RECLAMATION
Managing Water in the West

Initial Alternatives Information Report

Upper Klamath Basin Offstream Storage Investigations

Oregon and California

U.S. Department of the Interior
Bureau of Reclamation

May 2011

Cover Photographs

Top: Barnes Ranch and Agency Lake Ranch site located northwest of Upper Klamath Lake, showing the extensive conveyance and drainage canal systems necessary to manage water levels within these large and low-gradient land areas.

Bottom: Private farm groundwater well surface pump facility (photo courtesy of Ned Gates, Oregon Water Resources Department)

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prepared by

U.S. Department of the Interior
Bureau of Reclamation

Klamath Basin Area Office
Klamath Falls, Oregon

Technical Service Center
Denver, Colorado

U.S. Department of the Interior
Bureau of Reclamation

May 2011

Mission Statements

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

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Acronyms

ALR	Agency Lake Ranch
ALRS	Agency Lake Ranches (includes both Agency Lake Ranch and Barnes Ranch)
AL/Barnes	Agency Lake/Barnes Ranches
AL/BR	Agency Lake/Barnes Ranches
ASR	aquifer storage and recovery
BO	Biological Opinion
BR	Barnes Ranch
CDWR	California Department of Water Resources
D&S	Directives and Standards—Reclamation Planning Policy Implementation, Reclamation Manual
DEM	Digital Elevation Model
DOGAMI	Department of Geology and Mining Industry
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ENR	*Engineering and News Record*
EPA	Environmental Protection Agency
ESA	Endangered Species Act (ESA
FERC	Federal Energy Regulatory Commission
FR	Feasibility Report
ft^3/s	cubic feet per second
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information Systems
IAIR	Initial Alternatives Information Report
KB	Klamath Basin
KBRA	Klamath Basin Restoration Agreement
KBRT	Klamath Basin Rangeland Trust
KBWSI	Klamath Basin Water Supply Initiative
KDD	Klamath Drainage District
KSD	Klamath Straits Drain
LKL	Lower Klamath Lake
LLV	Long Lake Valley
NAS	National Academy of Sciences
NED	national economic development
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
O&M	operation and maintenance
ODEQ	Oregon Department of Environmental Quality
OWARS	Oregon Water Availability Report System

OWRD	Oregon Water Resource Department
P&Gs	principles and guidelines
Project	Klamath Project (Bureau of Reclamation)
Reclamation	Bureau of Reclamation
ROD	Record of Decision (ROD
ROW	right-of-way
SDWA	Safe Drinking Water Act
TAF	thousand acre-feet
TBD	to be determined
TMDL	total maximum daily load
TNC	The Nature Conservancy
TSC	Technical Service Center
UIC	underground injection control
UKB	Upper Klamath Basin
UKBOS	Upper Klamath Basin Offstream Storage
UKL	Upper Klamath Lake
UKNWR	Upper Klamath National Wildlife Refuge
USGS	United States Geological Survey
WQ	water quality
WRIMS	Water Resources Integrated Modeling System
WUMP	Water User Mitigation Program

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Executive Summary

The Bureau of Reclamation (Reclamation) has initiated the Upper Klamath Basin Offstream Storage (UKBOS) investigation under the authority of the Klamath Basin Water Supply Enhancement Act of 2000. So far, this investigation has been performed at the preliminary level of Reclamation's planning process. This investigation is designed to evaluate potential offstream water storage and other water delivery options in the Upper Klamath Basin and the Klamath Project that meet objectives called for in the Act. The Enhancement Act directs Reclamation to conduct planning investigations up to and including, if necessary, the feasibility planning level. Reclamation considers this to be an interim document of the authorized Reclamation planning process under Section 3(d) of the Enhancement Act. A key objective of the Enhancement Act investigated under the UKBOS studies is that of finding permanent solutions for effective carryover storage from year to year to ensure more stable water supplies.

If an option is moved forward from the first phase, or "preliminary planning," to the next phase, known as "appraisal," the option is then referred to as an alternative. If a given alternative is moved forward from the appraisal phase to the feasibility phase, a proposed action is developed within the feasibility studies. For an action to be federally implementable, the proposed action must be identified with the greatest net economic benefits. The proposed action must also be consistent with protecting the Nation's environment, unless the Secretary grants an exception, consistent with prescribed principles and guidelines (P&Gs) (WRC, 1983); with Section 404 of the Clean Water Act, which requires identification of the least environmentally damaging practicable option; and with other pertinent Federal laws and policy. However, since this report documents the preliminary level activities of the UKBOS investigation, the requirement for a net positive contribution to the Nation's economy from the perspective of the options' benefit-to-cost relationship has been investigated only on a preliminary basis.

The UKBOS investigation is needed to study options that would help alleviate the growing demand and competition for water in the Klamath Basin and to reduce future conflicts over water between the Upper and Lower Klamath Basins. Potential options were identified and developed in the 1990s through the Klamath Basin Water Supply Initiative (KBWSI), a public input process involving potentially affected State, local, and tribal interests as well as concerned stakeholders. The search for and identification of more permanent solutions to effectively carry over water storage is also supported within the terms of the Klamath Basin Restoration Agreement (KBRA), and its development process also helped to identify additional potential options for investigation. Directives and objectives in the Enhancement Act were quantified or developed into screening criteria by which a method would then exist for the identification of the options that best meet the directives and objectives in the Enhancement Act.

This Initial Alternatives Information Report (IAIR) documents results and outcomes of the UKBOS studies and evaluations, and identifies options investigated during the UKBOS studies and evaluations that meet screening criteria unique to the Upper Klamath Basin. Those options may be carried forward and refined in appraisal studies. Several options involving surface water storage were investigated that meet the study need described in Section 2 (1) of the Enhancement Act. However, the surface water storage options offer the best opportunity for water that could be made available in subsequent irrigation seasons. The UKBOS investigation has also investigated further innovations in the use of existing water resources that meet the study need outlined in Section 2 (3) of the Enhancement Act.

This IAIR shows how some initial options, including the without project option, have been dismissed for failing to meet the identified screening criteria. In particular, the without project option involves doing nothing. The subsequent impacts would include the continuation of demand growth and competition for water in the Klamath Basin as well as future conflicts over water between the Upper and Lower Klamath Basins. Numerous different water storage schemes were examined and evaluated during the UKBOS studies including surface storage reservoirs and groundwater storage. A total of 36 water storage options were developed at preliminary level and screened to identify the most promising opportunities to address the goals of the Enhancement Act.

This report favors advancing two options to appraisal studies: (1) an aquifer storage and recovery (ASR) groundwater option at Gerber Reservoir and (2) a hybrid option involving ASR (groundwater) at Clear Lake and surface storage at a new Boundary Dam and Reservoir even though neither option presents strong economic viability at this point. These and other options could be combined for more enhanced benefits, but this would involve keeping studies open to determine their preliminary economic, cultural, and environmental viability.

1.0 Introduction

The Bureau of Reclamation (Reclamation)—in cooperation with Federal and State agencies, tribal entities, and local water interests—is investigating potential opportunities for additional water storage in the upper Klamath Basin as a means to address increasing water demands while preserving vital environmental resources. Reclamation has initiated the Upper Klamath Basin Offstream Storage (UKBOS) study to conduct preliminary level investigations on potential storage options that could be employed to alleviate water shortages in the Klamath Basin. At this point in the UKBOS study, this Initial Alternatives Investigation Report (IAIR) is needed to describe and document the preliminary screening of those storage options and the resulting options that emerge as initial alternatives with a high priority for further planning stages.

Key IAIR Topics:

- *Defining the Klamath Basin study area*
- *Identifying resource planning problems, needs, opportunities, and objectives*
- *Summarizing the status of Klamath Basin water storage studies completed to date*
- *Developing and screening potential water storage options at preliminary level*
- *Identifying current initial alternative priorities for further planning investigations*

Reclamation and other stakeholders in the Upper Klamath Basin have undertaken a number of technical studies in recent years that have produced an array of potentially viable storage options along with supporting information that could be useful in further planning for individual water storage projects. Consequently, this IAIR serves to document the status of water storage investigations conducted to date. It provides a framework for tracking more detailed planning stages and updating the framework as water storage investigations are completed, projects are implemented, or circumstances in the Klamath Basin change.

1.1 Purpose for Investigations

Limited water supplies and increasing demands for water throughout the Klamath Basin have led to competing water needs and conflicts between the Upper and Lower Klamath Basins during times of water shortages. These conditions present difficult and contradicting objectives for Reclamation water operations.

Short term seasonal storage of excess annual runoff for use later in the year, and extended carryover water storage during wet years for use later during dry years could both help to alleviate critical water shortage problems. Water storage costs and benefits depend on many factors including site conditions, conveyance needs, and surface or groundwater facilities. As a result, preliminary studies are essential before undertaking detailed design planning efforts.

This investigation was undertaken to gather information on water storage options and conduct preliminary level planning studies to evaluate options equitably. The overall purpose is to screen storage options with the greatest potential to improve supply reliability and better integrate essential water and environmental resources. This IAIR documents the UKBOS studies and investigations that are an interim step in the Reclamation planning process that identifies storage options recommended as initial alternatives that could be considered in subsequent alternative formulation and planning.

1.2 Study Basis and Authorization

In 2006, Reclamation initiated the UKBOS investigation and feasibility study under the authority of the Klamath Basin Water Supply Enhancement Act of 2000 (Enhancement Act). UKBOS investigations and related planning studies represent an essential first phase in formulating alternatives for further analysis in a feasibility study.

> Appraisal studies, special studies, and/or technical investigations and reports are authorized under Federal Reclamation Law (Act of June 17, 1902, 32 Stat. 388, and acts amendatory thereof of supplementary thereto). However, feasibility studies cannot be initiated until specifically authorized in accordance with the Federal Water Project Recreation Act (Public Law 89-72, Section 8; 79 Stat. 217).
>
> (CMP 05-02; Reclamation, 2000).

General authority and requirements for planning studies through the preliminary, appraisal, and feasibility stages are outlined in Reclamation Directives and Standards (D&S) CMP 05-0, quoted in the box on this page. The UKBOS investigations have general and specific authority in supporting the Enhancement Act objectives.

Reclamation has a history of management and involvement in water-related resources issues in the Klamath Basin since the original construction of the Klamath Project—a Federal water project constructed in the early 1900s that is Reclamation manages to deliver water for agriculture in the service area south and east of Upper Klamath Lake (UKL). Implementation of Endangered Species Act biological opinion (BO) requirements since the mid-1990s have resulted in growing demands throughout the basin and occasional conflicts between competing water needs, particularly during times of water shortages. Official determinations regarding endangered fish species have led to additional criteria for instream flows and lake water levels that pose complicated constraints on existing water systems.

Water storage is one of the most direct, reliable, and significant ways to provide supplemental water for later use when no surplus flows or optimal water supplies are available. In the last 20 years or more, many different storage schemes have been proposed in the Klamath Basin ranging from localized seasonal methods to

Klamath Basin Water Supply Enhancement Act of 2000; Public Law 106–498

SEC. 2. AUTHORIZATION TO CONDUCT FEASIBILITY STUDIES.

In order to help meet the growing water needs in the Klamath Basin, to improve water quality, to facilitate the efforts of the State of Oregon to resolve water rights claims in the Upper Klamath Basin including facilitation of Klamath tribal water rights claims, and to reduce conflicts over water between the Upper and Lower Klamath Basins, the Secretary of the Interior (hereafter referred to as the ''Secretary'') is authorized and directed, in consultation with affected State, local and tribal interests, stakeholder groups and the interested public, to engage in feasibility studies of the following proposals related to the Upper Klamath Basin and the Klamath Project, a Federal reclamation project in Oregon and California:

(1) Increasing the storage capacity, and/or the yield of the Klamath Project facilities while improving water quality, consistent with the protection of fish and wildlife.

(2) The potential for development of additional Klamath Basin groundwater supplies to improve water quantity and quality, including the effect of such groundwater development on nonproject lands, groundwater and surface water supplies, and fish and wildlife.

(3) The potential for further innovations in the use of existing water resources, or market-based approaches, in order to meet growing water needs consistent with State water law.

(Source: Enhancement Act; Public Law 106-498, 2000)

store runoff for release later in the year to meet annual shortages to larger-scale projects that involve carryover storage to release water during multiyear drought conditions. Previous studies have ranged from initial concept formulation to detailed, site-specific engineering planning investigations.

In 2000, the Enhancement Act was passed to support planning investigations that could help to resolve critical water supply problems and reduce water conflicts throughout the Klamath Basin. Section 2 of the Enhancement Act (quoted in the box on this page)—as directed by the Secretary of the Interior (Secretary)—authorizes Reclamation to conduct feasibility planning investigations. In 2006, Reclamation initiated the UKBOS investigation specifically to address provisions in Section 2 concerning proposed measures that could be implemented to increase the water storage capacity and/or yield of the Klamath Project facilities.

To further uphold these provisions, Reclamation's Mid-Pacific Regional Director, with concurrence from the Department of Interior Solicitor, signed waivers approving the UKBOS study process as conducted under the terms of the Enhancement Act to proceed up to completing feasibility studies without requiring Reclamation to secure cost-sharing with potential stakeholders according to guidelines in the Reclamation D&S; CMP 05-01, Section D.

These UKBOS studies are under way to assess if there is a Federal interest in any proposed measures (Sections 2 and 3 of the Enhancement Act) to improve water supply reliability upstream and downstream, provide added fish and wildlife benefits, provide water for Klamath Project agricultural uses, and offer potential furtherance of tribal trust responsibilities. The findings discussed in this IAIR meet the Enhancement Act directives by documenting studies to find viable options for additional surface water or groundwater storage or other means such as conjunctive use or water-trading programs employed to increase the water available in the Upper Klamath Basin during times of water shortage.

1.3 Reclamation Planning Process

Guidelines for conducting studies to support feasibility decisions are embodied in the Reclamation planning process for implementing water resource projects using Federal funding. Major stages leading to project implementation include project planning (through feasibility level), construction, and long-term operations and maintenance. The project planning process breaks down further into three basic levels—preliminary, appraisal, and feasibility—that culminate in the approval of the feasibility report and associated environmental compliance documents.

This IAIR is an interim document of the authorized feasibility study process that identifies, discusses, and examines measures to address the need for water storage in the Upper Klamath Basin. Many storage concepts have been identified previously through independent studies and as part of interagency efforts such as the Klamath Basin Water Supply Initiative and this UKBOS study. Consequently, the IAIR is an important means to apply a consistent basis for screening the array of potential storage options identified to date. After priority options have met the initial screening criteria, the IAIR can help in tracking priority options that are carried forward and refined in subsequent appraisal and feasibility investigations.

1.3.1 Overview of investigation stages

Major stages involved in the Reclamation project planning process are illustrated in the schematic diagram in table 1-1. On the left side, the project status column shows the three phases of planning, construction, and ongoing operations and maintenance (O&M) required for implementing water resource facilities. The planning phase is broken down further in the right column to the three main planning levels. Each major milestone (e.g., feasibility or final design) frequently involves other activities or steps not shown here. However, for the purposes of this IAIR, this diagram gives a good conceptual picture of the project planning sequence.

The remaining discussion focuses on the primary planning stages—preliminary, appraisal, and feasibility. These stages represent the sequence for progressively formulating features and details for identified alternatives and refining the level of information, potential impacts, and economic factors that are used to compare and evaluate potential alternatives or options.

