

6. RESOURCE MANAGEMENT MEASURES

Following the development of the planning objectives, constraints, and criteria for the NODOS Investigation, the next major steps are to identify and evaluate potential resource management measures and to formulate initial alternatives. In conjunction with investigating resource management measures, past studies and investigations were consulted, such as the CALFED Storage element.

This section begins with a summary of the CALFED storage elements, including its findings relevant to viable, developable surface storage sites in California, followed by a review of CALFED's surface storage screening results to determine their relevancy to the NODOS Investigation's primary objectives. Those surface storage sites suitable for consideration as potential NODOS measures are identified and included in the broad range of measures developed by the IAIR study team. The study team identified those candidate measures that appeared most viable to meeting the NODOS objectives by performing an initial, qualitative screening of a broad range of measures. Following the initial screening, additional considerations specific to retained measures are identified, and these retained measures are further screened to ascertain a suite of measures appropriate for consideration in the development of potential initial alternatives.

6.1 DEFINITION OF RESOURCE MANAGEMENT MEASURES

A resource management measure is a feature or activity, structural or non-structural, that addresses a specific planning objective. Potential resource management measures were identified as part of previous studies, programs, and projects to address problems, needs, and opportunities in the study area. The identified measures were evaluated for their ability to address the primary and secondary planning objectives. The ranking of measures was qualitative; the decision-making regarding how well a measure accomplished a specific objective was collectively determined by the IAIR study team. The following sections describe the wide range of measures considered, justification for deleting or retaining measures, and further information on measures that were retained and how the measures might be incorporated into initial alternatives.

6.2 CALFED STORAGE INVESTIGATIONS

DWR began the NODOS Investigation as a reconnaissance-level study in late 1997 as part of the ISI. ISI included three types of investigations: surface storage, conjunctive management and groundwater, and barrier removal (fish passage improvement). ISI was funded to provide information for inclusion in CALFED's programmatic EIS/EIR. In the programmatic Record of Decision, CALFED included a storage component to investigate surface, conjunctive, and groundwater storage programs.

The ROD notes that, "additional storage [is] needed to meet the needs of a growing population and, if strategically located, will provide much needed flexibility in the system to improve water quality and support fish restoration efforts." DWR and Reclamation were directed by the ROD to study five surface storage projects with up to 3.5 MAF of additional capacity, as well as a major expansion of groundwater storage for an additional 0.5 to 1.0 MAF. The NODOS study team has incorporated this surface and groundwater approach to storage by including both as potential measures to address NODOS objectives. Later, when alternatives are redefined during the PFR stage, a NODOS alternative could include groundwater storage, surface storage, or both.

The study team recognizes that many of the CALFED-related objectives under consideration by the NODOS investigation will require integration of new storage into the California's existing water

management and infrastructure system. Integration of either surface or groundwater storage will require some modification of existing operations. Indeed, the “much needed flexibility” identified in the ROD clearly indicates changes in operations. These potential operational changes, including their potential benefits and effects, will be evaluated in the PFR and ultimately in the EIS/EIR for the NODOS Investigation.

6.2.1 CALFED Groundwater Storage

The CALFED Programmatic EIS/EIR identified projects in the Sacramento Valley, in the Delta, in the San Joaquin Valley, and in Southern California that could provide 500 TAF to 1 MAF of groundwater storage. The NODOS Investigation will rely significantly upon information from the CALFED groundwater storage investigations, under DWR, as potential groundwater storage measures are conceived and evaluated. The most recently published 2004 CALFED annual report notes that, “significant headway has been made on efforts to expand groundwater storage. More than \$240 million in grants and loans has been awarded statewide for more than 160 local groundwater storage and conjunctive use studies and projects. The local cost share on these projects is approximately \$900 million. Partnerships with local and regional agencies are ongoing in 18 areas of the state to improve groundwater management and develop conjunctive use projects and programs.” The ROD also notes that CALFED agencies intend to support voluntary, locally controlled groundwater projects that are designed to address local water needs first, before considering regional or statewide benefits. Finally, groundwater storage is being included in the Common Assumptions process so that many of the projects being supported by DWR will be included in future no action and NODOS alternative project conditions.

Groundwater storage measures will be evaluated in a more comprehensive manner as additional information becomes available from CALFED’s groundwater storage investigations in the PFR.

6.2.2 CALFED Surface Storage

CALFED began an initial screening of 52 potential surface storage sites (the screening process is summarized in Appendix F) to reduce the number of sites to a more manageable number for further CALFED consideration. CALFED criteria eliminated sites providing less than 0.2 MAF of storage, as well as those that conflicted with CALFED solution principles, objectives, or policies. CALFED removed 40 surface storage sites from the list during the initial screening process, as detailed in the Initial Surface Water Storage Screening Report (CALFED, 2000). CALFED specifically looked for projects that could contribute significantly to CALFED’s program objectives. These included potential sites that could provide broad benefits for water supply, flood control, water quality, and the ecosystem. Those sites not retained for additional CALFED consideration may still be developed for other purposes.

This CALFED screening resulted in the selection of the following 12 reservoir sites for further CALFED consideration:

- ❖ Four north-of-the-Delta offstream storage reservoirs – Red Bank, Newville, Colusa, and Sites;
- ❖ In-Delta storage and enlargement of Los Vaqueros Reservoir, which would divert water from the Sacramento-San Joaquin Delta;
- ❖ Four south-of-the-Delta storage reservoirs – Ingram Canyon, Quinto Creek, Panoche, and Montgomery; and
- ❖ Enlargement of Shasta Lake (Shasta Dam) and Millerton Lake (Friant Dam).

The 52 surface storage sites first investigated by CALFED were revisited for the NODOS Investigation to determine whether some of them should be included as NODOS Investigation measures. The 52 surface storage sites were evaluated for their ability to address the planning objectives in this investigation. This NODOS evaluation of the 52 surface storage sites is also included in Appendix F. This screening activity resulted in the identification of three viable surface storage measures suitable for continued IAIR consideration—Newville, Colusa, and Sites Reservoirs. These offstream surface storage measures have been added to the broader range of measures identified by this IAIR for comparison and screening against the NODOS Investigation objectives.

6.3 RESOURCE MANAGEMENT MEASURES SCREENING

Resource management measures were screened by their ability to address at least one planning objective without adverse impact on other planning objectives. Measures were analyzed for the degree to which they fulfill a specific planning objective and were rated on a scale from low to high. The primary planning objectives consist of a number of elements that can be used to assess the benefits of each measure. The elements are listed below the two primary objectives:

Water Supply and Reliability Objective

- ❖ Water supply
- ❖ Supply reliability
- ❖ Operational flexibility (agriculture, M&I, environment)
- ❖ Delta water quality
- ❖ EWA
- ❖ ERP
- ❖ Focus on offstream storage

Anadromous Fish Survivability Objective

- ❖ Flow (volume, timing, and location)
- ❖ Passage (amount of flow and location)
- ❖ Habitat
- ❖ Water quality (including temperature and location)
- ❖ Benefits to other aquatic species

The secondary objectives are single-element objectives that include:

- ❖ Ancillary hydropower generation benefits to the statewide power grid;
- ❖ Additional recreational opportunities in the study area; and
- ❖ Incremental flood control storage opportunities in support of major northern California flood control reservoirs.

The ranking of measures was qualitative; the decision regarding how well a measure accomplishes a specific objective was partially subjective. The IAIR study team collectively determined the rankings for each measure. A measure was ranked “low” for a specific objective if only a few (or none) of the elements would be accommodated by that measure. An intermediate ranking of “moderate” indicates that approximately half of the elements would benefit from that measure. A ranking of “high” indicates that most (or all) of the elements would benefit. For single-element objectives, a “low” ranking indicates the objective would not be met, a “moderate” ranking indicates partial benefit to that objective, and a “high” ranking indicates significant benefit to that objective. Finally, a determination was made regarding whether or not each measure should be retained for further consideration or deleted from this investigation.

Measures deleted from this investigation are not precluded from reconsideration in future study activities. (Future events may create project or study area conditions that require the resurrection of particular measures discarded under this IAIR investigation.) Measures that do not directly address the planning objectives also may be reconsidered for inclusion in future alternative plans as possible mitigation elements or ancillary plan features, if they provide some incremental benefit deemed acceptable by federal and/or non-federal interests.

6.4 MEASURES TO ADDRESS PRIMARY PLANNING OBJECTIVES

The following subsections identify resource management measures that address the primary planning objectives introduced in Section 5.2 of this report.

