Annex X

Comprehensive Baseline Cost Estimate

Annex X: Comprehensive Baseline Cost Estimate

X.1 General

The construction costs presented in this annex were developed by the Walla Walla District Cost Engineering Branch of the Corps based on the scope of work, assumptions, and methodology presented in the companion engineering annexes (Annexes A through V of this appendix). The following sections summarize specific details concerning the basis of costs for each of the engineering efforts and present cost summary tables for each effort. The comprehensive, detailed, cost estimates were developed using MCACES™ and are on file with the Walla Walla District Cost Engineering Branch of the Corps (see Table X1).

X.2 Embankment Modifications

X.2.1 Cost

Components of construction include the following five cost elements: labor, permanent materials, construction equipment, subcontracts, and contractor's expendable supplies. The key ingredient in determining the cost of each of these elements is productivity of the work force and the construction equipment used to perform the various work activities. Productivity rates for the embankment excavation work were selected to reflect local weather, site conditions, work week hours, craft experience and availability, appropriate construction techniques, schedule sequencing, and experience gained on previous construction projects.

There is a difference between the cost for the riprap and the shot rock. The difference is attributable to two basic concepts: 1) riprap will be obtained from quarries, where the relative volume of useable material (yielding larger diameter riprap) is estimated to be about 40 percent; and 2) shot rock is more readily attained as quarries can generally produce a higher yield of rock that meet the requirements for size and gradation. These assumptions were made until further site-specific investigations, test blasting, test fills, and other fieldwork is performed.

Most costs were built up using databases for the cost of components of labor, materials, and equipment. In some cases, costs from the bid tabulations of previously bid and constructed projects were selected to represent the actual cost of similar type portions of this project (i.e., fabrication of trailers to haul fish). These historic values were then escalated to dollar values and adjusted for economies of scale and other factors to provide a rapid and relatively accurate reflection of the cost to do the work. A third source of prices included commercially available construction cost data guides. Generally, costs were built up for the most significant impact items, such as embankment dam excavation, driving interlocking steel sheet piles, levee construction, and production and transportation of riprap/shot rock.

Quantities were developed by Raytheon and are documented in the report entitled, *Embankment Excavation River Channelization and Removal of Concrete Structures*. Quantities developed in this report are intended to be “in-place” quantities. Factors such as swell and compaction are handled by adjusting the quantities in the estimate.

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

US Army Corps of Engineers®
Walla Walla District

Cost Numbers are for Economic Study Purposes Only
Not Intended for Program Funding
Assumes Unrestricted Funds, No Escalation

DESCRIPTIONS - for Ice Harbor, Lower Monumental, Little Goose & Lower Granite Locks & Dams -> Mc Nary Dam not included.

