9,139	42,616	9,057	0	0	0	0	75,682	47,430	19,304	509
grays	196,048	193,501	187,774	227,489	249,235	214,412	233,710	213,446	228,775	211,757	243,353	211,712
eliot	129,402	119,461	116,713	126,117	132,278	122,439	160,331	200,489	181,331	130,920	151,600	85,468
woody	147,844	207,517	220,658	259,894	245,221	178,994	147,501	161,289	173,584	131,403	171,073	183,942
marsh	69,937	44,272	65,115	69,783	43,914	45,313	44,055	86,005	79,271	97,227	115,789	83,245
sveni	141,945	134,406	141,814	135,738	139,612	129,513	106,169	132,782	134,829	150,661	145,846	132,932
cbnc3	0	2,699	40,407	58,579	37,377	22,346	18,699	0	0	0	0	0
mottb	82,293	77,553	85,587	84,185	152,967	129,149	120,493	110,488	69,041	58,938	61,120	61,792
coaof	76,680	75,796	72,105	74,784	89,714	91,807	61,634	73,660	72,467	101,287	102,860	99,392

Table D.9. Number of reported CORIE measurements of water temperature between 1996 and 2004.

Station ID	January	February	March	April	May	June	July	August	September	October	November	December
chnke	30,850	9,607	7,366	41,357	28,554	40,138	24,336	13,845	38,243	41,906	38,456	40,772
sandi	143,094	167,471	194,201	195,569	151,717	72,490	75,324	75,217	94,735	112,115	121,194	151,337
dsdma	176,664	164,158	138,492	183,785	258,016	270,112	265,112	246,023	224,275	280,923	237,534	235,938
red26	175,009	160,296	246,247	242,222	220,079	237,804	242,924	222,262	216,953	271,253	292,526	293,796
tansy	400,565	380,684	404,549	361,400	376,048	290,844	235,471	276,389	324,588	329,196	325,824	290,164
am169	104,505	129,889	132,741	134,065	132,265	144,944	122,913	127,087	199,994	224,441	172,559	167,943
grays	207,790	200,805	203,803	240,277	249,266	214,713	239,567	225,937	235,905	229,897	250,651	217,338
eliot	131,724	120,019	118,790	126,582	132,743	123,738	169,385	208,701	192,266	202,236	200,437	169,484
woody	207,766	262,510	271,528	325,112	288,761	222,538	186,019	233,532	214,290	158,055	182,633	200,101
marsh	97,946	78,664	86,082	126,795	124,014	92,920	121,850	129,017	138,334	172,007	159,813	152,833
sveni	128,201	121,569	127,846	123,878	129,681	120,229	99,391	122,527	123,245	140,091	137,116	123,653
cbnc3	98,079	124,333	145,653	158,850	142,606	126,965	120,360	121,139	137,902	128,699	138,387	110,222
mottb	126,781	118,388	128,887	157,181	204,382	195,230	181,600	209,033	177,419	177,085	153,543	169,053
coaof	76,680	77,860	77,238	84,684	96,609	114,174	104,035	110,326	75,725	101,287	105,064	105,576

Table D.10. Number of reported CORIE measurements of salinity between 1996 and 2004.

Station ID	January	February	March	April	May	June	July	August	September	October	November	December
chnke	30,865	9,607	7,366	41,357	28,553	39,324	5,944	7,129	38,049	36,989	42,878	40,772
sandi	0	33,087	67,546	74,230	63,377	58,449	69,462	9,749	45,466	75,899	45,655	20,156
dsdma	35,934	40,534	44,634	36,066	69,956	96,964	90,345	35,372	78,660	119,491	33,681	48,100
red26	96,906	122,544	133,201	128,572	86,845	74,685	102,208	102,018	133,045	168,684	169,036	140,429
tansy	131,370	118,754	131,725	79,656	123,382	107,514	47,996	63,196	51,593	85,105	42,651	88,847
am169	54,911	79,524	88,034	120,093	132,265	110,603	67,102	44,494	76,838	136,174	88,672	80,333
grays	138,854	158,007	157,606	154,511	160,760	141,831	161,893	119,465	63,248	30,903	26,688	16,554
eliot	131,724	120,019	118,790	126,582	132,743	123,738	169,385	208,701	192,266	202,236	201,901	169,484
woody	0	0	0	0	513	41,156	30,035	20,852	0	0	0	0
marsh	97,946	78,664	86,082	126,795	124,014	92,919	121,851	129,017	96,539	128,433	117,100	123,540
sveni	87,864	79,959	83,770	83,614	87,618	81,597	84,542	81,940	80,685	70,876	53,109	42,425
cbnc3	98,079	124,333	120,715	116,933	126,903	126,378	112,687	118,330	75,647	43,562	28,770	17,215
mottb	48,895	40,247	59,784	29,439	0	42,884	21,863	39,379	37,179	72,888	43,117	68,297
coaof	33,159	39,395	0	0	0	0	40,029	39,621	41,878	14,631	21,350	23,043

Decision Criteria and the AEM Process for Physical-Chemical Parameters

In the event that monitored daily values of water depth, temperature, or salinity in association with channel dredging are at variance with the decision criteria developed for these parameters, corresponding hypothesis tests for significant differences in the corresponding monthly average values will be performed to determine if the adaptive component of the AEM Plan should be invoked. If there are no significant differences, the monitoring and the AEM Process would continue as prescribed in the AEM Plan.

If there are significant monthly differences, the following analyses, for example, could be undertaken to help understand the differences determined by the MA-1 monitoring:

1. MA-1 data for the variable(s) that exceeded the percentile criteria will be further analyzed for the potentially impacted monitoring station to determine if the differences can be explained by unusual changes in natural (e.g., tides, precipitation) or managed (e.g., Bonneville Dam operations) processes that contribute to the overall variability in the monitored physical-chemical parameters at the station.

2. MA-1 data that exceeded the criteria will be analyzed in relation to corresponding values for one or more nearby monitoring stations (e.g., stations located more seaward and more inland). The analyses will be used to determine if similar trends in the parameter(s) of interest can be established at nearby locations. This evaluation would complement the analyses in Step 1 of the AEM Plan to determine if unusual variability at the MA-1 station might reasonably be reflected in nearby locations as well. If the analyses suggest that nearby stations are responding similarly to changes in natural or managed processes as the MA-1 station, the AEM Process would continue with normal MA-1 monitoring. If, however, natural or managed processes cannot satisfactorily explain observed significant monthly differences at the MA-1 stations and further analyses also indicate similar differences in nearby locations, then, current or future Project activities might be modified in accordance with the AEM Plan.

These and other analyses (e.g., modeling) could be used to examine the likelihood that any measured monthly differences constitute "false positives" in relation to the AEM Plan. If the variances suggested by the decision criteria can be satisfactorily explained in terms of unusual natural variability, such as a shift in climatic conditions, or regulation of flows at Bonneville Dam, the differences would be classified as "false positives" and no further action would be required by the AMT. Under these circumstances, the AEM Plan prescribes a return to the basic MA-1 monitoring. However, if significant differences cannot be explained by naturally varying or managed conditions, the likelihood of impacts due to channel dredging would not be dismissed and further consideration of adapting the dredging (e.g., scheduling) would be undertaken as directed by the AEM Plan.

Higher-Order Decision Criteria

In addition to considering decision criteria developed individually for each of the parameters described previously in this report, it is possible to derive criteria that attempt to quantify possible impacts of channel improvement in a more integrated fashion. Decision criteria developed to detect changes in the functional interrelationships of processes fundamental to the ecological function of the river and estuary represent higher-order criteria.

The seasonal progression of water elevations, temperature, and salinity values are clearly influenced by the regime of river flow through the estuary, tidal forcings, and circulation within the estuary. The net result can be characterized by calculating the correlations of the monthly median values for these physical-chemical factors for each of the sampling locations. The structure (or pattern) of these correlations capture some of the interrelationships among these factors. These patterns of correlations (i.e., depth x temperature, depth x salinity, temperature x salinity) could serve as higher-order decision criteria for the CRCIP AEM Plan. Changes in the nature of these correlations measured in relation to channel improvements might well signal higher-level changes in the way these factors co-vary.

Statistical analyses performed thus far using the pre-project CORIE data suggest that despite this considerable monitoring effort, there are insufficient data to develop useful spatial-temporal correlations among the values reported for the various sampling locations, including the three stations that comprise the MA-1 effort.

3-2 MA-2 Volumes of Dredged Materials

MA-2 will provide annual dredging volumes associated with construction and operation of the 43-foot channel. Volumes will be reported for each dredging bar (~3-mile reaches). Volumes of dredged materials will be compared to projected values (e.g., Table D.11). This management action will continue through the project's duration.

One decision criterion for dredging volume is whether or not actual volumes of dredged materials exceed the volumes proposed in development of the CRCRIP. In addition, the adaptive component of the proposed AEM Plan might be initiated if the volumes of dredged materials exceed the capacity for disposal.

Table D.11. Template for decision criteria based on comparison of projected and measured volumes of dredged materials in cubic yards (cy).

Item No.	Dredging and disposal contract description	Estimated quantity (cy)	Actual dredged quantity (cy)
006	CRM 95 to RM 103+07, Oregon Rehandle, Hayden Island	835,000	
007	CRM 95 to RM 97+00, Oregon Rehandle, Increment for Gateway Disposal (optional)	500,000	
008	CRM 97 to CRM 103+07+50, Oregon Rehandle, Increment for Gateway Disposal (optional)	335,000	
009	OR Slough CRM 0+00 to CRM 1+00, Oregon Rehandle, Hayden Island (optional)	465,000	
010	OR Slough CRM 0+00 to CRM 1+00, Oregon Rehandle, Increment for Gateway Disposal (optional)	465,000	
011	CRM 103+07 to CRM 105+25, Consolidated Material	1,250,000	

Dredging and the disposal of dredged materials will be conducted in accordance with state (i.e., Washington Department of Ecology and Oregon Department of Environmental Quality) concerns regarding undesired modifications of river and estuary bathymetry. Flowlane disposal of dredged materials will be conducted in a manner to minimize potential direct (e.g., burial, behavior) or indirect (e.g., habitat disruption, food resources) impacts on smelt and sturgeon.

Table D.12 lists detailed disposal plans for dredged materials as described in Table S4-1 in the FSEIS. The implementation of each of the disposal plans can be reviewed by the AMT as part of the MA-2 evaluation process. Substantial changes in the execution of these individual disposal plans might justify adaptive management. The degree of acceptable deviations or modifications of the plans outlined in Table D.12 will have to be determined by the AMT.

3-3 MA-3 Channel Bathymetry

Potential variances between projected and actual volumes of dredged materials will be assessed through MA-2 of the CRCIP. MA-3 will evaluate potential impacts of dredging on bathymetry, and accretion/erosion of the side slopes. MA-3 will provide information to assess physical alterations to habitat caused by side-slope adjustments resulting from dredging. Adjustments to side slopes are expected to occur adjacent to the navigation channel both naturally and as a result of deepening.

The MA-3 will examine accretion/erosion and changes in bathymetry of the main channel in relation to the channel deepening. Surveys will be conducted annually for two years prior to construction, two years during construction, and three years after construction. Crossline surveys will be conducted within a December–February time period to coincide with the end of the dredging season. Surveys will be conducted along the navigation channel from Columbia River mile (CRM) 3 to CRM 106. Statistical analyses will produce estimates of mean and median depth at each sampled location across the channel; minimum and maximum values as well as standard deviation and coefficients of variation will also be determined.

The consensus AMT decision criteria for MA-3 are defined as an "envelope" calculated as the minimum surveyed depth +1 standard deviation and the maximum depth +1 standard deviation. The envelope is defined across the channel for each survey with particular emphasis on the northern and southern boundaries of the navigation channel. Changes in bathymetry which exceed the criteria defined by these envelopes will be evaluated by the AMT to determine the need for possible modifications to the Project, as summarized in the AEM Plan.

