Yakima River Basin Integrated Water Resource Management Plan

Technical Memorandum:
Cost Risk Assessment of Six Projects from the Proposed Integrated Water Resource Management Plan

U.S. Bureau of Reclamation
Contract No. 08CA10677A ID/IQ

Prepared by

HDR Engineering, Inc.

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Columbia-Cascades Area Office

State of Washington
Department of Ecology
Office of Columbia River

June 2012

MISSION STATEMENTS

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

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Disclaimer

The risk-based estimating process, Cost Risk Assessment (CRA), is iterative in nature. This process represents a "snapshot in time" for each specific project and represents the conditions known at the time of the workshop.

The information contained in this report represents the professional opinions of the subject matter experts (SMEs) during the CRA. These opinions were based on the information provided to the SMEs at the time of the workshop. As the project continues to develop, new information will become available, and this information will need to be evaluated on how it may affect the risks and findings in this report.

Note: unless otherwise noted all cost shown in this report are current year dollars (2012).

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1.0 Introduction

A Cost Risk Assessment (CRA) workshop was held April 12-13, 2012 for six of the projects within the Yakima River Basin *Proposed Integrated Water Resource Management Plan* (Integrated Plan) (Reclamation and Ecology 2011a). These six projects are located in Kittitas and Yakima Counties, Washington.

The Integrated Plan identifies a comprehensive approach to water resources and ecosystem restoration improvements in the Yakima River basin. The Integrated Plan includes seven elements: reservoir fish passage, structural and operational changes to existing facilities, surface water storage, groundwater storage, habitat/watershed protection and enhancement, enhanced water conservation, and market reallocation. The Integrated Plan was developed to address a variety of water resource and ecosystem problems affecting fish passage, fish habitat, and water supplies for agriculture, municipal water systems, and domestic uses.

The six projects include:

- Cle Elum Dam Fish Passage
- Bumping Lake Reservoir Enlargement & Fish Passage
- Keechelus to Kachess Pipeline
- Kachess Reservoir Inactive Storage (Alternatives 1 & 2)
- Wymer Dam and Reservoir
- Wymer Downstream Conveyance System

1.1 CRA Workshop Objectives

The overall objective of the CRA workshop was to quantify uncertainty and risk related to costs and schedules. The workshop included the following activities:

- Develop a common understanding among participants of the CRA as well as the project, including project characteristics, schedule, costs, and risk issues
- Review and validate the base cost estimate (pre-workshop)
- Quantify uncertainty in quantities and bid prices surrounding the base cost estimate (pre-workshop)
- Review and validate the project schedule (pre-workshop)
- Identify and quantify cost and schedule risks

The Risk Lead and the various subject matter experts performed a baseline risk assessment of the project. The potential risk events and elements facing the project were discussed. For each risk element identified, it was determined whether the risk would affect cost, schedule, or both. The team then determined the probability of the risk occurring along with the expected impacts.

1.2 Base Cost Review

For each project, the project team provided the CRA Team an opinion of probable construction cost (OPCC) for review and validation. The OPCCs came from the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c).

The base cost estimate represents project cost that can reasonably be expected if the project materializes as planned and there is no occurrence of risk. The base cost estimate is unbiased and neutral - it is neither optimistic nor conservative. The base cost includes both known and quantified items and the known but not yet quantified items (miscellaneous item allowance). the base cost estimate does not include any risks, unknown/unknowns, or contingencies.

The OPCCs include contingencies for minor design and scope changes, minor refinements to the cost estimates, overruns on quantities, changed site conditions and change orders.

A CRA pre-workshop was held on April 6, 2012 to review the cost and schedules for the projects. Prior to the pre-workshop, the CRA Cost Lead reviewed the scope included in each OPCC. The scopes were reviewed for omissions and duplications, contingencies, and uncertainty. This review concentrated upon the major cost items of the OPCCs, and items with the greatest potential for uncertainty and risk.

Uncertainty

Estimating is not an exact science; a cost estimate is only an approximation of the costs and is made up of many elements that may not be completely or equally defined at the time the estimate is prepared. As a result, there is variability or uncertainty associated with any estimate. When applied to the project estimate, this uncertainty establishes the range of costs that the base cost could fall within.

A numerical value of uncertainty is, in essence, an estimate of the error or tolerance within the quantity or unit price of an item. For any given project, the level of uncertainty is directly related to its position in the project life cycle, i.e., the earlier in the project development process, the greater the uncertainty; conversely, the closer to completion, the less uncertainty.

In establishing the uncertainty ranges, consideration was given to factors that might affect quantities or bid prices, such as level of design, delivery method, large or small quantities, project location and accessibility, project terrain, source and availability of materials and water, and season of the year in which the work is to be done.

Uncertainty is typically expressed in terms of a percentage (of the quantity and/or unit cost) lower or higher than the base. Uncertainty can be as high as plus or minus 50 percent during the early stages of a project life (less than 5 percent design). As the project nears completion (95 to 100 percent design) uncertainty drops to around plus or minus 5 percent. Uncertainty was established prior to cost indexing each project to the 1st quarter of 2012.

1.3 Model Results Summary

This report presents the results of the CRA including costs, schedule, and key risks. Each of the graphic outputs and tables provide a representation of the projects as understood at the time of the analysis. Pre-construction (planning, design & environmental), right-of-way, and

construction costs are included in the analysis. The uncertainty of quantities and unit prices is calculated and creates a range surrounding the base cost of each project. The base costs do not include any significant risks.

Figures within this report detail the results of the risk analysis and reflect the information provided by all parties involved, prior to and during the CRA workshop, and represent outcomes based on this "snapshot in time". All results presented are before any risk response strategies were identified as no mitigation measures were quantified for any of the risks at the workshop.

It should be understood that if at a future date, response strategies for key risks are developed and followed, the realized outcomes include lower cost and/or earlier completion dates than those generated in this analysis.

In performing the cost risk analysis, a risk-based modeling tool was incorporated to model the overall risk of the project. The subject matter experts identified a total of 69 independent risks for the six projects that pose potential schedule and/or cost threats and opportunities. During the workshop a likely range of impact and probability of occurrence was identified for each risk.

The following table summarizes results from the cost risk analysis for six of the Yakima River Basin Water Resource Integrated Plan projects.

Table 1. Cost Estimate Range

Yakima River Basin Water Resource Integrated Plan CRA Current Year (CY) Cost Range ($ Millions)			
Project	10th Percentile	50th Percentile	90th Percentile
Cle Elum Dam Fish Passage	$69	$87	$110
Bumping Lake Reservoir Enlargement	$467	$571	$696
Keechelus to Kachess Pipeline	$153	$197	$250
Kachess Inactive Storage Alternative 1	$215	$279	$351
Kachess Inactive Storage Alternative 2	$161	$205	$259
Wymer Dam and Reservoir	$870	$1,138	$1,443
Wymer Downstream Conveyance System	$208	$289	$391

1.4 Comparing Costs

Costs of the six projects reviewed are compared with the costs listed in the Integrated Plan. The basis of these comparisons is as follows:

April 2011 Estimate

- Indexed to 3rd Quarter 2010
- Fish Passage added to Bumping Lake
- Power House removed from Wymer Downstream Conveyance

May 2012 CRA Results

- All design & construction contingencies removed
- Adjusted Base Cost indexed to 1st quarter 2012
- 50th percentile cost risk assessment results shown
- All other IP Projects escalated by 6.8 percent (not reviewed using the CRA process)

Table 2. Cost Comparison

Yakima River Basin Water Resource Integrated Plan CRA		
Project	April 2011 [a] ($M)	May 2012 – CRA [b] ($M)
Cle Elum Dam Fish Passage	$88	$87
Bumping Lake Reservoir Enlargement	$403	$571
Keechelus to Kachess Pipeline	$191	$197
Kachess Inactive Storage Alternative 1	$254	$279
(Kachess Inactive Storage Alternative 2)	*($226)*	*($205)*
Wymer Dam & Reservoir (Thorp Intake)	$1,410	n/a
Wymer Dam & Reservoir (Lmuma Intake)	n/a	1,138
Wymer Downstream Conveyance System	$229	$289
Sub-total [c]	$2,575	$2,561
Other Integrated Plan Projects	$1,415	$1,514
Total [c]	$3,990	$4,075

a. April 2011 estimates are given in 2010 dollars.
b. May 2012 estimates are given in 2012 dollars.
c. To avoid double-counting, totals and subtotals do not include Kachess Inactive Storage, Alternative 2. In addition, the total does not include costs of the land acquisition program.

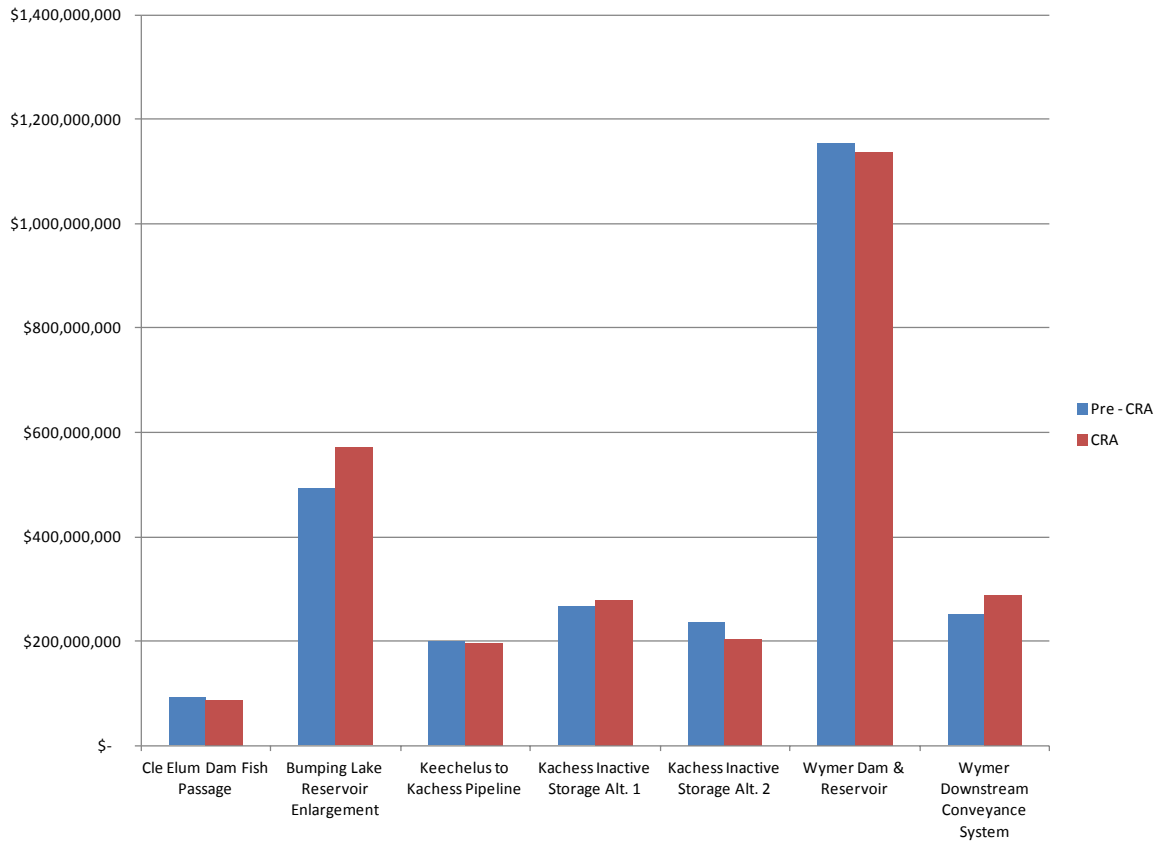

Figure 1. Cost Comparison of Projects

Table 3. Range of Integrated Plan Costs with Cost Risk Results

	Costs ($M)[1]		
	10th Percentile	50th Percentile	90th Percentile
Projects from Cost Risk Analysis			
Cle Elum Fish Passage	69	87	110
Bumping Lake Enlargement	467	571	696
K to K Conveyance	153	197	250
Kachess Inactive Storage, Alternative 1	215	279	351
Wymer Dam	870	1,138	1,443
Wymer Downstream Conveyance	208	289	391
Subtotal	1,982	2,561	3,241
Other Projects from Integrated Plan[2]	1,185	1,514	2,147
Total with All Projects	3,167	4,075	5,388

[1] All values expressed in first quarter, 2012 dollars.

[2] Other projects from Integrated Plan (April 2011) use low, medium and high values, escalated to 2012 dollars, as rough equivalents to the 10th, 50th and 90th percentiles.

1.5 Interpreting the Graphs

The risk analysis results for each project are given in the form of graphs showing the relationship between cost and the probability of not exceeding that cost. See the generic example in Figure 2 (this does not represent any project from the Integrated Plan).

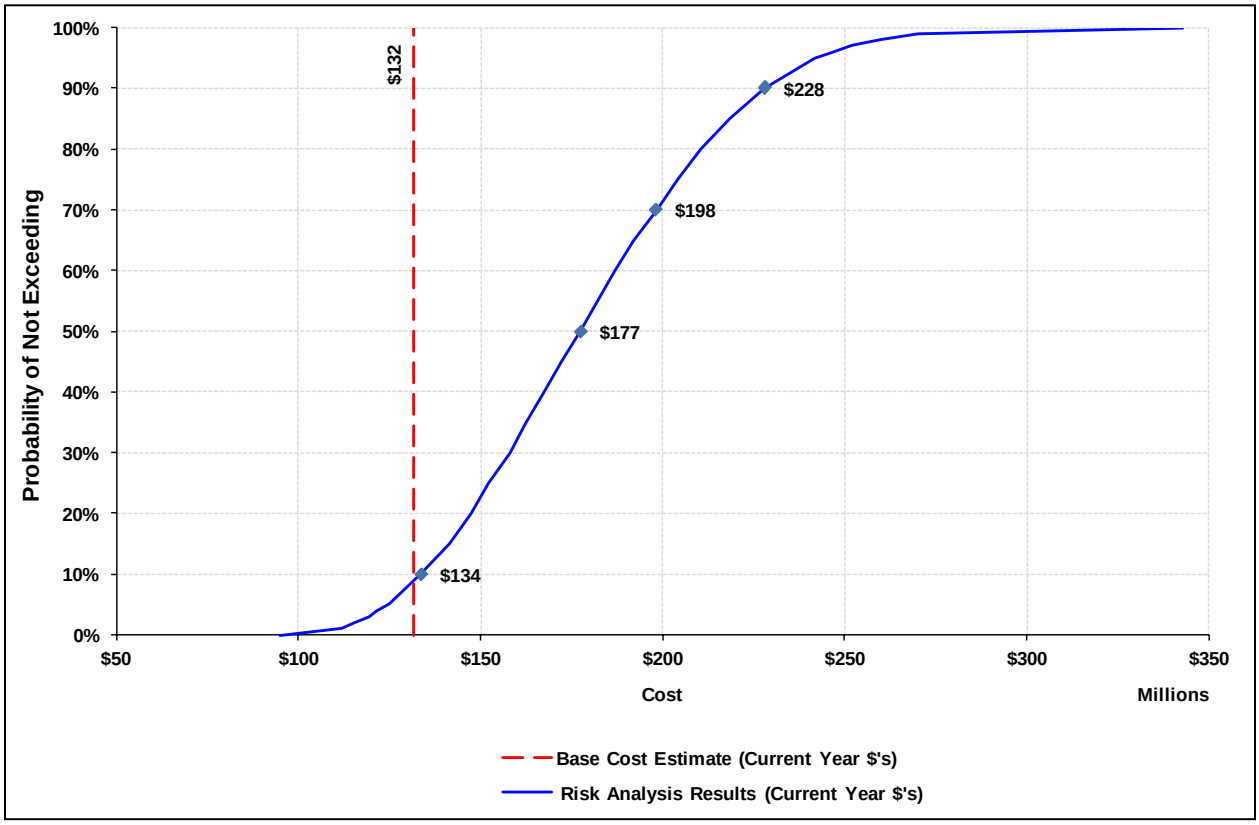

Figure 2. Example Graph

The **red** vertical dashed line represents the base cost in current year (CY) dollars. The base cost is the cost without any contingencies.

The **blue** S-curve represents the cumulative probability distribution after adding in the risks (threats and opportunities) to the base costs and their uncertainties. This "S-curve" represents all possible values the costs could take, expressed in CY dollars. No escalation was applied since Reclamation uses cost indices to adjust the estimates of projects prior to authorization of funding.

Each graph indicates the best opinion of the cost ranges by the workshop participants at the time of their analysis. All construction cost results include extended overhead for delay caused by any identified schedule risks:

Extended Overhead = Base Construction Cost / Base Construction Schedule (months) x 8 percent.

1.6 Workshop Participants

The following staff participated in the Workshop held on April 12 and 13, 2012.

Workshop Leaders

Ken Smith	HDR	Risk Lead
Blane Long	HDR	Cost Lead

Subject Matter Experts

Dan Maag	Reclamation	Cost Estimating
Robert Welsh	Reclamation	Civil Engineering
Jerry Kelso	Anchor QEA	Civil Engineering
Bob Montgomery	Anchor QEA	Water Resources
Jim Peterson	HDR	Civil Engineering
Molly Adolfson	ESA	Environmental
Bob King	HDR	Civil Engineering
Andrew Graham	HDR	Planning/Project Manager
Richard Glassen	HDR	Cost Estimating

Outside Resources

Keith Ferguson	HDR	Dams
Norm Wagner	HDR	Cost Estimating

Risk Modelers

John Stout	HDR	Economist
Hicham Haboussi	HDR	Economist

2.0 Cle Elum Dam Fish Passage

2.1 Overview

Cle Elum Dam impounded and enlarged a natural lake. Lack of fish passage at the dam blocked access to the lake and upstream habitat for salmon, eliminating one of the largest sockeye salmon runs in the Columbia River Basin from the Yakima River basin. Lack of passage also prevents fish in the reservoir such as bull trout from moving throughout the basin.

Reclamation selected a preferred alternative in the Final Environmental Impact Statement (FEIS) (Reclamation and Ecology 2012) and in the Record of Decision (ROD) issued August 12, 2011. The environmental review for the project has been completed, but there is no authorization for additional design or construction; therefore, it is included in the Integrated Plan.

The proposed downstream fish passage facility would consist of a multilevel intake structure with gated openings that would operate at approximately reservoir elevation 2,190 feet and above (from about 50 percent full to full pool), see Figure 3 (Reclamation and Ecology 2011d).

The intake structure would be located against and accessed from the right bank abutment of the existing dam (i.e., the right-hand side, to an observer facing downstream). A juvenile bypass conduit located on the right bank would be installed to carry passage flows from the upstream intake structure to discharge fish into the spillway stilling basin.

For upstream passage, a trap-and-haul adult fish passage facility would be located on the right bank and would include a fish ladder and a collection facility.

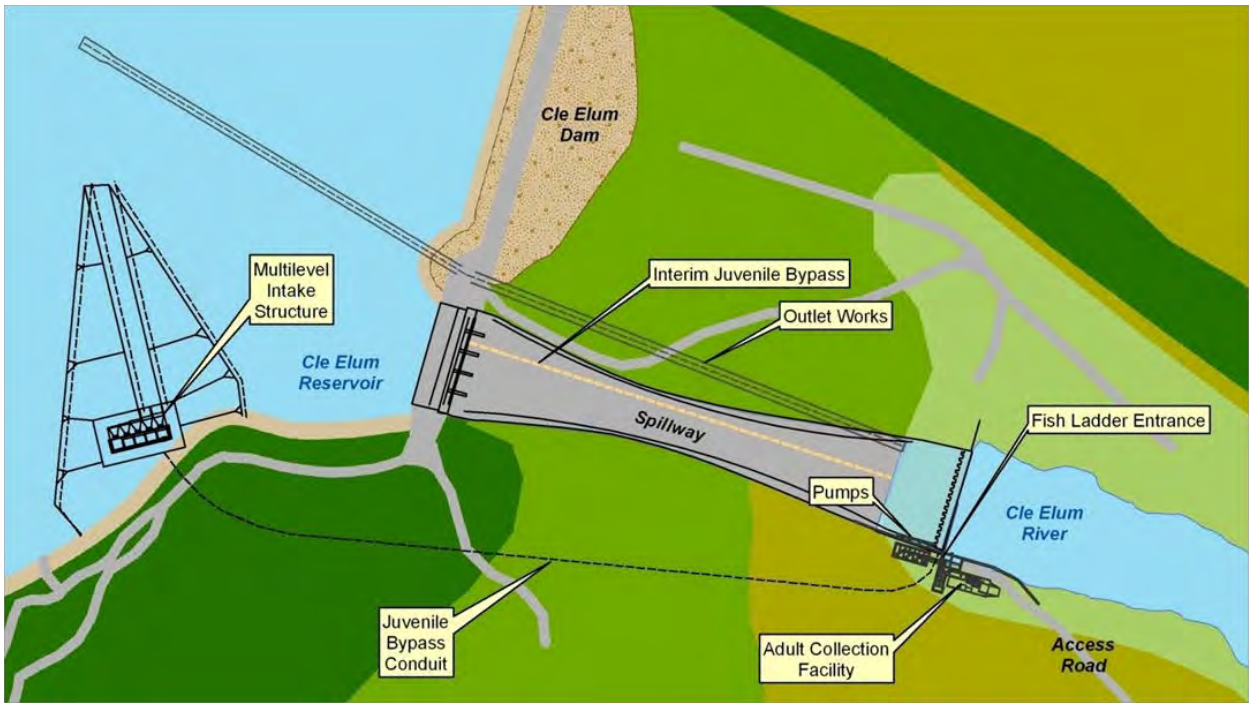

Figure 3. Cle Elum Dam Fish Passage

2.2 Base Cost Review

The CRA Team was provided a cost estimate for the Cle Elum Dam Fish Passage project from the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c) for review and validation during the workshop.

Prior to the workshop the Cost Lead reviewed the estimate for omissions and duplications, contingencies and uncertainty and presented the findings to the CRA Team. Review of the estimate concentrated upon the major cost items of the estimate, and items with the greatest potential for uncertainty and risk (both threats and opportunities).

Table 4. Base Cost for Cle Elum Dam Fish Passage

Component Amount	
1. Materials and Labor	
Fish Passage – Cle Elum Lake Dam	$46,317,000
Materials and Labor	46,317,000
2. Mobilization and Design Contingency	11,225,000
Contract Cost	57,542,000
3. Contingencies	14,386,000
Field Cost	71,928,000
Construction Cost	$71,928,000
Non-Contract Cost	$15,700,000
Project Total	$87,628,000

The provided estimate for fish passage at Cle Elum Lake Dam was indexed to the third quarter of 2010 from an estimate previously prepared by Reclamation in January 2008 (Reclamation and Ecology 2011c).

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights of way that may be required for construction of the project features.

2.3 Base Cost Modifications

The purpose of the estimate review process is to validate the estimate components using both expert opinion and team consensus. At the time of the workshop the quantity values for the items of work listed in the estimate were very preliminary, which is expected since the Cle Elum Dam Fish Passage project was at a design level of less than 15 percent. Significant changes made as a result of the validation process and workshop were as follows:

Contingencies

The contingencies for both construction and design were removed from the base estimate summary and were replaced by project risks (threats and opportunities) by the CRA Team.

Miscellaneous Item Allowance

The base estimate summary included a line item for unlisted minor items. This remained, but was renamed to miscellaneous item allowance to cover known but unquantified items of work not covered in the individual items within the base estimate summary.

Non-Contract Costs

In the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c), Table 1 indicated the non-contract costs were $15.7 million. During the pre-workshop the non-contract costs were divided into the following categories and values:

- **Pre-Construction** - After discussion, the percentage of pre-construction for this project was established at 10 percent of the Contract Cost.
- **Planning Report/EIS** - The Planning Report and FEIS for the Cle Elum Dam Fish Passage project were completed on August 12, 2011. Therefore no cost was included for this item.
- **Construction Engineering** - After discussion, the percentage of construction engineering for this project was established at 10 percent of the Contract Cost.
- **Right-of-Way** - The Cle Elum Dam Fish Passage project as presented does not require right-of-way to be purchased.

Sales Tax

The sales tax was assumed to be included in the items of the original estimate. There was no documentation in the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c) to confirm this assumption. Therefore, sales tax was added, at the rate used in Kittitas County (8.0 percent).

Cost Index

The costs for this project were originally indexed to the 3rd quarter of 2010. The Cost Lead indexed the costs to the 1st quarter of 2012.

Table 5. Cost Indexing for Cle Elum Dam Fish Passage

Components	Original Estimate ($M)	Indices		Index Category	Adjusted Base ($M)
		3rd Q 2010	1st Q 2012		
Upstream - Roads and Road Structures	$0.08	411	445	Secondary Roads	$0.08
Downstream - Roads and Road Structures	$0.55	411	445	Secondary Roads	$0.59
Upstream - Structures and Improvements	$2.73	340	363	Composite Trend	$2.92
Upstream Auxiliary Water Supply	$3.54	340	363	Composite Trend	$3.78
Upstream - Waterway Structures	$4.38	343	364	Outlet works	$4.65
Downstream - Waterway Structures	$16.83	325	351	Spillway	$18.18
Downstream - Dam	$18.21	303	326	Earth Dams	$19.59
Total	$46.31 M				$49.78 M

Uncertainty

The base estimate that was provided for the workshop was originally from January 2008 and had been indexed to the 3rd quarter of 2010, with the design at less than 15 percent. Most of the estimate was at a very high level with many of the values being based on historical averages of the identified items and traditional percentages.

With the project still very early in the development process the base uncertainty for the Cle Elum Dam Fish Passage project was established to be in the range of minus 20 to plus 40 percent by the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c).

Table 6. Uncertainty Ranges for Cle Elum Dam Fish Passage

Components	Low	Under	Base	Over	High
Upstream - Roads and Road Structures	$62,640	-20%	$78,300	50%	$117,450
Downstream - Roads and Road Structures	$437,288	-20%	$546,610	50%	$819,915
Upstream - Structures and Improvements	$2,184,498	-20%	$2,730,623	46%	$3,983,514
Upstream Auxiliary Water Supply	$2,828,099	-20%	$3,535,124	41%	$4,986,627
Upstream - Waterway Structures	$3,505,994	-20%	$4,382,493	40%	$6,155,639
Downstream - Waterway Structures	$14,113,897	-16%	$16,831,571	44%	$24,213,969
Downstream - Dam	$15,034,505	-17%	$18,209,985	43%	$26,010,112
Totals	$38,166,923	-18%	$46,314,706	43%	$66,287,227

The uncertainty of items within each component was reviewed by the CRA Cost Lead and, if needed, was adjusted slightly based on various factors such as level of design, location of work, amount of quantities, etc. See Appendix A - Uncertainty Calculations for further information.

The Upstream – Roads and Road Structures consisted mostly of minor items which resulted in a slight increase in uncertainty. The lump sum item, Dewatering accounted for an increase in uncertainty in the component, Downstream – Dam, and the lump sum item Storm Drain System accounted for an increase in uncertainty in the component, Downstream – Waterway Structures.

Adjusted Base Cost Estimate

The adjusted base cost estimate (1st quarter 2012) for the Cle Elum Dam Fish Passage project is shown in the following table:

Table 7. Adjusted Base Cost Estimate for Cle Elum Dam Fish Passage

Components		Under ($M)	%	Base ($M)	%	Over ($M)
Upstream - Roads and Road Structures				$0.08		
Downstream - Roads and Road Structures				$0.59		
Upstream - Structures and Improvements				$2.92		
Upstream Auxiliary Water Supply				$3.77		
Upstream - Waterway Structures				$4.65		
Downstream - Waterway Structures				$18.18		
Downstream - Dam				$19.59		
Subtotal		$41.02	-18%	$49.78	43%	$71.25
Miscellaneous Item Allowance	4%	$1.64		$1.99		$2.85
Bid Items Subtotal		$42.66		$51.77		$74.10
Mobilization	5%	$2.13		$2.59		$3.70
Subtotal with Mobilization		$44.80		$54.36		$77.80
Sales Tax	8.0%	$3.58		$4.35		$6.22
Contract Cost (Base Cost for Construction)		$48.38		$58.71		$84.03
Pre-Construction	10%	$4.84		$5.87		$8.40
Planning Report & EIS				N/A		
Construction Engineering	10%	$4.84		$5.87		$8.40
Right of Way Costs				N/A		
Project Total		$58.06		$70.45		$100.83

Base Cost Comparison

Table 8 compares the main elements of the provided Base Cost Estimate (adjusted to 2012) and the Adjusted Base Cost Estimate that was established following the workshop review. The Adjusted Base Cost was used in the risk analysis model.

Table 8. Base Cost Summary for Cle Elum Dam Fish Passage

Item	Base Cost Estimate $ Million (2012)	Adjusted Base Cost $ Million (2012)
Components	$49.79	$49.78
Miscellaneous Item Allowance		$1.99
Mobilization	$2.49	$2.59
Design/Scope Contingency	$8.19	
Construction Contingency	$15.47	
Sales Tax		$4.35
Pre-Construction (Design)		$5.87
Planning Report & EIS		
Construction Engineering		$5.87
Right of Way		
Non-Contract Cost	$16.88	
Project Total	$92.82	$70.45

The contingencies for both construction and design were removed from the base cost estimate and were replaced by project risks (threats and opportunities) by the CRA Team.

2.4 Project Escalation Assumptions

Reclamation's Construction Cost Trends [CCT] (Reclamation 2012) are used to track construction relevant to the primary types of projects being constructed by the organization. All the various cost indexes consist of two elements, contractor labor and equipment costs and contractor supplied materials and equipment.

Reclamation uses cost indices which provide a rapid means of determining the current cost of construction of various properties based on former estimates. For these projects all budgets will be calculated in current year dollars and then indexed to the year of construction once funding is authorized.

2.5 Project Schedule Validation

For the purpose of the CRA workshop the following schedule was assumed.

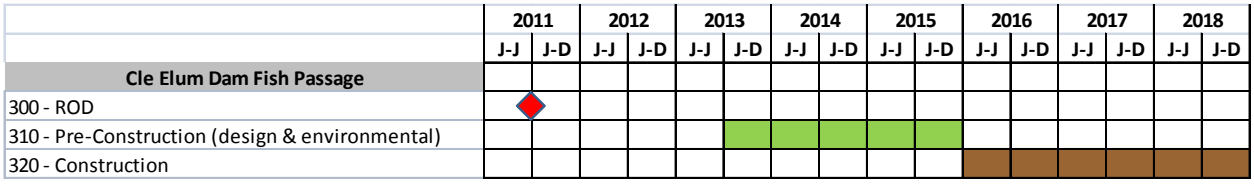

Figure 4. Project Schedule for Cle Elum Dam Fish Passage

2.6 Cost Risk Assessment

Risk Elicitation

During the discussion of the project, the workshop participants identified eight high risk elements or potential events which may impact the project. See the Risk Register in the Appendix B for additional information on each project risk.

These included:

- Historical and Cultural Resources
- Cle Elum Fish Passage Construction - Juvenile Bypass Conduit
- Differing Site Conditions
- Mitigation for Loss of Habitat
- Tribal Employment Rights Office (TERO)
- Design and Scope Changes
- Minor Aggregate Risk

The tornado diagram for the top risks impacting cost is shown in Figure 5. This tornado diagram shows the expected value, based on Monte Carlo simulation, of the cost of each event risk.

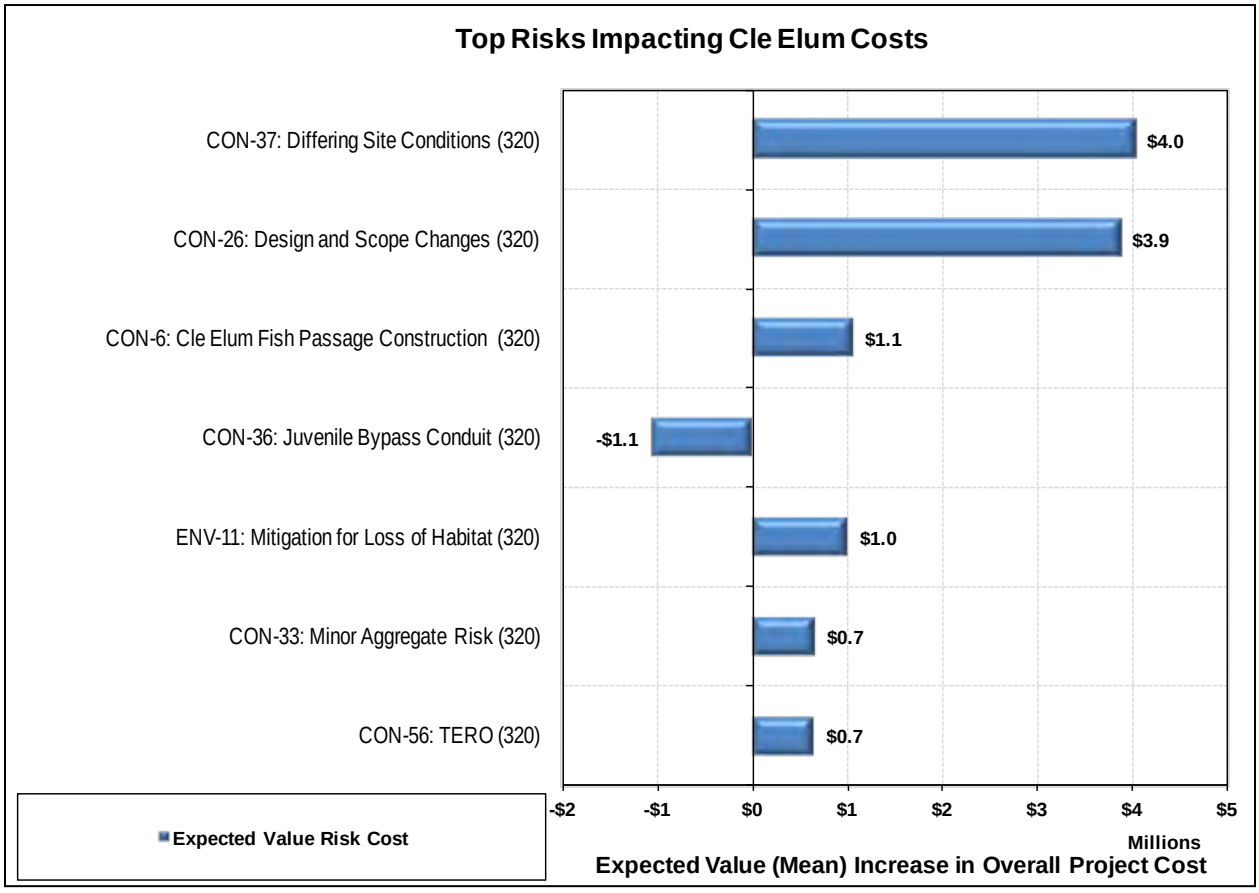

Figure 5. Tornado Diagram of Risks for Cle Elum Fish Passage

The direct event risk cost impact is measured as the probability of the risk occurring times the mean cost impact developed from the risk cost ranges recorded within the risk register during the CRA Workshop.

Cost Results

Figure 6 details the probabilistic total project cost results after accounting for risks and uncertainty. The 80 percent confidence interval, described by the cost range between the 10th percentile and 90th percentile figures, reveals that the total project cost is expected to fall between $69 million and $110 million.

There is 50 percent chance that the total project cost will be less than $87 million.

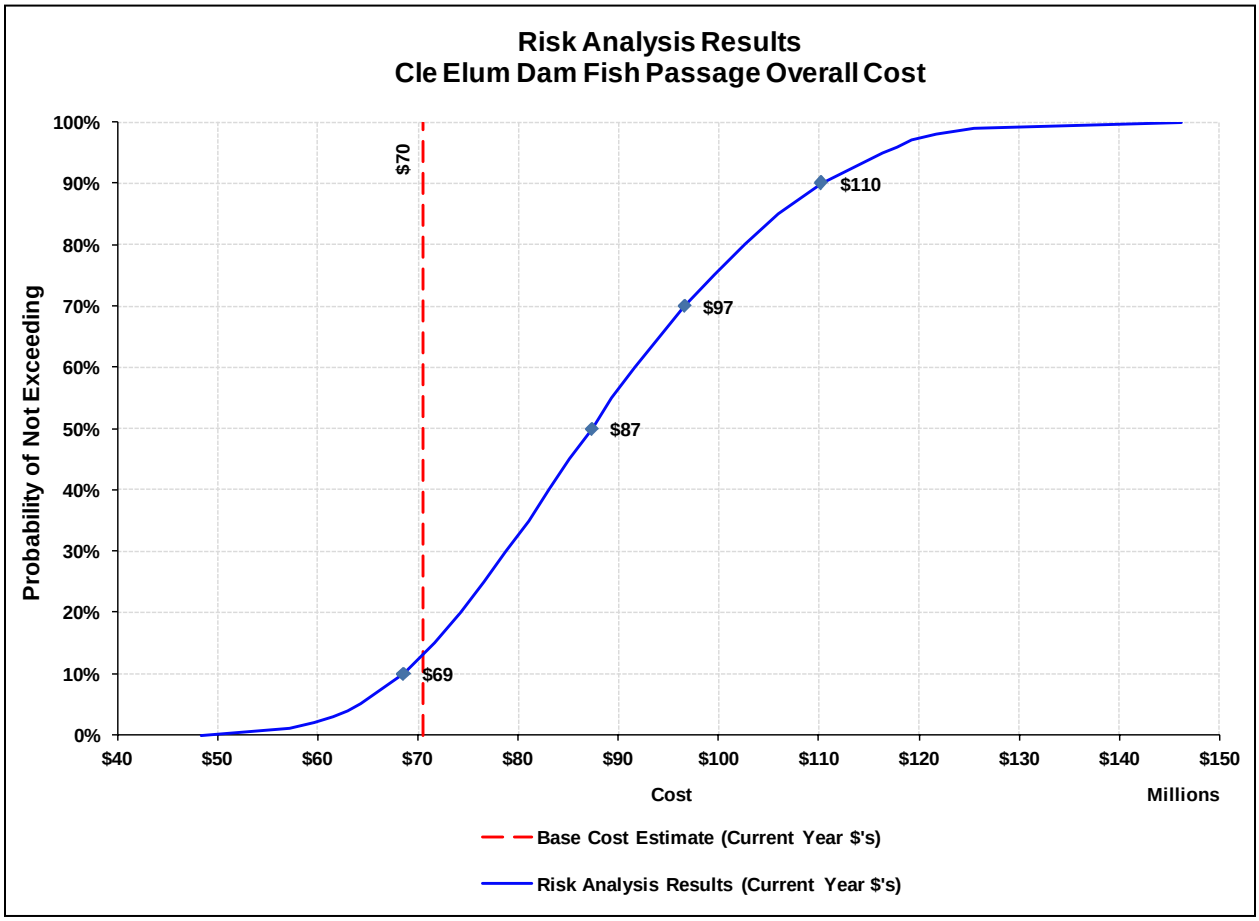

Figure 6. Total Project Costs for Cle Elum Dam Fish Passage

Figure 7 details the probabilistic construction cost results after accounting for risks and uncertainty. The 80 percent confidence interval reveals that the construction cost is expected to fall between $61 million and $103 million.

