RECLAMATION

Appendix A
Plan Formulation

North-of-the-Delta Offstream Storage Investigation

July 2017

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A.1 Introduction

This appendix describes the plan formulation and evaluation process for the North-of-the-Delta Offstream Storage (NODOS) Investigation. Significant work in support of the NODOS Investigation was performed between 2000 and 2014 by the United States Department of Interior, Bureau of Reclamation, Mid-Pacific Region (Reclamation) and the California Department of Water Resources (DWR), subsequent to the release of the CALFED Bay-Delta Program (CALFED) Programmatic Record of Decision (ROD) (CALFED 2000a). Further studies have been performed since 2015 by Reclamation and the Sites Project Authority (Authority).

This appendix documents details of the plan formulation process and provides background information that support the main body text of the Draft Feasibility Report, but are not otherwise included in the report.

The plan formulation and evaluation process has been an iterative process conducted over several years. It is consistent with the United States Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&Gs) (WRC 1983); and when possible, the *Principles, Requirements and Guidelines for Federal Investments in Water Resources* (WRC 2013).The process to date has been documented in a series of interim reports that culminate in this Draft Feasibility Report and Environmental Impact Report / Environmental Impact Statement (EIR/EIS). These documents include the following:

- Scoping Report: The Scoping Report (Reclamation and DWR 2002) documented the results of the tribal and public scoping meetings held for the NODOS/Sites Reservoir Project during the 2001–2002 timeframe. Several comments suggesting various conceptual alternatives were captured.
- Initial Alternatives Information Report (IAIR): The IAIR (Reclamation and DWR 2006) tiered off of previous work performed under CALFED; identifying initial planning objectives and management measures. The IAIR was primarily focused on the evaluation of potential reservoir locations.
    - Plan Formulation Report (PFR): The PFR (Reclamation and DWR 2008) clarified the problems and needs, planning objectives, and planning constraints. This report also provided a more comprehensive evaluation of management measures, and identified a preliminary range of Sites Reservoir alternative concepts.
    - 2013 Progress Report: The Progress Report (Reclamation 2013) provided information on the development of alternatives, alternative accomplishments, and the estimated benefits.
- Investigation Highlights: The Investigation Highlights (DWR 2014a) provided a description of the project facilities and an interim cost estimate prepared by DWR.

- Preliminary Administrative Draft Environmental Impact Report: This draft document (DWR 2014b) provided preliminary findings regarding the environmental impacts, as evaluated by DWR in 2014.
- Feasibility Report and Environmental Impact Report/Environmental Impact Statement: These reports are the final step in the planning process for the NODOS/Sites Reservoir Project; their results will determine the engineering, environmental, economic, and financial feasibility of the project. Finalizing these documents includes the following efforts:
  - The Authority developed a Locally Preferred Alternative, which has been added to both the Draft Feasibility Report and the EIR/EIS.
  - Reclamation and the Authority jointly developed an EIR/EIS for the project.
  - A cost allocation and feasibility analysis was developed to support the completion of the Draft Feasibility Report.
  - Reclamation completed the review of the construction cost estimate, in support of an October 2015 estimate.

The contents of this appendix include the following:

- Updated screening of management measures
- Updated screening of potential reservoir locations (including two additional locations submitted for public comment)
- Screening of conveyance options and reservoir sizes
- Screening of preliminary alternatives that were developed for the PFR that informed the development of the alternatives evaluated in this Draft Feasibility Report (see Chapter 6, Alternative Development and Evaluation, in the main text of the Draft Feasibility Report)

A.2 Problems, Needs, and Opportunities

This section provides a brief summary of Chapter 2, Problems, Needs, and Opportunities, in the main body of the Draft Feasibility Report.

The problems, needs, and opportunities to be addressed in the NODOS Investigation are derived from the CALFED Programmatic ROD, the study authorizations, the public scoping process, and prior studies that have suggested the potential benefits that could be obtained from new surface water storage north of the Sacramento–San Joaquin River Delta (Delta).

Specifically, the CALFED Bay-Delta Programmatic Environmental Impact Statement/ Record of Decision (CALFED ROD) identified a need to improve:

- Water supply and water supply reliability
- Survival of anadromous fish and other aquatic species
- Water quality

The NODOS/Sites Reservoir Project has the potential to address all of these needs. Levee system integrity for levees in the Delta was also identified as an issue to be addressed in the CALFED ROD; however, the NODOS/Sites Reservoir Project does not significantly affect levees in the Delta.

Public scoping, in accordance with the P&Gs, the National Environmental Policy Act (NEPA), and the California Environmental Quality Act (CEQA), is affording interested and affected agencies, groups, and persons opportunities to participate throughout the planning process. For the current study, the initial step in identifying problems, needs, and opportunities specific to the NODOS/Sites Reservoir Project included a public scoping effort to solicit public and stakeholder input. On November 5, 2001, the Notice of Preparation (NOP) was filed with the State Clearinghouse; and on November 9, 2001, the federal Notice of Intent (NOI) was published in the *Federal Register*. The formal scoping process for the NODOS/Sites Reservoir Project began with the publication of the NOP and NOI, and concluded on February 8, 2002. During the 2001–2002 scoping period, one tribal and three public scoping meetings were held.

The study team received 57 comments that addressed program alternatives. Some comments were specific suggestions related to the types or range of alternatives, such as water-use efficiency, conjunctive use, land fallowing, wastewater reclamation and recycling, and Shasta Lake enlargement. Others discussed more generally which alternatives should or should not be developed, and the possible benefits/impacts from alternatives. The Scoping Report (Reclamation and DWR 2002) includes a complete summary of the comments received during the scoping period. Additional information on the resolution of scoping comments is available in the EIR/EIS.

Based on the evaluation of problems and needs, the feasibility of the following opportunities is being studied as part of the NODOS Investigation:

- Water supply and water supply reliability
  - Agricultural water supply
  - Municipal and industrial (M&I) water supply
  - Level 2 Water Supply for wildlife refuges (see Chapter 12, Glossary)
- Incremental Level 4 Water Supply for Wildlife Refuges (see Chapter 12, Glossary)
- Sustainable hydropower generation
- Survival of anadromous fish and other aquatic species
  - Coldwater pool improvements
  - Stabilization of fall flows
- Water quality
  - Delta Environmental Water Quality
  - Urban and Agricultural Water Quality improvements
- Recreation
- Flood-Damage Reduction
- Supplemental Flows for Emergency Response

The problems, needs, and opportunities are more fully discussed in Chapter 2, Problems, Needs, and Opportunities, in the main body of the Draft Feasibility Report.

A.3 Planning Objectives and Constraints

The planning objectives for the NODOS Investigation are based on the identified problems, needs, and opportunities; and incorporate National, State, and study-specific objectives.

The NODOS Investigation includes a series of both primary and secondary objectives, as described below. The primary objectives are considered essential to developing a viable project. Alternatives must meet all of the primary objectives to advance in the evaluation process. The NODOS/Sites Reservoir Project alternatives have not been formulated to maximize the secondary objectives; however, opportunities to achieve them are included in the alternatives, and evaluated to the extent that they are available.

Planning Objectives

The primary objectives for the NODOS feasibility studies are:

- Improve Water Supply and Water Supply Reliability. By capturing water from the Sacramento River watershed during peak flows and wet years, the NODOS project alternatives would be able to provide additional water supply and improve the reliability of water in all water-year types.
- Provide Incremental Level 4 Water Supply to Wildlife Refuges. Provide additional and more reliable water supplies to wildlife refuges south of the Delta.
- Improve the Survival of Anadromous Fish and Other Aquatic Species. This objective includes managing the NODOS project alternatives to improve temperature conditions and provide supplemental flows to support fish migration.
- Improve Water Quality in the Delta Environment and for Delta Export. The NODOS project would be managed to release high-quality surface water to the Sacramento River watershed during months when water quality in the Delta is typically impaired.

The secondary objectives are:

- Provide Sustainable Hydropower Generation. The NODOS project provides an opportunity to generate hydropower, and will be developed in a manner that facilitates integration with renewable energy projects, including solar and wind generation.
- Provide Opportunities for Recreation. The NODOS/Sites Reservoir Project can provide new opportunities for recreation.
- Provide Flood Damage Reduction. The NODOS/Sites Reservoir Project can be developed to provide local flood protection.

National Goals

The Water Resources Development Act of 2007 Section 2031, Water Resources Principles and Guidelines, establishes National Water Resources Planning Policy. and specifies that all Federal water resources investments should reflect national priorities, encourage economic development, and protect the environment by:

- Seeking to maximize sustainable economic development
- Seeking to avoid the unwise use of floodplains and flood-prone areas, and minimizing adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used
- Protecting and restoring the functions of natural systems, and mitigating any unavoidable damage to natural systems

No hierarchal relationship can be specified for these goals. As a result, tradeoffs among potential solutions need to be evaluated during the decision making process. Federal investments in water resources as a whole should strive to maximize public benefits, with appropriate consideration of costs (WRC 2013). This document is grandfathered in to the 1983 guidelines, and incorporates the 2007 congressional guidance when possible. Public benefits include environmental, economic, and social goals. Both monetary and non-monetary effects can be considered.

California Goals

In addition to the national goals and requirements, California's objective for the feasibility studies is to provide technical and financial information to implementing agencies. Key factors that agencies must consider are whether the NODOS/Sites Reservoir Project can be implemented to assure public health and safety; and whether it can provide statewide benefits (e.g., water supply reliability, water quality, ecosystem restoration) at a reasonable cost.

The California Water Action Plan identifies specific actions for improving California's water supply and the environment, including expanding water storage capacity and improving groundwater management. Proposition 1 provides $2.7 billion for the costs allocated to public benefits for new surface and groundwater storage projects. Per the California Water Action Plan:

> "The bottom line is that we need to expand our state's storage capacity, whether surface or groundwater, whether big or small. Today, we need more storage to deal with the effects of drought and climate change on water supplies for both human and ecosystem needs. Climate change will bring more frequent drought conditions and could reduce by half our largest natural storage system—the Sierra snowpack—as more precipitation falls as rain rather than snow, and as snow melts earlier and more rapidly."

In the California process, an EIR is required for project environmental compliance under CEQA, and to identify permitting and mitigation requirements. Reclamation and the Authority are preparing a joint EIR/EIS for the NODOS feasibility studies. This feasibility study, including both the EIR/EIS and Feasibility Report, is scheduled for completion in late 2017.