3-4 MA-4 Habitat Surveys

MA-4 will augment the estuary habitat surveys being conducted by NMFS as part of the Anadromous Fish Evaluation Program (AFEP) (Bottom and Gore 2001). The objective is to determine if changes in habitat result from modifications to the channel. The surveys will assess those habitats currently being studied by NMFS. The survey will also address habitat complexity, connectivity, and conveyance. Habitat-specific food availability will be quantified. The use of peripheral areas by juvenile salmonids will be measured. The survey will be conducted three years after construction.

Table D.12. Proposed Disposal Plan including beneficial use sites, ecosystem restoration and wildlife mitigation (Martin Island Embayment).

Disposal Site*	Disposal History**	Location/Name	Site Acres (rounded)	Site Capacity (cy)	Construction Disposal Volume Rounded (cy)	O&M Use for 20-year Term	43-foot O&M Disposal Volume Rounded (cy)	Total Disposal Volume Rounded (Construction and O&M)a	Final Height for Total Volume Placed (feet CRD)
In-water	DMMS	CRM 3-106 - 50'-65' deep, in or adjacent to channel***	NA	NA	2,000,000	20	26,000,000	28,000,000	NA
O-105.0	DMMS	West Hayden Island	102	5,750,000	600,000	20	3,900,000	4,500,000	60
W-101.0	New	Gateway	40	2,300,000	587,000	20	1,600,000	2,300,000	65
W-97.1	DMMS	Fazio Sand & Gravel	27	650,000	112,000	20	1,000,000	1,200,000	Varies due to resale
W-96.9	New	Adjacent to Fazio	17	475,000	0	6-20	As needed	Varies	Varies due to resale
O-91.5	New	Lonestar	45	5,350,000	900,000	20	3,200,000	4,400,000	NA; gravel pit
O-87.8	New	RR Corridor	12	540,000	300,000	20	0	400,000	46
W-86.5	Used	Austin Point	26	1,645,000	136,000	20	1,500,000	1,700,000	Varies due to resale
O-86.2	Used	Sand Island	28	1,250,000	150,000	20	860,000	1,000,000	Shoreline; varies due to erosion
O-82.6	Used	Reichold	49	1,285,000	320,000	20	2,300,000	2,600,000	Varies due to resale
W-82.0	Used	Martin Bar	32	1,500,000	46,000	20	700,000	760,000	51
W-80.0	New Mitigation Site	Martin Is. Mitigation	16	550,000	370,000	Not used	0	460,000	-8
O-77.0	Used	Lower Deer Island	29	1,498,000	440,000	20	700,000	1,200,000	44
O-75.8	DMMS	Sandy Island	30	1,100,000	120,000	20	860,000	1,000,000	42
W-71.9	Used	Northport	27	900,000	189,000	20	1,800,000	1,900,000	Varies due to resale
W-70.1	Used	Cottonwood Is.	62	3,200,000	240,000	20	1,300,000	1,500,000	49
W-68.7	DMMS	Howard Island	200	6,400,000	0	20	600,000	600,000	29
O-67.0	Used	Rainier Beach	52	1,095,000	450,000	20	2,400,000	3,000,000	65
W-67.5	Used	International Paper	29	1,000,000	140,000	20	2,700,000	2,900,000	Varies due to resale
O-64.8	DMMS	Rainier Industrial	53	2,235,000	270,000	20	2,400,000	2,700,000	64
O-63.5	DMMS	Lord Island Upstream	25	1,255,000	0	20	600,000	600,000	63
W-63.5	Used	Reynolds Aluminum	13	500,000	180,000	20	0	200,000	Varies due to resale
W-62.0	New	Mt. Solo	47	2,500,000	300,000	20	2,100,000	2,400,000	49
W-59.7	DMMS	Hump Island	69	1,500,000	400,000	6	900,000	1,500,000	42
O-57.0	DMMS	Crims Island	46	1,600,000	30,000	20	1,100,000	1,200,000	40

Table D.12. Proposed Disposal Plan including beneficial use sites, ecosystem restoration and wildlife mitigation (Martin Island Embayment). (Continued).

Disposal Site*	Disposal History**	Location/Name	Site Acres (rounded)	Site Capacity (cy)	Construction Disposal Volume Rounded (cy)	O&M Use for 20-year Term	43-foot O&M Disposal Volume Rounded (cy)	Total Disposal Volume Rounded (Construction and O&M)a	Final Height for Total Volume Placed (feet CRD)
O-54.0	Used	Port Westward	50	1,875,000	150,000	20	1,500,000	1,700,000	46
W-46.3/ 46.0	DMMS	Brown Island	72	4,700,000	1,200,000	20	3,400,000	4,700,000	66
W-44.0	New	Puget Is. (Vik Prop.)	100	3,500,000	500,000	20	2,700,000	3,300,000	41
O-42.9	DMMS	James River	53	1,280,000	240,000	20	830,000	1,070,000	39
O-38.3	DMMS	Tenasillahe Island	42	2,300,000	0	10	2,300,000	2,300,000	60
O-34.0	DMMS	Welch Island	42	446,000	0	3 (18-20)	400,000	400,000	25
W-33.4	Used	Skamokawa	11	250,000	0	As needed	varies	varies	Shoreline; varies due to erosion and resale
O-27.2	DMMS	Pillar Rock Island	56	2,555,000	0	20	1,000,000	1,000,000	34
	New Restoration	Miller-Pillar Ecosystem Restoration Feature	235	5,500,000	0	15	5,500,000	5,500,000	Surveyed reference (tidal marsh & intertidal flat) elev.
O-23.5	DMMS	Miller Sands	151	NA	0	20	7,000,000	7,000,000	Shoreline; varies due to erosion
W-21.0	DMMS	Rice Island	228	5,500,000	0	20	5,500,000	5,500,000	53
	New Restoration	Lois Island Embayment Ecosystem Restoration Feature	191	6,200,000	4,000,000	20	2,000,000	6,000,000	Surveyed reference (tidal marsh) elev.
Shallow Water Site	Used	Ocean	580	NA	MCR O&M(1)	20	0	0	NA
Deep Water Site	New	Ocean	8,980	225,000,000	0	20	0	0	NA

1. Between 2.0-2.5 mcy per year in Site E and North Jetty Site per year.
2. Construction plus 20 years channel project only; additional material from MCR operations and maintenance (O&M) as needed. 50-year volume 37 mcy.
***** "W" and "O" refer to the Washington or Oregon shoreline. The number refers to the approximate river mile on the navigation channel.
****** DMMS = site is in the No Action Alternative (existing 40-foot channel maintenance) New = site is new for this study Used = site previously used by Corps for disposal
*** Disposal would occur in depths over 65 feet at CRM 5, 29-35, 36.5-37.5, 39-40, 54-56.3, and 72.2 - 73.2 a - Total includes 40-foot O&M volume that is included in material dredged with 43-foot construction material.

Threshold values of change (i.e., decision criteria) will be defined for each habitat type. Measures that exceed any of the decision criteria may result in adaptation to current management actions.

3-5 MA-5 Sediment Contaminants

The MA-5 will include the review of sediment chemistry data to evaluate the potential impacts of channel deepening on the exposure of aquatic organisms to toxic contaminants. The SEDQUAL database will be reviewed annually to determine if there are areas affected by CRCIP that would require additional sampling and analysis. This will ensure that the channel construction does not disturb undetected deposits of fine-grained material, potentially causing redistribution of contaminants that could pose a risk to salmonids and trout. The USACOE, the USFWS, and the NMFS will annually review any new sediment chemistry from the LCR and estuary from sources such as the SEDQUAL database and known permit applicants and determine if there are any changes in the “Management Area Ranking” as defined in the DMEF manual. This management action will occur 2 years before construction, 2 years during the construction period, and annually during maintenance

3-6 MA-6 Fish Stranding

MA-6 addresses the potential impacts of channel improvements on fish stranding by commercial vessels navigating on the LCR and estuary.

Frequency and Probability of Stranding

The proposed decision criteria are based on comparisons of pre- and post-project numbers of stranded fish and associated estimates of the probability of fish stranding. An increase in the probability of fish stranding following channel improvements will initiate the adaptive components of the CRCIP AEM Plan. An important consideration in developing these decision criterion lies in establishing a statistical difference between pre- and post-project fish stranding probability. Table D.13 summarizes the results of intensive field studies aimed at understanding the potential for fish stranding by commercial navigation in the Columbia River and estuary (Pearson et al. 2005). The studies suggest site-specific differences in the frequency of vessel passages that result in fish stranding. On average across all three locations, approximately 26% of the vessel passages were associated with stranding events. This frequency ranged from ~18 to 30% for these three locations. If corresponding post-project stranding frequencies are statistically greater than the values summarized in Table D.13, it would prove reasonable and prudent to follow the adaptive components of the AEM Plan and attempt to determine the likely cause for the measured increase. The feasibility in performing these statistical comparisons will be determined by (1) the quantitative nature of the previous and continuing measures of fish stranding; (2) the statistical design of MA-6 for the collection of appropriate post-construction fish stranding data and (3) the application of a complex, multivariate statistical model. This model forecasts the likelihood of stranding events in relation to local site characteristics, river conditions, fish availability, and commercial vessel characteristics (Pearson et al. 2005).

Table D.13. Summary of stranding events and mean number of fish stranded (Pearson et al., 2005).

Site	Number of events	Percent of total events	Mean number of fish stranded	Percent of total fish stranded
Barlow Point	26	56.5	14.9	53.6
County Line Park	6	13.1	7.3	26.3
Sauvie Island	14	30.4	5.6	20.1

Fish Susceptibility to Stranding

In addition to potentially changing the frequency of fish stranding events, channel modifications in the Columbia River and estuary might alter the susceptibility of different fish species to stranding. Pearson et al. (2005) estimated the relative percentage of 16 species commonly collected in the locations of the stranding studies (Table D.14). (Two unidentified trout and salmonids from Pearson et al. (2005) were not included in Table B.14.) The results of seining indicated that the relative abundance of fish subject to stranding was dominated by three-spine stickleback, peamouth chub, American shad, and age 0+ chinook salmon. The relative abundances of these species among the stranded fish were also calculated. Dividing the relative frequency of stranding by the relative abundance produced a ratio that defines the susceptibility for each of the 16 species (Table D.14). Ratios greater than 1.0 indicate greater susceptibility to stranding. That is, the species is proportionally over-represented among the stranded fish compared to its relative availability. In contrast, susceptibility ratios less than 1.0 indicate some ability of the species to reduce its likelihood of stranding.

Bass (fry) were the most susceptible of the 16 species to stranding by commercial vessel passage. Coho, mountain whitefish, and age 0+ chinook were also susceptible. The remaining species demonstrated some capability to avoid stranding. The susceptibility ratios can also serve as decision criteria for fish stranding in the AEM Plan. Potential modifications in fish habitat and changes in fish behavior associated with channel modifications could increase the local availability or susceptibility of these (or other) species. If post-project susceptibility ratios increase significantly compared to those reported in Table D.14, the AEM Plan should be followed to determine the likely reason for the increases.

Table D.14. Relative susceptibility of different fish species to stranding (Pearson et al. 2005).

Species	Percent stranded	Percent of catch	Susceptibility ratio
0+ Chinook	81.9	49.1	1.7
1+ Chinook	0	0.6	0
Chum	1.5	1.6	0.9
Coho	1.3	0.2	6.5
Mountain whitefish	1.5	0.4	3.8
Threespine stickleback	7.7	21.6	0.4
American shad	0.8	6.4	0.1
Banded killifish	1.3	1.4	0.9
Yellow perch	0.4	2.3	0.2
Bass (fry)	1.0	0.1	10.0
Lepomis sp.	0.2	0	-
Crappie	0.2	0	-
Peamouth chub	1.7	15.1	0.1
Northern pike minnow	0	0.1	0
Sculpin	0	0.3	0
Starry flounder	0.2	0.4	0,5

D.4 Decision Criteria for Other Important Species

The AEM Plan focuses on the potential risks posed by channel improvements to juvenile salmonids. However, other important ecological resources are also of concern in implementing the plan. Accordingly, decision criteria are proposed to assess possible impacts of channel modifications on sturgeon, smelt, and Dungeness crab. The nature of these criteria differs conceptually from those developed in relation to MA-1 through MA-6. The AEM decision criteria for the monitoring actions are dynamic and flexible, and are evaluated within the context of the overall AEM Plan. In contrast, the decision criteria for the following resources are derived mainly as administrative constraints imposed by key stakeholders in the AEM Process. These resource criteria are evaluated as issues of compliance in the AEM Process rather than as flexible or adaptable criteria.