There is 50 percent likelihood that construction costs will not exceed $80 million.

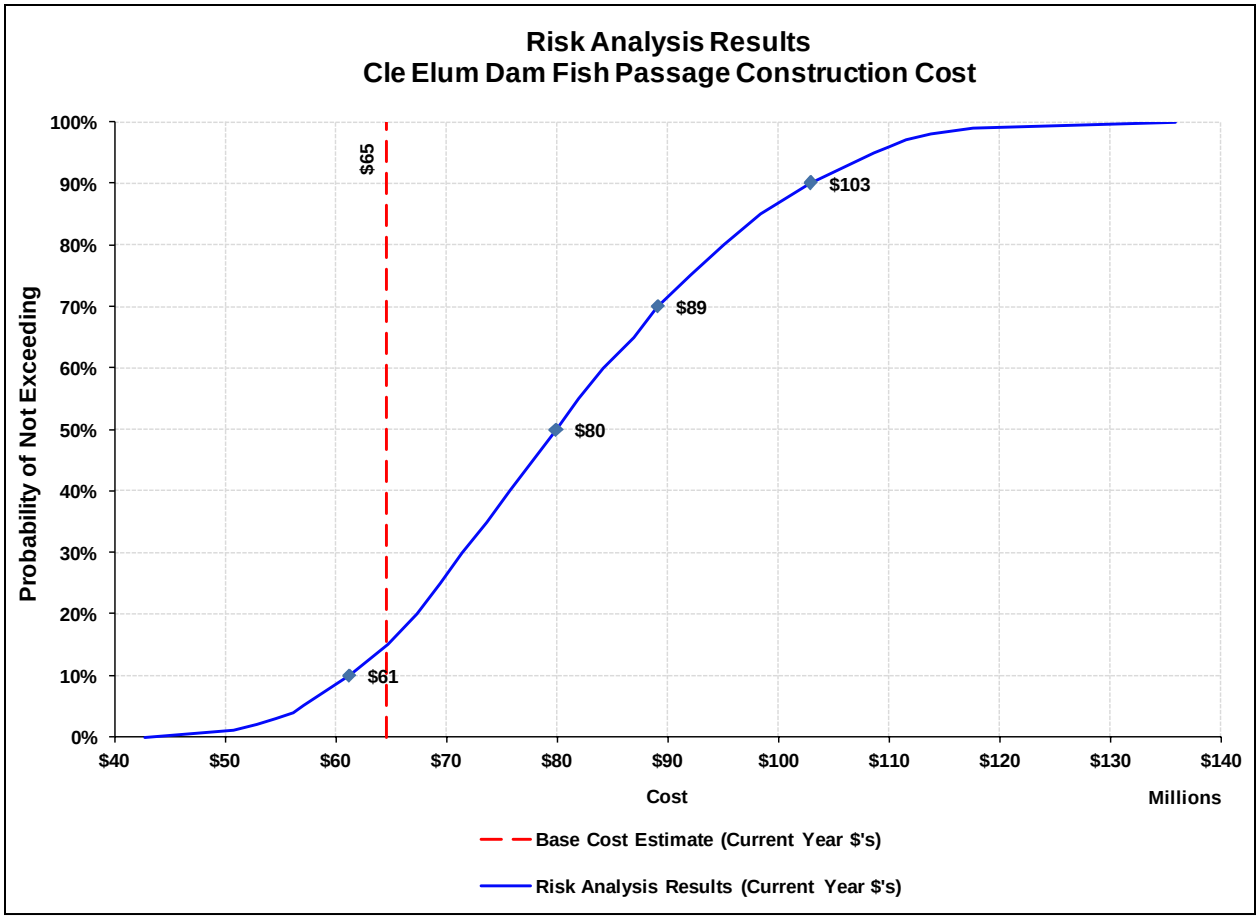

Figure 7. Construction Costs for Cle Elum Dam Fish Passage

Schedule Results

There was only one identified schedule risk for the Cle Elum Dam Fish Passage project – Historical and Cultural Resources. This risk had an expected impact of 1 week.

Final Cost Comparison

For a basis of comparison the following charts were created showing the cost of each project before and after the CRA workshop.

The Pre-CRA costs include:

- Base Cost (3rd quarter 2010)
- Contingencies
- The cost to index the project to the 1st quarter 2012 using the Reclamation cost indices

The CRA costs include:

- Adjusted Base Cost (Indexed to 1st quarter 2012)
- Base Cost Uncertainty at 50th percentile
- Risk Impact at 50th percentile

Costs are shown in millions of dollars.

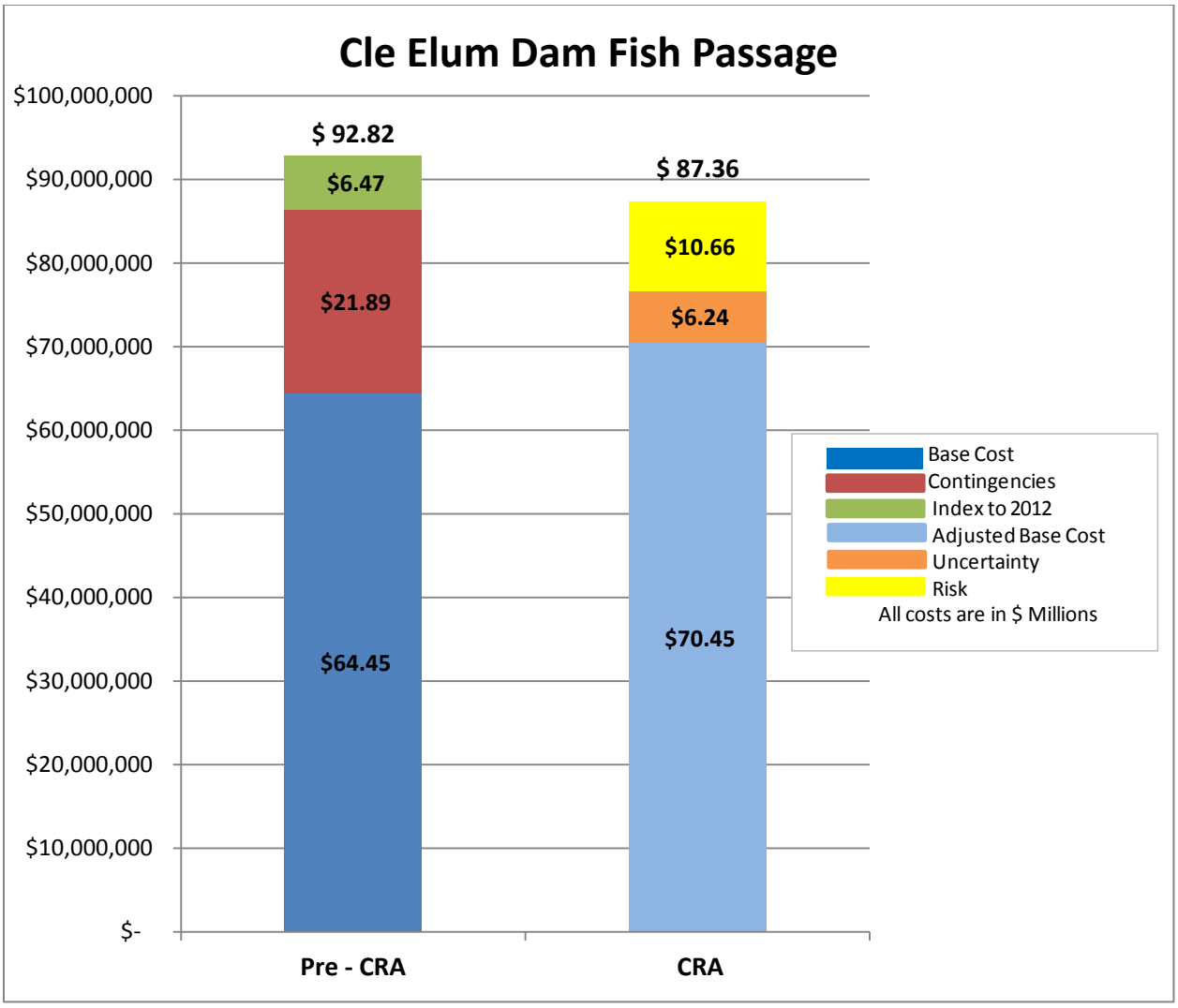

Figure 8. Final Cost Comparison for Cle Elum Dam Fish Passage

3.0 Bumping Lake Reservoir Enlargement

3.1 Overview

Bumping Lake Dam is located on the Bumping River, a tributary of the Naches River, approximately 40 miles northwest of Yakima. Bumping Lake Dam (**blue line** on Figure 9) was constructed in 1910 and created a reservoir with a capacity of 33,700 acre-feet at elevation 3,425 feet.

Enlargement of Bumping Lake Reservoir includes construction of a new dam and fish passage facilities about 4,500 feet downstream (**purple line** on Figure 9) from the existing Bumping Lake Dam (Reclamation and Ecology 2011b). The reservoir would be enlarged to a total active capacity of approximately 190,000 acre-feet at approximate elevation 3,490 feet (**orange line** on Figure 9). The existing dam would be breached following construction to allow full use of the existing pool.

The additional storage created by this project is a critical component for meeting the instream habitat and water supply goals of the Integrated Plan. Bumping Lake Reservoir's location in the basin also would allow Reclamation greater flexibility in releasing flows. The operations of Bumping Lake and Rimrock Reservoirs (also located in the Naches River basin) would be coordinated with reservoirs in the upper Yakima River basin to assist in meeting both instream flow and water supply needs.

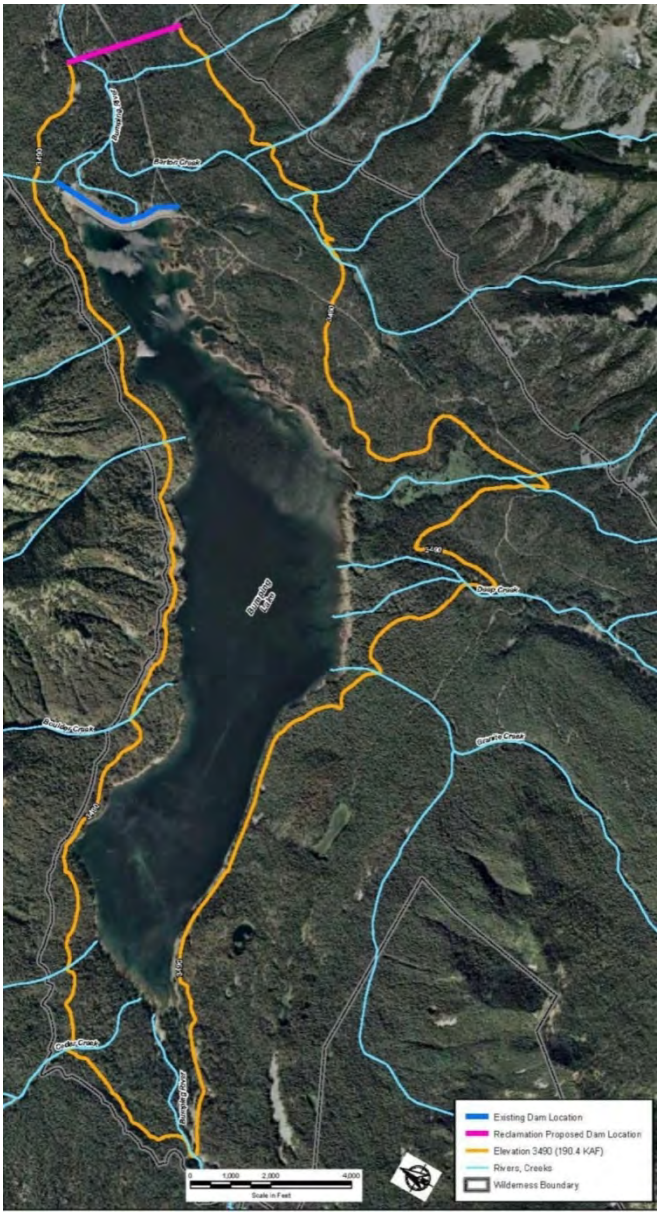

Figure 9. Aerial View of Bumping Lake

The enlarged reservoir would inundate an additional 1,900 acres of land for a total inundation area of 3,200 acres. The reservoir would extend approximately 5 miles upstream from the dam and create approximately 3 more miles of shoreline, for a total of 15 miles.

The site of the proposed new dam and the lands that would be inundated by the expanded reservoir are contained entirely within the area reserved by Reclamation for the purposes of the Yakima project. The lands are located within the Okanogan-Wenatchee National Forest, but outside William O. Douglas Wilderness (**gray line** on Figure 9) and other roadless areas.

The construction of Bumping Lake Dam impounded and enlarged a natural glacial lake, blocking passage to an area that historically supported native Chinook, summer steelhead, coho, sockeye salmon, and bull trout. Currently, the Bumping River supports native spring Chinook and steelhead below the dam, and bull trout above the dam

Fish passage at Bumping Lake Dam would make available habitat in the reservoir as well as high-quality migration, spawning, and rearing habitat in the Bumping River and its tributaries.

Upstream and downstream fish passage would be installed at the proposed Bumping Lake Dam as part of the proposed Bumping Lake Reservoir enlargement. These fish passage facilities are expected to be similar to those proposed for the Cle Elum Dam Fish Passage project.

3.2 Base Cost Review

The CRA Team was provided a cost estimate for the Bumping Lake Reservoir Enlargement project from the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c) for review and validation during the workshop.

The Cost Lead reviewed the estimate for omissions and duplications, contingencies and uncertainty and presented the findings to the workshop team. Review of the estimate concentrated upon the major cost items of the estimate, and items with the greatest potential for uncertainty and risk (both threats and opportunities).

Table 9. Base Cost for Bumping Lake Reservoir Enlargement

Component		Amount
1.	Materials and Labor	
	Land Rights	$713,000
	Relocation of Property of Others	3,488,000
	Clearing Lands	11,266,000
	Roads and Road Structures	4,019,000
	Dams	180,717,000
	Materials and Labor	200,204,000
2.	Field Overhead and Mobilization	6,006,000
3.	Other Contractor Costs	36,465,000
	Contract Cost	242,675,000
4.	Contingencies	60,669,000
	Field Cost	303,344,000
5.	Sales Tax	6,270,000
Construction Cost		$309,614,000
Non-Contract Costs		$92,800,000
Project Total		$402,414,000

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract

administration and management, and costs associated with land acquisition and relocation or rights of way that may be required for construction of the project features.

The provided construction cost that was indexed for this workshop did not include the cost of fish passage at the proposed Bumping Lake Dam. However, the enlargement project will require fish passage and the cost is assumed to be similar to the cost for the Cle Elum Dam Fish Passage ($46.3 million prior to markups).

3.3 Base Cost Modifications

The purpose of the estimate review process is to validate the estimate components using both expert opinion and team consensus. To that end, some adjustments were made to the estimate based on discussion with the team during the workshop. At the time of the workshop the quantity values for the items listed in the estimate were very preliminary which is expected since the design of the Bumping Lake Reservoir Enlargement project was at less than 5 percent. Significant changes made as a result of the validation process and workshop was as follows:

Contingencies

The contingencies for both construction and design were removed from the base estimate summary and were captured as project risks (threats and opportunities) by the CRA Team.

Miscellaneous Item Allowance

The base estimate summary included a line item for unlisted minor items. This item remained but was renamed to miscellaneous item allowance to cover known but unquantified items of work not covered in the individual items within the base estimate summary.

Non-Contract Costs

Non-contract costs were broken into categories; pre-construction (design & environmental permitting), planning report/EIS, construction engineering and right-of-way costs. These categories replaced the generic 30 percent added to each project.

- **Pre-Construction** - After discussions during the pre-workshop, the percentage of pre-construction for this project was established at 9 percent of the Contract Cost.
- **Planning Report/EIS** - After discussions during the pre-workshop and during the workshop, the cost of the planning report and EIS was estimated to be $3 million.
- **Construction Engineering -** After discussions during the pre-workshop, the percentage of construction engineering for this project was established at 10 percent of the Contract Cost.
- **Right-of-Way -** This project does not require the purchase of right-of-way. The relocation of campgrounds and cabins are included in the construction costs.

Sales Tax

Sales tax was calculated at 8.2 percent on only the equipment and materials in the provided estimate. Sales tax for Yakima County (7.9 percent) was applied to the entire contract in the adjusted base cost estimate.

Cost Index

The costs for this project were originally indexed to the 3rd quarter of 2010. The Cost Lead indexed the costs to the 1st quarter of 2012.

Table 10. Cost Indexing for Bumping Lake Reservoir Enlargement

Components	Original Estimate ($M)	Indices		Index Category	Adjusted Base ($M)
		3rd Q 2010	1st Q 2012		
Land Rights	$0.71	375	383	Washington	$0.73
Relocation of Property of Others	$3.49	375	383	Washington	$3.56
Roads and Road Structures	$4.02	411	445	Secondary Roads	$4.35
Clearing Lands	$11.27	340	363	Composite	$12.03
Fish Passage	$44.18	357	371	Steel Pipeline	$45.91
Dam	$180.72	303	326	Earth Dam	$194.43
Total	$244.38 M				$261.01 M

Uncertainty

With the project still very early in the development process (less than 5 percent design) the base uncertainty for the Bumping Lake Reservoir Enlargement project was established to be in the range of minus 20 to plus 40 percent by the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c).

Table 11. Uncertainty Ranges for Bumping Lake Reservoir Enlargement

Components	Low	Under	Base	Over	High
Land Rights	$570,097	-20%	$712,621	50%	$1,068,932
Relocation of Property of Others	$2,790,742	-20%	$3,488,427	41%	$4,918,815
Roads and Road Structures	$3,215,199	-20%	$4,018,999	41%	$5,648,342
Clearing Lands	$9,013,186	-20%	$11,266,482	40%	$15,773,075
Fish Passage	$35,344,000	-20%	$44,180,000	40%	$61,852,000
Dam	$153,218,697	-15%	$180,716,997	45%	$261,684,209
Total	$204,151,920	-16%	$244,383,526	44%	$350,945,372

The uncertainty of items within each component was reviewed by the CRA Cost Lead and, if needed, was adjusted slightly based on various factors such as level of design, location of work, amount of quantities, etc. See Appendix A - Uncertainty Calculations for further information.

Being early in the project development process the uncertainty for some components ranged from minus 20 to plus 50 percent depending on the items of work. The quantities within the Dam category are very preliminary and as such the uncertainty was adjusted to account for this. A higher uncertainty was also applied to some items such as embankment because of the need for this project to "winter over" 4 times during construction because of snow in the mountains. The Land Rights component consisted of mostly minor items resulting in an increase in uncertainty.

Adjusted Base Cost Estimate

The adjusted base cost estimate (1st quarter 2012) for the Bumping Lake Reservoir Enlargement project is shown below.

Table 12. Adjusted Base Cost Estimate for Bumping Lake Reservoir Enlargement

Component		Under ($M)	%	Base ($M)	%	Over ($M)
Land Rights				$0.73		
Relocation of Property of Others				$3.56		
Roads and Road Structures				$4.35		
Clearing Lands				$12.03		
Fish Passage				$45.91		
Dam				$194.43		
Subtotal		$220.08	-16%	$261.01	44%	$376.90
Miscellaneous Item Allowance	4%	$8.80		$10.44		$15.08
Bid Items Subtotal		$228.88		$271.45		$391.97
Contractors Field Overhead	2%	$ 4.58		$5.43		$7.84
Contractor's Fee	6%	$13.73		$16.29		$23.52
Contractor's Bond & Insurance	1.5%	$3.43		$4.07		$5.88
Subtotal with Contractor Markups		$250.63		$297.24		$429.21
Mobilization	1%	$2.51		$2.97		$4.29
Subtotal with Mobilization		$253.13		$300.21		$433.50
Sales Tax	7.9%	$20.00		$23.72		$34.25
Contract Cost (Base Cost for Construction)		$273.13		$323.93		$467.75
Pre-Construction	9%	$24.58		$29.15		$42.10
Planning Report & EIS		$2.70	-10%	$3.00	10%	$3.30
Construction Engineering	10%	$27.31		$32.39		$46.78
Right of Way Costs				N/A		
Project Total		$327.72		$388.47		$559.92

Base Cost Comparison

Table 13 compares the main elements of the Base Cost Estimate provided and the Adjusted or CRA Base Cost Estimate that was established following the workshop review. The Adjusted Base Cost was used in the risk analysis model.

Table 13. Base Cost Comparison for Bumping Lake Reservoir Enlargement

Item	Base Cost Estimate $ Million (2012)	Adjusted Base Cost $ Million (2012)
Components (includes fish passage)	$261.01	$261.01
Miscellaneous Item Allowance	$8.34	$10.44
Contractors Field Overhead	$4.27	$5.43
Contractor's Fee	$14.46	$16.29
Contractor's Bond & Insurance	$3.62	$4.07
Mobilization	$2.14	$2.97
Design/Scope Contingency	$8.34	
Cost Estimate Refinement	$4.18	
Construction Contingency	$64.80	
Sales Tax	$6.70	$23.72
Pre-Construction (Design)		$29.15
Planning Report & EIS		$3.00
Construction Engineering		$32.39
Right of Way		
Non-Contract Cost	$113.36	
Project Total	$491.22	$388.47

The contingencies for both construction and design were removed from the base cost estimate and were replaced by project risks (threats and opportunities) by the CRA Team.

3.4 Project Escalation Assumptions

Reclamation's Construction Cost Trends [CCT] (Reclamation 2012) are used to track construction relevant to the primary types of projects being constructed by the organization. All the various cost indexes consist of two elements, contractor labor and equipment costs, and contractor supplied materials and equipment.

Reclamation uses cost indices which provide a rapid means of determining the current cost of construction of various properties based on former estimates. For these projects all budgets will be calculated in CY dollars and then indexed to the year of construction once funding is authorized.

3.5 Project Schedule Validation

For the purposes of the CRA workshop the following schedule was assumed.

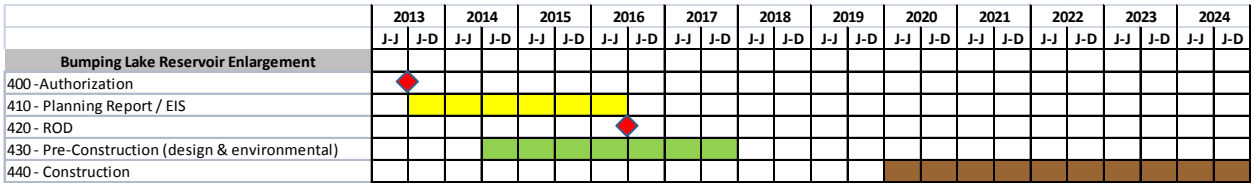

Figure 10. Project Schedule for Bumping Lake Reservoir Enlargement

3.6 Cost Risk Assessment

Risk Elicitation

During the discussion of the project, the workshop participants identified 15 high risk elements or potential events which may occur that would impact the project. See the Risk Register in the Appendix B for additional information on each project risk.

The top active risks included:

- Bumping Dam Cutoff Wall
- Bumping Dam Seepage Collection
- Bumping Dam Cutoff Wall Not Deep Enough
- Bumping Site Specific Seismotectonic Study
- Bumping Hazardous Materials
- Bumping Fish Passage Mitigation for Loss of Habitat
- Appeal of Project Level EIS
- Historical and Cultural Resources
- Material Source Availability
- Added Cost and Duration for Planning Report and EIS
- Drain and Filter System
- Tribal Employment Rights Office (TERO)
- Design and Scope Changes
- Minor Aggregate Risk

It was recognized during the CRA workshop that all of the geology within the project area could be considered preliminary or regional geology. It is based on limited site specific information. In most cases, assumptions have been made on what the foundation conditions might be for a specific structure based on existing geologic surface maps.

Bumping Lake Reservoir Enlargement project has had some actual drill hole investigation, but it is very limited. The depth of the surface material (+250 feet) above bedrock has not actually

been verified by any drilling. In other words, the foundation conditions at the proposed Bumping Lake Dam enlargement are not specifically verified by geologic exploration. This lack of current geotechnical information accounted for large risks to the cost of the project.

Mitigation for features of the built environment at the existing Bumping Lake (e.g. road, campground, cabins) was included in the base cost estimates, and therefore is not treated as a risk item.

The tornado diagram for the top cost risks is shown in Figure 11 below. This tornado diagram shows the expected value of the cost for each event risk, based on Monte Carlo simulation.

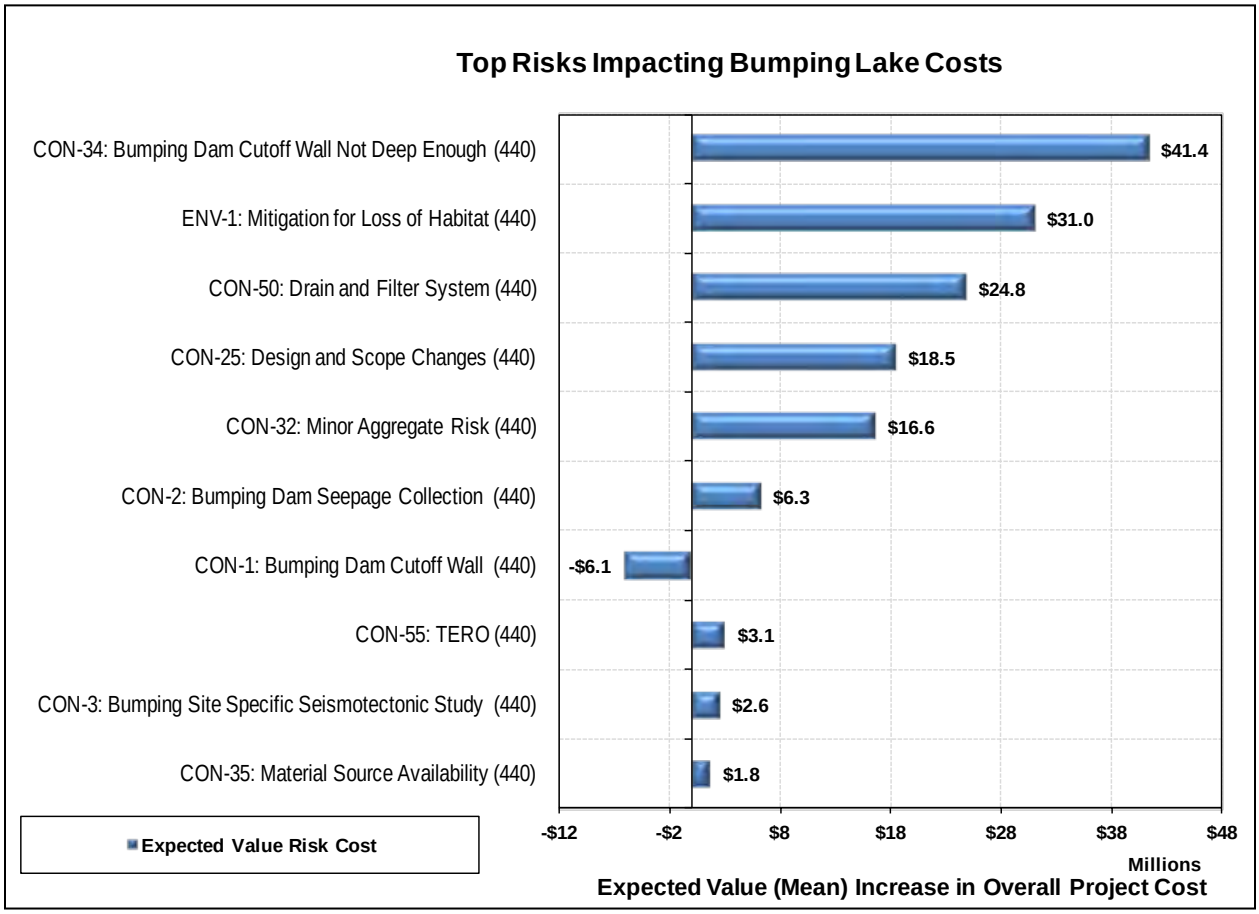

Figure 11. Tornado Diagram of Risks for Bumping Lake

The direct event risk cost impact is measured as the probability of the risk occurring times the mean cost impact developed from the risk cost ranges recorded within the risk register during the CRA Workshop.

Cost Results

Figure 12 details the probabilistic total project cost results after accounting for risk and uncertainty. The 80 percent confidence interval, described by the cost range between the 10th percentile and 90th percentile figures, reveals that the total project cost is expected to fall between $467 million and $697 million. There is 50 percent chance that the total project cost will be less than $571 million.

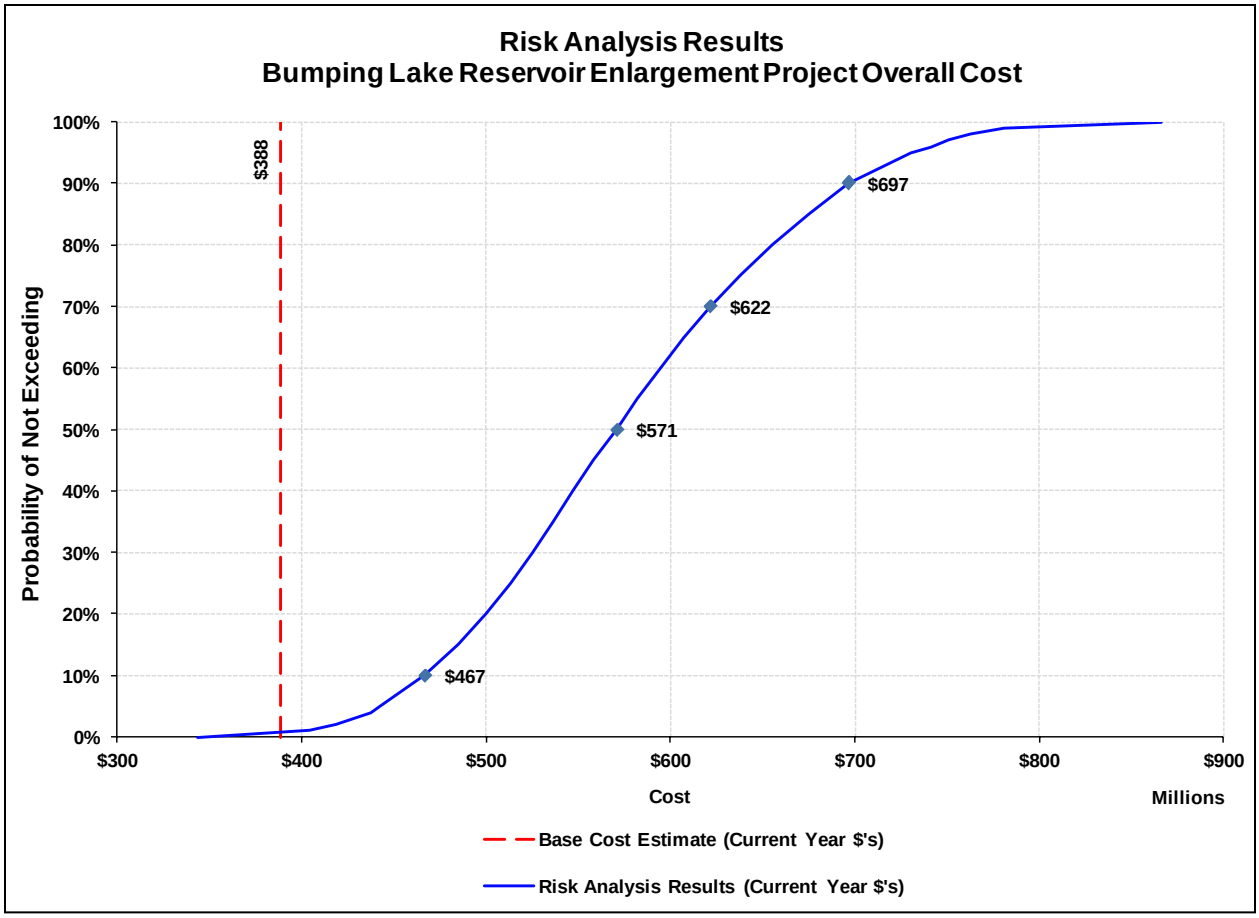

Figure 12. Total Project Costs for Bumping Lake Reservoir Enlargement

Figure 13 details the probabilistic construction cost results after accounting for risks and uncertainty. The 80 percent confidence interval reveals that the construction cost is expected to fall between $421 million and $649 million.

There is 50 percent likelihood that construction costs will not exceed $522 million.

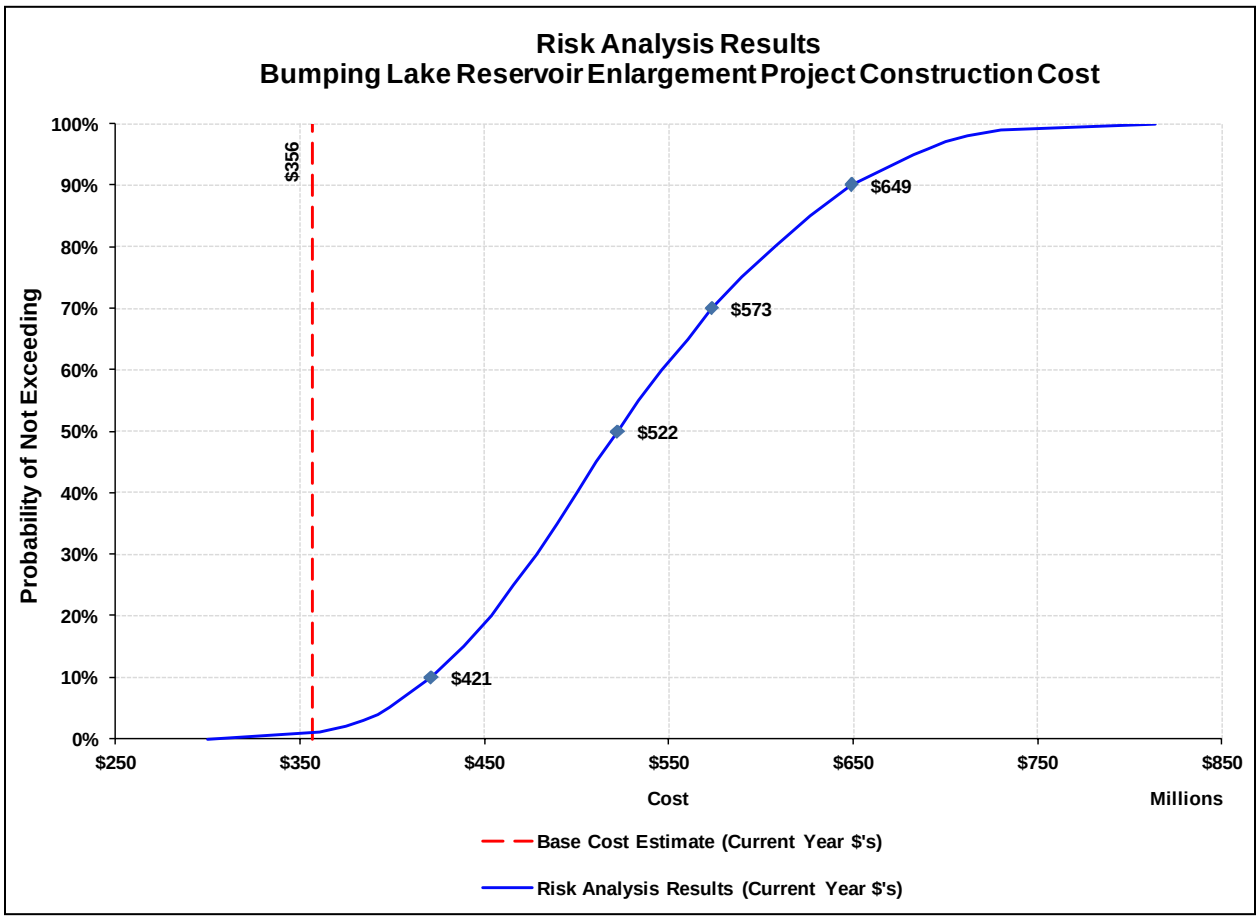

Figure 13. Construction Costs for Bumping Lake Reservoir Enlargement

Schedule Results

There were only two risks identified that may impact the overall project schedule:

- Historical and Cultural Resources (expected impact = 1 week)
- Added Cost and Duration for Planning Report and EIS (expected impact = 12 months)

Final Cost Comparison

For a basis of comparison the following charts were created showing the cost of each project before and after the CRA workshop.

The Pre-CRA costs include:

- Base Cost (3rd quarter 2010)
- Contingencies
- The cost to index the project to the 1st quarter 2012 using the Reclamation construction cost trend index

The CRA costs include:

- Adjusted Base Cost (Indexed to 1st quarter 2012)
- Base Cost Uncertainty at 50th percentile
- Risk Impact at 50th percentile

The costs shown are in millions of dollars.