Planning Constraints and Other Considerations

The scope of the NODOS Investigation is limited by the following constraints:

- CALFED ROD. The CALFED ROD includes program goals, objectives, and projects intended primarily to benefit the Delta system, its tributaries, and areas that receive water supplies exported from the Delta. In addition to new storage north of the Delta, the Preferred Program Alternative in the CALFED ROD includes four other surface water and various groundwater storage projects to help meet water supply needs, improve water quality, and improve the ecosystem functions of the Delta system. Although the CALFED ROD does not identify the NODOS/Sites Reservoir Project as a specific project to be pursued, the ROD does identify the NODOS/Sites Reservoir Project (the proposed Sites Reservoir) as a project requiring further investigation. Developed plans should, therefore, incorporate the goals, objectives, and programs or projects of the CALFED ROD.
- Offstream Storage. By definition, and consistent with the CALFED ROD, the NODOS feasibility studies are focused on offstream storage locations. The creation of reservoirs that would interrupt major watercourses and impede the migration of fish are not included in this investigation.
- Laws, Regulations, and Policies. Laws, regulations, and policies that must be considered include, but are not limited to, NEPA, Fish and Wildlife Coordination Act, Clean Air Act, Clean Water Act, National Historic Preservation Act, Federal Endangered Species Act (ESA), and California ESA, CEQA, and the Central Valley Project Improvement Act (CVPIA). The CVPIA of 1992 (Public Law 102-575) influences water supply deliveries, river flows, and related environmental conditions.
- Coordinated Operations Agreement and Reallocation of Contract Water Supplies. The Coordinated Operations Agreement (COA) is a settlement agreement allocating water between the Central Valley Project (CVP) and State Water Project (SWP) executed in November 1986, pursuant to the Coordinated Operations Act (Public Law 99-546), authorizing Reclamation to implement the agreement. Federal authorizations for the NODOS Investigation focus on CALFED-related storage studies to provide additional supply reliability and water management flexibility to support CALFED objectives. Federal authorizations do not provide authority to reallocate CVP water supplies among the long-term contractual commitments.

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A.4 Alternative Development Process

The development of alternatives for the NODOS feasibility studies is an iterative process that began with the CALFED ROD. Figure A-1 provides an overview of the alternative development process from the CALFED ROD to the NODOS Feasibility Report and accompanying EIR/EIS.

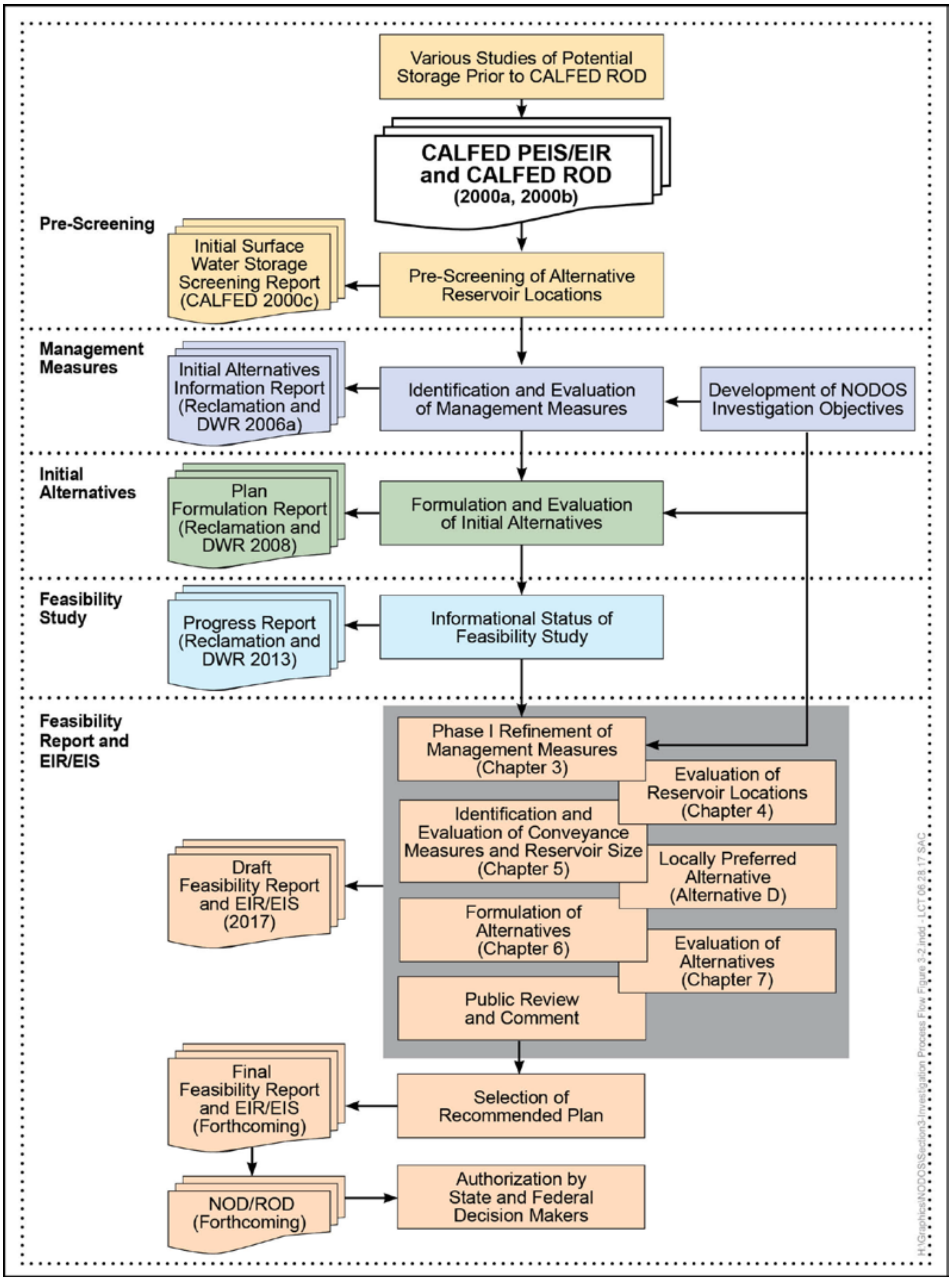

Figure A-1. NODOS Feasibility Studies Process

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A.5 Management Measures

Management measures have been identified to address each of the primary planning objectives. Measures were initially identified in the IAIR (Reclamation and DWR 2006), and subsequently refined in the PFR (Reclamation and DWR 2008) and follow-on feasibility studies.

Water Supply and Reliability (Including Incremental Level 4 Water Supply)

Water management measures were identified to address the primary water supply and reliability objective. This objective includes increasing water supplies, water supply reliability, and Sacramento Valley water management flexibility for agricultural, M&I, and environmental purposes. Table A-1 identifies the measures considered, their potential to address the primary objective, and whether the measures were retained or not recommended for further consideration.

The water supply measures identified were separated into nine categories: (1) surface water storage, (2) reservoir reoperation, (3) groundwater storage, (4) conjunctive water management, (5) coordinated operation and precipitation enhancement, (6) demand reduction, (7) recycling, (8) water transfers and purchases, and (9) conveyance and Delta export.

Table A-1. Summary of Management Measures Considered to Address Water Supply and Reliability Primary Objective

Management Measures	Potential to Address Objective	Status/Rationale
Construct Colusa Reservoir Complex, a new offstream surface water storage facility in Glenn and Colusa Counties.	High potential to address water supply reliability.	Retained – Measure is consistent with planning objectives.
Construct Cottonwood Reservoir Complex, a new offstream surface water storage facility in Tehama County.	Moderate to high potential to increase water supply reliability.	Retained – Difficult to fill in all Water Year types without negatively affecting other water supplies. Could have negative impacts on steelhead and salmon.
Construct Newville Reservoir, a new offstream surface water storage facility in Glenn County.	High potential to address water supply reliability.	Retained – Measure is consistent with planning objectives.
Construct Red Bank Project, a new offstream surface water storage facility in Tehama County.	High potential to address water supply reliability.	Retained – Measure is consistent with planning objectives.
Construct Sites Reservoir, a new offstream surface water storage facility in Glenn and Colusa Counties.	High potential to address water supply reliability.	Retained – Measure is consistent with planning objectives.
Construct Veteran's Lake, a new offstream surface water storage facility in southwest Shasta County.	Moderate to high potential to increase water supply reliability.	Retained – Difficult to fill in all Water Year types without negatively affecting other water supplies. Could have negative impacts on steelhead and salmon.

Management Measures	Potential to Address Objective	Status/Rationale
Raise Shasta Dam.	Moderate to high potential to increase water supply reliability.	Under study by Reclamation independent from the NODOS Investigation, as part of the Shasta Lake Water Resources Investigation and a separate feasibility study under P.L. 96-375.
Construct new surface water storage reservoir(s) upstream from Shasta Lake.	Low potential – Several sites/projects would provide only marginal increases in water supply reliability.	Not recommended – Measure would provide only marginal increases to water supply reliability, coupled with higher unit costs, inconsistency with CALFED evaluation criteria, and lack of local support.
Construct new surface water storage on other tributaries to the Sacramento River downstream from Shasta Dam.	Low to High potential – Several sites/projects (e.g., Auburn Dam) would increase system water supply reliability.	Not recommended – Measure would be limited in its ability to contribute to other planning objectives (e.g., water quality and aquatic resources), and have overriding environmental issues and opposition.
Increase total or seasonal conservation storage at other CVP/SWP/local/private facilities.	Moderate potential for increasing storage in existing reservoirs (e.g., Los Vaqueros Reservoir).	Raising Los Vaqueros Dam has been evaluated by CCWD independent from the NODOS Investigation, and construction is being planned. This action does not address all planning objectives of the NODOS feasibility studies.
Increase conservation storage space in existing north-of-the-Delta surface water storage facilities by changing operations, including reallocating space from flood control.	Low potential – Considerable space would have to be reallocated to improve water supply reliability.	Measure is being evaluated independently from the NODOS Investigation as part of the water system reoperation and optimization studies currently under way by DWR, as specified under California State Water Code 83002.
Increase conservation pool in existing north-of-the-Delta surface water storage facilities by encroaching on dam freeboard.	Low potential – Very small space increase would be possible.	Not recommended – Measure would have very limited potential to encroach on existing freeboard above gross pool and would increase flood risk.
Develop groundwater storage facilities.	Potential to satisfy the objective north of the Delta is limited without depleting existing groundwater levels. Aquifer depletion has been observed near Orland, but supply would be insufficient to provide water supply reliability or public benefit through release to the Sacramento River watershed.	Not recommended – Aquifers in the Sacramento River Basin are fully recharged during years of normal precipitation. Therefore, aquifer capacity is unavailable for conventional groundwater storage. This alternative would also have high potential for public and legal challenge due to water rights issues and potential third-party impacts.
Increase opportunities for conjunctive use of surface and groundwater storage	Significant potential to integrate groundwater storage with the operation of new surface water storage to achieve sustainable water surface elevations. North-of-the-Delta storage could support both Sacramento River Valley and San Joaquin River Valley groundwater storage.	Retained – effective in combination with surface storage.
Implement additional precipitation enhancement.	Low potential to improve drought-period water supply reliability.	Not recommended – Does not contribute to increasing the flexibility of the water supply system because its effectiveness is greatly reduced under drought conditions.