Preliminary investigations are completed as appropriate to screen potential concepts or strategies and identify viable options or priorities for moving on to appraisal level. Preliminary studies are intended to use available data although this can involve a range of information collection or technical studies, as needed, to equitably define options. Design details are often not developed to support accurate itemized cost estimates. Therefore, preliminary estimates are limited to screening purposes. Although not a required part of the Reclamation planning process, preliminary screening is often an essential way to narrow an extensive range of options so that resources are efficiently allocated first to the most promising options for more detailed planning stages.

Appraisal studies examine alternatives equitably including sufficient plan detail development to support initial economic analyses. Appraisal studies are based on having at least one potentially viable solution that warrants Federal involvement and use existing information to develop plans for meeting current and projected resource needs.

Thus, appraisal studies are a secondary series of investigations used primarily to determine the viability (e.g., technically or economically) and interest in proceeding with feasibility studies. Findings summarized in an appraisal report include recommendation to either proceed to the feasibility level or terminate studies for a given alternative. The appraisal report also describes important information needs and potential issues that could affect the feasibility scope (Reclamation, 2008).

Table 1-1.—The Reclamation planning process—a schematic diagram of project development stages from initial planning through project construction and long-term operation and maintenance. Reclamation Manual FAC09-0.

Project status	Project stage	Level of cost estimate produced
Planning	Planning	**Preliminary**
		Appraisal
		Feasibility
Construction	Design	Percent design (updated feasibility)
		Prevalidation of funds
	Solicitation	Independent government cost estimate (award)
	Construction	Independent government cost estimate for contract modifications
Operation and maintenance	Operation	One or more of the previously defined estimates

Feasibility studies represent the culmination of all data collection and analysis for viable alternatives, and Reclamation has definitive requirements for the scope and documentation of feasibility planning (see the box on the next page). Reclamation water facility projects extend the term feasibility beyond the traditional scope applied in private practice civil engineering project design. There are several reasons for this particular aspect of Reclamation feasibility studies. Feasibility studies are detailed investigations that are used to support decisions to seek congressional authority and appropriations for project implementation.

Feasibility attributes—

Feasibility studies include data collection and analyses to develop and consider a full and reasonable range of alternatives. Feasibility studies [are] conducted consistent with Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.

The feasibility process will include such items as: the identification of present and future conditions, identification of problems and needs, evaluation of resource capabilities, formulation of alternative plans, analysis and comparison of alternatives, and plan selection.

Feasibility studies [are] normally integrated with compliance under the National Environmental Policy Act (NEPA), Fish and Wildlife Coordination Act, Endangered Species Act, National Historical Preservation Act (NHPA), and other related environmental and cultural resource laws. Feasibility studies also comply with State, Tribal, and local environmental and cultural resource laws and ordinances, as appropriate.

(CMP 05-02; Reclamation, 2000).

For these purposes, feasibility studies generally involve the collection of critical plan data, environmental impact and compliance review, participation by public agencies and entities, and defined economic considerations. The final feasibility report, environmental documentation, and compliance reports also become the principal supporting documentation for Congress.

Cost estimates are progressively refined at each project planning stage as indicated in table 1-1. Feasibility level cost estimates must support budget appropriation requests, and consequently, engineering designs for feasibility alternatives are highly detailed—extending well into final design, as necessary, to support accurate itemized cost estimates and economic analyses.

Another area in which Reclamation feasibility efforts differ from typical industry practices is that compliance with the National Environmental Policy Act (NEPA) of 1969 is investigated to coincide with the feasibility planning process. The NEPA process involves thorough review of potential resource impacts for alternatives and is often an iterative process to adjust the proposed features or components to mitigate impacts when possible. The NEPA and feasibility activities are also conducted to have public review at key stages. Reclamation has specific guidelines for preparing feasibility reports (Reclamation, 2008). These pertinent findings from feasibility planning and the NEPA compliance process are summarized in final feasibility and NEPA reports or an integrated feasibility-NEPA document.

1.3.2 Iterative UKBOS-IAIR framework

Historic activities in the Upper Klamath Basin leading into the Enhancement Act and UKBOS, and the interactive planning process between preliminary, appraisal, and feasibility stages are illustrated in table 1-2. In the 1980s, basinwide water supply problems and storage needs were recognized, and various options were considered to alleviate shortages. In the 1990s, the Klamath Basin Water Supply Initiative (KBWSI) identified several storage options, and since 2000, UKBOS has formulated and compiled information on additional options.

Table 1-2.—Schematic diagram showing Upper Klamath Basin historic water resource planning activities leading to the present UKBOS-IAIR planning framework

Dates, stages	**Historic events and UKBOS-IAIR framework planning stages**
Pre–1980s	Upper Klamath Basin water resource issues and stakeholder activities ↓ *(Basinwide water supply problems and storage needs raised)*
1980s	Riker Report cites options to address Klamath Basin water constraints ↓ ↓ *(Upper Klamath Lake dredging and other minor options)*
1990s	KBWSI water supply planning ↓ ↓ ↓ *(Identified water supply options including storage)*
2000	Klamath Basin Water Supply Enhancement Act of 2000 enacted ↓ ↓ ↓ ↓ *(Initiates Klamath Basin feasibility Studies)*
Present: **UKBOS—IAIR**	Upper Klamath Basin Offstream Storage planning studies begin ↓ ↓ ↓ ↓ ↓ *(Compile and review all storage options)*
Preliminary— Plan formulation, reconnaissance studies, review data, and screen options	UKBOS preliminary investigations reviewed and evaluated previous and current water storage options. The scope of investigation for options depends on information available, technical complexity, and institutional or economic factors. KBWSI viable storage options updated and evaluated with suboption variants ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ UKBOS storage options and related suboptions consistently evaluated – IAIR documents UKBOS studies results ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
Appraisal— Alternatives are evaluated equitably including initial economics and critical resource implications Iterative studies to optimize and refine appraisal	***Example 1*** <u>Gerber Reservoir</u> Appraisal studies showed raising the dam to expand storage would not produce adequate supply benefit to justify costs; planning was terminated at this stage. No further planning efforts expected at this time. ***Example 2*** <u>Long Lake Valley</u> Appraisal report completed 2010 indicated water supply benefits do not justify costs. Congressional direction is necessary for any further appraisal studies initiated to refine analyses or optimize features and reassess the economic aspects. ↕ ↕ ↕ Examples include studies on hydrologic operations, power generation, or water quality attributes. ↕ ↕ ***Example 3*** <u>Aquifer storage</u> Preliminary studies found potential aquifer storage and recovery (ASR) locations. ↓ ↓ ↓ Further studies required to formulate site-specific ASR alternative features. ↕ ↕ To be determined
Feasibility— Design planning, itemized costs, economics, and resource impact assessments	Feasibility not viable at this time. Feasibility planning would depend on modified, updated appraisal findings and Congressional review and approval. ↕ ↕ To be determined

The lower part of the schematic (table 1-2) illustrates the iterative process within each stage and between stages. A number of KBWSI and UKBOS options are at preliminary data collection and screening stages. A few storage alternatives have advanced to appraisal level (indicated by examples). UKBOS alternatives would have to be proven viable to proceed with feasibility planning.

At each planning level, different types of data collection, technical investigations, and analyses are applied based on the characteristics and circumstances associated with a given option or alternative. For example, viable preliminary options could advance to formulate appraisal alternatives and ultimately be selected for detailed feasibility design planning investigations. The level of uncertainty is reduced and the accuracy of analytical results and cost estimates rises at each stage.

Different aspects of this iterative planning process are indicated in the examples shown under the appraisal category (table 1-2). In the first example, an appraisal study was conducted to examine the potential to increase the storage capacity at Gerber Reservoir by raising the dam. In this case, the benefits did not justify the costs. No potential adjustments were identified, and planning investigations were discontinued. The second example indicates that appraisal studies completed in 2010 for the proposed Long Lake Valley (LLV) reservoir showed inadequate economic justification. Congressional direction would be required to undertake further LLV studies for reconsideration with other UKBOS options. The last example involves implementing aquifer storage and recovery (ASR) technology at identified sites in the Klamath Basin study area. In this case, the diversity among ASR locations, variable underground conditions, and different schemes for groundwater recharge and recovery cycles require an extensive series of preliminary data collection and applied research studies to develop and screen potential ASR options with respect to identified UKBOS surface water storage options.

This IAIR serves a key role in the iterative planning process to assess and identify priority options and in doing so, narrow the range of alternatives that are carried to more detailed appraisal and feasibility stages. The IAIR framework bridges the preliminary and appraisal stages by screening options to identify high priority initial alternatives. The commencement of any level of planning does not guarantee advancement to subsequent planning. However, the IAIR framework provides a systematic means to assess the array of UKBOS options and update the viability or priorities periodically at each stage of the planning process.

1.3.2.1 Preliminary planning investigations

Preliminary planning formulates strategies, develops storage facility components, identifies key concerns or data gaps, and collects data for screening against other options. In this case, several water storage options were proposed as part of the KBWSI planning efforts, and other storage options have been assessed separately as developed by Reclamation staff or proposed by sponsor stakeholders. During the initial UKBOS studies, added storage options were indentified. The IAIR describes all of the surface and groundwater options and compares them against basic criteria.

Preliminary activities are undertaken to identify priority options fundamental to the UKBOS study objectives and screening criteria, determine which options offer the best potential to meet the resource purpose and need, designate the selected specific options to move to more advanced planning studies as initial alternatives, and define the scope of work, schedule, and budget to accomplish the subsequent appraisal studies for priority storage options.

1.3.2.2 Early appraisal—planning studies

Basic data and available information for defined storage alternatives are collected, compiled, and analyzed. This could include conducting limited studies to define irrigation and normative instream flow criteria—for example, determining water needs for agriculture, fisheries, municipal and industrial uses; defining potential water supply shortages to meet the needs listed; assessing the water availability in the Upper Klamath Basin for short- or long-term storage; evaluating the capacity of UKBOS options to store water to meet defined time and demand criteria. At this stage, it would also be important to identify the Klamath Basin water users who are capable of receiving water from the identified UKBOS alternatives.

1.3.2.3 Final appraisal—plan formulation

Before proceeding to feasibility, the final appraisal analysis involves formulating identified plan elements to consider the future without water storage project and the future with water storage (for identified alternatives) scenario. At least one viable alternative plan is identified to carry forward into more detailed feasibility investigations. If no UKBOS options advanced further than appraisal study level, the appraisal study report with plan formulation (or supplemental plan formulation report) would serve as an interim document to advise Congress of appraisal completion under Section 3(d) of the Enhancement Act and also include any potential recommendations for subsequent planning stages.

The IAIR framework tracks and carries prospective alternatives through to the final appraisal plan formulation. Although potential issues and information needs are identified during prefeasibility stages, these studies do not replace the required full compliance assessments that are finalized during feasibility.

1.3.2.4 Feasibility and environmental analyses

Reclamation planning studies add increasingly accurate information and refined analysis. A number of investigations and planning activities involved at the feasibility stage are required to complete the NEPA compliance process and to make the request for Congressional action. Typical activities include:

- Alternatives analysis.—Viable alternative plan(s) are developed and analyzed including adequate data collection and engineering design to delineate critical features and support cost estimates and economic analyses of appropriate accuracy.

- Draft feasibility documents.—The draft final feasibility report (FR) / NEPA compliance documents are prepared during a NEPA public review and comment period, and agency staff responses to those comments.

- Final FR/NEPA compliance documents.—All final FR/NEPA documents are reviewed and certified (Reclamation D&S). Certification would be necessary even if the final feasibility report recommended no further Federal interest because that report would serve to advise Congress of Enhancement Act studies status.

- FR/NEPA compliance document and Congressional action.—The Department of the Interior and the Office of Management and Budget review and submit the documents to Congress under Section 3(d) of the Enhancement Act to request funding and authority (based on feasibility findings) to construct and implement the project.

1.3.2.5 Construction and implementation

After feasibility, full project implementation involves many other activities that are associated with final design plans and specifications, property acquisition, and construction contracting and management. Reclamation guidelines are available for these activities separately.

1.3.3 Planning scope of UKBOS-IAIR

The remaining focus of this UKBOS-IAIR is on preliminary and appraisal planning stages with the primary focus on preliminary studies stage.

1.4 Existing Agreements and Constraints

Certain fixed constraints, planning activities, laws, and regulations have important implications for any further UKBOS planning. The prominent agreements, constraints, and provisions that are currently identified include:

- Klamath Basic Restoration Agreement (KBRA) provisions and actions

- Endangered Species Act (ESA) and BO determinations and requirements

- Klamath Project operational implications (project or non-project water users, potentially impacted species, and tribal trust responsibilities)

- NEPA compliance process and requirements considerations

- Reclamation internal directives, guidelines, policies, and procedures

- Other applicable institutional or regulatory provisions (e.g., the Clean Water Act, the Safe Drinking Water Act, or State or local requirements)

The KBRA, signed in 2010, is a comprehensive settlement agreement that affects nearly all water-related activities in the Klamath Basin. The KBRA was prepared to help resolve longstanding conflicts concerning basin water resources by agreement between stakeholders and recognizing crucial relationships between water and environmental resources. The scope of the KBRA is both the Upper and Lower Klamath Basins and many interrelated water supply aspects including removing four hydropower dams on the Klamath River, maintaining instream flows for fish, ensuring reliable water supplies for irrigation, reintroducing salmon in the upper basin, large-scale habitat restoration throughout the basin, legal safe harbor for participating farmers and ranchers, renewable and affordable energy options for agricultural communities, economic revitalization for tribal communities, and establishment of a council to coordinate watershed issues. The agreement is complex and not addressed here in detail; nevertheless, the KBRA could influence almost any water storage options identified through the UKBOS studies.

Water-related ESA issues in the Klamath Basin include two endemic fish species in UKL and one species in the lower basin. These issues are integrally tied to Klamath Project operations related to UKL water storage levels, Klamath River flows, and Project irrigation water supplies. The U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS) issued official BOs concerning Klamath Project operational implications on listed species (FWS, 2008; NMFS, 2010). Added storage from the UKBOS options could influence conditions for endangered fishes, and the operational characteristics for any proposed UKBOS options would require evaluation of potential ESA implications. In addition, although water operations are more directly linked to fishery habitats, the implications of UKBOS options on terrestrial listed species and tribal trust responsibilities would likely require additional environmental evaluation and compliance (i.e., NEPA, National Historic Preservation Act, CWA compliance, etc.).

For viable alternatives identified in the IAIR that proceed to the appraisal level of study, the studies necessary for NEPA compliance would likely be initiated during the final appraisal stage and extend into feasibility planning. If Federal interest were determined to be a positive outcome of appraisal studies, Reclamation would proceed with a combined feasibility study and NEPA compliance effort under the Enhancement Act.

The UKBOS study process is primarily at the preliminary level. As a result, any potential issues identified in the studies and documented in the IAIR or early appraisal investigations do not circumvent or replace required environmental compliance processes.

Reclamation internal directives, guidelines, policies, and procedures are important considerations that affect all UKBOS planning activities. several pertinent aspects of these internal procedures affect the IAIR. For example, all environmental documentation must be consistent with Federal *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G; WRC, 1983) and Reclamation directives and standards (Reclamation D&S).

The Reclamation Manual D&S and P&Gs provide guidelines for data collection, conducting investigations, and documenting findings in an appraisal or feasibility report. All UKBOS findings and any subsequent appraisal or feasibility planning activities will adhere to applicable internal Reclamation requirements.