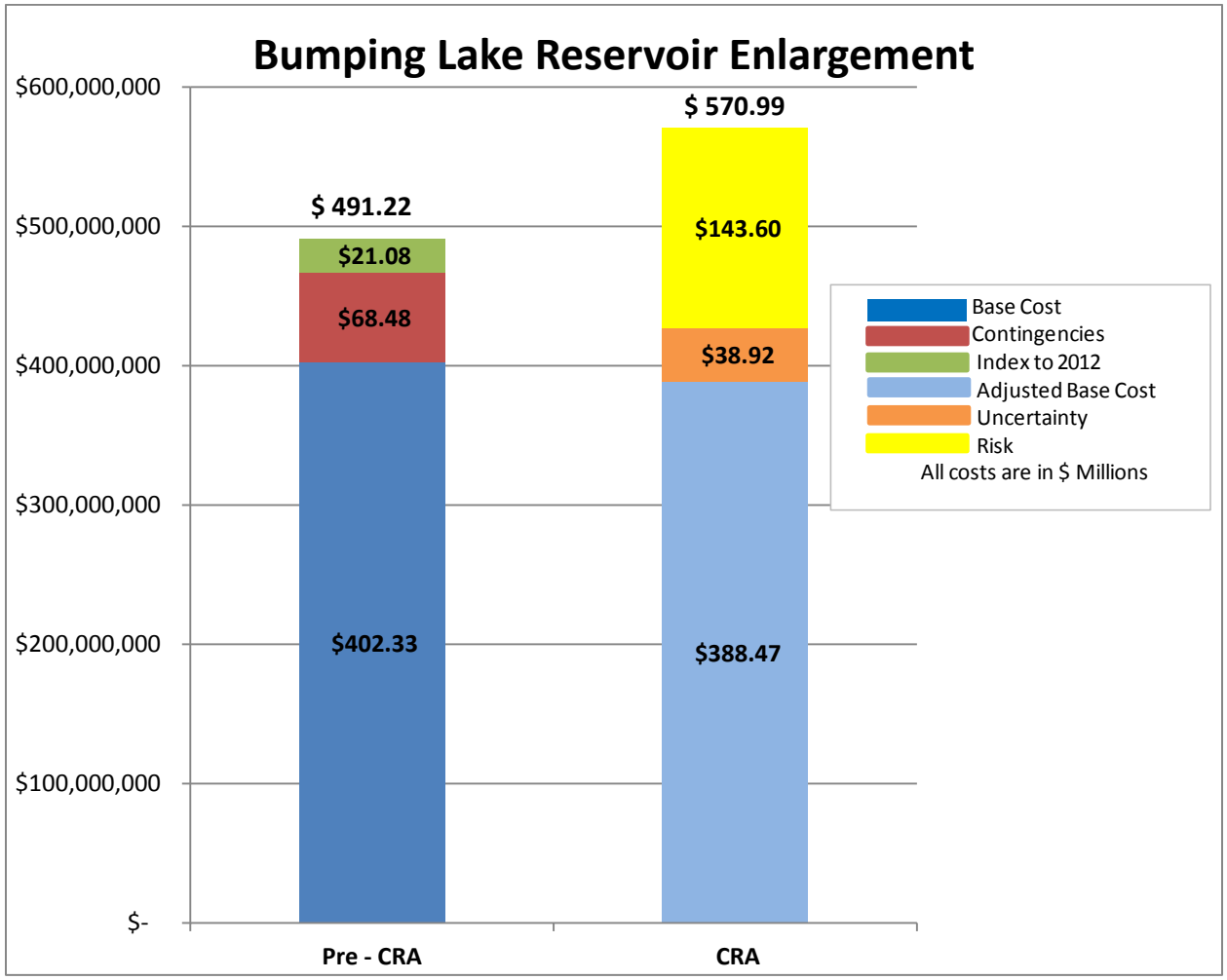

Figure 14. Final Cost Comparison for Bumping Lake Reservoir Enlargement

4.0 Keechelus to Kachess Conveyance

4.1 Overview

The Keechelus-to-Kachess Conveyance project proposes to transfer water directly from the Keechelus Reservoir to Kachess Reservoir (Reclamation and Ecology 2011e). The drainage basin for the Keechelus Reservoir produces more runoff than can be contained in the reservoir, while the Kachess Reservoir can be difficult to fill in some years. The conveyance system would increase the amount of water that could be stored in Kachess Reservoir in some years, increasing total water supply available (TWSA) and improving Reclamation's flexibility in providing water for both irrigation and fish needs.

The project would also allow some releases from Keechelus Reservoir to be routed through Kachess Reservoir, reducing unnaturally high flows in the Yakima River below Keechelus Reservoir, improving fish habitat conditions. The conveyance system would also help Kachess Reservoir refill after using inactive storage as proposed below in the Surface Water Storage Element.

A pipeline between the Keechelus Reservoir outlet and the existing Kachess Reservoir high-water shoreline would be approximately 5 miles long. The outfall pipe would extend into Kachess Reservoir to discharge below a proposed future minimum water lake surface elevation of approximately 2,110 feet.

Figure 15. Keechelus to Kachess Pipeline

A gravity pipeline will be used to convey flow from Keechelus Reservoir to Kachess Reservoir with a 40 to 50 foot cut required to get through the high point in the alignment. The 96-inch diameter steel gravity flow pipeline will convey an average of 400 cfs from Keechelus to Kachess. New fish screens and outlet bifurcation will convey flows to a new a new gravity flow

pipeline. A diffuser would be used to dissipate residual head at the pipeline outlet into Kachess Reservoir.

4.2 Base Cost Review

The CRA Team was provided a cost estimate for the Keechelus to Kachess Pipeline project from the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c) for review and validation during the workshop.

The Cost Lead reviewed the estimate for omissions and duplications, contingencies and uncertainty and presented the findings to the workshop team. Review of the estimate concentrated upon the major cost items of the estimate, and items with the greatest potential for uncertainty and risk (both threats and opportunities).

Table 14. Base Cost Summary Keechelus to Kachess Pipeline

Component	Amount
1. Materials and Labor	
Intake Screens & Connection to Existing Aqua Duct	$1,768,000
Wye Structure & Connections to Existing	4,446,000
Pipeline from Wye Structure to Future Outlet Control Valve Building	86,373,000
Pipeline from Future Outlet Control Valve Building to STA 275+10	958,000
Materials and Labor	93,546,000
2. Field Overhead and Mobilization	2,806,000
3. Other Contractor Costs	16,712,000
Contract Cost	113,064,000
4. Contingencies	28,266,000
Field Cost	141,330,000
5. Sales Tax	5,339,000
Construction Cost	$146,669,000
Non-Contract Cost	$44,000,000
Project Total	$190,669,000

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights of way that may be required for construction of the project features.

4.3 Base Cost Modifications

The purpose of the estimate review process is to validate the estimate components using both expert opinion and team consensus. To that end, some adjustments were made to the estimate based on discussion with the team during the workshop.

At the time of the workshop the quantity values for the items listed in the estimate were very preliminary which is expected since the design of the Keechelus to Kachess Pipeline was at less than 5 percent. Changes made as a result of the validation process and workshop was as follows:

Contingencies

The contingencies for both construction and design were removed from the base estimate summary and were captured as project risks (threats and opportunities) by the CRA Team.

Miscellaneous Item Allowance

The base estimate summary included a line item for unlisted minor items. This remained but was renamed to miscellaneous item allowance to cover known but unquantified items of work not covered in the individual items within the base estimate summary.

Non-Contract Costs

Non-contract costs were broken into categories, pre-construction (design & environmental permitting), planning report/EIS, construction engineering and right-of-way costs. These categories replaced the generic 30 percent added to each project.

- **Pre-Construction** - After discussions during the pre-workshop, the percentage of pre-construction for this project was established at 10 percent of the Contract Cost.
- **Planning Report/EIS** - After discussions during the pre-workshop and workshop, the cost of the planning report and EIS was estimated to be $2 million.
- **Construction Engineering** - After discussions during the pre-workshop, the percentage of construction engineering for this project was established at 9 percent of the Contract Cost.
- **Right-of-Way** - The Keechelus to Kachess Pipeline project will require the purchase of right-of-way and easements. The estimated cost to the project is $1.5 million.

Sales Tax

Sales tax was calculated at 8.2 percent on only the equipment and materials in the provided estimate. Sales tax for Kittitas County (8.0 percent) was applied to the entire contract amount in the adjusted base cost estimate.

Cost Index

The costs for this project were originally indexed to the 3rd quarter of 2010. The Cost Lead indexed the costs to the 1st quarter of 2012.

Table 15. Cost Indexing Keechelus to Kachess Pipeline

Component	Original Estimate ($M)	Indices		Index Category	Adjusted Base ($M)
		3rd Q 2010	1st Q 2012		
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10	$0.96	357	371	Steel Pipeline	$1.00
Intake Screens and Connection to existing Aqueduct	$1.71	325	351	Spillway	$1.85
Wye Structure & Connections to existing Pipeline from Wye	$4.45	357	371	Steel Pipeline	$4.62
Pipeline from Wye Str. to Outlet Control Valve Bldg	$86.37	357	371	Steel Pipeline	$89.76
Total	$93.49 M				$97.23 M

Uncertainty

With the project still very early in the development process (less than 5 percent design) the base uncertainty for the Keechelus to Kachess Pipeline project was established to be in the range of minus 20 to plus 40 percent by the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c).

Table 16. Uncertainty Ranges Keechelus to Kachess Pipeline

Component	Low	Under	Base	Over	High
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10	$766,439	-20%	$958,049	44%	$1,375,048
Intake Screens and Connection to existing Aqueduct	$1,370,336	-20%	$1,712,920	42%	$2,430,373
Wye Structure & Connections to existing Pipeline from Wye	$3,556,970	-20%	$4,446,213	40%	$6,243,541
Pipeline from Wye Str. to Outlet Control Valve Bldg	$73,413,445	-15%	$86,373,170	45%	$125,244,847
Total	$79,107,190	-15%	$93,490,352	45%	$135,293,808

The uncertainty of items within each component was reviewed by the CRA Cost Lead and, if needed, was adjusted slightly based on various factors such as level of design, location of work, amount of quantities, etc. See Appendix A - Uncertainty Calculations for further information.

With this project's schedule showing that it will "winter over" 3 times the uncertainty was adjusted up on the excavation and pipeline items.

The amount of rock excavation that will be needed also accounted for an increase in uncertainty in the Wye Structure & Connections to existing Pipeline from Wye component.

Adjusted Base Cost Estimate

The adjusted base cost estimate (1st quarter 2012) used during the cost risk assessment for the Keechelus to Kachess Pipeline project is shown below.

Table 17. Adjusted Base Cost Estimate Keechelus to Kachess Pipeline

Component		Under ($M)	%	Base ($M)	%	Over ($M)
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10				$1.00		
Intake Screens and Connection to existing Aqueduct				$1.85		
Wye Structure & Connections to existing Pipeline from Wye				$4.62		
Pipeline from Wye Str. to Outlet Control Valve Bldg				$89.76		
Subtotal		$82.28	-15%	$97.23	45%	$140.70
Miscellaneous Item Allowance	4%	$3.29		$3.89		$5.63
Bid Items Subtotal		$85.57		$101.12		$146.33
Contractors Field Overhead	2%	$1.71		$2.02		$2.93
Contractor's Fee	6%	$5.13		$6.07		$8.78
Contractor's Bond & Insurance	1.5%	$1.28		$ 1.52		$2.19
Subtotal with Contractor Markups		$93.70		$110.73		$160.23
Mobilization	1%	$0.94		$1.11		$1.60
Subtotal with Mobilization		$94.64		$111.83		$161.83
Sales Tax	8.0%	$7.57		$8.95		$12.95
Contract Cost (Base Cost for Construction)		$102.21		$120.78		$174.77
Pre-Construction	10%	$10.22		$12.08		$17.48
Planning Report & EIS		$1.80	-10%	$2.00	10%	$2.20
Construction Engineering	9%	$9.20		$10.87		$15.73
Right of Way Costs		$1.43	-5%	$1.50	20%	$1.80
Project Total		$124.85		$147.23		$211.98

Base Cost Comparison

Table 18 compares the main elements of the Base Cost Estimate provided and the Adjusted or CRA Base Cost Estimate that was established following the workshop review. The Adjusted Base Cost was used in the risk analysis model.

Table 18. Base Cost Comparison Keechelus to Kachess Pipeline

Item	Base Cost Estimate $ Million (2012)	Adjusted Base Cost $ Million (2012)
Components	$97.23	$97.23
Miscellaneous Item Allowance	$3.67	$3.89
Contractors Field Overhead	$1.94	$2.02
Contractor's Fee	$6.56	$6.07
Contractor's Bond & Insurance	$1.64	$1.52
Mobilization	$0.98	$1.11
Design/Scope Contingency	$3.67	
Cost Estimate Refinement	$1.83	
Construction Contingency	$29.40	
Sales Tax	$5.55	$8.95
Pre-Construction (Design)		$12.08
Planning Report & EIS		$2.00
Construction Engineering		$10.87
Right of Way		$1.50
Non-Contract Cost	$45.76	
Project Total	$198.23	$147.23

The contingencies for both construction and design were removed from the base cost estimate and were replaced by project risks (threats and opportunities) by the CRA Team.

4.4 Project Escalation Assumptions

Reclamation's Construction Cost Trends [CCT] (Reclamation 2012) are used to track construction relevant to the primary types of projects being constructed by the organization. All the various cost indexes consist of two elements, contractor labor and equipment costs, and contractor supplied materials and equipment.

Reclamation uses cost indices which provide a rapid means of determining the current cost of construction of various properties based on former estimates. For these projects all budgets will be calculated in CY dollars and then indexed to the year of construction once funding is authorized.

4.5 Project Schedule Validation

For the purposes of the CRA workshop the following schedule was assumed.

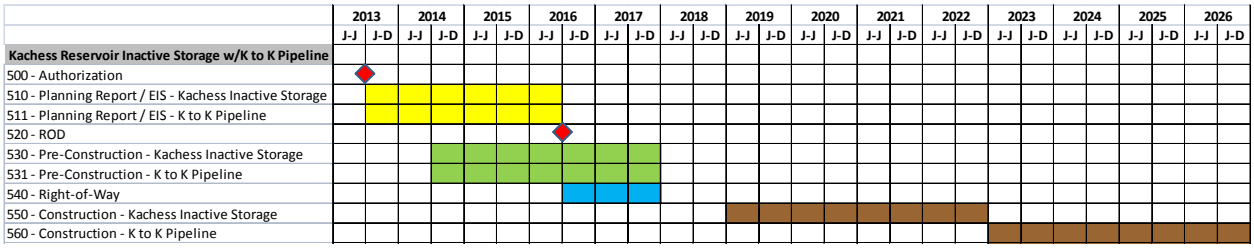

Figure 16. Project Schedule Keechelus to Kachess Conveyance

4.6 Cost Risk Assessment

Risk Elicitation

During the discussion of the project, the workshop participants identified 12 high risk elements or potential events which may occur that would impact the project. A tunnel option was considered along with the original pipeline option. See the Risk Register in Appendix B for additional information on each project risk. These active risks included:

- Historical and Cultural Resources
- K to K Pipeline Revised Alignment
- K to K Tunnel Alignment Alternative Lack of Geological Information
- Water Treatment
- Trench Excavation
- Permanent Access Roads
- Mitigation for Loss of Habitat
- Property Acquisition
- Tribal Employment Rights Office (TERO)
- Design and Scope Changes
- Minor Aggregate Risk

It was recognized during the CRA workshop that all of the geology within the project plan area could be considered preliminary or regional geology. The Keechelus to Kachess Conveyance has no site specific exploration. The geology along the pipeline alignment is based on interpretation of existing geologic surface maps.

The tornado diagram for the top cost risks is shown in Figure 17. This tornado diagram shows the expected value of the cost for each event risk, based on Monte Carlo simulation.

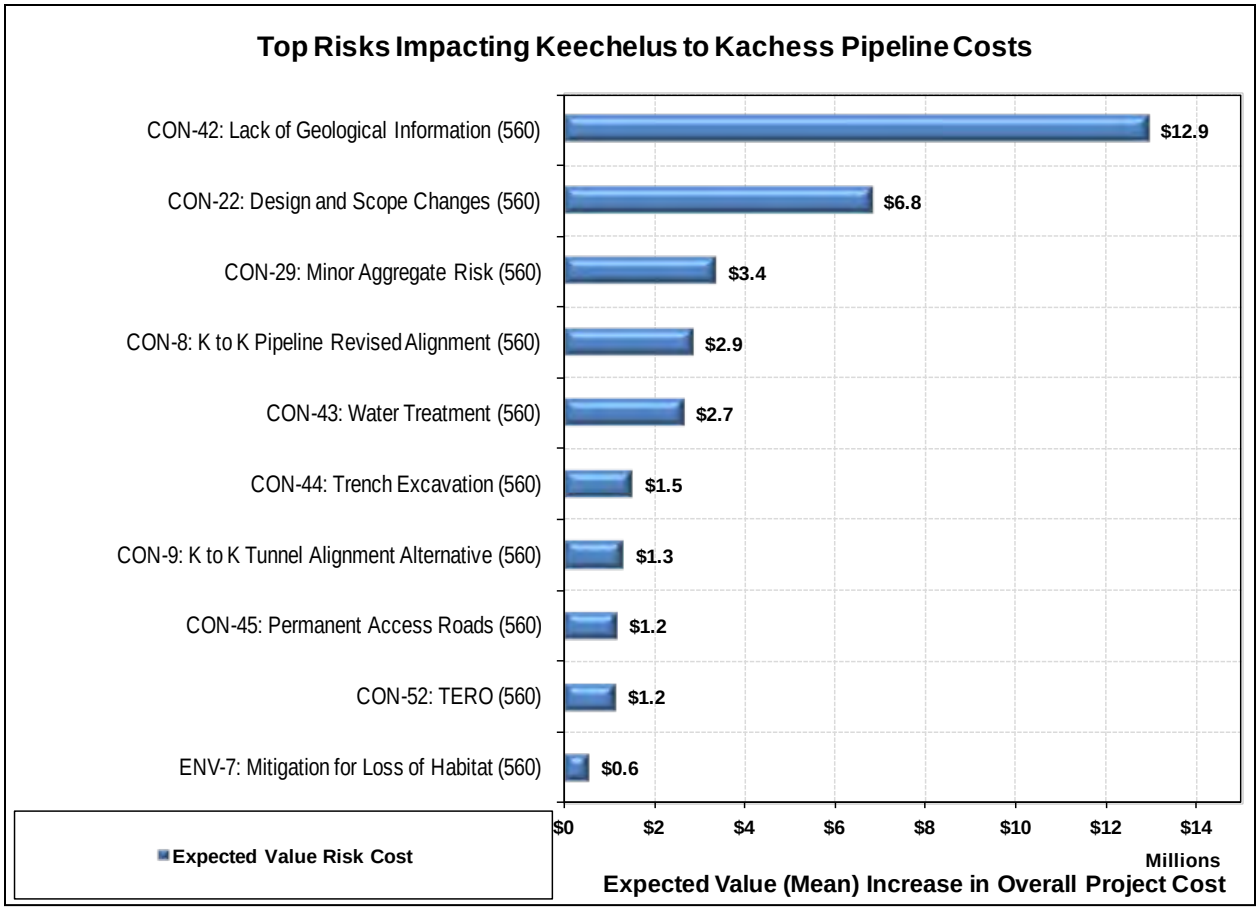

Figure 17. Tornado Diagram of Risks for the Keechelus to Kachess Conveyance

The direct event risk cost impact is measured as the probability of the risk occurring times the mean cost impact developed from the risk cost ranges recorded within the risk register during the CRA Workshop.

Cost Results

Figure 18 details the probabilistic total project cost results after accounting for risks and uncertainty. The 80 percent confidence interval, described by the cost range between the 10th percentile and 90th percentile figures, reveals that the construction cost is expected to fall between $153 million and $250 million.

There is also a 50 percent chance that the total project cost will be less than $197 million.

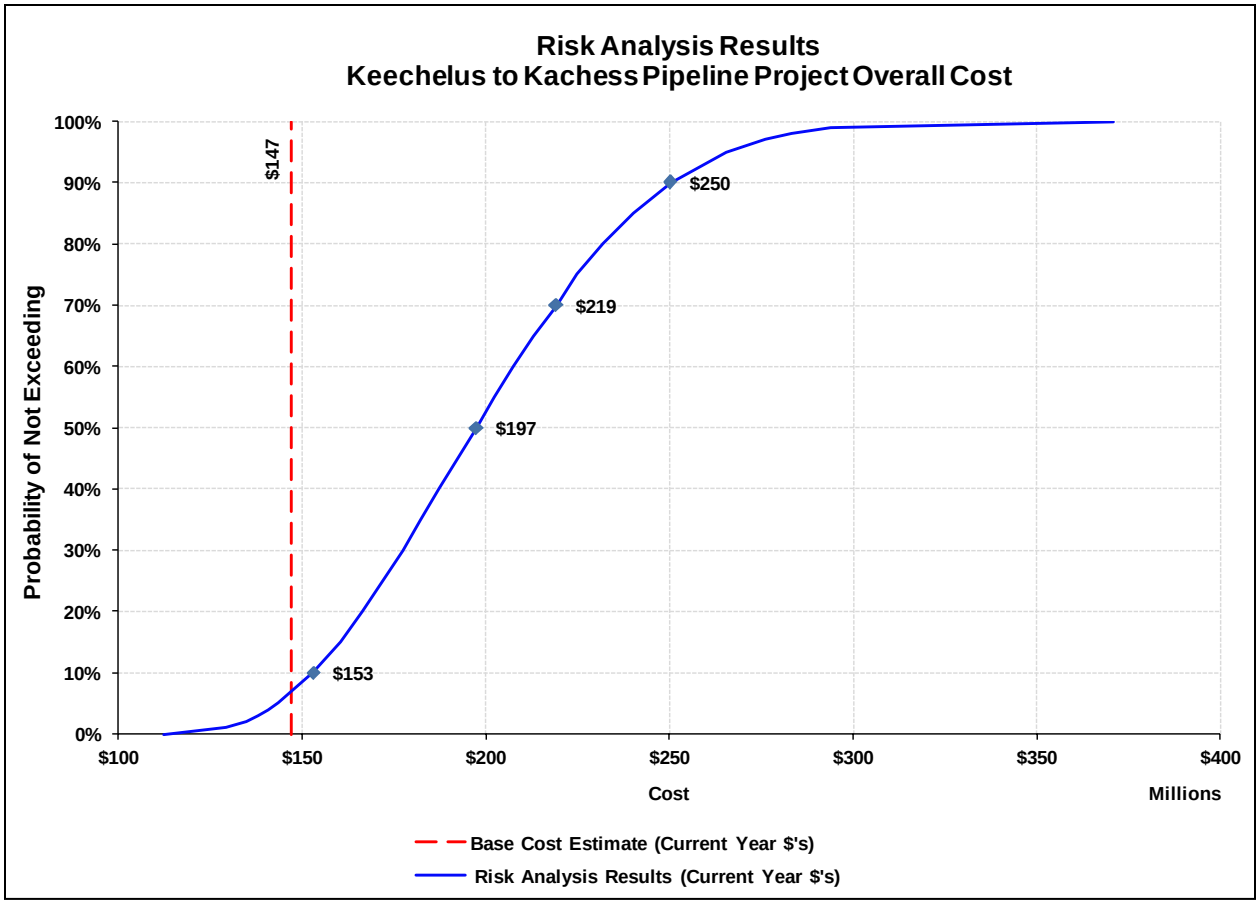

Figure 18. Total Project Cost Keechelus to Kachess Conveyance

Figure 19 details the probabilistic construction cost results after accounting for risks and uncertainty. The 80 percent confidence interval reveals that the construction cost is expected to fall between $134 million and $228 million.

There is 50 percent likelihood that construction costs will not exceed $177 million.

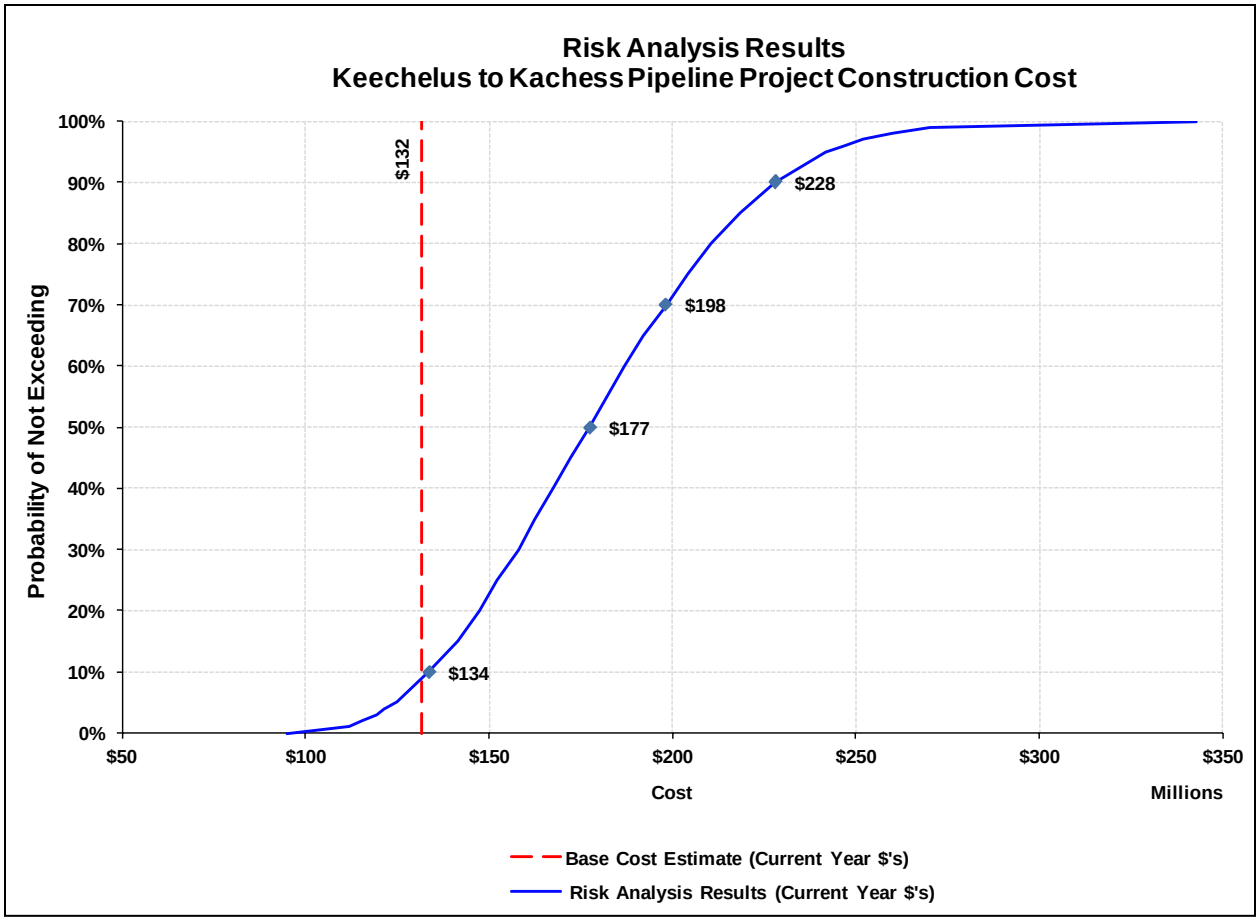

Figure 19. Construction Costs Keechelus to Kachess Conveyance

Schedule Results

There was only one identified schedule risk for the K to K Pipeline project – Historical and Cultural Resources. This risk has an expected impact of 1 week.

Final Cost Comparison

For a basis of comparison the following charts were created showing the cost of each project before and after the CRA workshop.

The Pre-CRA costs include:

- Base Cost (3rd quarter 2010)
- Contingencies
- The cost to index the project to the 1st quarter 2012 using the Reclamation construction cost trend index

The CRA costs include:

- Adjusted Base Cost (Indexed to 1st quarter 2012)
- Base Cost Uncertainty at 50th percentile
- Risk Impact at 50th percentile

The costs shown are in millions of dollars.

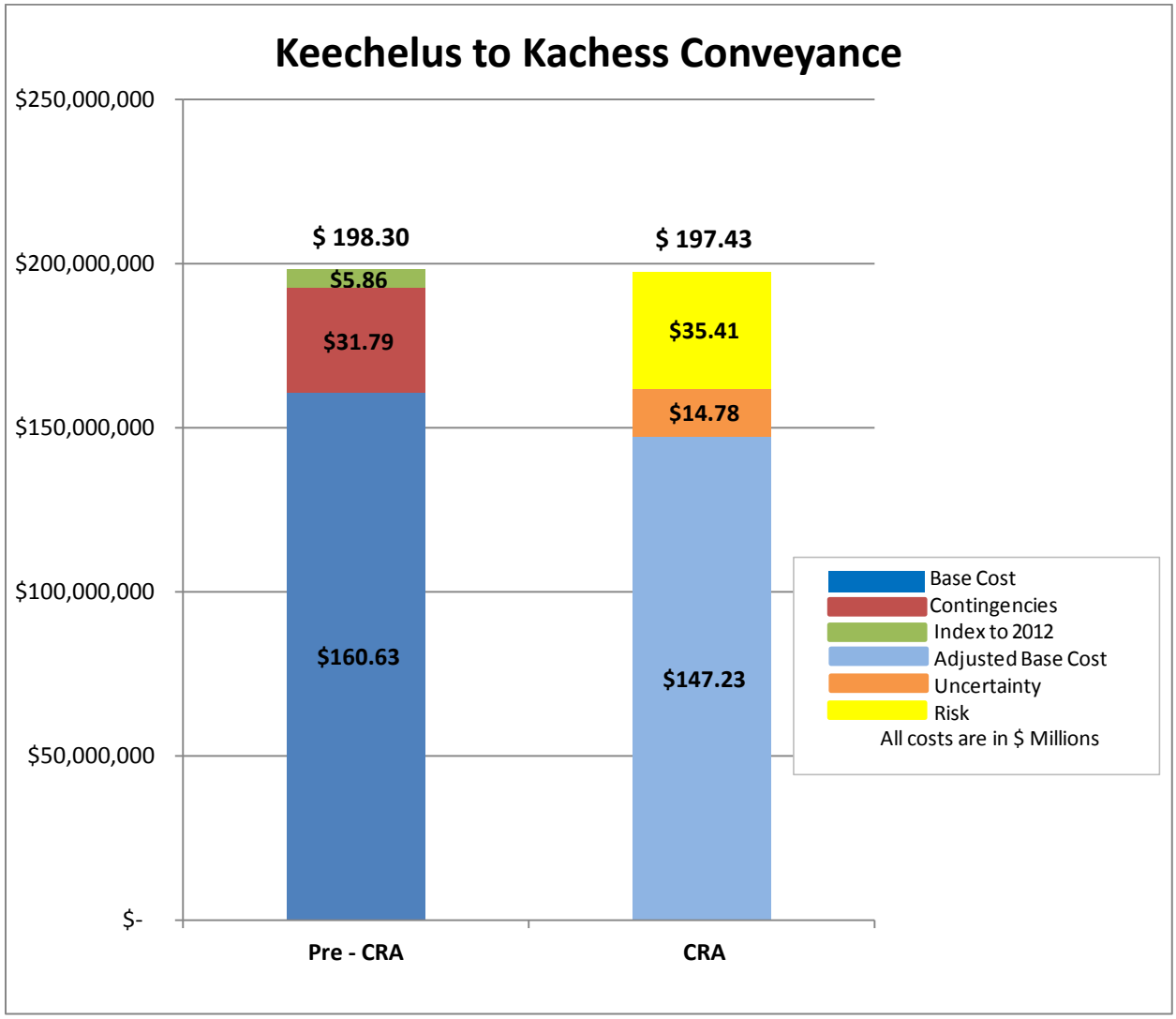

Figure 20. Final Cost Comparison for Keechelus to Kachess Conveyance

5.0 Kachess Inactive Storage Alternative 1

5.1 Overview

The Kachess Reservoir is located just east of I-90 near Easton, Washington. The project would modify the outlet to Kachess Reservoir to allow it to be drawn down approximately 80 feet lower than the current outlet. This would provide the ability to withdraw another 200,000 acre-feet of water from the lake, when needed, for downstream uses during drought conditions (Reclamation and Ecology 2011f).

Two options have been identified to withdraw the additional water from Kachess Reservoir, both starting from a new lake tap outlet in the Kachess Dam about 80 feet deeper than the existing outlet at the southeast end of the lake.

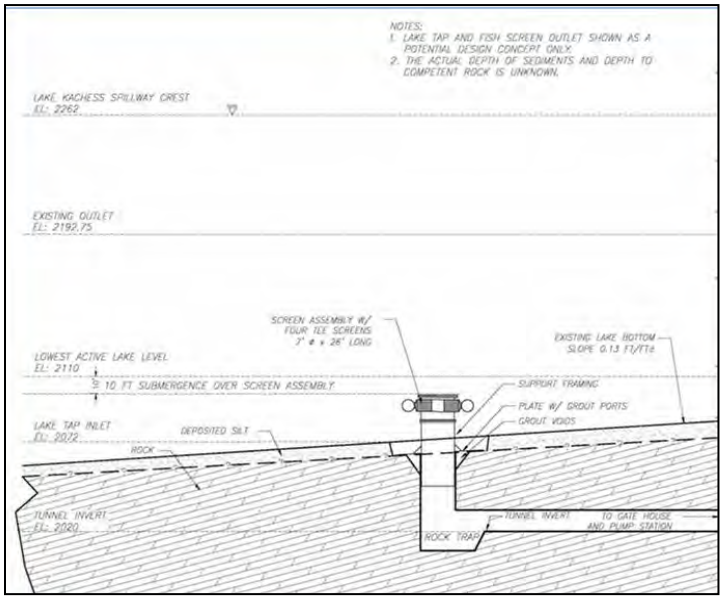

Figure 21. Lake Tap

Lake tapping is a method of blasting an intake into a body of water from below the natural water surface without lowering that surface or installing a cofferdam around the tap hole. Lake taps are done by first excavating a tunnel almost to the water/rock contact and then blasting out the final rock plug at one time to allow water to suddenly inflow into the tunnel from the lake.

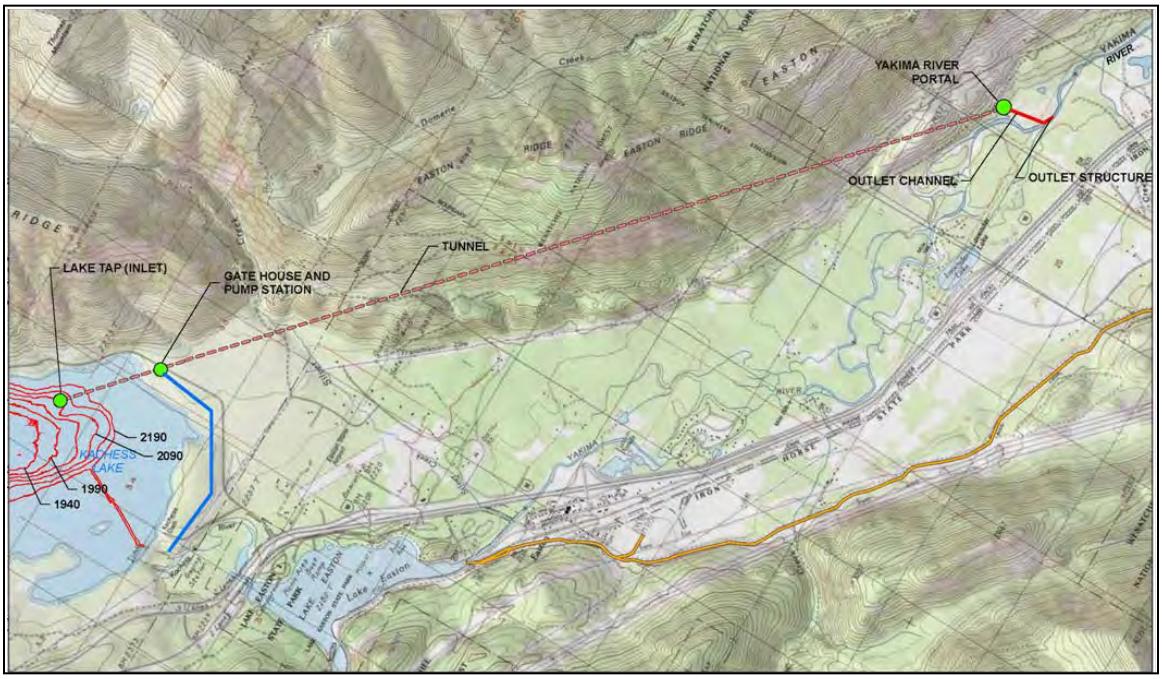

Figure 22. Kachess Inactive Storage Alternatives

Alternative 1 (**red dashed line** on Figure 22) would use a gravity-flow tunnel that would discharge into the Yakima River approximately 4.6 miles southeast of the Kachess Dam.

5.2 Base Cost Review

The CRA Team was provided a cost estimate for the Kachess Inactive Storage Alternative 1 project from the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c) for review and validation during the workshop.

The Cost Lead reviewed the estimate for omissions and duplications, contingencies and uncertainty and presented the findings to the workshop team. Review of the estimate concentrated upon the major cost items of the estimate, and items with the greatest potential for uncertainty and risk (both threats and opportunities).

Table 19. Base Cost Summary for Kachess Inactive Storage Alternative 1

Component	Amount
1. Materials and Labor	
Lake Kachess Outlet to Pump Station	$12,909,000
Pump Station – 20 CFS	15,329,000
Pipeline – 20" from Pump Station to Kachess River Discharge	3,122,000
Tunnel From Pump Station to Yakima River	85,997,000
Yakima River Discharge Structure	4,489,000
Kachess River Discharge Structure	586,000
Materials and Labor	122,432,000
2. Field Overhead and Mobilization	7,346,000
3. Other Contractor Costs	25,640,000
Contract Cost	155,419,000
4. Contingencies	38,855,000
Field Cost	194,273,000
5. Sales Tax	970,000
Construction Cost	$195,243,000
Non-Contract Cost	$58,600,000
Project Total	$253,843,000

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights of way that may be required for construction of the project features.

5.3 Base Cost Modifications

The purpose of the estimate review process is to validate the estimate components using both expert opinion and team consensus. To that end, some adjustments were made to the estimate based on discussion with the team during the workshop. At the time of the workshop the

quantity values for the items listed in the estimate were very preliminary which is expected since the design of the Kachess Inactive Storage Alternative 1 was at less than 5 percent.

Significant changes made as a result of the validation process and workshop was as follows:

Contingencies

The contingencies for both construction and design were removed from the base estimate summary and were captured as project risks (threats and opportunities) by the CRA Team.

Miscellaneous Item Allowance

The base estimate summary included a line item for unlisted minor items. This remained but was renamed to miscellaneous item allowance to cover known but unquantified items of work not covered in the individual items within the base estimate summary.