Management Measures	Potential to Address Objective	Status/Rationale
Implement water-use efficiency methods.	Moderate potential to benefit overall California water supply reliability.	Retained – Although water-use efficiency does not increase water supplies, conservation is being actively pursued as part of the CALFED program. The measure is retained as a complementary action in the No Project Alternative.
Retire agricultural lands.	Low to moderate potential – Would reduce water demand rather than increase ability to meet projected future demands.	Not recommended – Measure would not contribute to increasing system flexibility or meeting the planning objectives. Land retirement test programs are being performed by Reclamation. On a large scale, this measure could have substantial negative impacts on the agricultural industry.
Implement additional recycling.	Moderate potential to address statewide water needs.	Retained – Additional recycling is retained as a complementary action.
Transfer water between users and source shift (use groundwater in lieu of surface water).	Very low potential – Would not generate a sufficient increase in water supply reliability.	Retained – Measure would not be an alternative to new surface water sources or a reliable substitute for new surface water storage north of the Delta. The measure is likely to be accomplished with or without additional efforts to develop new sources, and is retained as a complementary action in the No Project Alternative.
Extend Tehama-Colusa Canal to Vacaville.	Low potential – Would not improve the water supply reliability of existing contractors.	Not recommended – The focus for the NODOS Investigation is on improving water supply reliability for existing contractors, not establishing new contracts.
Improve Delta export and conveyance capability through coordinated CVP and SWP operations.	Moderate potential to help increase water supply reliability south of the Delta.	Not recommended – Joint Point of Diversion is being pursued in other programs, pending resolution of Biological Opinion issues. Measure is not an alternative to increasing water supply reliability north of the Delta. It does not address planning objectives or constraints/principles/criteria.
Construct New Delta Conveyance.	High potential to increase water supply reliability south of the Delta.	Not recommended – Project is being actively pursued by the State of California as part of the California Fix project (formerly known as the Bay-Delta Conservation Plan) independent of the NODOS Investigation.

CALFED = CALFED Bay-Delta Program
CCWD = Colusa County Water District
CVP = Central Valley Project
DWR = California Department of Water Resources
NODOS = north-of-the-Delta offstream storage
P.L. = Public Law
SWP = State Water Project

Surface Water Storage

Colusa Reservoir Complex – The Colusa Reservoir Complex would be located in north-central Colusa County and south-central Glenn County, approximately 10 miles west of the town of Maxwell. The Colusa Reservoir Complex would provide up to 3.3 million acre-feet (MAF) of new offstream storage, giving it a high potential to address the water supply reliability planning objective. This reservoir would encompass the entire footprint of Sites Reservoir, but be approximately twice the size of Sites Reservoir. This management measure was retained for further consideration.

Cottonwood Reservoir Complex – The Cottonwood Reservoir Complex would be in northwestern Tehama County, approximately 12 miles southwest of Anderson. Cottonwood Reservoir Complex configurations include a 0.4 MAF reservoir (Cottonwood South Reservoir), or a 1.0 MAF reservoir (Cottonwood South Reservoir and Cottonwood North Reservoir). This results in a moderate to high ability to address the water supply reliability planning objective. As the largest undammed tributary on the Sacramento River, Cottonwood Creek has been designated as critical habitat for salmon and steelhead. Construction of the Cottonwood Reservoir Complex would not support the project purpose of increasing the populations of anadromous fish and other aquatic species. Also, the ability to reliably fill the reservoir without pulling water out of other reservoirs is questionable. The Cottonwood North Reservoir would be filled from the Beegum Creek and Dry Creek watersheds. The Cottonwood South Reservoir would be an onstream reservoir on Salt Creek. This measure was retained for further consideration.

Newville Reservoir – Newville Reservoir (also known as Thomes-Newville Reservoir) would be in north-central Glenn County, approximately 18 miles west of Orland. Newville Reservoir would be upstream from Black Butte Lake, which is owned and operated by the United States Army Corps of Engineers (USACE). Water from Thomes Creek would be diverted to fill the reservoir. The reservoir would provide 1.8 to 3.0 MAF of storage resulting in a high potential to address the water supply reliability planning objective. This management measure was retained for further consideration.

Red Bank Project – The Red Bank Project would be in northwestern Tehama County, approximately 17 miles west of Red Bluff. The Red Bank Project includes four small reservoirs in close proximity to each other: Dippingvat, Blue Door, Lanyan, and Schoenfield. The Red Bank Project would divert water from the South Fork Cottonwood Creek at Dippingvat Reservoir, from the North Fork Red Bank Creek to fill the Blue Door and Lanyan Reservoirs, and from Red Bank Creek to fill the Schoenfield Reservoir. The combined storage would be 0.2 to 0.4 MAF, resulting in a moderate potential to address the water supply reliability planning objective. This management measure was retained for further consideration.

Sites Reservoir – Sites Reservoir would be in north-central Colusa County and south-central Glenn County, approximately 10 miles west of the town of Maxwell. Sites Reservoir would provide 0.7 to 2.1 MAF of storage (a variety of reservoir sizes were evaluated) resulting in a high potential to satisfy the water supply reliability planning objective. This management measure was retained for further consideration.

Veteran’s Lake – Veteran’s Lake would be provided as an offstream reservoir in southwestern Shasta County near Ono, approximately 17 miles west of Anderson. Veteran’s Lake could provide up to 1.0 MAF of storage resulting in a moderate to high ability to address the water supply reliability planning objective. Veteran’s Lake would be filled from the North Fork and Middle Fork of Cottonwood Creek. Also, the ability to reliably fill the reservoir without pulling water out of other reservoirs is questionable. As the largest undammed tributary on the

Sacramento River, Cottonwood Creek has been designated as critical habitat for salmon and steelhead. Construction of Veteran's Lake would not support the project purpose of increasing the populations of anadromous fish and other aquatic species. This management measure was retained for further consideration.

Increase Conservation Storage Space in Shasta Lake by Raising Shasta Dam – This management measure would increase the amount of available space for conservation storage in Shasta Lake by raising the height of Shasta Dam, a Federal CVP facility on the Sacramento River north of Redding. This action could increase water supply reliability for Sacramento Valley users, the CVP and SWP; improve Delta water quality; and contribute to ecosystem restoration. Compared to the other facilities, this management measure would result in a moderate to high increase in water supply reliability, depending on the size of the raise.

The feasibility of raising the height of Shasta Dam is being independently evaluated by Reclamation, as part of the Shasta Lake Water Resources Investigation authorized by Public Law 96-375.

Construct New Conservation Storage Reservoir(s) Upstream from Shasta Lake – This management measure would consist of constructing a dam and reservoir at one or more locations upstream from Shasta Lake, primarily for increased water conservation storage and operational flexibility. Numerous reservoir storage projects have been considered, and many have been constructed in the watershed upstream from Shasta Lake. These potential project sites would be capable of only marginally improving water supply reliability to the CVP. For example, an additional offstream storage site at Goose Valley, near Burney, was considered; however, the likely costs to develop the project would exceed water supply benefits by at least 2 to 1. Furthermore, larger project sizes at the Goose Valley site are physically feasible, but there is little potential for water to fill the facility. Accordingly, this site was not considered further, and this management measure was not recommended for further consideration in the NODOS feasibility studies.

Construct New Conservation Storage on Other Tributaries to the Sacramento River Downstream from Shasta Dam – Numerous onstream surface water storage projects along tributaries to the Sacramento River downstream from Shasta Dam have been investigated in past studies. Several of those projects could contribute substantially to increasing water supply reliability, including the Auburn Dam Project (up to approximately 2.3 MAF on the Middle Fork American River near Sacramento), and the Marysville Lake Project (920,000 acre-feet [AF] on the Yuba River near Marysville). Depending on the location, the potential increase in water supply reliability ranges from low to high. Although each of these potential projects could contribute considerably to increasing the water supply reliability of the CVP and SWP systems, State and local interests have rejected them as potential candidates for new water supply sources. Each has been eliminated from further consideration, primarily because it would not contribute to the primary planning objectives, or because it would have overriding environmental issues and opposition. This management measure was not recommended for further consideration in the NODOS feasibility studies.

Increase Total or Seasonal Conservation Storage at Other CVP/SWP/ Local/Private Facilities – This measure would consist primarily of providing additional conservation storage space in other major reservoirs in the Sacramento River watershed by enlarging existing dams and reservoirs. Candidate projects include additional storage in facilities such as Lake Berryessa on Putah Creek, Folsom Lake on the American River, Trinity Lake on the Trinity River, and Lake Oroville on the Feather River. The resulting increase in water supply reliability if the measure was implemented would be moderate at best. All known efforts to increase storage space in other northern California CVP or SWP reservoirs were rejected by CALFED and local interest groups. Most of these alternatives would have a higher unit cost than the NODOS/Sites Reservoir Project to achieve significant increases in water storage. An independent evaluation for enlarging Los Vaqueros Dam was previously performed, and efforts are under way to obtain funding for expansion.