Other institutional or regulatory factors could include applicable water rights laws or environmental requirements. For example, certain Clean Water Act provisions define water quality standards to protect aquatic life, require permits for any outflows into designated Waters of the United States, and require permits for working in jurisdictional wetlands. Any active injection recharge into a defined potable aquifer must meet requirements of the underground injection control (UIC) provisions of the Safe Drinking Water Act. In many instances, regulations pertaining to water resource activities are administered by State agencies. In addition, other legal, institutional, or economic factors may apply under specific circumstances.

These provisions could apply to a given storage site, option, or strategy, and all alternatives moved from the UKBOS studies forward to higher planning studies as documented in this IAIR will require review to identify and address applicable regulatory statutes or legal determinations. It should again be noted that just because a concept is advanced to a higher planning level does not imply that concept will be advanced all the way through the planning process to implementation. The planning process steps are each a pass/fail test mechanism.

1.5 Study Area and Scope of the IAIR

The primary study area for UKBOS investigations encompasses the Upper Klamath Basin, defined as the Klamath River's watershed upstream from Keno Dam plus the small Spencer Creek watershed as shown in figure 1-1. This study area includes four subbasins—the Williamson Basin, Sprague Basin, Lost Basin, and directly contributing areas around Upper Klamath Lake and the Klamath River between Link River Dam and Keno Dam. The primary study area includes 6,780 mi^2 of lands.

The extended study area also includes the Lower Klamath Basin (border line in figure 1-1). Although the UKBOS studies focus on water storage opportunities in the primary upper basin study area, identified storage alternatives are evaluated

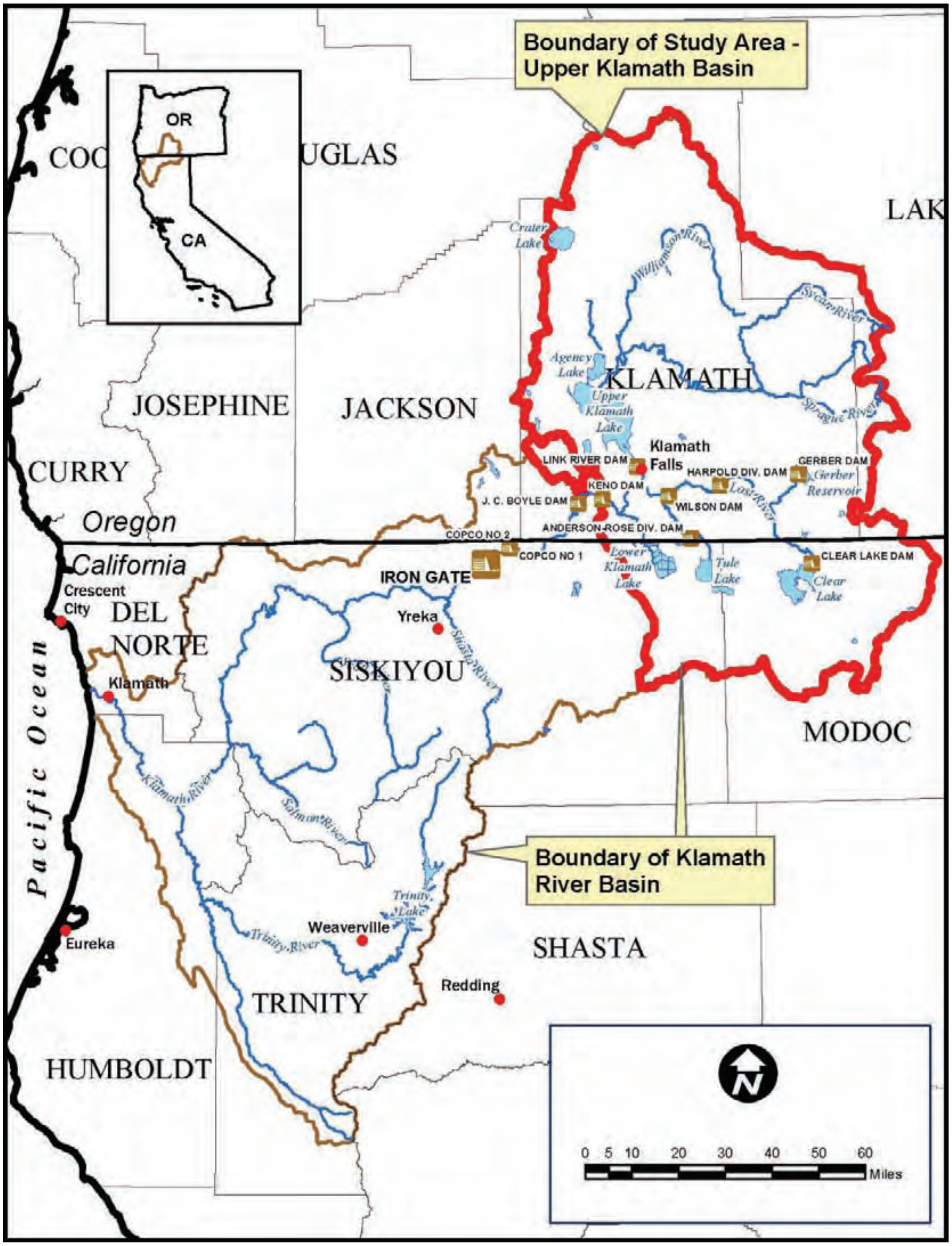


Figure 1-1.—UKBOS study area (thick red line), and extended lower Klamath Basin study area (fine brown line).

with respect to water resource conditions throughout the Klamath Basin to reduce conflicts over water between upper and lower basins.

Storage options identified in the UKBOS studies and documented in this IAIR could enhance the flexibility for managing water in providing for irrigation;

improved water quality where possible; fish and wildlife needs; furtherance of tribal trust responsibilities; and conjunctive use of surface and groundwater resources. Carryover storage could potentially provide additional water supply during limited drought periods and could also assist with optimizing hydropower operations. Additional storage could increase both water operations flexibility and water supply reliability for the Klamath Project and Klamath Basin as a whole.

Numerous water supply studies have been undertaken in the study area including strategies pertaining to water storage. These storage options have been proposed by water users, working teams, stakeholders, or resource agencies. Reclamation has identified and formulated additional storage options during the course of UKBOS investigations. The information available and level of detail vary among studies depending on circumstances at the time of the studies.

In some cases, initial assessments by Reclamation found important issues or barriers that led to elimination of certain options during early planning review. In other instances, preliminary studies have recommended continuing with more detailed appraisal investigations.

This IAIR is intended to assist in gathering and screening information on the array of storage options. The primary objectives for the IAIR include:

- Compiling available information on water storage studies that have been completed to date and remain as viable options.

- Developing additional storage options and equitably performing screening evaluations on all potentially viable options.

- Identifying option priorities identified as initial alternatives for more detailed planning stages (subject to authority and funds available).

The overall goal of this IAIR is to summarize the status and findings for identified storage options in a practical framework that can guide future planning and facilitate periodic review and updating as appropriate.

1.6 Report Contents and Organization

This IAIR document summarizes relevant UKBOS background, screening criteria applied, attributes of the UKBOS options, preliminary cost estimates and potential issues for further review, and leading priority options that are identified for continuation into advanced planning stages.

This IAIR contains these key topics:

- Section 1.—Outstanding problems, needs, and opportunities; UKBOS study authority and planning process; possible constraining factors that influence the UKBOS studies; and the study area and scope of the IAIR.

- Section 2.—Background on the study area conditions; water operations; history of water and environmental resource considerations; water storage needs; and conditions expected without water storage.

- Section 3.—Information on previous water storage studies; initial screening of storage options; and the status of the UKBOS storage options.

- Section 4.—Preliminary formulation methods and criteria; level of engineering development; water operations modeling used to assess water supply benefits; water treatment factors; and identification of the UKBOS options to be further evaluated and included and discussed in this IAIR.

- Section 5.—Description, characteristics, and status for the individual UKBOS storage options examined in this IAIR at a preliminary level.

- Section 6.—Preliminary cost estimates; defined water supply benefits; potential issues for further investigation; findings comparison between UKBOS options assessed; unresolved issues and information needs.

- Section 7.— Findings and conclusions of the UKBOS studies and evaluations; priority UKBOS options identified; further plan formulation needs; appraisal process and schedule considerations; and specific recommendations for future action.

2.0 Study Area Background

In many ways, the Klamath River is the reverse of most river systems. Initially, the headwaters flow through relatively flat, open country, later flowing through mountainous areas and growing larger with cold water from the major tributaries. The convergence of the Pacific, Juan de Fuca, and North American tectonic plates at or near the Klamath Basin influenced this unusual river course. The Klamath River passes through four distinct geologic provinces, (1) the Basin and Range Upland, (2) the Cascades, (3) the Klamath Mountains, and (4) the Coast province.

Section 2 Topics:

- *Description of the study area geography, land uses, existing resources, and climate conditions*
- *Klamath Project service area, history, and major water service facilities*
- *History of water and environmental resource issues in the study area*
- *Focus on water storage as a critical need to reduce water shortages in the Klamath Basin*
- *Future without storage project conditions*

Accordingly, the river has warm, flat portions upstream, while the downstream portions tend to be cold and steep. The Klamath River from the Oregon-California State line to downstream from Iron Gate Dam is a predominantly nonalluvial, sediment-supply-limited river flowing through mountainous terrain. Downstream from the dam and for most of the river's length to the Pacific Ocean, the river maintains a steep, high-energy, coarse-grained channel frequently confined by bedrock.

Forests dominate the study area, the 6,780-mi^2 Upper Klamath Basin, which encompasses the Klamath River watershed at and above the river's confluence with Spencer Creek. This semiarid region averages 13.5 inches of precipitation per year and 20- to 125-day growing seasons depending on the 3,800- to 9,500-foot range of elevations. The area is seismically active, although earthquakes probably would not affect aquifers.

The Upper Klamath Basin, together with the Lost River subbasin, encompass the Klamath Project in southern Oregon and northern California. The Project provides water for both agricultural and National Wildlife Refuge lands and provides flood control along the Klamath River, and in the Lost River and Tule Lake subbasins. The Secretary authorized the Klamath Project on May 15, 1905, in accordance with the Reclamation Act (43 U.S.C. S 372 *et seq*, Act of June 17, 1902, 32 Stat. 388). The Klamath Project generally provides water to approximately 200,000 to 240,000 (Reclamation, annual) acres of agricultural lands. On average, annual net water use on the Klamath Project is approximately 2.0 acre-feet per acre (Reclamation).

Droughts in the early 1990s first drew attention to water distribution. Since then, Reclamation has been required to distribute more water for endangered fish species, prompting Reclamation's UKBOS program, with its dozens of concepts, and other efforts to increase water supplies.

Without increasing water supplies or storage, conflicts between uses would continue, endangered fish could lose critical habitat, damage to the agricultural economy in the Upper Klamath Basin could continue, and the region would lose an opportunity to mitigate long-range reductions in water supplies due to climate change.

2.1 Upper Klamath Basin Watershed

The study area (figure 2-1) is the portion of the Klamath Basin above Keno Dam, known as the Upper Klamath Basin, which encompasses approximately 6,780 mi^2 or 4.3 million acres. This area additionally includes the Spencer Creek drainage, tributary to the Klamath River just below Keno Dam, so that the Buck Lake storage option can be included.

This area is part of the East Cascades Ecoregion that spans the eastern slope of the Cascade mountain range from south central Washington to northern California.

2.2 Existing Conditions, Climate, and Land Use

2.2.1 Natural features and land uses

Approximately 70 percent of Klamath County is forested. More than half of the forested land is publicly owned, with 44 percent of these public lands located in the Winema National Forest. The area's diverse landscape supports a wide variety of biological communities. The eastern slopes of the Cascades host abundant fir forests, while pine and juniper thrive on the ridges of the east plateau.

2.2.2 Climate and basin hydrology

The climate of the Upper Klamath Basin is characterized as semiarid with moderate temperatures, including winters with moderate to low temperatures. About two-thirds of the precipitation in the basin falls as snow between October and March. The annual long-term average snowfall in Klamath Falls is about 41 inches per year. Crater Lake (62 miles northwest of Klamath Falls) averages about 521 inches of snow annually. Average precipitation ranges from as little as 10 inches at lower elevations to more than 70 inches in the mountains to the west. The mean yearly precipitation from 1961 to 1990 was 13.5 inches as measured at Klamath Falls.

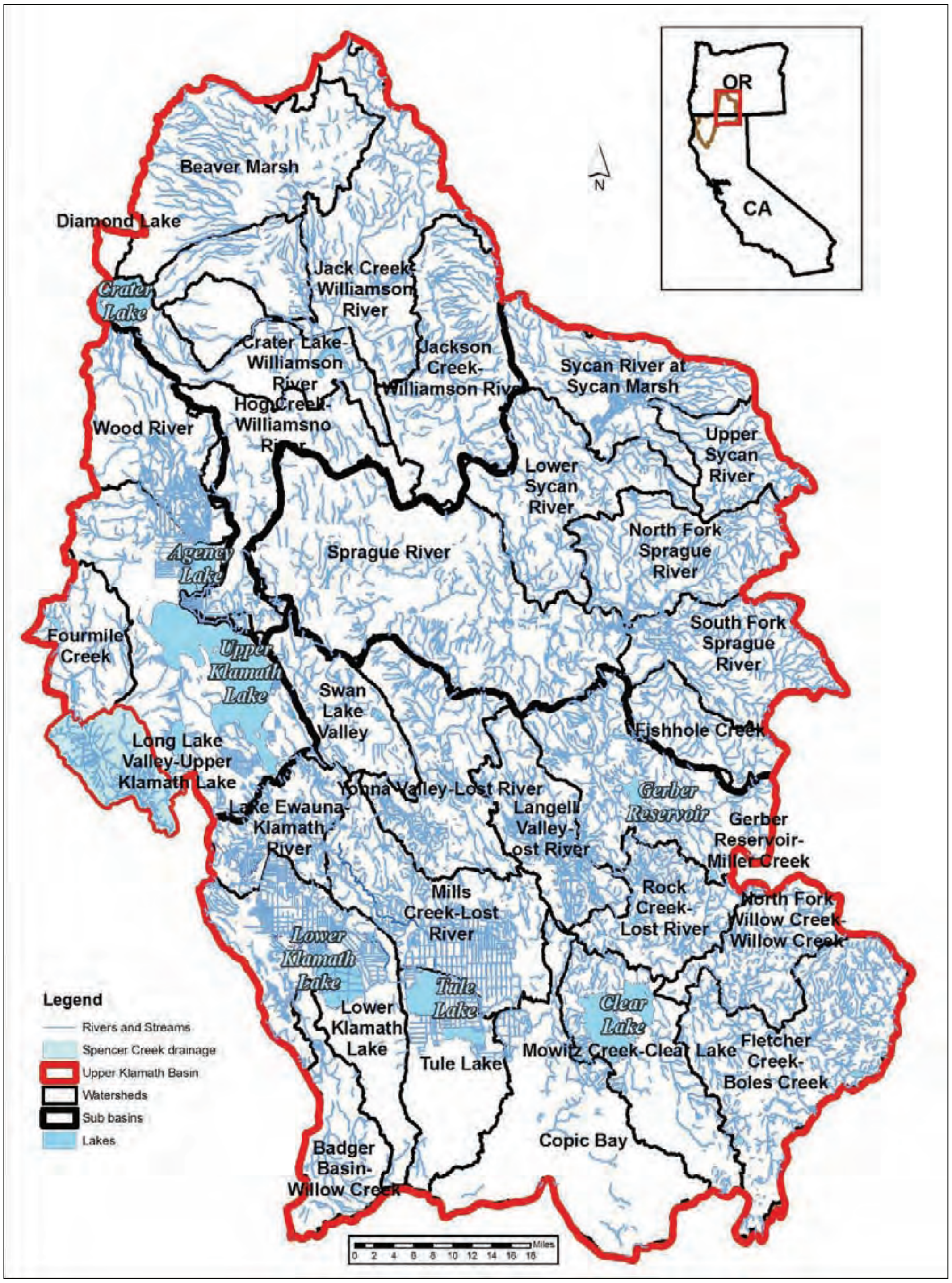


Figure 2-1.—Location map showing the UKBOS study area encompassing the entire Upper Klamath Basin and one smaller watershed—the Spencer Creek drainage (western side)—and overall location in southern Oregon and northern California.