The following sections outline the compliance-based decision criteria developed for sturgeon, smelt, and Dungeness crab. These criteria largely take the form of specific administrative constraints, several of which have been addressed by previous and continuing studies. The results of these studies could be used to determine the importance (i.e., relevance, weight) of decision criteria for these resources in the overall implementation of the CRCIP AEM Plan.

4-1 Sturgeon

Criteria to protect sturgeon as part of the AEM Process address the possible CRCIP impacts on the mortality, movements, feeding behavior, and habitat utilization of these fish in relation to the dredging process and the disposal of dredged materials. Development of such criteria entails the statement of possible impacts of concern, and an associated management response for each impact. The first column in Table D.15 lists the potential impacts on sturgeon that are of concern in the AEM Plan. Column two describes the associated desired management responses to these possible impacts. These actions emphasize the selection of alternative methods for dredging if significant impacts are observed. In addition, the dredging schedule could be modified to minimize impacts on sturgeon.

The third column in Table D.15 briefly describes the results of field monitoring studies of 20+ individual sturgeon (Parsley and Popoff 2004). These investigators collected, electronically tagged, and subsequently monitored the movements of these fish in the Columbia River and estuary. Importantly, the data suggest that individual sturgeon are not impacted by dredging or the disposal of dredged materials. These fish either did not leave areas of active dredging or disposal, or returned shortly after dredging stopped. The study results also indicated that diurnal sturgeon movements, likely associated with feeding, were not affected by dredging.

Table D.15. Decision criteria and observations of sturgeon in relation to dredging monitoring results (Parsley and Popoff 2004).

Potential impacts	Management response	Monitoring results
Direct mortality		
1.Immediate mortality of significant numbers of fish due to burial	1. Do not dispose in area or use additional sites in future, and/or modify schedule to minimize impact	
2. Delayed mortality of significant numbers of fish due to burial	2. Do not dispose in area or use additional sites in future, and/or modify schedule to minimize impact	
3. Fish survive disposal action	3. No mitigation action	3. Fish not impacted by dredging or disposal
Disturbance		
1. Significant number of fish leave area permanently	1. Do not dispose in area or use additional sites in future, and/or modify schedule to minimize impact	
2. Significant numbers of fish leave area temporarily	2. Schedule use of site for periods of low abundance	
3. Fish do not leave area	3. No mitigation action	3. Fish did not leave area, or returned shortly
Feeding – sturgeon feeding in site:		
1. Significant long-term effects	1. Do not dispose in area or use additional sites in future, and/or modify schedule to minimize impact	
2. Minor short-term effects	2. No mitigation action	2. Diurnal movements not affected
3. Sturgeon not feeding in site	3. No mitigation action	3. Fish possibly not feeding
Loss of habitat		
1. Sturgeon do not use habitat after disposal	1. Do not dispose in area or use additional sites in future, and/or modify schedule to minimize impact	
2. Sturgeon return to area a short time after disposal	2. No mitigation action	2. Fish did not leave area, or returned shortly
3. Fish return to area a long time after disposal	3. No mitigation action	3. Fish possibly not feeding

In addition to the potential impacts outlined in Table D.15, there are concerns that modification of channel slopes and bedform might impact the quality and distribution of preferred sturgeon habitat. Preliminary analysis of the monitoring data suggests that these fish prefer steeply-sloped channels and rough channel bedform. Further analysis continues to examine this initial result. If confirmed, changes in bathymetry caused by disposal actions might require further examination of proposed Project dredging.

The results of the Parsley and Popoff (2004) study raise the question concerning the need for a component of the AEM Process that explores opportunities to remove resources from consideration, if it appears that channel modifications will have negligible or no measured impact. The results summarized in Table D.15 indicate that sturgeon might reasonably be excluded as a risk endpoint in implementation of the AEM Plan. Admittedly, these results are based on the monitoring of a comparatively small number of individual sturgeon. However, the degree of consistency in the general behavioral patterns recorded for these fishes questions the added value of further monitoring.

4-2 Smelt (Eulachon)

Decision criteria to minimize channel improvement impacts on smelt derive from the monitoring of flow lane disposal of dredged materials. The criteria take the form of depth constraints (43 ft.) on flow lane disposal for specified river miles (e.g., between CRM 35 and CRM 75).

Additional criteria derive from the timing of smelt out migration. Particular attention will be paid to in-water disposal, which is not permitted between the 8^{th} and 20^{th} weeks of the year throughout CRM 35 and CRM 75.

The smelt AEM criteria are perhaps best summarized as compliance measures (Table D.16).

Table D.16. Compliance measures offered as decision criteria for smelt in implementation of the CRCIP AEM Plan.
Washington
In-water disposal of dredged material will not occur in areas shallower than 43-feet between CRM 35 and CRM 75 along the Washington shoreline. These areas are defined by depths determined in the pre-construction bank-to-bank bathymetry supplemented by additional channel bathymetry.
Washington, Oregon
In-water disposal will not occur during the period of peak Eulachon out migration (between the 8^{th} and 20^{th} weeks of the year) from the identified spawning areas (CRM 35–CRM 75). If in-water disposal is essential during the period of peak out migration, then the Corps shall further study the potential for Eulachon losses as a result of dredged material disposal impacts. Appropriate mitigation measures shall be developed based on the study outcomes, as determined through an Adaptive Management Process.

4-3 Dungeness Crab

The objectives of the AEM Plan concerning Dungeness crab are to avoid or minimize entrainment mortality and burial by disposal of dredged materials. Several studies (Table D.17) were requested to determine the likely impacts of dredging and disposal of dredged materials on Dungeness crab in the Columbia River estuary (e.g., Pearson et al. 2005).

Table D.17. Requested studies and compliance issues for Dungeness crab.
Washington, Oregon
1. The Corps will conduct additional study of crab entrainment to assess seasonal variations and salinity influence on entrainment rates, and to assess differences among various class sizes (e.g. age O+, 1+, 2+).
2. The Corps shall continue with its efforts to develop a crab distribution and salinity model and shall use the best available model as a management tool for scheduling dredging and disposal in the lower estuary to avoid and minimize entrainment and adverse effects of disposal.
3. The Corps will develop and adhere to a crab mitigation strategy designed to avoid and minimize entrainment and burial of Dungeness crab. The strategy shall specify impact thresholds and compensatory mitigation contingencies for unavoidable impacts to Dungeness crab, and shall be developed through the Adaptive Management Process.
4. Hydraulic dredging at Desdemona Sands and Flavel Bar* shall be conducted during times of least Dungeness crab abundance. To determine times of least abundance, entrainment sampling as described in "Entrainment of Crab in the Columbia River Estuary: June 2002 measurements and status of Summer 2002 measurements" (Pearson, Williams, and Skalski, September 5 2002) shall be conducted at each site each time those locations are dredged using USACE equipment, for a minimum of 5 years or to the extent necessary to gather sufficient data. The resulting crab entrainment data, along with real-time flow and salinity data shall be utilized to develop a model to predict times of least abundance. *Subsequent discussions among the AMT members and crab researchers concluded that dredging will focus on Desdemona. Under this circumstance, Flavel Bar would no longer be a focal point for crab entrainment in the AEM Plan.
5. Flowlane disposal of sediment in areas supporting populations of Dungeness crab shall be limited to times of least crab abundance as determined by the model in condition B.2. The crab unavoidably buried by flowlane disposal shall be calculated. By conducting maintenance dredging during low abundance periods, sufficient avoidance of Dungeness crab shall be accomplished to mitigate those unavoidably lost.
Oregon
The Corps will conduct additional study of crab entrainment to assess seasonal variations and salinity influence on entrainment rates, and to assess differences among various class sizes (e.g. age O+, 1+, 2+).
(vi) The Corps shall continue with its efforts to develop a crab distribution and salinity model and shall use the best available model as a management tool for scheduling dredging and disposal in the lower estuary to avoid and minimize entrainment and adverse effects of disposal.
(vii) The Corps will develop and adhere to a crab mitigation strategy designed to avoid and minimize entrainment of Dungeness crab. The strategy shall specify impact thresholds and compensatory mitigation contingencies for unavoidable impacts to Dungeness crab, and shall be developed through the Adaptive Management Process specified in Condition I (1), above.
(viii) Hydraulic dredging and flow-lane disposal occurring below river mile 17 and in known or suspected areas of overall high crab abundance, shall be conducted during seasons or river conditions of least crab abundance. The seasons or river conditions of least abundance shall be determined through entrainment sampling at dredging sites correlated with real-time flow and salinity data or through application of a salinity-crab model once a final, scientifically rigorous model is available.

Field studies were undertaken from 2002–2004 to estimate the numbers of crabs entrained and killed by the dredging process. These studies also produced a model that predicts the distribution and entrainment of crab as a function of salinity (Pearson et al. 2005).

Entrainment studies were performed at several locations within the estuary, including the mouth of the Columbia River, Desdemona Shoals, Upper Sands, Miller Sands, and Flavel Bar. Estimated crab entrainment rates varied by location, age class, and study year. Entrainment rates decreased progressively upriver from the mouth of the estuary, presumably in relation to the reduced abundance of crabs. Table D.18 summarizes the 2004-entrainment estimates.

Table D.18. Crab entrainment rates (crabs/cy) estimated for 2004 (Pearson et al. 2005).

Location	Age 0+	Age 1+	Age 2+	Age 3+	All
MCR All	0.0572	0.0028	0.0210	0.0128	0.0937
MCR-1	0.0535	0.0023	0.0147	0.0179	0.0883
MCR-2	0.0445	0.0022	0.0341	0.0126	0.0934
MCR-3	0.0760	0.0042	0.0137	0.0067	0.1007
Desdemona	0.0139	0	0.0035	0.0065	0.0239
Flavel Bar	0	0.0031	0.0035	0.0046	0.0112

Estimates of entrainment rates and projected volumes of construction dredging were used to estimate numbers of entrained crabs. These entrainment mortalities were extrapolated to an expected number of lost future adults and losses to the crab fishery (Pearson et al. 2005). Table D.19 presents estimated upper and lower 95% confidence intervals for adult equivalent losses (AEL) for age 2+ and 3+ crab and loss to the fishery. These calculations were made for projected dredging volumes at selected locations. The results summarized in Table D.19 underscore the considerable uncertainty (imprecision) inherent to these estimates. Despite these uncertainties, the kinds of results presented in Table D.19 can be used as AEM decision criteria to assess crab entrainment in relation to channel modifications. Not shown in the above tables are seasonal differences in entrainment estimates. Pearson et al. (2005) present monthly estimates of entrainment rates that indicate reduced rates during the winter months when salinity values (and presumably crab abundance) are reduced in relation to higher river discharge. This seasonality in projected impacts could be used to schedule dredging activities to reduce crab entrainment.

Table D.19. Summary of crab adult equivalent losses and loss to fishery for construction dredging (Pearson et al. 2005).