	TYPE OF COST	DESIGN & CONSTRUCTION DURATION	MID POINT OF CONSTR.	DAM REMOVAL OPTIONS DRAW DOWN CHANNEL BYPASS	DAM REMOVAL OPTIONS DRAW DOWN COMPLETE DAM REMOVAL
		FEASIBILITY ALTERNATIVES ====>		ALT # 4	
		ENGINEERING APPENDIXES & PATH OPTIONS ====>		(Natural R Channel) *OPTION A-3c*	(Natural River) *OPTION A-3t*
				Thousand Dollars	Thousand Dollars
CONSTRUCTION AND ACQUISITION COSTS		Summary of Fish Improvements I & II		$858,939	$1,795,822
ANADROMOUS FISH EVALUATION PROGRAM		Annual Costs for 27 Years	Each Year	$2,462	$2,329
ALL FOUR DAMS (Monitoring & Mitigation)					
Anadromous Fish Evaluation Program Studies (AFEP)		27 Years	Each Year	$2,462	$2,329
BREACHING DAMS		Summary of all the Breach Constr. Dams Costs Below		$858,939	$1,795,822
ICE HARBOR LOCK & DAM	Oct 98 Price Level	Summary		$206,902	$463,287
Power House Turbine Modifications		2 Years	FY 2005	$7,857	$7,875
Dam Embankment Removal		2 Years	FY 2005	$65,524	$60,153
River Channelization		1 Years	FY 2006	$35,349	N/A
Full Concrete Structure Removal		2 Years	FY 2007	N/A	$298,016
Temporary Fish Handling Facilities		2 Years	FY 2005	$19,702	$19,637
Project Dam Decommissioning		1 Years	FY 2006	$1,477	$456
Railroad Relocations		2 Years	FY 2004	$6,261	$6,299
Bridge Pier & Abutment Protection		3 Years	FY 2005	N/A	N/A
Reservoir Embankment Protection		3 Years	FY 2004	$44,892	$44,985
Drainage Structures Protection		3 Years	FY 2004	$1,867	$1,872
Railroad and Roadway Damage Repair		3 Years	FY 2007	$6,020	$6,032
Recreation Access Modification		2 Years	FY 2007	$2,470	$2,472
HMU Modification		2 Years	FY 2006	$3,238	$3,214
Reservoir Revegetation (For Air & Water Quality)		4 Years	FY 2007	$8,237	$8,255
Cultural Resources Protection		2 Years	FY 2006	$2,275	$2,281
Cattle Watering Facilities		2 Years	FY 2006	$1,392	$1,399
Real Estate (Excessing Property)		4 Years	FY 2007	$341	$341
LOWER MONUMENTAL LOCK & DAM	Oct 98 Price Level	Summary		$173,021	$415,590
Power House Turbine Modifications		2 Years	FY 2005	$7,857	$7,875
Dam Embankment Removal		2 Years	FY 2005	$41,441	$39,663
River Channelization		1 Years	FY 2006	$31,847	N/A
Full Concrete Structure Removal		2 Years	FY 2007	N/A	$277,798
Temporary Fish Handling Facilities		2 Years	FY 2005	N/A	N/A
Project Dam Decommissioning		1 Years	FY 2006	$1,539	$472
Railroad Relocations		2 Years	FY 2004	$13,921	$13,629
Bridge Pier & Abutment Protection		3 Years	FY 2005	$6,414	$6,429
Reservoir Embankment Protection		3 Years	FY 2004	$38,113	$37,789
Drainage Structures Protection		3 Years	FY 2004	$2,062	$2,056
Railroad and Roadway Damage Repair		3 Years	FY 2007	$4,753	$4,763
Recreation Access Modification		2 Years	FY 2007	$2,043	$2,048
HMU Modification		2 Years	FY 2006	$2,434	$2,439
Reservoir Revegetation (For Air & Water Quality)		4 Years	FY 2007	$6,578	$6,593
Cultural Resources Protection		2 Years	FY 2006	$1,578	$1,582
Cattle Watering Facilities		2 Years	FY 2006	$2,459	$2,466
Lyons Ferry Hatchery Modifications		3 Years	FY 2005	$9,710	$9,716
Real Estate (Excessing Property)		4 Years	FY 2007	$272	$272
LITTLE GOOSE LOCK & DAM	Oct 98 Price Level	Summary		$192,134	$386,999
Power House Turbine Modifications		2 Years	FY 2005	$7,863	$7,863
Dam Embankment Removal		2 Years	FY 2005	$26,589	$25,353
River Channelization		1 Years	FY 2006	$53,462	N/A
