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Deschutes Estuary Feasibility Study
Independent Technical Review

FINAL VERSION

Prepared for

Washington Department of Fish and Wildlife

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with

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1. INTRODUCTION

Capitol Lake was created in 1951 by damming a portion of the southern Budd Inlet. Since that time sedimentation and water quality issues have affected the management of the lake. Over the past 10 years there has been growing interest as to whether estuarine process can be restored to the lake.

A Deschutes Estuary Feasibility Study (DEFS) was initiated in 2003 to evaluate whether restoring tidal exchange to the lower Deschutes River is environmentally, economically and socially feasible alternative to maintaining Capitol Lake. Four broad, conceptual alternatives were proposed, all variants of dam removal. The purpose of DEFS was not to determine whether any of the estuarine restoration alternatives were preferable to a lake management alternative but to:

1. Clarify whether estuarine restoration is at all feasible; and, if so,
2. To support a subsequent, and more detailed, alternatives analysis involving refined lake management and estuary restoration design scenarios.

To analyze the environmental and socio-economic consequences of the DEFS alternatives four technical studies were commissioned by WDFW, on behalf of the Capitol Lake Adaptive Management Plan (CLAMP) Steering Committee, detailing:

1. Sediment Transport & Hydraulic Modeling
2. Reference Estuary Study & Biological Conditions
3. Engineering Design & Cost Estimate
4. Net Social and Economic Benefit Analysis

The PWA team has been commissioned to provide an independent technical review of these reports, with regards to whether they address the question: is it feasible to restore estuarine processes to Capitol Lake? The team's review provides an assessment of the scientific objectivity and technical merits of each report and provides a consensus review that integrates disciplines in the four reports. The PWA team has not been commissioned to review any of the prior reports, nor provide guidance on selection of a preferred DEFs alternative.

In September 2007 the ITR scope was extended to include responses to review by previous study contractors.

2. CONCLUSIONS

2.1 CAN ESTUARINE PROCESSES BE RESTORED TO CAPITOL LAKE?

The technical studies did not identify any factors that necessarily would preclude restoration of estuarine processes to Capitol Lake. Dam removal will result in re-establishment of estuarine hydrodynamics, mixing processes, and sediment transport processes typical of natural estuaries in Puget Sound. Estuarine habitats and ecologic processes will respond to these restored physical conditions. While the exact mosaic of restoring ecology will depend upon design selection there is no indication that the project will not establish ecologic benefits comparable with those provided by the range of ecological conditions found at nearby reference estuaries.

2.2 DO THE TECHNICAL STUDIES CLARIFY WHETHER ESTUARINE RESTORATION IS FEASIBLE?

To ascertain feasibility the impacts of a proposed project action need to be assessed against a prescribed set of metrics of acceptability. These metrics - environmental, socio-cultural, legal, financial, and economic - have yet to be determined.

2.3 DO THE TECHNICAL STUDIES SUPPORT A SUBSEQUENT, AND MORE DETAILED, ALTERNATIVES ANALYSIS INVOLVING REFINED LAKE MANAGEMENT AND ESTUARY RESTORATION DESIGN SCENARIOS?

Given there is clear indication that restoration of estuarine conditions to Capitol Lake is physically and ecologically possible it is reasonable to consider a full comparative assessment of alternatives that include restoration as well as continued lake management. Under a subsequent broader alternatives assessment these design alternatives should be refined further to optimize hydraulic, geomorphic, ecological and socio-economic benefits. Refinements to design alternatives should be based upon analysis of project goals and objectives as well as opportunities and constraints (see recommended next steps).

2.4 HAVE ANY FATAL FLAWS OR DATA GAPS BEEN IDENTIFIED THAT WOULD PRECLUDE ESTUARINE RESTORATION?

The reports have not identified fatal flaws but environmental and socio-economic information gaps have come to light that will likely require resolving during any further assessment.

3. ITR TEAM QUALIFICATIONS

Philip Williams, Ph.D. PE, Project Director, has been engaged in a wide range of national and international hydrologic and engineering hydraulics investigations since he received his PhD in 1970. In 1976, after working in civil engineering and environmental planning firms, he opened his own practice, expanding to form Philip Williams & Associates in 1979. During the past three decades, he has developed considerable expertise in a wide range of technical and water-related policy issues both in the U.S. and abroad. From his original research field of sediment hydraulics, Phil has pioneered practical technical analyses in wetland hydrology, multi-objective river corridor management, lake water balances, the impacts of climate change, the hydraulics of coastal lagoons, and estuarine management. He has supervised over 300 studies related to the management and restoration of estuaries, including numerous feasibility assessments.

Steve Crooks, Ph.D., Project Manager, is a coastal geomorphologist and wetland scientist with specialized knowledge of estuarine and tidal systems. In the 11 years since his Ph.D. in coastal geomorphology Steve has coordinated or contributed to numerous studies on estuarine restoration as well as the integration of physical and socio-economic approaches for coastal management planning. For PWA, Steve coordinates the geomorphic modeling and design of tidally-influenced systems and undertakes research within interdisciplinary teams to develop scientific understanding to guide estuary restoration.

Bob Battalio, PE, **engineering design and cost estimate specialist**, is a civil engineer and PWA's Practice Director who was previously the principal in charge of the Coastal and Design Groups. Bob has extensive experience with flood management, restoration design, coastal engineering, preparation of construction documents, and project management. He has directed all phases of waterfront and restoration civil works, including field data collection, conceptual design, preliminary design/feasibility analysis, final design/construction documents, and construction management. He has led numerous, multi-discipline engineering studies focused on alternative evaluations, feasibility and preliminary design.

Matt Brennan, Ph.D., numerical modeling specialist, is a water resources engineer specializing in the application of tidal hydraulics to coastal restoration and management. His expertise in numerical modeling includes assessment of flow and sediment dynamics as well as prediction of project impacts. The numerical models that Matt is experienced with include DELFT3D, TRIM, and EFDC. He has applied numerical models to predict geomorphic change in response to industrial salt pond restoration and estuarine morphological response to modified tidal dynamics.

Ernie Niemi, senior economist, is Vice President of ECONorthwest. Ernie has managed over 200 projects in natural-resource management and economic development since 1978. He specializes in applying the principles of cost-benefit analysis to the problems of economic valuation and decision-making. Ernie has managed and participated in numerous water-management projects and is familiar with the economic impacts of resource policies on various classes of stakeholders. Ernie has worked on most of ECO’s natural-resource projects, throughout the western U.S, including preparation of the economic element of a programmatic environmental impact statement for Washington's new Columbia River Water Management Plan, and evaluating the feasibility of establishing riparian forests to meet water-quality standards for temperature in the Chehalis River.

Cleve Steward, fisheries scientist, has over 25 years experience in the fisheries management field and has undertaken numerous projects for federal and state agencies, Indian tribes, universities, private firms, and environmental groups from throughout the region. He is frequently solicited to provide expert opinion and help resolve conflicts involving fisheries and aquatic resources, including surface water management, watershed impacts, salmon hatchery impacts, salmon smolt passage survival and behavior, and monitoring and evaluation techniques. As a member of the NOAA-appointed Willamette-Lower Columbia River Technical Recovery Team, Cleve has conducted population viability and limiting factors analyses for six ESA-listed salmonid species that traverse the lower Columbia River estuary. Cleve will be supported by several other Steward & Associates biologists with extensive experience investigating estuarine environments in the Pacific Northwest.

Kirk Steinhorst, PhD. statistician, has taught multivariate analysis for over 20 years and has provided statistical consulting services to university and non-university researchers since 1966. A number of those projects have involved multivariate analysis. The bulk of his statistical consulting experience is in the natural resources area, but as a general statistics consultant he also has worked with researchers in agriculture, biology, business, engineering, hydrology, and education. He has numerous refereed publications that used multivariate methods for analysis.

4. ITR REVIEW METHODOLOGY

4.1 ITR GOALS

The goal set of the ITR is to provide a credible evaluation of the scientific objectivity and technical merits of each of the four technical reports, and to assess confidence limits on their results and the level of uncertainty inherent in their predictions of change under various management approaches.

4.2 DEVELOPING A COMMON UNDERSTANDING

This review approach is guided by the ITR team's understanding of the planning steps necessary to take an environmental restoration concept to a successful engineering action.

Determining whether estuarine restoration is feasible is the establishment of clear terminology and a common understanding of central concepts:

> *Estuarine restoration* may be defined as: actions taken in a converted or degraded natural estuary that will result in the re-establishment of hydrologic, geomorphic and ecological processes, functions and biotic / abiotic linkages and lead to a persistent, resilient system integrated within its landscape. [based upon SWS concept of wetland restoration: SWS, 2000]
>
> *Feasibility* may be defined as proposed action will achieve desired benefits within the limits of acceptable costs.

4.3 REVIEW APPROACH

The approach to the technical review is broken down in to five major tasks:

1. Establish with WDFW a set of questions / criteria against which the reports will be evaluated (milestone: an agreed assessment structure).
2. Individual study technical review by experts with parallel experience (milestone: individual peer-review level technical memoranda; Appendix A).
3. Response to technical review by study contractors (not included in report).
4. Conference of ITR members to provide a consensus review that cuts across disciplines (Milestone: summary in main body of this report).
5. Presentation to the CLAMP Steering Committee.