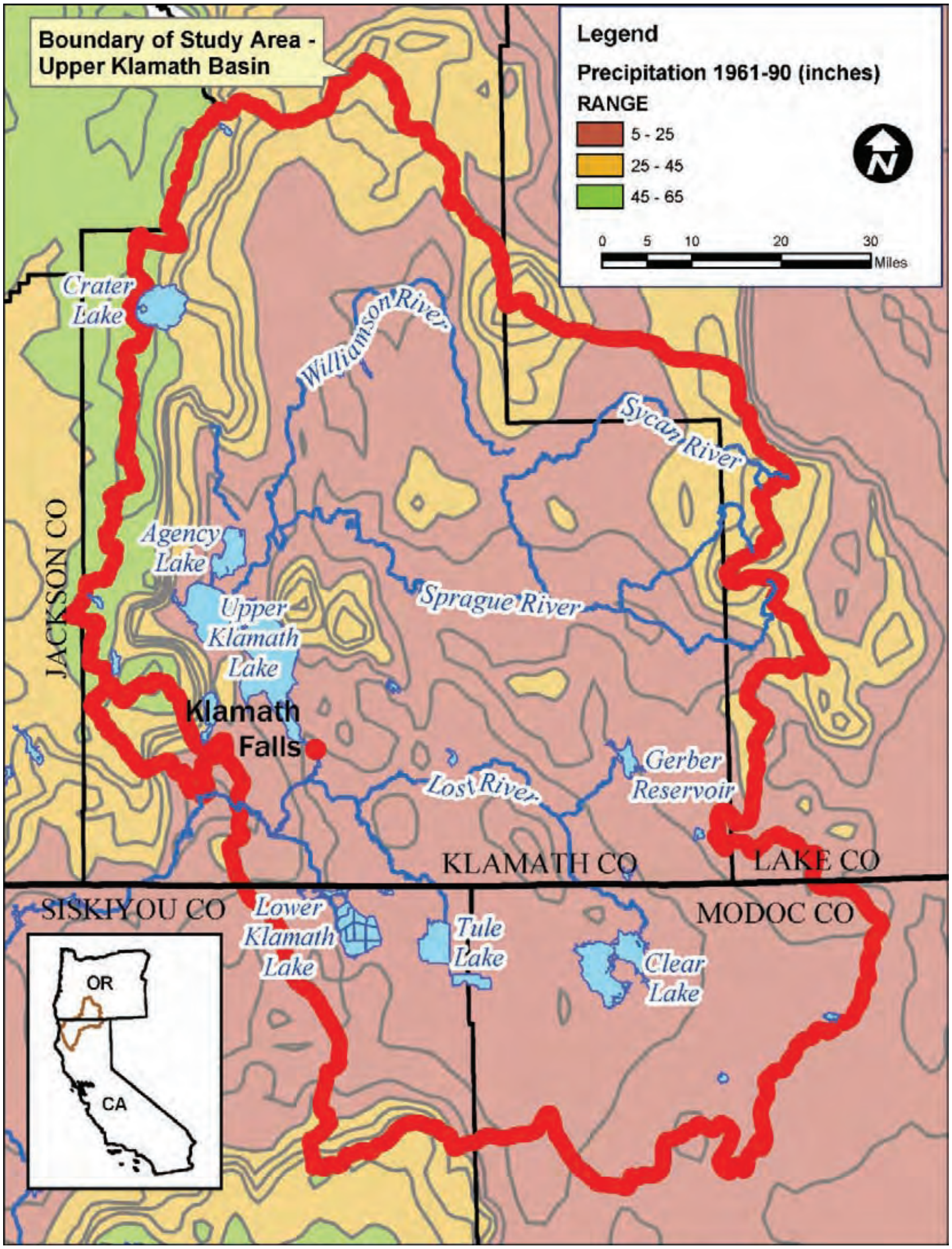


Figure 2-2.—Upper Klamath Basin average annual precipitation.

Killing frosts have been recorded throughout the basin in every month of the year. As a result, growing seasons range from 20 to 40 days at higher elevations to 100 to 180 days in low-lying areas. Thus, climate is the limiting factor upon the variety of crops that can be grown in most parts of the basin.

The ecoregion, as a whole, is characterized by volcanic geology (basalt flows with ash and pumice deposits) dominated by pine forests. Elevations in the basin range from 3,800 to about 9,500 feet above sea level. The remaining lands form the northernmost part of the Great Basin, a semiarid high desert plateau ranging from 4,000 to 6,000 feet in elevation.

The hydrology of the Upper Klamath Basin has a complex history. Upper Klamath Lake is one of the few surviving Pliocene (about 5 million years ago) lakes and perhaps the only functional Pliocene lake, with normal alkalinity and a large amount of relict fauna.

2.2.3 Geology and seismic issues

There are seismic risks to above-ground storage features. The area around Klamath Falls is considered seismically active (Zone 3), and maximum credible earthquake magnitudes, duration of shaking, and earthquake return periods have been determined by Reclamation. Geologic features in the basin indicate that relatively recent seismic activity has severely shaken the area.

Structures (i.e., pumping plants, tunnels, outlet work structures, etc.) would have to be designed to withstand earthquakes of the magnitude determined and continue to function reliably throughout their design life. Liquefaction, slumping, or settlement of dikes and levees composed of low-strength fill may take place during severe seismic shaking.

Underground aquifers in the Klamath Falls area have undergone tens of thousands to millions of years of exposure to local seismic events. Most of the material hosting these aquifers has probably settled as much as it naturally will. There may be a greater risk of damage to underground aquifers, and their capacity to store and yield water, by improper well development and improper operational pumping than by future seismic activity.

2.3 Klamath Project Historical Background

The Klamath Project is located in the Upper Klamath River and Lost River sub-basins in southern Oregon and northern California. The Klamath Project provides irrigation water for both agricultural and National Wildlife Refuge lands, and provides flood control in the immediate area of the Klamath Project, in the Lost River and Tule Lake sub-basins, and also downstream of the Klamath Project.

Prior to Klamath Project development, which began in 1905, agriculture in the surrounding area was limited. Between 1905 and the 1960s, wetlands (formerly called swamp lands) in the Upper Klamath Basin were reduced from about 350,000 acres to about 75,000 acres (an 80-percent reduction) when these areas were diked, drained, and converted for agriculture by private farmers and ranchers and some portions by Reclamation. In those times, drainage of wetlands was not limited to the Klamath Project. Efforts are under way in the basin to restore some of these former wetland areas. Examples of this are the Agency Lake Ranch/Barnes Ranch property as well as other properties owned by The Nature Conservancy and others. For purposes of the UKBOS studies, the terms "dike" and "levee" are used interchangeably.

Prior to development of the Klamath Project, the two major watersheds (the Klamath and Lost River watersheds) were linked by a flood channel, the Lost River Slough, which allowed water from the Klamath River to enter the Lost River and flow to Tule Lake during high runoff conditions. The two watersheds are now linked by the Lost River Diversion Channel,[1] which facilitates flood control and the use of water by the Klamath Project for both wildlife and irrigation purposes.

The Klamath Project was authorized to drain and reclaim lands from the Lower Klamath and Tule Lakes; to store water from the Klamath and Lost Rivers, including storage of water in Lower Klamath and Tule Lakes; to divert irrigation supplies; and to control flooding on the reclaimed lands.

The Klamath Project historically included approximately 240,000 acres of irrigable lands including additional national wildlife refuge lands (including some wetlands) within Klamath County in Oregon, and Siskiyou and Modoc Counties in California. Klamath Project facilities provide water to approximately 1,400 farms covering about 200,000 acres as well as about 27,000 acres of refuge lands. On average, net annual water use on the Klamath Project is approximately 2.0 acre-feet per acre (Reclamation, annual), including the water used by the FWS in the Tule Lake and Lower Klamath National Wildlife Refuges. Principal crops raised on the Klamath Project include alfalfa, irrigated pasture, small grains, and potatoes. Wildlife benefits derived from Klamath Project operations include water delivery to seasonal and permanent marsh as well as benefits derived from agricultural activities (i.e., grain feed, shelter, etc.).

2.4 Water and Environmental Resource History

Development in the Klamath Basin has affected its water and environmental resources ever since irrigation of agricultural lands in the area now comprising the Klamath Project was initiated in 1882 by private interests with construction of a simple irrigation canal. Private interests further developed the private project by constructing several more canals in 1886, and 1887, which diverted water from

[1] The Lost River Diversion Channel was built as part of the Klamath Project. Specifications can be found in the historic operations report (Reclamation, 2000b).

Link River. By 1903, approximately 13,000 acres were irrigated by private interests.

In 1903, the Reclamation Service made investigations that led, in 1904, to the first withdrawal of land by the Secretary for developing a Federal irrigation project. Early in 1905, California and Oregon ceded certain rights in Upper and Lower Klamath Lakes and Tule Lake to the United States. On May 1, 1905, a board of engineers issued a report that served as the basis for authorization.

After the Secretary authorized development of the Klamath Project in 1905, construction began in 1906 with the building of the main A Canal. Water was first made available May 16, 1907, to the lands now known as the Main Division.

After World War 1 and again after World War 2, returning war veterans were offered the opportunity to homestead on the Klamath Project and considerable numbers did so. Six separate offerings for homesteading were made with considerable promise that lands and water were available to the homesteaders. Currently, there are water rights claims belonging to the Federal Government that are provided through perpetual contracts to the irrigators. There has been little additional development on the Klamath Project since 1960.

The Klamath Project deals with three Endangered Species Act listed species. Lost River and shortnose suckers are found in UKL and in most of the water bodies in the upper basin. The Fish and Wildlife Service listed both species of suckers as endangered in 1988. Coho salmon use the Klamath River below Iron Gate Dam as a link between the ocean and the tributaries where they spawn and rear. The National Marine Fisheries Service (NMFS) listed this species as threatened in 1997.

The drought conditions in the early 1990s resulted in increased interest from outside entities regarding the operation of the Klamath Project. These include Native American Tribes, fishing and environmental organizations, State agencies from both Oregon and California, other Federal agencies, and irrigation districts.

The same drought conditions first brought water limits and environmental resources into focus in the Klamath Basin. Ever-increasing water demands throughout the basin have lead to competing water needs between the Upper and Lower Klamath Basins in times of water shortages. This has presented difficult, contradicting objectives for Reclamation water management operations. For example, when the FWS and NMFS both issued official BOs in 2001 concerning Klamath Project operational effects on species listed under the Endangered Species Act, the provisions of these BOs, coupled with extended dry conditions, forced Reclamation to curtail water deliveries to agricultural water use contracts during the summers of 2001 and 2010.

As a result of the sucker listings, the FWS issued a BO on Klamath Project operations in July 1992. Several additional opinions on Klamath Project operations were subsequently issued by the FWS.

According to the FWS, the suckers need water left in UKL. The conflict arises with the need, as determined by NMFS that the coho salmon need water in the river.

The spring of 2001 saw less than 20 percent of average snowfall in the Klamath Basin. On March 28, 2001 Governor John Kitzhaber issued an Executive Order declaring a state of Drought Emergency in Klamath County. Inflow to UKL was projected to be 108,000 acre-feet, or about 22 percent of the average year inflow of 500,000 acre-feet.

In April 2001, FWS and NMFS issued their respective BOs for 2001 operations of the Klamath Project.

That month, Judge Saundra Armstrong issued an injunction that set the stage for conflict. Among many other things, the Judge's order prevented Reclamation from sending water deliveries to irrigation whenever flows dropped below the minimum flows recommended in the 2001 NMFS BO.

Reclamation's Klamath Basin Office Area Manager responded by issuing a statement announcing that in order to comply with the ESA requirements outlined in the 2001 BOs and tribal trust obligations, water in UKL was sufficient only to support the endangered species and no water would be available for irrigation or wildlife refuges purposes. The BOs had placed conflicting requirements on the distribution of available water, including each other.

This situation was ameliorated, somewhat, by the Secretary in July 2001 when she announced that 75,000 acre-feet of water could be released for irrigation. She enlisted the NAS to review Reclamation's biological assessment and the FWS's BOs.

In February 2002, NAS released their draft report. In the conclusion to their report, NAS said on the basis of its interim study, the committee concluded that there was no substantial scientific foundation, at that time, for changing the operation of the Klamath Project to maintain higher water levels in UKL for endangered suckers or higher minimum flows in the Klamath River mainstem for the threatened coho salmon population.

Prior to the release of the draft NAS report, Reclamation had prepared a draft BA on its upcoming 2002 through 2011 operations. The main ingredient in that draft BA to making the operations work, when coupled with the ESA responsibilities, required that water be withdrawn from agriculture when ESA needs had to be met. After the NAS report was released, Reclamation changed its approach in the

Table 2-1.—Upper Klamath Basin—Timeline of events and planning efforts concerning water and environmental resource issues.

Dates	Description
1882	First irrigation in the Klamath Project area
1904	First withdrawal of land by the Secretary of the Interior for developing a Federal irrigation project
1905	Congress authorizes development of the Klamath Project
1906	Construction began with the building of the main A Canal
1907	Water first made available
1910	Clear Lake Dam and Evaporation Reservoir completed
1921	Link River Dam completed, creating additional storage in Upper Klamath Lake
1925	Gerber Dam and Reservoir constructed
Post-WW I and post-WW II	GIs homesteaded under perpetual water contracts with the Federal government. There has been little development since 1960.
Early 1990s	Drought conditions prompt interest in the Klamath Project from new entities
1988	The FWS lists two species of suckers in the Klamath Basin as endangered
1992	The FWS issues a Biological Opinion on Klamath Project operations
1997	The NMFS lists coho salmon as threatened
Late 1990s	Options for enhancement developed with stakeholder involvement (the KBWSI)
2000	Enhancement Act enacted
March 2001	The governor of Oregon issues an executive order declaring a state of drought emergency in Klamath County
April 2001	The FWS and NMFS issue respective BOs. Judge Saundra Armstrong issues an injunction against full irrigation deliveries.
July 2001	The Secretary announces that 75,000 acre-feet of water could be released for irrigation and enlists the National Academy of Sciences (NAS) to review Reclamation's Biological Assessment and the FWS's BOs
2002	The NAS releases a draft report scientifically disagreeing with conclusions in the BOs. Irrigation releases return to normal.
2002	The FWS and NMFS issue final BOs
2003	Judge Armstrong rules that parts of the NMFS BO were ''arbitrary and capricious''' and orders that the BO be amended.
2006	Reclamation initiates the UKBOS feasibility study.
2008	New FWS UKL BO
2010	LLV appraisal report issued
2010	New NMFS Klamath River BO
2010	KBRA signed

final BA to encompass the direction given in the NAS report. The final BOs were issued in 2002.