Full Concrete Structure Removal		2 Years	FY 2007	N/A	$250,941
Temporary Fish Handling Facilities		2 Years	FY 2005	$18,052	$18,037
Project Dam Decommissioning		1 Years	FY 2006	$1,471	$495
Railroad Relocations		2 Years	FY 2004	N/A	N/A
Bridge Pier & Abutment Protection		3 Years	FY 2005	$12,772	$12,772
Reservoir Embankment Protection		3 Years	FY 2004	$39,718	$39,349
Drainage Structures Protection		3 Years	FY 2004	$1,789	$1,781
Railroad and Roadway Damage Repair		3 Years	FY 2007	$9,814	$9,814
Recreation Access Modification		2 Years	FY 2007	$3,257	$3,257
HMU Modification		2 Years	FY 2006	$2,643	$2,633
Reservoir Revegetation (For Air & Water Quality)		4 Years	FY 2007	$11,100	$11,100
Cultural Resources Protection		2 Years	FY 2006	$1,435	$1,435
Cattle Watering Facilities		2 Years	FY 2006	$1,973	$1,973
Real Estate (Excessing Property)		4 Years	FY 2007	$196	$196
LOWER GRANITE LOCK & DAM	Oct 98 Price Level	Summary		$286,882	$529,946
Power House Turbine Modifications		2 Years	FY 2005	$8,130	$8,130
Dam Embankment Removal		2 Years	FY 2005	$28,376	$26,231
River Channelization		1 Years	FY 2006	$27,544	N/A
Full Concrete Structure Removal		2 Years	FY 2007	N/A	$274,492
Temporary Fish Handling Facilities		2 Years	FY 2005	N/A	N/A
Project Dam Decommissioning		1 Years	FY 2006	$1,522	$487
Railroad Relocations		2 Years	FY 2004	N/A	N/A
Bridge Pier & Abutment Protection		3 Years	FY 2005	$32,672	$32,672
Reservoir Embankment Protection		3 Years	FY 2004	$56,092	$55,395
Drainage Structures Protection		3 Years	FY 2004	$2,838	$2,830
Railroad and Roadway Damage Repair		3 Years	FY 2007	$109,420	$109,420
Recreation Access Modification		2 Years	FY 2007	$7,973	$7,973
HMU Modification		2 Years	FY 2006	$1,745	$1,746
Reservoir Revegetation (For Air & Water Quality)		4 Years	FY 2007	$7,729	$7,729
Cultural Resources Protection		2 Years	FY 2006	$1,538	$1,538
Cattle Watering Facilities		2 Years	FY 2006	$1,037	$1,037
Real Estate (Excessing Property)		4 Years	FY 2007	$266	$266
OPERATION & MAINTENANCE COSTS		Summary of Dam Routine & Minor Repair Costs, Each Year		$5,776	$5,776
ALL FOUR DAMS (Monitoring & Mitigation)	Oct 98 Price Level	Summary		$133,444	$133,444
Wildlife Monitoring Costs		25 Years	FY 2019	$395	$395
Vegetation Monitoring Costs		25 Years	FY 2019	$858	$858
Fish Monitoring Costs		25 Years	FY 2019	$67,500	$67,500
Water Quantity Monitoring Costs		12 Years	FY 2012	$9,600	$9,600
Air Quality Monitoring Costs		10 Years	FY 2011	$750	$750
Sedimentation Monitoring Costs		10 Years	FY 2011	$2,158	$2,158
Fish & Wildlife Mitigation Costs		25 Years	FY 2019	$42,183	$42,183
Culture Resources Mitigation Costs		10 Years	FY 2011	$10,000	$10,000
ANNUAL ROUTINE OPERATIONS, MAINTENANCE & REPAIR COSTS			Each Year	$4,633	$4,633
ICE HARBOR LOCK & DAM		Annual Costs, Summary of Oper & Main Cost In the Detail Below, Each Year		$1,631	$1,631
NOTE: For the Drawdown Options, Ice Harbor Lock & Dam will Operate another 6 Years after start of project work.					
Operation Costs					
Sub Total Operations	Annual Costs	Summary	Each Year	$1,218	$1,218
Navigation - (Locks Work)				$0	$0
Power - (Turbines, Generators, & Power Lines Work)				$0	$0
Recreation - (Parks Work)				$764	$764
Fish - (Barging, Ladders, Screens Work & AFEP)				$0	$0
Fish - (5 Each Extra Barges)				$0	$0