6.4.1 Measures to Address Water Supply, Reliability, and Management Flexibility Needs

Various potential water resources management measures were identified to address the primary objective of increasing water supplies, water supply reliability, and Sacramento Valley water management flexibility for agricultural; M&I; and environmental purposes, including CALFED programs such as Delta water quality, EWA, and ERP, to help meet California's current and future water demands, with a focus on offstream storage. Table 6-1 identifies the measures considered, and whether they were retained or deleted from further IAIR consideration.

The study of potential surface storage measures is part of a larger CALFED program to address four objectives for managing water resources in California: water supply reliability, levee system integrity, water quality, and ecosystem restoration. As stated previously, storage is one of 12 program elements designed to achieve these four CALFED objectives. The program elements are also conceived to be interrelated and interdependent so that elements can be implemented in a complementary and non-competitive fashion. All program elements are assumed to be implemented consistent with program implementation guidelines. CALFED complementary actions (WUE and Transfers), described in Section 3, will be implemented concurrently and will, therefore, be included in all NODOS alternatives, including the No-Action alternative and the initial alternatives described later in this report. Because these complementary actions are already included in all the alternatives, CALFED complementary actions are not included in the list of measures to achieve NODOS objectives. More specifically, the CALFED Surface Storage Common Assumptions effort will assume implementation of both WUE and Transfers so that ultimately the NODOS Investigation will assume WUE and Transfers in the No-Action Alternative and all NODOS alternatives.

6.4.2 Measures to Address Anadromous Fish Survival

Various potential water resources management measures were identified to address the primary objective of increasing the survival of anadromous fish populations in the Sacramento River and increasing the health and survival of other aquatic species. Table 6-2 identifies measures considered and whether they were retained or deleted.

6.5 MEASURES TO ADDRESS SECONDARY PLANNING OBJECTIVES

The following subsections identify resource management measures that address the secondary planning objectives.

6.5.1 Measures to Address Increasing Hydropower Generation

Various potential water resources management measures were identified to address the secondary objective of exploring the ancillary benefits that hydropower generation can offer to the statewide energy grid. (Benefits from hydropower considerations under this investigation are ancillary and are not intended as major facilities that provide significant power contributions to the statewide grid.) Table 6-3 identifies measures considered, and whether they were retained or deleted.

6.5.2 Measures to Address Recreation Opportunities in the Study Area

Various potential measures were identified to address the secondary objective of increasing recreational opportunities in the study area. Table 6-4 identifies measures considered, and whether they were retained or deleted.

6.5.3 Measures to Address Flood Control Opportunities in the Study Area

The opportunity may exist to allocate some portion of the NODOS storage facility as incremental flood control storage. Although offstream storage would provide flood control on the small watersheds discharging into a NODOS facility, an additional increment of flood control storage is possible to support major flood control storage facilities in California north of the Delta. In essence, incremental flood control storage could not only support Lake Shasta flood storage capacity but could also, depending on operational actions, support flood control capacities for other northern California facilities, such as Lake Oroville and Folsom Lake.

Incremental flood control storage at a NODOS reservoir would function as ancillary storage for other major flood control storage facilities by capturing early reservoir releases dictated by operational actions taken for forecasted storm events. The ability to provide incremental flood control storage at a NODOS facility would be predicated upon available storage space in the facility, degree of accuracy in the forecast, the operating capacity of the NODOS conveyance system at the time of the forecast, and the ability to modify operational criteria at other major northern California flood storage facilities. Table 6-5 identifies measures considered, and whether they were retained or deleted.

6.6 SUMMARY OF MEASURES RETAINED FOR FURTHER CONSIDERATION

This section summarizes the measures that best address the primary and secondary NODOS planning objectives and were retained for formulation of initial alternatives. Please note that measures screened at any point during the plan formulation may be reconsidered in the future as mitigation measures or optional features of the plan. Additional measures, not yet considered, also may be added to alternative plans as they are formulated.

6.6.1 Measures that Address the Primary Planning Objectives

Table 6-6 identifies the measures that best address the primary planning objectives.

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**Table 6-1
Resource Management Measures to Address Water Supply Needs and Reliability**

Resource Management Measure	Potential to Address Planning Objective	Status/Rationale
Construct Sites Reservoir, a new conservation offstream surface storage facility near the Sacramento River downstream from Shasta Dam	High – Potential for this offstream storage reservoir to meet all components of this primary objective.	Retained – Consistent with primary planning objectives and directly contributes to secondary planning objectives.
Construct Colusa Reservoir, a new conservation offstream surface storage facility near the Sacramento River downstream from Shasta Dam	High – Potential for this offstream storage reservoir to meet all components of this primary objective.	Retained – Consistent with primary planning objectives and directly contributes to secondary planning objectives.
Construct Newville Reservoir, a new conservation offstream surface storage facility near the Sacramento River downstream from Shasta Dam	High – Potential for this offstream storage reservoir to meet all components of this primary objective.	Retained – Consistent with primary planning objectives and directly contributes to secondary planning objectives.
Raise Shasta Dam	Moderate to High – Measure would increase water supply reliability.	Deleted – Measure is being considered through the Shasta Lake Water Resources Investigation and a separate FS.
Increase efficiency of Shasta Reservoir operation	Low – Potential for incremental increase in water supply reliability at Shasta Reservoir. Does not meet other objective components.	Deleted – There is a low potential for increased water supply reliability. Does not address other planning objectives.
Increase conservation pool in Shasta Reservoir by encroaching on dam freeboard	Low – Very small space increase possible.	Deleted – Very limited potential to encroach on existing freeboard above gross pool, which is only 9.5 feet. High relative cost to resolve uncertainty issues related to encroachment.
Develop additional groundwater storage south of the Sacramento-San Joaquin River Delta	Moderate – Potential to enhance system yield for many potential uses.	Deleted – Measure would be located out of the primary study area.
Develop groundwater storage near the Sacramento River, downstream from Shasta Dam	Moderate to High – Potential to enhance system yield for many potential uses.	Retained – Consistent with primary planning objectives.
Improve Delta export and conveyance capability through coordinated CVP and SWP operations	Moderate – Potential to enhance system yield when combined with new offstream storage. Significant potential to help increase water supply reliability south of the Delta.	Deleted – JPOD* is being actively pursued in other programs and is therefore part of the without-project condition. Not an alternative to increasing water supply reliability north of the Delta. Does not address planning objectives or constraints/principles/criteria.
Retire agricultural lands	Moderate – Would reduce water demand rather than increase ability to meet projected future demands.	Deleted – Not an alternative to new storage. Does not address planning objectives and constraints/criteria. Land retirement test programs are being performed by Reclamation. On a large scale, could have significant negative impacts on agricultural industry.
Construct Delta-Mendota Canal/California Aqueduct intertie	Moderate – Significant potential to help increase water supply reliability south of the Delta.	Deleted – This project is being actively pursued by other CALFED programs. Not an alternative to increasing water supply north of the Delta. Does not address planning objectives or constraints/principles/criteria. Likely to be accomplished with or without additional efforts to develop new sources.
Pursue seawater desalination programs	Low to Moderate – Potential to enhance system yield in the coastal regions	Deleted – Limited contribution to water supply needs, water supply reliability, and water management flexibility in the Sacramento Valley. Would not address other planning objectives.
Expand Big Dry Creek Reservoir – San Joaquin River Dry Creek Watershed	Low – Uncertainty regarding the dam's ability to store more than a few TAF of water.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Given seepage concerns and insufficient inflow, it was uncertain what capacity the reservoir would have. Measure would not address planning objectives.
Raise Pine Flat Dam – Kings River Watershed	Low – Measure would not significantly increase water supply reliability.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure would produce increase of only 124 TAF, and CALFED eliminated measures <200 TAF in other screening processes. In addition, measure was not supported by the KRCD, which represents the users of water stored in the Pine Flat Reservoir. The measure does not increase supply to the Sacramento Valley.

* The joint operation of the two projects (SWP and CVP) is commonly referred to as the joint point of diversion (JPOD).