Non-Contract Costs

Non-contract costs were broken into categories, pre-construction (design & environmental permitting), planning report/EIS, construction engineering and right-of-way costs. These categories replaced the generic 30 percent added to each project.

- **Pre-Construction** - After discussions during the pre-workshop, the percentage of pre-construction for this project was established at 10 percent of the Contract Cost.
- **Planning Report/EIS** - After discussions during the pre-workshop and workshop, the cost of the planning report and EIS was estimated to be $1 million.
- **Construction Engineering** - After discussions during the pre-workshop, the percentage of construction engineering for this project was established at 9 percent of the Contract Cost.
- **Right-of-Way** - The Kachess Inactive Storage Alternative 1 project will require the purchase of right of way and easements. The estimate cost to the project is $1.5 million.

Sales Tax

Sales tax was calculated at 8.2 percent on only the equipment and materials in the provided estimate. Sales tax for Kittitas County (8.0-percent) was applied to the entire contract amount in the adjusted base cost estimate.

Cost Index

The costs for this project were originally indexed to the 3rd quarter of 2010. The Cost Lead indexed the costs to the 1st quarter of 2012.

Table 20. Cost Indexing for Kachess Inactive Storage Alternative 1

Component	Original Estimate ($M)	Indices		Index Category	Adjusted Base ($M)
		3rd Q 2010	1st Q 2012		
Kachess River Discharge Structure	$0.59	343	364	Outlet Works	$0.62
Pipeline 20" from Pump Station to Kachess River Discharge	$3.12	357	371	Steel Pipeline	$3.24
Yakima River Discharge Structure	$4.49	343	364	Outlet Works	$4.76
Tunnel - Lake Outlet to Pump Station	$12.91	351	370	Tunnel	$13.61
Pump Station 20 CFS	$15.33	326	344	Pumping Plants	$16.17
Tunnel from Pump Station to Yakima River	$86.00	351	370	Tunnel	$90.65
Total	$121.32 M				$127.88 M

Uncertainty

With the project still very early in the development process (less than 5 percent design) the base uncertainty for the Kachess Inactive Storage Alternative 1 project was established to be in the range of minus 20 to plus 40 percent by the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c).

Table 21. Uncertainty Ranges for Kachess Inactive Storage Alternative 1

Component	Low	Under	Base	Over	High
Kachess River Discharge Structure	$469,049	-20%	$586,311	50%	$879,467
Pipeline 20" from Pump Station to Kachess River Discharge	$2,497,802	-20%	$3,122,252	40%	$4,380,760
Yakima River Discharge Structure	$3,591,503	-20%	$4,489,379	40%	$6,292,008
Tunnel - Lake Outlet to Pump Station	$10,788,356	-15%	$12,909,399	47%	$18,994,832
Pump Station 20 CFS	$12,262,808	-20%	$15,328,510	40%	$21,472,349
Tunnel from Pump Station to Yakima River	$73,097,104	-16%	$85,996,593	45%	$124,695,060
Total	$102,706,621	-17%	$122,432,444	44%	$176,714,474

The uncertainty of items within each component was reviewed by the CRA Cost Lead and, if needed, was adjusted slightly based on various factors such as level of design, location of work, amount of quantities, etc. See Appendix A - Uncertainty Calculations for further information.

The uncertainty of the construction methods for the Lake Tap resulted in an increase to the uncertainty of the Tunnel – Lake Outlet to Pump Station component. The Tunnel from Pump Station to Yakima River and the Kachess River Discharge Structure components consisted of mostly minor items resulting in an increase in uncertainty.

Adjusted Base Cost Estimate

The adjusted base cost estimate (1st quarter 2012) for the Kachess Inactive Storage Alternative 1 project is shown below.

Table 22. Adjusted Base Cost Estimate for Kachess Inactive Storage Alternative 1

Component		Under ($M)	%	Base ($M)	%	Over ($M)
Kachess River Discharge Structure				$0.62		
Pipeline 20" - Pump Station to Kachess River Discharge				$3.24		
Yakima River Discharge Structure				$ 4.76		
Tunnel - Lake Outlet to Pump Station				$13.61		
Pump Station 20 CFS				$16.17		
Tunnel from Pump Station to Yakima River				$90.65		
Subtotal		$107.70	-17%	$129.05	44%	$185.74
Miscellaneous Item Allowance	4%	$4.31		$5.16		$7.43
Bid Items Subtotal		$112.01		$134.21		$193.17
Contractors Field Overhead	4%	$4.48		$5.37		$7.73
Contractor's Fee	8%	$8.96		$10.74		$15.45
Contractor's Bond & Insurance	1.5%	$1.68		$2.01		$2.90
Subtotal with Contractor Markups		$127.13		$152.33		$219.25
Mobilization	2%	$2.54		$3.05		$4.38
Subtotal with Mobilization		$129.67		$155.38		$223.68
Sales Tax	8.0%	$10.29		$12.32		$17.74
Contract Cost (Base Cost for Construction)		$140.05		$167.81		$241.52
Pre-Construction	10%	$14.00		$16.78		$24.15
Planning Report & EIS		$0.90	-10%	$1.00	10%	$1.10
Construction Engineering	9%	$12.60		$15.10		$21.74
Right of Way Costs		$0.50	-30%	$ 0.72	40%	$1.01
Project Total		$168.06		$201.41		$289.52

Base Cost Comparison

Table 23 compares the main elements of the Base Cost Estimate provided and the Adjusted or CRA Base Cost Estimate that was established following the workshop review. The Adjusted Base Cost was used in the risk analysis model.

Table 23. Base Cost Comparison for Kachess Inactive Storage Alternative 1

Item	Base Cost Estimate $ Million (2012)	Adjusted Base Cost $ Million (2012)
Components	$129.05	$129.05
Miscellaneous Item Allowance	$5.12	$5.16
Contractors Field Overhead	$5.17	$5.37
Contractor's Fee	$11.97	$10.74
Contractor's Bond & Insurance	$2.25	$2.01
Mobilization	$2.58	$3.05
Design/Scope Contingency	$5.12	
Cost Estimate Refinement	$2.56	
Construction Contingency	$40.96	
Sales Tax	$1.02	$12.43
Pre-Construction (Design)		$16.78
Planning Report & EIS		$1.00
Construction Engineering		$15.10
Right of Way		$0.72
Non-Contract Cost	$61.75	
Project Total	$267.57	$201.41

The contingencies for both construction and design were removed from the base cost estimate and were replaced by project risks (threats and opportunities) by the CRA Team.

5.4 Project Escalation Assumptions

Reclamation's Construction Cost Trends [CCT] (Reclamation 2012) are used to track construction relevant to the primary types of projects being constructed by the organization. All the various cost indexes consist of two elements, contractor labor and equipment costs, and contractor supplied materials and equipment.

Reclamation uses cost indices which provide a rapid means of determining the current cost of construction of various properties based on former estimates. For these projects all budgets will be calculated in CY dollars and then indexed to the year of construction once funding is authorized.

5.5 Project Schedule Validation

For the purposes of the CRA workshop the following schedule was assumed.

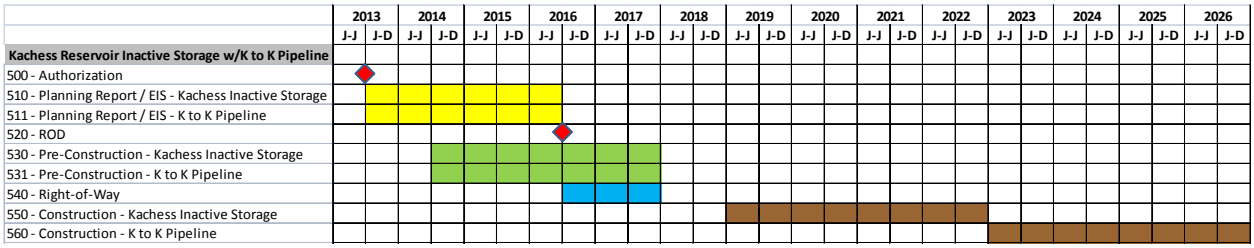

Figure 23. Project Schedule for Kachess Inactive Storage Alternative 1

5.6 Cost Risk Assessment

Risk Elicitation

During the discussion of the project, the workshop participants identified 10 high risk elements or potential events which may occur that would impact the project. See the Risk Register in Appendix B for additional information on each project risk. These active risks included:

- Historical and Cultural Resources
- Kachess Lake Tap & Tunnel
- Mitigation for Loss of Habitat
- Lack of Geological Information
- Pumping from Lake Easton
- Portal Construction
- Water Treatment
- Tribal Employment Rights Office (TERO)
- Design and Scope Changes
- Minor Aggregate Risk

It was recognized during the CRA workshop that all of the geology within the project area could be considered preliminary or regional geology. The lake tap design at Kachess Reservoir has had no site specific investigation. The assumption that the structure will have a rock foundation and the elevation of suitable rock is an educated guess that is unverified. Lake taps and tunneling are, of themselves, risky and difficult features to construct even with good geologic information.

There is also 4.6 miles of tunnel whose alignment has not been investigated by any drill holes. Risk were identified based upon the design assumptions that were made on what the foundation conditions might be for a specific alignment based on existing geologic surface maps.

The tornado diagram for the top cost risks is shown in Figure 24. This tornado diagram shows the expected value of the cost for each event risk, based on Monte Carlo simulation.

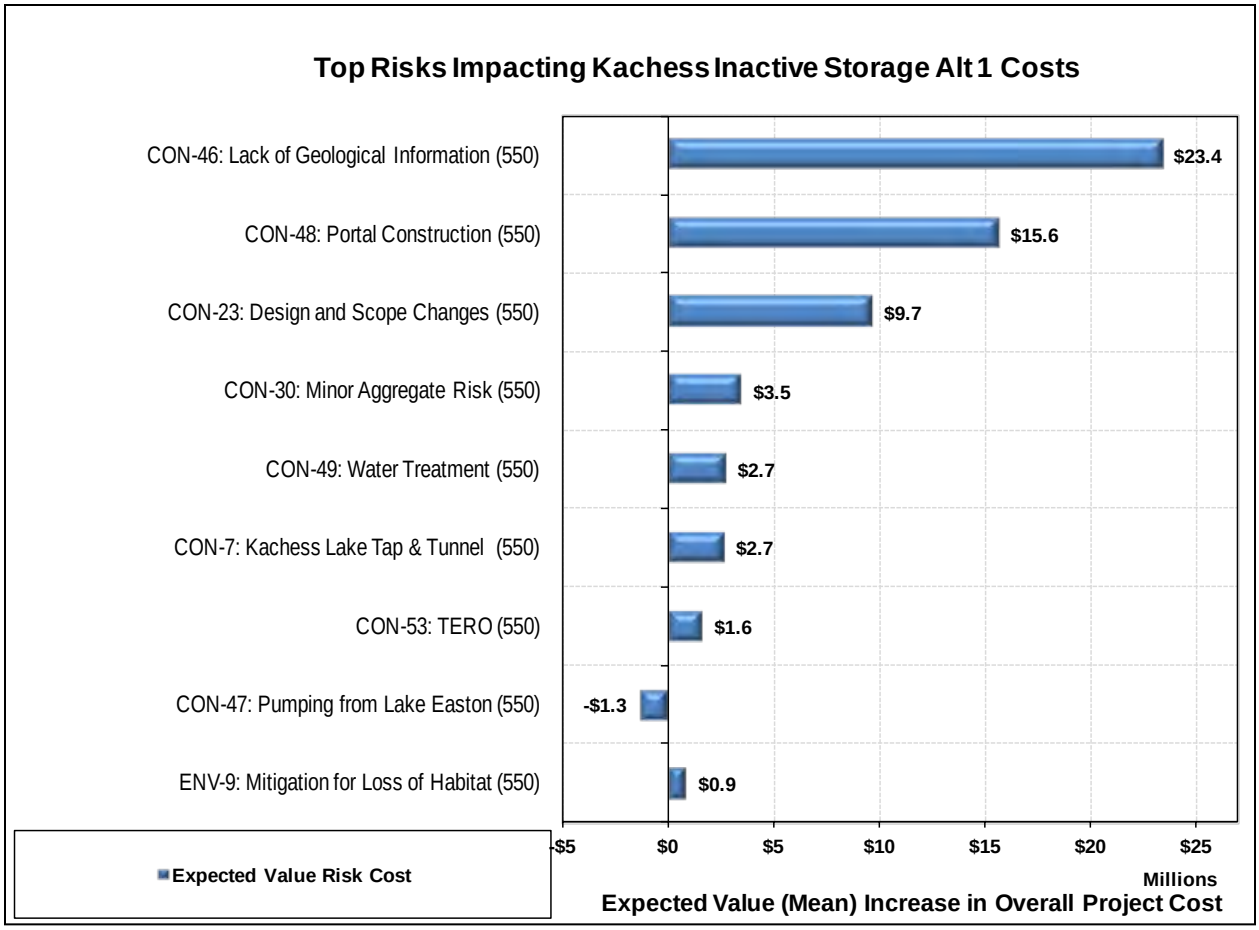

Figure 24. Tornado Diagram of Risks for Kachess Inactive Storage, Alternative 1

The direct event risk cost impact is measured as the probability of the risk occurring times the mean cost impact developed from the risk cost ranges recorded within the risk register during the CRA Workshop.

Cost Results

Figure 25 details the probabilistic total project cost results after accounting for risks and uncertainty. The 80 percent confidence interval, described by the cost range between the 10th percentile and 90th percentile figures, reveals that the construction cost is expected to fall between $215 million and $351 million.

There is 50 percent chance that the total project cost will be less than $279 million.

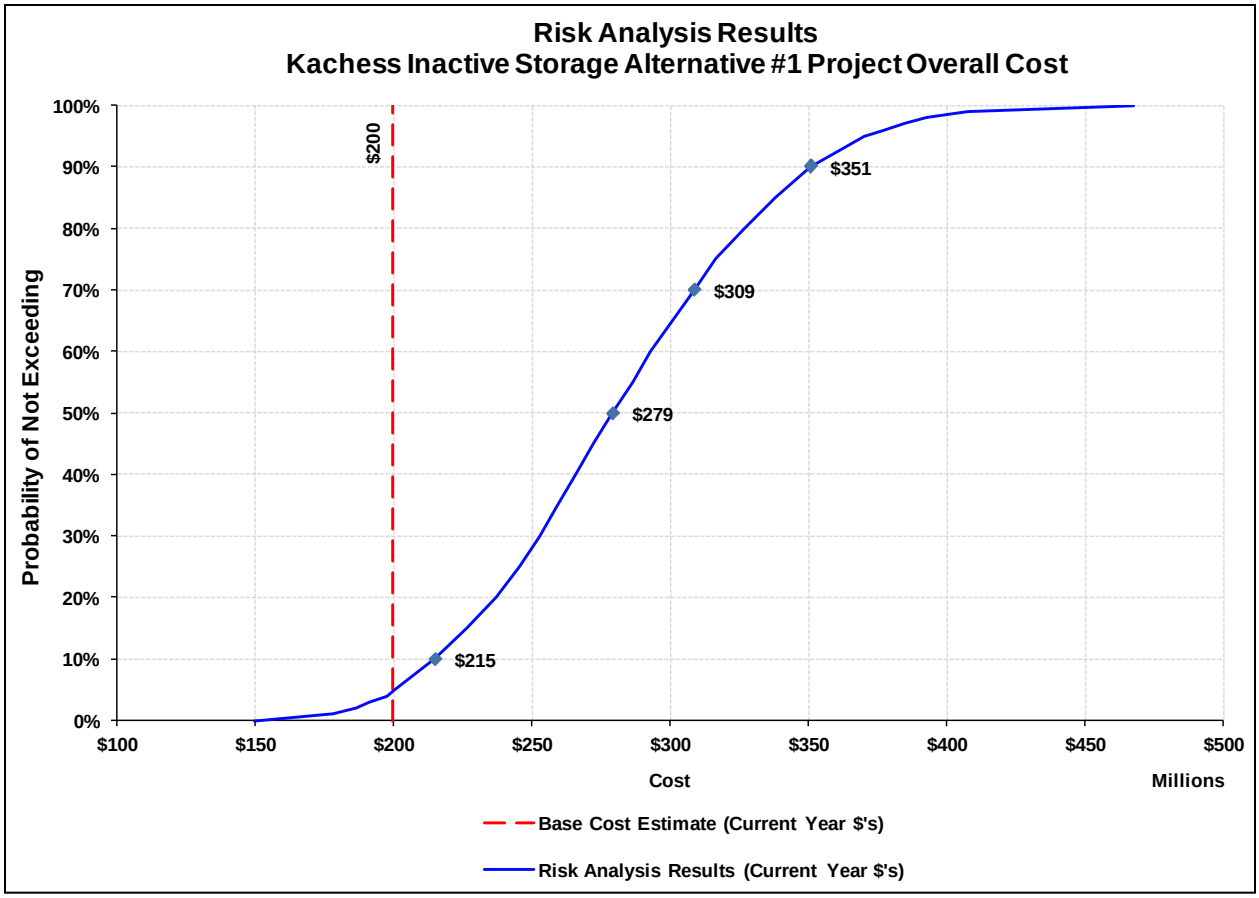

Figure 25. Total Project Costs for Kachess Inactive Storage Alternative 1

Figure 26 details the probabilistic construction cost results after accounting for risks and uncertainty. The 80 percent confidence interval reveals that the construction cost is expected to fall between $193 million and $323 million.

There is 50 percent likelihood that construction costs will not exceed $254 million.

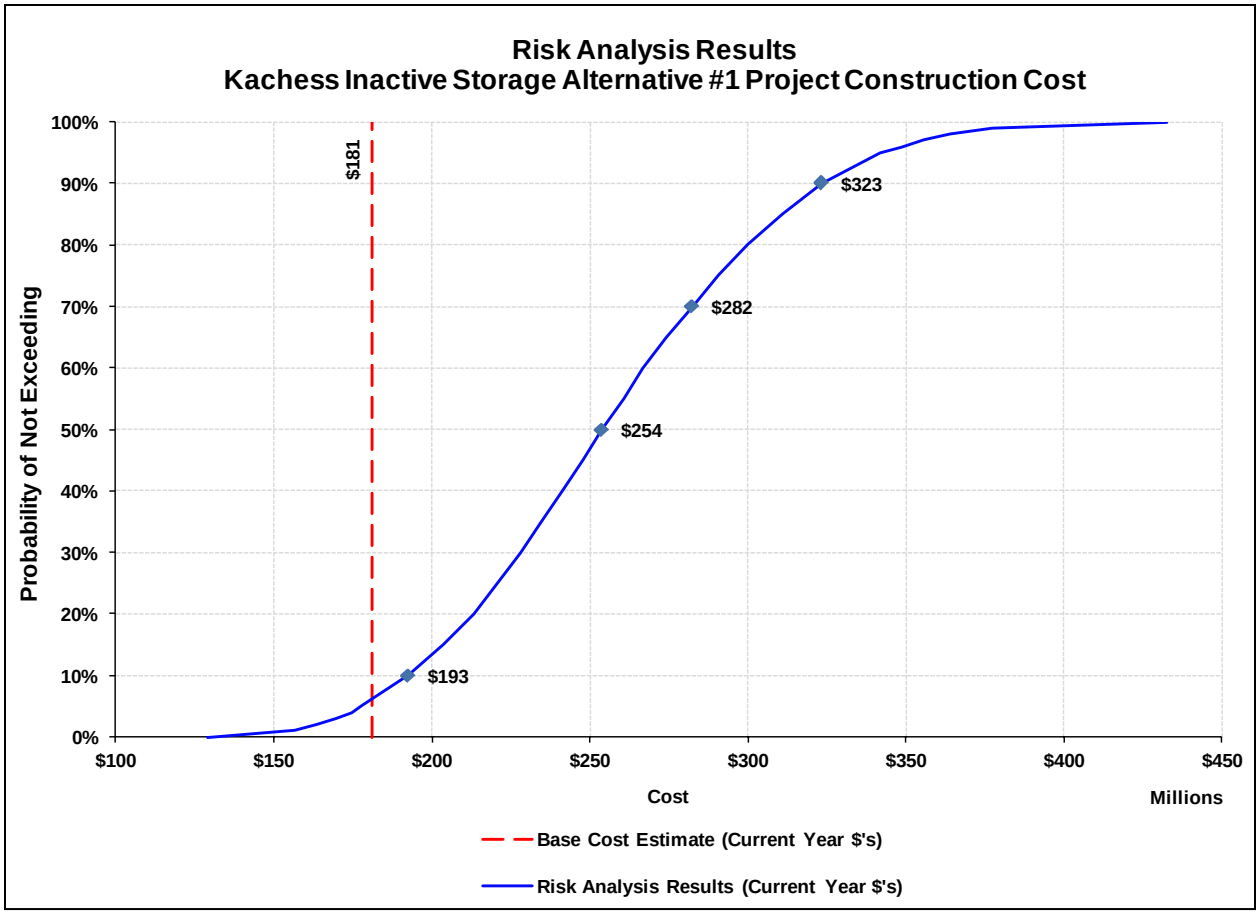

Figure 26. Construction Costs for Kachess Inactive Storage Alternative 1

Schedule Results

There was only one identified schedule risk for the Kachess Inactive Storage Alternative 1 project – Historical and Cultural Resources. This risk has an expected impact of 1 week.

Final Cost Comparison

For a basis of comparison the following charts were created showing the cost of each project before and after the CRA workshop.

The Pre-CRA costs include:

- Base Cost (3rd quarter 2010)
- Contingencies
- The cost to index the project to the 1st quarter 2012 using the Reclamation's construction cost trend index

The CRA costs include:

- Adjusted Base Cost (Indexed to 1st quarter 2012)
- Base Cost Uncertainty at 50th percentile
- Risk Impact at 50th percentile

The costs shown are in millions of dollars.

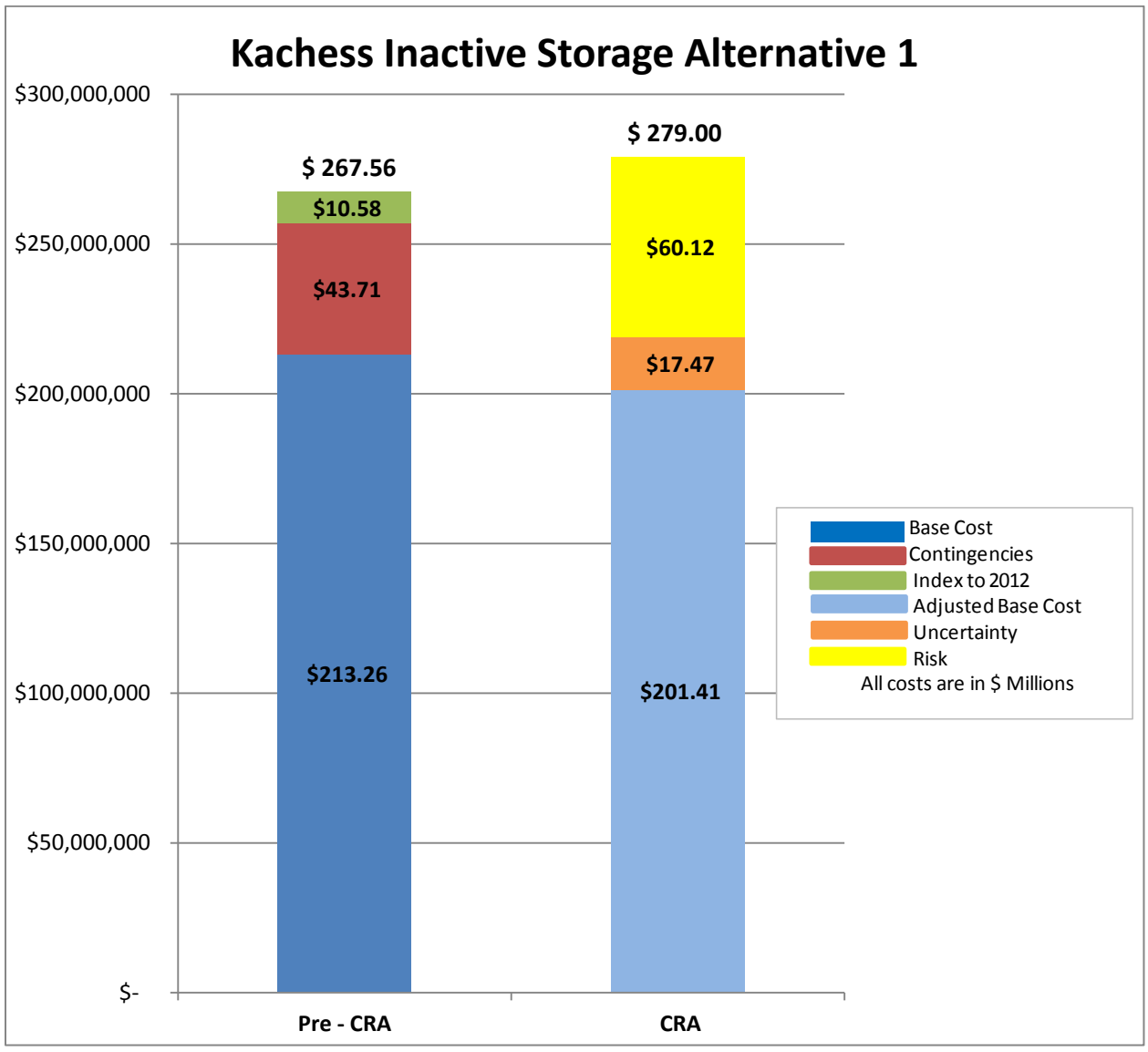

Figure 27. Final Cost Comparison for Kachess Inactive Storage Alternative 1

6.0 Kachess Inactive Storage Alternative 2

6.1 Overview

The Kachess Reservoir is located just east of I-90 near Easton, Washington. The project would modify the outlet to Kachess Reservoir to allow it to be drawn down approximately 80 feet lower than the current outlet. This would provide the ability to withdraw another 200,000 acre-feet of water from the lake for downstream uses during drought conditions (Reclamation and Ecology 2011f).

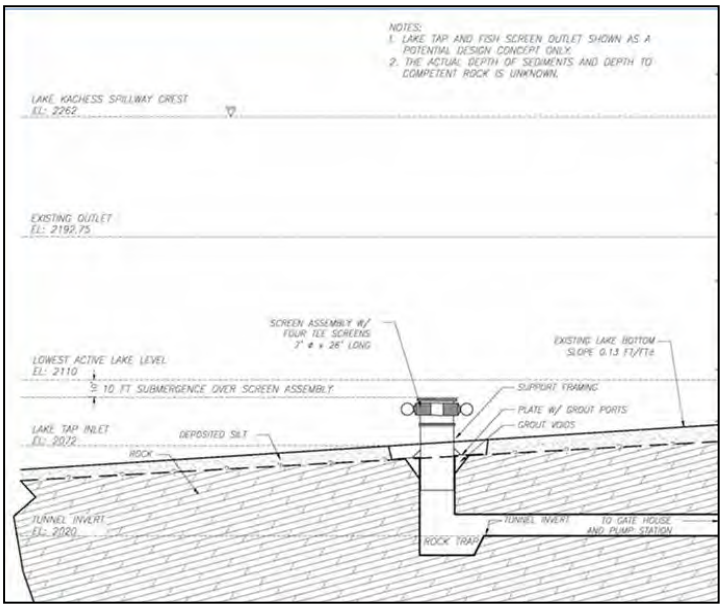

Figure 28. Lake Tap

Two options have been identified to withdraw the additional water from Kachess Reservoir, both starting from a new lake tap outlet in the Kachess Dam about 80 feet deeper than the existing outlet at the southeast end of the lake.

Lake tapping is a method of blasting an intake into a body of water from below the natural water surface without lowering that surface or installing a cofferdam around the tap hole. Lake taps are done by first excavating a tunnel almost to the water/rock contact and then blasting out the final rock plug at one time to allow water to suddenly inflow into the tunnel from the lake.

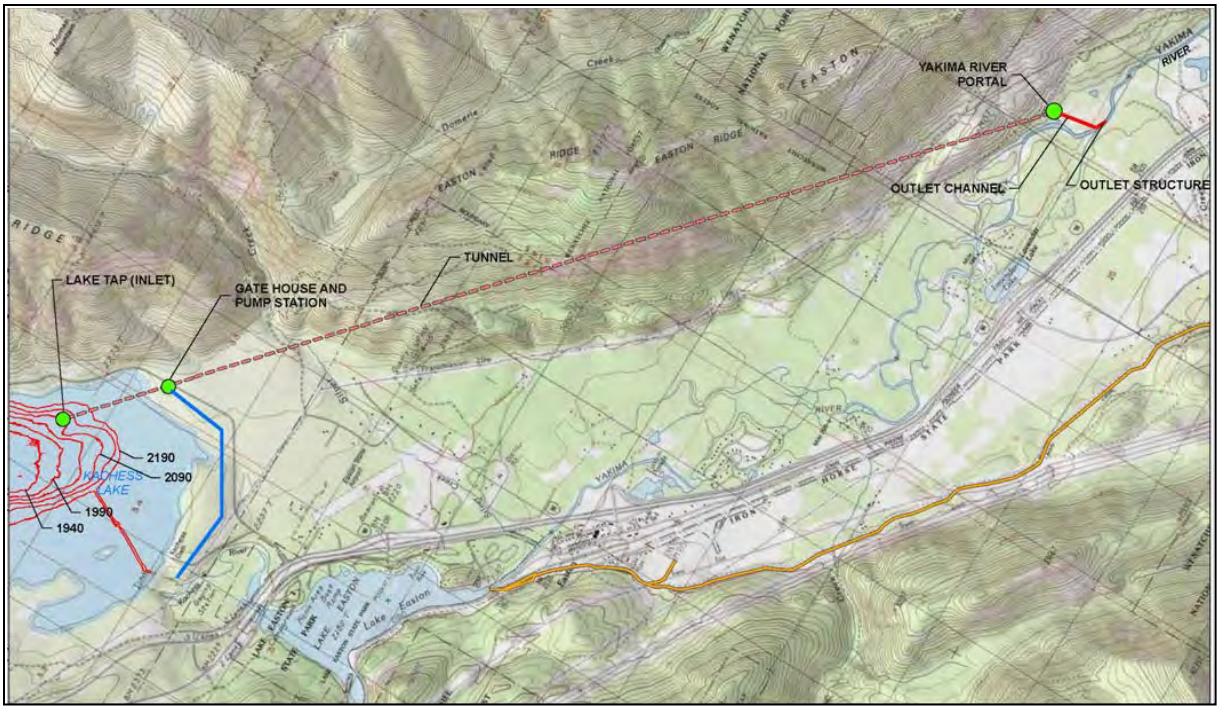

Figure 29. Kachess Inactive Storage Alternatives

Alternative 2 (**blue line** on Figure 29) would withdraw water from the outlet and use a pump station near the lake shoreline to pump through a pipeline to a discharge to the Kachess River just downstream of the dam. Either Alternative would include fish passage improvements at Box Canyon Creek to improve fish passage for bull trout.

6.2 Base Cost Review

The CRA Team was provided a cost estimate for the Kachess Inactive Storage Alternative 2 project from the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c) for review and validation during the workshop.

The Cost Lead reviewed the estimate for omissions and duplications, contingencies and uncertainty and presented the findings to the workshop team. Review of the estimate concentrated upon the major cost items of the estimate, and items with the greatest potential for uncertainty and risk (both threats and opportunities).

Table 24. Base Cost Summary for Kachess Inactive Storage Alternative 2

Component Amount		
1.	Materials and Labor	
	Lake Kachess Outlet to Pump Station	$12,909,000
	Pump Station – 1,000 CFS	79,251,000
	Pipeline – Pump Station to Kachess River Discharge	14,515,000
	Kachess River Discharge Structure	1,343,000
	Materials and Labor	10,8018,000
2.	Field Overhead and Mobilization	6,481,000
3.	Other Contractor Costs	19,975,000
	Contract Cost	134,474,000
4.	Contingencies	33,618,000
	Field Cost	168,092,000
5.	Sales Tax	5,527,000
Construction Cost		$173,620,000
Non-Contract Cost		$52,100,000
Project Total		$225,720,000

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights of way that may be required for construction of the project features.

6.3 Base Cost Modifications

The purpose of the estimate review process is to validate the estimate components using both expert opinion and team consensus. To that end, some adjustments were made to the estimate based on discussion with the team during the workshop. At the time of the workshop the quantity values for the items listed in the estimate were very preliminary which is expected since the design of the Kachess Inactive Storage Alternative 2 was at less than 5 percent.

Significant changes made as a result of the validation process and workshop was as follows:

Contingencies

The contingencies for both construction and design were removed from the base estimate summary and were captured as project risks (threats and opportunities) by the CRA Team.

Miscellaneous Item Allowance

The base estimate summary included a line item for unlisted minor items. This remained but was renamed to miscellaneous item allowance to cover known but unquantified items of work not covered in the individual items within the base estimate summary.

Non-Contract Costs

Non-contract costs were broken into categories, pre-construction (design & environmental permitting), planning report/EIS, construction engineering and right-of-way costs. These categories replaced the generic 30 percent added to each project.

- **Pre-Construction** - After discussions during the pre-workshop, the percentage of pre-construction for this project was established at 10 percent of the Contract Cost.
- **Planning Report/EIS** - After discussions during the pre-workshop and workshop, the cost of the planning report and EIS was estimated to be $1 million.
- **Construction Engineering** - After discussions during the pre-workshop, the percentage of construction engineering for this project was established at 9 percent of the Contract Cost.
- **Right-of-Way** - The project does not require the purchase of right-of-way.

Sales Tax

Sales tax was calculated at 8.2 percent on only the equipment and materials in the provided estimate. Sales tax for Kittitas County (8.0 percent) was applied to the entire contract amount in the adjusted base cost estimate.

Cost Index

The costs for this project were originally indexed to the 3rd quarter of 2010. The Cost Lead indexed the costs to the 1st quarter of 2012.

Table 25. Cost Indexing for Kachess Inactive Storage Alternative 2

Component	Original Estimate ($M)	Indices		Index Category	Adjusted Base ($M)
		3rd Q 2010	1st Q 2012		
Tunnel - Lake Outlet to Pump Station	$12.91	351	370	Tunnel	$13.61
Pump Station 1000 CFS	$79.25	326	344	Pumping Plants	$83.63
Pipeline - Pump Station to Kachess River Discharge	$14.51	357	371	Steel Pipeline	$15.08
Kachess River Discharge Structure	$1.34	343	364	Outlet Works	$1.43
Total	$108.02 M				$113.75 M

Uncertainty

With the project still very early in the development process (less than 5 percent design) the base uncertainty for the Kachess Inactive Storage Alternative 1 project was established to be in the range of minus 20 percent to plus 40 percent by the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c).

Table 26. Uncertainty Ranges for Kachess Inactive Storage Alternative 2

Component	Low	Under	Base	Over	High
Tunnel - Lake Outlet to Pump Station	$10,788,355	-16%	$12,909,398	47%	$18,994,830
Pump Station 1000 CFS	$63,400,725	-20%	$79,250,906	40%	110,985,632
Pipeline - Pump Station to Kachess River Discharge	$11,611,618	-20%	$14,514,523	40%	$20,336,008
Kachess River Discharge Structure	$1,074,721	-20%	$1,343,401	44%	$1,933,435
Total	$86,875,419	-20%	$108,018,228	41%	$152,249,904

The uncertainty of items within each component was reviewed by the CRA Cost Lead and then if needed was adjusted slightly based on various factors such as level of design, location of work, amount of quantities, etc. See Appendix A - Uncertainty Calculations for further information.

The uncertainty of the construction methods for the Lake Tap resulted in an increase to the uncertainty of the Tunnel – Lake Outlet to Pump Station component.

The Kachess River Discharge Structure component consisted of mostly minor items resulting in an increase in uncertainty.

Adjusted Base Cost Estimate

The adjusted base cost estimate (1st quarter 2012) for the Kachess Inactive Storage Alternative 2 project is shown below.

Table 27. Adjusted Base Cost Estimate for Kachess Inactive Storage Alternative 2

Component		Under ($M)	%	Base ($M)	%	Over ($M)
Kachess River Discharge Structure				$1.43		
Tunnel - Lake Outlet to Pump Station				$13.61		
Pipeline - Pump Station to Kachess R. Discharge				$15.08		
Pump Station 1000 CFS				$83.63		
Subtotal		$91.49	-20%	$113.75	41%	$160.33
Miscellaneous Item Allowance	4%	$3.66		$4.55		$6.41
Bid Items Subtotal		$95.14		$118.30		$166.74
Contractors Field Overhead	4%	$3.81		$ 4.73		$ 6.67
Contractor's Fee	6%	$5.71		$7.10		$10.00
Contractor's Bond & Insurance	1.5%	$1.43		$1.77		$2.50
Subtotal with Contractor Markups		$106.09		$131.90		$185.92
Mobilization	2%	$2.12		$2.64		$ 3.72
Subtotal with Mobilization		$108.21		$134.54		$189.64
Sales Tax	8.0%	$8.49		$10.76		$14.87
Contract Cost (Base Cost for Construction)		$116.69		$145.31		$204.51
Pre-Construction	10%	$11.67		$14.53		$20.45
Planning Report & EIS		$0.90	-10%	$1.00	10%	$1.10
Construction Engineering	9%	$10.50		$13.08		$18.41
Right of Way Costs				N/A		
Project Total		$139.77		$173.91		$244.47

Base Cost Comparison

Table 28 compares the main elements of the Base Cost Estimate provided and the Adjusted or CRA Base Cost Estimate that was established following the workshop review. The Adjusted Base Cost was used in the risk analysis model.

Table 28. Base Cost Comparison for Kachess Inactive Storage Alternative 2

Item	Base Cost Estimate $ Million (2012)	Adjusted Base Cost $ Million (2012)
Components	$113.75	$113.75
Miscellaneous Item Allowance	$4.46	$4.55
Contractors Field Overhead	$4.55	$4.73
Contractor's Fee	$7.91	$7.10
Contractor's Bond & Insurance	$1.98	$1.77
Mobilization	$2.27	$2.64
Design/Scope Contingency	$4.46	
Cost Estimate Refinements	$2.23	
Construction Contingency	$35.40	
Sales Tax	$5.82	$10.76
Pre-Construction (Design)		$14.53
Planning Report & EIS		$1.00
Construction Engineering		$13.08
Right of Way		
Non-Contract Cost	$54.85	
Project Total	$237.68	$173.91

The contingencies for both construction and design were removed from the base cost estimate and were replaced by project risks (threats and opportunities) by the CRA Team.