	AEL Age 2+		**AEL Age 3+**		**Loss to fishery**	
Project/location	**Lower 95% CL**	**Upper 95% CL**	**Lower 95% CL**	**Upper 95% CL**	**Lower 95% CL**	**Upper 95% CL**
Dredge to 40’						
Desdemona	36,076	83,560	16,234	37,602	5,683	13,161
Flavel	0	14,874	0	6,694	0	2,343
Upper sands	0	450	0	200	0	70
Tongue Point	0	102	0	46	0	17
Total	**36,076**	**98,968**	**16,234**	**44,542**	**5,683**	**15,591**
Dredge 40’–43’						
Desdemona	28,790	66,686	12,956	30,008	4,535	10,503
Flavel	0	32,080	0	14,436	0	5,053
Upper sands	0	2,498	0	1,124	0	393
Tongue Point	0	1,350	0	608	0	213
Total	**28,790**	**102,614**	**12,956**	**46,176**	**4,535**	**16,162**
Combined Scenarios	**64,866**	**201,600**	**29,190**	**90,718**	**10,218**	**31,752**

The salinity model developed by Pearson et al. (2005) identifies 16 psu as the “bright line” value, below which crab abundance markedly decreases. Characterization of the spatial-temporal distribution of water >16 psu can be used to estimates crab abundance throughout the estuary. The model can be used, at least in a relative sense, to estimate the potential implications of alterations in the circulation patterns and associated salinities attributed to channel modifications. Previous modeling studies (e.g., Baptista et al.2005) indicate that the channel deepening might increase the intrusion of higher salinity water, especially near the channel bottom.

In addition to salinity decision criteria derived from the analysis of existing pre-CRCIP data, additional criteria might be developed through the use of a salinity–crab distribution model. This model would be designed to address potential dredging impacts on patterns of salinity that might impact Dungeness crab. The model would complement management actions aimed at assessing entrainment of crabs during dredging, as well as potential burial of crabs by flowlane disposal of dredged materials. Decision criteria developed to protect Dungeness crab should address possible differences in sensitivities among various age classes of crabs (e.g., 0+, 1+, 2+).

4-4 Sediments

Sediment management has not been formally and separately developed within the AEM Plan. However, the results of AEM monitoring actions (MA-2, MA-3 and MA-4) will provide information that can address the stated concerns regarding the disposal of Project dredged materials and potential risks posed to coastal zone resources. The data produced by these monitoring actions can be evaluated as components of a regional sediment management program. Importantly, differences between pre- and post-construction sediment characterizations within the lower river and estuary can enter into the AEM decision-making process and influence future disposal of Project-related dredged materials.

In parallel to MA-3 and MA-4 decision criteria, the assessment of potential Project impacts on sediment management will be based on comparison of pre- and post-construction sediment disposition. To permit this comparison, the Corps has implemented monitoring actions within the AEM Plan that include the following pre- and post-construction tasks. In addition, the volumes of projected and actual dredged materials that will be determined during MA-2 can enter into the assessment of Project potential impacts on sediments within the lower river and estuary.

Pre-Construction

Prior to Project construction, surveys of riverbed bathymetry and inter-tidal beach/shoreline topography will be completed. The results of MA-3 and MA-4 monitoring actions will contribute information for establishing baseline conditions. The baseline surveys will be comparable in accuracy and data point density to the 1958 and 1982 bathymetric surveys. The bank-to-bank baseline surveys will cover the estuary from CRM3 to CRM 40. Suggested methods for data collection include multi-beam bathymetry measures at high tide and airborne topographic lidar at low tide. The resulting data can be used to generate baseline maps of sediment distributions within the inter-tidal zones.

Post-Construction

Within two years following construction, bank-to-bank bathymetric surveys will be repeated from CRM 3 to CRM 18. The post-construction surveys will be of similar accuracy as the baseline surveys. However, the data density of the post-construction surveys might be reduced to approximately one-half of the baseline effort. In addition, approximately ten bank-to-bank bathymetric survey transects will be conducted at approximately 2-mile intervals from CRM 18 to CRM 40. The cross-sectional and longitudinal coverage of the post-construction data collection should permit analysis of the potential impacts of Project construction on sediment dynamics within the lower river and estuary.

The results of the pre- and post-construction surveys will be summarized and reported to the Adaptive Management Team. The report can include the results of the baseline and post-construction bathymetric surveys, aerial photography, estimated volumes of construction and maintenance dredging in the channel, and available information on river flow and sediment transport during the pre- through post-construction period.

Decisions concerning the management of sediments in relation to channel improvements will be based on comparisons of pre- and post-construction sediment distribution within the lower river and estuary. Bathymetric and estuarine habitat data collected by the Corps as part of Project monitoring actions (MA-3 and MA-4) can be used to assess temporal and spatial bathymetric changes in the estuary with respect to potential impacts on sediment budget and estuarine habitats. Should any unanticipated, negative impacts become evident, the Corps shall use the adaptive management process to determine an appropriate response.

D.5 Decision Criteria Based on Salmon Performance

The discussion has thus far emphasized the identification of physical-chemical decision criteria for a monitoring program that supports the AEM Plan (Bartell and Nair 2005). This emphasis underscores the focus of the AEM Plan on possible direct physical-chemical impacts posed by channel deepening. Again, it is presumed that the CRCIP will pose no additional indirect risks to juvenile salmonids if there are no measurable changes in the physical-chemical parameters directly affected by channel improvement (Bartell and Nair 2005). At the same time, the plan does address the potential need to incorporate decision criteria that focus more directly on juvenile salmonid performance, if variances to the agreed upon physical-chemical criteria are observed during the monitoring. MA-4 is the first step in this analysis. A comparison will be done between the data gathered on juvenile salmon abundance and habitat use by the AFEP study with the year of data to be collected three years after deepening. This is being done to verify that even if the physical parameters do not change significantly that there is no change in the biological factors.

An additional evaluation could also be done of any changes in habitat opportunity by repeating the habitat opportunity evaluation done prior to deepening. Habitat opportunity is defined as the availability (volume) of suitable estuarine habitats for salmon, often determined by physical (spatial) processes. In a sense, the decision criteria derived from a physical-chemical perspective can enter into the analysis of habitat opportunity. For example, Bottom et al. (2001) use a hydrodynamic model to estimate changes in habitat opportunity defined by water velocity and depth for pre-development times (*circia* 1880) compared to more recent conditions. Repeating this analysis could be done to further verify if there had been any changes in habitat associated with the channel deepening.

References

Allen, T.F.H. and T.B. Starr. 1982. Hierarchy–perspectives for ecological complexity. University of Chicago Press, Chicago, IL. 310 pp.

Baptista, A.M., Y.-L. Zhang, A. Chawla, M.A. Zulauf, C. Seaton, E.P. Myers, J. Kindle, M. Wilkin, M. Burla, and P.J. Turner. 2005. "A cross-scale model for 3D baroclinic circulation in estuary-plume-shelf systems: II. Applications to the Columbia River". Continental Shelf Research 25:935–972.

Bartell, S.M. and S.K. Nair. 2005. An adaptive environmental management plan for the Columbia River Channel Improvement Project. Report prepared for the US Army Corps of Engineers, Portland, Oregon.

Bottom, D. L. and K. Gore. 2001. *Estuarine habitat and juvenile salmon–Current and historic linkages in the lower Columbia River and estuary.* Final Research Proposal to the Anadromous Fish Evaluation Program. Portland District, U.S. Army Corps of Engineers. ??pp.

Bottom, D.L., C.A. Simenstad, A.M. Baptista, D.A. Jay, J. Burke, K. Jones, E. Casillas, and M.H. Schiewe. 2001. Salmon at river's end: the role of the estuary in the decline and recovery of Columbia River salmon. U.S. National Marine Fisheries Service, Seattle, WA. 271 pp.

Dixon, W.J. and F.J. Massey, Jr. 1969. Introduction to statistical analyses. McGraw-Hill, New York, NY. 638 pp.

Gardner, R.H. 1998. Pattern, process, and the analysis of spatial scales, pp. 17–34. In, Peterson, D.L. and V.T. Parker (eds.), Ecological scale–theory and applications. Columbia University Press, New York, NY. 615 pp.

Gardner, R.H. and R.V. O'Neill. 1991. Pattern, process, and predictability: the use of neutral models for landscape analysis, pp. 289-307. In, Turner, M.G. and R.H. Gardner (eds.), Quantitative methods in landscape ecology. Springer-Verlag, New York, NY. 536 pp.

Kukulka, T. and D.A. Jay. 2003. Impacts of Columbia River discharge on salmonid habitat: 1. A nonstationary fluvial tide model. Journal of Geophysical Research 108:3293.

Parsley, M.J. and N.D. Popoff. 2004. Site fidelity, habitat associations, and behavior during dredging operations of white sturgeon at Three Tree Point in the Lower Columbia River. Final Report to U.S. Army Corps of Engineers, Portland District, Portland, Oregon. 146 pp.

Pearson, W.H., J.R. Skalski, K.L. Sobucinski, M.C. Miller, G.E. Johnson, G.D. Williams, J.A. Southard, and R.A. Buchanan. 2005. A study of stranding of juvenile salmon by ship wakes along the Lower Columbia River using a before-and-after design: Before phase results. Draft report to the U.S. Army Corps of Engineers, Portland, Oregon. 204 pp.

Platt, T. and K.L. Denman. 1975. Spectral analysis in ecology. Annual Review of Ecology and Systematics 6:189-210.

Ripley, B.D. 1981. Spatial statistics. John Wiley & Sons, New York. 252 pp.

Shugart, H.H., Jr. 1978. Time series and ecological processes. Society for Industrial and Applied Mathematics, Philadelphia, PA. 303 pp.

Appendix E

Combined Conditions

Columbia River Channel Improvement Project
Adaptive Environmental Management Plan

March 2006

E.1 Adaptive Management

The Adaptive Environmental Management Plan developed for the Columbia River Channel Improvement Project (CRCIP) was motivated in part by issues of concern to the states of Washington (Department of Ecology) and Oregon (Department of Environmental Quality, Department of Land Conservation and Development). The following tables outline the issues of concern and specify actions and conditions addressed by adaptive management in support of the Section 401 Water Quality Certification.

The first set of tables list the state's issues that should be addressed through adaptive management. The second set of tables list those issues that must be complied with in relation to the Section 401 Certification.

Table E.1. List of Oregon and Washington issues, concerns, and evaluation criteria to be addressed through adaptive management in relation to channel improvement.

COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT STATES' CONDITIONS evaluated through the adaptive management process; number in this document is not the same as the number in the decisions			
	WDOE	DEQ	DLCD
ADAPTIVE MANAGEMENT			
ADAPTIVE MANAGEMENT COMPOSITION	X	X	X
PROCESS	X	X	X
COORDINATE WITH FEDERAL AMT	X	X	X
FLOWLANE DISPOSAL			
WDOE B.6 The Corps shall monitor the flowlane disposal to assess at a minimum: changes in estuarine sedimentation and bathymetry and potential direct and indirect effects of disposal on estuarine species. The Corps shall also monitor the effects of flowlane disposal at CRM 5 and 27 - 42 to ensure that in-water disposal does not have adverse hydraulic affects. The Corps shall use the adaptive management process under Condition IV.A if monitoring demonstrates that flowlane disposal is adversely affecting estuarine species, or is creating an adverse hydraulic impact.	X		X
This condition will be monitored using the surveys collected for the NOAA Bi-op. Information will be provided to WDOE and brought to the State AMT.			
DEQ: Flowlane disposal within Oregon waters in areas deeper than 65 feet around River Mile 5 and between River Miles 27 and 42 is not allowed. The Corps shall not conduct flowlane disposal of materials from the construction of this project, or of subsequent maintenance materials from this project, in estuarine waters deeper than 65 feet until the results of ongoing sturgeon studies have been obtained, have been fully evaluated by the Adaptive Management Team, and a determination made as to whether these areas may be used.		X	
DLCD: (4) Flow-lane disposal shall be restricted as follows: a) Flow-lane disposal within Oregon waters in areas deeper than 65 ft. around Columbia River Mile 5 and between Columbia River Miles 27 to 42 is not authorized. The Corps shall not conduct flow-lane disposal of materials from the construction of this Project, or of subsequent maintenance materials from this Project, in estuarine waters deeper than 65 ft. until and unless an exception or change to the Clatsop County depth policy has been granted by the county.			X
b) Flow-lane disposal within Washington waters in areas deeper than 65 ft. between Columbia River Miles 27-42, 54-56, and 72-73 shall not be conducted unless it is carried out in accordance with applicable regulatory decisions of the State of Washington. Flow-lane disposal in this vicinity shall be modified or halted if monitoring or research findings indicate negative impacts to sturgeon, an Oregon coastal zone resource, through direct disposal impacts or long-term changes in bottom habitats. If such impacts are documented, modified flow-lane disposal shall be allowed only as determined through the adaptive management process specified in Condition I (1).		X	X
c) All flow-lane disposal shall be monitored to assess at a minimum: changes in estuarine sedimentation and bathymetry and potential direct and indirect effects of disposal on estuarine species.		X	X
This condition will be monitored using the surveys collected for the NOAA Bi-op. Information will be provided to the State AMT.			