Table 6-1
(Continued)

Resource Management Measure	Potential to Address Planning Objective	Status/Rationale
Construct Mill Creek Reservoir – Kings River Watershed	Moderate – Measure would increase water supply reliability in San Joaquin Valley.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure would supply up to 200 TAF, and CALFED eliminated measures <200 TAF in other screening processes. Measure also would cause adverse impacts to an extensive sycamore alluvial woodland. Measure does not increase supply to the Sacramento Valley.
Construct Rogers Crossing Reservoir – Kings River Watershed	Moderate – Measure would increase water supply reliability in San Joaquin Valley.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure would supply up to 950 TAF of water. Measure would cause inundation of a Special Management Area and a Wild and Scenic River and would violate expressed Congressional intent. Measure does not increase supply to the Sacramento Valley.
Construct Dinkey Creek Reservoir – Kings River Watershed	Low – Measure would not significantly increase water supply reliability.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure would produce an increase of only up to 90 TAF. Measure would adversely affect trout habitat and migration and deplete recreational opportunities in the project area. Measure does not increase supply to the Sacramento Valley.
Construct Dry Creek Reservoir – Kaweah River Watershed	Low – Measure would not significantly increase water supply reliability.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure would produce an increase of only up to 70 TAF and would adversely affect rare sycamore alluvial woodland. Measure does not increase supply to the Sacramento Valley.
Construct Hungry Hollow Reservoir – Tule River Watershed	Moderate – Measure would increase water supply reliability in San Joaquin Valley.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure would supply up to 800 TAF. Measure would adversely affect rare sycamore alluvial woodland, and dam would be located on extensive young alluvial deposits (poor foundation). Measure does not increase water management flexibility in the Sacramento Valley.
Raise Friant Dam	Moderate to High – Measure would increase water supply reliability in San Joaquin Valley.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure does not increase water management flexibility in the Sacramento Valley.
Construct Temperance Flat Reservoir	Moderate to High – Measure would increase water supply reliability in San Joaquin Valley.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure does not increase water management flexibility in the Sacramento Valley.
Construct Fine Gold Reservoir	Moderate to High – Measure would increase water supply reliability in San Joaquin Valley.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure does not increase water management flexibility in the Sacramento Valley.
Construct Yokohl Valley Reservoir	Moderate to High – Measure would increase water supply reliability in San Joaquin Valley.	Deleted – Measure is being considered through the Upper San Joaquin River Basin Storage Investigation and a separate FS. Measure does not increase water management flexibility in the Sacramento Valley.

CVP = Central Valley Project
 Delta = Sacramento-San Joaquin River Delta
 FS = feasibility study
 JPOD = joint point of diversion
 KRCD = Kings River Conservation District
 SWP = State Water Project
 TAF = thousand acre-feet

Table 6-2
Resource Management Measures to Address Anadromous Fish Survival

Resource Management Measure	Potential to Address Planning Objective	Status/Rationale
Restore abandoned gravel mines along the Sacramento River	Moderate to High – Addresses primary planning objective.	Retained – Increased potential to address the primary objective and high likelihood of success. Consistent with other anadromous fish programs and high likelihood for local interest. Provides benefits for both aquatic and floodplain/riparian habitat.
Construct instream aquatic habitat downstream from Keswick Dam	Moderate to High – Addresses primary planning objective.	Retained – Increased potential for combining with other measures. Relatively low initial cost but high O&M costs. Difficult to construct and maintain. Low certainty for long-term success.
Replenish spawning gravel in the Sacramento River	Moderate to High - Addresses primary planning objective.	Retained – Increased potential for combining with other measures. Demonstrated benefits that continue as gravel moves downstream. Low initial cost but very high annual cost relative to initial cost. Concerns over induced downstream impacts on agricultural facilities. Depends on long-term commitment to regular and recurring project replacement for success.
Construct instream fish habitat on tributaries to the Sacramento River	Low to Moderate – Benefits planning objective.	Deleted – Significant benefit to tributaries. Relatively low initial cost but high O&M costs. Difficult to construct and maintain. Low certainty for long-term success. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Remove instream sediment along Middle Creek, an intermittent tributary to the Sacramento River between Keswick Dam and Redding	Low – Indirectly benefits planning objective.	Deleted – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River. High uncertainty, given increased need for long-term remediation.
Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood Creeks	Low – Indirectly benefits planning objective.	Deleted – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Restore the streambed near the ACID siphon on Cottonwood Creek	Low – Indirectly benefits planning objective.	Deleted – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River.
Make additional modifications to Shasta Dam for temperature control	Low to Moderate – Potential to contribute to planning objective by improving temperatures for anadromous fish.	Deleted – Consistent with primary planning objective, but limited potential exists to further modify the temperature control device to benefit anadromous fish with increased storage at Shasta, but modifications to Shasta are being considered through a separate FS.
Enlarge Shasta Lake cold water pool	Moderate to High – Directly contributes to planning objective by improving water temperature conditions for anadromous fish.	Deleted – Consistent with primary objective and goals of CALFED, but modifications to Shasta are being considered through a separate FS.
Modify storage and release operations at Shasta Dam	Moderate to High – Directly contributes to planning objective by improving flow conditions for anadromous fish.	Deleted – Consistent with goals of CALFED, but modifications to Shasta are being considered through a separate FS.
Modify ACID diversions to reduce flow fluctuations	Moderate – Reduced flow fluctuations would benefit anadromous fish, directly contributing to the planning objective.	Deleted – Conflicts with other primary planning objective of water supply reliability.
Increase instream flows on Clear, Cow, and Bear Creeks	Low – Indirectly benefits planning objective on the Sacramento River.	Deleted – Independent of hydraulic/hydrologic conditions in upper Sacramento River.
Construct a storage facility on Cottonwood Creek to augment spring instream flows	Low – Indirectly benefits planning objective on the Sacramento River.	Deleted – Independent of hydraulic/hydrologic conditions in upper Sacramento River. Adverse environmental impacts expected to exceed benefits.
Improve fish trap below Keswick Dam	Low to Moderate – Directly contributes to planning objective by reducing mortality and supplying more fish to hatcheries.	Deleted – Although helps fish populations, does not contribute to favorable conditions for sustained spawning and rearing of anadromous fish.
Remove or screen diversions on Battle Creek	Moderate – Indirectly benefits planning objective on the Sacramento River.	Deleted – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River.
Construct a fish barrier at Crowley Gulch on Cottonwood Creek	Moderate – Indirectly benefits planning objective on the Sacramento River.	Deleted – Significant benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River.

Table 6-2
(Continued)

Resource Management Measure	Potential to Address Planning Objective	Status/Rationale
Increase conservation storage space in Shasta Reservoir by raising Shasta Dam	Moderate – Potential to improve flow regime on the Sacramento River and benefit temperature control.	Deleted – Consistent with primary planning objective and contributes to secondary objectives, but modifications to Shasta Dam are being considered through a separate FS.
Construct new conservation storage reservoir(s) upstream from Shasta Reservoir	Moderate – Potential to improve flow regime on the Sacramento River and benefit temperature control.	Deleted – Upstream storage sites capable of system wide CVP benefits would be very costly, result in environmental impacts difficult to mitigate, and be inconsistent with the CALFED ROD principles.
Construct Sites Reservoir, a new conservation offstream surface storage facility near the Sacramento River downstream from Shasta Dam	High – Potential for this offstream storage project to meet all components of this primary objective.	Retained – Consistent with primary planning objectives and directly contributes to secondary planning objectives.
Construct Newville Reservoir, a new conservation offstream surface storage facility near the Sacramento River downstream from Shasta Dam	High – Potential for this offstream storage project to meet all components of this primary objective.	Retained – Consistent with primary planning objectives and directly contributes to secondary planning objectives.
Construct Colusa Reservoir, a new conservation offstream surface storage facility near the Sacramento River downstream from Shasta Dam	High – Potential for this offstream storage project to meet all components of this primary objective.	Retained – Consistent with primary planning objectives and directly contributes to secondary planning objectives.
Construct new conservation surface water storage south of the Sacramento-San Joaquin River Delta	Low – Would have little to no benefit to the mainstem Sacramento River.	Deleted – Would have little to no benefit to the mainstem Sacramento River.
Improve fish passage at Red Bluff Diversion Dam	High – Potential to improve fish passage and provide spawning access.	Retained – Substantial benefit to spawning conditions.
Develop additional conservation groundwater storage south of the Sacramento-San Joaquin River Delta	Moderate – Potential to enhance conditions for anadromous fish.	Deleted – Measures are located out of the primary study area and are being considered in Common Assumptions. Limited contribution compared to storage north of the Delta. Would not contribute to other planning objectives. Potential for subsidence is unknown.
Develop groundwater storage near the Sacramento River, downstream from Shasta Dam	Moderate to High – Potential to enhance conditions for anadromous fish.	Retained – Use of groundwater storage can be physically and economically effective. Groundwater storage is being considered through CALFED and other programs. DWR is providing financial and technical assistance for some studies associated with expanded use of north-of-the-Delta groundwater storage.