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Cost data does not include inflation costs.

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY			DAM REMOVAL OPTIONS	
			DRAW DOWN	
US Army Corps of Engineers® Walla Walla District		DESIGN & CONSTRUCTION	CHANNEL BYPASS	COMPLETE DAM REMOVAL
Cost Numbers are for Economic Study Purposes Only	TYPE OF	MID POINT OF		
Not Intended for Program Funding	COST	DURATION CONSTR.		
		FEASIBILITY ALTERNATIVES ====>	ALT # 4	
Assumes Unrestricted Funds, No Escalation			(Natural R Channel)	(Natural River)
		ENGINEERING APPENDIXES & PATH OPTIONS ====>	*OPTION A-3c*	*OPTION A-3c*
DESCRIPTIONS - for Ice Harbor, Lower Monumental, Little Goose & Lower Granite Locks & Dams -> Mc Nary Dam not included.			Thousand Dollars	Thousand Dollars
Wildlife - (Managing Lands Work)			$279	$279
Other - (Operations, Dredging, Pumping Plants, Bldgs, Plant Eq. all the rest Work except for above items)			$175	$175
SBC System - Extra Costs due to Options			$0	$0
Maintenance Costs				
Sub Total Maintenance	Annual Costs	Summary Each Year	$413	$413
Navigation - (Locks Work)			$0	$0
Power - (Turbines, Generators, & Power Lines Work)			$0	$0
Recreation - (Parks Work)			$155	$155
Fish - (Barging, Ladders, Screens Work & AFEP)			$100	$100
Fish - (5 Each Extra Barges)			$0	$0
Wildlife - (Managing Lands Work)			$133	$133
Other - (Operations, Dredging, Pumping Plants, Bldgs, Plant Eq. all the rest Work except for above items)			$25	$25
SBC System - Extra Costs due to Options			$0	$0
LOWER MONUMENTAL LOCK & DAM	Annual Costs, Summary of Oper & Main Cost In the Detail Below, Each Year		**$782**	**$782**
NOTE: For the Drawdown Options, Lower Monumental Lock & Dam will Operate another 6 Years after start of project work.				
Operation Costs				
Sub Total Operations	Annual Costs	Summary Each Year	$309	$309
Navigation - (Locks Work)			$0	$0
Power - (Turbines, Generators, & Power Lines Work)			$0	$0
Recreation - (Parks Work)			$138	$138
Fish - (Barging, Ladders, Screens Work & AFEP)			$0	$0
Fish - (5 Each Extra Barges)			$0	$0
Wildlife - (Managing Lands Work)			$171	$171
Other - (Operations, Dredging, Pumping Plants, Bldgs, Plant Eq. all the rest Work except for above items)			$0	$0
SBC System - Extra Costs due to Options			$0	$0
Maintenance Costs				
Sub Total Maintenance	Annual Costs	Summary Each Year	$473	$473
Navigation - (Locks Work)			$0	$0
Power - (Turbines, Generators, & Power Lines Work)			$0	$0
Recreation - (Parks Work)			$150	$150
Fish - (Barging, Ladders, Screens Work & AFEP)			$100	$100
Fish - (5 Each Extra Barges)			$0	$0
Wildlife - (Managing Lands Work)			$223	$223
Other - (Operations, Dredging, Pumping Plants, Bldgs, Plant Eq. all the rest Work except for above items)			$0	$0
SBC System - Extra Costs due to Options			$0	$0
LITTLE GOOSE LOCK & DAM	Annual Costs, Summary of Oper & Main Cost In the Detail Below, Each Year		**$630**	**$630**
Operation Costs				
NOTE: For the Drawdown Options, Little Goose Lock & Dam will Operate another 5 Years after start of project work.				
Sub Total Operations	Annual Costs	Summary Each Year	$395	$395
Navigation - (Locks Work)			$0	$0
Power - (Turbines, Generators, & Power Lines Work)			$0	$0
Recreation - (Parks Work)			$167	$167
Fish - (Barging, Ladders, Screens Work & AFEP)			$0	$0
Fish - (5 Each Extra Barges)			$0	$0
Wildlife - (Managing Lands Work)			$228	$228
Other - (Operations, Dredging, Pumping Plants, Bldgs, Plant Eq. all the rest Work except for above items)			$0	$0
SBC System - Extra Costs due to Options			$0	$0
Maintenance Costs				
Sub Total Maintenance	Annual Costs	Summary Each Year	$235	$235
Navigation - (Locks Work)			$0	$0
Power - (Turbines, Generators, & Power Lines Work)			$0	$0
Recreation - (Parks Work)			$27	$27
Fish - (Barging, Ladders, Screens Work & AFEP)			$100	$100
Fish - (5 Each Extra Barges)			$0	$0
Wildlife - (Managing Lands Work)			$108	$108
Other - (Operations, Dredging, Pumping Plants, Bldgs, Plant Eq. all the rest Work except for above items)			$0	$0
SBC System - Extra Costs due to Options			$0	$0
LOWER GRANITE LOCK & DAM	Annual Costs, Summary of Oper & Main Cost In the Detail Below, Each Year		**$1,590**	**$1,590**
NOTE: For the Drawdown Option, Lower Granite Lock & Dam will Operate another 5 Years after start of project work.				
Operation Costs				
Sub Total Operations	Annual Costs	Summary Each Year	$839	$839
Navigation - (Locks Work)			$0	$0
Power - (Turbines, Generators, & Power Lines Work)			$0	$0
Recreation - (Parks Work)			$447	$447
Fish - (Barging, Ladders, Screens Work & AFEP)			$0	$0
Fish - (5 Each Extra Barges)			$0	$0
Wildlife - (Managing Lands Work)			$217	$217
Other - (Operations, Dredging, Pumping Plants, Bldgs, Plant Eq. all the rest Work except for above items)			$175	$175
SBC System - Extra Costs due to Options			$0	$0
Maintenance Costs				
Sub Total Maintenance	Annual Costs	Summary Each Year	$751	$751
Navigation - (Locks Work)			$0	$0
Power - (Turbines, Generators, & Power Lines Work)			$0	$0
Recreation - (Parks Work)			$161	$161
Fish - (Barging, Ladders, Screens Work & AFEP)			$100	$100
Fish - (5 Each Extra Barges)			$0	$0
Wildlife - (Managing Lands Work)			$429	$429
Other - (Operations, Dredging, Pumping Plants, Bldgs, Plant Eq. all the rest Work except for above items)			$61	$61
SBC System - Extra Costs due to Options			$0	$0
MINOR - REPAIR COSTS	Annual Costs	Summary of the Dams Each Year	$1,143	$1,143
ICE HARBOR LOCK & DAM	Annual Costs, Summary of Oper & Main Cost In the Detail Below, Each Year		**$408**	**$408**
LOWER MONUMENTAL LOCK & DAM	Annual Costs, Summary of Oper & Main Cost In the Detail Below, Each Year		**$196**	**$196**
LITTLE GOOSE LOCK & DAM	Annual Costs, Summary of Oper & Main Cost In the Detail Below, Each Year		**$158**	**$158**
LOWER GRANITE LOCK & DAM	Annual Costs, Summary of Oper & Main Cost In the Detail Below, Each Year		**$382**	**$382**
MAJOR - REPAIR & REHAB COSTS				
TURBINE UNITS & POWER HOUSE REHAB	Oct 98 Price Level - Summary, One Total Rehab Shown only		**N/A**	**N/A**
COSTS FOR OTHERS				
FISH HATCHERIES	Summary of Fish Hatcheries Operations, Minor & Rehab Costs	Each Year	$14,450	$14,450
FISH HATCHERIES OPERATIONS	Annual Costs	Summary Each Year	$13,762	$13,762
DWORSHAK FISH HATCHERY			$2,250	$2,250
LOWER SNAKE RIVER FISH COMP PLAN			$11,512	$11,512
INCLUDING WASHINGTON, OREGON, & IDAHO STATE ALSO NEZ PERCE & CONFEDERATED TRIBES OF THE UMATILLLA				
FISH HATCHERIES MINOR & REHAB COSTS	Annual Costs	Summary Each Year	$688	$688
An assume costs that goes across the board.		5.0%		
BOR - WATER ACQUISITION AND TRANSACTION COSTS		Summary Each Year	$2,386	$2,386
AMOUNT OF THE WATER PURCHASED			*427,000 Acre-Ft*	*427,000 Acre-Ft*
PURCHASING WATER RIGHTS				
ALL FOUR DAMS	Annual Costs	Each Year	-->See BOR Report, Par 4.1.2 (Allen Reiners	

