Shasta Dam and Reservoir Enlargement

Appraisal Assessment of the Potential for Enlarging Shasta Dam and Reservoir

United States Department of the Interior
Bureau of Reclamation
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Executive Summary

Increasing demands for clean, reliable water in the Central Valley are prompting water agencies to consider methods which could be used to increase water supplies. One project that could increase water supply would be the enlargement of Shasta Dam.

This appraisal-level study investigated three enlargement options to illustrate the potential costs, technical issues, and impacts associated with dam raises of 6.5, 102.5, and 202.5 feet. No engineering or geologic conditions were identified that preclude the modification of the existing dam for a raise up to 200 feet. Implementing the options would provide from about 300,000 to 9,000,000 acre-feet of additional storage space in the reservoir, inundating between 2,000 and 30,000 additional acres.

The investigation of enlargement options included consideration of the following:

- Spillway modifications
- Outlet works modifications
- Temperature control device modifications
- Existing penstock and powerplant modifications
- Development of a new powerplant and penstocks
- Existing switchyard modifications
- Development of new switchyards
- Reservoir dikes
- Relocation of Interstate Highway 5 and the Union Pacific Railroad, including replacement of Interstate 5 - Union Pacific Railroad Bridge at Bridge Bay
- Other road and bridge relocations
- Recreation facility relocations
- Community relocations
- Keswick Dam and Powerplant modifications
- Current and potential modifications to water operations
- Water rights issues
- Technical issues associated with construction
- Scheduling and sequencing of construction
- Potential environmental effects and opportunities
- Identification of potential flood control, water supply, hydropower, and environmental benefits
- Potential effects of protective State legislation and protective agreements relative to areas affected by Shasta enlargement.

Significant flood control benefits and greatly enhanced flexibility to maintain downstream instream flows and water quality could be derived from this additional storage. Costs of options range from about $122 million for a 6.5-foot raise to $5.8 billion for a 200-foot raise. The cost per acre-foot of storage ranges from about $422 to $992. Table ES-1 summarizes potential enlargement options.

Further studies examining the opportunities for a small enlargement of Shasta Dam and reservoir would be very useful. Through more advanced studies, engineering considerations and cost savings measures can be refined, operational opportunities can be further defined in the context of Statewide water issues and programs, and benefits can be optimized in relation to meeting multiple demands.

Table ES-1 Summary Table - Enlargement Option Features

FEATURE	EXISTING DAM	HIGH OPTION	INTERMEDIATE OPTION	LOW OPTION
Dam Crest Elevation (ft)	1,077.50	1,280	1,180	1,084
Dam Crest Length (ft)	3,460	4,930	4,590	3,660
Height Raise (ft)	None	202.5	102.5	6.5
Joint Use and Top of Gates Elevation (ft)	1,067	1,273.50	1,173.50	1,075.50
Total Reservoir Capacity (MAF)	4.6	14	8.5	4.9
Increase in Capacity (MAF)	None	9.4	3.9	0.3
Spillway Crest Elevation (ft)	1,037	1,246	1,146	1050
Spillway Gates	three 28' by 110' drum type	six 27.5- by 55-foot radial	six 27.5- by 55-foot radial	six 27.5- by 55-foot radial
Outlet Works	18 outlets in 3 tiers at elev. 950 (six 96" tubes), 850 (eight 96" tubes), and 750 (four 102" tubes)	Replace all 14 existing outlet tubes to handle increased head	Replace outlets in two lower tiers of existing dam (upper tier can accommodate increased head from raise)	Replace 4 tube valves on lower tier outlets for greater reliability and discharge capacity
[illegible]				
Interstate 5-Union Pacific Railroad Bridge -Bridge Bay	Not applicable	Yes	Yes	No
Recreation Facilities	Not applicable	Yes	Yes	Minor
Resort Facilities	Not applicable	Yes	Yes	No
Communities	Not applicable	Yes	Yes	No
[illegible]				
Temperature Control Device	250' by 300' shutter structure and 125' by 170' with operating range between elev. 840 and 1065.low level intake structure	Raise operating controls	Raise operating controls	Raise operating controls
Existing Penstocks and Penstock Intakes	Five 15' diameter steel penstocks at elev. 815	New 16' by 25' gates, Replace existing pipes with thicker walled steel pipes, strengthen exposed pipe supports	New 16' by 25' gates, Replace existing pipes with thicker walled steel pipes, strengthen exposed pipe supports	Strengthen exposed pipe supports
New Penstocks and Penstock Intakes	Not applicable	Five new 20' diameter penstocks and intakes at elev. 970 on left abutment	Five new 20' diameter penstocks and intakes at elev. 880 on left abutment	None
Existing Powerplant	Currently rated at 578 MW with ongoing uprating program to increase generation to 676 MW. Operation level between elev. 840 and 1065.	No modifications for existing powerplant to upgrade power generation. Upstream isolation valves required to protect existing spiral cases for reservoir elevations above 1186 feet.	No modifications for existing powerplant to upgrade generation. New upstream isolation valves not required.	No modifications for existing powerplant to upgrade generation. New upstream isolation valves not required.
New Powerplant	Not applicable	Five 260 MW turbine/generator units (combined capacity of 1,300 MW) for operation between elevations 980 and 1,280 feet.	Five 215 MW units (combined plant capacity of 1,075 MW) operating between elevations 890 and 1180.	None
Switchyard	Existing switchyard located at left abutment.	Replace the existing switchyard with a new 230kV switchyard (required space 1,250' by 400') at a downstream location. Develop a new 525 kV switchyard (required space 700' by 500')along left abutment.	Replace the existing switchyard with a new 230kV switchyard (required space 1,250 by 400') at a downstream location. Develop a new 525 kV switchyard (required space 350' by 500') along left abutment.	None
[illegible]				
Centimundi	No	Yes	No	No
Bridge Bay	No	Yes	No	No
Jones Valley	No	Yes	Yes	No
Clickapudi Creek	No	Yes	Yes	No
[illegible]				
Keswick Dam and Powerplant	Not applicable	Enlargement required up to 25 feet to accommodate increased releases from new powerplant.	Enlargement required up to 25 feet to accommodate increased releases from new powerplant.	None
Scheduling/Sequencing	Not applicable	8 to 10 year construction period	8 to 10 year construction period	4 year construction period
Total Investment Cost	Not applicable	$5,810,927,000	$3,889,729,000	$122,281,000