ACID = Anderson Cottonwood Irrigation District
 CVP = Central Valley Project
 FS = feasibility study
 O&M = operations and maintenance
 ROD = Record of Decision

Table 6-3
Resource Management Measures to Address Opportunities for Hydropower Generation

Resource Management Measure	Potential to Address Planning Objective	Status/Rationale
Modify existing generation facilities at Shasta Dam to take advantage of increased hydraulic head due to Shasta Dam raise	Moderate – Could contribute to planning objective.	Deleted – Limited potential to realize an increase in hydropower output from Shasta Dam with increasing size of Shasta Reservoir, but modifications to Shasta Dam are being considered through a separate FS.
Construct new hydropower generation facilities in Sacramento Valley	Moderate to High – Would contribute to planning objective.	Deleted – Does not address primary planning objectives or constraints/ principles/criteria. Limited potential to find locations and construct new facilities with primary purpose of power generation. Limited potential to augment existing facilities currently without generation capabilities. Limited potential for sizeable gain in hydropower output for those facilities with existing generation capabilities.
Construct new hydropower generation facilities on Sites Reservoir	Moderate to High – Would contribute to planning objective.	Retained – Could directly contribute to secondary planning objective. Power generation facilities would offset the power usage and cost of reservoir pumping and provide ancillary power benefits to the local or state power grid.
Construct new hydropower generation facilities on Colusa Reservoir	Moderate to High – Would contribute to planning objective.	Retained – Could directly contribute to the secondary planning objective. Power generation facilities would offset the power usage and cost of reservoir pumping and provide ancillary power benefits to the local or state power grid.
Construct new hydropower generation facilities on Newville Reservoir	Moderate to High – Would contribute to planning objective.	Retained – Could directly contribute to the secondary planning objective. Power generation facilities would offset the power usage and cost of reservoir pumping and provide ancillary power benefits to the local or state power grid.

FS = feasibility study

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**Table 6-4
Resource Management Measures to Address Recreational Opportunities**

Resource Management Measure	Potential to Address Planning Objective	Status/Rationale
Construct new conservation offstream surface storage at Newville Reservoir	Moderate to High – Increased storage would contribute to increased recreational opportunities.	Retained – Consistent with primary planning objectives and directly contributes to this secondary planning objective.
Construct new conservation offstream surface storage at Colusa Reservoir	Moderate to High – Increased storage would contribute to increased recreational opportunities.	Retained – Consistent with primary planning objectives and directly contributes to this secondary planning objective.
Construct new conservation offstream surface storage at Sites Reservoir	Moderate to High – Increased storage would contribute to increased recreational opportunities.	Retained – Consistent with primary planning objectives and directly contributes to this secondary planning objective.

FS = feasibility study
PL = Public Law

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**Table 6-5
Resource Management Measures to Address Incremental Flood Control Storage Opportunities**

Resource Management Measure	Potential to Address Planning Objective	Status/Rationale
Provide incremental flood control storage at Newville Reservoir through re-operation of other major northern California reservoir(s)	Moderate to High – Increased storage would contribute to increased flood control storage opportunities in the study area.	Retained – Consistent with primary planning objectives and directly contributes to this secondary planning objective.
Provide incremental flood control storage at Colusa Reservoir through re-operation of other major northern California reservoir(s)	Moderate to High – Increased storage would contribute flood control storage opportunities in the study area.	Retained – Consistent with primary planning objectives and directly contributes to this secondary planning objective.
Provide incremental flood control storage at Sites Reservoir through re-operation of other major northern California reservoir(s)	Moderate to High – Increased storage would contribute flood control storage opportunities in the study area.	Retained – Consistent with primary planning objectives and directly contributes to this secondary planning objective.

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**Table 6-6
Retained Measures that Address the Primary Objectives**

Primary Objective	Resource Management Measure
Water Supply and Reliability	Construct new conservation offstream surface storage at the Sites Reservoir site
	Construct new conservation offstream surface storage at the Newville Reservoir site
	Construct new conservation offstream surface storage at the Colusa Reservoir site
	Develop conservation groundwater storage near the Sacramento River, downstream from Shasta Dam
Anadromous Fish Survival	Restore abandoned gravel mines along the Sacramento River
	Construct in-stream aquatic habitat downstream from Keswick Dam
	Replenish spawning gravel in the Sacramento River
	Construct new conservation offstream surface storage at the Newville Reservoir site
	Construct new conservation offstream surface storage at the Colusa Reservoir site
	Construct new conservation offstream surface storage at the Sites Reservoir site
	Improve fish passage at Red Bluff Diversion Dam
	Develop conservation groundwater storage near the Sacramento River, downstream from Shasta Dam

Primary problems in the study area related to the Sacramento River are water supply reliability, Delta water quality, and water management flexibility. Fully addressing these problems will require the development and management of additional water supplies in the Upper Sacramento River Valley Basin. Development and management of new water supplies, consistent with the constraints described in Section 5, can be accomplished with additional storage and resulting changes in project operation. In addition, federal authorization for the NODOS Investigation specifically directs the initiation of feasibility studies for a NODOS storage facility.

The retained storage measures could support multiple primary objectives. New yield developed by increasing storage for the Sacramento River system could be used for any or all of the primary objectives. Measures will be evaluated based on their benefit in developing and managing water supplies to contribute to increasing water supply reliability, improve Delta water quality, provide supplies for the EWA, enhance anadromous fish passage and aquatic restoration, provide storage and operational benefits for other CALFED programs, and increase water flow-related benefits for the ERP. Although groundwater storage and the three surface storage measures can address both planning objectives, all of these could also be combined with other measures to increase the benefits of an alternative plan. Figure 6-1 depicts the three offstream surface storage measures located in the Sacramento Valley north-of-the-Delta.

6.6.1.1 Water Supply and Reliability Measures

Following is a brief description of each water supply and reliability measure:

- ❖ **Sites Reservoir** – Sites Reservoir would be located about 10 miles west of the town of Maxwell and formed by constructing dams on Stone Corral Creek and Funks Creek. Evaluation of Sites Reservoir has focused on a (maximum) 1.8 MAF reservoir, though a 1.2 MAF reservoir has been considered. A 1.8 MAF Sites Reservoir would require the construction of nine saddle dams along

the southern edge of the Hunters Creek watershed. Diversion from the Colusa Basin Drain, the Sacramento River, and local tributaries are potential sources of water supply for the Sites Reservoir project. These water sources have been studied with 14 optional conveyance systems from the Sacramento River and two gravity flow conveyance options from Stony Creek.

- ❖ **Colusa Reservoir** – Colusa Reservoir is a proposed 3.0 MAF storage project that would include the area inundated by the 1.8-MAF Sites Reservoir, plus the adjacent Logan Creek and Hunter Creek watersheds to the north (called the Colusa Cell). The Colusa Cell requires four additional dams along Logan ridge; one for Logan Creek and three for Hunters Creek and its tributaries. Colusa Reservoir requires seven saddle dams. Water supply source and conveyance options are essentially the same as for Sites Reservoir, though total conveyance capacity probably would be greater to fill Colusa Reservoir.
- ❖ **Newville Reservoir** – Newville Reservoir would be located upstream from Black Butte Lake, 18 miles west of Orland. Alternative reservoir sizes being evaluated are 1.9 and 3.0 MAF. For the purposes of this evaluation, the smaller 1.9 MAF facility will be considered throughout the measures screening. Constructing a dam on North Fork Stony Creek and a small saddle dam at Burrows Gap would form the smaller proposed reservoir. Up to five additional saddle dams and a dike are required for a 3.0 MAF reservoir alternative. Current study challenges include investigating a diversion facility that would allow anadromous fish migration in Thames Creek while allowing the creek's floodflows to be diverted to Newville Reservoir. Multiple conveyance options are possible utilizing existing infrastructure (canals); new infrastructure (canals, tunnels and/or pipelines); or a combination of new and existing mechanisms to provide increased flexibility and reliability in operations of both existing as well as new infrastructure.
- ❖ **Groundwater storage downstream of Shasta Reservoir** – Development of additional groundwater storage in the Sacramento Valley is being investigated as part of DWR's Conjunctive Water Management Program. The goal of the Conjunctive Water Management Program is to increase water supply reliability statewide through planned, coordinated management and use of groundwater and surface water resources. Local agencies are studying development of groundwater resources with technical and financial support from DWR. This general measure will be refined in the PFR to assess the feasibility of specific groundwater development proposals that can contribute to water supply, reliability, and flexibility needs identified by the NODOS Investigation.