Reservoir Reoperation

Increase Conservation Storage Space in Existing North-of-the-Delta Storage Facilities by Changing Operations, Including Reallocating Space from Flood Control – This measure would consist of changing the flood control operations of facilities north of the Delta: Shasta Dam (CVP), Oroville Dam (SWP), Folsom Dam (CVP), or other facilities north of the Delta. This measure includes changes in the timing, as well as reducing the maximum flood pool to increase water supply. The potential increase in water supply reliability from these actions is considered low. A comprehensive water system reoperation and optimization study looking at these and other options is currently under way by DWR as specified under California Water Code (CWC) 83002—independent from the NODOS Investigation—to determine how much additional water, if any, could be stored.

Increase the Conservation Pool in Existing North-of-the-Delta Facilities by Encroaching on Dam Freeboard – This management measure would consist of increasing the conservation storage space by raising the gross pool elevation without raising dam height. It is estimated that major modifications to dams and appurtenances would be required to allow operational encroachments on the design freeboard of the dams, only to gain a small potential increase in water supply yield. This management measure was not recommended for further development, primarily because of the limited potential for encroaching on the existing freeboards, and the relatively high cost to resolve the uncertainty issues associated with encroachments.

Groundwater Storage

Develop Groundwater Facilities in the Sacramento River Basin – This management measure would involve using groundwater banking opportunities in the Primary Study Area to increase water supply and water supply reliability. One way this could be accomplished is through the construction of a large-scale aquifer storage and recovery project.

DWR data show that Sacramento Valley aquifers are generally fully recharged during years of normal precipitation (DWR 2003). Therefore, groundwater banking areas are not as prevalent in northern California as they are in other areas (e.g., the San Joaquin Valley) (NHI and GCID 2011; Reclamation and DWR 2008). The potential to increase water supply reliability from constructing facilities is considered low in the Sacramento Valley. Reclamation, DWR, and others have pursued ongoing groundwater programs, such as the Sacramento Valley Water Management Program to study and optimize the use of groundwater resources.

Conjunctive Water Management

Increase Opportunities for Conjunctive Use of Surface and Groundwater Storage – This management measure would consist of using groundwater storage and/or transfers in conjunction with new or existing surface storage. New storage north of the Delta could support recharging aquifers in the San Joaquin River Valley; and to a lesser extent, in the Sacramento River Valley. If developed by others, potential future operations of a NODOS project would be coordinated with the Sacramento Valley Water Management Program, the Yuba Accord Conjunctive Use Program, the Drought Risk Reduction Investment Program, the Dry Year Program, and transfers from willing sellers to buyers. This management measure is being separately evaluated as part of the reoperations study under way by DWR to meet the requirements of CWC 83002. This measure can be implemented by CVP and SWP contractors who would receive water from new offstream surface storage, and was retained for further evaluation.

Coordinated Operation and Precipitation Enhancement

Implement Additional Precipitation Enhancement – Precipitation enhancement is a process by which clouds are stimulated to produce more rainfall or snowfall than naturally produced.

Precipitation enhancement is not a short-term remedy for droughts because supply increases can only be achieved during years when it would otherwise rain or snow naturally—in other words, in above-average precipitation years. Accordingly, precipitation enhancement is not an alternative to new system storage, which focuses on conserving water in wetter years for use in dryer years. The potential to improve water supply reliability is considered low. This measure was not recommended for further consideration in the NODOS feasibility studies primarily because it would not address the planning objectives and is not an alternative to the NODOS/Sites Reservoir Project.

Demand Reduction

Implement Water-Use Efficiency (WUE) Methods – Potential critical impacts to agricultural and urban resources resulting from water shortages could be reduced through WUE methods. The *California Water Plan Update 2005: A Framework for Action* (DWR 2005) identified a variety of agricultural and urban WUE measures. Supporting information to the Plan is contained in the *CALFED Bay-Delta Program Water Use Efficiency Element, Water Use Efficiency Comprehensive Evaluation* (CALFED 2006). This CALFED document indicated that the potential for recovering what are currently deemed irrecoverable agricultural losses in the Sacramento River and San Joaquin River Basins could be approximately 142,000 AF on an average annual basis, with resulting unit costs of approximately $200/AF. Larger amounts are technically feasible; however, the cost to achieve these amounts increases considerably. The report also identified various urban WUE programs with the potential to reduce average annual urban water use by approximately 1.1 million AF per year by 2030, through a series of best management practices. Statewide, the ability to improve water supply reliability is considered moderate.

WUE would help reduce demands and should be pursued to help offset future shortages in water supplies. Accordingly, the concept of WUE was retained.

Retire Agricultural Lands – Although the equivalent unit cost of water for this measure might be competitive with other potential water sources, this measure was not recommended for further consideration, primarily because it likely would have only a limited ability to help meet future water demands outside of the San Joaquin Valley. The potential to increase water supply reliability through retirement is considered low to moderate. There might be a limited ability to successfully apply this measure at costs similar to the cost for less productive lands, but this measure would not address the other planning objectives of the NODOS feasibility studies.

Recycling

Implement Additional Recycling – Opportunities to implement recycling in the Primary Study Area are limited. Additional recycling is being implemented on a statewide basis. The potential to improve water supply reliability through recycling is considered low. Recycling must be considered as an element of any plan addressing the future of water in California, and is included as a complementary action.

Water Transfers and Purchases

Transfer Water between Users and Source Shifting – Transfers and source shifting would not generate new water for the CVP or SWP, but would simply transfer surface water from a seller willing to forgo surface water use, for a time, to a willing buyer. In addition, ongoing infrastructure limitations on conveying water from north to south of the Delta are expected to encourage the most feasible and reliable water transfers to be implemented under future no project conditions. Any remaining opportunities for transfers probably would include high uncertainties; be small; difficult to implement; and more costly. Consequently, this measure was retained as a complementary action.

New or Modified Conveyance Facilities

Extension of the Tehama-Colusa (T-C) Canal to Vacaville – The T-C Canal could be extended to Vacaville to deliver water to additional service areas. However, extending the T-C Canal does not deliver water to the locations required to meet the NODOS feasibility studies' primary objectives of increased survivability of anadromous fish and other aquatic species or Delta water quality improvement. Furthermore, the intent of the NODOS feasibility studies is to provide greater flexibility to existing contractors, and not to establish new contracts. The potential to improve water supply reliability is considered low. Therefore, this measure was not recommended for further consideration under the NODOS feasibility studies.

Improve Delta Export and Conveyance Capability through Coordinated CVP and SWP Operations – This measure would consist of improving Delta export and conveyance capability by more effectively coordinating the management of surplus flows in the Delta using a Joint Point of Diversion. This type of operation would allow Federal and California water managers to use excess or available capacity in their respective southern Delta diversion facilities at the Tracy and Banks pumping plants. The potential to improve water supply reliability with this measure is considered moderate. This measure was not recommended for further consideration in the NODOS feasibility studies because implementation has been postponed pending resolution of ongoing Biological Opinion issues in the Delta.

Construct New Delta Conveyance – Alternative conveyance options are being considered to route water to the Banks and Jones pumping plants. The new facilities under consideration through the California WaterFix process would not increase the capacity of the pumping plants or conveyance to the south, but could increase water supply reliability by reducing the current operational constraints on pumping that protect endangered species. A variety of canal, through-Delta, and tunneling options are under evaluation. The potential for increasing water supply reliability with new Delta conveyance is considered high. However, this measure does not contribute to all of the planning objectives for the NODOS/Sites Reservoir Project, and was not recommended for further consideration in the NODOS feasibility studies. Alternatives are being studied separately through Bay Delta Conservation Plan. If adopted, new Delta conveyance would increase the water supply benefits derived from a NODOS/Sites Reservoir Project.

Anadromous Fish Survivability

Various potential water 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 A-2 identifies the measures considered; their potential to address the primary objective; and whether the measures were retained or not recommended for further consideration.

Table A-2. Summary of Management Measures Considered to Address Anadromous Fish Survivability Primary Objective

Management Measures Considered	Potential to Address Primary Objectives	Status/Rationale
Improve Fish Habitat		
Restore abandoned gravel mines along the Sacramento River.	Moderate potential – Addresses primary planning objective.	Not recommended – Difficult to incorporate into north-of-the-Delta offstream storage, although the success of these projects could be enhanced in the future with additional flows or colder water temperatures that may be supported by the project.
Restore floodplains with opportunities to construct instream aquatic habitat downstream from Keswick Reservoir.	Moderate potential – Addresses primary planning objective.	Not recommended – Difficult to incorporate into north-of-the-Delta offstream storage, although the success of these projects could be enhanced in the future with additional flows or colder water temperatures that may be supported by the project.
Replenish spawning gravel in the Sacramento River.	Moderate to high potential – Addresses primary planning objective.	Not recommended – Currently required under CVPIA. Difficult to incorporate into north-of-the-Delta offstream storage, although the success of these projects could be enhanced in the future with additional flows or colder water temperatures that may be supported by the project.
Remove instream sediment along Middle Creek.	Low potential – Indirectly benefits planning objective.	Not recommended – Substantial benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River, and does not contribute directly to improved ecological conditions along main stem Sacramento River. High uncertainty, given increased need for long-term remediation.
Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood Creeks.	Low potential – Indirectly benefits planning objective.	Not recommended – Substantial benefit to spawning conditions in tributaries. Independent of hydraulic/ hydrologic conditions in upper Sacramento River, and does not contribute directly to improved ecological conditions along main stem Sacramento River.