6.4 Project Escalation Assumptions

Reclamation's Construction Cost Trends [CCT] (Reclamation 2012) are used to track construction relevant to the primary types of projects being constructed by the organization. All the various cost indexes consist of two elements, contractor labor and equipment costs, and contractor supplied materials and equipment.

Reclamation uses cost indices which provide a rapid means of determining the current cost of construction of various properties based on former estimates. For these projects all budgets will be calculated in CY dollars and then indexed to the year of construction once funding is authorized.

6.5 Project Schedule Validation

For the purposes of the CRA workshop the following schedule was assumed.

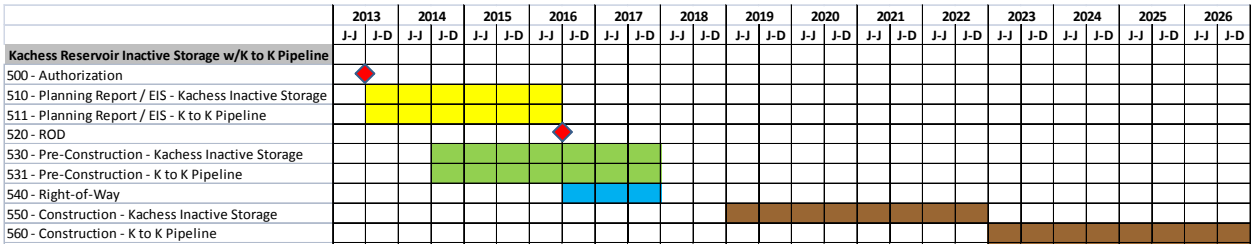

Figure 30. Project Schedule for Kachess Inactive Storage Alternative 2

6.6 Cost Risk Assessment

Risk Elicitation

During the discussion of the project, the workshop participants identified 6 high risk elements or potential events which may occur that would impact the project. See the Risk Register in Appendix B for additional information on each project risk. The top risks included:

- Historical and Cultural Resources
- Kachess Lake Tap & Tunnel
- Mitigation for Loss of Habitat
- Tribal Employment Rights Office (TERO)
- Kachess Inactive Storage #2 - Construction Duration
- Design and Scope Changes
- Minor Aggregate Risk

It was recognized during the CRA workshop that all of the geology within the project plan area could be considered preliminary or regional geology. The lake tap design at Kachess Reservoir has had no site specific investigation. The assumption that the structure will have a rock foundation and the elevation of suitable rock is an educated guess that is unverified. Lake taps and tunneling are, of themselves, risky and difficult features to construct even with good geologic information. Design assumptions were made been made on what the foundation conditions might be for a specific tunnel based on existing geologic surface maps.

The tornado diagram for the top cost risks is shown in Figure 31 below. This tornado diagram shows the expected value of the cost for each event risk, based on Monte Carlo simulation.

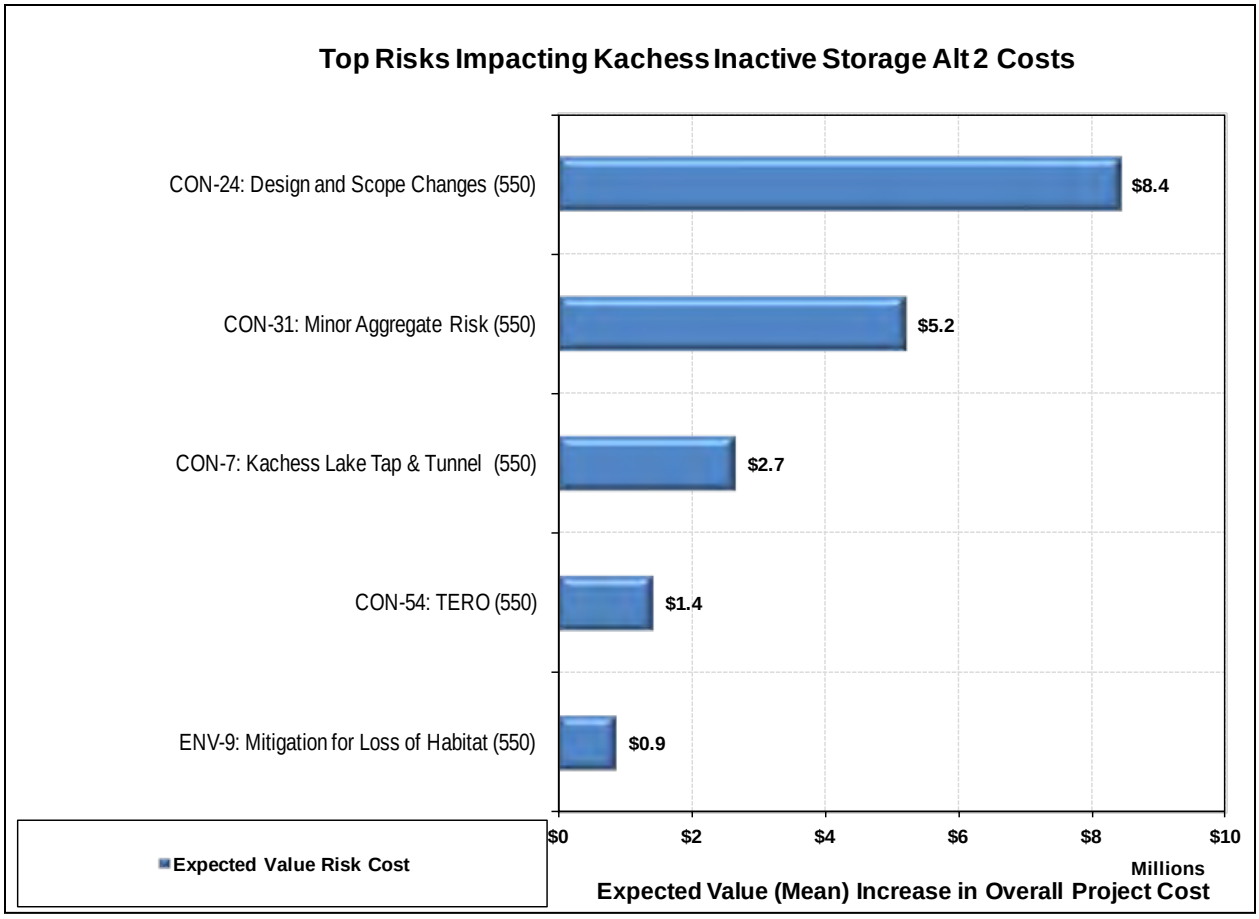

Figure 31. Tornado Diagram of Risks for Kachess Inactive Storage, Alternative 2

The direct event risk cost impact is measured as the probability of the risk occurring times the mean cost impact developed from the risk cost ranges recorded within the risk register during the CRA Workshop.

Cost Results

Figure 32 details the probabilistic total project cost results after accounting for risks and uncertainty. The 80 percent confidence interval, described by the cost range between the 10th percentile and 90th percentile figures, reveals that the total project cost is expected to fall between $161 million and $259 million.

There is 50 percent chance that the total project cost will be less than $205 million.

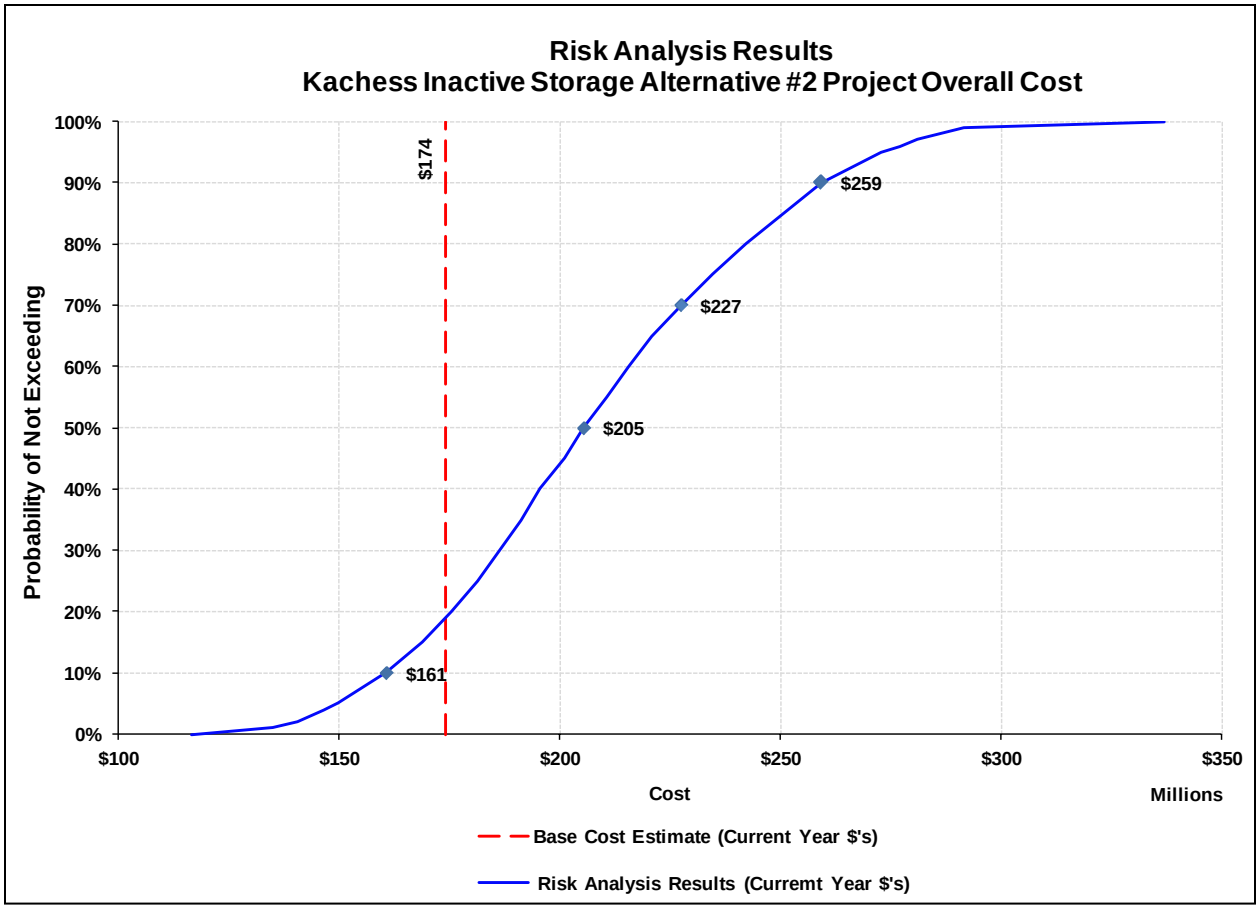

Figure 32. Total Project Costs for Kachess Inactive Storage Alternative 2

Figure 33 details the probabilistic construction cost results after accounting for risks and uncertainty. The 80 percent confidence interval reveals that the construction cost is expected to fall between $143 million and $241 million.

There is 50 percent likelihood that construction costs will not exceed $187 million.

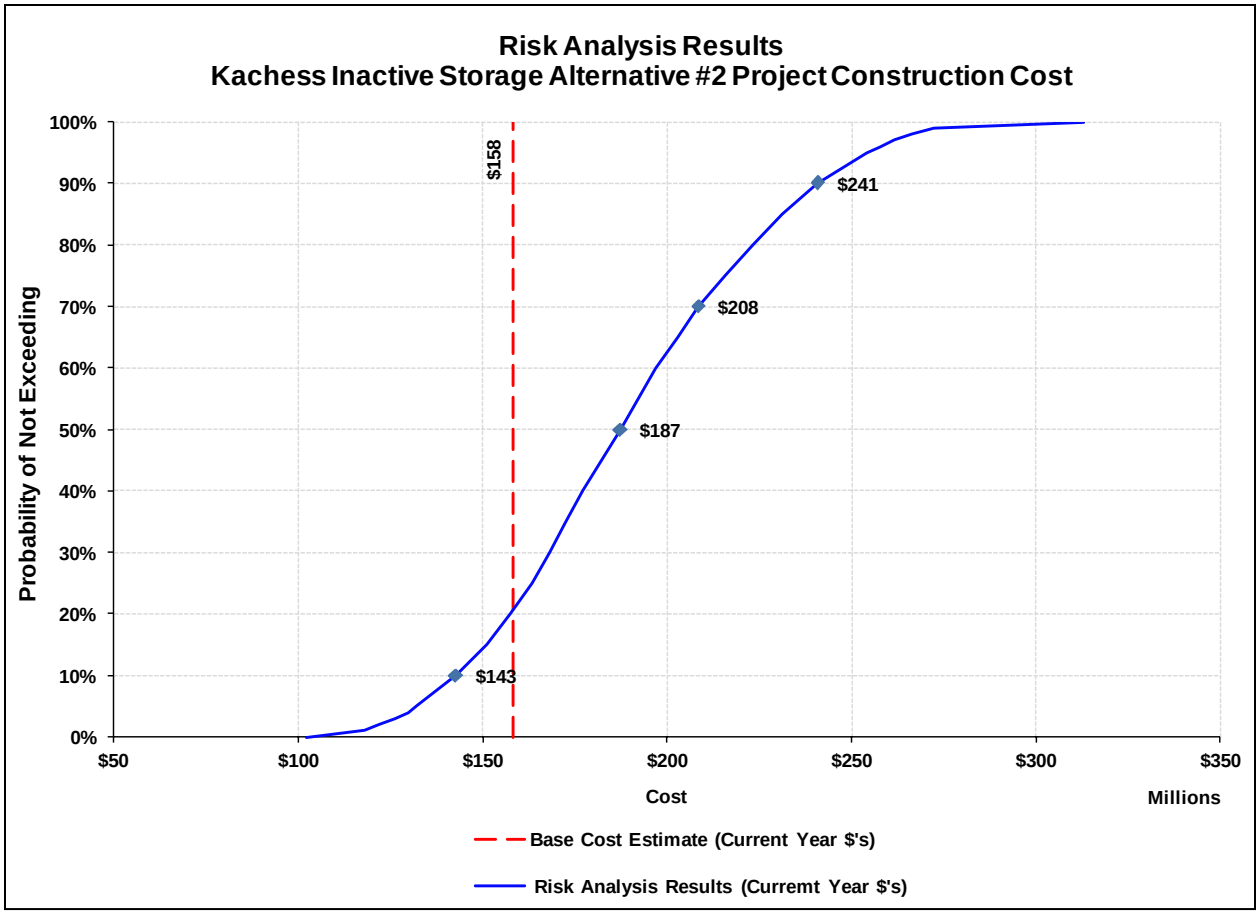

Figure 33. Construction Costs for Kachess Inactive Storage Alternative 2

Schedule Results

There was only one identified schedule risk for the Kachess Inactive Storage Alternative 2 project – Historical and Cultural Resources. This risk has an expected impact of 1 week.

Final Cost Comparison

For a basis of comparison the following charts were created showing the cost of each project before and after the CRA workshop.

The Pre-CRA costs include:

- Base Cost (3rd quarter 2010)
- Contingencies
- The cost to index the project to the 1st quarter 2012 using the Reclamation construction cost trend index.

The CRA costs include:

- Adjusted Base Cost (Indexed to 1st quarter 2012)
- Base Cost Uncertainty at 50th percentile
- Risk Impact at 50th percentile

The costs shown are in millions of dollars.

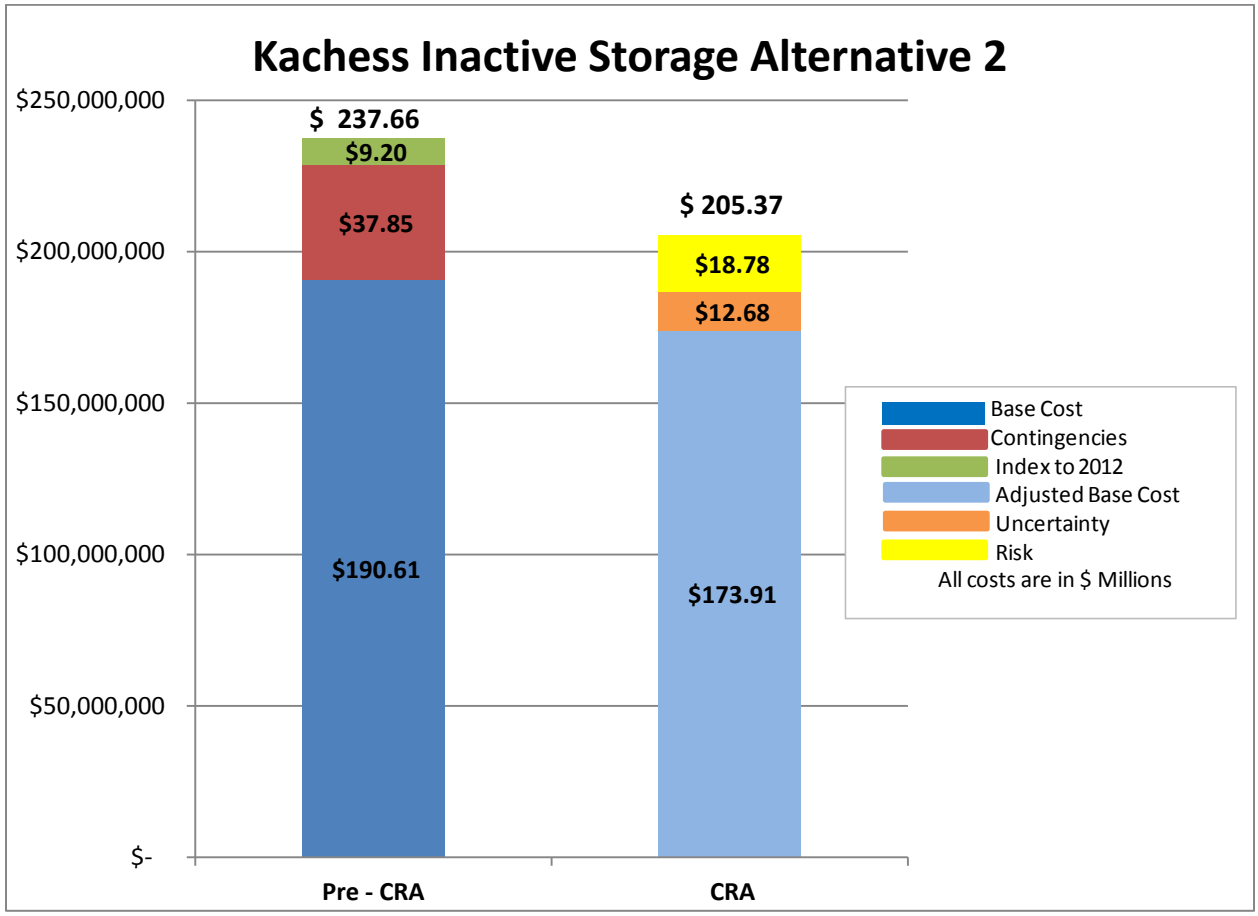

Figure 34. Final Cost Comparison for Kachess Inactive Storage Alternative 2

7.0 Wymer Dam and Reservoir

7.1 Overview

Wymer Dam and Reservoir would be constructed to create a new off-channel storage facility in the intermittent stream channel of Lmuma Creek, which enters the Yakima River approximately 8 miles upstream of the Roza Diversion Dam. The storage capacity of the reservoir would be approximately 162,500 acre-feet (Reclamation and Ecology 2011h). The proposed reservoir site is currently under private ownership.

The dam would be a concrete-faced rockfill embankment approximately 450 feet high with a full-pool elevation of approximately 1,730 feet. An approximately 180-foot-high central core rockfill dike would be constructed in a saddle on the north side of the reservoir. Rockfill dams and dikes have the ability to safely accommodate large seismic event loadings.

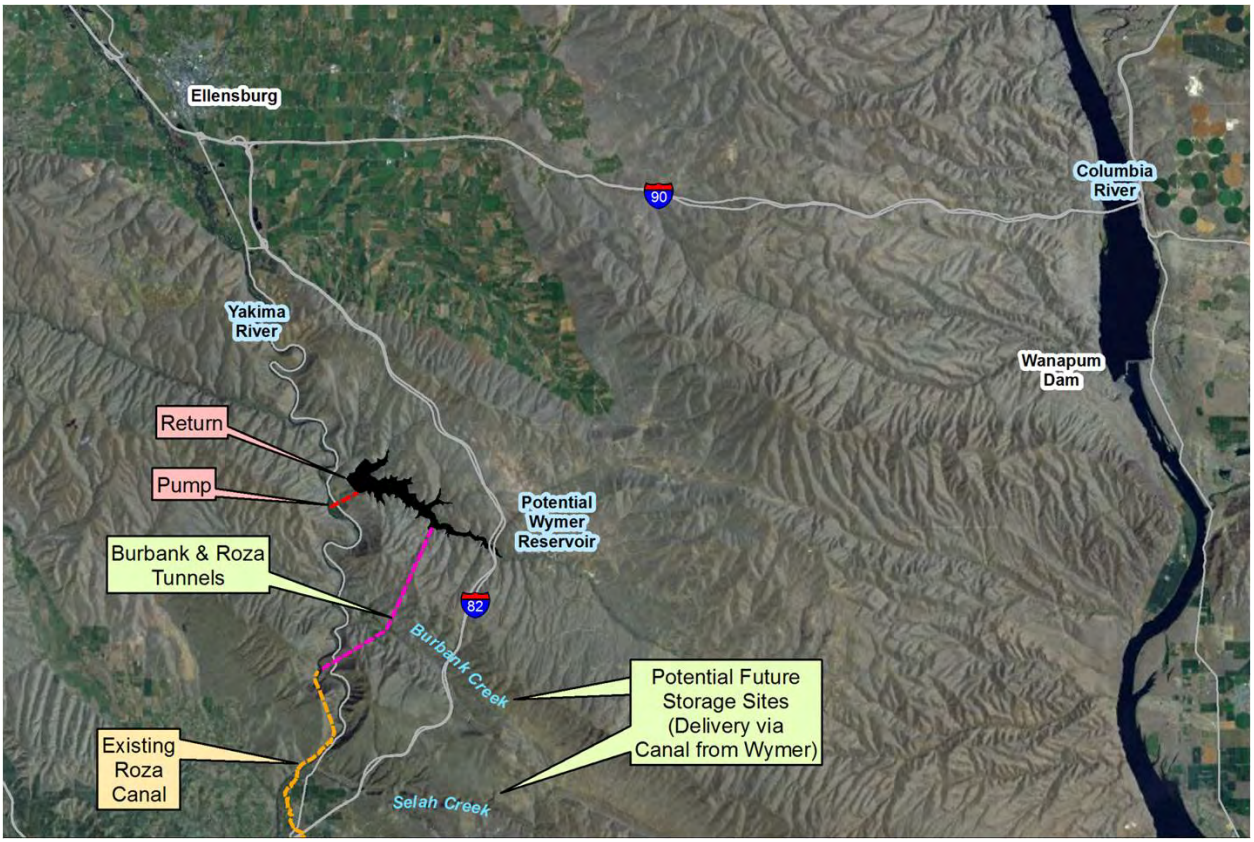

Figure 35. Wymer Dam and Reservoir

The reservoir would be filled by a pumping plant with a capacity of approximately 400 cfs that would withdraw water from the Yakima River. A screened intake channel, approximately 200 feet long, on the Yakima River would carry water to the pumping plant.

A spillway and stilling basin would be located on the south abutment of the dam to discharge water into Lmuma Creek. Outlet works on the south dam abutment, sized for approximately 1,600 cfs, would return flow to Lmuma Creek and the Yakima River.

Water would be pumped into the reservoir from the Yakima River during winter, spring, and potentially summer, during high-flow periods and times when upstream reservoirs are releasing water specifically for filling the reservoir. The facility would allow for increases in winter flows and decreases in summer flows in the upper Yakima River to benefit fish. On average 82,500 acre-feet of the storage capacity would be used annually to improve instream flows upstream and downstream of the reservoir. The remaining storage capacity would be used for carryover or drought relief storage.

7.2 Base Cost Review

The CRA Team was provided an estimate for the Wymer Dam and Reservoir project from the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c) for review and validation during the workshop.

The Cost Lead reviewed the estimate for omissions and duplications, contingencies and uncertainty and presented the findings to the workshop team. Review of the estimate concentrated upon the major cost items of the estimate, and items with the greatest potential for uncertainty and risk (both threats and opportunities).

Table 29. Base Cost Summary for Wymer Dam and Reservoir

Component Amount		
1.	Materials and Labor	
	Yakima River Intake	$20,844,000
	Pumping Station	60,809,000
	Switchyard and Transmission Line	6,545,000
	Discharge Line	27,724,000
	Dam and Dike	399,921,000
	Spillway and Outlet Works	63,578,000
	Diversion During Construction	4,769,000
	Road and Creek Improvements	6,610,000
	Materials and Labor	590,800,000
2.	Field Overhead and Mobilization	17,724,000
3.	Other Contractor Costs	56,730,000
	Contract Cost	665,254,000
4.	Contingencies	166,313,000
	Field Cost	831,567,000
5.	Sales Tax	85,000
Construction Cost		$831,652,000
Non-Contract Cost		$249,500,000
Project Total		$1,081,152,000

The provided estimate for the Wymer Dam and Reservoir project was indexed to the third quarter of 2010 from an estimate previously prepared by Reclamation in April 2007.

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights of way that may be required for construction of the project features.

7.3 Base Cost Modifications

The purpose of the estimate review process is to validate the estimate components using both expert opinion and team consensus. To that end, some adjustments were made to the estimate based on discussion with the team during the workshop.

At the time of the workshop the quantity values for the items listed in the estimate were very preliminary which is expected since the design of the Wymer Dam and Reservoir was at less than 5 percent. Significant changes made as a result of the validation process and workshop was as follows:

Contingencies

The contingencies for both construction and design were removed from the base estimate summary and were captured as project risks (threats and opportunities) by the CRA Team.

Miscellaneous Item Allowance

The base estimate summary included a line item for unlisted minor items. This remained but was renamed to miscellaneous item allowance to cover known but unquantified items of work not covered in the individual items within the base estimate summary.

Non-Contract Costs

Non-contract costs were broken into categories, pre-construction (design & environmental permitting), planning report/EIS, construction engineering and right-of-way costs. These categories replaced the generic 30 percent added to each project.

- **Pre-Construction** - After discussions during the pre-workshop, the percentage of pre-construction for this project was established at 10 percent of the Contract Cost.
- **Planning Report/EIS** - After discussions during the pre-workshop and workshop, the cost of the planning report and EIS was estimated to be $2.25 million.
- **Construction Engineering** - After discussions during the pre-workshop, the percentage of construction engineering for this project was established at 9 percent of the Contract Cost.
- **Right-of-Way** - The Wymer Dam and Reservoir project requires the purchase of right-of-way. This is only 1 property owner and the estimated cost is $1.4 million.

Sales Tax

The sales tax was assumed to be included in the items of the original estimate. There was no documentation to confirm this assumption. Sales tax was added for Kittitas County (8.0 percent) to the contract amount of the base cost estimate.

Cost Index

The costs for this project were originally indexed to the 3rd quarter of 2010. The Cost Lead indexed the costs to the 1st quarter of 2012.

Table 30. Cost Indexing for Wymer Dam and Reservoir

Component	Original Estimate ($M)	Indices		Index Category	Adjusted Base ($M)
		3rd Q 2010	1st Q 2012		
Diversion During Construction	$4.77	323	341	Diversion Dam	$5.03
Switchyard and Transmission Line	$6.54	317	333	Switchyards & Substations	$6.88
Road and Creek Improvements	$6.61	411	445	Secondary Roads	$7.16
Yakima River Intake	$20.84	326	344	Pumping Plants	$22.00
Discharge Line	$27.72	357	371	Steel Pipeline	$28.81
Pumping Station	$60.87	351	370	Tunnel	$64.16
Spillway and Outlet Works	$63.58	343	364	Outlet Works	$67.47
Dam and Dike	$399.92	303	326	Earth Dam	$430.28
Total	$590.86 M				$731.79 M

Uncertainty

With the project still very early in the development process (less than 5 percent design) the base uncertainty for the Kachess Inactive Storage Alternative 1 project was established to be in the range of minus 20 to plus 40 percent by the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c).

Table 31. Uncertainty Ranges for Wymer Dam and Reservoir

Component	Low	Under	Base	Over	High
Diversion During Construction	$3,815,144	-20%	$4,768,930	40%	$6,691,048
Switchyard and Transmission Line	$5,235,828	-20%	$6,544,785	41%	$9,217,262
Road and Creek Improvements	$5,287,930	-20%	$6,609,912	40%	$9,255,324
Yakima River Intake	$16,675,518	-20%	$20,844,398	40%	$29,201,727
Discharge Line	$22,179,186	-20%	$27,723,983	40%	$38,834,883
Pumping Station	$48,875,183	-20%	$60,869,541	39%	$84,515,836
Spillway and Outlet Works	$48,976,627	-23%	$63,578,112	37%	$87,182,152
Dam and Dike	$299,940,406	-25%	$399,920,541	47%	$587,570,252
Total	$450,985,822	-24%	$590,860,202	44%	$852,468,484

The uncertainty of items within each component was reviewed by the CRA Cost Lead and, if needed, was adjusted slightly based on various factors such as level of design, location of work, amount of quantities, etc. See Appendix A - Uncertainty Calculations for further information.

The earthwork quantities needed for the Dam and Dike component are very large which should bring a lower unit cost price, but the level of current design brings with it a large uncertainty of the actual quantities needed to construct the Dam and Dike component.

Adjusted Base Cost Estimate

The adjusted base cost estimate (1st quarter 2012) for the Wymer Dam and Reservoir project is shown on Table 32.

Table 32. Adjusted Base Cost Estimate for Wymer Dam and Reservoir

Component		Under ($M)	%	Base ($M)	%	Over ($M)
Diversion During Construction				$5.03		
Switchyard and Transmission Line				$6.88		
Road and Creek Improvements				$7.16		
Yakima River Intake				$22.00		
Discharge Line				$28.81		
Pumping Station				$64.16		
Spillway and Outlet Works				$67.47		
Dam and Dike				$430.28		
Subtotal		$482.23	-24%	$631.79	44%	$911.52
Miscellaneous Item Allowance	4%	$19.29		$ 25.27		$36.46
Bid Items Subtotal		$501.52		$657.06		$947.98
Mobilization	3%	$15.05		$19.71		$28.44
Subtotal with Mobilization		$516.56		$676.77		$976.42
Sales Tax	8.0%	$41.32		$54.14		$78.11
Contract Cost (Base Cost for Construction)		$516.56		$730.92		$1,054.53
Pre-Construction	8%	$41.32		$58.47		$84.36
Planning Report & EIS		$2.03	-10%	$2.25	10%	$2.48
Construction Engineering	8%	$41.32		$58.47		$84.36
Right of Way Costs		$1.33	-5%	$1.40	40%	$1.96
Project Total		$602.57		$851.51		$1,227.69

Base Cost Comparison

Table 33 compares the main elements of the Base Cost Estimate provided and the Adjusted or CRA Base Cost Estimate that was established following the workshop review. The Adjusted Base Cost was used in the risk analysis model.

Table 33. Base Cost Comparison for Wymer Dam and Reservoir

Item	Base Cost Estimate $ Million (2012)	Adjusted Base Cost $ Million (2012)
Components	$631.79	$631.79
Miscellaneous Item Allowance	$26.03	$25.27
Contractors Field Overhead		
Contractor's Fee		
Contractor's Bond & Insurance		
Mobilization	$18.96	$19.71
Design/Scope Contingency	$23.09	
Cost Estimate Refinements	$11.55	
Construction Contingency	$177.86	
Sales Tax		$54.14
Pre-Construction (Design)		$58.47
Planning Report & EIS		$2.25
Construction Engineering		$58.47
Right of Way		$1.40
Non-Contract Cost	$266.79	
Project Total	$1,156.07	$851.51

The contingencies for both construction and design were removed from the base cost estimate and were replaced by project risks (threats and opportunities) by the CRA Team.

7.4 Project Escalation Assumptions

Reclamation's Construction Cost Trends [CCT] (Reclamation 2012) are used to track construction relevant to the primary types of projects being constructed by the organization. All the various cost indexes consist of two elements, contractor labor and equipment costs, and contractor supplied materials and equipment.

Reclamation uses cost indices which provide a rapid means of determining the current cost of construction of various properties based on former estimates. For these projects all budgets will be calculated in CY dollars and then indexed to the year of construction once funding is authorized.

7.5 Project Schedule Validation

For the purposes of the CRA workshop the following schedule was assumed.

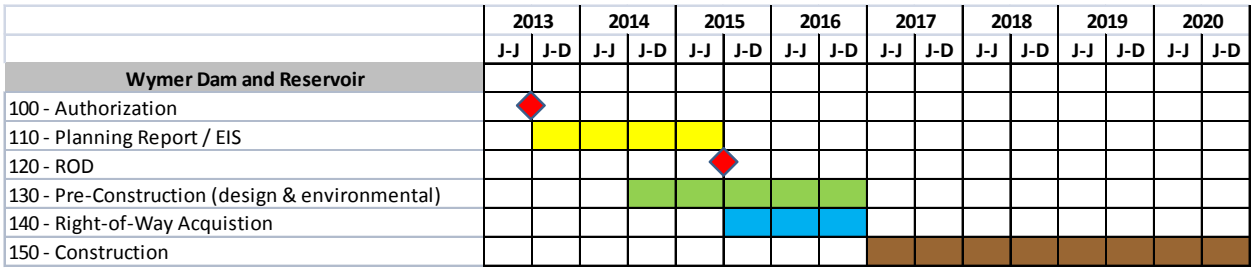

Figure 36. Project Schedule for Wymer Dam and Reservoir

7.6 Cost Risk Assessment

Risk Elicitation

During the discussion of the project, the workshop participants identified 13 high risk elements or potential events which may occur that would impact the project. See the Risk Register in Appendix B for additional information on each project risk. The active risks included:

- Wymer Dam Geotechnical Issues
- Wymer Dam Refinements
- Yakima River Canyon Seismic Concerns
- Tribal Employment Rights Office (TERO)
- Mitigation for Loss of Habitat
- Historical and Cultural Resources
- I-82 Bridge Abutment Protection
- Pump Station May Need to be Relocated
- Outlet Structure
- Design and Scope Changes
- Minor Aggregate Risk

It was recognized during the CRA workshop that all of the geology within the project area could be considered preliminary or regional geology. It is based on limited site specific information. The foundation conditions at the proposed dam and dike sites are not specifically verified by geologic exploration. This lack of current geotechnical information accounted for large risks to the cost of the project.

The USGS is also currently evaluating faulting in the Yakima River canyon close to the Wymer dam site. The exact location of faults adjacent to the dam accounted for major risks to the cost of the project.

The tornado diagram for the top cost risks is shown in Figure 37 below. This tornado diagram shows the expected value of the cost for each event risk, based on Monte Carlo simulation.

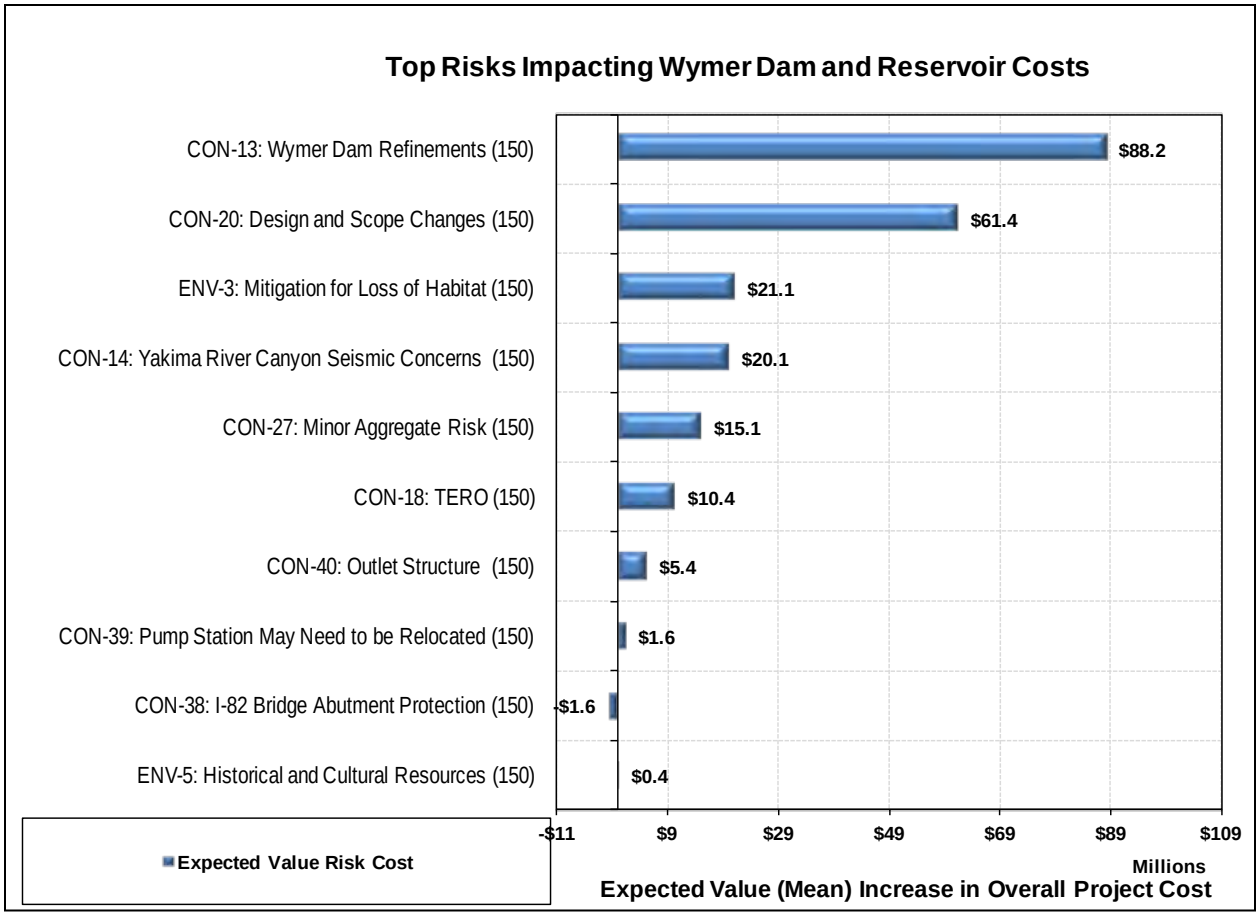

Figure 37. Tornado Diagram of Risks for Wymer Dam and Reservoir

The direct event risk cost impact is measured as the probability of the risk occurring times the mean cost impact developed from the risk cost ranges recorded within the risk register during the CRA Workshop.