6.6.1.2 Anadromous Fish Survival Measures

The following is a brief description of measures that support anadromous fish survival:

- ❖ ***Restore abandoned gravel mines along the Sacramento River*** – This measure could benefit the restoration of aquatic and floodplain habitat along the Sacramento River at abandoned instream gravel mine locations. Instream gravel mining has created large, artificial pits that disrupt natural geomorphic processes and riparian regeneration, and former gravel mining sites are typically unsuitable for spawning and rearing. Abandoned gravel pits can cause high fish mortality from stranding and unnatural predation. This measure would include acquiring, restoring, and reclaiming inactive gravel mining sites along the Sacramento River near the project study area to create valuable aquatic and floodplain habitat. The stream channel and floodplain would be filled and recontoured to emulate natural conditions. Side channels and other features could be created to encourage spawning and rearing and prevent stranding. This measure was retained for potential

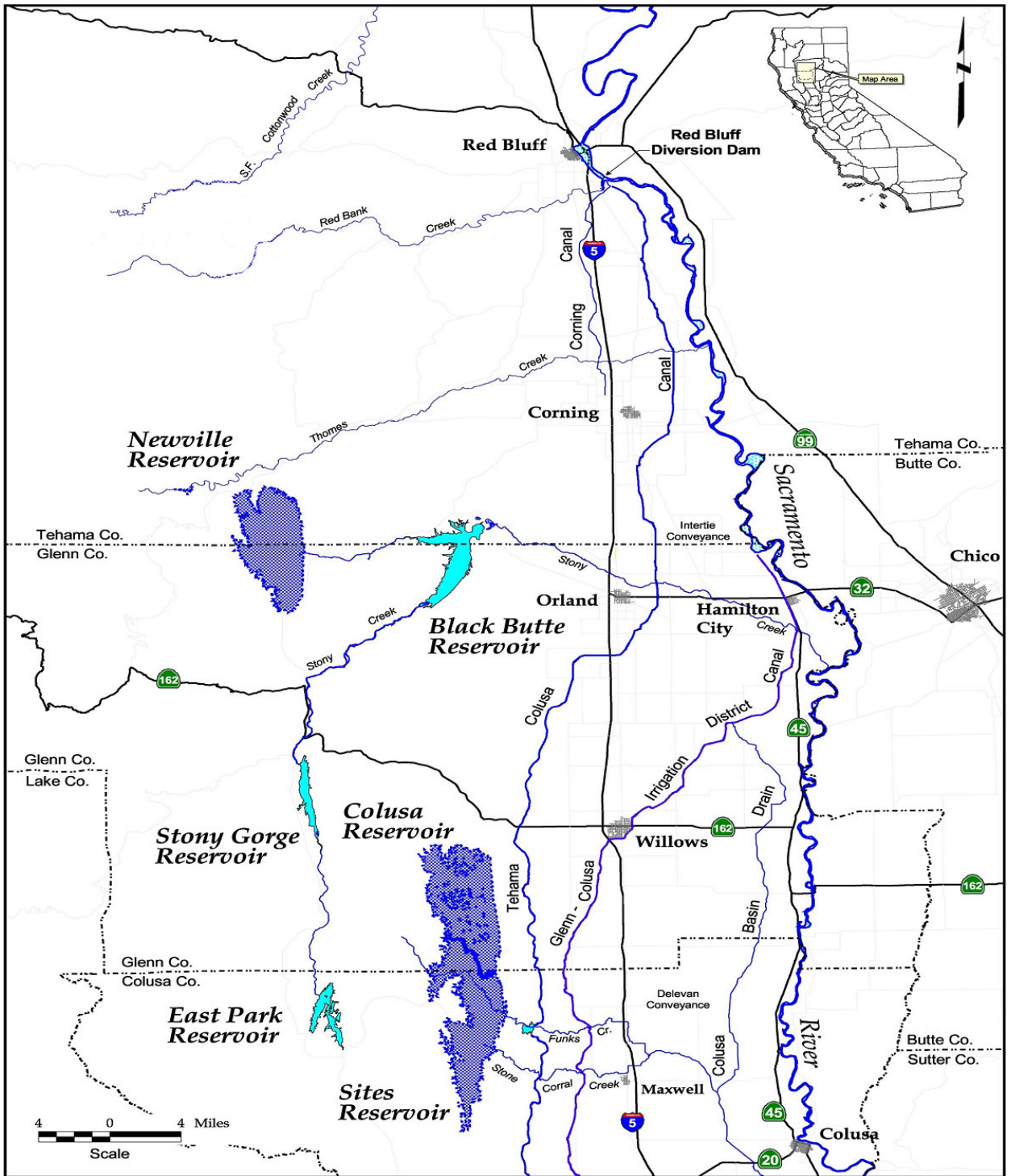


Figure 6-1. Proposed Offstream Storage Locations

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further development because it has a high likelihood for success in helping to achieve the primary objective; in addition, it could be combined with other potential measures related to water supply and reliability.

- ❖ ***Construct instream habitat downstream from Keswick Dam*** – Aquatic habitat is poor for spawning and rearing of anadromous fish, and predation can be high because of the lack of instream cover caused by dam releases that have scoured the channel. Keswick Dam is the uppermost barrier to anadromous fish migration on the Sacramento River, and it blocks the passage of gravels, bed sediments, and woody debris that were replenished historically by upstream tributaries. Despite these unfavorable channel conditions, cold water releases from Keswick Dam attract large numbers of spawners to this reach. This measure includes constructing aquatic habitat in and adjacent to the Sacramento River downstream from Keswick Dam by acquiring lands adjacent to the river, conducting earthwork along the riverbank to construct side channels for spawning, and strategically placing instream cover structures within the river channel, including large boulders, anchored root wads, and other natural materials. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve the primary objective; in addition, it could be combined with other potential measures related to water supply and reliability.
- ❖ ***Replenish spawning gravel in the Sacramento River*** – Dams, river diversions, gravel mining, and other obstructions have blocked or reduced gravel sources that have historically provided a continuous sources of high-quality gravel to the Sacramento River. Gravel suitable for spawning has been identified as a significant influencing factor in the recovery of anadromous fish populations in the Sacramento River. Several programs, including CALFED and the AFRP, are proceeding with gravel replenishment on the Sacramento River in selected locations. This measure consists of replenishing spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff. Gravel would be transported and injected into the Sacramento River. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve the primary objective; in addition, it could be combined with other potential measures related to water supply and reliability. It should be noted that this measure depends on long-term commitment to regular and recurring project maintenance, which may prevent this measure from being integrated into an initial alternative based on further review and evaluation using the federal planning criteria.
- ❖ ***Construct new conservation offstream storage at the Newville Reservoir location*** – Newville would be located upstream from Black Butte Lake, 18 miles west of Orland, and would create up to 3.0 MAF. Current study challenges include investigating a diversion facility that would allow anadromous fish migration in Thomes Creek while allowing the creek's floodflows to be diverted to Newville Reservoir. Offstream storage would provide additional supplies for use in the Sacramento Valley watershed during shortages and during below-normal, dry, and critical water years. Offstream storage would allow changes in the timing, magnitude, and duration of diversions from the Sacramento River; these changes could reduce or eliminate diversion effects and help assure the appropriate flows necessary for critical life stages for anadromous fish and riparian habitat. This additional water supply from the Sacramento River also would contribute to statewide supply reliability by augmenting supplies available during dry and critical water years. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve both primary objectives.
- ❖ ***Construct new conservation offstream storage at the Colusa Reservoir location*** – Colusa is a proposed 3.0 MAF storage project that would include the area inundated by the 1.8-MAF Sites Reservoir, plus the adjacent Logan Creek and Hunter Creek watersheds to the north. Offstream

storage would provide additional supplies for use in the Sacramento Valley watershed during shortages and during below-normal, dry, and critical water years. Offstream storage would allow changes in the timing, magnitude, and duration of diversions from the Sacramento River to reduce or eliminate diversion effects and help assure appropriate flows necessary for critical life stages for anadromous fish and riparian habitat. This additional water supply from the Sacramento River would also contribute to statewide supply reliability by augmenting supplies available during dry and critical water years. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve both primary objectives.