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LOWER SNAKE RIVER JUVENILE SALMON MIGRATION
FEASIBILITY STUDY

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Walla Walla District

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DESCRIPTIONS - for Ice Harbor, Lower Monumental, Little Goose & Lower Granite Locks & Dams -> Mc Nary Dam not included.

	TYPE OF COST	DESIGN & CONSTRUCTION DURATION	MID POINT OF CONSTR.	DAM REMOVAL OPTIONS: DRAW DOWN CHANNEL BYPASS	DAM REMOVAL OPTIONS: COMPLETE DAM REMOVAL
		FEASIBILITY ALTERNATIVES ====>		ALT # 4	
		ENGINEERING APPENDIXES & PATH OPTIONS ====>		(Natural R Channel) *OPTION A-3c*	(Natural River) *OPTION A-3b*
				Thousand Dollars	Thousand Dollars
Annual Acquisition Costs (Spill effect the amount of water purchases for 427,000 Acre-Ft)			$5.35/Acre-foot	$2,286	$2,286
Annual Transaction Costs (Spill effect the amount of water purchases for 427,000 Acre-Ft)			4.45%	$100	$100
Annual Transaction Costs (Spill effect the amount of water purchases for 1,000,000 Acre-Ft)			$18.0/Acre-foot		
BOR - PURCHASING WATER RIGHTS for an extra 1,000,000 Acre-Ft		10 Years	Each Year		

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The assumed swell factors are based on generally accepted values as follows:

- Impervious core—damp; 1,990 kg/m^3 (3,350 lb/cy); 67 percent swell; to 1,190 kg/m^3 (2010 lb/cy);
- Earth rock mixture—25 percent E & 75 percent R, 31 percent swell;
- Gravel—wet, good gradation, 16 percent swell;
- Riprap rock—average; 2,670 kg/m^3 (4,500 lb/cy); 72 percent swell; to 1,550 kg/m^3 (2610 lb/cy).

Prevailing wage rates were obtained and payroll taxes and insurance applied as appropriate to wage and labor standards. The estimate uses Davis-Bacon Labor Rates from general decision WA980001, Modification 13. Materials prices were obtained from appropriate local supply sources, or estimated, based on the cost of erection and operation of site processing plants to handle large volumes of materials available at or near the site. Construction equipment rates for materials excavation, transportation and placement were established to include the cost of ownership, fuel consumption, maintenance and repair and other operations costs (except the labor for equipment operation). The source for these equipment rates is from *Construction Equipment Ownership and Operating Expense Schedule* EP 1110-1-8, Volume 8, September 1997.