Management Measures Considered	Potential to Address Primary Objectives	Status/Rationale
Improve Water Flows and Quality		
Improve flows and temperature by integrating new offstream storage into system operation.	High potential to meet all components of primary objective.	Retained – Consistent with primary planning objectives and contributes directly to secondary planning objectives.
Enlarge Shasta Lake coldwater pool by enlarging Shasta Dam.	Moderate to high potential – Directly contributes to planning objective by improving water temperature conditions for anadromous fish.	Consistent with primary objective and goals of CALFED, but modifications to Shasta are being considered through a separate feasibility study.
Modify timing of TCCA and GCID diversions.	Moderate potential – Changes in timing and/or reduced flow would benefit anadromous fish.	Retained – As a stand-alone measure, conflicts with the other primary planning objective of water supply reliability.
Construct a storage facility on Cottonwood Creek to augment spring instream flows.	Low potential – Indirectly benefits planning objective on Sacramento River.	Not recommended – Adverse environmental impacts expected to exceed benefits.
Remove Shasta Dam and Reservoir.	Very low potential to benefit anadromous fish, with major adverse impacts to all other planning objectives.	Not recommended – Violates basic plan formulation criteria, and no known project or projects can replace the lost benefits provided by Shasta and Keswick Dams, reservoirs, and appurtenant facilities at any price.
Improve Fish Migration		
Screen diversions on Old Cow and Cow Creeks.	Moderate potential – Indirectly benefits planning objective on Sacramento River.	Not recommended – Substantial benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in the upper Sacramento River, and does not contribute to improved ecological conditions along the main stem of the river.
Remove or screen diversions on Battle Creek.	Moderate potential – Indirectly benefits planning objective on Sacramento River.	Not recommended – Substantial benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River, and does not contribute to improved ecological conditions along main stem Sacramento River.
Construct a fish barrier at Crowley Gulch on Cottonwood Creek.	Moderate potential – Indirectly benefits planning objective on Sacramento River.	Not recommended – Substantial benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River, and does not contribute to improved ecological conditions along main stem Sacramento River.
Construct a migration corridor from the Sacramento River to the Pit River.	Low potential – High uncertainty regarding the potential to successfully benefit area resources.	Not recommended – Extremely high cost. Multiple physical obstructions to effective fish passage, even after implementation. Very low certainty of success.
Re-operate the CVP to improve overall fish management.	Low potential to improve anadromous fish survival along upper Sacramento River.	Not recommended – See previous measure regarding RBDD. Issues regarding re-operating facilities on Trinity River addressed in Trinity River Record of Decision (DOI 2000). Any further modification in that system violates planning criteria for the NODOS/Sites Reservoir Project.

Management Measures Considered	Potential to Address Primary Objectives	Status/Rationale
Construct a fish ladder on Shasta Dam.	Very low potential for marginal benefit to anadromous fish on upper Sacramento River.	Not recommended – Extremely high cost, relatively small benefit on limited stream system, and very low potential for physically implementing a workable ladder.
Reintroduce anadromous fish to areas upstream from Shasta Dam.	Low potential for marginal benefit to anadromous fish on upper Sacramento River.	Not recommended – Likely high cost, low potential for successful recapture of out-migrants, and potential for major impacts to existing warm- and coldwater species in upper river.

CALFED = CALFED Bay-Delta Program
CVP = Central Valley Project
CVPIA = Central Valley Project Improvement Act
GCID = Glenn-Colusa Irrigation District
NODOS = north-of-the-Delta offstream storage
RBDD = Red Bluff Diversion Dam
TCCA = Tehama-Colusa Canal Authority

Improved Fish Habitat

Restore Abandoned Gravel Mines Along the Sacramento River – Instream gravel mining has contributed to the degradation of aquatic and floodplain habitat. These activities have created large, artificial pits at various locations in the Sacramento River Basin that disrupt natural geomorphic processes and riparian regeneration. High fish mortality from stranding and unnatural predation occurs in many abandoned pits that either lose their connections with the river during low-flow periods, or otherwise interfere with effective fish passage between the river and mine areas. The potential for improving survivability is considered to be low to moderate, depending on the scale of implementation. This measure would consist of acquiring, restoring, and reclaiming several inactive gravel mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Implementation of this measure requires extensive in-river construction to place fill into the abandoned pits. Although there are long-term benefits, the short-term impacts associated with the in-river construction effort on water quality (e.g., turbidity) and aquatic species are significant. This measure was not recommended for further development as part of the NODOS feasibility studies.

Restore Floodplains with Opportunities to Construct Instream Aquatic Habitat Downstream from Keswick Dam – Keswick Dam is the uppermost barrier to anadromous fish migration on the Sacramento River. Releases from the dam have scoured the channel, and the dam blocks downstream passage of gravels, bed sediments, and woody debris that were historically replenished by upstream tributaries. As a result, aquatic habitat is poor for the spawning and rearing of anadromous fish, and predation can be high because instream cover is lacking. Despite these unfavorable channel conditions, coldwater releases from Keswick Dam attract large numbers of spawning fish to this reach. This measure would consist of floodplain restoration efforts that include opportunities for constructing aquatic habitat in and adjacent to the Sacramento River downstream from Keswick Dam. The primary objective of this effort is to create spawning and rearing habitat for anadromous fish (CALFED 2008). The potential for increasing survivability of anadromous fish with this measure is considered to be moderate to high. This measure was retained for potential further development because it has a high likelihood of success in helping to achieve the primary objective.

Replenish Spawning Gravel in the Sacramento River – Gravel suitable for spawning has been identified as an important influencing factor in the recovery of anadromous fish populations in the Sacramento River. Several programs, including CALFED and the Anadromous Fish Restoration Program (AFRP), are proceeding with annual gravel replenishment on the Sacramento River in selected locations. With the exception of the CVPIA (b)(13) program, these programs represent single applications at discrete locations. This measure would consist of helping to replenish spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff on a long-term basis, beyond the existing CVPIA program. Although some water quality impacts are associated with introducing gravel into the river, it is much less construction-intensive than gravel mine restoration. The potential for increasing the survivability of anadromous fish with this measure is considered to be moderate. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve the primary objective.

Remove Instream Sediment along Middle Creek – This measure would consist of implementing a fine-sediment removal and control program along Middle Creek, an intermittent tributary to the Sacramento River between Keswick Dam and Redding. Lower Middle Creek supports spawning runs of rainbow trout, steelhead, and salmon. This measure would not contribute directly to improved ecological conditions along the main stem of the Sacramento River, and the potential for increasing the survivability of anadromous fish with this measure is considered to be low. This measure was not recommended for further development primarily because it is unrelated to other measures recommended for further study.

Rehabilitate Inactive Instream Gravel Mines along Stillwater and Cottonwood Creeks – This measure would consist of rehabilitating ecological conditions in former instream gravel mining sites along Stillwater Creek. Restoring these gravel mines could help Stillwater Creek provide additional seasonal habitat for various anadromous and resident fish. The potential increases in survivability of anadromous fish with this measure are considered to be low. This measure is independent of the construction of the other measures associated with the NODOS/Sites Reservoir Project, and would not benefit from coordination of operations with Shasta Dam or other anticipated project results. This measure was not recommended for further development.

Improved Water Quality/Flow/Temperature for Fish

Improve Flows and Temperature by Integrating a New Offstream Storage Facility into System Operations – When integrated into system operations, offstream storage provides opportunities to increase coldwater pools and improve flows in the Sacramento River. This includes additional storage in Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. These changes help assure the appropriate flows necessary for critical life stages for anadromous fish and riparian habitat. This measure has a high potential for improving water temperature and flows to benefit anadromous fish. This measure was retained for potential further development because it has a high likelihood for success in helping to achieve the primary objective.

Enlarge Shasta Lake Coldwater Pool and Improve Flow Conditions by Enlarging Shasta Dam – Cold water released from Shasta Dam greatly influences water temperature conditions on the Sacramento River between Keswick and Red Bluff, and can have an extended influence on river temperatures farther downstream. This measure would consist of enlarging the coldwater pool by either raising the height of Shasta Dam and enlarging the minimum operating pool, or increasing the seasonal carryover storage in Shasta Lake.

In addition to water temperature, flow conditions in the Upper Sacramento River are important in addressing anadromous fish needs. Enlarging Shasta Dam and modifying seasonal storage and releases would also benefit anadromous fisheries. This measure has a moderate to high potential for improving flow and temperature conditions, depending on the size of the enlargement. This measure is being independently evaluated in a separate feasibility study under Public Law 96–375.

Modify Tehama-Colusa Canal Authority (TCCA) and Glenn-Colusa Irrigation District (GCID) Canal Diversions – This measure would consist of modifying operations at existing diversions to irrigation districts to change the timing, or reduce flows and their resulting impacts on anadromous fish. This measure has a moderate potential for improving flow conditions for anadromous fish. Negative impacts on water deliveries from the diversions potentially conflict with another primary objective of increasing water supply reliability. This measure was retained to evaluate changes in timing, and the potential benefits of increased flexibility arising from providing additional intakes for alternatives that include Sacramento River pumping.

Construct a Storage Facility on Cottonwood Creek to Augment Spring Instream Flows – This measure would consist of constructing a dry dam or offstream storage facility on upper Cottonwood Creek to support flows for spring-run Chinook salmon. A storage facility would allow late-spring and summer releases for spring-run Chinook salmon, and improve overall seasonal aquatic conditions. This measure was not recommended for further development because it is highly likely that this measure would have considerable and overriding adverse environmental impacts on the Cottonwood Creek watershed. It could potentially sever access to existing spawning locations. Although this measure would improve flows, the negative effects likely outweigh benefits to anadromous fish.

Remove Shasta Dam and Reservoir – This measure would consist of removing the existing Shasta Dam and Reservoir to benefit anadromous fishery resources. The Shasta Division of the CVP provides supplemental irrigation services to almost one-half million acres of land in California’s Central Valley. It also provides water for M&I purposes, and power generation amounting to approximately 680,000 kilowatt-hours. In addition, Shasta Dam helps reduce flooding over a large area along the Sacramento River. Estimates of flood damages prevented by Shasta Dam and Reservoir during the major storms of 1995 and 1997 were approximately $3.5 and $4.3 billion, respectively. Although the potential benefit to anadromous fish resources along the Upper Sacramento River might be sizeable (numerous studies would be required to define the potential benefits and disadvantages to the fisheries), these benefits would by no means begin to approach the monetary benefit associated with the existing project. No known project or projects could replace the benefits provided by Shasta and Keswick Dams, Reservoirs, and appurtenant facilities at any price. This measure was not recommended for further consideration primarily because it would violate at least one of the planning criteria concerning the potential to adversely impact existing project purposes.

Improved Fish Migration

Screen Diversions on Old Cow and Cow Creeks – This measure would consist of screening diversion intakes in the Cow Creek watershed to reduce fish mortality. This measure might reduce salmonid mortality at diversions in the Cow Creek watershed. The overall potential for improving fish migration throughout the Sacramento River watershed with this measure is considered to be low. However, this measure was not recommended for further development primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival in the Sacramento River Basin.

Remove or Screen Diversions on Battle Creek – This measure would consist of removing or screening diversions and other water control facilities on Battle Creek to allow full use of the watershed's high-quality, coldwater spawning habitat. Some of these diversions have been screened over the past several years, but there are others that could be screened. The overall potential for improving fish migration with this measure is considered to be moderate. This measure was not recommended for further development, primarily because there are already independent efforts under way to address unscreened diversions.