- ❖ ***Construct new conservation offstream storage at the Sites Reservoir location*** – Sites Reservoir would be located about 10 miles west of the town of Maxwell and would create 1.8 MAF of new storage. Offstream storage would provide additional supplies for use in the Sacramento Valley watershed during shortages and during below-normal, dry, and critical water years. Offstream storage would allow changes in the timing, magnitude, and duration of diversions from the Sacramento River; the changes could reduce or eliminate diversion effects and help assure appropriate flows necessary for critical life stages for anadromous fish and riparian habitat. This additional water supply from the Sacramento River also would contribute to statewide supply reliability by augmenting supplies available during dry and critical water years. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve both primary objectives.
- ❖ ***Improve fish passage at Red Bluff Diversion Dam*** – This measure includes reducing or minimizing the impacts of the RBDD on upstream and downstream migration of juvenile and adult anadromous fish. Feasible alternatives considered involve “gates-in” and “gates-out” scenarios, as well as possible improvements to existing facilities and construction of new fish ladders, fish screens, and pumping facilities. When the RBDD gates are lowered into the Sacramento River (“gates in” position), the elevation of the water surface behind the dam is raised, allowing gravity diversion into the Tehama-Colusa and Corning Canals for delivery to irrigation districts. The “gates-in” position presents a barrier for both upstream- and downstream-migrating fish and may subject juvenile salmonids to increased predation. Raising the gates (“gates-out” position) allows the river to flow unimpeded but precludes gravity diversion into the irrigation canals. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve the primary objective; in addition, it could be combined with other potential measures related to water supply and reliability. This measure has a high likelihood of being implemented through other CALFED programs, which may prevent it from being integrated into an initial alternative based on further review and evaluation.
- ❖ ***Groundwater storage downstream of Shasta Reservoir*** – Development of additional groundwater storage in the Sacramento Valley is being investigated as part of DWR’s Conjunctive Water Management Program. The goal of the Conjunctive Water Management Program is to increase water supply reliability statewide through planned, coordinated management and use of groundwater and surface water resources. Additional storage, surface or groundwater, within the Sacramento Valley can support a number of fish restoration actions. This general measure will be refined in the PFR to assess the feasibility of specific groundwater development proposals that can contribute to anadromous fish needs.

6.6.2 Measures that Address the Secondary Planning Objectives

Table 6-7 identifies the measures that best address the secondary planning objectives.

**Table 6-7
Retained Measures that Address the Secondary Objectives**

Secondary Objective	Resource Management Measure
Hydropower Generation	Construct new hydropower generation facilities on Sites Reservoir
	Construct new hydropower generation facilities on Colusa Reservoir
	Construct new hydropower generation facilities on Newville Reservoir
Recreational Opportunities	Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam
	Construct new conservation offstream surface storage at the Newville Reservoir site
	Construct new conservation offstream surface storage at the Colusa Reservoir site
	Construct new conservation offstream surface storage at the Sites Reservoir site
Incremental Flood Control Storage Opportunities	Provide incremental flood control storage at Newville Reservoir through re-operation of other major northern California reservoir(s)
	Provide incremental flood control storage at Colusa Reservoir through re-operation of other major northern California reservoir(s)
	Provide incremental flood control storage at Sites Reservoir through re-operation of other major northern California reservoir(s)

The following is a brief summary of opportunities to address the secondary planning objectives:

- ❖ **Hydropower Generation** – Providing hydropower generation facilities at the retained reservoir facilities will help offset energy usage and the cost of pumping into those facilities, as well as provide ancillary benefits to the local and statewide power grid.
- ❖ **Recreational Opportunities** – New conservation storage will help increase the opportunity for recreational activities for the Upper Sacramento Valley. Each of the potential reservoir measures incidentally provides increased opportunities for recreational benefits.
- ❖ **Flood Control Storage Opportunities** – Incremental surface storage space allocated to flood control will improve flood protection for the Sacramento River basin upstream of the Delta. By managing timed releases from flood control storage reservoirs where increased early releases to downstream rivers (and the Delta) are offset by capture and storage of commensurate flows into a NODOS facility, flood flows in leveed, agricultural, and/or urbanized regions can be decreased, thereby reducing the potential for flooding and related damages.

6.7 NODOS MEASURES SCREENING

Prior to the development of initial alternatives, the measures retained in the previous section will be evaluated for their ability to address the planning objectives while maximizing project benefits and minimizing any adverse effects to the study area. Table 6-8 summarizes retained measures that will be further evaluated and subsequently used to develop initial alternatives.

Table 6-8

Summary of Resource Management Measures that Address Planning Objectives

Measure	Primary Objective: Water Supply & Reliability	Primary Objective: Anadromous Fish Survivability	Secondary Objective: Hydropower (Ancillary Benefits)	Secondary Objective: Recreation Potential	Secondary Objective: Incremental Flood Control Storage
Construct new conservation offstream surface storage at the Newville Reservoir site	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Construct new conservation offstream surface storage at the Colusa Reservoir site	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Construct new conservation offstream surface storage at the Sites Reservoir site	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Develop groundwater storage downstream of Shasta Reservoir	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			
Restore abandoned gravel mines along the Sacramento River		<input checked="" type="checkbox"/>			
Construct in-stream aquatic habitat downstream from Keswick Dam		<input checked="" type="checkbox"/>			
Replenish spawning gravel in the Sacramento River		<input checked="" type="checkbox"/>			
Improve fish passage at RBDD		<input checked="" type="checkbox"/>			
Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam*				<input checked="" type="checkbox"/>	

* Although this measure satisfies the secondary planning objective for recreational opportunities, it does not address the primary planning objectives and will not be carried forward in the NODOS Investigation.

Three of these measures address both the primary and secondary planning objectives and involve construction of new offstream surface storage near the Sacramento River downstream from Shasta Dam. Another measure, groundwater storage downstream of Shasta Reservoir, would likely address the two primary objectives, but none of the secondary objectives. All acceptable measures will be evaluated (and possibly packaged with ancillary features) to develop alternative plans that best address the primary planning objectives and, to the extent possible, the secondary planning objectives. Groundwater storage opportunities downstream of Shasta Dam will be evaluated with more detail and specificity in the PFR.

As described earlier in this chapter and in Appendix F, the study of potential surface storage measures is part of a larger CALFED program to address multiple objectives for managing water resources in California. In Appendix F, the 52 surface storage measures were evaluated for their ability to address the planning objectives for the NODOS investigation. The NODOS Investigation has reviewed CALFED’s four potential offstream storage reservoirs on the western side of the Sacramento Valley, north of the Delta. Consistent with the measures screening in this section, three (of the four) offstream storage reservoirs at Newville, Colusa, and Sites have been determined to best address the planning objectives. A more detailed comparison of the offstream surface storage measures is provided in Appendix G.

Consistent with previous studies, storing water in offstream reservoirs during excess flow periods provides more opportunities to increase water storage in an environmentally sensitive way. The stored water then could be made available for beneficial uses, including enhancing water management flexibility, reducing water diversion on the Sacramento River during critical fish migration periods, increasing the reliability of supplies for a significant portion of the Sacramento Valley, and providing storage and operational benefits for other CALFED programs, including Delta water quality and the EWA. These measures could satisfy the planning objectives for the NODOS Investigation.

Three of the four water supply and supply reliability measures are offstream surface storage facilities and involve diverting water out of a major stream and transporting the water through various conveyance systems to a reservoir. A future action for assessing feasibility of offstream storage projects within NODOS will include extensive evaluation of diversion and conveyance facilities to carry water to and from the reservoir. For the IAIR, it is assumed that conveyance elements are economically justifiable, constructible, and operable and that any environmental impacts associated with improvements can be avoided or mitigated.

The following discussion focuses on identifying the surface storage measure that best meets the federal planning criteria and NODOS objectives. In the PFR, the remaining surface storage measures will be compared against a more specific groundwater storage measure.

6.7.1 Additional Considerations of Surface Storage Measures to Address the Water Supply Reliability Objective

The three remaining offstream surface storage measures provide a range of potential water supply reliability benefits and serve similar project purposes. Because all of these surface storage projects are upstream from the Delta and adjacent to the Sacramento River, the kinds of benefits, such as supplemental yield for various uses and reduced diversions from the Sacramento River during the peak local delivery period, will vary primarily in scale. All of the reservoir measures are located within the Coast Range foothills along the western edge of the northern Sacramento Valley (see Figure 6-1). All have been investigated in the past; current studies have updated and augmented these past studies to allow the comparative evaluation of alternatives.