In July 2003, Judge Armstrong ruled that parts of the NMFS BO were "arbitrary and capricious" and ordered that the BO be amended. She required Reclamation to implement Phase 3 flows.

The FWS and NMFS issued new BOs in 2008 and 2010, respectively.

2.5 Focus on Offstream Water Storage Needs

Precipitation in the Klamath Project area occurs mainly during the winter months in the form of snow. A snow pack develops that provides most of the water available for the Klamath Project and surrounding areas when the snow melts in the spring. A portion of the runoff is retained in Klamath Project reservoirs for release during the summer. The main sources of water supply for the Klamath Project include Upper Klamath Lake, the Klamath River, Clear Lake, and Gerber reservoirs, and the Lost River. There is currently a lack of carryover storage to hold surplus water supplies which means Klamath Project deliveries depend on gradual snowmelt runoff during the season of need.

One additional storage source is Agency Lake Ranch (ALR), acquired by Reclamation in 1998, to make water available to all users in the Klamath Basin. The purchase of the Barnes Ranch (adjacent to the ALR) in 2007 by Reclamation in partnership with the FWS and The Nature Conservancy (TNC) also provides additional offstream water storage and flexibility in water storage operations at UKL. The FWS is investigating the possibility of breaching the dikes between UKL and Agency Lake and Barnes Ranches to allow direct connectivity of these storage areas to Upper Klamath Lake and to help restore UKL wetland habitat. Ownership of these properties has been transferred to the FWS, however, historic storage operations will be continued per the direction in the KBRA.

Upper Klamath Lake is the primary storage reservoir for the Klamath Project. It is a large, shallow, hypereutrophic (high biological productivity) lake with extensive wetlands, numerous shoreline springs, and several tributaries. This lake is the largest body of fresh water in Oregon and varies from 6 to 14 miles wide and is approximately 25 miles long. UKL has a maximum surface area of approximately 81,000 acres and a total capacity of about 508,000 acre-feet. The operational capacity, as controlled by Link River Dam, is approximately 508,000 acre-feet; however, this number is greater than available storage based on the minimum lake levels required by the 2008 FWS BO. Net inflow for the entire year averages 1.3 million acre-feet but ranges anywhere from 576,000 to 2.4 million acre-feet.

The Sprague River is tributary to the Williamson River, which, in turn, empties into UKL, draining the northern, central and eastern part of the Upper Klamath Basin. Additionally, the Wood River drains the Southern slopes of Crater Lake National Park as well as some other eastern slopes of the Cascade Mountains. The Wood River flows into Agency Lake which is hydrologically connected, and functionally considered to be a part of UKL. The outlet for Upper Klamath Lake is the Link River, which empties into a two mile expanse of water called Lake Ewauna. The Klamath River begins at the southern end of Lake Ewauna and flows southwest into California.

2.6 Future without Project Implications

A without project alternative/option would involve the continuation of demand growth and competition for water in the Klamath Basin and future conflicts over water between the Upper and Lower Klamath Basins.

It would not involve storage of surplus surface flows in the Upper Klamath Basin and thus not meet minimum storage screening criteria. Even though the without project option involves no life-cycle costs, it is not a politically viable prospect because of the potential future conflicts.

A "future without project option" assumes storage at the Agency Lake /Barnes Ranch property has already been implemented. This work includes restoration of the property through hydrologic reconnection to UKL and incorporation into the FWS refuge system. Plans for implementation of this option are being finalized concurrently with the development of this report. The current AL/Barnes Ranches managed storage attributes are discussed and listed in Sec 6 for comparison purposes.

2.6.1 Water resource limitations

The Upper Klamath Basin's hydrology limits water resources. Agricultural demand is generally about 2.0 acre-feet per acre on the Klamath Project (Reclamation). Evaporation of open water ranges from 2 to 4 feet per year. The States of Oregon and California determine water rights for surface water and groundwater.

Computer modeling of climate change is in progress in an effort to predict future temperature and precipitation impacts in the Upper Klamath Basin. The resulting changes in water flow could threaten water supplies, cause more floods, and threaten ecological systems. The region will probably need to rely on water conservation and infrastructure improvements to mitigate these problems.

2.6.2 Activities in progress

The following current or future activities could impact the available water supply and water management in the Klamath Basin. The agencies responsible for these actions are listed in parenthesis:

- Assembly Bill No. 2514, Energy Storage Systems, California passed in 2010
- Return of the Agency Lake Ranch/Barnes Ranch property to UKL by restoring the hydrologic connection (FWS)
- Water Supply Enhancement Act studies (Reclamation)
- Williamson River Delta restoration (TNC)
- Federal Energy and Regulatory Commission relicensing of four hydroelectric dams located on the Klamath River (PacifiCorp)
- ESA Section 7 consultation for operation of the Klamath Project (Reclamation)
- Klamath Basin Restoration Agreement (numerous stakeholders)
- Completion of Oregon Water Resource Department (OWRD) water rights adjudication process

2.6.3 Future without storage projects

A without project alternative/option would involve the continuation of demand growth and competition for water in the Klamath Basin and future conflicts over water between the Upper and Lower Klamath Basins. The without project term, for purposes of this IAIR, refers to conditions without implementing water storage and/or delivery infrastructure improvements described for storage options but is also not meant to imply any changes in the current existing Klamath Project.

An example of a conflict over water, which could recur given the future without project alternative/option, occurred in 2001 and 2010, when different FWS and NMFS BOs concerning the Klamath Project's operational effects on listed species forced Reclamation to withhold irrigation water from Klamath Project water users.

Nonstructural options to alleviate water supply problems such as water banking, demand reduction (land idling), or water rights purchase have been investigated but were found to be only temporary solutions while physically reliable surplus water supply carryover storage is being sought.

3.0 Related Studies and Programs

The historic water resource constraints in the Upper Klamath Basin have been the driving force behind many investigations and planning efforts conducted by State and Federal agencies in conjunction with water user stakeholders. Over the years, Reclamation has either directly undertaken, sponsored, or participated in many of these water resource investigations. This section gives an overview of prominent water supply planning efforts and in particular, those leading to the present focus on exploring options for water storage. The options incorporated into the UKBOS studies and documented in this IAIR were identified both during the KBWSI in the late 1990s and in subsequent studies by Reclamation via the UKBOS planning process and water user interest group input. As options were identified, information was gathered and used to define preliminary attributes for initial screening review and comparison between options. In developing the IAIR framework, some options were eliminated early because major problems were evident right away. In other instances, options with apparent barriers are still included in the IAIR to illustrate essential factors or for comparison purposes. This section describes the water storage options identified in KBWSI and UKBOS planning stages and summarizes in this IAIR the options to be carried forth for evaluation of potential initial alternative priorities.

Section 3 Topics:

- *Overview of Klamath Basin water supply planning efforts and water storage needs*
- *Identify storage concepts originally cited during the Klamath Basin Water Supply Initiative*
- *Identify additional storage options developed during the initial UKBOS planning stages*
- *Status update for water storage options either eliminated or carried forth in this IAIR*

3.1 Previous Water Supply Planning Efforts

Previous water supply studies illustrate the significant efforts that have been undertaken to address water issues in the Upper Klamath Basin. These previous planning efforts have also demonstrated the most effective approaches and limitations associated with different water resource management scenarios and the importance of incorporating a means of water supply storage to provide long-term water management flexibility and reliability.

3.1.1 Early water storage studies

In 1959 and 1960, the California-Oregon Power Company—currently known as PacifiCorp—contracted Dames and Moore to conduct geotechnical investigations of potential offstream storage in the Aspen Lake, Round Lake, and Long Lake basins located in the mountain valleys to the southwest of UKL. Several years later, the Pacific Power and Light Co. (PPLC, a subsidiary of PacifiCorp) contracted with Shannon and Wilson, Inc. to conduct another independent geotechnical review of offstream storage potential in the Aspen-Round-Long Lake area. Building on the previous Dames and Moore site investigations, Shannon and Wilson drilled ten additional holes and excavated several test pits to define the subsurface geology and hydraulic conductivity of individual unit areas. Like their predecessors, they focused most of this field testing work in the Aspen Lake basin with less work in Round Lake or Long Lake Valleys. Findings from these investigations indicated that, although potential seepage problems were evident at each reservoir site, this did not conclusively eliminate Long Lake, Round Lake, or Aspen Lake from a technical feasibility standpoint.

A few years later, Reclamation reviewed preliminary investigations into the potential for offstream storage in the UKL area based on studies completed by government agencies and private organizations (Reclamation, 1987). The findings indicated that storage in the land-locked Round Lake, Aspen Lake, and Long Lake basins could have high development costs due to the geological seepage and need for impervious lining. More detailed planning investigations on these sites were not conducted at these sites until after the Enhancement Act enactment.

Around the same time as these early offstream storage evaluations, other studies were completed to assess the potential for dredging UKL to increase the storage capacity. Although the initial findings showed a physical ability to dredge shallow areas of the Howard Bay area in UKL, the significant increase in the active storage could not be produced without drawing the lake down below elevation 4137 (Reclamation datum). Only one small area at the far northwest end of UKL was identified where dredging above the minimum operational level could produce up to 2,000 acre-feet of added storage. As discussed later, the economic value of this does not appear favorable for this fairly minor increment of active storage. Other KBWSI options are either evaluated through the UKBOS study process and evaluations or dismissed as discussed in previous (1.3.2) and following (3.2) sections.

In the 1990s and early 2000s, Reclamation worked with the Bureau of Land Management to restore wetlands within the Wood River Ranch at the northern end of the Agency Lake/UKL water body. Reclamation purchased the nearby Agency Lake Ranch (ALR) in 1998 to provide adjunct UKL water storage, wildlife habitat, and potential water quality benefits. This levee-bounded ranch property has since been operated as offstream storage for about 16,000 acre-feet of Klamath Project water. Reclamation, the FWS, and The Nature Conservancy, purchased the adjacent Barnes Ranch in 2006 to increase the storage capacity of the two properties (AL/Barnes Ranches) and restore wetland conditions. The FWS owns these properties now although the FWS will not manage them differently until planning efforts for breaching containment dikes are complete.

Although these Agency Lake Ranches (ALRS) were originally purchased to provide multipurpose storage and habitat enhancement benefits, the operating agreements (including the KBRA) called for potentially breaching the containment dikes, which would open the ALRS lands to flooding by the ambient water levels in Agency/UKL. As a result, the ALRS properties could provide an incremental storage increase, but it cannot be managed to release water later in the year or during years of water shortages when supplemental water needs are greatest.

3.1.2 Groundwater supply evaluations

Since the late 1990s, Reclamation has provided substantial cost-share funding to the Oregon Water Resources Department (OWRD) and the California Department of Water Resources (CDWR) to cosponsor studies of the groundwater resources of the Upper Klamath Basin above Iron Gate Dam south of the California-Oregon border. The objectives of these studies have centered on characterizing potential groundwater demonstration projects, assessing the relationships between surface water and groundwater resources, and quantifying associated groundwater volume that could be pumped to contribute to Klamath Project long-term water needs during times of limited surface water availability.

In 2002, a groundwater demonstration project was completed by the OWRD and the Shasta View Irrigation District. The project results indicated that installing additional groundwater well capacity in that area could produce a supplemental supply to surface water in dry years but that water levels should be allowed to recover in years of adequate surface water availability. In addition, any additional aquifer withdrawals should proceed cautiously by monitoring use rates and well water levels for the purpose of terminating development if depletion were evident.

The OWRD has also investigated other groundwater demonstration projects in the Upper Klamath Basin. The results from these studies have been considered in selecting groundwater wells that were incorporated in the 2003 and 2004 water banks (described in the following pages under the concept of demand reduction).

The CDWR has been monitoring water levels in domestic and irrigation wells in the California portion of the Klamath Basin since late 1999. Water levels were measured monthly at 75 existing wells in California, and these measurements continued through September 2006.

In June 2004, Reclamation entered into a 3-year interagency agreement with the OWRD to maintain an extensive network of monitoring wells and stream gauges that provide information on the response of the groundwater system to climatic cycles, long-term climate trends, and pumping at both regional and subregional scales throughout the Upper Klamath Basin. Other objectives of the agreement involved support for OWRD uniformity of data collection and quality-assurance methods, monitoring schedules, data storage and archiving, and data dissemination, along with establishment of a long-term interagency funding structure for the data collection and analysis. These activities were also cost-shared with the U.S. Geological Survey (USGS).

Reclamation has also provided cost-share funding to the OWRD and USGS for a comprehensive Upper Klamath Basin groundwater investigation conducted from 2002 to present. This study is developing a quantitative scheme for the groundwater flow system of the Upper Klamath Basin and numeric models to test flow system concepts and simulate groundwater development scenarios or optimize resource management scenarios in the basin (USGS, 2010).

3.1.3 Water demand reduction efforts

The potential exists to reduce water use demands as a means of addressing water supply shortages in the Klamath Basin. To fully evaluate this potential, Reclamation has provided funding since 2001 to support various innovative pilot demand reduction programs under authority of the Enhancement Act. Specific objectives for the pilot programs conducted to date in the Klamath Basin include:

- To determine the practical ability of using annual demand reduction programs as a long-term means to reduce the potential for water shortages
- To determine the actual interest of irrigation water users in participating in a long-term demand reduction program
- To assess the ability to achieve an overall net reduction or change in irrigated acreage in order to produce a net reduction in water use
- To collect necessary technical data to assist in developing and evaluating the effectiveness of long-term demand reduction programs

Reclamation has obtained useful practical information and data from the demand reduction programs sponsored by these programs since 2001.

Long-term Federal funding for a potential water demand reduction program probably will not be viable.

3.1.3.1 2001 nonuse banking program

In 2001, Reclamation solicited bids from water users who were willing to reduce water demand by taking their irrigated crop lands out of production (land idling) in exchange for payment. Reclamation accepted bids and entered into contracts to purchase about 37,500 acre-feet of water for about 15,600 acres which otherwise would have been irrigated.

3.1.3.2 2003 and 2004 water banks

In 2002, the National Oceanographic and Atmospheric Administration (NOAA) and NMFS issued a BO (NMFS, 2002) concerning Klamath Project water operations. The BO required Reclamation to establish a pilot water bank to release water for fish species in the Klamath River. The BO water bank requirements called for 25,000 acre-feet in 2002, 50,000 acre-feet in 2003, 75,000 acre-feet in 2004, and 100,000 acre-feet annually from 2005 to March 2011. Initial assessments of these targets indicated that in dry years or months, the pilot water bank requirements would conflict with Klamath Project ability to meet authorized operational requirements to deliver adequate water supplies for contracted project water uses.

Reclamation was required to deliver the “banked” water in a timely manner. By March 31st of each year, the NMFS and Reclamation was required to determine the pilot water bank distribution and releases. According to the BO, water banking was primarily used to improve instream flows for adult coho salmon in the Klamath River mainstem. It can also be used to improve downstream smolt survival and overall coho fry survival in the spring, or to investigate the possible effects of increased flows on summer rearing conditions for the juveniles, or for a combination of these uses.

The 2003 pilot water bank consisted of land idling and substitution of well water for Klamath Project surface water (groundwater substitution). Applications were received and Reclamation contracted with water users to purchase nearly 58,600 acre-feet for the water bank. Of this total, about 35,400 acre-feet were from 14,400 acres included in the land idling program. The other 23,200 acre-feet was derived from groundwater substitution on about 11,000 acres. Reclamation also stored about 13,000 acre-feet on the Agency Lake Ranch lands and acquired an additional 12,000 acre-feet from Klamath Basin Rangeland Trust (KBRT).