Table E.1. List of Oregon and Washington issues, concerns, and evaluation criteria for consideration in adaptive management in relation to channel improvement. (Continued).

SALMONIDS			
WDOE: E. Salmonids: 1. To further avoid and minimize impacts to salmonids the Corps shall comply with the Best Management Practices, including timing windows, for dredging and disposal identified in the project Biological Assessment and referenced in the Biological Opinions issued by NOAA Fisheries and U.S. Fish and Wildlife for the project, and the Implementation Plan for the Biological Opinions, unless modified through the federal adaptive management process.	X		X
2.In the event that substantial, unauthorized deviations from the Best Management Practices occur during dredging and disposal operations, the Corps shall document the occurrence(s) along with the response and remedies implemented. This information shall be made available upon request and shall be shared through the adaptive management process.	X		X
3.The Corps shall provide Ecology/DLCD with all reports, meeting notices, monitoring and research data, management findings, and other similar information generated under the federal adaptive management process outlined in the project Biological Assessment, the Biological Opinions issued by NOAA Fisheries and U.S. Fish and Wildlife for the project, and the Implementation Plan for the Biological Opinions.	X		X
4.The Corps shall provide written notice to Ecology/DLCD at least 30 days prior to meetings, and workshop related to issues and actions coming before the federal adaptive management team so that it is possible for the state to provide meaningful input to the federal adaptive management process outlined in the project Biological Assessment, the Biological Opinions issued by NOAA Fisheries and U.S. Fish and Wildlife for the project, and the Implementation Plan for the Biological Opinions. In addition, the Corps will report and send documents to Ecology in a timely manner on all issues considered and actions taken through the federal adaptive management process.	X		X
FISH STRANDING			
WDOE: F. Fish Stranding: 1. The Corps shall mitigate effects of fish stranding through the following actions: a. Develop and implement a stranding study to be developed in conjunction with the adaptive management process specified in Condition IV.A, above.	X		
i. The study shall: (a) Include monitoring that encompasses the peak out migration period for all species of salmonids that are listed under the Federal Endangered Species Act; and	X		
(b) Include evaluation of physical parameters that influence ship wake stranding (e.g., water level, bank configuration, wave height, type, size, draft, and speed of vessel, etc); and	X		
(c) Substantially follow the seven study recommendations prepared by S.P. Cramer and Associates, Inc. (FSEIS Exhibit K-3, Effects of Vessel Wake Stranding of Juvenile Salmonids in the Lower Columbia River, 2002, - A Pilot Study September 26, 2002); and	X		
(d) Include goals, milestones for completion, check-in points, and triggers for management change, sampling/testing protocols and proposed mitigation measures.	X		
(e) Identify and implement mitigation measures designed to avoid, minimize, and reduce losses of fish life from ship wake stranding.	X		
b. Provide compensatory mitigation for all unavoidable losses of fish life that are attributed to this project. Mitigation shall be based on extrapolation from scientifically-credible fish stranding studies. Potential compensatory mitigation actions should include habitat restoration activities (e.g., large woody debris placement, channel improvements, riparian habitat restoration, etc.) in tributary streams designed to replace, through increased habitat capacity, those fish lost from ship wake stranding. Compensatory mitigation should take into account losses throughout the life of the project.	X		
REGIONAL SEDIMENT MANAGEMENT and SEDIMENT BUDGET			
DLCD: (iv) The Corps shall pursue a regional sediment management program that encompasses the Project as well as other Columbia River navigation projects. High priority will be given to development of near shore dredge disposal sites that can be shown to effectively contribute to the littoral sediment budget. When available for use, such near shore sites should be given priority over estuarine in-water disposal and deepwater ocean disposal as a way to minimize potential disposal impacts to coastal zone resources.			X
WDOE: G. Sediment Budget/Habitat: 1. The Corps shall develop a regional sediment management (RSM) program that encompasses the construction, operations and maintenance of this project as well as other Columbia River navigation projects. High priority shall be given to development of near shore dredge disposal sites that can be shown to effectively contribute to the littoral sediment budget. When available for use, the Corps shall fully integrate these near shore sites into this project over estuarine in-water disposal and deepwater ocean disposal as a way to minimize potential disposal impacts to water quality and coastal zone resources.	X		
2. Monitoring: a. The Corps shall implement a Monitoring Program that includes, at a minimum, the following tasks: i. Pre-construction bathymetry - Prior to project construction, a baseline estuary bathymetric (seafloor/riverbed) and topographic (inter-tidal beach/shoreline) survey shall be performed. These surveys shall meet or exceed the resolution (in terms of accuracy and data point density) of the 1958 and 1982 bathymetric surveys. The baseline survey shall cover the estuary from bank-to-bank from River Mile 3 to River Mile -40. Ecology recommends that the Corps collect multi-beam bathymetry at high tide and airborne topographic lidar at low tide to perform the surveys and adequately map the inter-tidal zones without data gaps.	X		
WDOE will notify COE by 2 July 04 if the bathymetric survey conducted satisfies this condition.			
ii Post-construction bathymetry - Within two (2) years after completion of construction, a bank-to-bank bathymetric survey from River Mile 3 to River Mile 18 of at least the same accuracy and one-half the data density of the baseline survey listed in Condition VI.A.1. shall be completed. A corresponding minimum of 10 bank-to-bank bathymetric survey transects shall be collected from River Mile 18 to River Mile 40 (spaced at approximately two (2) mile intervals).	X		
iii. Report - following completion of project construction in the estuary, a report shall be generated including the results of the bathymetric surveys, aerial photography, volumes of construction and maintenance dredging in the channel, and available information on river flow and sediment transport. These monitoring results shall be used to analyze the extent of the movement of marine sediments into the estuary. Should any unanticipated, negative impacts become evident, the Corps shall use the adaptive management program specified in Condition IV.A to determine an appropriate response.	X		
UPLAND DISPOSAL:			
DLCD: (3) The Corps shall monitor its use of upland disposal sites to ensure dredged material placement is within site boundaries such that estuarine aquatic areas are not converted to uplands. Monitoring shall be accomplished by comparing currently available information on site conditions with aerial photos taken periodically at the same tidal level and at a scale of 1:24,000 or larger. No measurable conversion of estuarine aquatic areas to upland is authorized under this decision.			X

Table E.1. List of Oregon and Washington issues, concerns, and evaluation criteria for consideration in adaptive management in relation to channel improvement. (Continued).

SMELT			
WDOE: D. Eulachon (Smelt): The following conditions shall be implemented by the Corps in order to mitigate adverse impact to Eulachon (smelt): 1. In-water (flowlane) disposal of dredged material shall not occur in areas shallower than 43 -feet between CRM 35 and CRM 75 along the Washington shoreline using the depths determined in the pre-construction bank –to-bank bathymetry supplemented by additional channel bathymetry to determine depth.	X		
2. In-water disposal shall not occur during the period of peak Eulachon out migration (between the 8th and 20th weeks of the year) downstream from the identified spawning areas (CRM 35 – CRM 75). If in-water disposal is essential during the period of peak out migration, then the Corps shall further study the potential for Eulachon losses as a result of dredged material disposal impacts. Appropriate mitigation measures shall be developed based on the study outcomes, as determined through the adaptive management process required under Condition IV.A.	X		
DLCD: c) Eulachon (Smelt): (i) No in-water disposal should occur during the period of peak eulachon out migration (between the 8th and 20th weeks of the year) downstream from identified spawning areas (river miles 35-75). If in-water disposal is essential during the period of peak out migration, then the Corps shall further study the potential for eulachon losses as a result of dredged material disposal impacts as determined through the adaptive management process required under Condition I (1). Appropriate mitigation measures shall be developed based on the study outcomes, as determined through the adaptive management process required under Condition I (1).		X	X
Sturgeon			
WDOE 3. The Corps shall use the table below to identify measures to ensure that no-net-loss of sturgeon and productive habitat results from disposal from this project:	X		

Potential Impacts	Responses
Direct Mortality 1) Immediate mortality of significant numbers of fish due to burial. 2) Delayed mortality of significant numbers of fish due to burial 3) Fish survive disposal action	1 & 2) Do not dispose in area or use additional sites in the future, and/or modify/schedule disposal to minimize impact. 3) No mitigation action.
Disturbance 1) Significant numbers of fish leave area permanently. 2) Significant numbers of fish leave area temporarily. 3) Fish do not leave area.	1) Do not dispose in area or additional sites in the future and/or modify/schedule disposal to minimize impact. 2) Schedule use of site for periods of low abundance. 3) No mitigation action.
Feeding Sturgeon feed in site: 1) Significant, long-term effects. 2) Minor, short-term effects. 3) Sturgeon not feeding in site.	1) Do not dispose in area or use additional sites in the future, and/or modify/schedule disposal to minimize impacts. 2) No mitigation action. 3) No mitigation action.
Loss of Habitat 1) Do not use habitat after disposal. 2) Return to area a short time after disposal. 3) Return to area a long time after disposal.	1) Do not dispose in area or use additional sites in the future, and/or modify/schedule disposal to minimize impact. 2) No mitigation action. 3) No mitigation action.

Sturgeon: (iv) The Corps shall continue to utilize the bi-state sturgeon work group to identify and carry out appropriate mitigation measures pending various sturgeon study outcomes.	X	X	X
The Corps shall adjust dredging and disposal operations as appropriate, and as indicated utilizing the adaptive management process specified under Condition I (1), if results of the on-going sturgeon telemetry studies indicate negative response in sturgeon behavior to dredging and disposal operations.	X	X	X
(vi) The Corps shall study the long-term response of sturgeon to habitat changes in deepwater habitat areas (>-50 ft. depth) generated or reasonably likely to be generated from planned flow-lane disposal.		X	X
The State AMT will review the findings of the Sturgeon research and decided upon next steps.			
ASSESS MONITORING DATA GENERATED UNDER MA-2, MA-3, MA-4, AND MA-5			
WDOE: In addition to the proposed assessment of monitoring data with respect to indicators for salmonids, the Corps shall to the maximum extent possible assess monitoring data generated under Corps monitoring actions MA-1, MA-2, MA-3, MA-4, and MA-5 with respect to potential, long-term effects of dredging and dredged material disposal on other beneficial uses, such as sturgeon, smelt, and Dungeness crab. Ecology/DLCD will be informed of such monitoring results or changes in monitoring recommended by the federal adaptive management team related to these monitoring actions. {The indicators listed in Term and Condition 4e are basic parameters that have relevance to issues broader than salmonid impacts.}	X		X
DLCD: e) Sediment Budget/Habitat: (iii) Bathymetric data collected by the Corps as part of project monitoring (Corps monitoring action #MA-3) shall be assessed for temporal and spatial bathymetric changes in the estuary region with respect to potential impacts on sediment budget and estuarine habitats. The cross-sectional and longitudinal coverage of the data collection shall be sufficient to allow for analysis of these potential impacts. The Corps shall report in writing on its findings at least once during construction and after completion of data collection in year 3 after construction. Should any unanticipated, negative impacts become evident, the adaptive management program specified in Condition I (1) will be used to determine an appropriate response.			X
This condition will be monitored using the surveys collected for the NOAA Bi-op. Information will be provided to WDOE and brought to the State AMT.			

Table E.1. List of Oregon and Washington issues, concerns, and evaluation criteria for consideration in adaptive management in relation to channel improvement. (Continued).