Given that the offstream surface storage measures are similar, several assumptions have been made to simplify comparison of the measures:

- ❖ Additional measures screening focuses on the offstream reservoir sites;
- ❖ All offstream reservoir sites will have conveyance and connectivity options; and
- ❖ All offstream reservoir sites will have comparable anadromous fish measures.

To facilitate the additional measures screening, the offstream storage measures were evaluated and compared based on the above assumptions, as well as previous studies conducted at the proposed reservoir sites.

A detailed comparison of the three offstream storage facilities is provided in Appendix G. The following measures screening discussion summarizes conclusions taken from the detailed comparisons. The screening discusses conclusions applicable to all of the storage facilities and conclusions specific to each of the facilities.

The following list summarizes findings from Appendix G that warrant consideration in screening the measures to identify those most appropriate to the objectives as well as the development of initial alternatives. All three measures possess some common features (bullets 1, 2, and 4 below) requiring further detailed investigations as part of future feasibility study efforts, whereas other features are more specific to a particular site. The following have been grouped by locale to further aid in the screening process.

Sites, Colusa, and Newville Measures:

- ❖ The dominant natural plant community in the Sites, Colusa, and Newville Reservoir areas is California annual grassland.
- ❖ Habitat for the valley elderberry longhorn beetle (VELB) occurs throughout the primary study area. VELB emergence holes were found, but no adult beetles were observed at any of the proposed reservoir sites.
- ❖ No threatened or endangered amphibians were found within the Sites, Colusa, or Newville Reservoir areas. (Amphibian surveys were not conducted at the Newville Reservoir area during the current efforts. Findings for the Newville Reservoir were from studies conducted in the early 1980s.)
- ❖ Review of existing databases indicated that nine state and federally listed avian species could be found within the counties covering the western side of the Sacramento Valley and foothills. Three of these species were identified during field surveys, including sporadic wintering use by both adult and immature bald eagles, which have been documented at each of the reservoir sites.

Newville Measure:

- ❖ Jurisdictional wetlands and waters of the U.S. are present in all candidate reservoir areas. The Newville Reservoir area, with 413 acres of jurisdictional wetlands and 231 acres of other waters of the U.S., has the most acreage of all the reservoir areas.
- ❖ Thomes Creek was surveyed in 1980-81, in 1981-82, and again in 1999 for the presence of salmon and steelhead. Fall and late-fall runs of salmon and steelhead were seen during these surveys. In the 1999 survey, one adult spring-run Chinook salmon was found.

Sites and/or Colusa Measures:

- ❖ The streams flowing through the Sites Reservoir and Colusa Cell are warm-water streams with poor water quality. These streams do not support habitat for anadromous fish and are generally intermittent in nature. Sampling of game and non-game fishes within these streams found very few fish above 6 inches long, suggesting that fish only rear in these areas. Hitch are the most abundant fish found in both reservoir areas.
- ❖ The embankment-to-storage ratio for the Colusa Cell is high, increasing the project cost considerably. This results primarily from the very large embankments required to construct four main dams and seven saddle dams that would form the Colusa Cell. This large embankment volume increases the cost of the project and the unit cost of water considerably.

6.7.2 Preliminary Capital Cost and Unit Cost Comparison of Offstream Surface Storage Measures

The offstream surface storage measures were compared with respect to their total capital construction costs, their yield, and their unit cost per deliverable volume. This comparison helped identify, on an annualized basis, the relative cost-effectiveness of each measure. The federal P&Gs define efficiency as

the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation’s environment. In principle, this criterion can be applied to the major offstream surface storage facilities assuming other ancillary aspects (conveyance facilities, for example) will be similar in scope and magnitude for each of the measures. A measure of efficiency with respect to the storage reservoirs proper (reservoir dams only) was performed to ascertain a relative comparison of efficiency between each of the storage facilities.

The comparative costs for Sites, Colusa, and Newville Reservoirs (Table 6-9) were calculated to show the difference in total reservoir dam cost for each of the three reservoirs. The total dam cost (in 2004 dollars) for Sites Reservoir was calculated to be \$320,250,000; Colusa Reservoir at \$1,411,520,000; and Newville Reservoir at \$235,134,000.

**Table 6-9
Reservoir Dam Costs for Sites, Colusa, and Newville Reservoirs**

Project Dams (Height in ft.)	Embankment Volume (Cubic Yards)	Dam(s) Cost (2004\$)
Sites (290)	3,800,000	\$57,500,000
Golden Gate (310)	10,600,000	\$151,000,000
9 Sites Saddle Dams (130)	9,396,992	\$111,750,000
Total Dam Cost for Sites Reservoir	23,796,992	\$320,250,000
Sites (290)	3,800,000	\$57,500,000
Golden Gate (310)	10,600,000	\$151,000,000
Prohibition (230)	11,300,000	\$161,025,000
Owens (260)	11,700,000	\$166,725,000
Hunters (260)	24,700,000	\$351,975,000
Logan (270)	30,600,000	\$436,050,000
7 Colusa Saddle Dams (140)	7,337,691	\$87,245,000
Total Dam Costs for Colusa Reservoir	100,037,691	\$1,411,520,000
Newville (325)	16,000,000	\$228,000,000
1 Newville Saddle Dam (75)	600,000	\$7,134,000
Total Dam Costs for Newville Reservoir	16,600,000	\$235,134,000

Embankment volumes for each dam (Table 6-9) were taken from the North-of-the-Delta Offstream Storage Investigation Progress Report (DWR, 2000, Table 3-1, pg. 3-2), except for Sites and Colusa saddle dams, which were taken from Appendix P of the Progress Report. Sites Reservoir dam costs were taken from the Sites Reservoir Engineering Feasibility Report (DWR, 2003) and include such items as foundation preparation, embankment materials, and clearing and grubbing. These costs do not include lands, easements, rights-of-way, relocations, appurtenant structures, conveyance, road relocation or recreation. Using the embankment volumes from the Progress Report and costs from the Sites Engineering Feasibility Report, gross unit costs were calculated for the Sites Reservoir dams. The unit price for Sites Dam (major dam) was determined to be \$15.13 per cubic yard, Golden Gate Dam (major dam) was \$14.25 per cubic yard, and Sites saddle dams were \$11.89 per cubic yard. In applying unit costs

to other major NODOS dams, estimators determined that Golden Gate Dam was more similar than Sites Dam, which has considerably less volume than the other major dams. Unit costs were then applied to the other major dams and saddle dams in the Colusa and Newville Reservoirs.

A preliminary economic assessment was performed to compare the average annual cost per yield for the three surface storage measures. As seen in Table 6-10, the estimated average annual cost per yield is similar in magnitude for Sites and Newville Reservoirs, and is excessive for Colusa Reservoir. Sites Reservoir average annual cost per yield is approximately 36% greater than Newville Reservoir. However, Colusa Reservoir’s average annual cost per yield is about 367% greater than Sites Reservoir and about 500% greater than Newville Reservoir. In addition, the capital cost of Colusa Reservoir is approximately 4.4 times that of Sites Reservoir, and 6 times that of Newville Reservoir, while the increase in yield is only around 19 percent.

**Table 6-10
Comparison of Storage, Yield, and Reservoir/Dam Construction Costs**

Attribute	Measure		
	Sites Reservoir	Newville Reservoir	Colusa Reservoir
Gross Storage (AF)	1,800,000	1,900,000	3,000,000
Dead Storage (AF)	40,000	50,000	100,000
Capital Cost ^a (\$)	\$320,250,000	\$235,134,000	\$1,411,520,000
2005 Capital Cost ^b (\$)	\$339,500,000	\$249,250,000	\$1,496,500,000
Est. Average Annual Cost ^c (\$)	\$17,500,000	\$13,000,000	\$77,000,000
Est. Average Annual Yield ^d (AF)	274,000	275,000	328,000
Avg. Annual Cost / Yield (\$/AF)	\$64 / AF	\$47 / AF	\$235 / AF

^a Cost of major dam(s) only including clearing and grubbing, foundation preparation, and embankment materials; excludes other costs such as lands, easements, rights-of-way, relocations, conveyance, or recreation. Basis year of costs is 2004.

^b Average construction cost increase in California for 2004-2005 was 6.019%; rounded to nearest \$250,000. [CA Construction Cost Index].^c

^c Avg. Ann. Cost based on P = Project Life Cost (\$2005), n = 100 years, I = 5.125% (current amortization rate used by Reclamation); formula is:

$$A = P \left[\frac{i(1+i)^n}{(1+i)^n - 1} \right] \text{ where:}$$

A = average annual cost
 P = present-day total capital investment (project life cap. cost)
 i = annual amortization rate
 n = number of amortization periods

^d Based on SWP/CVP only (excludes local); from the 2000 DWR Progress Report.