The 2004 pilot water bank incorporated dry-land farming, groundwater substitutions, options for pumping groundwater on an as-needed basis, and reduced diversions to KBRT for pasture irrigation. Reclamation used a bidding process rather than offer fixed prices for water as in 2003. Bids were received and some of these were accepted for contract. Reclamation also signed options contracts for pumping groundwater from large volume wells on an as-needed basis. The 2004 pilot water bank provided a total of about 82,700 acre-feet of water.

Overall, the 2003 and 2004 pilot water bank programs demonstrated how the storage in Upper Klamath Lake is essential for water accounting. During most years prior to the BOs, UKL would reach the maximum capacity and excess water was released by spilling through the Link River Dam (although no spill occurred in 2004). Annual spill conditions typically occurred from February to late May or early June, and were driven by rising runoff originating from rainfall, snow melt, and base flows throughout the winter and spring. In many years, spilling is allowed before reaching the peak lake water levels to avoid damage to the existing containment dikes that regulate flooding in the low-lying agricultural lands near the lake. During the pilot water bank program, Reclamation and NOAA-Fisheries agreed to include spill flow from UKL that was within the defined downstream Klamath River and the water bank flow schedule as part of the annual water bank budget.

These pilot water bank programs were able to meet NMFS BO requirements for the 2003 and 2004 water years. The mechanisms and cost factors are useful information to assess other potential water storage or trading programs. Reclamation started off employing a combination of land idling and groundwater substitution in attempting to meet the increased 100,000 acre-foot water banking objective set for 2005 through March 2011. However, Judge Armstrong's 2006 decision to go to Phase 3 flows eliminated the water bank BO requirement.

3.1.3.3 Overall water bank findings

These pilot water banking programs demonstrated important findings concerning the overall effectiveness and key considerations in meeting multiple water supply needs. Key findings from these pilot water banking programs included:

- The 2003 pilot water bank showed how water obtained from land idling accrues to the water supply throughout the irrigation season in the same pattern and rates as it would normally be diverted for irrigation, and therefore it is not suitable for the BO uses cited concerning spring flows in the Klamath River.

- Spring BO flows must be provided when UKL is full and spilling; otherwise early withdrawals, if large enough, could result in shortages to the storage used to meet UKL BO elevations, river flows, and irrigation water needs in the summer.

- The 2004 pilot water bank proved that pumping large volumes of groundwater is not sustainable long term or during extended drought.

- These findings collectively demonstrated that although a water banking concept can be used to alleviate short-term water supply problems, banking is limited by the prominent need for additional carryover water storage in the Klamath Basin.

3.1.4 Comprehensive planning efforts

Many previous water supply planning efforts in the Upper Klamath Basin were undertaken individually as interest and opportunities arose. Although these individual studies have produced useful information, it is difficult to compare between potential water supply scenarios or to prioritize planning to allocate resources efficiently. These factors were recognized, and comprehensive planning efforts have been initiated to provide a systematic and effective means to address basin water supply issues.

The remaining discussion in this section centers on the prominent need for water storage improvements and the potential storage options that were identified in the comprehensive KBWSI and other storage options identified during the UKBOS study process.

3.2 Klamath Basin Water Supply Initiative Studies

Beginning with its inception in 1997, the KBWSI identified many potential mechanisms to address water resource development and use in the Klamath Basin. The KBWSI was a collaborative effort with participation by agricultural water users, Native American tribes, local area residents, and other interested groups or individuals. This initiative acknowledged that without some positive actions to address crucial water supply issues, continued demand competition in the Klamath Basin would likely lead to further competition for water resources and future conflicts between upper and lower basin water needs.

3.2.1 KBWSI planning activities

In 1998, as a leading sponsor and KBWSI participant, Reclamation prepared the KBWSI Draft Options Report (Reclamation, 1998) that identified 96 options for increasing water supplies in the Klamath Basin. Initial screening of the options eliminated seven options and identified those which met the objectives and had sufficient information available for development. Options were grouped into categories including: demand reduction; groundwater pumping; habitat restoration; new storage facility; operational changes; raise existing dam; reduce evaporation/seepage; and water import/export.

3.2.2 KBWSI water storage options

In 2004, Reclamation prepared the draft *Klamath Basin Water Supply Options Status Report* (Reclamation, 2004), which included an updated table of KBWSI options based on the original 1998 list. Twenty-six KBWSI options that would increase the total storage in the upper basin were recommended for additional study including three options identified as new storage facilities and two that involved raising existing dams. In addition to those five, two groundwater pumping/trading options and four storage options at sites near UKL resulted in a total of 11 KBWSI options that were screened with respect to UKBOS study objectives.

3.2.2.1 Klamath River Valley groundwater—in-lieu pumping (KBWSI #23)

This KBWSI concept is effectively a water trading strategy that involves seasonal surface and groundwater conjunctive use exchanges. Reclamation implemented a trial program from 2004 through 2008. In 2009, Reclamation and the irrigation districts agreed that Reclamation would continue funding this in-lieu pumping for another 3 years starting in 2009 with the irrigation districts taking over the program after 3 years. The maximum storage that this program, the Water User Mitigation Program (WUMP), is expected to yield is 30,000 to 70,000 acre-feet in any one year. This program could also become part of the overall settlement issues within the KBRA.

This option is not considered a long-term storage solution because it would not provide carryover storage from one water year to the next. This option was not carried forth in UKBOS study evaluations and is not further discussed in this IAIR document.

3.2.2.2 Klamath River Valley groundwater pumping with recharge (KBWSI #24)

This original KBWSI concept has been redefined more generally within the UKBOS study process as an ASR program, and specific ASR site options were investigated in consultation with the USGS (2010). These preliminary studies also included a more comprehensive characterization of the Upper Klamath Basin groundwater systems. Early studies indicated the potential for storing volumes up to 16 TAF of water within identified ASR locations, and this general option category is carried forward in the IAIR option array.

3.2.2.3 Agency Lake North and West (KBWSI #34)

Reclamation purchased the ALR property in 1998 and has used this site for seasonal offstream storage by filling the site during high water levels in winter and spring and pumping back into Agency Lake later in summer. To increase storage and restore additional lacustrine wetlands, Reclamation and the FWS purchased the adjacent Barnes Ranch property in 2006 under an interagency agreement that calls for potentially reconnecting both properties to Agency Lake. In 2008 and 2009, the AL/Barnes Ranches properties were discussed within the KBRA terms for potential primary purpose surface water storage use. Reclamation studied both the open-to-lake and an upgraded managed storage options at the preliminary level, and these options are included in the IAIR option array.

3.2.2.4 Long, Round, and Aspen Valleys (KBWSI #40)

These three storage sites were grouped together in the KBWSI because they are all closed basins located southwest of UKL. The sites offer potential for pumped storage of UKL water and could provide multiyear carryover storage depending on seepage containment and conveyance requirements. For comparison purposes all three sites are included as options. Appraisal studies have been completed for the LLV site (Reclamation, 2010b). Although the baseline reservoir option was found not viable, this option (for comparison purposes) and a water quality variant are included in the IAIR option array.

3.2.2.5 Swan Lake (KBWSI #41)

The existing Swan Lake site could be also adapted for storing UKL water. There are some apparent uncertainties concerning long- and short-term carryover storage, seepage containment, and potential for evaporation losses at this site. Two water supply variants were identified and carried forward in the IAIR option array.

3.2.2.6 Lower Klamath and Tule Lake National Wildlife Refuges (KBWSI #60 and #61)

The KBWSI identified two possible locations for storing water using the existing ponds within the Lower Klamath National Wildlife Refuge (LK-NWR). The site identified as LK-NWR Unit 13 (KBWSI #60) was scoped. The other site (KBWSI #61) is located in the Tule Lake NWR. Both options involve large, shallow water bodies that could have significant evaporation and provide comparatively small carryover storage. The option features were adjusted somewhat, and both of these KBWSI options are included in the IAIR option array.

3.2.2.7 Raise Gerber Dam (KBWSI #70)

Several original KBWSI concepts involved raising existing dams. Gerber Dam is one of two identified dam-raising concepts with the potential to provide additional storage in the upper basin. In 2001, Reclamation initiated feasibility planning to assess the potential for increasing storage in Gerber Reservoir. Raising the dam height by either 3, 5, or 10 feet was considered.

In January 2005, an initial review of the feasibility costs, benefits, and potential environmental issues indicated that the water supply benefits would be relatively minor, whereas resource impacts could be significant. The interdisciplinary review team recommended discontinuing further planning for three principal reasons:

- Raising the dam 10 feet could provide only minimal hydrological relief for Klamath River flows or agricultural demands except for irrigation in the area immediately downstream of Gerber Reservoir.

- Based on this limited hydrological relief, economic analyses indicated that potential benefits would not be great enough to justify costs.

- The cultural resources and historic properties in the reservoir area would require extensive time and funding to inventory, evaluate, and mitigate within the raised Gerber Reservoir site area.

The Klamath Tribes also raised serious objections to the project. Based upon the interdisciplinary study team recommendations, Reclamation terminated further planning studies. Consequently, this option was eliminated and is not carried forth in the UKBOS study evaluations.

3.2.2.8 Raise Link River Dam (KBWSI #72)

The potential to raise Link River Dam to increase the active storage in UKL was also identified during the KBWSI formulation. In general, the ability to raise an existing dam can have lower infrastructure costs or related impacts than building a new reservoir of equal size. However, in this case, raising the dam would involve significant impacts to connected water supply systems, transportation and UKL containment levee infrastructure, and the populations located around the lake. Raising UKL/Link River Dam was included in the IAIR option array to evaluate costs changes from previous estimates and to provide a reference for comparison to the other options.

3.2.3 KBWSI storage options status

Water storage strategies identified in the KBWSI and the status of options that are included in this IAIR are summarized in table 3-1.

Table 3-1.—Water storage options identified in Klamath Basin Water Supply Initiative and option status for IAIR framework planning

KBWSI ID #	KBWSI option	Status for IAIR
# 23	Klamath River Valley GW—in-lieu pumping	Eliminated from UKBOS study evaluations based on lack of long-term storage potential
# 24	Klamath River Valley GW—pumping w/recharge	Modified to evaluate ASR strategies at various locations with 10 site options included in the IAIR (USGS, 2010)
# 34	Agency Lake north and west (Barnes Ranch and Agency Lake Ranch properties)	Preliminary planning defined an open-to-lake option and managed storage option included in UKBOS study evaluations (Reclamation, 2010a)
# 40	Aspen Lake	New reservoir option at existing lake included in UKBOS study evaluations
# 40	Round Lake	New reservoir option at existing lake included in UKBOS study evaluations
# 40	Long Lake Valley	Appraisal findings identified a base reservoir option and a modified water release option included in UKBOS study evaluations (Reclamation, 2010b)
# 41	Swan Lake	Modified to consider two possible inlet supply and water options included in UKBOS study evaluations
# 60	Lower Klamath National Wildlife Refuge	Modified option for storage in existing refuge ponds included in UKBOS study evaluations
# 61	Tule Lake National Wildlife Refuge	Modified option for storage in existing refuge ponds included in UKBOS study evaluations
# 70	Raise Gerber Dam	Eliminated from the IAIR based on findings and recommendation from previous feasibility study completed 2005 (Reclamation, 2005)
# 72	Raise Link River Dam	Updated option included in UKBOS study evaluations to reassess cost factors and affects of raised water levels in Upper Klamath Lake

Note: KBWSI water storage strategies in this IAIR are from KBWSI studies (Reclamation, 1998) with identification numbers as cited in the Klamath Basin Water Supply Options Status Report (Reclamation, 2004).

3.3 Water Storage Options Developed since 2000

Since 2000, many additional studies have been conducted to assess other potential water storage options according to the Enhancement Act. This includes review of information available on options identified during initial UKBOS planning stages and more detailed investigations undertaken to assess certain options identified in the KBWSI or other Upper Klamath Basin planning efforts.

3.3.1 UKBOS preliminary studies

A number of water storage options were identified and evaluated during early UKBOS planning studies. The UKBOS options identified to date, preliminary findings, and the status of water storage options eliminated or included in the IAIR evaluation framework are indicated in table 3-2.

Table 3-2.—Water storage options identified in the UKBOS investigations and status of options for IAIR framework planning

Concept source	UKBOS option	Status for IAIR
Reclamation	Without storage—future conditions	Two options—one baseline and one demand reduction option included in UKBOS study evaluations
Sponsor	On-farm storage	Eliminated from UKBOS study evaluations based on initial review finding of a lack of multiyear storage potential
Sponsor	Deming Creek site	Eliminated from UKBOS study evaluations based on initial site review finding of a lack of capacity and reliable delivery
Sponsor	UKL Internal storage (Viets concept plan)	Eliminated from UKBOS study evaluations based on initial review finding of a high expected costs and limited capacity
Riker, Reclamation	UKL Dredging to expand capacity	Option included in UKBOS study evaluations to provide a cost reference for screening purposes
Reclamation	Caledonia Marsh site	One option for this drained UKL lowland site included in UKBOS study evaluations
Reclamation	Wocus Marsh site	Two options—one lower levee and one higher levee option included in UKBOS study evaluations
Reclamation	Klamath Drainage District storage site	One option for storage in existing drainage holding ponds included in UKBOS study evaluations
Reclamation	Whiteline Reservoir expanded storage	One option with expanded storage at existing reservoir included in UKBOS study evaluations
Reclamation	Torrent Springs and Williamson River sites	Two options—one new on-river reservoir at each location included in UKBOS study evaluations
Reclamation	Buck Lake storage	One new reservoir option at existing lake included in UKBOS study evaluations
Reclamation	Clear Lake and Boundary area	Three options—one using Clear Lake storage, one new Boundary Reservoir, and one combining Clear Lake ASR with Boundary storage included in the IAIR
Reclamation	Bryant Mountain reservoir site	One new storage reservoir with pumped storage option included in UKBOS study evaluations

Note: Only water storage options identified in the UKBOS studies to date are shown. The full array of options in the IAIR framework also includes the KBWSI options cited previously.

3.3.1.1 Without storage—future conditions

The potential implications of not implementing any water storage improvements in the Upper Klamath Basin was included to provide a baseline point of reference to assess the storage options. Future conditions without new storage would imply continued demand competition in the Klamath Basin and competition for water between the Upper and Lower Klamath Basins. This option also would not involve, or take advantage of potential opportunities for storage of surplus surface flows in the Upper Klamath Basin. Therefore, it does not meet the UKBOS goals and is not a considered a viable means to address the Klamath Basin water supply challenges or help resolve potential future conflicts.

For evaluation purposes, the without storage option is effectively the projected conditions under a status quo of existing storage facilities. The option continues the existing water management challenges that are limited by water years when there is enough water available to fill UKL, supply irrigation water, and also meet required UKL elevations and targeted river flows, all using only the existing storage or water trading strategies when possible. A "future without project" option, without storage—future conditions, is included in UKBOS study evaluations. The "future without project" assumes ALR/Barnes Ranch containment levees are breached and the unit as a whole is joined hyrologically to UKL.

A second, related without storage option would involve nonstructural demand reduction measures that would be applied without implementing any new water storage improvements. This option could involve land idling and/or groundwater substitution similar to the programs employed in recent years. Demand reduction programs conducted to date provide information that is useful to consider the full implications of future conditions without storage. This option, without storage—demand reduction, is included in the UKBOS study evaluations.