Construct a Fish Barrier at Crowley Gulch on Cottonwood Creek – This measure would consist of constructing a fish barrier at the mouth of Crowley Gulch on Cottonwood Creek to eliminate the stranding of adult fall-run Chinook salmon. The overall potential to improve fish migration throughout the Sacramento River Basin is considered low. This measure was not recommended for further development, primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival throughout the Sacramento River Basin.

Construct a Migration Corridor from the Sacramento River to the Pit River – This measure would consist of providing passage to spawning areas upstream from Shasta Dam for anadromous fish from the Sacramento River. One concept would include connecting the upper Pit River to the Sacramento River. Although there is a moderate potential for increasing populations of fish with this measure, the associated cost and uncertainties are high. This and similar measures were not recommended for further consideration, primarily because of the high cost for complex infrastructure; the major impacts to other facilities and extensive long-term operation, maintenance, and replacement (OM&R) requirements; and the high uncertainty of the potential to achieve and maintain successful fish passage and spawning.

Re-operate the CVP to Improve Overall Fish Management – This measure would include re-operating all of the CVP facilities in the Upper Sacramento River system to improve anadromous fish resources. CVPIA implementation already includes reoperation to benefit fish. Additional reoperation is likely to provide a diminished level of benefits and have an adverse impact on other project objectives. The potential to improve survivability with this measure is considered to be low. This measure was not recommended for further development.

Construct a Fish Ladder on Shasta Dam – This measure would include constructing a fish ladder on Shasta Dam to allow the passage of anadromous fish to access Shasta Lake and approximately 40 miles of the Upper Sacramento River, approximately 24 miles of the lower McCloud River, and various small creeks and tributaries to Shasta Lake. Implementing a fish ladder of this magnitude has significant uncertainties; therefore, the potential for improving the survivability of anadromous fish throughout the Sacramento River Basin with this measure is considered to be low. This measure was not recommended for further consideration because of the estimated high cost of constructing and operating the fish ladder; the low likelihood for success in getting the fish to successfully ascend the ladder; and the likely major impacts to existing warm- and coldwater species in the upper river reaches.

Reintroduce Anadromous Fish to Areas Upstream from Shasta Dam – This measure would include trapping anadromous fish along the Sacramento River immediately downstream from Keswick Dam, transporting the fish by tanker truck from the Delta to areas along the Upper Sacramento River near Volmers, and releasing the fish in the Upper Sacramento River to spawn. This measure also would include trapping the potential out-migrating fish and transporting them to the Sacramento River near Keswick for release into the lower river. The potential for improving the survivability of fish in the Sacramento River Basin with this measure is considered to be low. This measure was not recommended for further consideration because of the high cost to implement the plan; its low likelihood for success, given the inability to recapture the out-migrants; and likely major impacts to existing warm- and coldwater species in the upper river.

Water Quality

The various potential water management measures identified to address the primary objective of improving water quality in the Delta for M&I users fall into two major categories: increased flow to improve Delta water quality; and source water treatment improvements. Table A-3 identifies the measures considered; their potential to address the primary objective; and whether the measures were retained, or not recommended for further consideration.

Increased Flow to Improve Delta Water Quality

Improve Water Quality by Increasing Flows from New Conservation Offstream Surface Storage – Offstream storage could provide additional flow to the Delta to augment Delta outflow and improve water quality during periods of poor water quality. Offstream storage could allow changes in the timing, magnitude, and duration of diversions from the Sacramento River. This measure was retained for potential further development because it has a high likelihood of success in helping to achieve both primary objectives.

Table A-3. Summary of Management Measures Considered to Address Water Quality Primary Objective

Management Measures Considered	Potential to Address Primary Objective	Status/Rationale
Increased Flow to Improve Delta Water Quality		
Improve water quality by increasing flows from new conservation offstream surface storage	High potential to meet all components of primary objective.	Retained – Consistent with primary planning objectives and contributes directly to secondary planning objectives.
Extend Tehama-Colusa Canal to Cache Creek to provide flow from the NODOS project to the Delta	Low potential – Releases from NODOS project storage to Cache Creek offer far less benefit to water quality than releases to the Sacramento River because of water quality degradation in Cache Creek. Releases to the creek could further mobilize mercury to the Delta.	Not recommended – Construction would have adverse environmental impacts and provide minimal benefit to water quality as a result of mercury contamination in Cache Creek. Releases would be constrained by capacity limitations on Cache Creek flows.
Source Water Treatment Improvements		
Implement treatment/supply of agricultural drainage water	Very low potential to improve water supply reliability for agricultural uses.	Not recommended – Not a viable alternative to new water storage. Very high unit water cost.
Construct desalination facility	Low potential – Although it provides a growing source for urban water supplies in California, it has low potential to address NODOS project planning objectives.	Not recommended – Would not address other planning objectives. Very high unit water cost.

NODOS = north-of-the-Delta offstream storage

Extend T-C Canal to Cache Creek to provide flow from Sites Reservoir to the Delta – This measure would involve extending the T-C Canal to Cache Creek or installing a pipeline from the T-C Canal to Cache Creek. Water then could be released from the NODOS project into Cache Creek to flow into the Sacramento River. Cache Creek has water quality issues, including high concentrations of mercury in sediments, which would be difficult to remove. The creek also has flow limitations. Most sediment releases occur under high-flow conditions during the wet season. Any water quality benefits from discharging water from the NODOS project to Cache Creek are overshadowed by the mobilization of mercury-laden sediments during July through September. This alternative would face substantial public and agency resistance; therefore, it was not recommended for further consideration in the NODOS feasibility studies.

Source Water Treatment Improvements

Implement Treatment/Supply of Agricultural Drainage Water – This measure would consist of collecting agricultural drainage water from farms along the Sacramento and San Joaquin Rivers, and treating the drainage water for reuse. Major elements of this measure probably would include an agricultural drainage collection system, pre-treatment of drainage water, desalination facilities, ancillary facilities associated with desalination and brine disposal, and conveyance of treated water to end users. In addition, removal of total organic carbons and pesticides, plus supplementary disinfection, might be required before municipal agencies would consider using the treated agricultural runoff as a potable water supply. This measure would be costly to implement and operate initially; in addition, there would be problems relative to brine disposal.

This measure would not reduce raw water quality concerns in the Delta. Accordingly, this measure was not recommended for further evaluation.

Construct Desalination Facility – This measure would consist of constructing seawater or brackish surface or groundwater desalination plants to supplement existing water supplies and help offset future demands. In addition, a conveyance system would be needed to transport the desalinated water to the customer or to the water agency distribution systems. Although technological advances have substantially decreased treatment costs, desalination remains costly compared with most other water sources. Even with continual improvement in membrane technology, energy costs can account for as much as one-half of the total cost of desalination. This measure would not reduce raw water quality concerns in the Delta. This measure was not recommended for further evaluation.

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A.6 Alternative Reservoir Locations

CALFED Evaluation of Alternative Reservoir Locations

CALFED performed an initial evaluation of 52 potential reservoir sites within the larger CALFED solution area (Figure A-2). Further evaluation took place, and is documented as part of the NODOS IAIR.

Specifically, CALFED looked for sites that could contribute substantially to its multiple-purpose objectives. These objectives included potential sites that could provide broad benefits for water supply, flood control, water quality, and the ecosystem. CALFED eliminated locations providing less than 0.2 MAF of storage; and those that conflicted with CALFED solution principles, objectives, or policies.

Of the 52 surface storage sites, 40 were removed from CALFED's list during the initial evaluation process, detailed in the *Initial Surface Water Storage Screening Report* (CALFED 2000b). The remaining 12 surface storage sites were recommended by CALFED for further consideration:

- Four NODOS/Sites Reservoir Project alternatives: the Colusa Reservoir Complex, Red Bank Project, Sites Reservoir, and Newville Reservoir (also known as Thomes-Newville Reservoir)
- In-Delta storage and enlargement of Los Vaqueros Reservoir (under independent investigation)
- Four South-of-the-Delta storage alternatives, including Ingram Canyon Reservoir, Quinto Creek Reservoir, Panoche Reservoir, and Montgomery Reservoir (under independent investigation)
- Enlargement of Shasta Lake (Shasta Dam) and Millerton Reservoir (Friant Dam) (both are under independent investigation)

The NODOS feasibility studies were initiated as a result of the first of the above recommendations bulleted above. The other recommendations were pursued independently. Two additional candidate sites north-of-the Delta were suggested by the public in addition to the four sites identified through the CALFED process. These sites are the Cottonwood Reservoir Complex and Veteran's Lake.

Reservoir Location Descriptions

Locations for offstream storage evaluated during the NODOS feasibility studies are described below and shown on Figure A-3.

- Colusa Reservoir Complex – The Colusa Reservoir Complex is in north-central Colusa County and south-central Glenn County, approximately 12 miles southwest of the community of Willows and 10 miles west of Maxwell. The Colusa Reservoir Complex would include the area of the proposed Sites Reservoir and the Colusa Cell. The Colusa Cell would be due north of Sites Reservoir, and could be constructed with Sites Reservoir facilities to form a single, 28,000-acre reservoir. The inundation area of the Colusa Cell is in the Logan Creek and Hunter Creek watersheds (35,000 acres), with the associated United States Geological Survey (USGS) subbasins. A mean full pool elevation of 520 feet would inundate approximately 14,000 acres in the Colusa Cell, and could store an additional 1.2 MAF. The maximum storage of the Colusa Reservoir Complex would be 3.3 MAF. The Colusa Cell requires a total of 16 dams. It requires all dams for Sites Reservoir and four additional major dams along Logan Ridge: one for Logan Creek, and three for Hunter Creek and its tributaries. Colusa Reservoir Complex requires seven saddle dams. The Colusa Reservoir Complex would provide greater total storage capacity (up to 64 percent greater storage capacity).