Therefore, with respect to the federal planning criterion on “efficiency,” Colusa Reservoir is being dismissed from further consideration as a potential, viable measure for this IAIR.

6.7.3 Preliminary Environmental Impact Comparison of Offstream Surface Storage Measures

The remaining offstream surface storage measures were next compared with respect to their potential impact to environmental/ecological attributes. The federal P&Gs define acceptability as the workability and viability of the alternative plan with respect to acceptance by State and Local entities and the public and compatibility with existing laws, regulations, and public policies. Policies and regulations mandate

due diligence in the consideration of “Environmental Quality” (EQ) relevant to any project of federal interest as established in P&G’s four accounts (see Section 5.1.1.2). In reviewing this study’s guiding principles (Section 5.3.2), the study team also resolved to avoid or minimize the potential environmental impacts and impacts to potential cultural resources associated with the remaining measures.

Table 6-11 compares the number of potential environmental impacts associated with Sites Reservoir and Newville Reservoir. (The larger value of the two for each attribute considered is highlighted by bold text.)

**Table 6-11
Relative Environmental Impacts Comparison**

Preliminary Site Survey Results (Biological/Ecological Attribute)	Sites Reservoir	Newville Reservoir
Wetland (acres)	249	525
Riparian (acres)	75	476
Blue oak woodland (acres)	924	2,532
Valley oak woodland (acres)	4	104
Valley elderberry longhorn beetle		
# of Elderberry stems > 1 inch diameter	684	1,204
# of Elderberry stems with emergence holes	18	222
Total # of bird Species	160	146
# of state and federal bird species of concern	25	19
Prehistoric cultural resource components	45	240+
Historic cultural resource components	27	65+

The review of potential environmental impacts between Sites and Newville Reservoirs indicates a significantly greater impact potential for Newville. With the exception of potential impacts to the number of state and federal bird species of concern, possible project-related impacts for all the other biological/ecological attributes are higher for Newville Reservoir. Therefore, at this time, the Newville Reservoir measure is being dismissed from further consideration as a potential, viable measure for this IAIR.

6.7.4 Summary of NODOS Surface Storage Measures Screened from Further Consideration

All three surface storage measures were qualitatively and, to some extent, quantitatively screened in relationship to each other with respect to their expected performance relative to impacts, constructability, and present local and social acceptability. The following measures appear to induce greater impacts, thus reducing their suitability as viable measures for further consideration under the NODOS Investigation. This does not, however, preclude them from either being investigated further in the future, or under some other program and/or future study authorization.

Colusa Reservoir – The proposed Colusa Reservoir meets the primary and secondary planning objectives satisfactorily, with some exceptions. The Colusa Reservoir would affect twice the land area of Sites Reservoir, with little increase in project benefits. In addition, water from the Colusa Reservoir would have a much higher unit cost, in part because of the larger amount of earthwork required for dams and appurtenant structures. This reservoir site requires significant embankment construction in order to

impound a sufficient quantity of water, resulting in considerable project expenses, which translates into higher unit costs for stored water.

Newville Reservoir – The Newville Reservoir alternative satisfactorily meets the investigation’s primary and secondary planning objectives. However, Newville Reservoir has greater potential environmental impacts than Sites Reservoir. The Newville footprint would affect in excess of 400 acres of jurisdictional wetlands and over 230 acres of other waters of the U.S. Construction of Newville would jeopardize fall and late-fall runs of salmon and steelhead observed in Thomes Creek during past field surveys. The required static lift (pumping) above the Tehama-Colusa Canal (TC Canal) required for this measure is the highest of the three measures that could utilize the TC Canal for source water (Sites, Colusa and Newville). By comparison to the Sites measure, these environmental impacts are significantly greater and more environmentally damaging. The public disclosure of these finding has reduced local interest and support for any Newville project formulation. In addition, private landowners within the reservoir footprint are opposed to giving access to property for the purpose of collecting data for further analyses. As a result of the significantly greater environmental impacts and the lack of local support to advance this measure, the Newville Reservoir measure has been screened from further consideration.

6.7.5 Storage Measures Retained

Sites Reservoir – Based on the Federal P&Gs, the Sites Reservoir alternative meets the planning criteria and satisfactorily meets the NODOS Investigation primary and secondary planning objectives. The CALFED ROD specifically proposes the Sites Reservoir for further technical work, environmental review, and development of cost-sharing arrangements during CALFED Stage 1 implementation, before a decision is made to implement the project as part of the CALFED program. The ROD states that the Sites Reservoir project could enhance water management flexibility in the Sacramento Valley, reduce diversion from the Sacramento River during critical fish migration periods, increase the reliability of water supplies for a significant portion of the Sacramento Valley, and provide storage and operational benefits for other programs, including Delta water quality and the EWA.

Groundwater storage downstream of Shasta Reservoir – Based on the Federal P&Gs, the general measure of developing additional groundwater downstream of Shasta Reservoir appears at this point to meet the planning criteria and satisfactorily meets the NODOS investigation primary planning objectives. This general measure has not received the same level of analysis or assessment as other measures presented in this IAIR. However, this general measure will be refined in the PFR to assess the feasibility of specific groundwater development proposals that can contribute to NODOS investigation objectives.

Evaluation criteria will be developed to quantify additional yield, estimate capital and annual project costs, identify specific institutional arrangements that would be required for implementation, and identify local entities that would implement the project to support NODOS Investigation objectives in subsequent phases of the FS. Those initial alternatives with the greatest potential would be subjected to detailed modeling analyses, including the application of water quality standards and Delta operating rules, to quantify the potential benefits available.

Based on the potential yield that could be developed with additional storage, as described in this report, it is likely that storage actions alone may not be adequate to fully support the needs of the study area, including objectives such as anadromous fish survival. It is likely that other measures will be required to accomplish the planning objectives.

6.7.6 Further Screening of Measures to Address the Anadromous Fish Survival Objective

The three offstream storage measures and other measures, generally dealing with spawning area or habitat improvement, were retained in the previous screening as potential measures that may address anadromous fish survival. Preliminary screening, as described in previous subsections, identified two of the three offstream storage measures (Newville Reservoir and Colusa Reservoir) as either less cost-effective or inducing greater environmental impacts relative to the Sites Reservoir measure. Thus, these two were dropped from further consideration at this time. Although the two discontinued surface storage measures may have the potential to address anadromous fish survival on the Sacramento River mainstem through increased water supply and reliability, other aspects of the projects would adversely affect anadromous fish. Development of groundwater storage downstream of Shasta Dam appears to also support a number of anadromous fish survival actions. This measure will be refined in the PFR to allow more detailed assessment of its ability to support NODOS planning objectives.

The measures that involve spawning area and habitat improvements, however, do not address the primary objective for increased water supply and reliability. It is likely that, during development of the initial alternatives, some combination of these measures will be packaged with Sites Reservoir to develop alternatives that maximize benefits to anadromous fish survival.

6.8 SUMMARY OF REMAINING RESOURCE MANAGEMENT MEASURES

Table 6-12 identifies the measures carried forward into the “Initial Alternatives” formulation process.

**Table 6-12
Measures Carried Forward for Development of Initial Alternatives**

Planning Objective	Resource Management Measures
<u>Primary:</u> Water Supply and Supply Reliability	<ul style="list-style-type: none"> • Construct new conservation offstream surface storage at the Sites Reservoir site • Develop groundwater storage downstream of Shasta Dam
<u>Primary:</u> Anadromous Fish Survivability	<ul style="list-style-type: none"> • Construct new conservation offstream surface storage at the Sites Reservoir site • Develop groundwater storage downstream of Shasta Dam • Restore abandoned gravel mines along the Sacramento River • Construct instream aquatic habitat downstream from Keswick Dam • Replenish spawning gravel in the Sacramento River • Improve fish passage at RBDD
<u>Secondary:</u> Ancillary Hydropower Opportunity	<ul style="list-style-type: none"> • Construct new conservation offstream surface storage at the Sites Reservoir site
<u>Secondary:</u> Potential Recreation Opportunity	<ul style="list-style-type: none"> • Construct new conservation offstream surface storage at the Sites Reservoir site
<u>Secondary:</u> Incremental Flood Control Storage	<ul style="list-style-type: none"> • Construct new conservation offstream surface storage at the Sites Reservoir site

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