An additional without storage suboption would involve water rights purchase. Purchasing water rights anywhere within the Klamath Basin will be very controversial and may be seen by some stakeholders as land idling of irrigated land in one part of the basin to provide water for another part of the basin. Water rights are an issue currently addressed in the KBRA in the form of a goal of the voluntary reduction in off-Project use of 30,000 ac-ft. To request stakeholders to forego more water use would be highly controversial.

3.3.1.2 On-farm storage concept

The potential for building multiple on-farm water storage units is another concept that has been discussed at water supply meetings. For these purposes, the concept was reviewed to assess the practical viability. A pond or tank farm facility would be needed to make this functional. For example, a 160-acre farm unit with an estimated annual preliminary design allocation of two acre-feet per acre would have to have 320 acre-feet maximum available for storage. Tanks and associated infrastructure would likely be more expensive than construction of an embankment levee pond. A pond levee would need to be 13 to 15 feet high to store water 10-feet deep over a 32-acre pond with protection against wind wave damage. Levee construction, water conveyance modifications, land costs, production losses, and related O&M costs would be required at many farm sites to produce significant storage. For example, 500 systems with storage of 320 acre-feet would be required to produce a total capacity of 160,000 acre-feet. The connection to the on-farm distribution and irrigation system would need to be developed by and at cost of the farmer

In addition, evaporation losses could range from about 50-100 acre-feet in each pond over a typical summer and pond seepage could add to water losses. As a result of these factors and considerations regarding how to implement and reliably manage this type of storage program, this on-farm storage concept is not included in UKBOS study evaluations.

3.3.1.3 Deming Creek storage concept

Reclamation completed an initial review of three potential storage sites located on Deming Creek, a tributary to the South Fork of the Sprague River. The potential for reservoirs at these sites was proposed by the Deming Creek Ranch—a private landowner sponsor interested in restoring native fish species and riparian habitats in the area while possibly creating more water storage. Reclamation conducted a site reconnaissance and initial review of the hydrology, site topography, and major cost factors (Reclamation, 2010c).

Although no pumping would be involved, several barriers to storage at this site were identified. There are no stream gauge stations or other flow data available to accurately estimate the annual hydrologic water yield in the Deming Creek watershed. The two largest reservoir sites would have relatively small storage capacity (5,400 acre-feet total). This tributary is located in the upper Sprague River watershed, far from UKL, which raises some uncertainty concerning potential downstream storage benefits. Native fishery restoration activities introduce additional uncertainty. In addition, existing wetlands at the reservoir sites could require land acquisition and construction for wetlands mitigation features. As a result of these factors, this option was eliminated and is not included in UKBOS study evaluations.

3.3.1.4 UKL internal storage concept (Viets)

This concept involves isolating a portion of UKL near Howard Bay by constructing a containment levee in and through UKL. Water could then be pumped into this internal reservoir and released back into the natural UKL later. For UKBOS study purposes, initial review of this concept (proposed by a private sponsor) indicated extensive construction would be required to build a large levee through UKL. Very high costs would be expected to accommodate construction dewatering, foundation requirements, and post-construction operations and maintenance.

In addition, there would be significant potential for disturbing existing natural processes that govern water quality in UKL and in the internal reservoir. Water treatment, thought to be necessary as the stored water may undergo water quality changes and require State permitting prior to release back to UKL, would involve expensive facilities and operational requirements that further raise the storage costs. As a result of the high unit costs expected, potential for major impacts and possible legal barriers to implementation, this internal UKL storage concept is not included in UKBOS study evaluations. This proposal is also addressed in the current Klamath Hydroelectric Project dam removal studies.

3.3.1.5 UKL dredging to expand capacity

For the past three decades or more, interested agencies, groups, and individuals have raised the concept of increasing the water volume in UKL by active dredging to remove bottom sediments. Dredging could increase the total UKL water volume and may improve seasonal water quality conditions in the lake. However, the actual potential to provide active storage is influenced by the minimum operating lake water levels. The current BO provisions (FWS, 2008) require a minimum UKL water surface elevation of 4137.5 (Reclamation datum) and higher monthly water levels are required at certain times of the year. In addition, the existing UKL outlet works and A Canal Headworks currently restrict minimum UKL water levels to elevation 4137 and as a result, dredged storage is practically restricted to areas within UKL that have bottom substrates above elevation 4137.

To better assess the potential for dredging, Reclamation prepared preliminary cost estimates based the existing lake bottom bathymetry. The initial review findings confirmed that dredging often has relatively high unit costs. Although this option does not involve pumping, it appears limited by the locations where active storage is possible; but it does provide a useful economic reference for the other storage options and provides information to assess similar proposals that could arise. Therefore, dredging to increase UKL capacity is included in UKBOS study evaluations. This proposal is also addressed in the Klamath Settlement Final Report (http://klamathrestoration.gov).

3.3.1.6 Caledonia and Wocus Marsh sites

These privately owned sites are both low-lying lands next to UKL that have levee dikes installed to control flooding inundation and are used for agricultural production. Reclamation conducted preliminary studies on both sites to assess the potential conversion and use for water storage. Water from UKL would be stored within the low-lying reservoir sites with some new levee construction required to contain stored water. For the Caledonia Marsh site, water would fill the site by gravity flow at high UKL lake levels and then pumped back into UKL when water is needed. At the Wocus marsh site, UKL water would be pumped to the storage reservoir site and gravity flow released back to the lake. Two potential storage configurations were developed for the Wocus Marsh storage site. One is a low water surface and the other a high water surface option. These three storage options, including one at Caledonia Marsh and the two options for the Wocus Marsh site are included in UKBOS study evaluations.

3.3.1.7 Klamath Drainage District storage

Reclamation has conducted preliminary studies for offstream storage using some existing basins within the Klamath Drainage District (KDD). No impoundments would be required to store water on the identified site. Excess UKL/Klamath River water could be stored at the identified site by gravity flow and later released through pumping from storage downstream to the Klamath River. Potential water quality regulations (e.g., stream standards and total maximum daily load [TMDL]) could play a role in the timing of releases to the Klamath River and restrictions could affect this option. Preliminary plans for one option were developed and this option is included in UKBOS study evaluations.

3.3.1.8 Whiteline Reservoir expanded capacity

The potential to increase the storage capacity of the existing Whiteline Reservoir was considered as a potential UKBOS option. The reservoir capacity could be expanded significantly by raising the existing low embankment dam. Pumped storage to and from UKL would be accomplished using some existing and some newly constructed canal, tunnel and pump systems. Using the existing reservoir could reduce construction costs and potential impacts somewhat versus a new reservoir, although conveyance costs would be higher than other pumped storage locations closer to the UKL water supply. Based on preliminary planning, one option for expanding the capacity of Whiteline Reservoir to provide additional storage in the Upper Klamath Basin is included in UKBOS study evaluations.

3.3.1.9 Torrent Springs and Williamson River

Potential new reservoir sites were identified for each of these two sites located on tributaries that flow into UKL. Preliminary studies were conducted on both sites to identify the major components and potential implications of constructing new reservoirs. At the Torrent Springs site, a new dam would be constructed to store excess flows in the Sycan River tributary to the Sprague River. The reservoir site is directly on the river so no additional conveyance systems are required.

The other potential on-river reservoir at Williamson River Canyon site is located upstream from the Sprague River confluence. A new dam and reservoir would be constructed to store excess flows in the upper Williamson River and this reservoir would also not require additional conveyance systems. Both sites are tributaries to UKL and could release stored water to UKL for subsequent storage and use existing distribution systems. Options for the Torrent Springs and Williamson River Canyon sites are included in UKBOS study evaluations.

3.3.1.10 Buck Lake tributary storage

Reclamation conducted preliminary studies on the water storage potential in the existing Buck Lake basin. Although this site is located outside of the study area, it is in the Spencer Creek drainage, which is just west of the Upper Klamath Basin divide. The existing Buck Lake storage capacity would be increased by building a small impoundment and gravity intake diversion systems to collect surplus water from Clover Creek and Spencer Creek. Stored water would be released by gravity to augment flows in the Klamath River. Although the benefits are limited to the downstream basin and not available to the Klamath Project irrigated lands, this Buck Lake option is included in UKBOS study evaluations as it could reduce the amount of water needed directly from UKL for downstream uses.

3.3.1.11 Clear Lake and Boundary area

Three potential water storage schemes were identified within the Clear Lake and the Oregon-California boundary region (Boundary Site) of the Lost River. These potential storage options include a scheme that would use the existing capacity of Clear Lake via a water supply tunnel supplied by pumped Klamath Project "J" Canal water, an on-river dam and reservoir at the Boundary Site, and a combined storage scheme that would involve groundwater pumped extraction/recovery in the Clear Lake basin and conveyance to a new Boundary Reservoir for storage. Collectively these options capture a variety of issues associated with storage in the Lost Basin and also bracket a range of possible cost factors or combined storage strategies. As a result, all three Clear Lake and Boundary Site options are included in UKBOS study evaluations.

3.3.1.12 Bryant Mountain reservoir site

Initial studies have been undertaken for a combined storage, power generation, dual reservoir, water recirculation scheme at the Bryant Mountain site. New dam and reservoir facilities would be constructed at the site and water would be supplied using existing canal systems. More detailed studies are necessary to assess technical, institutional, and economic factors and this Bryant Mountain reservoir option is included in UKBOS study evaluations.

3.3.2 ASR applied research studies

Preliminary UKBOS applied research studies into the potential for groundwater storage or ASR, in the Upper Klamath Basin have been conducted in consultation with the USGS. These studies have included a comprehensive study of the groundwater systems in the Upper Klamath Basin, groundwater aquifer recharge characteristics in indentified areas, and potential sites for ASR operations with respect to the UKBOS objectives. These preliminary findings are summarized in a USGS Administrative Report (2010). Additional information on these preliminary ASR studies is in appendix D.

The potential for ASR was explored because it appears to offer several advantages compared to surface storage including lower costs than constructing new surface reservoirs. ASR facilities often do not require large amounts of land that displace other land uses (i.e., agriculture) or require extensive restoration or mitigation for inundation impacts. Underground water storage generally has lower evaporation losses than surface reservoir storage, which can allow for more continuous storage with opportunities to add water over a period of years. Groundwater storage does require detailed investigations to assess factors including the subsurface formation characteristics, groundwater flow, timing and capacity, recharge mechanisms, and other factors that influence the storage water supply and water recovery.

3.3.2.1 Passive and active ASR strategies

The term ASR is commonly associated with developed technology that involves pressurized wells used to inject water into the aquifer, and pumped well recovery of stored water. However, for the UKBOS preliminary planning purposes, ASR is used more broadly to include groundwater storage by natural passive recharge, constructed passive surface infiltration ponds, and direct injection systems. It should be noted that all ASR schemes, passive or active, require pumping for production or extraction of the groundwater resource. Water recovery strategic infrastructure includes combined injection and recovery wellhead facilities, well fields located within the defined storage area, or groundwater extraction at a separate location to either recover actual stored water or water available through a surface or groundwater conjunctive use water exchange. Groundwater recovery, groundwater pumping, groundwater production, and groundwater extraction are all synonymous terms from the UKBOS studies perspective. Likewise, groundwater is synonymous with aquifer and infiltration is synonymous with percolation from the UKBOS studies perspective.

ASR, as it applies to UKBOS ASR options, is predicated on an annual cycle comprised of two seasons. The first is the demand season of irrigation where supplies are extracted/pumped/recovered/produced from the aquifer for use on the surface. The second is the non-irrigation season where recharge of the aquifer is accomplished by one of several ways: (1) actively injecting by pumping surplus surface supplies (active ASR) back into the aquifer, (2) by passive recharge by surface percolation either by natural means (percolation from streams and wetlands) or by manmade features such as leveed ponds constructed for the specific reason to percolate temporarily stored surface water or (3) by natural recovery (recharge) of the aquifer itself (passive ASR) again by the above mentioned percolation of surface water from natural featuresor by percolation of precipitation which falls upon the earth’s surface. It is assumed, again from UKBOS study ASR options’ perspective, that there is a natural aquifer recovery rate even for the passive natural recharge UKBOS ASR options. The optimization of timing and pumping rates of extraction/production (pumping out) of a naturally recharged/recovered aquifer would need to be studied should a passive ASR option be advanced for higher level planning studies. The notion that there should be straight groundwater pumping options is not entirely correct due to the fact that depending on the location of the well and aggregated wells (well field) and timing of pumping/extraction of the groundwater resource (aquifer), an aquifer will have a natural recovery component and thus naturally recharge to a greater or lesser degree. It is this degree, timing, seasonality and rate of recovery that must be studied should an option advance to higher level planning studies.

From an infrastructure perspective, it is often advantageous for ASR schemes to group wellheads in proximity to one another to form a "wellfield."

In addition to physical aspects of water supply and conveyance systems for ASR, water quality is often a crucial factor to consider in any groundwater storage and recovery schemes. This can include both technical and regulatory issues that can affect the ASR effectiveness. For example, the water supplies for direct injection must be free from sediment or organic matter that cause plugging problems and/or require higher injection pressures and energy use. Geochemical interactions can cause mineral precipitation within the aquifer. Injection ASR frequently requires the supply water to meet Safe Drinking Water Act standards to protect potable groundwater resources. The water quality considerations may be less stringent for surface infiltration recharge, although supply water treatment is still a possibility. For natural recharge, water quality is more of a contamination issue that may involve watershed hydrologic investigations. These factors were considered for each of the potential ASR strategies identified and evaluated in the preliminary UKBOS groundwater storage investigations.

3.3.2.2 Active injection ASR technology

General operating scenarios for active injection ASR technology are illustrated in figure 3-1. These scenarios show that under ideal conditions, ASR can be a very

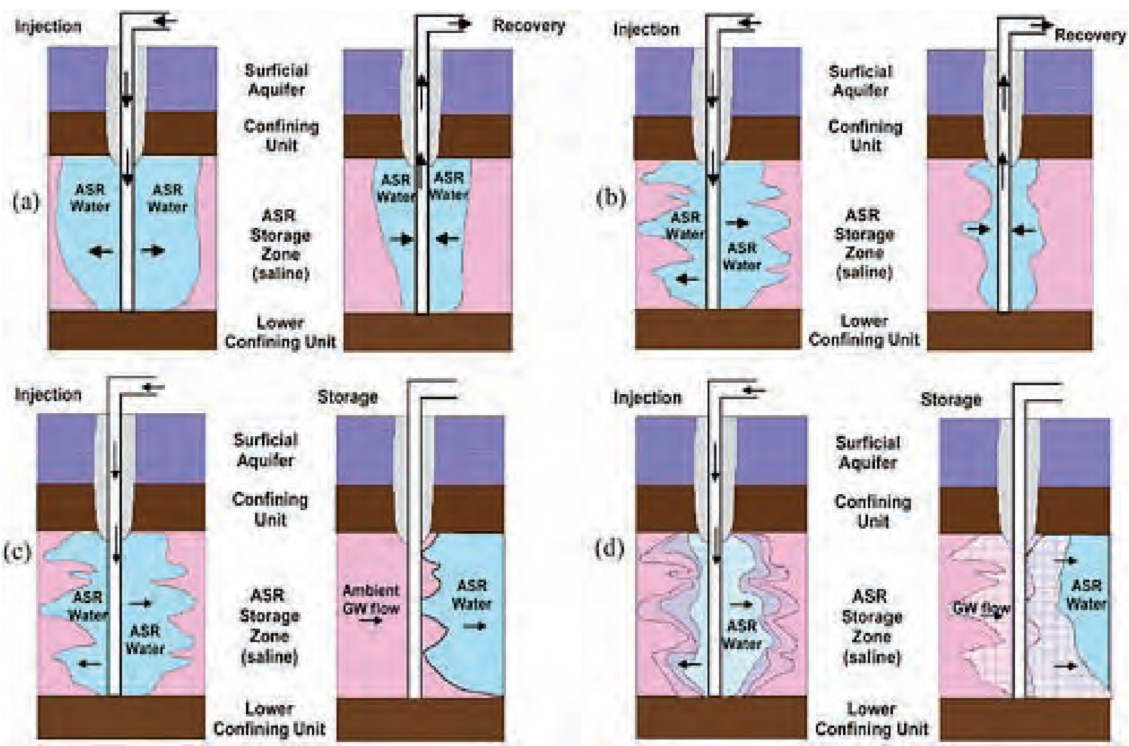


Figure 3-1.—ASR diagrams of potential ASR operating conditions including: (a) idealized aquifer storage and recovery system with possible effects of; (b) aquifer heterogeneity; (c) ambient flow and transport; and (d) mixing and water rock interactions. Scenarios (a) and (b) illustrate effects on recovery; whereas (c) and (d) illustrate effects during storage. (National Research Council, 2005)

efficient means of storing and recovering water without losses. In other cases, the advective mixing and transport exchange of injected water with aquifer water can make it difficult to recover the same injected water or the same volume of water to that injected. Even in the absence of aquifer flow losses, water-quality changes induced by mixing or subsurface geochemical interactions could affect the actual amount of recoverable stored water that is suitable for designated uses.