Cost Results

Figure 38 details the probabilistic total project cost results after accounting for risks and uncertainty. The 80 percent confidence interval, described by the cost range between the 10th percentile and 90th percentile figures, reveals that the total project cost is expected to fall between $870 million and $1,443 million.

There is also a 50 percent chance that the total project cost will be less than $1,138 million.

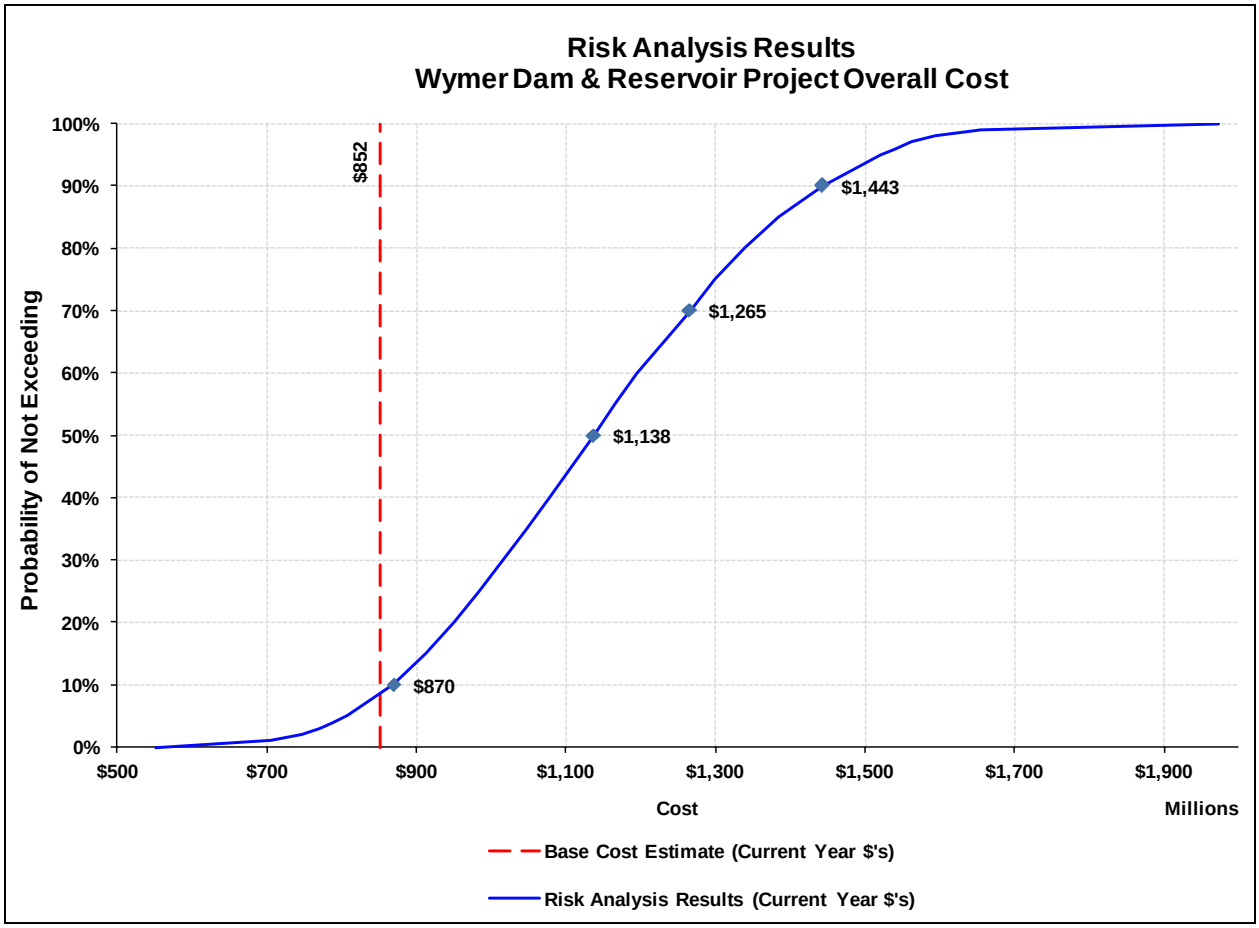

Figure 38. Total Project Costs for Wymer Dam and Reservoir

Figure 39 details the probabilistic construction cost results after accounting for risks and uncertainty. The 80 percent confidence interval reveals that the construction cost is expected to fall between $791 million and $1,362 million.

There is 50 percent likelihood that construction costs will not exceed $1,055 million.

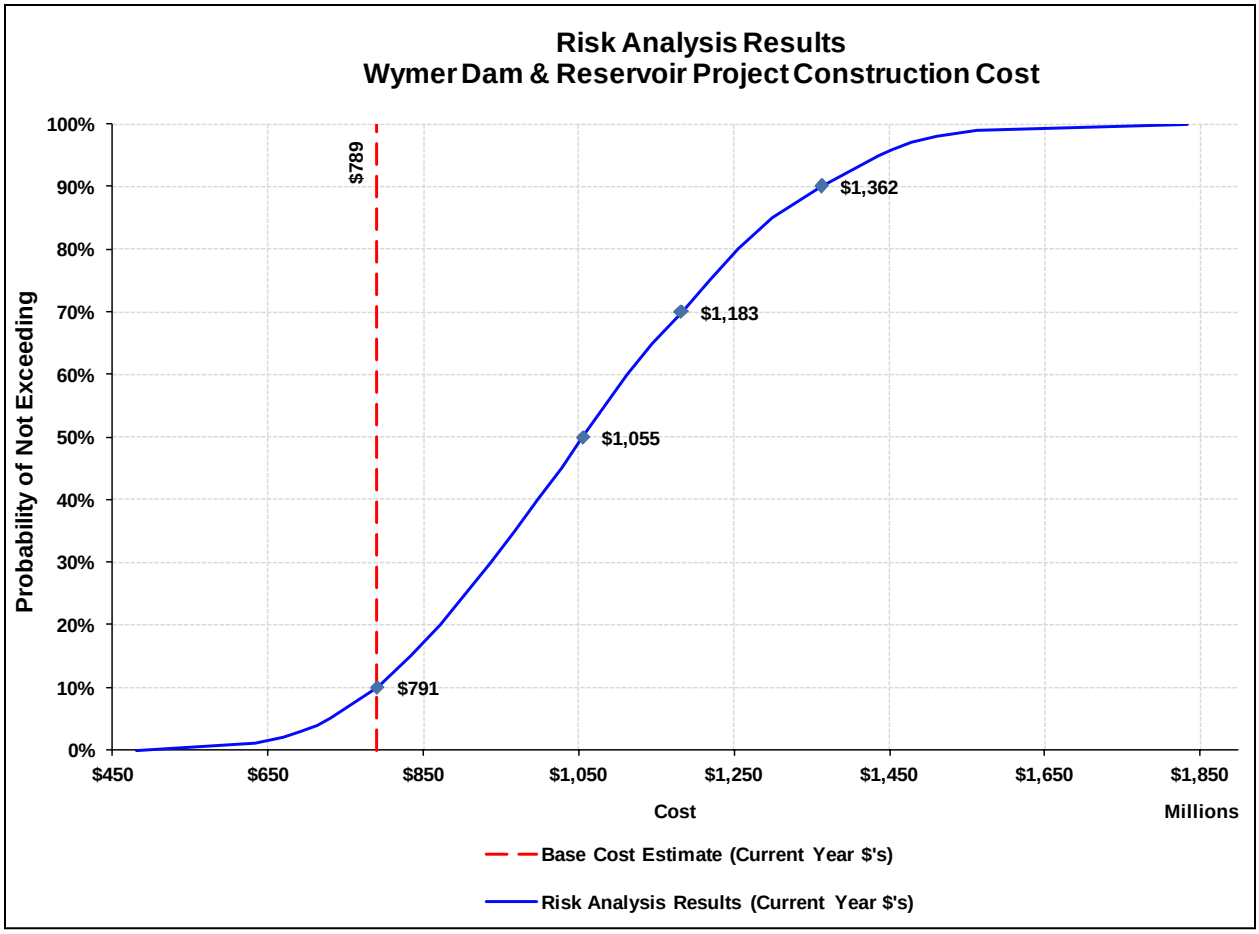

Figure 39. Construction Costs for Wymer Dam and Reservoir

Schedule Results

There was only one identified schedule risk for the Wymer Dam and Reservoir project – Historical and Cultural Resources. This risk has an expected impact of 1 week.

Final Cost Comparison

For a basis of comparison the following charts were created showing the cost of each project before and after the CRA workshop.

The Pre-CRA costs include:

- Base Cost (3rd quarter 2010)
- Contingency
- The cost to index the project to the 1st quarter 2012 using the Reclamation construction cost trend index.

The Post-CRA costs include:

- Adjusted Base Cost (1st quarter 2012)
- Base Cost Uncertainty at 50th percentile
- Risk Impact at 50th percentile

The costs shown are in millions of dollars.

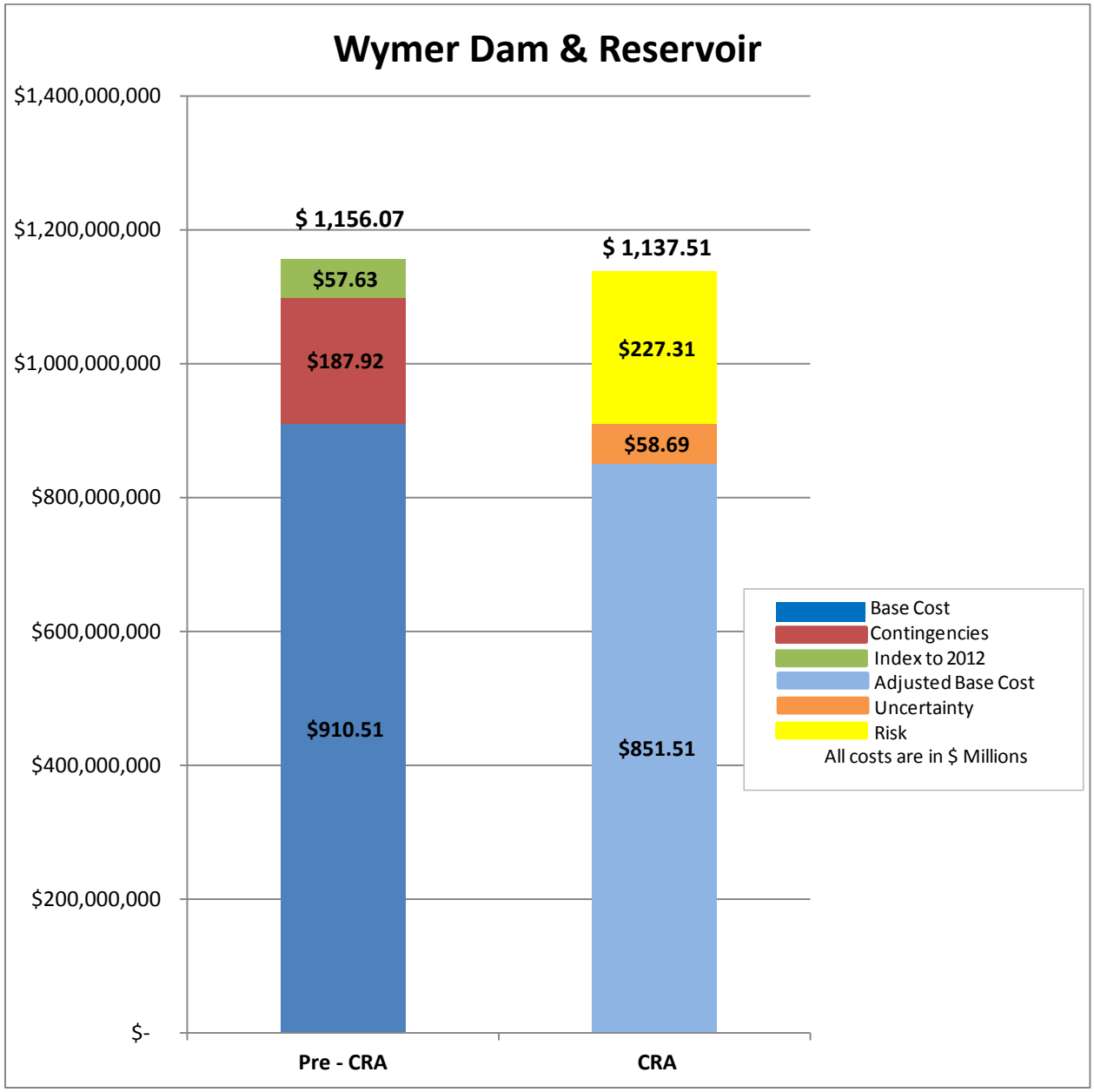

Figure 40. Final Cost Comparison Wymer Dam and Reservoir

8.0 Wymer Downstream Conveyance System

8.1 Overview

Two alternatives are being evaluated for release of the water from the proposed Wymer Reservoir to the Yakima River. The first would release the water to the Yakima River directly below the dam as described in Wymer Dam and Reservoir project narrative.

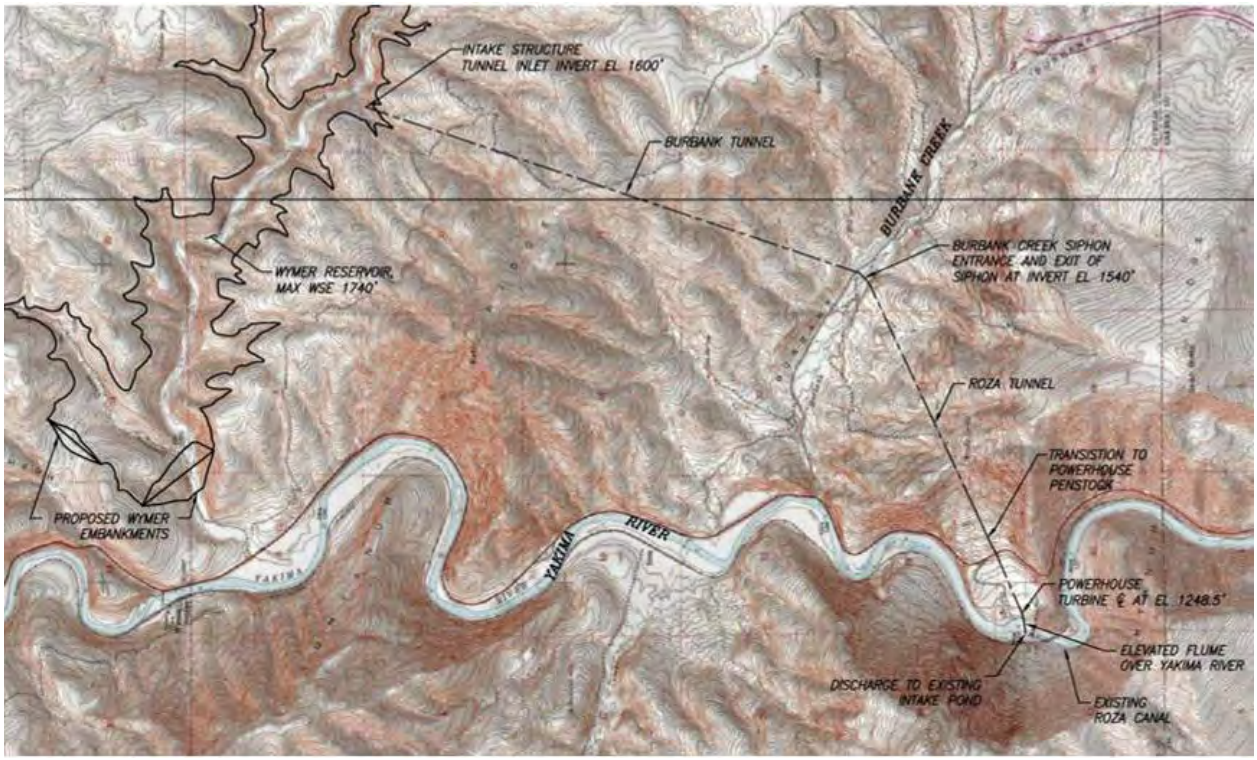

Figure 41. Assumed Tunnel Alignments

An additional proposal would route the water through proposed tunnels Burbank & Roza, see Figure 41. This proposal would carry water to the Roza Canal. These two tunnels would also provide a connection with future potential storage sites within the Burbank Creek and Selah Creek Drainages.

This project is very early in planning requires further engineering analysis to define the advantages and disadvantages to connecting to these storage options and how their operation would be integrated to maximize the benefits.

The proposed design includes a siphon across the Burbank Creek drainage to connect the two tunnels.

At the downstream end of the Roza Tunnel the installation of a hydroelectric power plant to dissipate the energy of the water prior to discharge into the Roza Tunnel was included in the provided estimate. The development of power is no longer included so the power plant was removed from the project for the purposes of this cost risk assessment.

8.2 Base Cost Review

The CRA Team was provided a cost estimate for the Wymer Downstream Conveyance System project from the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c) for review and validation during the workshop.

The Cost Lead reviewed the estimate for omissions and duplications, contingencies and uncertainty and presented the findings to the workshop team. Review of the estimate concentrated upon the major cost items of the estimate, and items with the greatest potential for uncertainty and risk (both threats and opportunities).

Table 34. Base Cost Summary for Wymer Downstream Conveyance System

Component	Amount
1. Materials and Labor	
Tunnels, Siphon and Penstock	$112,382,000
Tailrace Flume	3,067,000
Powerhouse	45,679,000
Materials and Labor	161,128,000
2. Field Overhead and Mobilization	17,281,000
3. Other Contractor Cost	16,804,000
Contract Cost	195,213,000
4. Contingencies	48,803,000
Field Cost	244,016,000
5. Sales Tax	930,000
Construction Cost	$244,946,000
Non-Contract Cost	$73,500,000
Project Total	$318,446,000

The cost of the powerhouse was removed for the CRA workshop and an energy dissipation structure was added. This removed $45.70 million and added $4.5 million prior to markups.

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights of way that may be required for construction of the project features.

8.3 Base Cost Modifications

The purpose of the estimate review process is to validate the estimate components using both expert opinion and team consensus. To that end, some adjustments were made to the estimate based on discussion with the team during the workshop.

At the time of the workshop the quantity values for the items listed in the estimate were very preliminary which is expected since the design of the Wymer Downstream Conveyance System

was at less than 5 percent. Significant changes made as a result of the validation process and workshop was as follows:

Contingencies

The contingencies for both construction and design were removed from the base estimate summary and were captured as project risks (threats and opportunities) by the CRA Team.

Miscellaneous Item Allowance

The base estimate summary included a line item for unlisted minor items. This remained but was renamed to miscellaneous item allowance to cover known but unquantified items of work not covered in the individual items within the base estimate summary.

Non-Contract Costs

Non-contract costs were broken into categories, pre-construction (design & environmental permitting), planning report/EIS, construction engineering and right-of-way costs. These categories replaced the generic 30 percent added to each project.

- **Pre-Construction** - After discussions during the pre-workshop, the percentage of pre-construction for this project was established at 10 percent of the Contract Cost.
- **Planning Report/EIS** - After discussions during the pre-workshop workshop, the cost of the planning report and EIS was estimated to be $0.5 million.
- **Construction Engineering** - After discussions during the pre-workshop, the percentage of construction engineering for this project was established at 9 percent of the Contract Cost.
- **Right-of-Way** - The Wymer Downstream Conveyance System project does not requires the purchase of any right-of-way.

Sales Tax

Sales tax was calculated at 8.2 percent on only the equipment and materials in the provided estimate. Sales tax for Kittitas County (8.0 percent) was applied to the entire contract amount in the adjusted base cost estimate.

Cost Index

The costs for this project were originally indexed to the 3rd quarter of 2010. The Cost Lead indexed the costs to the 1st quarter of 2012.

Table 35. Cost Indexing for Wymer Downstream Conveyance System

Component	Original Estimate ($M)	Indices		Index Category	Adjusted Base ($M)
		3rd Q 2010	1st Q 2012		
Penstock - Intake, Tunnels, Siphon	$ 112.38	351	370	Tunnel	$118.47
Tailrace Flume	$3.07	325	351	Spillway	$3.31
Discharge Line	$4.50	343	364	Outlet Works	$4.78
Total	$119.95 M				$126.56 M

Uncertainty

With the project still very early in the development process (less than 5 percent design) the base uncertainty for the Kachess Inactive Storage Alternative 1 project was established to be in the range of minus 20 to plus 40 percent by the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology 2011c).

Table 36. Uncertainty Ranges for Wymer Downstream Conveyance System

Component	Low	Under	Base	Over	High
Penstock - Intake, Tunnels, Siphon	$94,813,854	-16%	$112,382,354	44%	$162,268,864
Tailrace Flume	$2,453,213	-20%	$3,066,516	40%	$4,293,404
Discharge Line	$3,600,000	-20%	$4,500,000	40%	$6,300,000
Total	$100,867,066	-16%	$119,948,870	44%	$172,862,269

The uncertainty of items within each component was reviewed by the CRA Cost Lead and then if needed was adjusted slightly based on various factors such as level of design, location of work, amount of quantities, etc. See Appendix A - Uncertainty Calculations for further information.

Because the large amount of tunnel excavation included in the Penstock – Intake, Tunnels, Siphon component the uncertainty of unit price was increased slightly.

Adjusted Base Cost Estimate

The adjusted base cost estimate (1st quarter 2012) for the Wymer Downstream Conveyance System project is shown in Table 37.

Table 37. Adjusted Base Cost Estimate for Wymer Downstream Conveyance System

Component		Under ($M)	%	Base ($M)	%	Over ($M)
Tailrace Flume				$3.31		
Discharge Line				$4.78		
Penstock - Intake, Tunnels, Siphon				$118.47		
Subtotal		$106.43	-16%	$126.56	44%	$182.39
Miscellaneous Item Allowance	4%	$4.26		$5.06		$7.30
Bid Items Subtotal		$110.68		$131.62		$189.69
Contractor's Field Overhead	4%	$4.43		$5.26		$7.59
Contractors Fee	6%	$6.64		$7.90		$11.38
Contractor's Bond and Insurance	1.5%	$1.66		$1.97		$2.85
Subtotal with Contractor Markups		$123.41		$146.76		$211.50
Mobilization	3%	$3.70		$4.40		$6.34
Subtotal with Mobilization		$127.11		$151.16		$217.84
Sales Tax	8.0%	$10.17		$12.09		$17.43
Contract Cost (Base Cost for Construction)		$137.28		$163.25		$235.27
Pre-Construction	10%	$13.73		$16.33		$23.53
Planning Report & EIS		$0.45	-10%	$0.50	10%	$0.55
Construction Engineering	8%	$10.98		$13.06		$18.82
Right of Way Costs				N/A		
Project Total		$162.44		$193.14		$278.17

Base Cost Comparison

Table 38 compares the main elements of the Base Cost Estimate provided and the Adjusted or CRA Base Cost Estimate that was established following the workshop review. The Adjusted Base Cost was used in the risk analysis model.

Table 38. Base Cost Comparison for Wymer Downstream Conveyance System

Item	Base Cost Estimate $ Million (2012)	Adjusted Base Cost $ Million (2012)
Components	$126.56	$126.56
Miscellaneous Item Allowance	$5.61	$5.06
Contractors Field Overhead		$5.26
Contractor's Fee	$7.59	$7.90
Contractor's Bond & Insurance	$1.90	$1.97
Mobilization	$4.08	$4.40
Design/Scope Contingency	$5.61	
Cost Estimate Refinements	$2.80	
Construction Contingency	$38.54	
Sales Tax	$0.98	$12.09
Pre-Construction (Design)		$16.33
Planning Report & EIS		$0.50
Construction Engineering		$13.06
Right of Way		
Non-Contract Cost	$58.09	
Project Total	$251.76	$193.14

The contingencies for both construction and design were removed from the base cost estimate and were replaced by project risks (threats and opportunities) by the CRA Team.

8.4 Project Escalation Assumptions

Reclamation's Construction Cost Trends [CCT] are used to track construction relevant to the primary types of projects being constructed by the organization. All the various cost indexes consist of two elements, contractor labor and equipment costs, and contractor supplied materials and equipment.

Reclamation uses cost indices which provide a rapid means of determining the current cost of construction of various properties based on former estimates. For these projects all budgets will be calculated in CY dollars and then indexed to the year of construction once funding is authorized.

8.5 Project Schedule Validation

For the purposes of the CRA workshop the following schedule was assumed.

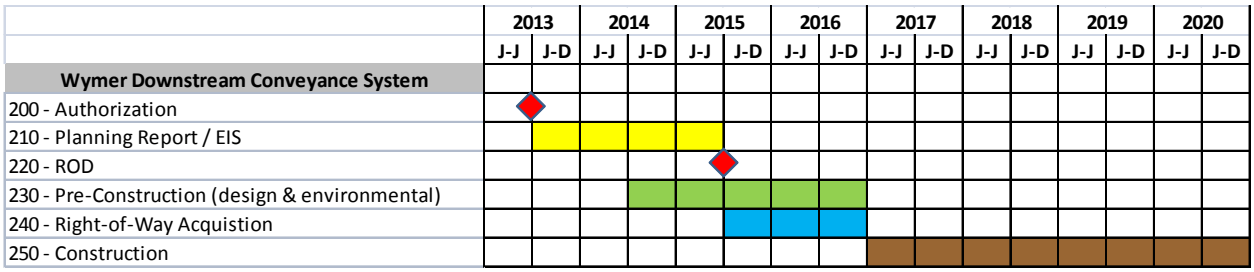

Figure 42. Project Schedule for Wymer Downstream Conveyance System

8.6 Cost Risk Assessment

Risk Elicitation

During the discussion of the project, the workshop participants identified 8 high risk elements or potential events which may occur that would impact the project. See the Risk Register in Appendix B for additional information on each project risk. The active risks included:

- Burbank Tunnel Alignment
- Tunnel Designs not compatible with Future Storage Options
- Lack of Geological Information
- Increase Tunnel Cross Section
- Mitigation for Loss of Habitat
- Tribal Employment Rights Office (TERO)
- Design and Scope Changes
- Minor Aggregate Risk

It was recognized during the CRA workshop that all of the geology within the project plan area could be considered preliminary or regional geology.

The Wymer Downstream Conveyance System includes two tunnels, Burbank at 3.2 miles long and Roza at 1.7 miles long. These tunnels whose alignments have not been investigated by any drill holes go through two different ridges. Risks associated with the design assumptions were made been made on what the rock conditions might be for a specific tunnel based on existing geologic surface maps.

The USGS is also currently evaluating faulting in the Yakima River canyon. The unknown location of faults running through the pipeline area accounted for major risks to the cost of the project.

The tornado diagram for the top cost risks is shown in Figure 43. This tornado diagram shows the expected value of the cost for each event risk, based on Monte Carlo simulation.

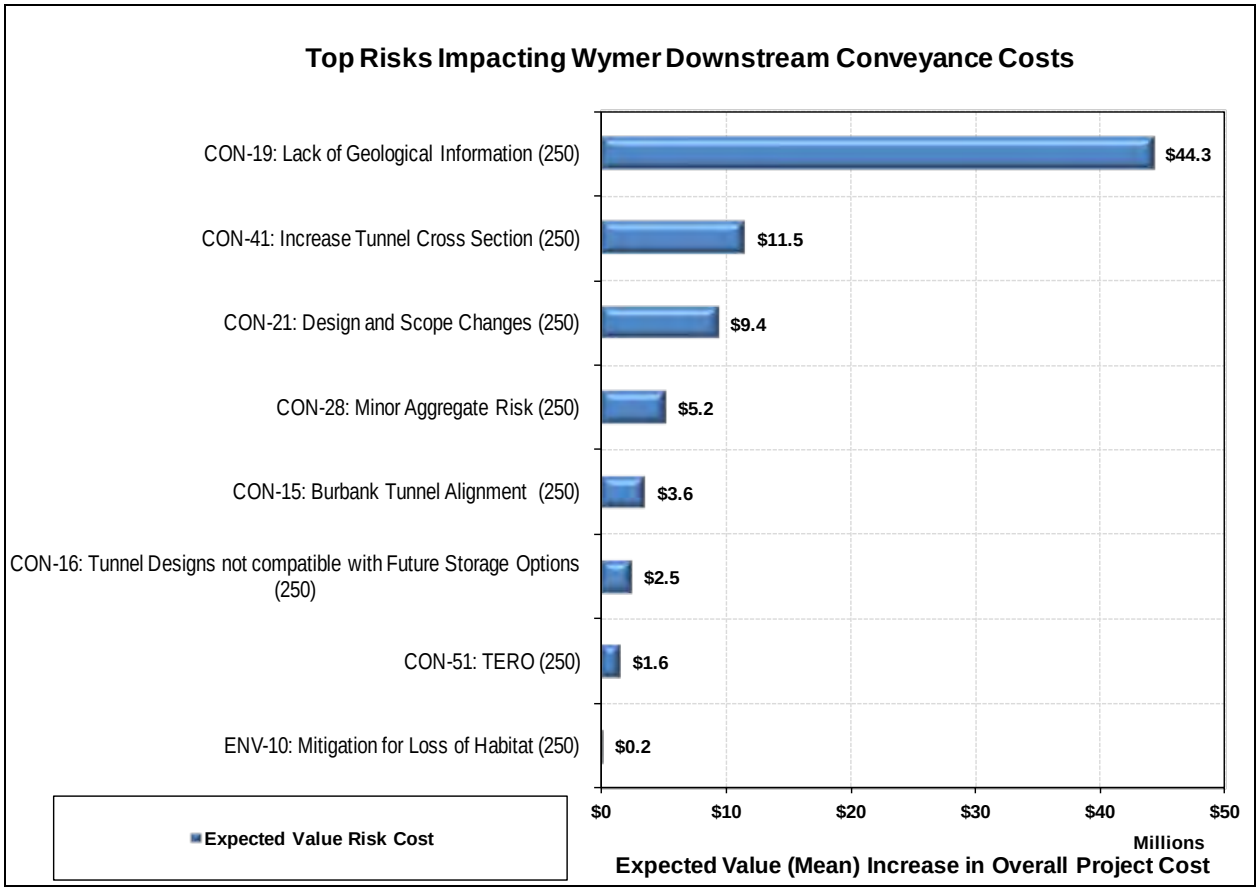

Figure 43. Tornado Diagram of Risks for Wymer Downstream Conveyance

The direct event risk cost impact is measured as the probability of the risk occurring times the mean cost impact developed from the risk cost ranges recorded within the risk register during the CRA Workshop.

Cost Results

Figure 44 details the probabilistic total project cost results after accounting for risks and uncertainty. The 80 percent confidence interval, described by the cost range between the 10th percentile and 90th percentile figures, reveals that the construction cost is expected to fall between $208 million and $391 million.

There is 50 percent chance that the total project cost will be less than $289 million.

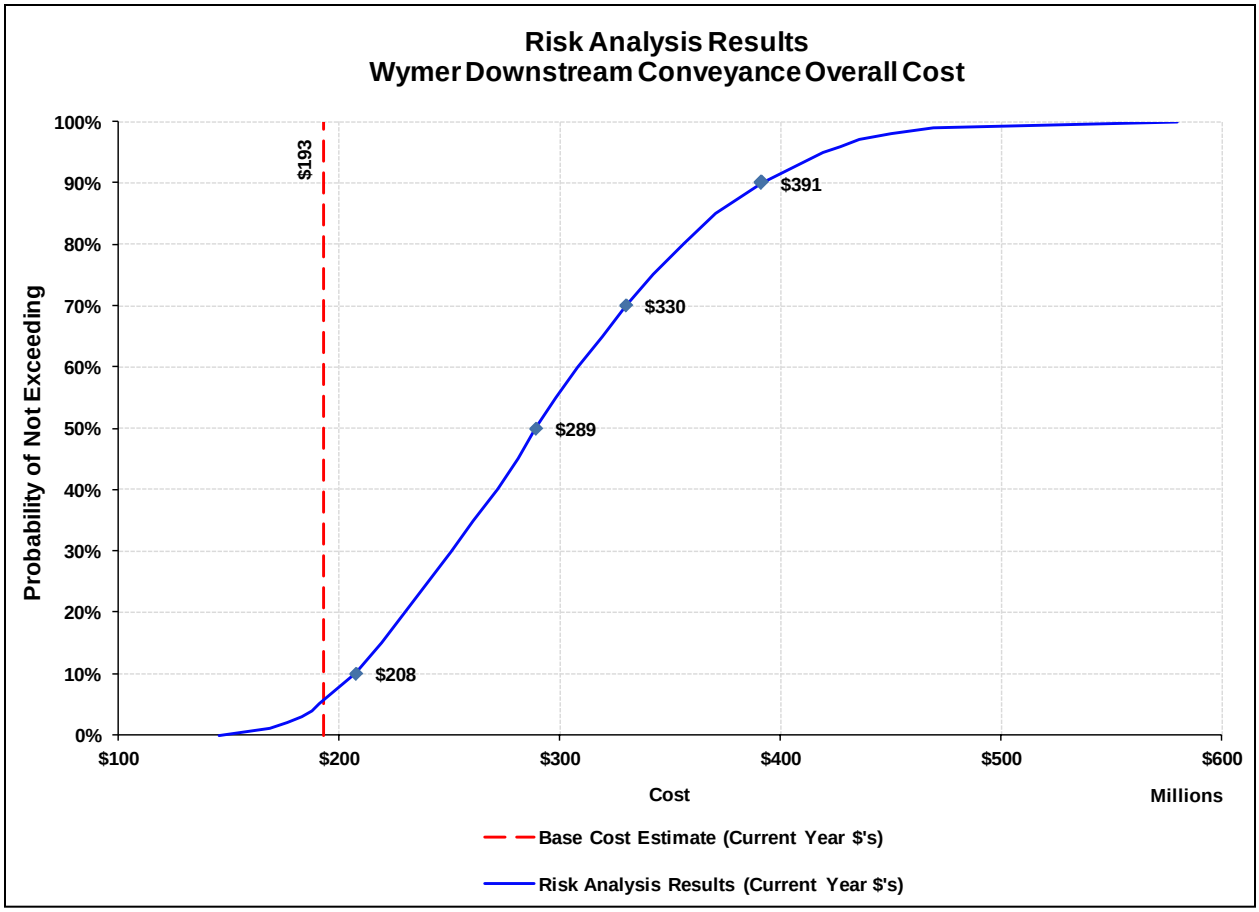

Figure 44. Total Project Costs for Wymer Downstream Conveyance System

Figure 45 details the probabilistic construction cost results after accounting for risks and uncertainty. The 80-percent confidence interval reveals that the construction cost is expected to fall between $187 million and $360 million.

There is 50-percent likelihood that construction costs will not exceed $264 million.

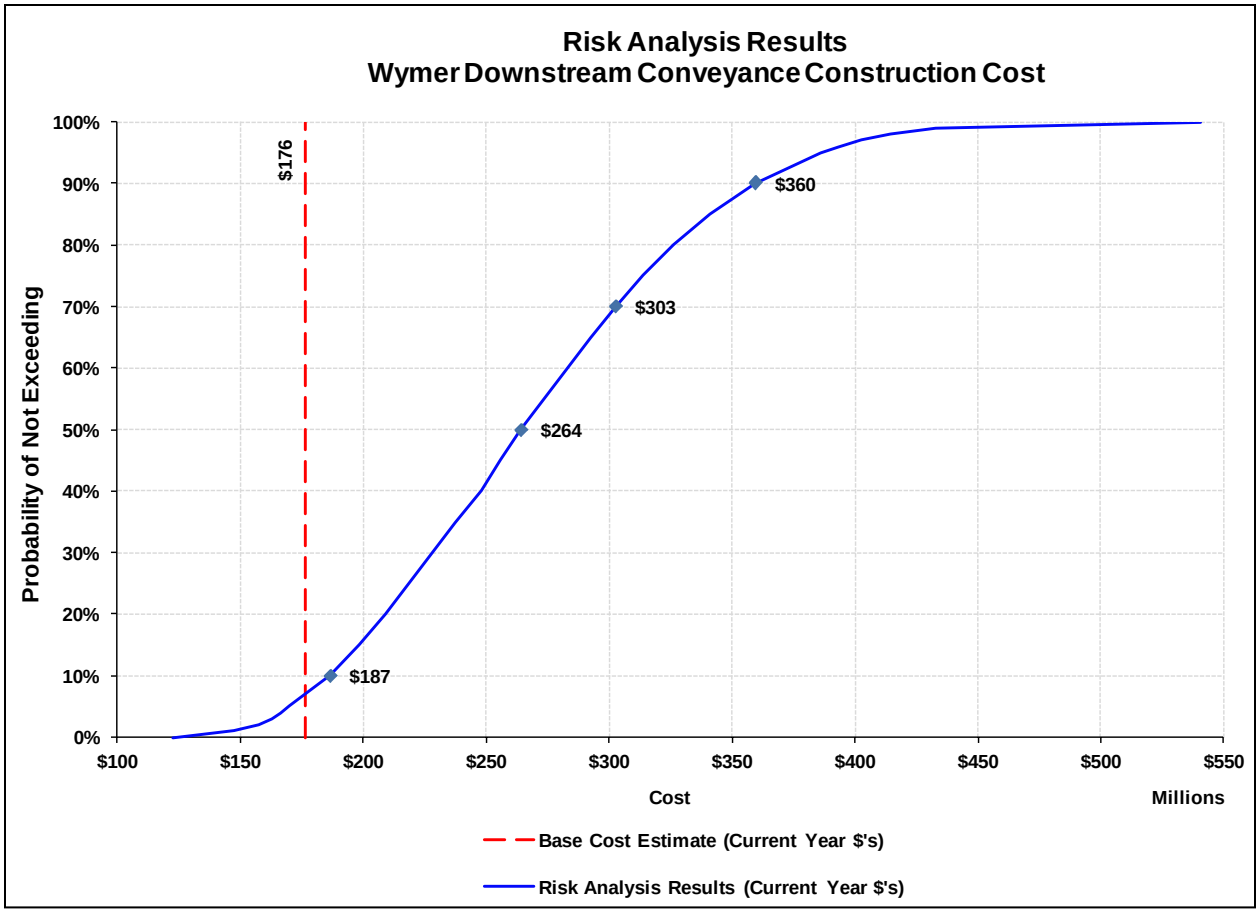

Figure 45. Construction Costs for Wymer Downstream Conveyance System

Schedule Results

No risks to the project schedule were identified during the workshop.