- Cottonwood Reservoir Complex – Cottonwood Reservoir is in northwestern Tehama County, approximately 21 miles southwest of Anderson. The Cottonwood Reservoir Complex could be designed as a 0.4 MAF reservoir (Cottonwood South Reservoir), or as a 1 MAF reservoir (Cottonwood South Reservoir and Cottonwood North Reservoir). At 0.4 MAF, the reservoir (Cottonwood South Reservoir) would cover 3,400 acres. At 1 MAF, the reservoir would cover 7,100 acres at a mean pool elevation of 1,300 feet. The Cottonwood South Reservoir would be filled by runoff from 179,500 acres in South Fork Cottonwood Creek, Salt Creek, and Hensley Creek watershed. The Cottonwood North Reservoir would be filled by runoff from 84,000 acres from the Beegum Creek and Dry Creek watershed. Cottonwood South Reservoir would be formed by a dam on Salt Creek just upstream from Dexter Gulch, 4 miles south of Route 36. Cottonwood North Reservoir would be formed by a dam on Dry Creek just downstream from the confluence with Pentacola Gulch, on Route 36.
- Newville Reservoir – Newville Reservoir would be situated in north-central Glenn County and south-central Tehama County, approximately 18 miles west of the City of Orland and 23 miles west-southwest of the City of Corning. This proposed reservoir project would be in portions of the North Fork Stony Creek watershed (51,200 acres) and Thomes Creek watershed (123,500 acres), as well as the associated USGS subbasins. A small diversion along Thomes Creek would transfer water to Newville Reservoir in the North Fork Stony Creek watershed. Alternative reservoir sizes of 1.8 and 3.0 MAF are being evaluated, with associated normal water surface elevations of 905 and 980 feet and corresponding reservoir surface areas of 14,500 and 17,000 acres, respectively. Newville Reservoir would be upstream from Black Butte Lake. 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 would be required for a 3.0 MAF reservoir alternative. Multiple conveyance options are possible using existing infrastructure, such as canals, new infrastructure, tunnels, and/or pipelines, or a combination of new and existing mechanisms, to provide increased flexibility and reliability in the operation of existing and new infrastructure.

Figure A-2. CALFED Surface Storage Locations

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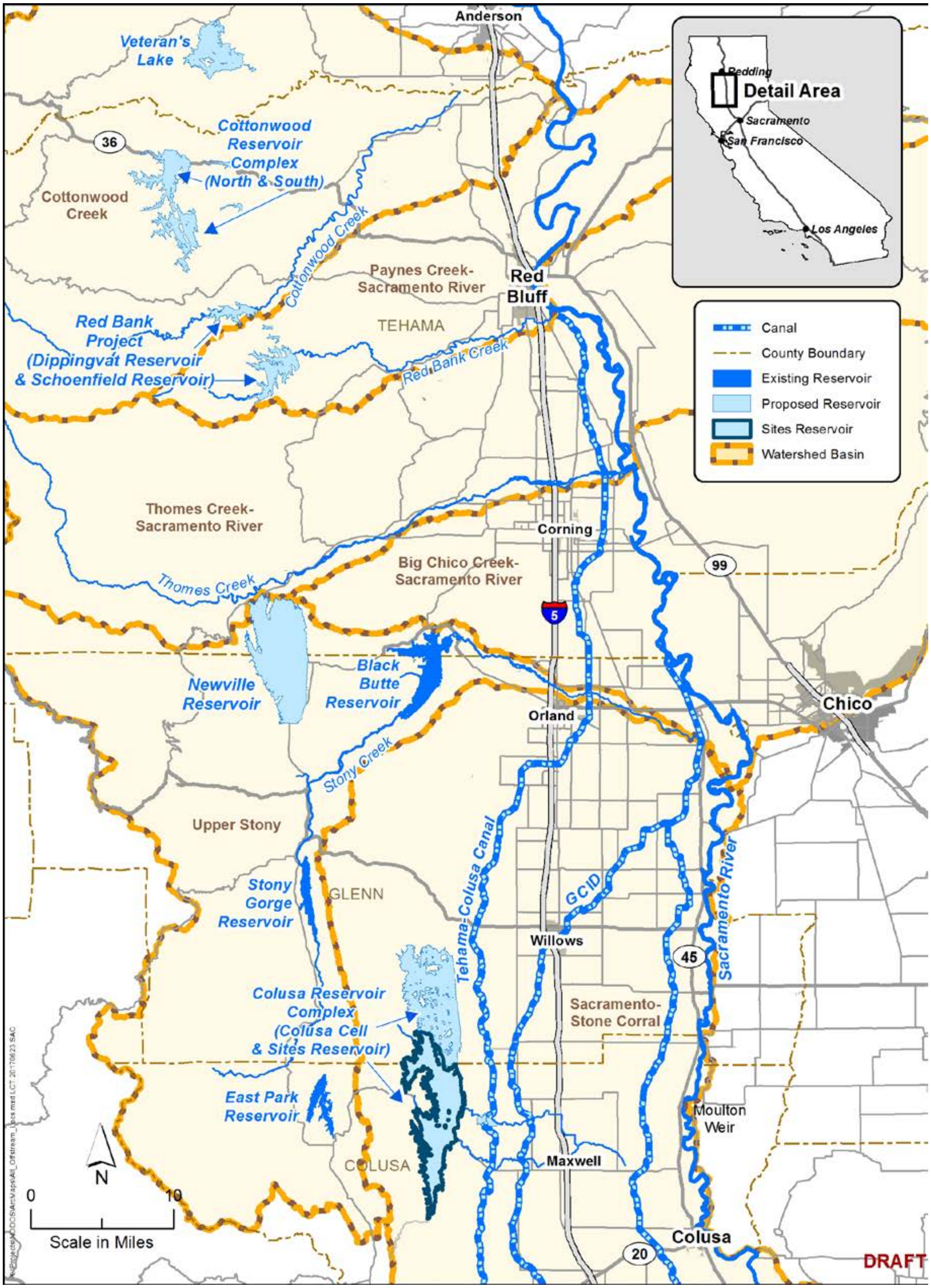

Figure A-3. Alternative Offstream Locations for the NODOS Project

- Red Bank Complex – Red Bank Complex is in northwestern Tehama County, approximately 17 miles west of the City of Red Bluff. This reservoir complex would include a diversion on South Fork Cottonwood Creek at Dippingvat Reservoir, two small reservoirs in the headwaters of North Fork Red Bank Creek (Blue Door and Lanyan Reservoirs), and a larger storage reservoir on Red Bank Creek (Schoenfield Reservoir). The South Fork Cottonwood Creek watershed is relatively large (81,900 acres), while the Red Bank Creek watershed is relatively small (27,300 acres). Dippingvat Reservoir would have a normal pool elevation of 1,205 feet, and an inundation area of 1,800 acres. Schoenfield Reservoir, with a normal pool elevation of 1,017 feet, would inundate 2,770 acres, and have a storage capacity of 0.25 MAF. Both Dippingvat Reservoir and Schoenfield Reservoir would be constructed on perennial streams, and be considered onstream facilities.
- Sites Reservoir – Sites Reservoir is in north-central Colusa County and south-central Glenn County, approximately 10 miles west of the community of Maxwell. Water would be diverted from the Sacramento River to fill the reservoir. The proposed reservoir inundation area includes most of Antelope Valley and the small community of Sites. The reservoir is in the Funks Creek and Stone Corral Creek watersheds (59,700 acres), with the associated USGS subbasins. A mean full pool elevation of 520 feet would inundate 14,000 acres and could store a maximum of 1.8 MAF. Alternative reservoir sizes of 1.3 and 1.8 MAF are under consideration. At 1.3 MAF, six saddle dams and two major dams (Sites and Golden Gate Dams) would be required. At 1.8 MAF, Sites Reservoir would require the construction of two major dams (Sites and Golden Gate Dams) and nine saddle dams along the southern edge of the Hunter Creek watershed. Diversions from the Colusa Basin Drain (CBD), the Sacramento River, Stony Creek, and local tributaries would provide potential sources of water supply for the Sites Reservoir project.
- Veteran's Lake – Veteran's Lake would be in southwestern Shasta County near Ono, approximately 17 miles west of Anderson, and would inundate 5,100 acres and store up to 0.6 to 1.0 MAF at a mean pool elevation of 1,050 feet. Veteran's Lake would be filled from the North Fork Cottonwood Creek, Middle Fork Cottonwood Creek, and Jerusalem Creek watershed, covering 109,500 acres. Veteran's Lake would be formed by Roaring Dam on Roaring Creek and by Crow Dam on Crow Creek, and six small saddle dams along the ridge between Roaring Creek and Bee Creek. Roaring Creek Dam would be approximately 3 miles downstream from Bland Road, off of A-16 Platina Road.

Initial Evaluation of Potential Locations

Potential reservoir sites for the NODOS feasibility studies were developed and reviewed during study team meetings, field inspections, and outreach for the NODOS feasibility studies.

Because all of the projects are upstream of the Delta and adjacent to the Sacramento River, the types of benefits (such as supplemental yield for various uses and reduced diversions from the Sacramento River during the peak local delivery period) would vary, primarily in scale. Current studies have been updated, as needed, to allow comparative evaluation of alternatives.

Physical Environment

All six of the proposed reservoir projects are in the Coast Range foothills along the western edge of the northern Sacramento Valley. Figure A-4 shows delineation of USGS watersheds and subbasins containing the proposed offstream reservoirs. Table A-4 lists the gross storage, dead storage, and the watersheds upstream of the dams.

Table A-4. Comparison of Storage and Watershed Areas

Attribute	Colusa Reservoir Complex	Red Bank Project	Sites Reservoir	Newville Reservoir	Cottonwood Reservoir Complex	Veteran's Lake
Gross Storage (acre-feet)	3,300,000 [a]	354,000 [a]	1,200,000 to 1,900,000 [a]	1,800,000 to 3,000,000 [a]	400,000 to 1,000,000	600,000 to 1,000,000
Dead Storage (acre-feet)	100,000	N/A	40,000	50,000	8,000 to 40,000	20,000
Watershed (acres)	94,700	109,200	59,700	174,700	263,500	109,500

[a] From Initial Surface Water Storage Screening Report (CALFED 2000c).
N/A = not available

Topography

The physical topography of the watersheds draining the eastern side of the Coast Range toward the Sacramento Valley is diverse. The topography ranges from steep, rugged, mountainous terrain in the upper watersheds, to rolling foothills in the study areas, to relatively flat alluvial terrain as the watersheds enter the Sacramento Valley. Elevations range from less than 40 feet on the valley floor to over 8,000 feet along the Coast Range divide.