Contractor's and subcontractors field office overhead, home office overhead and profit, were established using historical rates for similarly sized jobs and represent the contractor's cost of doing business and assuming the risks associated with construction work. The bond rates were also calculated.

X.2.2 Main Productivity Factor

For each of the construction scenarios, there is one key productivity factor, which controls the rate of material placement (or removal). The key productivity factor for embankment removal is the rate of excavation of the primary excavator. The productivity factor varies according to the amount of working space (related to the embankment elevation), the type and wetness of the material being excavated and the crew set-up needed to efficiently complement the selected types and numbers of primary excavators. The detailed elements of construction scheduling have not been optimized, but have been initially identified and used to set a pace of construction for the utilization and productivity of labor and equipment. Excavation of the earth embankment dam with impervious core could be economically performed with large hydraulic excavators and loaders at rates of 382 m^3/hr to 1,911 m^3 per hour (500 y^3 to 2,500 y^3 per hour) depending on the number of excavation units set up. Using a 6-day workweek with double shifting, embankment excavation and river channelization could be completed at all the dams by mid-January if drawdown begins on August 1. This pace combined with other activities, falls within the 8-month construction period for completion of the work.

X.2.3 Construction Equipment Selection

The type and size of hydraulic excavator selected for estimating this excavation was a CAT 5130 with a 10-m^3 (13-cy) bucket capable of producing 1,150 m^3 (1,500 cy) per hour. For cofferdam excavating and loading applications, a hydraulic excavator, with a rate of 320 m^3 (750 cy) per hour, was selected for material above the water surface and a dragline with a rate of 321 m^3 (420 cy) per hour for material below the water surface. The material hauling units selected were CAT 777-c (82-metric ton [90-ton] capacity) end dump trucks for all zones. Haul distances from the borrow sites at the dams to spoil locations were scaled from the project area topographic maps.

Additional support equipment selected for placement and compaction of soil and rock materials included more conventional smaller-sized dozers, graders, track and rubber-tired backhoes, and water trucks. Performance rates for these equipment spreads were selected from manufacturer's handbooks and adjusted by experience and site conditions. Costs were developed from *Construction Equipment Ownership and Operating Expense Schedule* EP 1110-1-8, Volume 8, September 1997

Additional costs were developed for drilling blasting, and processing costs, including sorting and crushing, of blasted rock. A barge and tug are part of the floating plant used for underwater drilling, blasting, and excavation.

X.3 Bridge Pier Modifications

The construction cost of modifications to the bridge piers and abutments for the Lower Snake River reservoirs were estimated based on site-specific data discussed in Section 3 of the *Lower Snake River Reservoir Stabilization Plan* (Raytheon, 1997). The estimate assumes that required riprap will be placed from barges prior to drawdown. The sheetpile will also be driven from floating plant. Once drawdown has occurred final dressing of the riprap will occur in the dry.

X.4 Reservoir Embankment Modifications

The construction cost of embankment protection for the Lower Snake River reservoirs was estimated based on quantities developed from information obtained from contracts let for relocation of the railroads and aerial photographs taken prior to filling of the reservoirs. Quantity takeoffs for these protection measures were based on dimensions developed by the Walla Walla District Engineering Division. Quantities were calculated separately for each embankment segment on each of the four reservoirs. A cost was developed for production of riprap based on crews required for drilling and blasting, assumed overburden depth, drill pattern, powder factor, yield of material, secondary blasting, handling of material, sorting and crushing. The other component of the proposed riprap protection was the cost of barge transportation and stockpiling in three of the reservoirs prior to drawdown and hauling from the stockpiles and quarries and placement at the site with final dressing of the slopes after drawdown of the reservoirs occur.

X.5 Reservoir Drainage Structure Modifications

The construction cost of drainage modifications for the Lower Snake River reservoirs were estimated based on site-specific data and generic sketches and layouts of modifications discussed in Section 6.3 of the *Lower Snake River Reservoir Stabilization Plan* (Raytheon, 1997). Quantity takeoffs for these modifications were based on dimensions shown on plan and section drawings for the proposed modifications (see Plates 6-9 to 6-12) and site-specific elevations and slope distances for all identified drains. Quantities were calculated separately for each drain location and combined into an estimate of the cost to construct all drain modifications on each of the four reservoirs.