SEDIMENT SAMPLING AND DREDGING			
DEQ: Sampling of sediments throughout the entire depth of dredging and analysis for toxic and metal contaminants shall be conducted prior to dredging for those areas to be dredged outside the 600-foot wide federal navigation channel, including turning basins and berthing areas. Sampling and analysis shall be conducted in accordance with the Dredged Material Evaluation Framework (DMEF). Results shall be provided to the Adaptive Management Team (AMT) detailed below. Dredging and disposal of sediments from these areas shall be conducted in accordance with the directions of the AMT. Any such sampling and analysis shall be conducted such that the Adaptive Management Team receives the results not less than 30 calendar days prior to dredging ion the area sampled.		X	
Information to be provided to DEQ to develop additional sampling Plan			
Dredging of the Astoria turning basin shall occur during the standard in-water work window of November 1 through February 28 unless a waiver of the standard timing window is approved by DLCD after consultation with relevant agencies.		X	In Mandatory list
Sediments from within the Astoria turning basin shall be tested in accordance with the Dredged Material Evaluation Framework (DMEF) prior to dredging. Sediment testing results shall be provided to DLCD, DEQ, City of Astoria, and Port of Astoria prior to dredging. Any materials exceeding DMEF thresholds shall be disposed of at an upland site approved by DEQ and in accordance with any other applicable local, state, and federal requirements.		X	In Mandatory list
Information to be provided to DEQ .			
Dredged materials from the Astoria turning basin that are deemed suitable for in-water disposal shall not be disposed of in a location or manner that is contrary to the conditions of this concurrence decision.		X	In Mandatory list
OCEAN DISPOSAL			
DLCD: (2) Use of the "deepwater" ocean disposal site ("103" or "102") by the Corps shall be in compliance with the following CZM conditions regarding ocean disposal. These conditions are based on DLCD's previous responses to ocean disposal as found in the December 1, 1999 decision for channel deepening and April 4, 2002 decision for maintenance dredging at the river mouth:			X
(a) Any use of the "deepwater" ocean disposal site shall be limited to materials dredged as part of the channel deepening and subsequent maintenance of the lower Columbia River (i.e., up to river mile 30).			X
(e) The Corps shall continue with biological data collection for the "deepwater" site to confirm its expectations about biological impacts and to further establish scientific understanding of the ocean area to be impacted by dredged material disposal. The Corps shall provide at least 30 day written notice of opportunities for comment on matters that are related to data collection for the "deepwater" site. All data and summary reports shall be made available to DLCD within a reasonable amount of time, not to exceed 30 days, after completion.			X
(f) The Corps shall develop, in consultation with the State, a monitoring program that addresses potential physical and biological impacts associated with any use of a "deepwater" disposal site for the project. The monitoring program shall be implemented no later than 1 year after site use occurring in conjunction with the project.			X
(g) The Corps will coordinate with DLCD regarding site management and shall acknowledge the need for periodic re-evaluation of this coastal zone decision for ocean disposal. (DLCD previously determined that a one-time coastal zone consistency decision for long-term use of ocean disposal off the Columbia River cannot be made due to a lack of sufficient information to assess resource and use impacts over the 20 to 50 year timeframes referred to in Corps project documents.)			X
(h) The Corps shall implement procedures for coordinating ocean disposal work with fishermen and other mariners. The Corps should also compensate fishermen for gear losses resulting from interaction with Corps or contract dredges.			X
(i) The Corps shall condition dredging orders and contracts to ensure that it can adequately control the location and manner of dredged material placement and will receive the data necessary to determine when disposal site use criteria and response thresholds have been met. Copies of these conditions and all data generated in association with these conditions, including the geographic locations given to the dredges for disposal areas and the GPS coordinates of actual dumps performed by the dredges, shall be provided to the OCMP when available. Real-time sharing of information should continue as necessary as should the Corps preparation of a consolidated, yearly report including recommendations for the next year.			X
DUNGENESS CRAB			
WDOE: B. Dungeness Crab: 1. The Corps will conduct additional study of crab entrainment to assess seasonal variations and salinity influence on entrainment rates, and to assess differences among various class sizes (e.g. age O+, 1+, 2+).	X		
2. The Corps shall continue with its efforts to develop a crab distribution and salinity model and shall use the best available model as a management tool for scheduling dredging and disposal in the lower estuary to avoid and minimize entrainment and adverse effects of disposal.	X		
3. The Corps will develop and adhere to a crab mitigation strategy designed to avoid and minimize entrainment and burial of Dungeness crab. The strategy shall specify impact thresholds and compensatory mitigation contingencies for unavoidable impacts to Dungeness crab, and shall be developed through the adaptive management process specified in Condition IV.A., above.	X		
4. Hydraulic dredging at Desdemona Sands and Flavel Bar shall be conducted during times of least Dungeness crab abundance. To determine times of least abundance, entrainment sampling as described in "Entrainment of Crab in the Columbia River Estuary: June 2002 measurements and status of Summer 2002 measurements" (Pearson, Williams, and Skalski, September 5 2002) shall be conducted at each site each time those locations are dredged using USACE equipment, for a minimum of 5 years or to the extent necessary to gather sufficient data. The resulting crab entrainment data, along with real-time flow and salinity data shall be utilized to develop a model to predict times of least abundance.	X		
5. Flowlane disposal of sediment in areas supporting populations of Dungeness crab shall be limited to times of least crab abundance as determined by the model in condition B.2. The crab unavoidably buried by flowlane disposal shall be calculated. By conducting maintenance dredging during low abundance periods, sufficient avoidance of Dungeness crab shall be accomplished to mitigate those unavoidably lost.	X		
DLCD: a) Dungeness Crab: (v) The Corps will conduct additional study of crab entrainment to assess seasonal variations and salinity influence on entrainment rates, and to assess differences among various class sizes (e.g. age O+, 1+, 2+).		X	X
(vi) The Corps shall continue with its efforts to develop a crab distribution and salinity model and shall use the best available model as a management tool for scheduling dredging and disposal in the lower estuary to avoid and minimize entrainment and adverse effects of disposal.		X	X
(vii) The Corps will develop and adhere to a crab mitigation strategy designed to avoid and minimize entrainment of Dungeness crab. The strategy shall specify impact thresholds and compensatory mitigation contingencies for unavoidable impacts to Dungeness crab, and shall be developed through the adaptive management process specified in Condition I (1), above.		X	X
(viii) Hydraulic dredging and flow-lane disposal occurring below river mile 17 and in known or suspected areas of overall high crab abundance, shall be conducted during seasons or river conditions of least crab abundance. The seasons or river conditions of least abundance shall be determined through entrainment sampling at dredging sites correlated with real-time flow and salinity data or through application of a salinity-crab model once a final, scientifically rigorous model is available.		X	X
UPDATE THE CORPS DREDGED MATERIAL MANAGEMENT PLAN EVERY 5 YEAR			
DLCD: (8) After construction of the deepened channel has been completed and no later than the 5th year of Project maintenance, the Corps shall update its dredged material disposal plan. The Corps dredged material disposal plan will then be updated at least ever 5 years there after for the life of the Project unless DLCD and the Corps agree to an alternative schedule.			X
Disposal plan updates shall cover: disposal site use to date in terms of volumes placed and locations used, verification that disposal of dredged material has occurred within site boundaries and in accordance with the conditions of this concurrence decision remaining disposal site practices, estimated disposal volumes for the upcoming 5-year interval, any relevant monitoring and research data regarding disposal impacts to estuarine habitats and species, and changes in disposal plans resulting from the federal or state adaptive management processes.			X
WELCH ISLAND AND MILLER SANDS			
DLCD: (9) The Welch Is. and Miller Sands disposal sites shall be addressed as follows: Welch Is. may not be used as sites for disposal of dredged material as a result of this Project until Clatsop County has completed the update of the Columbia River Dredged Material Management Plan (CRDMMP) to designate the site as an upland disposal site. Miller Sands shall not be utilized as a result of the Project beyond the footprint of the currently designated site until Clatsop County has completed the update of the CRDMMP to fully designate the site as an upland disposal site.			X

Table E.1. List of Oregon and Washington issues, concerns, and evaluation criteria for consideration in adaptive management in relation to channel improvement. (Continued).

COORDINATION AND REPORTING:			
DLCD: (vi) Progress on planned studies, monitoring, and other project-related data collection shall be discussed within the adaptive management process specified in Condition I (1). The Corps shall provide at least 30-day notice of opportunities to comment on proposed actions. Final study results and data shall be assessed by the Corps for any implications with respect to entrainment impacts, disposal impacts, potential use of timing windows for maintenance dredging & disposal affecting sturgeon and Dungeness crab, effects of any salinity changes on Dungeness crab, and other potential impacts to estuarine habitats and species.			X
(vii The Corps shall explain in writing to DLCD the significance of any new information developed or discovered in these efforts for potential project effects on estuarine species and habitats. All data and summary reports shall be made available to DLCD within a reasonable amount of time, not to exceed 30 days, after completion.			X
(2) The Corps shall provide copies of final dredge contracts and orders to DLCD upon request. Copies shall be provided in a reasonable amount of time (not to exceed 30 days) after receipt of the DLCD request			X
DLCD: (5) The Corps shall develop and implement a communication and coordination program focused on avoiding and minimizing conflicts between dredging and disposal operations and in-river commercial and recreational fishing. A copy of the communication and coordination program shall be provided to DLCD for its review, prior to construction of the Project.			X
DLCD: (6) The Corps shall obtain a final §401 water quality certification for the proposed project from the Oregon Department of Environmental Quality (DEQ). The Corps shall comply with any conditions placed on the §401 certification. The Corps shall not proceed with any part of the proposed project that requires §401 certification prior to receipt of a final certification from DEQ, including project maintenance after year 3.			X
DLCD: (10) The Corps shall submit a supplemental consistency determination for activities encompassed within the Project that are, or are planned to be, modified in a manner such that the potential effect of the modified action on coastal uses or resources will be substantially different than those effects considered by DLCD in this 2002-2003 review of the Project. Substantially different coastal zone effects are reasonably foreseeable if: The Corps makes a substantial change in a proposed activity that is relevant to the policies of Oregon's coastal management program; or there are significant new circumstances or information relevant to the proposed activity and the proposed activity's effect on any coastal use or resource.			X
DLCD reserves the right to require a supplemental consistency determination if, after consultation with the Corps, we determine that major modifications are proposed that could have substantially different coastal zone effects.			X
(11) The Corps shall keep DLCD informed of the initiation of and outcomes of other state and federal regulatory reviews for channel maintenance actions. The Corps shall specifically address any implications of these reviews and associated regulatory decisions in terms of the anticipated coastal zone effects of the project or the Corps compliance with this decision.			X
(12) In the event that any condition of this concurrence decision is found to be invalid by a court or agency with jurisdiction to review this concurrence decision, the concurrence decision is revoked when the order of such court or agency becomes final and any pertinent appeal periods have ended.			X
(4) The Corps shall notify DLCD and Clatsop County in writing if and when it determines that the long-term phase of the Tenasillahe Is. restoration project will proceed. Additional coordination with DLCD and Clatsop County may be required prior to implementation of long-term phase to ensure long-term functions and values of shoreland habitats are maintained or enhanced.			X
MEET ANNUALLY			
DLCD: (7) The Corps and DLCD shall meet annually to review implementation of the Project and the status of compliance with the conditions of the CZM decision. The agencies may mutually agree to an alternative meeting schedule.			X

E.2 Mandatory Conditions

The previously tabulated issues will be addressed within the context of the CRCIP Adaptive Management Plan. The following conditions are presented mainly as compliance issues for the Section 401 Certification.

Table E.2. Oregon and Washington compliance issues in relation to channel improvement.