4.4 QUESTIONS TO ASK?

To develop a credible evaluation of the scientific objectivity and technical merits of the studies the following series of questions were identified in discussions with the WDFW:

1. Where the right questions asked of the Contractor?
2. Did the contractor answer those questions?
3. Were the approaches used by the contractor appropriate to answer those questions?
4. Have "Standards of Practice" analytical tools been used effectively?
5. Is the quality and completeness of documentation and reporting satisfactory?
6. How significant are uncertainties in data and analysis in supporting report conclusions?
7. Can significant uncertainties or errors in the reports be rectified easily?
8. Do the data and/or literature used support the conclusions reached by the contractors?

The management approach adopted by DEFS towards assessing feasibility of restoring estuarine conditions to the lower Deschutes River has been to contract a number of technical studies, including the four technical studies reviewed within this document. Each of these studies was conducted by independent contractors, with later studies incorporating the outputs from earlier studies. No contractor was tasked with providing a fully integrated feasibility report.

As such the task of determining the information requirements expected from a particular technical study does not lie with the contractor but with the coordinating agency. It is the task of the contractor to understand the information needs of the client and to work with the client to develop a work program that balances information provided within the funds available.

Whether the right question was asked of the contractor is the key question to ask in this review. This question help to determine if the approaches adopted in the technical study are appropriate to answer the needs of the broader study or were defined by specific questions asked by the client. The remaining questions provide a technical assessment of the approach to address the information request.

5. REVIEW SCOPE

The ITR review is confined to the four reports listed below. These documents represent a significant component but not the full compliment of the DEFS study. A number of documents have not been reviewed by the ITR, including those related to flood and scour assessments. Beyond this review are additional assessment related to sediment and water quality that have recently been initiated.

Technical reports:

- **George, D. A., G. Gelfenbaum, G. Lesser, and A. W. Stevens. 2006.** Deschutes Estuary Feasibility Study: Hydrodynamics and Sediment Transport Modeling. U.S. Geological Survey Open File Report 2006-1318.
- **Garono, R.J., Thompson, E., and M. Koehler, Earth Design Consultants, Inc. 2006**. *Deschutes River Estuary Restoration Study: Biological Conditions Report.* Submitted to Thurston Regional Planning Council: Olympia, WA.
- **Moffatt & Nichol Engineers, EDAW, Inc., GeoEngineers. 2007** *Engineering Design and Cost Estimates, Final Report, Deschutes Estuary Feasibility Study, Phase 3*, Prepared for Washington Department of Fish and Wildlife.
- **Cascade Economics LLC, Northern Economics, Inc., and Spatial Informatics Group LLC. 2007.** *Deschutes Estuary Feasibility Study: Net Social and Economic Benefit Analysis Final Report.* Prepared for Capitol Lake Adaptive Management Plan Steering Committee and Washington Department of Fish and Wildlife

Additional information provided:

- Summary leaflet: *Background Information: Deschutes Estuary Restoration Study.* DRERS – Background Information 17 February 2007.
- Deschutes Estuary Feasibility Study Restoration Criteria. DRERS (date unknown)[1].
- Request for Proposals: Reference Study & Biological Conditions Report for the Deschutes River Estuary Restoration Study. Thurston Regional Planning Council (TRPC), March 14 2005.
- Scope of work: Hydraulics and Sediment Transport Analysis – Phase II for the Deschutes River Estuary Restoration Study
- Deschutes Estuary Feasibility Study Phase III, Request for Proposals: Engineering Cost Estimates. State of Washington, March 31 2005.

[1] ITR was informed by the WDFW that the Restoration Criteria presented in this document are not as yet adopted by the CLAMP and should not form the basis of the ITR assessment (5/10/07).

- Request for Proposal: Deschutes Estuary Feasibility Study: Net Social and Economics Benefits Analysis. State of Washington, RFP No. 06-0008. June 13 2006.

6. SYNTHESIS

Detailed peer-review level assessment of the technical studies is provided in Appendix A. This section outlines the synthesis of findings.

6.1 OUTCOME OF TECHNICAL STUDIES

The technical studies did not identify any significant impediments to restoring estuarine conditions in the lower Deschutes estuary. However there are two caveats to this statement.

1. A number of uncertainties exist, which may not be reconcilable with the information in hand: i) further refinement to estimates of the volume of sedimentation in downstream dredged channels post estuarine restoration; and ii) socio-economic implications of potential restoration alternatives. The level of sensitivity to these uncertainties should be determined before deciding whether to invest in further scientific study, to address using engineering approaches as part of the design or to manage post construction.
2. The technical studies cover the full range of analysis required to provide for a full feasibility assessment.

6.1.1 Sediment Transport & Hydraulic Modeling

The modeling report provides insight in to the behavior of tidal waters and sediment should estuarine restoration occur. Fill tidal circulation and reinitiating of the seaward movement of trapped sediment will result under all the proposed alternatives. By simply opening the system to tidal exchange will result in the re-establishment of predominantly mudflat and channel habitat. Over time, a quantity of sediment scoured from the former lake bed will be deposited down estuary in dredged channels and upon existing mudflats. It is difficult to quantify with certainty the volume of sediment that will be mobilized, nor the time it will take to erode.

6.1.2 Reference Estuary Study & Biological Conditions

With reestablishment of tidal circulation intertidal habitats in the Lower Deschutes River will be restored. Should the dam be removed without active 'grading' of the accumulated sediment topography, then the majority of the restored habitat will consist of intertidal mudflats and channels. While the technical study did not predict the exact ecology of the restoring estuary it is likely that the types of habitat restored will be similar in nature to those of nearby less disturbed estuaries.

6.1.3 Engineering Design and Cost Estimates

This study determined that there are no significant technological constraints to prevent restoration of tidal conditions to the Deschutes River estuary. It will not be until the planning opportunities and constraints have been fully assessed will the selection of the most appropriate design to reduce sedimentation in the dredged channel down estuary be possible. An engineer's estimate of costs is provided, based upon one possible design approach including a range of costs based upon a range of parameters.

6.1.4 Net Social and Economic Benefits Analysis

Placing an economic value on the environmental change is a challenging task. This study met with considerable information gaps that resulted in large uncertainties in the assessment of project benefits. Such a study outcome is a common occurrence when the requirements of an economic assessment are not directly incorporated in to the planning of deliverables from scientific and engineering assessments studies. Nevertheless, by undertaking this pilot study at an early stage of the planning processes a number of information needs have been identified who's future assessment will improve understanding of project socio-economic costs and benefits.

6.2 LEVELS OF CERTAINTY

The technical studies have achieved different levels of certainty in defining the specific outcome of estuarine restoration. Higher degrees of certainty are found within the hydraulic and sediment transport assessment, and the engineering cost estimates. Lesser degrees of certainty associated with quantifying ecological outcome and defining socio-economic consequences of estuarine restoration. While restoration of estuarine conditions appears physically and biologically broadly feasible the socio-economic net benefits remain unclear at this stage.

Table 1. A Qualitative Summary Of Confidence In Study Results

	Confidence in General Outcome	Confidence in Accuracy of Predictions	Potential for Surprises
Tidal exchange	High	High	Low
Sediment transport	High	Medium	Medium
Estuarine ecology	High	Medium	Low
Engineers estimates	High	Medium	Medium
Socio-economic net benefit	Low	Low	High

6.3 CONTRIBUTION TO THE PLANNING PROCESS

The technical studies contracted by the CLAMP supporting agencies are a positive step in a planning process to assess the preferred management alternative for the Lower Deschutes River. In this planning context the four technical studies represent a contribution to a pre-feasibility or scoping level assessment. The reviewed technical studies in themselves do not represent a full feasibility analysis but provide a firm basis for a decision to move forward or not along the planning processes.

The stages in the planning processes to assess future management of Capitol Lake/ Deschutes Estuary may be summarized as:

1. Scoping studies to evaluation environmental, economic and social *potential* for estuary restoration at Capitol Lake/ Deschutes estuary.
2. Independent Technical Review (this stage).
3. Identify project opportunities and constraints
4. Refinement of restoration alternatives (including lake management)
5. Alternatives assessment (comparison of lake management alternative[s] with estuary management alternative[s])
6. Preliminary design and permitting
7. Final design and construction

The next stage in the planning process will be the establishment of an explicit set of opportunities and constraints, based upon information gathered form these technical studies, and other studies ongoing or to be commissioned. Based upon the opportunities and constraints design criteria should be established to guide the further refinement of restoration alternative and so improve the potential that the project outcome will be successful. For example, an opportunity might be identified to use dredging for the beneficial reuse of sediment to restore a portion of the estuary to high intertidal habitat (salt marsh), which at the same time alleviates or reduces the constraint of sedimentation in down estuary channels.

6.3.1 Potential Opportunities (incomplete list)

1. Reestablish full tidal circulation
2. Improve water quality
3. Restore estuarine habitat
4. Use soft-engineering approaches to accelerate restoration of or establish preferred mix of tidal habitats
5. Reduce flood risk due to river flow
6. Minimize need to dredge lake
7. Gain of estuary recreational amenity

6.3.2 Potential Constraints (incomplete list)

1. Increased sedimentation in downstream dredged channel
2. Increased risk of flooding due to sea level rise (not part of these studies – to be determined)
3. Mobilization of contaminated sediments (if exist)
4. Configuration of existing infrastructure
5. loss of existing lake recreational amenity
6. Available budget

6.4 IDENTIFIED INFORMATION GAPS

A number of information gaps have been identified:

- Definition of the lake management alternative (baseline conditions)
- Defined restoration opportunities and constraints
- Economic consequences of altered patterns of sedimentation particularly related to marinas and dredge maintained channels
- Sediment quality within Capitol Lake
- Projected change in water quality under revised alternatives
- An analysis of flood potential will need to be accomplished for the selected alternative to confirm that flooding is not worsened. Flood assessment should incorporate projections for sea level rise.
- A geomorphic perspective to guide restoration alternatives

7. RECOMMENDATIONS

7.1 DEVELOP A COMMON PROJECT UNDERSTANDING

In order to address whether estuarine restoration is feasible requires a common understanding of central concepts:

> *Estuarine restoration* may be defined as: actions taken in a converted or degraded natural estuary that will result in the re-establishment of hydrologic, geomorphic and ecological processes, functions and biotic / abiotic linkages and lead to a persistent, resilient system integrated within its landscape. [based upon SWS concept of wetland restoration[2]]
>
> *Feasible* means a proposed action will achieve desired benefits within the limits of acceptable costs.