- Colusa Reservoir Complex – The Colusa Reservoir Complex area is between the Sacramento Valley to the east and the mountainous portion of the Coast Range on the west. In addition to the inundation area of Sites Reservoir, the proposed Colusa Reservoir would also inundate the valleys associated with both Hunter and Logan Creeks upstream of Logan Ridge. Topographic relief in the inundation area of the Colusa Cell is more varied than in Sites Reservoir; and numerous islands would be created from hills with elevations greater than 520 feet. The Colusa Cell inundation area would be approximately 10 miles long and 3 miles wide, with a maximum depth of 260 feet. The foothills separating the Colusa Cell from the Sacramento Valley are substantially lower in elevation than those found near Sites, with only a single peak in excess of 1,000 feet in elevation. Development of this project would require construction of numerous saddle dams, because a number of areas along the eastern edge of the project are less than the normal pool elevation of 520 feet.

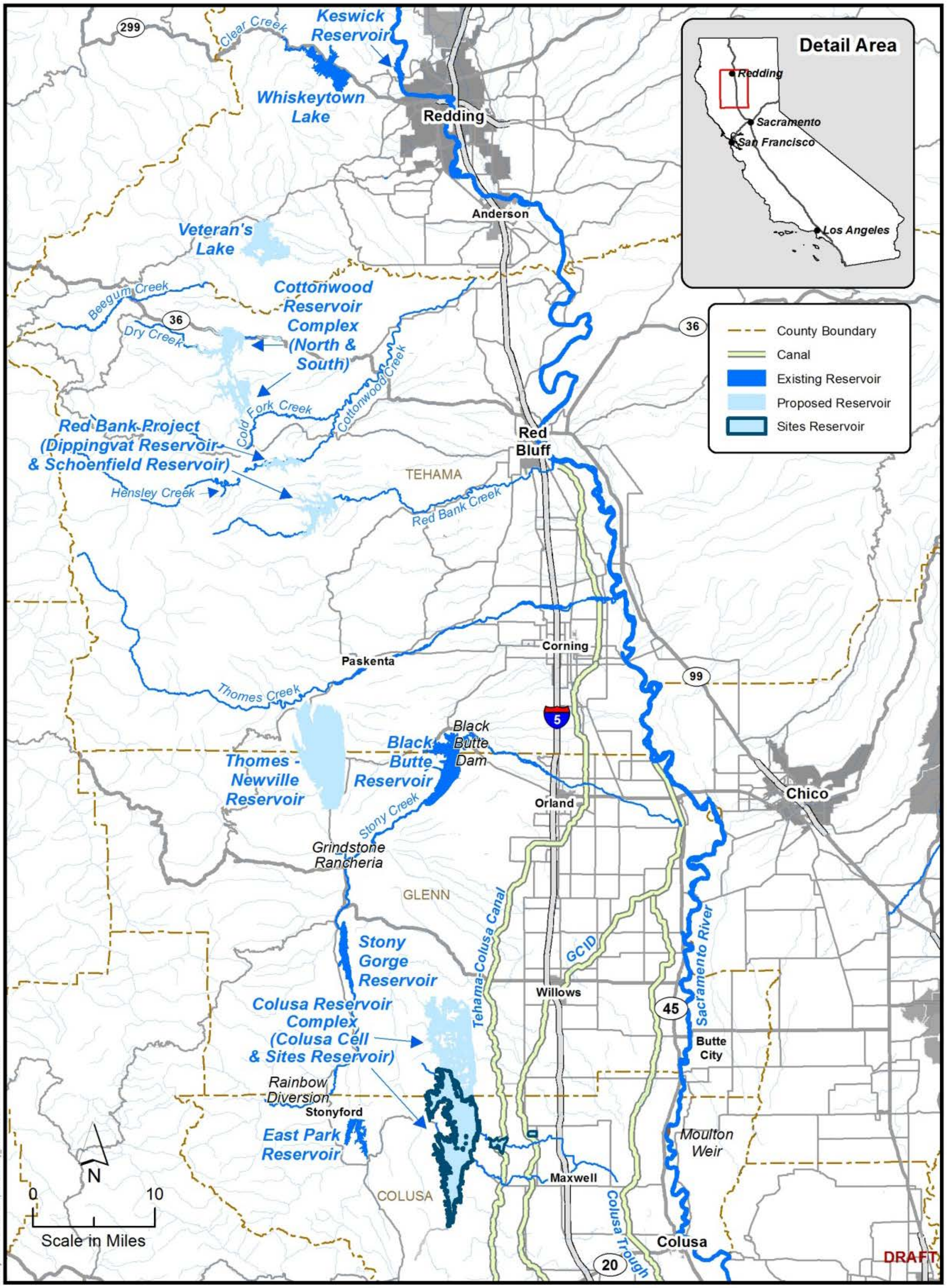

Figure A-4. Locations of Waterways in the NODOS Project Vicinity

- Cottonwood Reservoir Complex – The Cottonwood Reservoir Complex area consists of typical foothill topography made up of rolling hillocks and broad, shallow valleys. The project area is at the northern end of the Sacramento Valley, and the slopes and high peaks of the inner coastal range are located to the west of the site. The elevation in the Cottonwood Reservoir area ranges from approximately 890 feet to over 1,000 feet above sea level. Beegum Creek parallels State Highway 36, and is the main drainage feature in the project area; it dissects the project area in an approximately west-to-east direction heading to its confluence with the Dry Creek, Cottonwood Creek, and the Sacramento River south of Redding.
- Newville Reservoir – Newville Reservoir would be located in a large circular valley surrounding the North Fork Stony Creek. Topographical relief in the inundation area of Newville Reservoir is that of gently rolling terrain ranging in elevation from 630 feet to 975 feet. A single steep ridge (Rocky Ridge) separates the Newville Reservoir site from low, rolling foothill areas to the east. Rocky Ridge runs north and south, with several peaks above an elevation of 1,300 feet. Steep, rugged mountains form the western boundary of the reservoir area, with elevations up to 3,000 feet within 2 miles of the reservoir inundation area. The currently preferred diversion on Thomes Creek would be made at a low dam in a steep, narrow, confined reach below Thomes Creek Canyon at approximately 1,035 feet above mean sea level (msl).
- Red Bank Project – The Red Bank Reservoir footprint area is highly dissected, rugged, mountainous terrain. The primary drainages (and associated valleys) run from west to east. Linear alluvial terraces are associated with the major drainages, and stream gradients are much greater than those found in the other three proposed reservoirs. Topographical relief in the inundation area of the Red Bank Project varies from small areas of relatively flat alluvial terraces, to gently rolling terrain, to very steep hill slopes ranging in elevation from 780 to 1,200 feet.
- Sites Reservoir – The Sites Reservoir footprint area is situated between the Sacramento Valley to the east and the mountainous portion of the Coast Range to the west. A relatively narrow band of steep, rolling foothills, approximately 2 to 3 miles wide, separates the proposed reservoir area from the Sacramento Valley. Antelope Valley, the primary inundation area of the proposed Sites Reservoir, lies between this narrow band of foothills and the more mountainous Coast Range. This relatively narrow north-south–trending valley is approximately 13 miles long and up to 2 miles wide. Elevation of the Antelope Valley floor ranges from 320 to 400 feet above msl, while the foothills separating the valley from the Sacramento Valley reach a maximum elevation of 1,300 feet. Elevations along the western side of Antelope Valley increase rapidly, with several peaks within 2 miles of the valley margin above 2,000 feet.
- Veteran's Lake – The Veteran's Lake area consists of low-elevation rolling hills interspersed with wide and shallow valleys. The area is between the northernmost tip of the Sacramento Valley that lies to the east of the proposed project site, and the slopes and high peaks of the inner coastal range to the west of the site. Elevation in the project area ranges from approximately 950 feet to over 1,050 feet above msl. Roaring Creek is the main drainage feature in the project area, and dissects it in an approximately west-to-east

direction, heading to its confluence with the Cottonwood Creek, and eventually with the Sacramento River just south of Redding.

Water Resources

Table A-5 shows the optional water supply sources considered for the NODOS/Sites Reservoir Project alternatives. Colusa Reservoir Complex, Cottonwood Reservoir Complex, Red Bank Project, Sites Reservoir, Newville Reservoir, and Veteran’s Lake each have a number of optional water supply sources. These sources may be packaged in various combinations to generate sufficient water supply for a specific project. Cottonwood Reservoir Complex has 10 optional water supply sources and Veteran’s Lake has 9 optional water supply sources. Local inflow sources are not shown, but each offstream project would receive some local inflow from the relatively smaller streams that flow directly to the offstream reservoirs.

Table A-5. Optional Water Supply Sources for NODOS Projects

Colusa Reservoir Complex	Cottonwood Reservoir Complex	Newville Reservoir	Red Bank Project	Sites Reservoir	Veteran’s Lake
Colusa Basin Drain	Beegum Creek	Sacramento River	South Fork Cottonwood Creek	Colusa Basin Drain	Clear Creek
Grindstone Creek	Cold Fork Creek	Stony Creek		Grindstone Creek	Crow Creek
Little Stony Creek	Clear Creek	Thomes Creek		Little Stony Creek	Duncan Creek
Sacramento River	Dry Creek			Sacramento River	Jerusalem Creek
Stony Creek	Hensley Creek			Stony Creek	Middle Fork Cottonwood Creek
Thomes Creek	Sacramento River			Thomes Creek	North Fork Cottonwood Creek
	Salt Creek				Roaring Creek
	South Fork Cottonwood Creek				Sacramento River
	Stinking Creek				Wilson Creek
	Weemasoul Creek				

NODOS = north-of-the-Delta offstream storage

Streamflow records were reviewed to determine the relative quantity of water that has historically flowed in various streams. Table A-6 shows November through March streamflow volumes at representative locations from 1945 to 1994. The November through March period was chosen to avoid any operational conflicts with existing facilities and water rights. Local irrigation operations often begin in April, and conveyance facilities are being used for deliveries. Most of the data shown are directly from gage station streamflow records. A number of the data records needed to be extended or adapted using basic hydrologic correlations. Correlations for the entire period of record were required for Grindstone Creek, inflow to East Park Reservoir, South Fork Cottonwood Creek, North Fork Cottonwood Creek, Middle Fork Cottonwood Creek, Beegum Creek, Cold Fork Creek, Hensley Creek, Dry Creek, and Jerusalem Creek.