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Introduction

Shasta Dam.

Water management in the State of California faces many unique challenges in meeting current and future demands. One of these (increasing pressure to maintain and improve water supplies for environmental, urban, and agricultural uses) may require that additional water storage be developed.

Several key water resource management efforts are currently underway in California which will significantly influence water resource management into the next century. These include the CALFED Bay-Delta Program, Central Valley Project Improvement Act actions, and development of the Bay-Delta Water Quality Control Plan. These programs or efforts will significantly influence State water demands. Many stakeholders participating in these activities believe the only method of meeting all future demands for water is through a combination of improving water use efficiency and developing additional storage. In general, the most viable options for development of additional storage are considered to be at offstream storage sites, where environmental impacts may be less, or through enlargement of existing facilities in high precipitation regions where hydrologic conditions can sustain additional storage and environmental effects are reduced because of the facilities that already exist.

Shasta Dam, because of its location in the upper Sacramento River Basin and its basin hydrological characteristics, is a critical component in the existing water management system. It is particularly important and unique in its ability to meet water demands, including water quality and other environmental resource management goals of the Sacramento River and the Sacramento-San Joaquin Delta.

To facilitate a greater understanding of one water storage proposal, the Bureau of Reclamation has prepared this assessment of the potential for enlarging Shasta Dam. This is considered an appraisal-level study that is to be used to identify the scope of any project plan and to determine if more detailed feasibility studies are warranted. The primary purpose of this assessment was twofold. First, the purpose was to determine the costs of a wide range of potential enlargements. Second, the purpose was to identify critical issues that potentially affect project feasibility. The following chapters summarize the results of the assessment.

Specifications of Existing Dam

Total Drainage Area:	6,421 square miles
Dam Type:	Concrete gravity
Storage:	
With drum gates raised to elevation 1065.0	4,492,742 acre-feet
With 2-foot flashboards lowered to top of drum gates (maximum storage excluding surcharge space; elev. 1067)	4,552,000 acre-feet
At Maximum Storage (Elev. 1067):	
Reservoir Length	35 miles
Surface Area	29,605 acres
Shoreline	365 miles
Crest Length:	3,460 feet
Crest Elevation:	1077.5 feet
Crest Width:	41 feet, 5 inches
Structural Height (includes foundation):	602 feet
Height above Streambed at Dam Axis:	533 feet
Spillway:	
Width	350 feet
Gates	Drum type (3) each 110 feet x 28 feet
Spillway Outlets:	
Elevation 950	Six 96-inch tubes
Elevation 850	Eight 96-inch tubes
Elevation 750	Four 102-inch tubes
Powerplant:	
Five main units	
Five 15-foot-diameter plate steel penstocks	
Two station service turbines	

Shasta Dam and lake is located about 9 miles northwest of Redding, California, on the Sacramento River. The dam was built over an 8-year period between 1938 and 1945. The dam is a 533-foot-high concrete gravity dam which provides flood control, power, and water supply benefits. The lake is also used extensively for recreation. It is a key facility in the Federal Central Valley Project, representing about 41 percent of the total reservoir storage capacity of the entire Central Valley Project. Figure 1 shows the reservoir area. When Shasta Dam was being planned in the early 1930s, it was recognized that the site was not being developed to its full potential. At the time, the proposed dam height of 602 feet was pushing the technological limits of the day, and it was felt that further storage could be developed downstream near Red Bluff at some future time. The development of this additional storage downstream never occurred.

Three increases in dam heights were evaluated in this appraisal evaluation. These alternative heights (the High, Intermediate, and Low Options) were used to define cost curves and increased storage capabilities for the full range of elevations between the Low and High Options. The elevations of the three options were strategically selected, based upon engineering considerations that primarily defined breaks in the cost versus elevation curve. The elevation, storage, and reservoir surface area relationships of the full range of potential height increases are shown in figure 2.

Appendix A gives a tabular listing of the storage-area-elevation relationships. The direct actions which may be required in any potential enlargement fall into five different categories: (1) structural dam and abutment modifications, (2) relocations/replacements,