7.2 PLANNING AND STUDY EXPECTATION

We recommend careful use of terminology. 'Feasibility study' and 'net benefits analysis' are terms of specific technical reference and applying such technical terms sets expectations of a particular product or a process. Technical studies should document the scope of their analysis and describe expectations of their report.

7.3 PLACE TECHNICAL INFORMATION WITHIN A PLANNING CONTEXT

The following planning steps are suggested to aid a subsequent alternatives assessment:

- Set project goals and objectives
- Identify opportunities and constraints
- Define evaluation criteria
- Develop a conceptual model of restored estuarine system evolution and functioning
- Fill data gaps
- Refine alternatives, including business as usual (the lake management alternative)
- Forecast future conditions
- Comprehensively document preferred alternative and decision process.

[2] http://www.sws.org/documents/positionpapers/restoration.pdf

7.4 INTEGRATED INFORMATION TRANSFER THROUGHOUT TECHNICAL STUDIES

Information transfer across technical studies is necessary to provide a comprehensive feasibility assessment. It is recommended that information supply and needs be agreed prior to initiation of the feasibility analysis (for example, determine from the economists their information needs from the physical and biological assessments prior to initiation). Confirm that spatial and temporal scale of analysis is comparable across studies. Include provision for information refinement feedback loops as study progresses.

7.5 DEFINE BASELINE CONDITIONS

At the time the technical studies were initiated the Lake Management Alternative baseline condition was not defined. This information will be required should a more full alternative analysis be undertaken.

7.6 REFINE ALTERNATIVES

The alternatives developed so far are appropriate for a scoping level assessment of restoration potential. Moving forward, these alternatives should be refined further to balance opportunities for restoration against constraints to meet selected restoration objectives.

8. LIST OF PREPARERS

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9. APPENDIX A
DETAILED REVIEW OF TECHNICAL STUDIES

A-1.
Sediment Transport & Hydraulic Modeling

Reviewed Study:

George, D. A., G. Gelfenbaum, G. Lesser, and A. W. Stevens. 2006. Deschutes Estuary Feasibility Study: Hydrodynamics and Sediment Transport Modeling. U.S. Geological Survey Open File Report 2006-1318.

Were the right questions asked of the contractors in the RFP?

The RFP for hydrodynamic & sediment modeling was not provided to ITR team. In its absence, the Scope of Work (SOW) and the modeling task questions presented in the introduction of *Deschutes Estuary Feasibility Study: Hydrodynamics and Sediment Transport Modeling* (George et al, 2006)[3] are evaluated instead.

The SOW defines the contractors' proposed actions but only has a brief, general discussion of the task's objectives. As such, it is difficult to evaluate the questions asked of the contractors from this document. The modeling report presents a set of modeling task questions which were developed in conjunction with the CLAMP Technical Advisory Committee (Box 1.2, p. 1-4). These questions span most aspects of the physical systems that will be altered by restoration, including velocity, water level, salinity, and sediment response. As such, answering these questions will provide a good deal of insight into the physical processes that will exist in a restored estuary and the evolution of the restored estuary with time.

Although these questions are well formulated from a technical standpoint, from a wider perspective, they are too narrowly focused on the physical regime. While this is useful for assessing the physical components of estuarine restoration, the questions could go further, particularly since the other tasks rely on model output for their subsequent analysis. We recommend that the questions could have been rephrased to place the modeling task more directly in context of the larger feasibility study. For example, in comparing existing and restoration scenarios, the following questions could be asked:

- How will the form of the estuary evolve over time?
- Will the form of the estuary attain a long-term steady state or continue to evolve?
- Which type of hydrodynamic events control long term morphology – events near the annual mean or events with a return interval of a decade or more?
- How do water levels and velocities during average and extreme events compare?

[3] Hereafter, this document will be referred to as the 'modeling report' and any page, figure or other references refer to this document unless noted otherwise.

- What will be the resulting distribution of key geomorphic units, as defined by elevation relative to tidal datum?
- How does salinity vary seasonally through the estuary?
- What is the probability that the actual conditions will match the expected range of predicted conditions?

One technical question which is not included in the modeling report's list of questions is the impact of restoration on water quality. The increased circulation resulting from restoration is likely to improve water quality for some constituents, e.g. dissolved oxygen and nutrients. However, the re-mobilization of large volumes of sediment under restoration scenarios may create water quality concerns.

The questions do not establish a consistent baseline condition against which to compare model results. This makes it more difficult to assess restoration feasibility in context.

The questions outlined in the modeling report do not explicitly address the handling of model uncertainty. Rather, they call for only 'expected ranges'. This level of description only provides a rudimentary perspective on the model uncertainty. We suggest phrasing the questions to refine the definition of 'expected ranges' by assigning probabilities to these ranges.

Did the contractors answer those questions?

The contractors conducted modeling and analysis that successfully answers the questions posed in the modeling report regarding the expected ranges for velocity, water levels, salinity, and sediment transport.

Were the approaches used by the contractors appropriate to answer those questions?

Overall, the general approach shows excellent understanding of physical processes governing the system. At a strategic level, this understanding is manifested in the manner in which the contractors structure both these processes and the model runs in a hierarchy that balances model performance with project questions. After defining this structure, the contractors expertly modeled the system using a state-of-the-art model for hydrodynamics and sediment transport.

However, the contractor's approach consisted of only process-based, analytic modeling. While this approach enables predictions of short-term morphologic change, these models do not always capture the full scope of processes which ultimately determine the long-term morphology of a system (EMPHASYS Consortium, 2000). Because process-based models adopt a 'bottom-up' approach by modeling small-scale interactions to predicting large-scale change, they are susceptible to accumulating errors, may exacerbate or fail to incorporate nonlinearities, and require extensive computational resources.

Geomorphic approaches can complement process-based modeling (HR Wallingford et al, 2006). These semi-empirical models adopt a 'top-down' approach by applying general principals that are augmented with observations from a range of estuaries. As such, they are not subject to the same set of potential pitfalls of process-based models. The predictions based on geomorphic concepts provide bounds on the long-term morphologic regime against which process-based model predictions can be referenced. It is now common practice to deploy a combined or hybrid bottom-up and top-down approach to refine assessment of geomorphic change, thereby providing a cross check on model outputs and interpretation.

Have 'standard of practice' analytical tools been used effectively?

The contractors deploy both hydrodynamic modeling of flow and process-based morphological modeling of sediment transport. Hydrodynamic modeling is a widely utilized and peer-reviewed process with established 'standards of practice'. The contractors have met those standards.

Morphological modeling is an emerging research tool that has been deployed in only a few coastal settings. As such 'standards of practices' are not yet widely established for morphological modeling. The contractors are amongst the leaders in the research of morphological model development for assessment of coastal sediment transport, and are familiar with techniques that will likely establish standards of practice. The modeling report demonstrates a high level of expertise by the contractors in applying these analytic tools for assessing sediment transport. This expertise instills confidence in the overall quality of the report. However, as noted above, a useful tool that is missing from the contractors' analytic toolbox is a geomorphic approach.

To facilitate the application of the modeling results for an assessment of overall feasibility study and to facilitate the transfer of the modeling results to other tasks in the study, we suggest the following refinements. Some of these refinements are similar to the limitations described by the contractors in Chapter 4.

Sensitivity Analysis

1. Sensitivity analysis was only conducted formally for two types of parameters, vertical resolution and erodibility (Chapter 2, pp. 2-13 to 2-16). An elaboration on why sensitivity analysis was limited to these two parameters would be informative.
2. A critical variable for estimating sediment transport is the bed shear stress generated by the flow. However, the modeling report does not discuss the impact of the Chezy friction coefficient on bed shear stress. A constant, typical Chezy coefficient was employed in the modeling. Sensitivity of morphologic response to this parameter should be evaluated in conjunction with sediment erodibility.
3. Sensitivity analysis results are reported in Chapter 2 for different erodibility rates and a lower and higher erodibility level are identified. However, the long-term model simulations are conducted with a mixed set of sediment parameters that was not analyzed in the sensitivity analysis. The lower erodibility values are used with a lower sediment density of 500 kg/m^3. The significance of this parameter set should be discussed.

4. Results are not presented for ten years of morphologic change for the higher level of sediment erodibility. Since this higher level of erodibility was previously identified in the sensitivity analysis as an upper bound on the expected range of sediment parameters, the model results for this parameter set should be presented or at least the justification for excluding them discussed.