The total costs for riprap blanket slope protection, riprap blankets for energy dissipation, cleaning of exposed and submerged culverts, additional new culverts, and new combined drainage flow culverts in each of the four Lower Snake River reservoirs was then estimated. Slope protection treatment details and quantity worksheets for each reservoir are shown in the Raytheon Report (Raytheon, 1997).

Horizontal borings were estimated based upon available data for large diameter casings. A large portion of the total cost is involved in mobilizing and setting up the boring pit, aligning guiderails for the boring machine, and machine assembly. It was assumed that areas of horizontal borings would be accessible by existing roads.

The number of contract packages to execute the reservoir drainage modification work is assumed to be two contracts, one for riprap material supply and a separate one for installation. As two reservoirs are to be worked concurrently, this is probably the optimum arrangement for contract administration.

X.6 Road and Railroad Repair Plan

There are approximately 68 potential failures that may occur. This assumed number is based on problem areas observed during the 1992 drawdown. The total embankment repair cost could vary significantly from the present estimate. Some embankment failures may occur in areas that were not identified by this study; however, it is also expected that some of the areas identified for potential failure will not fail. Because of these uncertainties a relatively high contingency was used.

X.7 HMU Modifications

There are eight HMUs with a total of 11 surface water intake pump stations. An average increased pump requirement and piping distance was determined and used as a basis for developing the total cost for modifying all 11 pump stations. The following criteria were used to develop the cost estimate:

- All new piping will be 300 millimeters diameter
- The average distance of the piping will be 300 meters
- The average water requirement will be 79 liters/second
- The average pump size will be 100 horsepower
- The local power company will supply power, but the Corps will pay for trenching.

The two HMUs that use a well-supplied water source will also require significant modifications. It is assumed two new wells will have to be drilled and, at a minimum, require 92 meters of additional drilling below the existing wells depths to maintain the water supply. With this additional depth, higher horsepower pumps will also be required. The estimate also provides for temporary water supply to the existing system via a trailer mounted pump system that could be moved as the water level recedes.

X.8 Cultural Resources Protection Plan

All activities described below will be carried out in compliance with applicable cultural resources laws and regulations. This includes coordinating and consulting with the appropriate State Historic Preservation Office, Tribe(s), and other interested parties.

Mobilization/demobilization costs were factored based on the mileage from either Pasco, Washington, or Lewiston, Idaho, to each reservoir group for sites determined to be accessible by highway, railroad, or currently submerged roadway. Mobilization/demobilization costs for the remote sites were estimated assuming access either by helicopter or boat. Assumptions for remote sites were that equipment, personnel, and material would be trucked to a staging area. From there they would complete the trip to

the site via boat or helicopter. It was assumed that 10 percent of the sites would be accessed by boat while 5 percent would be accessed by helicopter.

The complement of equipment used for the bulk of site protection consists of an 8 m^3 (10 cubic yard) dump truck, pulling a flatbed tilting trailer, with a small front-end loader, and a crew/miscellaneous tool truck. The work crew consists of 4 individuals, 1 loader operator, 1 truck driver, 1 laborer, and 1 working supervisor. Labor tasks will be performed by all crew members. During work activities at remote sites, either a boat and trailer or helicopter will be added.

Since site locations are not specifically identified and each site is relatively small, it was assumed that equipment would be mobilized to each site each working day. Maximum and minimum mileage was computed to sites in each reservoir from the closer of Pasco, Washington or Lewiston, Idaho. The average distance to each reservoir was then used to calculate travel time for the crew and equipment.

The operations required to protect the cultural resource sites include:

- Grading and preparing the site including leveling the site as necessary and manually preparing the surface and placement and securing the geomembrane.
- Placing and compacting a 0.3-meter layer of random fill material. The fill material will be borrowed from any convenient nearby location.
- Preparing the seed bed (manually), applying seed (manually), and placing and securing the erosion protection material for the re-vegetation process.
- Pre-place riprap, gravel, and highway base materials (assumed) during the bank protection operations. The costs are the same as those developed for production and transportation of such materials. The total costs are based on calculated volumes for each type of site.

Access to remote sites by boat or helicopter is estimated by adding this type of equipment to the crews and substituting a bobcat for the small front-end loader.

X.9 Project Decommissioning Plan

X.9.1 Abandon Option Cost Estimate

The abandon option consists of costs to secure the four sites. This is done by placing a fence around the area and securing/hardening all openings.

X.9.2 Cost Estimate for Hazardous Materials

The estimated cost for disposal of hazardous materials, substances, chemicals and wastes at all four projects was estimated by obtaining an inventory to develop the quantities. A crew was developed to assemble the wastes at an on-site collection area. Costs for disposal were based on the current district hazardous waste removal contract.