COLUMBIA RIVER CHANNEL IMPROVEMENT PROJECT STATES' CONDITIONS			
	WDOE	DEQ	DLCD
MANDATORY CONDITIONS			
Dredging			
Timing			
Dredging may be conducted year-round in the existing federal navigation channel. However, dredging in areas outside the 600-foot designated navigation channel including turning basins, berthing areas and any overwidth dredging outside the 600 foot channel must adhere to ODFW in-water work periods approved by state and federal fishery management agencies. These periods are described in: Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources.		X	
No obstruction or impediment to fish passage is to occur.		X	
Turbidity			
All dredging of sediments shall be conducted so as to minimize siltation and turbidity in the Columbia River. Turbidity shall not exceed 10 percent above natural stream turbidities, except where allowed by OAR 340-41-0205(2)(c). This rule states, in part, that limited duration activities necessary to accommodate essential dredging, and which cause the turbidity standard to be exceeded may be authorized provided all practical turbidity control techniques have been applied and a Section 401 water quality certificate has been granted.		X	
Turbidity shall be measured during in-water dredging and recorded at a minimum every two hours during periods of active dredging. The designated person attending the monitoring equipment shall be responsible for notifying the project foreman of any exceedance of the turbidity standard. Monitoring points shall be 100 feet upstream (representative background), 100 feet downstream, and at the discharge point. A turbidimeter is to be used. Recorded turbidity of greater than 10 percent at a point 100 feet below the discharge point is an exceedance of the standard. If a 10 percent exceedance of the background level occurs at 100 feet below the project site, the applicant is required to modify or stop the activity causing the problem and continue to monitor every two hours.		X	
Turbidity shall be measured during in-water dredging and recorded at a minimum every two hours during periods of active dredging. The designated person attending the monitoring equipment shall be responsible for immediately notifying the project foreman of any exceedance of the turbidity standard. Monitoring points shall be 100 feet up stream (representative of background), at the outer limit of the mixing zone and at the discharge point. A turbidimeter is to be used. If measurements taken at the outer limit of the mixing zone show (a) recorded turbidity is greater then 5 NTU over background where the background is less then 50 NTU, or, (b) if more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU, occurs at the outer limit of the mixing zone, the Corps is required to modify or stop the activity causing the problem and continue to monitor every two hours. The Corps cannot restart dredging operations until turbidity levels return to below background.	X		
Class A water quality standards for turbidity are waived within the specified mixing zones as outlined within specific conditions of this Order.	X		
Dissolved Oxygen			
During dredging activity in areas outside the bounds of the 600-foot wide navigation channel, including turning bays outside the 600-foot channel, side slopes of the channel, and the 100 foot overwidth dredging area, dissolved oxygen levels shall be measured and recorded at a minimum, every two hours, during periods of active dredging. If dissolved oxygen levels fall below 6.5 mg/l, the applicant is required to modify the activity and continue to monitor every two hours. If dissolved oxygen levels fall below 6.0 mg/l as an instantaneous concentration, work shall stop until dissolved oxygen levels return above 6.0 mg/l. The designated person attending the monitoring equipment shall be responsible for notifying the project foreman of any exceedance of the dissolved oxygen standard. Monitoring points shall be 100 feet downstream, and at the discharge point.		X	
Class A water quality standards for dissolved oxygen are waived within the specified dilution zones, provided that total dissolved oxygen levels are not caused to drop below 6.0 mg/L.	X		
Dissolved oxygen levels shall be measured and recorded at a minimum, every two hours, during periods of active dredging. If dissolved oxygen levels fall below 6.0 mg/l, the Corps is required to modify the activity and continue to monitor every two hours. If dissolved oxygen levels fall below 6.0 mg/l as an instantaneous concentration, work shall stop until dissolved oxygen levels return above 6.0 mg/l. The designated person attending the monitoring equipment shall be responsible for immediately notifying the project foreman of any exceedance of the dissolved oxygen standard. Monitoring points shall be 100 feet downstream, and at the discharge point.	X		
Clamshell Dredging:			
Dilution Zone: 150 feet radially and 600 feet downcurrent from the point of dredging.	X		
Each pass of a clamshell bucket shall be complete with no stockpiling done in the water. Dredged material shall not be stockpiled on a temporary or permanent basis below the ordinary high water line.	X		
Large debris picked up by a clamshell dredge shall be removed from the dredged sediments prior to disposal at flowlane disposal sites. Large debris includes old pilings or sinker logs [longer then three feet or greater than one foot in diameter], tree	X		
If a bucket dredge of any type, including but not limited to grab or clamshell, dipper, dragline, or backhoe bucket, is used, all digging passes of the bucket shall be completed without any material, once in the bucket, being returned to the wetted area. No dumping of partial or full buckets of material back into the project area will be allowed. No dredging of holes or sumps below maximum depth and subsequent redistribution of sediment by dredging, dragging, or other means will be allowed. All large man-made debris observed in dredged materials shall be removed prior to flow lane disposal and transported to an appropriate disposal site.		X	

Table E.2. Oregon and Washington compliance issues in relation to channel improvement. (Continued).

Best Management Practices			
Dredging operations shall be conducted employing Best Management Practices (BMP's) which minimize disturbance or siltation to adjacent habitat or waters.		X	
Dredging operations shall be conducted in a manner that minimizes the disturbance or siltation of adjacent waters and prevents the accidental discharge of petroleum products, chemicals or other toxic or deleterious substances into waters of the State.		X	
Hopper and Pipeline Dredging:			
Mixing Zone for Pipeline Dredging: 150 feet radially from the point of dredging	X		
Mixing Zone for Hopper Dredging with Bin Overflow: 300 feet radially and 900 feet downcurrent from the point of dredging.	X		
Hopper and pipeline dredges shall be operated with the intake at or below the surface of the sediments being removed during all periods of operation. Reverse purging of the intake line shall be held to an absolute minimum. Should purging be necessary,	X		
The dragheads on a hopper dredge shall be lowered to at least 20 feet below the surface of the river if water is pumped through the dragheads to flush out the hopper bins.	X		
In order to help control turbidity, hopper and pipeline dredges shall be operated with the intake head at or below the surface of the sediments being removed during all periods of operation. Reverse purging of the intake line shall be kept to an absolute minimum. Should purging be necessary, the intake line shall be raised no more than three feet from the bottom. If water is pumped through the dragheads to flush out the hopper dredge bins, the heads shall be at least 20 feet below the water surface.		X	
Spills			
Any discharge of oil, fuel, or chemicals into state waters, or onto land with a potential for entry into state waters, is prohibited.	X		
Fuel hoses, oil drums, oil or fuel transfer valves and fittings, etc., shall be checked regularly for drips or leaks, and shall be maintained and stored properly to prevent spills into state waters. Proper security shall be maintained to prevent vandalism.	X		
In the event of a discharge of oil, fuel, or chemicals into state waters, or onto land with a potential for entry into state waters, containment and cleanup efforts shall begin immediately and be completed as soon as possible, taking precedence over normal work. Cleanup shall include proper disposal of any spilled substances and used cleanup materials.	X		
Spills into state waters, spills onto land with a potential for entry into state waters, or other significant water quality impacts, shall be reported immediately to Ecology's Southwest Regional Office at (360) 407-6300 (a 24-hour phone number).	X		
Petroleum products, chemicals, or other deleterious waste materials shall not be allowed to enter waters of the State. All fuel hoses, oil drums, oil or fuel transfer valves and fittings, shall be checked regularly for drips or leaks, and shall be maintained in order to prevent spills into State waters. In the event of any discharge of oil, fuel, or other chemicals into State waters, or onto land with a potential to enter State waters, containment and cleanup shall begin immediately and be completed as soon as possible. Spills into State waters, or onto land with a potential to enter State waters, shall be reported immediately to the Oregon Emergency Response System, phone (800) 452-0311.		X	
Dredging by Others			
The conditions in this certification are binding upon the Corps and any agent or contractor that the Corps may retain to undertake any or all parts of this project.		X	
Dredging Astoria Turning Basin			
(1) Dredging of the Astoria turning basin shall occur during the standard in-water work window of November 1 through February 28 unless a waiver of the standard timing window is approved by DLCD after consultation with relevant agencies.		In AMT List	X
(2) Sediments from within the Astoria turning basin shall be tested in accordance with the Dredged Material Evaluation Framework (DMEF) prior to dredging. Sediment testing results shall be provided to DLCD, DEQ, City of Astoria, and Port of Astoria prior to dredging. Any materials exceeding DMEF thresholds shall be disposed of at an upland site approved by DEQ and in accordance with any other applicable local, state, and federal requirements.		In AMT List	X
(3) Dredged materials from the Astoria turning basin that are deemed suitable for in-water disposal shall not be disposed of in a location or manner that is contrary to the conditions of this concurrence decision.		In AMT List	X
(4) The Corps shall coordinate the final dredging and disposal plans, including the work schedule, for the Astoria turning basin with DLCD, DEQ, City of Astoria, and Port of Astoria prior to the work commencing.		In AMT List	X
Disposal			
Upland Disposal			
The following conditions are provided to protect outmigrating juvenile salmonid smolts.		X	
Upland disposal sites shall be large enough to accommodate the quantity of material and water to be placed there in order to allow adequate settling. Return water turbidity from any constructed cell or upland site shall not exceed 10 percent above the turbidity in the Columbia River immediately adjacent to the disposal site. If the disposal cells contain weirs, they shall be maintained at a height that allows no more than three inches of overflow water from the cell.		X	
Adequate settling time is to be allowed in the upland settling basins to ensure that turbidity levels in-river are maintained at or below the ten percent water quality standard.		X	
Use filter bags, sediment fences, silt curtains, leave strips or berms, or other measures sufficient to prevent movement of spoils. These measures shall be inspected and maintained daily to ensure their proper function.		X	
Mixing Zone [for Single-point Effluent Discharge]: 150 feet radially from the point of discharge and 600 feet downcurrent.	X		
The Corps shall maintain a 300-foot habitat buffer at all new upland dredged material disposal sites (e.g., Gateway 3, Fazio Bothers, Mt. Solo and Puget Island).	X		
CDF Design and Operation. The following "best management practices" pertain to the design and operation of a CDF:	X		
The CDF should be designed to provide the maximum practical degree of solids retention during operation, and for the entire life of the site.	X		
The outfall should be located so as to provide the maximum amount of dilution or dispersion of the effluent and to minimize any potential scour or erosion effects to more sensitive aquatic resources such as small tributaries and sloughs, shallow tide flats, and wetlands.	X		
To the greatest extent practicable, CDF sites shall be stabilized to prevent significant offsite erosion of the dredged material by either water or wind transport.	X		
The Corps shall monitor its use of upland disposal sites to ensure dredged material placement is within site boundaries such that estuarine aquatic areas are not converted to uplands. Monitoring shall be accomplished by comparing currently available information on site conditions with aerial photos taken periodically at the same tidal level and at a scale of 1:24,000 or larger. No measurable conversion of estuarine aquatic areas to upland is authorized under this decision.	X		

Table E.2. Oregon and Washington compliance issues in relation to channel improvement. (Continued).