Model Boundary and Initial Conditions

1. Extreme events can play a significant role in morphological change, particularly since sediment transport scales exponentially with current velocity. The maximum velocities of 5 m/s predicted for the 100-yr flood event, which are more than three times larger than the maximum velocity predicted during the long-term morphological runs, indicate the potential for morphologic change during extreme events. Over a given ten year period, the probability of at least one occurrence of an extreme event is not insignificant, e.g. 65% for the 10-year flood, 18% for the 50-yr flood and 9.6% for the 100-yr flood. Since these probabilities are not trivial, their effect on morphologic change should be assessed.
2. The sediment supplied by the river during each year of the long-term morphological modeling is approximately the annual average of 25,200 m^3/yr. The corresponding fresh water discharge of a characteristic year exceeds the average, as it include multiple storms with a return interval greater than one year. Since the discharge regime is above average while the sediment discharge is only average, the riverine boundary condition probably overestimates the riverine scour relative to the sediment supply. This impact is probably most significant in the South Basin where morphology is most likely to be river dominated. In the other portions of the system, tidal fluctuations under restored conditions probably play the dominant role in morphologic change, so the influence of the riverine boundary condition will be less important.
3. Pre-dam simulations were conducted with no initial bed sediment distribution. This makes a comparison of sediment transport between pre-dam and restored conditions incongruent. The bed sediment distribution predicted by the model after 10 years restoration could provide a first order approximation for the pre-dam bed sediment distribution.

Analysis of Model Output

1. A comparison between flood modeling conducted for this study and existing FEMA flood modeling of the system would serve two purposes. A comparison of the model runs between existing conditions would provide a means of model verification and a comparison between restoration scenarios would highlight changes in flood conditions relative to existing conditions.

2. Model results for the change in bed elevation after three years for the high erodibility conditions (Figure 3.37) predict changes in bed elevation approaching 1 m in Percival Cove. This is close to the cove's depth, suggesting the possibility of a significant loss of open water available for recreation boating in the cove. Since flow and sediment discharge from Percival Creek is not included in the model, actual sedimentation rates in the cove may be differ from that predicted by the model.
3. The connection between hydrology and biology can be facilitated by using hydrologic results to characterize the habitat extent. Habitat regimes can be identified by either the annual inundation fraction already calculated or by bed elevation relative to tidal datums. Once identified, the spatial area of each habitat extent can be tabulated and compared for the pre-dam condition and the restoration scenarios at different instances in the future. The sensitivity of these habitat areas to morphologic predictions could also be assessed.
4. A more extensive comparison against the pre-dam model predictions would clarify how closely the restored estuary will approach the physical conditions of the predicted historic estuary. Currently, this comparison is limited to text descriptions in Chapter 4 and one figure, Figure 4.10. As an example, the pre-dam sediment fluxes, e.g. Table 3.2, could be included in Figures 4.3-5 and Figure 4.9 to provide a context for the sediment fluxes under restoration relative to the pre-dam estuary. (See suggestion above regarding a proposed initial condition for pre-dam bed sediment distribution.)
5. A comparison against current conditions would place impacts in context. For example, how do the predicted port and marina sedimentation rates under restoration compare with current observed rates?

Is the quality and completeness of documentation and reporting satisfactory?

In general, the modeling effort is well documented with clear text and extensive figures.
A few sections of the report that could include more detail are:

1. The naming convention ('5-yr+ flood', '2-yr flood', etc.) of the five river discharge classes used in for river schematization is ambiguous, particularly since the corresponding discharge values do not agree with Figure 2.6. We suggest clarifying how the discharge rates associated with these labels are derived and using available hydrograph data to assign a specific return interval these discharge rates.
2. Clarification of the boundary conditions used for multiyear modeling. No explanation is provided for choice of a 14 day period to represent a year. Also, the only mention of how the year-long boundary conditions are expanded into multi-year boundary condition is in a figure caption (Figure 2.7).

3. The captions on tables in Appendix B do not adequately describe data within the tables. Turning to the main body of report, the text describing the appendix states that the tables consist "of annual mean and maximum erosion/deposition and volume change" (p. 4-4). However, the volume change appears to be cumulative, not the annual average. Also, it would be helpful to define the sign convention for the mean erosion/deposition column – it appears that positive values indicate deposition.

How significant are uncertainties in data and analysis in supporting report conclusions?

The model results and analysis demonstrate that under expected conditions, a restored estuary will create functional hydrodynamic and sediment transport. The most significant uncertainty is whether the actual morphologic changes would be similar to those predicted by model. It is unlikely that morphologic uncertainty will alter the principal finding that a physically functional estuary can be restored. The morphologic uncertainty can be further quantified (see Question 7 below), but not entirely eliminated. Although the impact of morphologic uncertainty is unlikely to alter the principal finding, this uncertainty propagates to create significant uncertainty in more specific questions, such as dredging requirements, scour at bridges, water quality, and habitat extent.

Can significant uncertainties or errors in the reports be rectified easily?

Many of the suggestions noted above for refining the modeling effort do not require extensive effort. However, these suggestions alone will not eliminate uncertainty in morphologic predictions. The processes behind morphologic change are inherently complex and resist accurate prediction. Conducting a geomorphic assessment of the likely conditions under restoration further bounds the likely response of the system.

Do the data and /or literature used support the conclusions of reached by the contractors?

The data produced by the modeling effort support the conclusions about the expected hydrodynamic and sedimentary conditions resulting from estuarine restoration. To further support and interpret their conclusions, we recommend an additional effort at quantifying the uncertainty associated with the report's conclusions.

The conclusion that 'a dynamic equilibrium is reached within the first three to five years after dam removal' (p. 3-11) may underestimate the time scale at which the restored estuary approaches equilibrium. As shown in Figure 4.9, the rate of volumetric change in the estuary's sub-basins has not flattened completely even after ten years, particularly for the port, the marina and the South Basin.

References

EMPHASYS Consortium. 2000. Modeling Estuary Morphology and Process. Report TR 111. Prepared for MAFF Project FD1401.

George, D. A., G. Gelfenbaum, G. Lesser, and A. W. Stevens. 2006. Deschutes Estuary Feasibility Study: Hydrodynamics and Sediment Transport Modeling. U.S. Geological Survey Open File Report 2006-1318.

HR Wallingford, ABPmer, and J. Pethick. 2006. Review and Formalisation of Geomorphological Concepts and Approaches for Estuaries. Report No. FD2116/TR2. Prepared for the Defra and Environment Agency Joint Modelling and Risk Theme.

A-2.
Reference Estuary Study and Biological Conditions

Reviewed study:

Garono, R.J., Thompson, E., and M. Koehler, Earth Design Consultants, Inc. 2006. *Deschutes River Estuary Restoration Study: Biological Conditions Report*. Submitted to Thurston Regional Planning Council: Olympia, WA. 126 p.

<u>Were the right questions asked of the contractors in the RFP?</u>

The original Request for Proposals (RFP) distributed by the Thurston Regional Planning Council asked the overarching question, "[can] an estuarine community, with diverse populations of plants and other organisms…be reestablished in southern Budd Inlet?" The RFP included a scope of work that outlined specific tasks and methods to address this question. Implied within the scope of work is that the relationship between the physical parameters of a habitat and the type of biological community that becomes established is both quantifiable and predictable. In general terms, the sequence of tasks in the RFP follows a logical path and is consistent with ecological and statistical theory.

The RFP expressed intent to "predict the location and extent of estuarine community types…through time," although it was likely beyond the scope of the Reference Estuary Study to address issues such as community succession. More thorough investigation of the estuary restoration option may warrant a more detailed forecasting of biological communities over time – especially considering the scale of the initial disturbance and the potential for biological communities to shape the physical attributes of the habitat around them and thus create a feedback loop that would result in a departure from the anticipated scenario. The USGS Hydraulic and Sediment Transport model is apparently capable of generating trajectories of the physical parameters over time, but succession and stochastic biological processes were determined to be outside the scope of this study.

In light of information made available after this work was conducted, we feel a question that should be asked is, "are the anticipated contaminant loads of sediment in a restored Deschutes River estuary conducive to the regeneration of natural biological communities and to public health?" Removing the 5th Street dam has the potential to release toxic compounds in the Capitol Lake sediment and in the benthos below the Port of Olympia. Contaminants such as dioxins, which have been found in sediment around the Port, and may be present in the lake sediment, are known to bioaccumulate and pose a substantial risk to organisms that feed at high trophic levels. Restoration feasibility cannot be determined until appropriate assessments of this threat have been completed.

Did the contractors answer those questions?

The contractors concluded that removal of the dam and restoration of tidal influence to the Deschutes River estuary would likely result in the establishment of biological communities similar to those found in the reference estuaries. These types included primarily mud flats with sandy channels, and some high marsh around the periphery. This conclusion was based on field observations and review of published literature, not on the results from discriminant analysis as outlined in the RFP. In fact, the statistical analysis performed in the Reference Estuary Study failed to establish a relationship between biological community types and the associated physical parameters primarily as a result of misinterpreting statistical techniques and thus using inappropriate methods. Details of the statistical errors are discussed in following sections.

The Biological Conditions Report was included in the discussion (Chapter 4) and provide sufficient context for uncertainties and constraints that may affect restoration. Extensive review of the literature is incorporated into each of the requested sections (i.e. land use, water management, climate change, disturbance and recruitment, etc.). We felt the possible contamination of sediments should have been included in the discussion, but admit that no evidence suggesting this concern was available at the time. The RFP was not explicit in the level of detail desired for the Biological Conditions Report, but since these potential constraints involve a high degree of uncertainty, it would be difficult to address these concerns in a more quantitative, methodical way.

Were the approaches used by the contractors appropriate to answer those questions?