Final Cost Comparison

For a basis of comparison the following charts were created showing the cost of each project before and after the CRA workshop.

The Pre-CRA costs include:

- Base Cost (3rd quarter 2010)
- Contingency
- The cost to index the project to the 1st quarter 2012 using the Reclamation's construction cost trend index.

The Post-CRA costs include:

- Adjusted Base Cost (1st quarter 2012)
- Base Cost Uncertainty at 50th percentile
- Risk Impact at 50th percentile

The costs shown are in millions of dollars.

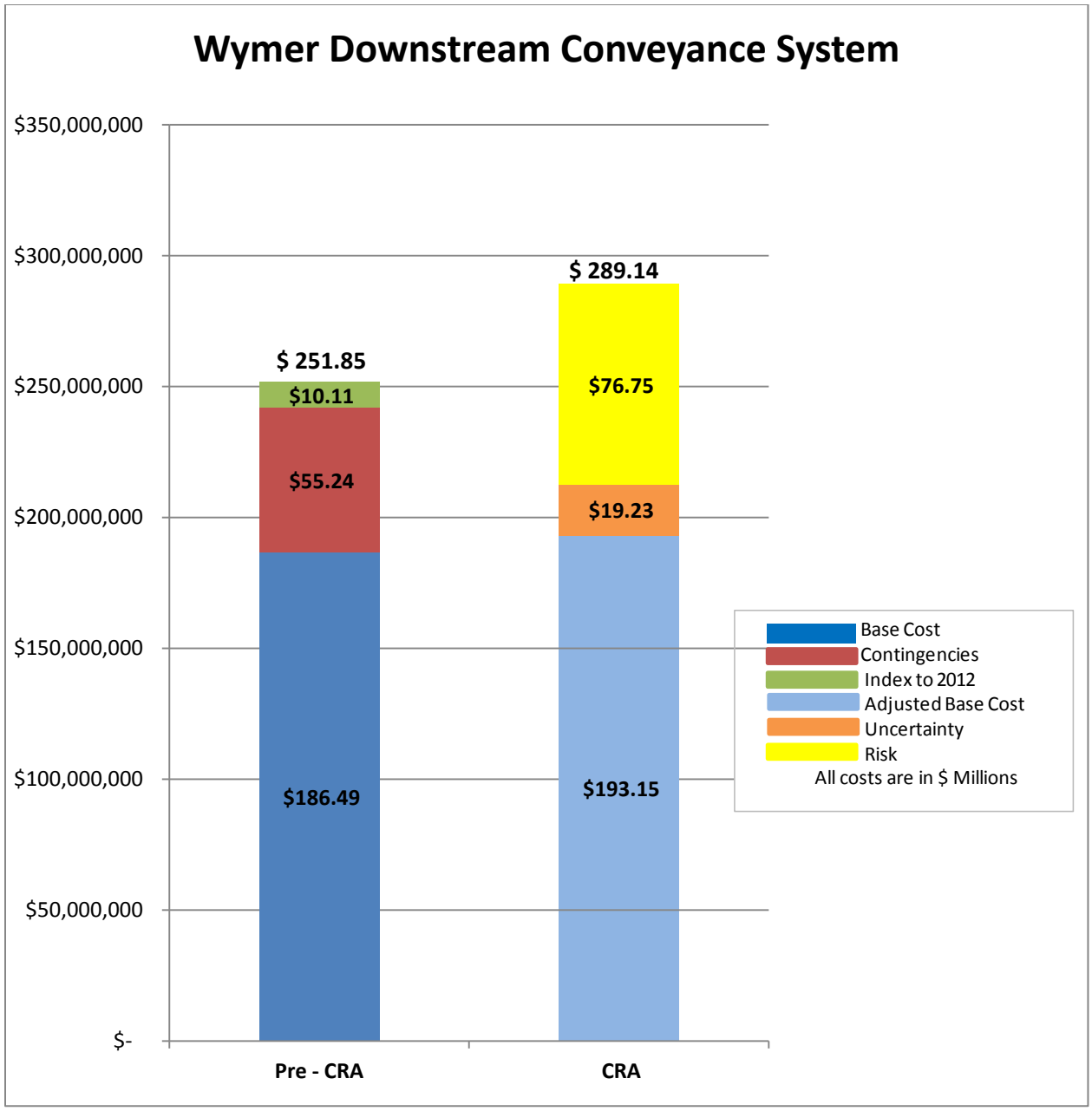

Figure 46. Final Cost Comparison for Wymer Downstream Conveyance System

9.0 References

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Reclamation , see Bureau of Reclamation.

Reclamation and Ecology, see Bureau of Reclamation and Washington State Department of Ecology.

10.0 List of Preparers

NAME	BACKGROUND	RESPONSIBILITY
HDR ENGINEERING, Inc.		
Blane Long	Value Engineering	Cost Lead, Primary Author
Ken Smith, P.E.	Engineering, Value Engineering	Task Lead
Ronan Igloria, P.E.	Water Resources Planning and Engineering	Reviewer
Andrew Graham	Water Resources Planning	Reviewer

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Appendix A
Uncertainty Calculations

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Uncertainty Calculatons

Cle Elum Dam Fish Passage Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 02 - SITE CONSTRUCTION							
Downstream - Roads and Road Structures	LS	$ 437,288	-20%	$ 546,610	50%	$ 819,915	Minor Item
Downstream - Dams	LS	$ 7,930,796	-15%	$ 9,330,348	45%	$ 13,529,005	Dewatering is lump sum
Downstream - Waterway Structures	LS	$ 11,026,886	-15%	$ 12,972,807	45%	$ 18,810,570	Storm Drain System is a lump sum
Upstream - Structures and Improvements	LS	$ 289,368	-20%	$ 361,710	50%	$ 542,565	Minor Item
Upstream - Roads and Road Structures	LS	$ 62,640	-20%	$ 78,300	50%	$ 117,450	Minor Item
Upstream - Waterway Structures	LS	$ 1,563,498	-20%	$ 1,954,372	40%	$ 2,736,121	
Upstream Auxiliary Water Supply	LS	$ -				$ -	
Subtotal Site Construction		$ 21,310,475	-16%	$ 25,244,147	45%	$ 36,555,626	
DIVISION 03 - CONCRETE							
Downstream - Roads and Road Structures	LS	$ -				$ -	
Downstream - Dams	LS	$ 3,896,218	-20%	$ 4,870,273	40%	$ 6,818,382	
Downstream - Waterway Structures	LS	$ 3,077,974	-20%	$ 3,847,468	40%	$ 5,386,455	
Upstream - Structures and Improvements	LS	$ 899,362	-20%	$ 1,124,203	40%	$ 1,573,884	
Upstream - Roads and Road Structures	LS	$ -				$ -	
Upstream - Waterway Structures	LS	$ 1,781,306	-20%	$ 2,226,633	40%	$ 3,117,286	
Upstream Auxiliary Water Supply	LS	$ -				$ -	
Subtotal Concrete		$ 9,654,862	-20%	$ 12,068,577	40%	$ 16,896,008	
DIVISION 05 - METALS							
Downstream - Roads and Road Structures	LS	$ -				$ -	
Downstream - Dams	LS	$ 743,896	-20%	$ 929,870	40%	$ 1,301,818	
Downstream - Waterway Structures	LS	$ 9,037	-20%	$ 11,296	50%	$ 16,944	Minor Item
Upstream - Structures and Improvements	LS	$ 309,716	-20%	$ 387,145	50%	$ 580,718	Minor Item
Upstream - Roads and Road Structures	LS	$ -				$ -	
Upstream - Waterway Structures	LS	$ 161,190	-20%	$ 201,488	50%	$ 302,232	Minor Item
Upstream Auxiliary Water Supply	LS	$ 48,406	-20%	$ 60,508	50%	$ 90,762	Minor Item
Subtotal Metals		$ 1,272,246	-20%	$ 1,590,307	44%	$ 2,292,474	

Cle Elum Dam Fish Passage Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 11 - EQUIPMENT							
Downstream - Roads and Road Structures	LS	$ -				$ -	
Downstream - Dams	LS	$ 141,758	-20%	$ 177,198	50%	$ 265,797	Minor Item
Downstream - Waterway Structures	LS	$ -				$ -	
Upstream - Structures and Improvements	LS	$ 307,038	-20%	$ 383,797	50%	$ 575,696	Minor Item
Upstream - Roads and Road Structures	LS	$ -				$ -	
Upstream - Waterway Structures	LS	$ -				$ -	
Upstream Auxiliary Water Supply	LS	$ 2,528,471	-20%	$ 3,160,589	40%	$ 4,424,825	
Subtotal Equipment		$ 2,977,267	-20%	$ 3,721,584	42%	$ 5,266,317	
DIVISION 15 - MECHANICAL							
Downstream - Roads and Road Structures	LS	$ -				$ -	
Downstream - Dams	LS	$ 2,066,671	-20%	$ 2,583,339	40%	$ 3,616,675	
Downstream - Waterway Structures	LS	$ -				$ -	
Upstream - Structures and Improvements	LS	$ 379,014	-20%	$ 473,768	50%	$ 710,652	Minor Item
Upstream - Roads and Road Structures	LS	$ -				$ -	
Upstream - Waterway Structures	LS	$ -				$ -	
Upstream Auxiliary Water Supply	LS	$ 59,684	-20%	$ 74,605	50%	$ 111,908	Minor Item
Subtotal Mechanical		$ 2,505,370	-20%	$ 3,131,712	42%	$ 4,439,234	
DIVISION 16 - ELECTRICAL							
Downstream - Roads and Road Structures	LS	$ -				$ -	
Downstream - Dams	LS	$ 255,166	-20%	$ 318,957	50%	$ 478,436	Minor Item
Downstream - Waterway Structures	LS	$ -				$ -	
Upstream - Structures and Improvements	LS	$ -				$ -	
Upstream - Roads and Road Structures	LS	$ -				$ -	
Upstream - Waterway Structures	LS	$ -				$ -	
Upstream Auxiliary Water Supply	LS	$ 191,538	-20%	$ 239,422	50%	$ 359,133	Minor Item
Subtotal Electrical		$ 446,703	-20%	$ 558,379	50%	$ 837,569	
						Contract Total	

Cle Elum Dam Fish Passage Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
		$ 38,166,923	-18%	$ 46,314,706	43%	$ 66,287,227	

Bumping Lake Reservoir Enlargement Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 01 - GENERAL REQUIREMENTS							
Land Rights	LS	$ -				$ -	
Relocation of Property of Others	LS	$ 1,164,197	-20%	$ 1,455,246	40%	$ 2,037,344	
Clearing Lands	LS	$ -				$ -	
Roads and Road Structures	LS	$ -				$ -	
Dams	LS	$ 806,704	-20%	$ 1,008,380	40%	$ 1,411,732	
Subtotal General Requirements		$ 1,970,901	-20%	$ 2,463,626	40%	$ 3,449,076	
DIVISION 02 - SITE CONSTRUCTION							
Land Rights	LS	$ 570,097	-20%	$ 712,621	50%	$ 1,068,932	Minor Item
Relocation of Property of Others	LS	$ 1,346,404	-20%	$ 1,683,005	40%	$ 2,356,207	
Clearing Lands	LS	$ 9,013,186	-20%	$ 11,266,482	40%	$ 15,773,075	
Roads and Road Structures	LS	$ 3,041,251	-20%	$ 3,801,564	40%	$ 5,322,190	
Dams	LS	$ 68,868,740	-15%	$ 1,022,047	45%	$ 117,481,968	quantities are very preliminary
							wintering over 4 times may increase unit pricing considerably
Subtotal Site Construction		$ 82,839,678	-16%	$ 98,485,719	44%	$ 142,002,371	
DIVISION 03 - CONCRETE							
Land Rights	LS	$ -				$ -	
Relocation of Property of Others	LS	$ 163,892	-20%	$ 204,865	50%	$ 307,298	Minor Item
Clearing Lands	LS	$ -				$ -	
Roads and Road Structures	LS	$ -				$ -	
Dams	LS	$ 78,097,949	-15%	$ 91,879,940	45%	$ 133,225,913	quantities are very preliminary
							wintering over 4 times may increase unit pricing considerably

Bumping Lake Reservoir Enlargement Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
Subtotal Concrete		$ 78,261,841	-15%	$ 92,084,805	45%	$ 133,533,211	
DIVISION 05 - METALS							
Land Rights	LS	$ -				$ -	
Relocation of Property of Others	LS	$ 2,664	-20%	$ 3,330	50%	$ 4,995	Minor Item
Clearing Lands	LS	$ -				$ -	
Roads and Road Structures	LS	$ -				$ -	
Dams	LS	$ -				$ -	
Subtotal Metals		$ 2,664	-20%	$ 3,330	50%	$ 4,995	
DIVISION 07 - THERMAL & MOISTURE PROTECTION							
Land Rights	LS	$ -				$ -	
Relocation of Property of Others	LS	$ 9,216	-20%	$ 11,520	50%	$ 17,280	Minor Item
Clearing Lands	LS	$ -				$ -	
Roads and Road Structures	LS	$ -				$ -	
Dams	LS	$ -				$ -	
Subtotal Metals		$ 9,216	-20%	$ 11,520	50%	$ 17,280	
DIVISION 14 - CONVEYING SYSTEMS							
Land Rights	LS	$ -				$ -	
Relocation of Property of Others	LS	$ -				$ -	
Clearing Lands	LS	$ -				$ -	
Roads and Road Structures	LS	$ -				$ -	
Dams	LS	$ 282,508	-20%	$ 353,135	50%	$ 529,703	Minor Item
Subtotal Conveying Systems		$ 282,508	-20%	$ 353,135	50%	$ 529,703	
DIVISION 15 - MECHANICAL							
Land Rights	LS	$ -				$ -	
Relocation of Property of Others	LS	$ -				$ -	
Clearing Lands	LS	$ -				$ -	
Roads and Road Structures	LS	$ -				$ -	
Dams	LS	$ 1,041,684	-20%	$ 1,302,105	40%	$ 1,822,947	

Bumping Lake Reservoir Enlargement Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
Subtotal Mechanical		$ 1,041,684	-20%	$ 1,302,105	40%	$ 1,822,947	
UNASSIGNED							
Land Rights	LS	$ -				$ -	
Relocation of Property of Others	LS	$ 104,369	-20%	$ 130,461	50%	$ 195,692	Minor Item
Clearing Lands	LS	$ -				$ -	
Roads and Road Structures	LS	$ 173,948	-20%	$ 217,435	50%	$ 326,153	Minor Item
Dams	LS	$ 4,121,112	-20%	$ 5,151,390	40%	$ 7,211,946	
Subtotal Unassigned		$ 4,399,429	-20%	$ 5,499,286	41%	$ 7,733,790	
						Contract Total	
		$ 168,807,920	-16%	$ 200,203,526	44%	$ 289,093,372	

Keechelus to Kachess Pipeline Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 01 - GENERAL REQUIREMENTS							
Intake Screens and Connection to existing Aqueduct	LS	$ 37,526	-20%	$ 46,908	50%	$ 70,362	Minor Item
Wye Structure & Connections to existing Pipeline from Wye	LS	$ -				$ -	
Pipeline from Wye Str. to Outlet Control Valve Bldg	LS	$ 60,000	-20%	$ 75,000	50%	$ 112,500	Minor Item
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10	LS	$ 229,295	-20%	$ 286,619	50%	$ 429,929	Minor Item
Subtotal General Requirements		$ 326,822	-20%	$ 408,527	50%	$ 612,791	
DIVISION 02 - SITE CONSTRUCTION							
Intake Screens and Connection to existing Aqueduct	LS	$ 183,299	-20%	$ 229,124	50%	$ 343,686	Minor Item
Wye Structure & Connections to existing Pipeline from Wye	LS	$ 14,304	-20%	$ 17,880	50%	$ 26,820	Minor Item
Pipeline from Wye Str. to Outlet Control Valve Bldg	LS	$ 19,999,069	-15%	$ 23,528,316	45%	$ 34,116,058	3 winters to deal with

Keechelus to Kachess Pipeline Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10	LS	$ 40,936	-20%	$ 51,170	50%	$ 76,755	Minor Item
Subtotal Site Construction		$ 20,237,608	-15%	$ 23,826,490	45%	$ 34,563,319	
DIVISION 03 - CONCRETE							
Intake Screens and Connection to existing Aqueduct	LS	$ 37,453	-20%	$ 46,816	50%	$ 70,224	Minor Item
Wye Structure & Connections to existing Pipeline from Wye	LS	$ 79,184	-20%	$ 98,980	50%	$ 148,470	Minor Item
Pipeline from Wye Str. to Outlet Control Valve Bldg	LS	$ -				$ -	
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10	LS	$ -				$ -	
Subtotal Concrete		$ 116,637	-20%	$ 145,796	50%	$ 218,694	
DIVISION 05 - METALS							
Intake Screens and Connection to existing Aqueduct	LS	$ -				$ -	
Wye Structure & Connections to existing Pipeline from Wye	LS	$ 930	-20%	$ 1,162	50%	$ 1,743	Minor Item
Pipeline from Wye Str. to Outlet Control Valve Bldg	LS	$ -				$ -	
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10	LS	$ -				$ -	
Subtotal Metals		$ 930	-20%	$ 1,162	50%	$ 1,743	
DIVISION 08 - DOORS & WINDOWS							
Intake Screens and Connection to existing Aqueduct	LS	$ -				$ -	
Wye Structure & Connections to existing Pipeline from Wye	LS	$ 4,333	-20%	$ 5,416	50%	$ 8,124	Minor Item
Pipeline from Wye Str. to Outlet Control Valve Bldg	LS	$ -				$ -	
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10	LS	$ -				$ -	
Subtotal Doors & Windows		$ 4,333	-20%	$ 5,416	50%	$ 8,124	

Keechelus to Kachess Pipeline Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 13 - SPECIAL CONSTRUCTION							
Intake Screens and Connection to existing Aqueduct	LS	$ 1,112,058	-20%	$ 1,390,072	40%	$ 1,946,101	
Wye Structure & Connections to existing Pipeline from Wye	LS	$ 51,991	-20%	$ 64,989	50%	$ 97,484	Minor Item
Pipeline from Wye Str. to Outlet Control Valve Bldg	LS	$ -				$ -	
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10	LS	$ -				$ -	
Subtotal Special Construction		$ 1,164,049	-20%	$ 1,455,061	40%	$ 2,043,584	
DIVISION 15 - MECHANICAL							
Intake Screens and Connection to existing Aqueduct	LS	$ -				$ -	
Wye Structure & Connections to existing Pipeline from Wye	LS	$ 3,406,229	-20%	$ 4,257,786	40%	$ 5,960,900	
Pipeline from Wye Str. to Outlet Control Valve Bldg	LS	$ 53,354,376	-15%	$ 62,769,854	45%	$ 91,016,288	rock ex appears low
Pipeline from Wye Str. to Outlet Control Valve Bldg to STA 275+10	LS	$ 496,208	-20%	$ 620,260	40%	$ 868,364	
Subtotal Mechanical		$ 57,256,813	-15%	$ 67,647,900	45%	$ 97,845,553	
						Contract Total	
		$ 78,985,291	-15%	$ 93,337,978	45%	$ 135,065,247	

Lake Kachess Inactive Storage - Alternate 1 |Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 01 - GENERAL REQUIREMENTS							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 20 CFS	LS	$ -				$ -	
Pipeline 20" from Pump Station to Kachess River Discharge	LS	$ 16,977	-20%	$ 21,221	50%	$ 31,832	Minor Item
Tunnel from Pump Station to Yakima River	LS	$ -				$ -	
Yakima River Discharge Structure	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal General Requirements		$ 16,977	-20%	$ 21,221	50%	$ 31,832	
DIVISION 02 - SITE CONSTRUCTION							
Tunnel - Lake Outlet to Pump Station	LS	$ 7,834,221	-15%	$ 9,216,731	50%	$ 13,825,097	2,900 LF = $3,178/LF (includes rock trap for lake tap)
Pump Station 20 CFS	LS	$ 3,419,562	-20%	$ 4,274,452	40%	$ 5,984,233	
Pipeline 20" from Pump Station to Kachess River Discharge	LS	$ 59,878	-20%	$ 74,847	50%	$ 112,271	Minor Item
Tunnel from Pump Station to Yakima River	LS	$ 73,097,104	-15%	$ 85,996,593	45%	$ 124,695,060	24,200 LF = $3,553/LF
Yakima River Discharge Structure	LS	$ 55,018	-20%	$ 68,773	50%	$ 103,160	Minor Item
Kachess River Discharge Structure	LS	$ 88,267	-20%	$ 110,334	50%	$ 165,501	Minor Item
Subtotal Site Construction		$ 84,554,050	-15%	$ 99,741,730	45%	$ 144,885,320	
DIVISION 03 - CONCRETE							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 20 CFS	LS	$ 2,790,067	-20%	$ 3,487,584	40%	$ 4,882,618	
Pipeline 20" from Pump Station to Kachess River Discharge	LS	$ -				$ -	
Tunnel from Pump Station to Yakima River	LS	$ -				$ -	
Yakima River Discharge Structure	LS	$ 3,536,485	-20%	$ 4,420,606	40%	$ 6,188,848	
Kachess River Discharge Structure	LS	$ 139,686	-20%	$ 174,607	50%	$ 261,911	Minor Item
Subtotal Concrete		$ 6,466,238	-20%	$ 8,082,797	40%	$ 11,333,377	
DIVISION 05 - METALS							

Lake Kachess Inactive Storage - Alternate 1 |Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 20 CFS	LS	$ 57,436	-20%	$ 71,795	50%	$ 107,693	Minor Item
Pipeline 20" from Pump Station to Kachess River Discharge	LS	$ -				$ -	
Tunnel from Pump Station to Yakima River	LS	$ -				$ -	
Yakima River Discharge Structure	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal Metals		$ 57,436	-20%	$ 71,795	50%	$ 107,693	
DIVISION 08 - DOORS & WINDOWS							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 20 CFS	LS	$ 42,040	-20%	$ 52,550	50%	$ 78,825	Minor Item
Pipeline 20" from Pump Station to Kachess River Discharge	LS	$ -				$ -	
Tunnel from Pump Station to Yakima River	LS	$ -				$ -	
Yakima River Discharge Structure	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal Doors & Windows		$ 156,912	-20%	$ 196,140	50%	$ 294,210	
DIVISION 11 - EQUIPMENT							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 20 CFS	LS	$ 890,378	-20%	$ 1,112,972	40%	$ 1,558,161	
Pipeline 20" from Pump Station to Kachess River Discharge	LS	$ -				$ -	
Tunnel from Pump Station to Yakima River	LS	$ -				$ -	
Yakima River Discharge Structure	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal Equipment		$ 1,089,330	-20%	$ 1,361,662	42%	$ 1,931,196	
DIVISION 13 - SPECIAL CONSTRUCTION							
Tunnel - Lake Outlet to Pump Station	LS	$ 2,954,134	-20%	$ 3,692,668	40%	$ 5,169,735	
Pump Station 20 CFS	LS	$ 963,200	-20%	$ 1,204,000	40%	$ 1,685,600	

Lake Kachess Inactive Storage - Alternate 1 |Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
Pipeline 20" from Pump Station to Kachess River Discharge	LS	$ -				$ -	
Tunnel from Pump Station to Yakima River	LS	$ -				$ -	
Yakima River Discharge Structure	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ 45,000	-20%	$ 56,250	50%	$ 84,375	Minor Item
Subtotal Special Construction		$ 5,942,042	-20%	$ 7,427,552	40%	$ 10,429,067	
DIVISION 15 - MECHANICAL							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 20 CFS	LS	$ 715,550	-20%	$ 894,438	40%	$ 1,252,213	
Pipeline 20" from Pump Station to Kachess River Discharge	LS	$ 2,420,947	-20%	$ 3,026,184	40%	$ 4,236,658	
Tunnel from Pump Station to Yakima River	LS	$ -				$ -	
Yakima River Discharge Structure	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal Mechanical		$ 13,040,874	-20%	$ 16,301,092	40%	$ 22,857,648	
DIVISION 16 - ELECTRICAL							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 20 CFS	LS	$ 3,384,575	-20%	$ 4,230,719	40%	$ 5,923,007	
Pipeline 20" from Pump Station to Kachess River Discharge	LS	$ -				$ -	
Tunnel from Pump Station to Yakima River	LS	$ -				$ -	
Yakima River Discharge Structure	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ 196,096	-20%	$ 245,120	50%	$ 367,680	Minor Item
Subtotal Electrical		$ 3,580,671	-20%	$ 4,475,839	41%	$ 6,290,687	
						Contract Total	
		$ 114,904,529	-17%	$ 137,679,828	44%	$ 198,161,028	

Lake Kachess Inactive Storage - Alternate 2 Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 01 - GENERAL REQUIREMENTS							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 1000 CFS	LS	$ -				$ -	
Pipeline - Pump Station to Kachess River Discharge	LS	$ 35,591	-20%	$ 44,489	50%	$ 66,734	Minor Item
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal General Requirements		$ 35,591	-20%	$ 44,489	50%	$ 66,734	
DIVISION 02 - SITE CONSTRUCTION							
Tunnel - Lake Outlet to Pump Station	LS	$ 7,834,221	-15%	$ 9,216,730	50%	$ 13,825,095	2,900 LF = $3,178/LF (includes rock trap for lake tap)
Pump Station 1000 CFS	LS	$ 6,673,565	-20%	$ 8,341,956	40%	$ 11,678,738	
Pipeline - Pump Station to Kachess River Discharge	LS	$ 89,811	-20%	$ 112,264	50%	$ 168,396	Minor Item
Kachess River Discharge Structure	LS	$ 162,187	-20%	$ 202,734	50%	$ 304,101	Minor Item
Subtotal Site Construction		$ 14,759,784	-17%	$ 17,873,684	45%	$ 25,976,330	
DIVISION 03 - CONCRETE							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 1000 CFS	LS	$ 8,707,090	-20%	$ 10,883,862	40%	$ 15,237,407	
Pipeline - Pump Station to Kachess River Discharge	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ 653,334	-20%	$ 816,667	40%	$ 1,143,334	
Subtotal Concrete		$ 9,360,423	-20%	$ 11,700,529	40%	$ 16,380,741	
DIVISION 05 - METALS							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 1000 CFS	LS	$ 73,314	-20%	$ 91,642	50%	$ 137,463	Minor Item
Pipeline - Pump Station to Kachess River Discharge	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal Metals		$ 73,314	-20%	$ 91,642	50%	$ 137,463	

Lake Kachess Inactive Storage - Alternate 2 Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 08 - DOORS & WINDOWS							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 1000 CFS	LS	$ 42,040	-20%	$ 52,550	50%	$ 78,825	Minor Item
Pipeline - Pump Station to Kachess River Discharge	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal Doors & Windows		$ 42,040	-20%	$ 52,550	50%	$ 78,825	
DIVISION 11 - EQUIPMENT							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 1000 CFS	LS	$ 27,650,050	-20%	$ 34,562,563	40%	$ 48,387,588	Vertical Turbine
Pipeline - Pump Station to Kachess River Discharge	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal Equipment		$ 27,650,050	-20%	$ 34,562,563	40%	$ 48,387,588	
DIVISION 13 - SPECIAL CONSTRUCTION							
Tunnel - Lake Outlet to Pump Station	LS	$ 2,954,134	-20%	$ 3,692,668	40%	$ 5,169,735	
Pump Station 1000 CFS	LS	$ 2,513,280	-20%	$ 3,141,600	40%	$ 4,398,240	
Pipeline - Pump Station to Kachess River Discharge	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ 63,000	-20%	$ 78,750	50%	$ 118,125	Minor Item
Subtotal Special Construction		$ 5,530,414	-20%	$ 6,913,018	40%	$ 9,686,100	
DIVISION 14 - CONVEYING SYSTEMS							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 1000 CFS	LS	$ 159,553	-20%	$ 199,441	50%	$ 299,162	Minor Item
Pipeline - Pump Station to Kachess River Discharge	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal Conveying Systems		$ 159,553	-20%	$ 199,441	50%	$ 299,162	
DIVISION 15 - MECHANICAL							

Lake Kachess Inactive Storage - Alternate 2 Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 1000 CFS	LS	$ 10,009,370	-20%	$ 12,511,713	40%	$ 17,516,398	
Pipeline - Pump Station to Kachess River Discharge	LS	$ 11,486,216	-20%	$ 14,357,770	40%	$ 20,100,878	
Kachess River Discharge Structure	LS	$ -				$ -	
Subtotal Mechanical		$ 21,495,586	-20%	$ 26,869,483	40%	$ 37,617,276	
DIVISION 16 - ELECTRICAL							
Tunnel - Lake Outlet to Pump Station	LS	$ -				$ -	
Pump Station 1000 CFS	LS	$ 7,572,463	-20%	$ 9,465,579	40%	$ 13,251,811	
Pipeline - Pump Station to Kachess River Discharge	LS	$ -				$ -	
Kachess River Discharge Structure	LS	$ 196,200	-20%	$ 245,250	50%	$ 367,875	Minor Item
Subtotal Electrical		$ 7,768,663	-20%	$ 9,710,829	40%	$ 13,619,686	
						Contract Total	
		$ 86,875,419	-20%	$ 108,018,228	41%	$ 152,249,904	

Wymer Dam and Reservoir Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 01 - GENERAL REQUIREMENTS							
Yakima River Intake	LS	$ -				$ -	
Pumping Station	LS	$ -				$ -	
Switchyard and Transmission Line	LS	$ -				$ -	
Discharge Line	LS	$ 534,622	-20%	$ 668,278	40%	$ 935,589	
Dam and Dike	LS	$ -				$ -	
Spillway and Outlet Works	LS	$ 2,382,464	-20%	$ 2,978,080	40%	$ 4,169,312	
Diversion During Construction	LS	$ -				$ -	
Road and Creek Improvements	LS	$ -				$ -	
Subtotal General Requirements		$ 2,917,086	-20%	$ 3,646,358	40%	$ 5,104,901	

Wymer Dam and Reservoir Item and Description	Unit	Cost Low	Under	Base	Over	High	Remarks
DIVISION 02 - SITE CONSTRUCTION							
Yakima River Intake	LS	$ 6,453,624	-20%	$ 8,067,030	40%	$ 11,293,842	
Pumping Station	LS	$ 3,382,523	-20%	$ 4,228,154	40%	$ 5,919,416	
Switchyard and Transmission Line	LS	$ 99,302	-20%	$ 124,128	50%	$ 186,192	Minor Item
Discharge Line	LS	$ 8,251,365	-20%	$ 10,314,206	40%	$ 14,439,888	
Dam and Dike	LS	$ 238,387,610	-25%	$ 317,850,147	50%	$ 476,775,221	Major Quantities should provide lower bid prices but large uncertainty in quantities
Spillway and Outlet Works	LS	$ 10,480,808	-20%	$ 13,101,010	40%	$ 18,341,414	
Diversion During Construction	LS	$ 3,245,222	-20%	$ 4,056,527	40%	$ 5,679,138	
Road and Creek Improvements	LS	$ 5,276,350	-20%	$ 6,595,438	40%	$ 9,233,613	
Subtotal Site Construction		$ 275,576,805	-24%	$ 364,336,640	49%	$ 541,868,724	
DIVISION 03 - CONCRETE							
Yakima River Intake	LS	$ 5,428,430	-20%	$ 6,785,537	40%	$ 9,499,752	Major Quantities should provide lower bid prices
Pumping Station	LS	$ 12,555,710	-25%	$ 16,740,946	35%	$ 22,600,277	Major Quantities should provide lower bid prices
Switchyard and Transmission Line	LS	$ 167,360	-20%	$ 209,200	50%	$ 313,800	Minor Item
Discharge Line	LS	$ 6,101,206	-20%	$ 7,626,508	40%	$ 10,677,111	
Dam and Dike	LS	$ 61,552,796	-25%	$ 82,070,394	35%	$ 110,795,032	Major Quantities should provide lower bid prices
Spillway and Outlet Works	LS	$ 28,287,939	-25%	$ 37,717,252	35%	$ 50,918,290	Major Quantities should provide lower bid prices
Diversion During Construction	LS	$ 95,326	-20%	$ 119,157	50%	$ 178,736	Minor Item
Road and Creek Improvements	LS	$ 11,579	-20%	$ 14,474	50%	$ 21,711	Minor Item
Subtotal Concrete		$ 114,200,345	-25%	$ 151,283,468	36%	$ 205,004,709	
DIVISION 05 - METALS							
Yakima River Intake	LS	$ 2,226,713	-20%	$ 2,783,391	40%	$ 3,896,747	
Pumping Station	LS	$ 3,137,213	-20%	$ 3,921,516	40%	$ 5,490,122	
Switchyard and Transmission Line	LS	$ 169,838	-20%	$ 212,298	50%	$ 318,447	Minor Item

Wymer Dam and Reservoir Item and Description	Unit	Cost Low	Under	Base	Over	High	Remarks
Discharge Line	LS	$ -				$ -	
Dam and Dike	LS	$ -				$ -	
Spillway and Outlet Works	LS	$ 441,096	-20%	$ 551,370	40%	$ 771,918	
Diversion During Construction	LS	$ 453,553	-20%	$ 566,941	40%	$ 793,717	
Road and Creek Improvements	LS	$ -				$ -	
Subtotal Metals		$ 6,428,413	-20%	$ 8,035,516	40%	$ 11,270,952	
DIVISION 07 - THERMAL & MOISTURE PROTECTION							
Yakima River Intake	LS	$ -				$ -	
Pumping Station	LS	$ 176,533	-20%	$ 220,666	50%	$ 330,999	Minor Item
Switchyard and Transmission Line	LS	$ -				$ -	
Discharge Line	LS	$ -				$ -	
Dam and Dike	LS	$ -				$ -	
Spillway and Outlet Works	LS	$ 232,290	-20%	$ 290,363	50%	$ 435,545	Minor Item
Diversion During Construction	LS	$ -				$ -	
Road and Creek Improvements	LS	$ -				$ -	
Subtotal Thermal & Moisture Protection		$ 408,823	-20%	$ 511,029	50%	$ 766,544	
DIVISION 08 - DOORS & WINDOWS							
Yakima River Intake	LS	$ -				$ -	
Pumping Station	LS	$ 38,372	-20%	$ 47,965	50%	$ 71,948	Minor Item
Switchyard and Transmission Line	LS	$ -				$ -	
Discharge Line	LS	$ -				$ -	
Dam and Dike	LS	$ -				$ -	
Spillway and Outlet Works	LS	$ -				$ -	
Diversion During Construction	LS	$ -				$ -	
Road and Creek Improvements	LS	$ -				$ -	
Subtotal Doors & Windows		$ 38,372	-20%	$ 47,965	50%	$ 71,948	
DIVISION 11 - EQUIPMENT							

Wymer Dam and Reservoir Item and Description	Unit	Cost Low	Under	Base	Over	High	Remarks
Yakima River Intake	LS	$ -				$ -	
Pumping Station	LS	$ 9,149,374	-10%	$ 10,165,971	40%	$ 14,232,359	
Switchyard and Transmission Line	LS	$ -				$ -	
Discharge Line	LS	$ -				$ -	
Dam and Dike	LS	$ -				$ -	
Spillway and Outlet Works	LS	$ -				$ -	
Diversion During Construction	LS	$ -				$ -	
Road and Creek Improvements	LS	$ -				$ -	
Subtotal Equipment		$ 9,149,374	-10%	$ 10,165,971	40%	$ 14,232,359	
DIVISION 13 - SPECIAL CONSTRUCTION							
Yakima River Intake	LS	$ 1,988,831	-20%	$ 2,486,039	40%	$ 3,480,455	
Pumping Station	LS	$ 184,397	-20%	$ 230,496	50%	$ 345,744	Minor Item
Switchyard and Transmission Line	LS	$ -				$ -	
Discharge Line	LS	$ 144,172	-20%	$ 180,215	50%	$ 270,323	Minor Item
Dam and Dike	LS	$ -				$ -	
Spillway and Outlet Works	LS	$ 80,834	-20%	$ 101,042	50%	$ 151,563	Minor Item
Diversion During Construction	LS	$ -				$ -	
Road and Creek Improvements	LS	$ -				$ -	
Subtotal Special Construction		$ 2,398,234	-20%	$ 2,997,792	42%	$ 4,248,084	
DIVISION 14 - CONVEYING SYSTEMS							
Yakima River Intake	LS	$ 5,452	-20%	$ 6,815	50%	$ 10,223	Minor Item
Pumping Station	LS	$ 684,902	-20%	$ 856,128	50%	$ 1,284,192	
Switchyard and Transmission Line	LS	$ -				$ -	
Discharge Line	LS	$ -				$ -	
Dam and Dike	LS	$ -				$ -	
Spillway and Outlet Works	LS	$ -				$ -	
Diversion During Construction	LS	$ -				$ -	
Road and Creek Improvements	LS	$ -				$ -	

Wymer Dam and Reservoir Item and Description	Unit	Cost Low	Under	Base	Over	High	Remarks
Subtotal Conveying Systems		$ 690,354	-20%	$ 862,943	50%	$ 1,294,415	
DIVISION 15 - MECHANICAL							
Yakima River Intake	LS	$ 421,362	-20%	$ 526,702	40%	$ 737,383	
Pumping Station	LS	$ 14,534,638	-20%	$ 18,168,297	40%	$ 25,435,616	
Switchyard and Transmission Line	LS	$ -				$ -	
Discharge Line	LS	$ 7,121,542	-20%	$ 8,901,927	40%	$ 12,462,698	
Dam and Dike	LS	$ -				$ -	
Spillway and Outlet Works	LS	$ 6,915,059	-20%	$ 8,643,824	40%	$ 12,101,354	
Diversion During Construction	LS	$ -				$ -	
Road and Creek Improvements	LS	$ -				$ -	
Subtotal Mechanical		$ 28,992,600	-20%	$ 36,240,750	40%	$ 50,737,050	
DIVISION 16 - ELECTRICAL							
Yakima River Intake	LS	$ 151,107	-20%	$ 188,884	50%	$ 283,326	Minor Item
Pumping Station	LS	$ 5,031,522	-20%	$ 6,289,402	40%	$ 8,805,163	
Switchyard and Transmission Line	LS	$ 4,799,327	-20%	$ 5,999,159	40%	$ 8,398,823	
Discharge Line	LS	$ 26,279	-20%	$ 32,849	50%	$ 49,274	Minor Item
Dam and Dike	LS	$ -				$ -	
Spillway and Outlet Works	LS	$ 156,137	-20%	$ 195,171	50%	$ 292,757	Minor Item
Diversion During Construction	LS	$ 21,044	-20%	$ 26,305	50%	$ 39,458	Minor Item
Road and Creek Improvements	LS	$ -				$ -	
Subtotal Electrical		$ 10,185,416	-20%	$ 12,731,770	40%	$ 17,868,799	
						Contract Total	
		$ 450,985,822	-24%	$ 590,860,202	44%	$ 852,468,484	

Wymer Downstream Conveyance System Item and Description	Unit	Cost					Remarks
		Low	Under	Base	Over	High	
DIVISION 01 - GENERAL REQUIREMENTS							
Penstock - Intake, Tunnels, Siphon	LS	$ 204,785	-20%	$ 255,981	50%	$ 383,972	Minor Item
Tailrace Flume	LS	$ -				$ -	
Discharge Line	LS	$ -				$ -	
Subtotal General Requirements		$ 204,785	-20%	$ 255,981	50%	$ 383,972	
DIVISION 02 - SITE CONSTRUCTION							
Penstock - Intake, Tunnels, Siphon	LS	$ 745,749	-20%	$ 932,186	40%	$ 1,305,060	
Tailrace Flume	LS	$ 2,256	-20%	$ 2,820	50%	$ 4,230	Minor Item
Discharge Line	LS	$ -				$ -	
Subtotal Site Construction		$ 748,005	-20%	$ 935,006	40%	$ 1,309,290	
DIVISION 03 - CONCRETE							
Penstock - Intake, Tunnels, Siphon	LS	$ 1,948,448	-20%	$ 2,435,560	40%	$ 3,409,784	
Tailrace Flume	LS	$ 719,311	-20%	$ 899,139	40%	$ 1,258,795	
Discharge Line	LS	$ -				$ -	
Subtotal Concrete		$ 2,667,759	-20%	$ 3,334,699	40%	$ 4,668,579	
DIVISION 15 - MECHANICAL							
Penstock - Intake, Tunnels, Siphon	LS	$ 8,479,374	-20%	$ 10,599,218	40%	$ 14,838,905	
Tailrace Flume	LS	$ -				$ -	
Discharge Line	LS	$ -				$ -	
Subtotal Mechanical		$ 8,479,374	-20%	$ 10,599,218	40%	$ 14,838,905	
UNASSIGNED							
Penstock - Intake, Tunnels, Siphon	LS	$ 83,435,498	-15%	$ 98,159,409	45%	$ 142,331,143	Tunneling, Burbank = 3,485/LF & Roza = 4,140/LF
Tailrace Flume	LS	$ 1,731,646	-20%	$ 2,164,557	40%	$ 3,030,380	
Discharge Line	LS	$ 3,600,000	-20%	$ 4,500,000	40%	$ 6,300,000	Similar to Yakima River Discharge on Kachess Alternate 1
Subtotal Unassigned		$ 88,767,143	-15%	$ 104,823,966	45%	$ 151,661,523	
						Contract Total	
		$ 100,867,066	-16%	$ 119,948,870	44%	$ 172,862,269	

Appendix B
Risk Register

A comprehensive documentation of the project's risks discussed at the April 12 & 13, 2012 Cost Risk Assessment workshop, both quantified and non-quantified, is included on the following pages.