In-River Disposal/Flowlane			
In-River disposal shall be conducted in accordance with the turbidity, dissolved oxygen and best management practices detailed above.		X	
Flowlane disposal within Oregon waters in areas deeper than 65 feet around River Mile 5 and between River Miles 27 and 42 is not allowed. The Corps shall not conduct flowlane disposal of materials from the construction of this project, or of subsequent maintenance materials from this project, in estuarine waters deeper than 65 feet until the results of ongoing sturgeon studies have been obtained, have been fully evaluated by the Adaptive Management Team, and a determination made as to whether these areas may be used.		X	
No in-river disposal is to occur between River Miles 35 and 75 during peak eulachon (smelt) outmigration downstream from the eulachon spawning areas.		X	
No bottom accumulation of sediments shall be allowed outside designated disposal or ecosystem restoration projects. The Corps shall ensure that sediments disposed in-river disperse in a uniformly thin layer.		X	
Mixing Zone [for disposal by hopper, bottom dump scow, or down spout]: 150 feet radially from the point of discharge and 900 feet downcurrent.	X		
Disposal of material shall be conducted in a manner that prevents mounding of the disposed material.	X		
Flowlane disposal by a hopper dredge or a bottom dump scow is approved provided the disposal sites are located: waterward of the minus 20-foot contour, Columbia River Datum (CRD) and	X		
to the greatest extent practicable, flowlane disposal sites shall be selected so that disposal material (i) disperses into or immediately adjacent to the mainstem navigational channel; (ii) is not likely to cause significantly increased shoaling in downstream side channels or to shoreline facilities such as docks, wharfs, vessel slips and marinas; and (iii) is not likely to cause a significant adverse alteration of bottom habitats critical to the life history of white sturgeon.	X		
Ecology will consider the use of alternative methods for flowlane disposal, such as a flat-topped barge unloaded by a small earth mover; however, the use of an alternative disposal method shall require special review and approval by Ecology under this Order prior to usage.	X		
Flowlane sites may be used for the disposal of sediments dredged by pipeline provided the dredged material is discharged through a downspout that is lowered at least 20 feet into the water column.	X		
The Corps shall monitor the flowlane disposal to assess at a minimum: changes in estuarine sedimentation and bathymetry and potential direct and indirect effects of disposal on estuarine species. The Corps shall also monitor the effects of flowlane disposal at CRM 5 and 27 - 42 to ensure that in-water disposal does not have adverse hydraulic affects. The Corps shall use the adaptive management process under Condition IV.A if monitoring demonstrates that flowlane disposal is adversely affecting estuarine species, or is creating an adverse hydraulic impact.	X		
Beach Nourishment			
Mixing Zone: 150 feet radially from the point of discharge and 900 feet downcurrent.	X		
Shoreline disposal operations, and particularly beach nourishment, may result in the placement of dredged material waterward of the ordinary high water mark. In such cases, the disposal site shall be regraded to an approximate slope of 10 to 15 percent, with no swales.	X		
Impacts to riparian vegetation at shoreline disposal sites shall be avoided or minimized whenever possible.	X		
Erosion control measures shall be carried out to prevent the wind erosion of dredged material back into the channel.	X		
Natural habitat features of Columbia River shorelines include large woody debris (LWD) such as trees, logs and stumps. Trees and logs are considered to be LWD if longer than 4 feet and greater than 12 inches in diameter. Whenever feasible, LWD shall be removed and set aside prior to the start of a shoreline disposal operation and then relocated on the shoreline or beach after the disposal area is regraded to a 9 to 1 slope or steeper. Consideration should be given to the placement of imported LWD to enhance habitat value and to help slow future erosion of the site.	X		
Ocean Disposal			
Use of the Deepwater site is limited to the disposal of construction and maintenance material from the lower Columbia River (i.e., up to CRM 30).	X		
At least 5 days prior to any use of the Deepwater site, the Corps shall notify Ecology in writing of its intent to use the Deepwater site.	X		
Use of the Deepwater site, whether designated under EPA's Ocean Dumping Act Section 102, 33 U.S.C. § 1412, authority or under the Corps Ocean Dumping Act Section 103, 33 U.S.C. § 1413, authority, the Corps shall implement the management and monitoring document currently proposed for the Section 102 site.	X		
The Corps shall not dispose of any materials deemed unsuitable for in-river disposal (i.e. contaminated materials) at the Deepwater site.	X		
Any disposal of materials within the Deepwater site shall be by repetitive, "pinpoint" dumping to minimize the footprint of the impacted disposal area.	X		
(1) DLCD shall be notified in writing of any use of the "deepwater" ocean disposal site, whether the current "103" site or a future "102" site, to occur in association with construction for channel deepening or maintenance of the deepened navigation channel.			X
(b) The Corps shall not dispose of any materials deemed unsuitable for in-river disposal (i.e., contaminated materials) at the "deepwater" ocean disposal site. Additional CZM review shall be required prior to disposal of any contaminated materials at the "deepwater" ocean disposal site.			X
(c) Use of "deepwater" ocean disposal for this project in no way removes the Corps responsibility to comply with coastal zone management conditions previously placed on ocean disposal associated with the maintenance project at the mouth of the Columbia River (MCR). (The Corps shall continue to give top priority to use of the shallow water, North Jetty, and Benson Beach sites for disposal of MCR materials with the deepwater site used only as a contingency site for disposal of MCR materials.)			X
(d) Any disposal of channel deepening materials (construction or maintenance) within the deepwater site shall be by repetitive, "pinpoint" dumping to minimize the footprint of the impacted disposal area.			X
(j) An ocean disposal taskforce or some alternative, comparable form of stakeholder involvement shall be used for discussion of the information requested above as well as other dredged material disposal issues potentially impacting on the MCR and channel deepening projects.			X

Table E.2. Oregon and Washington compliance issues in relation to channel improvement. (Continued).

Wildlife and Wetland Mitigation:			
General Conditions:			
The mitigation site(s) shall be constructed as described in the Columbia River Channel Improvement Project Final Supplemental Integrated Feasibility Report and Environmental Impact Statement - Exhibit K-5, dated January 2003, except as noted or otherwise conditioned within this Order. Any modification of the mitigation plan shall be determined through the adaptive management process required under Condition IV.A.	X		
The Corps shall submit a final mitigation plan to Ecology for review and approval at least 60 days prior to starting construction at the mitigation site(s). This plan shall include the proposed method of construction and an implementation plan for each site, including the goals, objectives of the mitigation, and performance standards for each element of the mitigation plan.	X		
The Corps shall meet the success criteria outlined within the mitigation plan.	X		
Dead or dying plants shall be replaced during the first available planting season with the same species or an agreed upon alternative.	X		
All plantings shall be watered and maintained, (including weeding), and replaced as needed, for a period of at least five (5) years after completion of the mitigation site.	X		
"As-Built" Report: an as-built report documenting the final design of the mitigation site(s) shall be prepared when the mitigation site is completed. The report shall include the following: final site topography; photographs of the area taken from established permanent reference points; a planting plan showing species, densities, sizes, and approximate locations of plants, as well as plant sources and the time of planting; habitat features (snags, large woody debris, etc) and their locations if any; drawings in the report shall clearly identify the boundaries of the project; locations of sampling and monitoring sites; and any changes to the plan that occurred during construction.	X		
The "As Built" report shall be sent to Ecology's Federal Permit Manager (Loree' Randall) within sixty 60 days of completing project construction and mitigation and in no case, later than December 31, 2006.	X		
The Corps shall monitor all mitigations sites for a period of 10 years after construction. Five monitoring events within that period; i.e., years 1, 3, 5, 7, and 10.	X		
Permanent deed restrictions shall be placed on the mitigation sites, in addition to title to the land.	X		
Specific Mitigation Site Conditions	X		
Martin Island:			
The Corps shall acquire Martin Island in its entirety for mitigation, including the 80 acres not identified as part of the final mitigation within the FSEIS.	X		
The 80 acres shall be incorporated into the mitigation plan as riparian forest development.	X		
This Order does not authorize the Corps to fill any part of the Martin Island embayment.	X		
The Corps shall plant dense shrubs or thorny plants along the shoreline of the Martin Bay embayment to discourage access to the island. Also the Corps shall post signs along the shorelines stating that the island is a Wildlife Restoration Project.	X		
Disposal of material excavated for regrading and reed canary grass and black berry removal shall be done at offsite, upland location, or in a manner that will not contribute to the spread of nuisance species. .	X		
Woodland Bottoms:			
The Corps shall construct the entire site as outlined within the FSEIS and final mitigation plan for this project	X		
Any modification of the mitigation site shall be reviewed and approved through the adaptive management process required under Condition IV.A.	X		
Purple Loosestrife Control:			
The Corps shall obtain all necessary authorizations from Ecology prior to any use of herbicides for purple loosestrife control.	X		
(5) The Corps shall coordinate with the DEQ and obtain any necessary state approval prior to initiating herbicide application as			X
Tidegate Restoration:			
Final plans and engineering specifications for the tidegate work shall be submitted to Ecology. In the event that the sponsoring ports take the responsibility for the tidegate work, they will need to obtain any additional state and local permits prior to initiating the work.	X		
General Conditions			
The certification is valid for five years from the date of issuance. DEQ assumes this will cover initial construction for two years and three years of maintenance dredging. Continuing maintenance dredging beyond the five year term of this certification will require separate certifications every five years, as in the past.		X	
DEQ reserves the right to modify, amend or revoke this certification, as necessary, in the event new information indicates that dredging/disposal activities are having a significant adverse impact on State water quality or critical fish resources.		X	
A copy of this certification letter shall be kept on the job site and be readily available for reference by the Corps, DEQ, contractors, and other appropriate state and local government inspectors.		X	
This certification is provided in respect to the project represented in the above letters of application. It remains valid for the dredging and disposal activities associated with the project as specified. The certification is invalid if the project is operated in a manner not consistent with the project description.		X	
Failure to comply with the conditions of this certification may lead to revocation of the certification.		X	
DEQ requires site access on day of request.		X	
The applicant shall notify DEQ of any change in the ownership, scope, or construction methods of the project subsequent to certification.		X	
This WQC shall remain in effect for a period of five (5) years from date of issuance. Continuing maintenance dredging beyond the five year term of this Order will require separate certifications every five years:	X		
Ecology reserves the option to reassess the terms of this Order and amend or revoke, as necessary, in the event that: new sources of potential contamination are discharged or otherwise stand to significantly affect the quality of sediments dredged from the lower Columbia River navigation channel, or new information indicates that dredging and/or disposal activities are having a significant adverse impact on water quality or characteristic uses of the lower Columbia River.	X		
(7) The Corps and DLCD shall meet annually to review implementation of the Project and the status of compliance with the conditions of the CZM decision. The agencies may mutually agree to an alternative meeting schedule.			X

Table E.2. Oregon and Washington compliance issues in relation to channel improvement. (Continued).

Emergency and/or Contingency Measures:			
If dredging/disposal operations are found not to be in compliance with the provisions of this order, or result in conditions causing distressed or dying fish, the operator shall immediately take the following actions: Cease operations. Assess the cause of the water quality problem and take appropriate measures to correct the problem and/or prevent further environmental damage. In the event of finding distressed or dying fish, the operator shall collect fish specimens and water samples in the affected area and, within the first hour of such conditions, make every effort to have the water samples analyzed for dissolved oxygen and total sulfides. Ecology may require such sampling and analyses before allowing the work to resume. Notify the Department of Ecology and the Department of Fish and Wildlife of the nature of the problem, any actions taken to correct the problem, and any proposed changes in operations to prevent further problems.	X		
Other Requirements:			
Copies of this Order shall be kept on the job site and readily available for reference by the Corps of Engineers, Ecology personnel, the contractor, and other appropriate state and local government inspectors.	X		
Ecology retains jurisdiction to make modifications hereto through supplemental order, if it appears necessary to protect the public interest during the construction and monitoring of this project.	X		
This certification does not exempt and is provisional upon compliance with other statutes and codes administered by federal, state, and local agencies.	X		
(8) After construction of the deepened channel has been completed and no later than the 5th year of Project maintenance, the Corps shall update its dredged material disposal plan. The Corps dredged material disposal plan will then be updated at least ever 5 years there after for the life of the Project unless DLCD and the Corps agree to an alternative schedule. Disposal plan updates shall cover: disposal site use to date in terms of volumes placed and locations used, verification that disposal of dredged material has occurred within site boundaries and in accordance with the conditions of this concurrence decision, remaining disposal site capacities, estimated disposal volumes for the upcoming 5-year interval, any relevant monitoring and research data regarding disposal impacts to estuarine habitats and species, and changes in disposal plans resulting from the federal or state adaptive management processes.			X
Reporting			
The Corps shall develop and maintain a publicly accessible web page upon which data collected as a result of the conditions in this certification relating to turbidity, dissolved oxygen and toxics shall be posted. Data shall be posted in as close to real-time as possible. The web page should be constructed similarly to the Corps' web page that reports hourly total dissolved gas and associated data from the various Columbia River hydropower projects.		X	
At the discretion of the Director, the Corps shall provide such reports to the Environmental Quality Commission, or such other forums as the Director shall determine appropriate, on the progress and execution of this project. The Director will provide adequate notice of such reports, which shall be not less than 30 days.		X	
The Portland District or their designated contractor shall notify Ecology at least 14 days prior to the scheduled start of dredging in any year. The Ecology person to contact is Loree' Randall at (360) 407-6068.	X		