We evaluated the approaches and methods used in Reference Estuary Study and Biological Conditions Report for consistency, logic, and sufficiency by comparing them with methods established by experts (Simenstad et al. 1989, Kramer et al. 1994). Several concerns arose regarding the sampling plan, which likely stem from limitation of funds. This affected the discriminant analysis. These concerns are described below.

The RFP was explicit in asking for community types; however the Reference Estuary Study only considered algae and macrophyte cover. We feel that benthic infauna should have also been included as part of the sampled biological community. Invertebrate shells were collected, but species presence was included only in an appendix, not in the analysis. This oversight is especially disconcerting considering that the primary habitat expected in a restored Deschutes River estuary, and the type most commonly sampled was intertidal mudflats, where very few macrophytes exist (see more detail on sampling below). While it was likely difficult to sample motile biota within the time constraints of this study, it should be noted that bacteria, phytoplankton, zooplankton, fish species, avifauna, and various mammals' species are all important to consider when assessing and describing community types. This type of information might have been useful for describing what is possible within the restored estuarine habitat site.

The sampling plan did not include enough of the different community types to adequately describe the differences in physical and biological parameters. Also, our review of other estuarine habitat studies revealed procedures that the contractor could have employed to improve their results. For example, Simenstad et al. (1989) and Kramer et al. (1994) recommend that sampling locations be considered in relation to salinity regimes, in addition to the parameters measured by the contractors. In the study, sample locations were chosen across various elevation, sediment and vegetation types, but there was no explicit indication that they coordinated with varying salinity levels within the reference estuaries (ranging from the mouth of creeks out towards marine waters).

Thorough characterization of an estuary requires sampling various parameters more than once a year (Simenstad et al. 1989, Kramer et al. 1994). Undoubtedly the contractor was constrained by time and budget but we suggest that any further investigation of estuary restoration consider changes over various time scales. The reference estuaries were only sampled once in August or September of 2005. The physical characteristics that were chosen for the study may vary in relation to factors such as seasonal variation in light and temperature, freshwater flow periods, tidal cycles, and various other processes (Kramer et al. 1994).

Another concern in the study was that the estuaries selected as references were much smaller freshwater/estuarine systems than the Deschutes River watershed. The freshwater input and circulation in this area could have important ecological impacts that discourage meaningful comparisons. This was addressed by the contractors (p. 3) and was determined to be beyond the scope of the study.

Have "Standard of Practice" analytical tools been used effectively?

Aside from minor differences with preferred methods (Simenstad et al. 1989) the contractor collected and processed field and laboratory samples in a logical and consistent way. The contractor used typical methods such as quadrats for vegetation coverage and coring cylinders for sediments. In some cases, recommended techniques may have slightly improved the results, for instance, by using quadrats of smaller areas (from 0.1 m2 to 0.25 m2 depending on the vegetation type) and using biomass, or dry weights, and densities per unit area for quantifying vegetation. Sediment sampling followed well documented protocols.

Is the quality and completeness of documentation and reporting satisfactory?

The quality and completeness of the documentation and technical information provided by the contractor was satisfactory in that it provided a descriptive overview of southern Puget Sound estuaries, the physical parameters that influence their biological structure, the methods and results that comprise the reference study, explanations for their conclusions and obvious discrepancies in outcomes. Key uncertainties and factors affecting restoration outcomes were addressed and suggestions for future work were proposed. Sources and literature cited were relevant, using research that had been conducted regionally and that had been peer-reviewed. In assessment of this study, references listed were verified. There are extensive numbers of resources available, and due to potential budget and time constraints, we assumed that all accessible documents and research was utilized.

How significant are uncertainties in data and analysis in supporting report conclusions?

The degree of certainty of the final conclusion presented in the Reference Estuary Study and Biological Conditions Report is discussed below in the final section of this memorandum. Regarding specifically the statistical analysis, significant uncertainty was apparent in the results, and more importantly in the methods themselves. We identified what we believe are the reasons for this uncertainty and describe them here.

We interpret the tasks 3-7 in the RFP as expressing a desire to develop a method for taking physical/environmental variables and predicting what community type is likely to be reestablished at any point in what is now Capitol Lake. The requirements listed in tasks 4 and 5 ask for sampling to be from the community types: emergent marsh, tidal channel, mudflat, sandflat, and gravel-cobbles. While it is true that each of these community types was sampled, the sampling was not designed in such a way that one could hope to characterize these community types. As described in the report, each estuary was divided into 2 or 3 large areas. Then 6 to 9 samples were taken "haphazardly" within each area. It would have been an accident if sufficient samples had been taken from each coarse community type to allow a characterization to be made. The preferred method would have been for the researchers to map the estuaries into the coarse community types and then to sample each as described in the RFP Scope of Work.

The sampling locations overlaid on the orthophotographs from the sites (figures 7a through 7e) indicate that most of the samples were not taken in areas with a lot of algae and macrophytes. This is also seen in the vegetation data matrix. Tallying the presence/absence of 11 vegetation variables contained in the "Deschutes_Reference_Table" that was provided to us for this review, one gets mostly zero cover for all cover types in the 90 samples except algae which occurred in 58 of 90 quadrats (see Table 1). It is not surprising that the multivariate analysis failed to find relationships between the mostly zero algae and macrophyte data and the bins defined using physical variables.

Table 2. Tabulation of Presence-absence of Algae and Macrophytes on Quadrats

Cover Type	Number of samples in which cover type was present (out of 90 total samples)
"Algae"	58
"Carex"	6
"Distichi"	8
"Atriplex"	5
"Salicorn"	5
"Puccinel"	2
"Juncus"	3
"Potentil"	3
"Jaumea"	2
"Trigloca"	2
"Zanniche"	1

Another major source of uncertainty and general confusion is the apparent reversal of the multivariate variables. In the report, habitat bins were formed using PCA and cluster analysis of physical and environmental variables. Discriminant analysis was then performed using these bins as the classification variable and percent plant cover as the continuous predictor variables. The result (if it had succeeded) would be a set of discriminant functions useful for taking a vector of plant covers and predicting what physical/environmental bin is likely to be found with that combination of plants, which was not the stated goal outlined in the RFP.

The contractor states that the study, "aims to develop discriminant functions for each of the different habitat bins. These discriminant functions can then be used to predict the plant and algal cover types for different elevation, sediment, and salinity combinations that may exist throughout Capitol Lake under each of the restoration scenarios," (p. 48). Unfortunately, the multivariate analysis they conducted cannot accomplish the stated goal because the roles of dependent and independent variables were reversed. They intended to predict algal and macrophyte cover type from physical and environmental variables. What they did was try to predict physical environment from algal and macrophyte data. In their discriminant analysis, the dependent (predictor or Y) variables were plant cover and the independent (classification or X) variable was physical and environmental bin.

Since the goal was to predict the plant and algal cover types from elevation, sediment, and salinity, then the classification (or X) variable should have been plant and algal community types and the continuous predictor (or Y) variables should have been elevation, sediment, and salinity. The role of physical/environmental variables and plant and algal variables was reversed.

Can significant uncertainties or errors in the reports be rectified easily?

While the reversal of variables represents a substantial error, it may have been possible to correct and re-run the discriminant analysis, had the original sampling been done correctly. However, based on our understanding of the sampling scheme, we believe the data collected were not suitable to achieve the RFP objectives even if the multivariate analysis had been properly conducted. Because the report interpreted "community types" as plant and algal community types rather than the classifications specified in the RFP (emergent marsh, tidal channel, mudflat, sandflat, and gravel-cobbles), the analysis would not have addressed the goals stated in the RFP even if the variables had not been reversed in the multivariate analysis. To collect the needed data, one would first have to map community types (defined more broadly than vegetation types) and then randomly sample elevation, sediment, salinity, and other variables within these community types. Such data would then become "training" data for predicting community type that would likely occur given elevation, sediment characteristics, salinity, etc. This analysis could still be conducted if, by chance, sufficient physical/environmental data happens to have been taken in the various community types of interest, but it is not clear from the sampling design that that is the case.

Do the data and/or literature used support the conclusions reached by the contractors?

The contractor concluded that the range of physical conditions (habitat) predicted for the restored Deschutes Estuary would be similar to the reference sites of Mud Bay and Kennedy Creek. Therefore the biological communities that form would also be similar to these reference sites. This conclusion was based on literature review and basic comparisons of the reference estuaries and the results of the hydraulic and sediment transport (USGS) DELFT 3D model. It was not based on the methods outlined in the RFP. Results from the discriminant analysis were inconclusive, primarily due to incorrectly applied methods, but also due to inadequate sampling. While the ultimate conclusions are not necessarily incorrect, they are not supported by the data and analysis in the way that the client expected. The ability to restore tidal exchange to a previously impounded ecosystem is a feasible project that is reflected in studies around the country (Roman et al. 1995, and Zajac and Whitlatch 2001, for example). The specific approach and methodology in establishing an effective reference study and the ability to predict the ensuing biological conditions needs to be carefully reviewed and given an appropriate amount of time to conduct a thorough investigation.

References

Garono, R.J., Thompson, E., and M. Koehler, Earth Design Consultants, Inc. 2006. *Deschutes River Estuary Restoration Study: Biological Conditions Report*. Submitted to Thurston Regional Planning Council: Olympia, WA. 126 p.

Kramer, K.J.M., Brockmann, U.H., and R.M. Warwick. 1994. *Tidal Estuaries: Manual of Sampling and Analytical Procedures.* Published for the European Commission. A.A. Balkema, Rotterdam, Netherlands. 304 p.