X.9.3 Project Security Cost Estimate

Costs for security were not included in the construction cost estimate, however they are presented here. The annual cost shown for surveillance is based on one person inspecting a project one time per month. Table X2 shows the estimated cost for project security.

Table X2. Estimated Cost For Security

Item	Annual Cost $
Manned surveillance	5,000
Total cost for Lower Granite Dam	5,000
Total for Little Goose Lock and Dam	5,000
Total for Lower Monumental Lock and Dam	5,000
Total for Ice Harbor Lock and Dam	5,000
Total cost for all four Snake River dams	**20,000**

X.9.4 Total Cost Estimate for Recommended Decommissioning Option

The abandon option is recommended for the four Snake River dams. The items included in this option are:

- Install facilities to backfeed power into the project from the existing grid so the existing lighting system can be used.
- Weld Navlock and spillway gates shut.
- Install security fences and signs.
- Secure and harden entrances to structures.
- Dispose and treat hazardous waste.

It is assumed that excess equipment and property will be sold off. Any funds received will offset the cost of removal and transportation.

X.10 Contingency Analysis

The goal in contingency development is to identify the uncertainty associated with an item of work or task, forecast the risk/cost relationship, and assign a value to this task that will limit the cost risk to an acceptable degree of confidence.

Contingencies were developed at a meeting held on August 18, 1998, with knowledgeable project personnel. Each task was analyzed and contingencies were developed based on the risk factors and uncertainties involved. An overall contingency was developed by applying these contingencies to the direct costs of the tasks and obtaining a weighted average.

Contingency guidance is provided in ER 1110-2-1302. For a reconnaissance/feasibility level, contingencies of 20 percent are considered reasonable for projects over $10 million and contingencies of 25 percent for projects less than $10 million. These overall contingency factors are a guide for contingency development and are not intended to restrict or limit contingencies to these values. Table X2 shows the contingencies assigned and the reasoning for the determinations.

Table X3. Contingency Analysis for Levee/Channelization Option

Task Description	Contingency Percentage (%)	Reason for Assigned Contingency
Powerhouse turbine modifications	30	Uncertainty regarding the routing of plumbing for cooling modifications and what additional controls and instrumentation would be required.
Dam embankment removal	20	Feasibility-level-of-detail risks involved in moving large amount of material in short time while reservoirs are being drawn down. Quantities and procedures fairly well defined.
River channelization	30	Final alignment and quantities involved are uncertain. Model studies and bathymetric surveys are required.
temporary fish handling facilities	30	High uncertainty in number of fish to be hauled.
Project decommissioning	40	Uncertainty in quantities of waste to be disposed of and requirements to harden structure to keep trespassers out.
Railroad relocations	30	High uncertainty as to requirements railroads will impose on new track alignment.
Bridge pier & abutment protection	25	Uncertainty in quantities and ability to perform installations under bridge structure.
Railroad and highway embankment protection	35	Uncertainty in viability of existing access roads to accommodate construction traffic. Access and slope conditions not full defined.
Drainage structures protection	40	Access to drainage structures is very problematic and high uncertainty because many drainage structures are located beyond the limits of embankment protection activity.
Railroad and roadway damage repair	75	Extremely high uncertainty as to extent of damage that will be caused by rapid drawdown of reservoirs. Amount of damage could easily double.
Recreation access modification	20	Fairly well defined quantities and standard procedures contingency below average for feasibility level.
Lyons Ferry Hatchery modification	30	Uncertainty in depth to which wells will have to be drilled in order to obtain water after drawdown. Unknown condition of long-term sediment accumulation around pipeline. Will dredging be required in order for floating plant to have access to perform work?
Habitat management unit (HMU) modifications	20	Generally good idea of what is required to modify HMUs uncertainty exists in sizing of pumps and requirements of where to place intake structures after drawdown.

Table X3 continued. Contingency Analysis for Levee/Channelization Option

Task Description	Contingency Percentage (%)	Reason for Assigned Contingency
Reservoir revegetation	30	Risk involved in aerial operations that are dependent on weather (i.e., high winds in canyons); also uncertainty in the extent of replanting that would be required. The success rate of aerial seeding is also suspect.
Cultural resources Protection	100	Uncertainty in site quantity, location, and access: since no vegetation would remain after drawdown, it is extremely likely that new sites would be discovered.
Cattle watering facilities	30	Uncertainty in location and depth of wells.
Total		
Weighted Average Contingency	34	