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Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Cle Elum Dam Fish Passage											
ENV-8	550, 560, 320	Historical and Cultural Resources	Surveys have not been completed so there is a risk of potential delay during construction if historical or cultural resources are found.	Schedule	25%							0.5	0.8	1.0
CON-6	320	Cle Elum Fish Passage Construction	[from draft Peer Review] The construction of the fish collection facility along the right wall of the stilling basin will require some careful planning and execution in terms of coffer dams), dewatering, sequencing, etc. Part of the risk is overtopping the coffer dam due to flooding. The coffer dam costs $10,000,000 and the risk is that the coffer dam is not tall enough.	Cost	50%	$1,000,000	$1,500,000	$2,000,000						
CON-26	320	Design and Scope Changes	Cle Elum Fish Passage Unknown Design and Scope Changes - Low = 1%, Most Likely = 4%, High = 6 %	Cost	95%	$800,000	$3,100,000	$4,700,000						
CON-33	320	Minor Aggregate Risk	Cle Elum Fish Passage	Cost	75%	$250,000	$600,000	$1,000,000						
CON-36	320	Juvenile Bypass Conduit	Deepest point is up to 70 feet. Current estimate has over-excavation at 3H to 1V. There is an opportunity to reduce the amount of excavation by using alternate shoring method.	Cost	50%	-$2,000,000	-$1,500,000	-$1,000,000						
CON-37	320	Differing Site Conditions	Construction change order risk due to encountering unexpected soil conditions and dewatering requirements.	Cost	50%	$3,000,000	$7,000,000	$8,000,000						
ENV-11	320	Mitigation for Loss of Habitat	Mitigation of habitat for Cle Elum fish passage. Close to 25 acres of second growth mostly impacted due to road construction.	Cost	95%	$500,000	$750,000	$1,000,000						
CON-56	320	TERO	[from draft Peer Review]. It appears that none of the work included in the Integrated Plan will be subject to TERO enacted pursuant to the Tribes inherent sovereign authority to self governance. However, the team believes this should be confirmed because if any of the work would be subject to these provisions, the costs would increase significantly and need to be reflected in the estimate for that work. None of the projects are located on or adjacent to Tribal Land. This may add 4% on construction on the low end, 10% most likely, and 20% for the high end.	Cost	5%	$3,100,000	$7,800,000	$15,700,000						

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Bumping Lake Reservoir Enlargment											
CON-1	440	Bumping Dam Cutoff Wall	[from draft Peer Review] The cutoff wall as designed will be constructed before the embankment and will be subjected to drag forces caused by consolidation of the foundation under the weight of the dam as it is constructed. With this design the cutoff wall could crack. The cutoff wall would be more effective if it were located near the upstream toe. If locate upstream, it could be constructed after the embankment so that consolidation and lateral movement had already occurred in the foundation. This is an opportunity in the staging of construction for both cost and schedule. This would require an impervious blanket between the cutoff and the dam.	Cost & Schedule	90%	-$8,000,000	-$4,000,000	-$200,000						
CON-2	440	Bumping Dam Seepage Collection	[from draft Peer Review] The seepage collection features are not sufficient. The toe drain is located beneath the embankment which is unwise because it would be difficult to maintain and repair at that location. The toe drain should be located at or beyond the toe of the embankment in a deep toe drain trench (say 20 feet deep) so that near surface seepage is collected and conveyed safely from beneath the dam. The relief wells are good insurance, but they will not intercept all of the seepage, especially if left on 100-foot centers. Also, there may be zones of pervious foundation that are unaffected by the relief wells. At this stage of knowledge about the foundation, the relief wells should probably be on 50-foot centers. The risk is needing additional relief wells, relocating the drain trench, and deeper excavation for the toe drain. Doubling the wells adds $500,000. Extending of the blanket, approximately $5,000,000, with moving the trench downstream and adding cost for a deeper trench.	Cost	75%	$4,500,000	$5,500,000	$7,000,000						
CON-34	440	Bumping Dam Cutoff Wall Not Deep Enough	[from draft Peer Review] Current estimate has a wall 3 feet thick and average 160 feet tall. The risk is that the average wall depth may need to be more than 160 feet.	Cost		$10,000,000	$25,000,000	$50,000,000	5%	80%	15%			
CON-3	440	Bumping Site Specific Seismotectonic Study	[from draft Peer Review] No site-specific seismotectonic study has been made at the site and more study is needed as described in Section V. of the Planning Design Summary, Bumping Lake Enlargement Dam, Yakima Basin Water Enhancement Project, April 1985. Under seismic stresses, there could be liquefiable materials in the underlying alluvium. The existing Bumping Lake Dam was modified in the 1990s to address the issue of foundation liquefaction and since it is less than a mile upstream of Bumping Lake Enlargement and founded on a similar foundation, there could be similar material at the new dam site. The slopes should be flattened to 1 V on 3H upstream and 1 V on 2.5H downstream until seismic analyses verifies the actual configuration of embankment that is necessary to resist seismic loading and the cost estimates refined accordingly. The risk is adding up to an additional 1 million cu yards of fill material estimated at $2,000,000.	Cost	80%	$1,500,000	$2,000,000	$3,000,000						
CON-4	440	Bumping Hazardous Materials	[from draft Peer Review] As mentioned in the report on the enlargement of Bumping Lake [HDR Engineering, 2011 b] the appraisal study did not conduct any studies to determine the depth and quantity of sediment retained behind the existing dam, the presence of heavy metals or other pollutants m the sediments, and any downstream fisheries and other environmental issues due to suspended sediments in he river once the dam is breached. However the risk analysis team sees this is minor risk because it is not thought that the dam breaching will remove sediment. - Minor Risk											
CON-5	440	Bumping Fish Passage	Based on statements in the cost estimation data, the Cost-Risk Team is using Cle Elum fish passage as a basis for Bumping fish passage. The Cle Elum dam is a shorter dam. However for Bumping Dam, it can be built during the construction of the new dam so it can be less. The base cost of Cle Elum fish passage is $45,000,000.	Cost	50%	-$10,000,000	$0	$8,000,000						
CON-25	440	Design and Scope Changes	Bumping Lake Reservoir Enlargement Unknown Design and Scope Changes - Low = 1%, Most Likely = 4%, High = 6 %	Cost	95%	$3,600,000	$14,300,000	$21,400,000						
CON-32	440	Minor Aggregate Risk	Bumping Lake Reservoir Enlargement	Cost	75%	$10,000,000	$15,000,000	$20,000,000						

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Bumping Lake Reservoir Enlargment											
ENV-1	440	Mitigation for Loss of Habitat	Mitigation of old growth habitat, second growth habitat, and inundation of wetlands for Bumping Lake Reservoir. With this project, the area mitigated is likely to be much smaller than the area impacted, due to benefits from the land acquisition program under the Integrated Plan. For cost purposes, 5-15% of the construction cost is estimated for mitigation.	Cost		$15,000,000	$30,000,000	$45,000,000	65%	30%	5%			
ENV-2	410	Appeal of Project Level EIS	Current schedule has ROD at mid 2016 with construction starting early 2020, so there is adequate time in the schedule already. **Not a significant budget impact for Bumping Lake.**											
ENV-4	440	Historical and Cultural Resources	Surveys have not been completed so there is a risk of potential delay during construction if historical or cultural resources are found.	Schedule	25%							0.5	0.8	1.0
CON-35	440	Material Source Availability	Assumption that 6 million cu yards of material source is available between existing dam and new dam sites. Risk is that material would be needed from more distant location greater than 3 miles from site. Additional cost will be $0.50 per yard per mile (most likely $2,000,000).	Cost	50%	$1,000,000	$2,000,000	$4,000,000						
ENV-6	410	Added Cost and Duration for Planning Report and EIS	Base estimate is $3,000,000 with a schedule of 36 months. The risk is that it will take another 24 months and cost an additional $2,000,000.	Cost & Schedule	50%	$1,000,000	$2,000,000	$3,000,000				12.0	24.0	36.0
CON-50	440	Drain and Filter System	Risk is may need to widen Zone 2 and 3 drain and filter system for Bumping Reservoir.	Cost	75%	$15,000,000	$22,000,000	$30,000,000						
CON-55	440	TERO	[from draft Peer Review]. It appears that none of the work included in the Integrated Plan will be subject to TERO enacted pursuant to the Tribes inherent sovereign authority to self governance. However, the team believes this should be confirmed because if any of the work would be subject to these provisions, the costs would increase significantly and need to be reflected in the estimate for that work. None of the projects are located on or adjacent to Tribal Land. This may add 4% on construction on the low end, 10% most likely, and 20% for the high end.	Cost	5%	$14,300,000	$35,600,000	$71,300,000						

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Keechelus to Kachess Pipeline											
ENV-8	550, 560, 320	Historical and Cultural Resources	Surveys have not been completed so there is a risk of potential delay during construction if historical or cultural resources are found.	Schedule	25%							0.5	0.8	1.0
CON-8	560	K to K Pipeline Revised Alignment	[from draft Peer Review] The Keechelus to Kachess Pipeline was considered at the appraisal level in the Yakima River Basin Water Storage Feasibility Study but not carried forward at that time for further analysis. The alignment for the Keechelus to Kachess Pipeline as currently designed crosses forest lands that are sensitive. This was recognized in the briefing and it was mentioned that further work would need to be done to assess the impacts and determine if realignments are necessary and to what extent mitigation will be required for environmental and cultural resources. Risk Analysis Team used: 60% chance that an alternative tunnel design is selected, 20%that a longer pipeline is selected, and 20% that the original pipeline (base) alternative is selected. **This risk is mutually exclusive to CON-9**	Cost	20%	$21,780,000	$24,200,000	$26,620,000						
CON-9	560	K to K Tunnel Alignment Alternative	[from draft Peer Review] The Keechelus to Kachess Pipeline was considered at the appraisal level in the Yakima River Basin Water Storage Feasibility Study but not carried forward at that time for further analysis. The alignment for the Keechelus to Kachess Pipeline as currently designed crosses forest lands that are sensitive. This was recognized in the briefing and it was mentioned that further work would need to be done to assess the impacts and determine if realignments are necessary and to what extent mitigation will be required for environmental and cultural resources. The Team recommends consulting with the US Forest Service and other affected parties on these issues before proceeding to the next step. The reason for this recommendation is to capture the estimated costs which can be significant. It appears the estimates presented to date do not account for any realignment. Also, there will be costs for mitigation of environmental and cultural resource impacts. As further analyses are conducted the above factors should be considered. 60% chance that Tunnel is selected, 20% that longer pipeline is selected, and 20% base alternative is selected. **This risk is mutually exclusive to CON-8**	Cost	60%	$1,350,000	$1,500,000	$1,650,000						
CON-22	560	Design and Scope Changes	Keechelus to Kachess Pipeline Unknown Design and Scope Changes - Low = 1%, Most Likely = 4%, High = 6 %	Cost	95%	$1,300,000	$5,300,000	$7,900,000						
CON-29	560	Minor Aggregate Risk	Keechelus to Kachess Pipeline	Cost	75%	$1,000,000	$3,000,000	$5,000,000						
CON-42	560	Lack of Geological Information	The designs and therefore, the cost estimates are based on the mostly on interpreted geology for all features of these projects. Specific cost estimates for the various features cannot be very accurately developed without good geology information. The costs for the K2K Tunnel alternative assumes the same costs as Kachess Inactive Tunnel. Drill and blast is the proposed design for the tunnels. The cost per LF is 3,500 LF. Without accurate geotechnical information, unexpected geotechnical conditions may increase cost and delay schedule. Hard rock is anticipated and other conditions could increase the cost of this tunnel by 30%. **This risk is mutually inclusive to CON-9.**	Cost	50%	$12,000,000	$24,000,000	$48,000,000						
CON-43	560	Water Treatment	The tunnel or pipeline construction could encounter groundwater that would need to be treated	Cost	90%	$1,000,000	$2,000,000	$3,000,000						
CON-44	560	Trench Excavation	The base assumes 100% rock excavation for trench excavation through the saddle area (10,000 feet) below the overburden layer. For the remained of the project, the assumption is 25% rock excavation. The risk is that additional rock excavation is required. **This risk cannot occur with CON-9**	Cost	50%	$2,000,000	$6,000,000	$8,000,000						
CON-45	560	Permanent Access Roads	Risk is additional road work for pipeline access.	Cost	80%	$500,000	$1,000,000	$1,500,000						
ENV-7	560	Mitigation for Loss of Habitat	Mitigation of old growth habitat, second growth habitat, and inundation of wetlands during construction of K2K pipeline. $1,000,000 estimate for wetland, shrub, and other mitigation for base alternative. $500,000 estimated for the longer pipeline alternative. **This risk cannot occur with CON-9**	Cost	95%	$500,000	$1,000,000	$1,500,000						

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Keechelus to Kachess Pipeline											
ROW-2	540	Property Acquisition	46 land owners in the pipeline alignment will require acquisition and or easements. The risk is additional land owners may be impacted or added costs for the existing alignment. **This risk cannot occur with CON-9**	Cost	75%	$0	$1,000,000	$1,500,000						
CON-52	560	TERO	[from draft Peer Review]. It appears that none of the work included in the Integrated Plan will be subject to TERO enacted pursuant to the Tribes inherent sovereign authority to self governance. However, the team believes this should be confirmed because if any of the work would be subject to these provisions, the costs would increase significantly and need to be reflected in the estimate for that work. None of the projects are located on or adjacent to Tribal Land. This may add 4% on construction on the low end, 10% most likely, and 20% for the high end.	Cost	5%	$5,300,000	$13,200,000	$26,300,000						

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Kachess Inactive Storage Alternative 1											
ENV-8	550, 560, 320	Historical and Cultural Resources	Surveys have not been completed so there is a risk of potential delay during construction if historical or cultural resources are found.	Schedule	25%							0.5	0.8	1.0
CON-7	550	Kachess Lake Tap & Tunnel	[from draft Peer Review] The Team believes that the Lake Tap and Tunnel, as currently proposed, needs further refinement. Lake taps and tunneling are, of themselves, risky and difficult features to construct even with good geologic information. The Team is especially concerned with the proposal as presented due to the lack of any subsurface geologic information. It is possible the lake tap cannot be constructed or cannot be constructed as envisioned. The tunnel could also be more problematic to construct than what is envisioned and estimated. The Team recommends, some limited subsurface geologic information be obtained to further refine this feature and verify that it is a viable element of the Integrated Plan. The risk is the depth of the Lake Tap is not known. A deeper shaft may be required. If the Lake Tap is not feasible, a bridge would be constructed out into the lake to house the lake pumps.	Cost	50%	$2,000,000	$3,500,000	$5,000,000						
ENV-9	550	Mitigation for Loss of Habitat	Mitigation of old growth habitat, second growth habitat, and inundation of wetlands during construction. Estimated $500,000 based on riparian buffers, shorelines.	Cost	95%	$250,000	$500,000	$1,000,000						
CON-23	550	Design and Scope Changes	Kachess Inactive Storage Alternate #1 Unknown Design and Scope Changes - Low = 1%, Most Likely = 4%, High = 6 %	Cost	95%	$1,800,000	$7,300,000	$10,900,000						
CON-30	550	Minor Aggregate Risk	Kachess Inactive Storage Alternative #1	Cost	75%	$1,000,000	$3,000,000	$5,000,000						
CON-46	550	Lack of Geological Information	The designs and therefore, the cost estimates are based on the mostly on interpreted geology for all features of these projects. Specific cost estimates for the various features cannot be very accurately developed without good geology information. Drill and blast is the proposed design for the tunnels. The cost per LF is 3,500 LF. Without accurate geotechnical information, unexpected geotechnical conditions may increase cost and delay schedule. Hard rock is anticipated and other conditions could increase the cost of this tunnel by 30%.	Cost	50%	$13,000,000	$26,000,000	$50,000,000						
CON-47	550	Pumping from Lake Easton	Opportunity to pump from Lake Easton would reduce the mechanical need with the 20 cfs pump station and reduce the length of the pipeline from Lake Kachess.	Cost	50%	-$2,250,000	-$1,750,000	-$1,250,000						
CON-48	550	Portal Construction	Risk is that an additional portal would be required for the construction of the tunnel and the overall length would increase. A revised alignment along the transmission line would increase the length by 2,000 feet (Low) Most likely includes increased length and additional portal.	Cost	75%	$7,000,000	$15,000,000	$20,000,000						
CON-49	550	Water Treatment	The tunnel construction could encounter groundwater that would need to be treated prior to discharge during the course of construction. Estimated at $100,000 per month.	Cost	90%	$1,000,000	$2,000,000	$3,000,000						
CON-53	550	TERO	[from draft Peer Review]. It appears that none of the work included in the Integrated Plan will be subject to TERO enacted pursuant to the Tribes inherent sovereign authority to self governance. However, the team believes this should be confirmed because if any of the work would be subject to these provisions, the costs would increase significantly and need to be reflected in the estimate for that work. None of the projects are located on or adjacent to Tribal Land. This may add 4% on construction on the low end, 10% most likely, and 20% for the high end.	Cost	5%	$7,300,000	$18,100,000	$36,300,000						

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Kachess Inactive Storage Alternative 2											
ENV-8	550, 560, 320	Historical and Cultural Resources	Surveys have not been completed so there is a risk of potential delay during construction if historical or cultural resources are found.	Schedule	25%							0.5	0.8	1.0
CON-7	550	Kachess Lake Tap & Tunnel	[from draft Peer Review] The Team believes that the Lake Tap and Tunnel, as currently proposed, needs further refinement. Lake taps and tunneling are, of themselves, risky and difficult features to construct even with good geologic information. The Team is especially concerned with the proposal as presented due to the lack of any subsurface geologic information. It is possible the lake tap cannot be constructed or cannot be constructed as envisioned. The tunnel could also be more problematic to construct than what is envisioned and estimated. The Team recommends, some limited subsurface geologic information be obtained to further refine this feature and verify that it is a viable element of the Integrated Plan. The risk is the depth of the Lake Tap is not known. A deeper shaft may be required. If the Lake Tap is not feasible, a bridge would be constructed out into the lake to house the lake pumps.	Cost	50%	$2,000,000	$3,500,000	$5,000,000						
ENV-9	550	Mitigation for Loss of Habitat	Mitigation of old growth habitat, second growth habitat, and inundation of wetlands during construction. Estimated $500,000 based on riparian buffers, shorelines.	Cost	95%	$250,000	$500,000	$1,000,000						
CON-24	550	Design and Scope Changes	Kachess Inactive Storage Alternative #2 Unknown Design and Scope Changes - Low = 1%, Most Likely = 4%, High = 6 %	Cost	95%	$1,600,000	$6,300,000	$9,500,000						
CON-31	550	Minor Aggregate Risk	Kachess Inactive Storage Alternative #2	Cost	75%	$2,000,000	$5,000,000	$7,000,000						
CON-54	550	TERO	[from draft Peer Review]. It appears that none of the work included in the Integrated Plan will be subject to TERO enacted pursuant to the Tribes inherent sovereign authority to self governance. However, the team believes this should be confirmed because if any of the work would be subject to these provisions, the costs would increase significantly and need to be reflected in the estimate for that work. None of the projects are located on or adjacent to Tribal Land. This may add 4% on construction on the low end, 10% most likely, and 20% for the high end.	Cost	5%	$6,300,000	$15,800,000	$31,700,000						
CON-10	550	Kachess Inactive Storage #2 - Construction Duration	The construction duration of Kachess Inactive Storage Alternative #2 would be up to 12 months shorter than Alternative #1	Schedule	50%							-12.0	-9.0	-6.0

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Wymer Dam and Reservoir											
CON-11	150	Wymer Dam Type	[from draft Peer Review]. There are limited geologic investigations/information currently available and this poses significant questions for the engineering designs and estimates. The site appears compatible to construction of a roller compacted concrete (RCC) dam or dike. It was recommended, during the DEC Review, that an RCC alternative be evaluated. It does not appear that this has been done. No alternative to a concrete faced rockfill dam was considered for Wymer Dam. The DEC Team recommended the Design Team develop a feasibility design level RCC dam alternative. The adopted response indicated additional review will be recommended in the Final PR/EIS to confirm the type of main dam at Wymer. Risk is that the dam would need be constructed as RCC dam. **The Risk Analysis team determined that currently, this risk is not quantifiable but should be a continued consideration as design progresses.**												
CON-12	150	Wymer Dam Geotechnical Issues	[from draft Peer Review]. There are limited geologic investigations/information currently available and this poses significant questions for the engineering designs and estimates. The original cost estimate discusses a possibility of hauling dam fill materials 17 miles one way. **Risk team concludes this will not be done; there is adequate material to build either a rock fill or RCC dam at the site.**											
CON-13	150	Wymer Dam Refinements	[from draft Peer Review]. There are limited geologic investigations/information currently available and this poses significant questions for the engineering designs and estimates. Several of the DEC recommendations offer suggested refinements to the embankment designs for the main and saddle dike dams with respect to filters, drains, and transition zones to protect against piping of materials into the fractured rock foundations. From the briefing given to the Team, it appears HDR Engineering took the previous Wymer design and simply indexed the costs. The Team recommends that these refinements be made to the designs and cost estimates are further refined. The risk is that grouting would be required in fractured rock and that the risk is that rotation of the dam will occur and additional material is required. The risk is that grouting would be required in fractured rock and/or that the dam axis will need to be rotated and thate additional material will be required to build this longer structure. **This risk is ME with CON-14.**	Cost	80%	$40,000,000	$80,000,000	$125,000,000						
CON-14	150	Yakima River Canyon Seismic Concerns	[from draft Peer Review]. The Team understands that USGS is evaluating faulting in the Yakima River canyon close to the Wymer dam site. The Team believes it is important that the Design Team follow up with USGS on the results as there have been some recent changes in earthquake engineering due to the Cascadia Subduction Zone generated earthquakes. Potentially, there may can be a fault near the current dam location. The risk is that the dam material would change. The additional cost could be $10 per cu yard ($150,000,000) for a composite structure. **This risk is ME with CON-13.**	Cost	50%	$100,000,000	$150,000,000	$200,000,000						
CON-18	150	TERO	[from draft Peer Review]. It appears that none of the work included in the Integrated Plan will be subject to TERO enacted pursuant to the Tribes inherent sovereign authority to self governance. However, the team believes this should be confirmed because if any of the work would be subject to these provisions, the costs would increase significantly and need to be reflected in the estimate for that work. None of the projects are located on or adjacent to Tribal Land. This may add 4% on construction on the low end, 10% most likely, and 20% for the high end.	Cost	5%	$52,300,000	$130,600,000	$261,300,000						
ROW-1	140	Right of Way Cost	Land costs have been estimated for the Wymer Dam and Reservoir project. The current estimate for ROW is $1,400,000 at $350 per acre. The risk is that the cost will be increased during the acquisition process. **This is a minor risk due to relatively low cost impact.**											
CON-20	150	Design and Scope Changes	Wymer Dam and Reservoir Unknown Design and Scope Changes - Low = 1%, Most Likely = 4%, High = 6 %	Cost	95%	$13,100,000	$52,300,000	$78,400,000						

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Wymer Dam and Reservoir											
CON-27	150	Minor Aggregate Risk	Wymer Dam and Reservoir	Cost	75%	$10,000,000	$15,000,000	$20,000,000						
ENV-3	150	Mitigation for Loss of Habitat	Mitigation of shrub-steppe, grasslands, and wetlands. With this project, the area mitigated may be much smaller than the area impacted due to other factors. However a substantial cost item for habitat restoration actions has been identifed as a potential risk.	Cost		$5,000,000	$15,000,000	$20,000,000	5%	70%	25%			
ENV-5	150	Historical and Cultural Resources	Surveys have not been completed so there is a risk of potential delay during construction if historical or cultural resources are found. Down by the river will be the highest likelihood of finding cultural or historical resources. Minor risk to overall schedule.	Schedule	25%							0.5	0.8	1.0
CON-38	150	I-82 Bridge Abutment Protection	There is an estimate to provide bridge abutment protection of the I-82 structures. The opportunity is that those items would not be necessary. The current estimate is $1,700,000.	Cost	95%	-$1,700,000	-$1,200,000	-$800,000						
CON-39	150	Pump Station May Need to be Relocated	The proposed pump station location may be moved 1.5 miles from it's current location. Could be an additional $750,000 for the discharge line pipe and $600,000 for additional mile of power transmission line.	Cost	90%	$1,100,000	$1,350,000	$1,600,000						
CON-40	150	Outlet Structure	Risk is a more substantial outlet structure will be needed. May need up to a $2,000,000 barrier. There is $2,900,000 to improve Lmuma Creek. A hydraulic conveyance structure may be required for discharge back to the river. Additional cost is $2,000,000 for open channel; 5,000,000 for pipe.	Cost	90%	$4,000,000	$4,500,000	$5,000,000						

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Wymer Downstream Conveyance System											
CON-15	250	Burbank Tunnel Alignment	[from draft Peer Review]. The alignment of the Burbank Tunnel is such that its intake is located in the upper reaches of the reservoir. Because of this, the tunnel does not access the full storage capacity of the Wymer Reservoir. During the design briefing, the reason given for this arrangement is to shorten as much as possible the length of the tunnel and therefore provide a lower cost than a tunnel alignment that has an intake closer to the proposed dam. Review of the drawing depicting the alignment suggests that the alignment could be adjusted slightly bringing the intake closer to the proposed dam to take advantage of most if not all of the water stored behind the dam. The incremental cost due to the longer tunnel may be worth it to increase the benefits from the additional water delivered to the Roza Canal. The risk is that you have a longer tunnel than what is in the base. The most likely extension is 1,000 feet.	Cost	75%	$1,000,000	$3,500,000	$5,000,000						
CON-16	250	Tunnel Designs not compatible with Future Storage Options	[from draft Peer Review]. The report documenting the proposed integrated plan states that these tunnels could provide connection with future potential storage sites within the Burbank Creek and Selah Creek drainages. What are not clear is what the advantages are for connecting to these future storage options and how their operation would be integrated to maximize benefits to the project. Further, if these drainages were to be connected at some future date, the current design of the tunnels may require substantial modifications to make that future connection possible. The current design of the siphon at Burbank Creek would require complete demolition of the siphon, construction of a new outlet for the Burbank Tunnel, and an intake for the Roza Tunnel. If the potential exists for development of storage in the Burbank Creek and Selah Creek drainages at a future date, then it would be prudent to develop an integrated design and operational scheme of these tunnels to account for that future development. The risk is the alignment might change and increase the length of the tunnel and siphon. The combined Burbank and ROza tunnels may be 20% longer or 10% shorter.	Cost	50%	-$1,000,000	$5,000,000	$7,000,000						
CON-17	250	Powerplant costs vs. Energy Dissipation costs	[from draft Peer Review]. At the downstream end of the Roza Tunnel the drawing included in the design briefing presentation showed the installation of a hydroelectric powerplant to dissipate the hydraulic head in the tunnel prior to discharge into the existing Roza Canal. During the briefing it was stated that development of power at this location was no longer included in the design and would be replaced with an energy dissipation structure. It was stated that the cost estimate included costs for the powerplant not the energy dissipation structure, it was felt that the cost of a powerplant would cover the costs of an energy dissipation structure at this location. If the design of the Roza Tunnel should move forward to feasibility design it should include designs and costs of the energy dissipation structure. **The cost of the powerplant has been removed from the base. The energy dissipation costs have been added.**											
CON-19	250	Lack of Geological Information	The designs and therefore, the cost estimates are based on the mostly on interpreted geology for all features of these projects. Specific cost estimates for the various features cannot be very accurately developed without good geology information. Drill and blast with 12" liner is the proposed design for the tunnels. Without accurate geotechnical information, unexpected geotechnical conditions may increase cost and delay schedule. This is a particular concern with the basalt and interflow geology in the area around Wymer. If encountered, problematic conditions could double the cost of the tunnels.	Cost	50%	$25,000,000	$50,000,000	$94,000,000						
CON-21	250	Design and Scope Changes	Wymer Downstream Conveyance System Unknown Design and Scope Changes - Low = 1%, Most Likely = 4%, High = 6 %	Cost	95%	$1,800,000	$7,100,000	$10,600,000						
CON-28	250	Minor Aggregate Risk	Wymer Downstream Conveyance System	Cost	75%	$2,000,000	$5,000,000	$7,000,000						

Risks						Risk Quantification								
						Cost Impact ($'s)						Schedule Impact (Mo's)		
Index	Activity Impacted	Threat/ Opportunity Events	Description	Type of Risk	Prob.	Low	Most Likely	High	P1	P2	P3	Low	Most Likely	High
C1	C9	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
			Wymer Downstream Conveyance System											
CON-41	250	Increase Tunnel Cross Section	There is potential that flow capacity may need to increase from the Wymer Reservoir through the Burbank Tunnel to accommodate future use from the Columbia River. This risk is that the cross section will increase. The cost will increase by $2000 per LF.	Cost	20%	$23,000,000	$37,000,000	$53,000,000						
ENV-10	250	Mitigation for Loss of Habitat	Mitigation of shrub step, grasslands, and wetlands along the siphon route thorugh Burbank Creek valley. With this project, the area mitigated may be much smaller than the area impacted due to the land acquisition program under the Integrated Plan.	Cost	95%	$50,000	$100,000	$200,000						
CON-51	250	TERO	[from draft Peer Review]. It appears that none of the work included in the Integrated Plan will be subject to TERO enacted pursuant to the Tribes inherent sovereign authority to self governance. However, the team believes this should be confirmed because if any of the work would be subject to these provisions, the costs would increase significantly and need to be reflected in the estimate for that work. None of the projects are located on or adjacent to Tribal Land. This may add 4% on construction on the low end, 10% most likely, and 20% for the high end.	Cost	5%	$7,100,000	$17,600,000	$35,300,000						

Appendix C
2012 CRA Workshop Agenda

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YAKIMA RIVER BASIN
INTEGRATED WATER RESOURCE MANAGEMENT PLAN

2012 CRA WORKSHOP AGENDA

APRIL 12 & 13, 2012

Workshop Location
HDR – Bellevue
Washington Conference Room (Rm 401)
500 108th Avenue NE, Suite 1200, Bellevue, WA
(425) 450-6200

Project webpage:

http://www.usbr.gov/pn/programs/yrbwep/2011integratedplan/index.html

CRA Workshops: Statement of Purpose

Provide a useful, sound and objective, analysis and report that the Project Team will own and act upon to improve, validate/confirm their project cost and/or schedule. Workshops, conducted collaboratively with cost-risk experts and project team will:

1. ***Define and review or validate cost and schedule base estimates***.
2. ***Replace (or greatly reduce) the traditional project "contingency"*** with key identifiable risks that can be more clearly understood and managed.
3. ***Identify and quantify key events*** in a project that can cause a significant deviation is the cost and/or schedule.
4. ***Perform a Monte Carlo simulation analysis to model the collective impact*** of base and risk issues.
5. ***Produce an estimate of a reasonable range and distribution for cost and schedule.***
6. ***Promote pro-active risk management by project teams***. Provide the project team with information on risk events that allow them to manage the risks (threats and opportunities) on an on-going basis.
7. ***Document assumptions and constraints*** used in developing the estimated project cost and schedule range.

Workshop Coordinator:	**Andrew Graham**
Risk Lead:	**Ken Smith**
Cost Lead:	**Blane Long**
Modeler:	**John Stout**

Project Briefing – 10 minutes

- A synopsis of what each project is about
- Assumptions and exclusions?
- Project Funding
- Project Delivery/Contracting Strategy

Base Schedule Validation – 5-10 minutes

- Review baseline schedule
- Environmental Process
- Design and Procurement
- Project Segments and Phasing
- Environmental Mitigation

Base Cost Validation – 10 minutes

- Define/Review and Validate Estimate
- Contingencies
- Pre-construction costs design
- Pre-construction costs environmental
- Construction costs
- Right of Way
- Soft costs and below the line items

Date/Time	Topic	Leading	Participants
CRA Workshop Day #1 – Thursday, April 12			
8:00 – 8:15	**A good start…** ▪ Welcome, Sign-in, Introductions ▪ Agenda review	Risk Lead	All participants attending any of the sessions
8:15 – 9:00	**What is Cost Risk Assessment?**	Risk Lead	All participants attending any of the sessions
9:00 – 10:30	**Cle Elum Dam Fish Passage** ▪ Project Briefing ▪ Base Schedule Validation ▪ Base Cost Validation ▪ What are the risks?	Risk Lead	Relevant project team and specialty members and cost estimators

Date/Time	Topic	Leading	Participants
10:30 – Noon	**Bumping Lake Reservoir Enlargement & Fish Passage** ▪ Project Briefing ▪ Base Schedule Validation ▪ Base Cost Validation ▪ What are the risks?	Risk Lead	Relevant project team and specialty members
60 min	**LUNCH (on your own)**		
1:00 – 2:30	**Bumping Lake Reservoir Enlargement & Fish Passage - Continued** ▪ Project Briefing ▪ Base Schedule Validation ▪ Base Cost Validation ▪ What are the risks?	Risk Lead	Relevant project team and specialty members and cost estimators
2:30 – 4:45	**Wymer Dam & Reservoir** ▪ Project Briefing ▪ Base Schedule Validation ▪ Base Cost Validation ▪ What are the risks?	Risk Lead	Relevant project team and specialty members
4:45 - 5:00	**Wrap-up** ▪ Additional information ▪ Clarifications ▪ Parking lot issues ▪ Improvements	Risk Lead	All participants attending any of the sessions
5:00	**ADJOURN**		
CRA Workshop Day #2 – Friday, April 13			
8:00 – 8:10	**A good start…** ▪ Recap of Yesterday	Risk Lead	All participants attending any of the sessions

Date/Time	Topic	Leading	Participants
8:10 – 10:00	**Wymer Downstream Conveyance System** ▪ Project Briefing ▪ Base Schedule Validation ▪ Base Cost Validation ▪ What are the risks?	Risk Lead	Relevant project team and specialty members
10:00 – Noon	**Keechelus to Kachess Pipeline** ▪ Project Briefing ▪ Base Schedule Validation ▪ Base Cost Validation ▪ What are the risks?	Risk Lead	Relevant project team and specialty members
60 min	**LUNCH (on your own)**		
1:00 – 3:00	**Kachess Reservoir Inactive Storage – Alternate #1** ▪ Project Briefing ▪ Base Schedule Validation ▪ Base Cost Validation ▪ What are the risks?	Risk Lead	Relevant project team and specialty members
3:00 – 4:45	**Kachess Reservoir Inactive Storage – Alternate #2** ▪ Project Briefing ▪ Base Schedule & Flow Chart Validation ▪ Base Cost Validation ▪ What are the risks?	Risk Lead	Relevant project team and specialty members
4:45 - 5:00	**Wrap-up** ▪ Additional information ▪ Clarifications ▪ Parking lot issues ▪ Improvements	Risk Lead	All participants attending any of the sessions
5:00	**ADJOURN**		