Roman, C.T., Garvine, R.W., and J.W. Portnoy. 1995. Hydrologic modeling as a predictive basis for ecological restoration of salt marshes. Environmental Management. 19(4): 559-566.

Simenstad, C.A., Tanner, C.D. and R.M. Thom. 1989. *Estuarine Habitat Assessment Protocol*. Prepared for United States Environmental Protection Agency Region 10, Office of Puget Sound. Wetland Ecosystem Team, Fisheries Research Institute, University of Washington: Seattle, WA. 201 p.

Zajac, R.N. and R.B. Whitlatch. 2001. Response of macrobenthic communities to restoration efforts in a New England estuary. Estuaries. 24(2): 167-183.

A-3.
Engineering Design and Cost Estimating

The review consisted of reading the following documents:

- Moffatt & Nichol Engineers, EDAW, Inc., GeoEngineers, *Engineering Design and Cost Estimates, Final Report, Deshutes Estuary Feasibility Study, Phase 3*, Prepared for Washington Department of Fish and Wildlife, February 9, 2007. (REPORT)
- Washington Department of Fish and Wildlife, Deshutes Estuary Feasibility Study Phase III Request for Proposal, (Appendices not included), undated. (RFP)
- Moffatt & Nichol Engineers, Deschutes Estuary Feasibility Study – Independent Technical Review, Letter to Curtis Tanner, Washington Department of Fish & Wildlife, October 3, 2007. (RESPONSES)
- Deschutes Estuary Feasibility Study Restoration Criteria. DRERS (date unknown).

The review was accomplished at a "high-level" and was not detailed in terms of checking calculations or unit costs.

<u>Were the right questions asked of the contractors?</u>

The RFP is ambiguous. It states

"2. On the basis of Phase II studies and in cooperation with CLAMP, ***analyze the three alternatives to determine that they are complete and that they meet restoration criteria****. Phase II studies have largely been theoretical and require engineering analysis to determine whether these alternatives are practical and achievable."*

These two sentences appear to ask two questions:

1. Will the project be successful in terms of achieving restoration criteria ?, and,
2. Can the project be constructed and implemented within a reasonable budget ?

The Report answers the second question as stated in the RFP: " *On the basis of Phase II studies…. "* which were done by others. This means that the engineering assessment (Report) is relying on other studies (e.g. modeling, scour, flooding) and any misconceptions, etc. in these studies are embedded in the engineering assessment, affecting its accuracy and precision.

The Report does not answer the first question directly. However, the REPORT may have provided adequate information for the CLAMP, in their judgment, to determine the answer to this question.
Whether the project will meet restoration objectives is a complex question that requires more than engineering expertise to answer. A geomorphic analysis resulting in a description of site evolution, including ecologic characteristics, is apparently missing. A geomorphic analysis would provide a project description adequate to allow the engineer to identify worst case conditions (whether just after construction, during evolution or at the future, equilibrium condition) and associated design criteria. These design criteria could be used to size the facilities, identify construction and maintenance actions, and identify key uncertainties and associated monitoring and adaptive management actions and their costs. Additional information was provided by RESPONSES:

"….*In the DEFS, the State decided early on to analyze the evolution of the restored estuary using primarily bottom-up morphodynamic tools rather than top-down geomorphic tools. We believe this was the correct decision. Had the plan been to restore the Deschutes Estuary to an entirely natural state, the decision could have been different. However, the Deschutes Estuary will remain a highly modified and managed system. The 500-foot bridge span is determined by existing infrastructure, and is smaller than the original unmodified tidal entrance – although it is large enough to allow unmuted tidal flow. Deschutes Parkway, the railroad bridge, and the I-5 Bridge all constrain the evolution of the estuary…*"

This information is useful in terms of clarifying why the recommended analysis was not conducted. It does not provide sufficient information to review and comment on the decisions alluded to or their basis.

Did the contractors answer those questions?

The Report provides a sound assessment of engineering feasibility and costs, presuming that prior studies by others are accurate and the project description is correct, as explained above.

Were the approaches used by the contractors appropriate to answer those questions?

Yes, the Report adequately addresses the engineering feasibility and cost question, based on the project description and basis provided by others.

Have 'standard of practice' analytical tools been used effectively?

Yes, the Report is complete in the detailed assessment of construction cost and schedule uncertainty.

Is the quality and completeness of documentation and reporting satisfactory?

Yes, with the following exceptions:

The Report does not address the significance of the assumptions made in key areas such as site evolution, flooding, scour, water quality, as described in the next section.

The following items could be improved, but are not required for satisfactory reporting:

- Construction Methods do not include consideration of floating equipment for slope stabilization elements. However, the REPONSES indicate that floating equipment was considered and the ranges of costs are adequate as is.
- The Report is not signed and stamped by a Professional Civil Engineer. RESPONSES indicate that this can be accomplished.
- The treatments of storm and sanitary waste outfalls are not described in sufficient detail to assess whether project feasibility and costs are affected. However, the RESPONSES state that the storm water outfalls are not a significant project element and sanitary outfalls do not exist. This implies that utility constraints have been considered adequately to assess feasibility.

How significant are uncertainties in data and analysis in supporting report conclusions?

There are major uncertainties that could affect the Report conclusions. The apparent uncertainties are:

1. Site Evolution: The Report relies on the Modeling studies to identify the site conditions following restoration (the cited source is USGS, 2006). The Report implies that the site will reach equilibrium within about 3 years following restoration and in Figure 5 shows the channel scouring down to about -11 to -12 feet NGVD. This elevation is only about 4' below Mean Lower Low Water (MLLW). The assumptions that the site will reach equilibrium in 3 years, that the channel thalweg will not scour below -4' MLLW, and that a model study can predict any of this with accuracy are all dubious. Long term scour is addressed for bridges as described in 3, below.

2. Flooding: The Report relies on the Modeling studies to predict the post-restoration tide ranges and combined tidal-fluvial flood risk (the cited source is USGS, 2006). The Report relies on prior flood studies for existing conditions (pre-restoration) to assess flood risk (the cited source is URS and Dewburry, 2003). The Report concludes that post-restoration flood risk will not be worse than existing. Presuming that increased flood risk could greatly affect project feasibility and cost, this is a major assumption not adequately addressed.

3. Scour at Bridges: The Report relies on a Scour study and the Modeling study to develop scour estimates for bridge design criteria (the cited sources are Entranco, 2000 and USGS, 2006). It is not clear whether the long term scour is based solely on hydraulic criteria or also a geomorphic analysis. The Report recommends a "full" scour analysis as part of future final design. The basis for bridge spans (e.g. Section 3.2 new Fifth Avenue Bridge "500-foot span to allow free tidal flow") and implications to scour and tidal hydrology and associated costs are not articulated in this Report.

4. Water Quality: Conceptually, water quality should improve with tidal flushing. However, the Report correctly notes that salinity changes can affect vegetation die-off which in turn can affect water quality under certain conditions. Also, increased velocities can mobilize sediments that may be contaminated. It is not clear whether water quality has been investigated and whether the project description and costs will be affected by water quality. RESPONSES note that there is no known sediment contamination and that water quality issues will probably not affect feasibility. Hence this topic could be addressed as the project progresses.

Can significant uncertainties or errors in the reports be rectified easily?

Yes. This can be accomplished by a follow-on study Report or Addendum after completion of the necessary technical studies to address the uncertainties listed above. It is recommended that this work be accomplished prior to permitting and final design (construction documents).

A geomorphic analysis is recommended. The geomorphic analysis will result in a description of the expected site evolution over time, and the equilibrium condition. The geomorphic analysis may not be definitive, as opined in the RESPONSES (see below). However, it is appropriate to take a geomorphic perspective in order to inform engineering judgment and reduce uncertainties and risk. This will be a different line of analysis and complement modeling and traditional engineering approaches. Additional modeling and other engineering analyses can then be directed to address key unknowns, enhance judgment and check the site conditions predicted by the geomorphic analysis. In particular, a check of hydraulic response and confirmation that flooding will not be exacerbated is recommended.

The RESPONSES point out that a geomorphic analysis was not considered appropriate owing to the site constraints that would preclude a more natural system for which reference data are available. The site constraints were generally referred to as infrastructure. There is insufficient information in the engineering report to support or contest whether the infrastructure constraints are over-whelming or how different the proposed project is from “natural” conditions. It seems entirely plausible that existing infrastructure would pose a significant constraint, and restoration of the historic landscape is not practical. Still, a constrained system does not preclude geomorphic assessments to inform feasibility and design. Also, the RESPONSES state that the range of construction costs adequately addresses the uncertainties in the project without a geomorphic analysis. However it is not clear that a range of costs adequately accounts for missing cost elements which may result from unanticipated system response.

Do the data and /or literature used support the conclusions of reached by the contractors?

Supporting literature and documents were not reviewed. The project documentation may need to be augmented to include the assessment of overriding infrastructure constraints.

Summary

The Report provides a solid engineering feasibility assessment and estimate of likely costs based on the project description provided by others. The Report does not identify and address key uncertainties associated with work by others. Additional analysis is recommended. Some of this analysis requires expertise outside the normal engineering practice, and therefore should be accomplished by professionals experienced with the application of fluvial and estuarine geomorphology in multi-discipline, multi-objective aquatic ecosystem restoration. Whether the Engineering Report needs updating depends on the results of the analysis and whether the project leaders prefer to move forward and incorporate results in later documents.. The recommended analysis is outside the scope of work described in the RFP, and would therefore be additional services.

References

Moffatt & Nichol Engineers, EDAW, Inc., GeoEngineers, *Engineering Design and Cost Estimates, Final Report, Deshutes Estuary Feasibility Study, Phase 3*, Prepared for Washington Department of Fish and Wildlife, February 9, 2007. (REPORT)

Washington Department of Fish and Wildlife, Deshutes Estuary Feasibility Study Phase III Request for Proposal, (Appendices not included), undated. (RFP)

Moffatt & Nichol Engineers, Deschutes Estuary Feasibility Study – Independent Technical Review, Letter to Curtis Tanner, Washington Department of Fish & Wildlife, October 3, 2007.

Deschutes Estuary Feasibility Study Restoration Criteria. DRERS (date unknown).

A-4.
Net Benefits Analysis

Reviewed Study:

Cascade Economics LLC, Northern Economics, Inc., and Spatial Informatics Group LLC. 2007. *Deschutes Estuary Feasibility Study: Net Social and Economic Benefit Analysis Final Report.* Prepared for Capitol Lake Adaptive Management Plan Steering Committee and Washington Department of Fish and Wildlife, June 1 2007.

Were the right questions asked of the contractor?

The RFP asked questions in three general areas, related to (1) the net social and economic benefits of restoration; (2) the potential impacts of restoration on social values identified by members of the local community, and (3) the economic feasibility of restoration. During the course of its work, the contractor, in consultation with WDFW staff and CLAMP staff, clarified these questions and how they might be answered given the limited amount of relevant information at hand.

Net Social and Economic Benefits. The title of the RFP, and some its text, asked the contractor to describe the net social and economic benefits of the proposed restoration. This request created false expectations, however, insofar as the available information fell far short of what the contractor would require to determine the net benefits.

To determine the net social and economic benefits of the restoration alternative, one would have to calculate the overall, gross benefits that would materialize if the alternative were implemented and subtract the overall, gross costs of producing these benefits. Such a calculation should take a broad perspective to identify the relevant benefits and costs. By controlling for other factors that might influence social and economic conditions during implementation of the alternative, the calculation should focus on isolating those benefits and costs uniquely attributable to the restoration. One standard practice for completing such a calculation, called a with-vs.-without comparison, entails constructing and comparing two scenarios of the future, one with restoration and one without it. Any positive differences in social and economic conditions would indicate the potential benefits of restoration; any negative differences would represent the potential costs. The benefits minus the costs would equal the net benefits.

The title of the RFP (and of the contractor's report) indicated that the contractor had been asked to conduct such an analysis. As I understand the circumstances facing the contractor, however, they made it impossible to quantify the net benefits of a restored estuary. Insufficient information existed to construct meaningful scenarios, either with or without restoration. The RFP itself indicated that important information would not be available:

> The Contractor will not need to assess many of the direct costs of estuary restoration and lake management (e.g., cost of dam removal, cost of sediment dredging) as these are (or will be) calculated by CLAMP member agencies. The qualitative analysis of goods and services should include a narrative description of the goods or services and a hypothesized, qualitative change in value that would result from estuary restoration.

In short, to calculate the net benefit of restoration, the contractor would have had to know—for each scenario, with and without restoration—the value of the goods and services society would expend to manage the area's resources and the value of the goods and services society would, in return, derive from these resources. This information, however, was not available. Hence, the contractor developed a narrower analytical framework that focused on a set of attributes and values, identified by stakeholders, that might be affected by restoration.

Community Values. This text, from the RFP, describes the set of community attributes and values identified by stakeholders:

> *In March of 2006, CLAMP sponsored a series of focus groups and an open public forum to gather input from stakeholders regarding the social and economic benefits they derive from the Deschutes Basin. The objective of this process was to engage stakeholders in the identification of priority areas for data collection by describing goods and services they associate with Capitol Lake and the lower Deschutes Basin. Data collection for this statement of work should focus on probable changes in the character and value of these goods and services if basin management were changed from impounded lake to restored estuary.*

This text indicates that, for these goods and services, the contractor was to compile relevant social and economic data, describe probable changes in their character and value, and support efforts of the CLAMP Steering Committee to analyze the social and economic implications of restoring the estuary.

This charge seems appropriate, given the context surrounding this project. Rather than address all the potential costs and benefits of restoration, it looks at only those about which stakeholders have expressed concern. It highlights the importance of determining how the value of a specified list of goods and services would change if the area's resources were managed for restoration rather than to maintain a lake.

The RFP provided further guidance by asking the contractor to develop an analytical framework reflecting the methodology reported by the Heinz Center, as well as "other relevant research." The Heinz Center's methodology, summarized in its 2002 report, Dam Removal: Science and Decision Making, recommends taking a broad view of all social and economic impacts of removing dams. It also urges using a with-vs-without comparison, rather than a before-after comparison for isolating these impacts.

These two approaches are not the same and they can yield widely different analytical outcomes. Restoration is but one of many factors that would affect the value of the goods and services identified by stakeholders and, to isolate the net benefits attributable solely to restoration, one must control for the effects of the other factors. This can be accomplished through a with-vs.-without analysis that entails comparing two scenarios of the future, one with restoration and one without. Any difference between them in terms of the goods and services derived from the basin's natural resources would provide an estimate of restoration's net effects. A before-after analysis would not do this. Instead, it would compare economic conditions before and after restoration and attribute any differences to the restoration when some or all of the differences may stem from other causes. Because of this flaw, the before-after approach does not comply with widely accepted, professional standards of economic analysis for determining the net benefits of a specific action, such as the proposed restoration.

The RFP asked the contractor to consider all types of potential social and economic effects: positive as well as negative effects of restoration, effects that are traded in markets as well as those that are not, those that are monetized as well as those that are not, and those that can be quantified as well as those that can be described only qualitatively. This broad request is appropriate, insofar as one cannot assess the net effects of restoration on the goods and services identified by the stakeholders unless one considers all the effects. It also asked (pp. 6-7) the contractor to fully disclose the methods and data that were used to provide "detailed descriptions" of at least these items:

- "The list of goods and services evaluated, and how they were assessed (quantitative or qualitative methods).
- "The analytical framework that was used to integrate information about the benefits and costs of estuary restoration to assess the associated net benefits.
- "A characterization of current and future economic activities associated with the Lower Deschutes Basin (assuming the current maintenance of Capitol Lake into the future).
- "Estimates of the economic costs and benefits of a restored Deschutes Estuary using market and non-market valuation techniques.
- "A characterization of the social benefits (non-economic) attributed to the Deschutes Basin using qualitative data and an assessment of potential changes in these benefits should the estuary be restored."

The RFP also appropriately asked the contractor to identify gaps in the available, relevant data, and to describe appropriate methods for filling them, should the CLAMP Steering Committee deem it necessary to do so.

Feasibility. The title of the RFP, Deschutes Estuary Feasibility Study: Net Social and Economic Benefit Analysis, provides a context for interpreting the details of the RFP, indicating the charge was to examine the net social and economic benefits of restoring the estuary, as part of an effort to assess the overall feasibility of restoration. The RFP did not, however, communicate a clear understanding of a core concept: what the state will be looking for as it determines whether or not restoration is feasible. As a consequence, the RFP creates ambiguities both in its charge to the contractor and in the expectations it generates for those reading the contractor's report.

The term, feasible, means capable of being done in the context of the expected means at hand and the relevant circumstances. The text of RFP, however, did not ask the contractor to fully assess the social and economic effects of restoration in this context. That is, it asked the contractor to describe some of the potential economic effects of restoration, but it did not specify that the contractor should place these effects in context that would enable the state to determine if these effects would significantly affect the feasibility of restoration. It did not, for example, ask the contractor to show whether the expected effects of restoration would be big or small in the context of the means at hand (e.g., state and local budgets). Nor did it ask the contractor to place its findings, regarding the potential impact of restoration on the value of the goods and services identified by stakeholders, in the context of relevant circumstances, such as other factors within the surrounding economy that might influence that value and make restoration more or less feasible.

Did the contractors answer those questions?

The contractor's report does not describe the net social and economic benefit of restoration. This outcome is at odds with the questions represented in the title of the RFP (and the title of the report) and in the RFP's text directing the contractor to "assess the most likely future social and economic scenarios with and without estuary restoration. Based on these two scenarios, the Contractor shall estimate the net social and economic effects of estuary restoration as compared to lake management." The absence of a calculation of restoration's net benefit is, however, consistent with the realities of the limited information available to construct viable scenarios of the potential costs and benefits under two scenarios, one with and the other without restoration. Specifically, it is consistent with the RFP's instruction not to consider the direct costs of managing the area's resources with or without restoration.

The report focuses on one, limited set of goods and services, identified in the Stakeholder Involvement Report sponsored by the CLAMP Steering Committee, that might be affected if the basin were managed to create a restored estuary rather than a lake. It describes efforts to compile relevant social and economic data regarding these goods and services, and to describe probable changes in their character and value if restoration were to occur, but it generally finds there is insufficient information to reach definitive conclusions. It does not explicitly look to the future and describe how socio-economic conditions in the area likely would evolve. Hence, it does not ascertain, qualitatively or quantitatively, likely trends in the value of these goods and services, not does it examine the extent to which restoration would either reinforce or fly in the face of these trends.

The report does not directly address concerns about the feasibility of restoration, That is, it does not describe the likelihood that restoration would be successful, from a social-economic perspective, given the means available for accomplishing restoration and the circumstances within which restoration would occur. It does provide information regarding the local community's potential support for restoration, concluding that support is mixed. It includes socio-economic data for Olympia and Thurston County in the appendix, supporting the expectation that a careful reading of the report will find the authors showed the relationship between restoration's potential impacts on community values and the region's overall social-economic characteristics. The report, however, does not use these, or other data, to provide context for assessing the extent to which the area has (or is likely to have) the economic means and circumstances to undertake restoration.

The report's analytical approach primarily adopts the before-after framework. It states, for example, "For the purposes of this study, the term 'Net Benefit Analysis' means an assessment of the annual benefits, including possible decreases in benefits, associated with restoring the Deschutes River estuary as compared to current lake management." [Bold emphasis added.] That is, the report says it compares future economic conditions, if restoration were implemented, with the current economic conditions, before restoration. As noted above, though, the contractor did not explicitly consider trends in the value of the goods and services it examined and how restoration might interact with these trends.

By employing a before-after approach rather than a with-vs.-without approach, the contractor deviated from the analytical methodology recommended by the Heinz Center. In addition, the contractor did not develop an analytical framework based on the methodology reported by the Heinz Center but, instead, adopted the structure of the Millennium Ecosystem Assessment. Both observe that dams, and the removal of dams, affect a suite of goods and services that humans derive from the affected ecosystem. They differ, however, in how they organize and describe the goods and services. The methodology reported by the Heinz Center portrays them in detail, and the Millennium Ecosystem Assessment obscures some of the detail by collapsing the goods and services into four categories.

The contractor generally disclosed all the methods and data used in the analysis, but did not find sufficient information to provide fully detailed descriptions of all these items listed in the RFP:

- The contractor listed the goods and services it evaluated and provided a detailed description of how they were assessed.
- The contractor described the analytical framework it used to integrate information about the benefits and costs of estuary restoration. It did not provide an overall assessment of the associated net benefits, however, because it had insufficient information to assess either the overall net benefits of restoration or the net effect of restoration on the value of the specific goods and services highlighted by stakeholders.
- The contractor did not fully characterize current and future economic activities associated with the Lower Deschutes Basin (assuming the current maintenance of Capitol Lake into the future). Instead, it assumed that current maintenance would remain unchanged, i.e., maintenance activities would not change in response to changing environmental and economic conditions. It also assumed that, if the current maintenance activities continued, then current economic activities associated with the area also would remain unchanged. It did not examine expected trends in the supply of and/or demand for different goods and services provided by the area. It did not describe elements of the area's economy that might interact with the resources of the river and estuary. Nor did it characterize foreseeable changes in public preferences, regulations, or other factors that might make the future value of a good or service significantly different from its value today. For

example, it did not place the potential restoration in the context of what is known about how the demand for resource-related goods and services is likely to be influenced by anticipated changes in population and household income, by anticipated changes in the populations of salmon and other species that might be affected by the restoration, or by actions, such as the Puget Sound Initiative, aimed at accomplishing restoration objectives throughout the region.

- The contractor concluded there is insufficient information to support reliable quantitative estimates of the economic costs and benefits of a restored Deschutes Estuary using market and non-market valuation techniques.
- The contractor focused on economic benefits but also provided a general characterization of some of the social benefits (non-economic) attributed to the Deschutes Basin using qualitative data and an assessment of potential changes in these benefits should the estuary be restored.

Were the approaches used by the contractors appropriate to answer those questions?

The contractor's decision not to determine the net social and economic benefit of restoration was appropriate, given the limitations discussed above. The title of its report, Deschutes Estuary Feasibility Study: Net Social and Economic Benefit Analysis, may, however, give some readers the misleading expectation that it overcomes these limitations, and describes the net benefits in the context of assessing the feasibility of restoration.

The contractor's use of a before-after approach, rather than a with–vs.–without approach, was not appropriate for determining the unique effects restoration would have on the value of the goods and services identified by stakeholders. The contractor attempted to apply market and non-market techniques appropriate to the task, but concluded the information it considered is insufficient to reach anything more than tentative, general conclusions.

Have 'standard of practice' analytical tools been used effectively?

The contractor deviated from widely accepted professional standards in several ways. By not applying a with–vs.–without analytical framework, it undermined the confidence in its conclusion that it identified effects attributable solely to the proposed restoration. In essence, it assumed that, absent restoration, the supply of and demand for goods and services from the area's resources would remain as they are today. Long-standing trends in public preferences, however, indicate that demand for resource-related goods and services will increase in the future, and some will increase more than others. The contractor might have considered, for example, the potential effect, all else equal, that factors such as these might have on the value of goods and services with restoration, relative to their value without restoration:

- Foreseeable changes in the area's population and household income.
- Foreseeable changes in the nature of urban development near the river.
- Actions, such as the Puget Sound Initiative, to restore the overall health of the region's ecosystem and to protect and restore populations of salmon and other species.

Stakeholders and others reviewing this report probably would benefit from knowing at least the general direction and magnitude of the influence each of these and other factors likely would exert on the value of the goods and services identified by stakeholders. Without taking these and other factors into account, it is impossible to characterize future economic activities associated with the basin, the future value of the goods and services highlighted by stakeholders, or what restoration's net effects on these values would be, over time.

The contractor sometimes attempted to apply the results from studies elsewhere to this setting, a process called benefit transfer. It limited itself, however, to studies that have been subjected to formal peer review, which meant that it generally found few, if any, applicable studies. This decision was too narrow, relative to the standard of practice for analyses of this type. In one of the references the contractor cited, Guidelines for Preparing Economic Analyses, the Environmental Protection Agency recommends a wider consideration of "published literature, reviews of survey articles, examination of databases, and consultation with researchers to identify government publications, unpublished research, works in progress, and other 'gray' literature." By considering only peer-reviewed articles, the contractor excluded relevant information from other sources regarding the value of goods and services that might be affected by restoration and the potential impacts of restoration on jobs and other characteristics of the economy. For example, apparently in response to comments from reviewers of a draft report, it did not describe some significant reports, specific to Washington, regarding the value of changes in salmon populations.

The contractor did not comply with widely accepted analytical standards in its description of the economy's dynamic character. Its adaptability is one of the greatest strengths of the American economy, and it seems reasonable to anticipate that, if restoration were undertaken, households, firms, and governmental units would adjust in ways that would seek to minimize their costs and maximize their benefits. The contractor's report, however, does not fully take this adaptability into account. Its description of restoration's impact on recreation and tourism, for example, does not account for the likelihood that many households have an inflexible budget for these activities, and any increase (decrease) in activity occasioned by the restoration likely would be accompanied by a roughly equivalent decrease (increase) elsewhere.

The contractor also deviated from standard practices in its treatment of transfers of wealth among different groups, when it concluded (p. 56), "The impacts on business revenue taxes would be added to any estuary restoration costs." Standard practice recognizes taxes not as a cost to society as a whole, but a transfer from one group (the payors) to another (the beneficiaries of governmental expenditures).

The contractor recognized the potential for restoration to affect the area's aesthetics, recreational opportunities, and educational opportunities, and it examined the value of these changes directly. It did not, however, examine the indirect, potential changes in the value of nearby properties, which is a widely recognized economic manifestation of changes in aesthetic, recreational, and educational amenities.

The contractor was inconsistent in its description of the geographic scope of its analysis. The report states that the scope is "the state of Washington as a whole, with a focus on the Deschutes River Basin." The report does not, however, fully examine the possibilities for interactions (positive or negative) between the potential restoration of the Deschutes estuary and other restoration activities within Puget Sound. Nor does it examine the likelihood that an initial effect of restoration might ripple through the rest of the economy: a positive (negative) initial impact on jobs, for example, might induce a worker to leave (look for) job opportunities elsewhere, so that, under full-employment conditions, the overall net impact for the larger economy would be smaller than the initial impact, and perhaps zero.

Is the quality and completeness of documentation and reporting satisfactory?

The contractor provided full documentation for the methods and data it used.

How significant are uncertainties in data and analysis in supporting report conclusions?

The title of the report creates significant uncertainty by incorrectly indicating that the contents describe the net social and economic benefit of restoration and assess the social and economic dimensions of the restoration's feasibility.

Uncertainties within the report dominate the contractor's conclusions. The contractor concluded that uncertainties in the assessments of restoration's physical and biological effects precludes quantification of the resulting changes in goods and services derived from the area's resources. In some instances, the contractor concluded the uncertainty precludes determining even the direction of the effect on the supply and value of goods and services. The contractor also concluded that, even if the effect on the quantity of a good or service were quantified, there is insufficient evidence to support a reliable calculation of its value.

Can significant uncertainties or errors in the reports be rectified easily?

Changing the title of the report (and/or of any future descriptions of the report), might reduce uncertainty regarding its contents. Descriptions of the report should make it clear that the report does not calculate the net benefit or assess the feasibility of restoration but, instead, presents some information about how restoration might affect the value of goods and services about which stakeholders have expressed concern.

Some of the uncertainty about economic values could be rectified by a more thorough review of relevant research, including non-peer-reviewed studies.

Do the data and /or literature used support the conclusions reached by the contractors?

Yes, except insofar as the conclusions are undermined by inappropriate assumptions, the contractor's analytical framework, or its narrow perspective of the economy that would interact with the restoration. To the extent that the contractor compared future social and economic conditions anticipated if restoration were to occur with current conditions, rather than with anticipated future conditions without restoration, then the conclusions fail to account for other factors that might come into play. The data and literature presented by the contractor do not support its conclusion that additional survey research would yield useful descriptions of preferences and values that would support calculation of the net benefits of restoration.