Under the appropriate circumstances, direct injection ASR has low storage losses by evaporation or water movement. Possible disadvantages of injection ASR can include the engineered technology, long term pumping energy use for active injecting and water recovery, and maintenance for a distributed system with hundreds of pumps and wells. Injection ASR also typically requires greater preinjection treatment to meet regulatory standards or environmental criteria. For the UKBOS preliminary assessments a projected injection rate was considered for the aggregated well field system. More detailed pilot studies would be necessary to determine the injection rate that can be reliably and cost effectively achieved at a given ASR site.

3.3.2.3 Active injection site assessments

The preliminary site assessments evaluated the potential for ASR operations at 14 identified locations in the study area as shown in figure 3-2. These ASR areas would potentially use the same aquifers as existing domestic and municipal water supply wells. Consequently the preliminary assessments of injection ASR at these sites, assumed a recovery efficiency of 70 percent, 30 percent loss during an injection cycle (USGS, 2010). The actual ASR recovery efficiency would be refined in more detailed further planning stages.

All of the areas that are close to the potential surplus surface water available in UKL or the Link River/Klamath River (figure 3-1) are sedimentary basins with groundwater levels near the land surface. These sites would probably not accept much storage water because of the low sediment permeability and any permeable strata that exist in the sediments are likely already saturated. Any water injected into the sediments would raise the water table and cause discharge to drains and surface streams. Injection to the volcanic formation beneath the sediments might be possible, although when pumping water into these confined aquifers with low storage coefficients, relatively small volumes of water could cause large increases in pumping head. In addition, although the water may not immediately discharge to open streams or drain channels, other existing wells that tap into the aquifer could start to overflow at the land surface.

It appears there could be potential for active injection ASR in the aquifer beneath the Tule Lake subbasin where groundwater levels have declined due to irrigation pumping. The objective would be to refill the depleted storage in this aquifer; however, the potential recovery and/or water exchange with existing groundwater user would require detailed studies. This area is located further from the potential

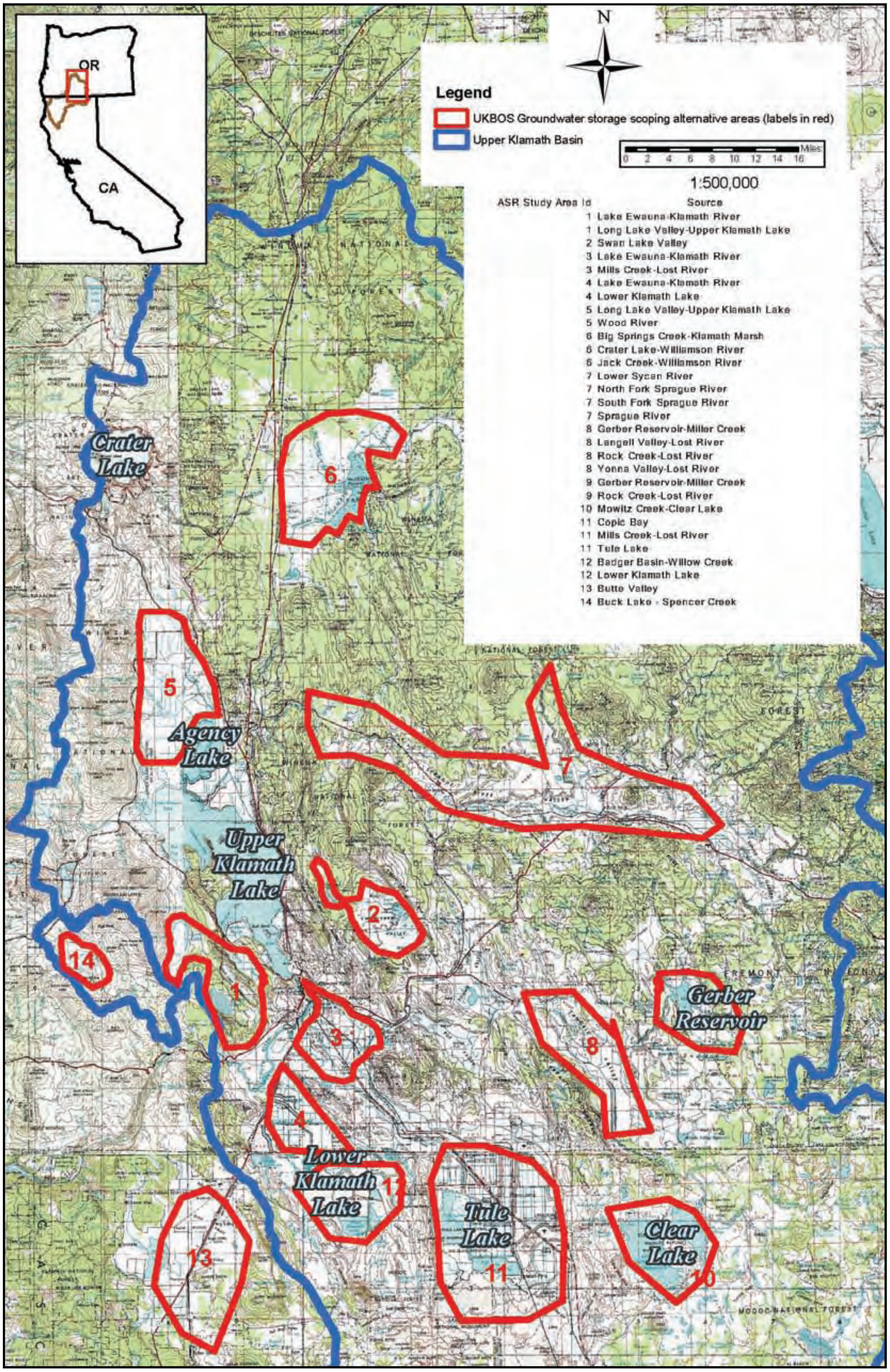


Figure 3-2.—Location map for ASR site assessments.

surplus supply water (UKL or Klamath River) and also from the Klamath Project distribution systems, which could increase conveyance and O&M costs.

As a result, the most promising injection ASR locations were identified in the site areas #3, #8, #10, #11, and #12 and one in the Sprague Basin site #7, and these sites are included in UKBOS study evaluations documented in this IAIR. It appears that injection ASR could be possible in the volcanic uplands surrounding the areas evaluated (figure 3-2); however, these areas were not assessed at this time because of the pumping and conveyance requirements and complicated geohydrology conditions.

Although surface conditions appear favorable for passive infiltration spreading via constructed percolation ponds (or basins) in the Gerber Reservoir basin, no contiguous areas of suitably flat lands were found near Barnes or Barnes Valley Creeks. These two streams would be the major source of surface water for any ASR scheme in the Gerber Reservoir basin area and it would also be advantageous from an O&M perspective to locate production well field systems close to the existing Gerber Reservoir facilities.

3.3.2.4 Passive recharge site assessments

The potential for passive recharge ASR was also evaluated for the 14 areas shown in figure 3-2. Preliminary results for surface infiltration at the sites assessed are summarized in table 3-3. The ability to use surface infiltration spreading ponds was only found at the Sprague Basin site #7a. Although spreading ponds appear limited at the Gerber, Clear Lake, and Langell Valley sites, it appears that some groundwater production (via pumping/extraction) may be possible using only natural recharge (or recovery) to replenish the groundwater resources as a modified ASR strategy for these sites.

Similarly at Langell Valley, although geologic conditions are suitable for passive infiltration ASR, there is a lack of contiguous flat land areas for infiltration ponds without impacting existing wetland areas adjacent to Miller Creek or in southern Langell valley near Malone Reservoir. The major water source for ASR schemes in the Langell Valley area is Miller Creek or Lost River.

Further south in the Tule Lake and Lower Klamath Lake areas, the site soils are composed of lakebed sediments that can limit infiltrated ASR. The potential for an infiltrated soil profile strategy was considered where shallow ponds would be used to infiltrate water into shallow aquifers to raise the water table until the soil profile was saturated prior to, or during the growing season. Significant barriers were identified for this type of strategy. For example, residences affected by the raised groundwater table would have to be relocated to higher elevation and the existing drain pumping operations would have to be closely coordinated with the pond recharge operations. Overall, passive infiltration ASR at this area does not appear as favorable as the injection exchange strategy described previously.

Table 3-3.—Preliminary assessment of Upper Klamath Basin potential site areas to apply passive infiltration recharge basins for ASR.

Ranking	Site # / Area	Remarks
1	# 6—Williamson River & Crater Lake	Due to the thick deposits of highly permeable ash from Mt. Mazama surface infiltration rates are expected to be high.
2	# 14—Surveyor Mtn. & Buck Lake	Area is situated within fractured volcanic rocks. Little is known about related aquifers.
3	# 9—Gerber Reservoir	Ares is situated within fractured volcanic rocks.
4	# 13—Butte Valley	Farmland is mostly pervious silty sand and ash above fractured volcanics. Aquifer depth is unknown.
5	# 7—Sprague Basin	Farmland is surrounded by fractured volcanics. Aquifer depth is unknown.
6	# 8—Langell Valley	Similar geologic conditions as the Sprague River area. Fractured volcanics surrounding agricultural land. Aquifer depth is unknown.
7	# 10—Clear Lake	Fractured volcanics surrounding lower-permeability lakebed sediments. Aquifer depth unknown.
8	# 1—Aspen, Round, and Long Lake	Fractured volcanics surrounding lower-permeability lakebed sediments. Regional aquifer depth known.
9	# 5—Agency Lake	Low permeability lakebed sediment overlain by deposits of medium permeability peat.
10	# 3—Northern Klamath Valley / Lost River	Well developed sedimentary basin overlying low permeability pyroclastic rock.
11	# 2—Swan Lake Valley	Well developed sedimentary basin overlying low permeability pyroclastic rock.
12	# 4—Worden	Long established sedimentary basin with low permeability lakebed deposits.
13	# 11—Tule Lake	Long established sedimentary basin with low permeability lakebed deposits.
14	# 12—Lower Klamath Lake	Long established sedimentary basin with low permeability lakebed deposits.

Notes:
(1) The ranking is based principally on review of existing data and information available on surface geology and soils conditions.
(2) The notation aquifer depth unknown indicates the lack of geohydrology information available at the time of geologist review.
(3) Relative ranking scale 1 = Greatest and 14 = Least potential for effective surface infiltration passive recharge operations (does not address active injection recharge).

The other areas evaluated for potential infiltration ASR are either located farther from a reliable water source or have apparent complications that could limit the practical effectiveness of attempting passive infiltration ASR operations.

Again, for purposes of the UKBOS studies, passive recharge ASR schemes are divided into two groups: (1) options with constructed surface infiltration facilities (ponds or basins) to assist aquifer recharge via percolation/infiltration of temporarily stored surface water and (2) options that rely solely on natural recharge with no constructed facilities to assist recharge. As with active injection (recharge) schemes, production/extraction is accomplished through aquifer pumping or extraction.

3.3.2.5 Identified ASR water storage options

Out of the 14 groundwater areas investigated in the Upper Klamath Basin, seven areas were not recommended for further consideration for reasons varying from no reliable surface water supply source, long conveyance distances, poor storage potential, unconfined aquifer, or too close to discharge feature such as springs. The other seven ASR areas were expanded to include both a passive and active recharge option in Sprague Basin and three site options for the south Lower Klamath Lake area. The resulting 10 ASR options are included in UKBOS study evaluations:

- Passive infiltration beds with groundwater extraction—no active injection—Sprague Basin site #7a
- Active injection recharge—Sprague Basin site #7a
- Active injection recharge—North Klamath site #3
- Passive natural recharge with groundwater extraction—no active injection—Langell Valley site #8
- Passive natural recharge with groundwater extraction—no active injection—Gerber Area site #9
- Passive natural recharge with groundwater extraction—no active injection—Clear Lake site #10
- Active injection/exchange—Tule Lake site #11
- Active injection recharge—South Lower Klamath Lake (LKL) site #12a
- Active injection recharge—South LKL site #12b
- Active injection recharge—South LKL site #12c

Information derived from the Upper Klamath Basin groundwater characterization and preliminary ASR evaluations (USGS, 2010) indicate the ASR options would have less storage capacity than larger surface reservoir options. However, these ASR options are described separately so they can be considered independently or in some combination as part of a comprehensive storage program.

Combined surface and groundwater storage strategies may also be possible based on the information from the preliminary ASR studies (USGS, 2010). An example of a combined surface and groundwater option involves an ASR production only scheme facilities at the Clear Lake site #10 with surface water storage in the proposed Boundary Reservoir and this option is also included in UKBOS study evaluations.

3.3.3 ALRS preliminary site studies

Barnes Ranch (BR) and ALR properties—collectively termed the Agency Lake Ranches (ALRS)—are located next to Agency Lake/UKL. The ALR property was acquired by Reclamation in 1998 under the authorization condition that the property would be operated to make water available to water users in the Klamath Basin (Reclamation, 2010a). In 2006, Reclamation and the FWS purchased the BR property under an agreement that it would be transferred to the FWS and incorporated into the Upper Klamath NWR managed by FWS. ALR and BR were transferred to the FWS in 2010.

The ultimate goal is to reestablish the historic open hydrological connection with Agency Lake. The property transfer and restoration plans are supported under the 2007 agreement between Reclamation, the FWS, and The Nature Conservancy, and in section 18.2.2 of the KBRA for the Sustainability of Public and Trust Resources and Affected Communities (KBRA, 2010). Restoring open-to-lake conditions could involve various methods to establish or enhance site characteristics. Future planning for site restoration is the responsibility of the FWS.

Reclamation completed a number of preliminary investigations on the ALRS site to assess existing characteristics, potential management options contributing to wetlands restoration or water storage values, and possible relationships with the Klamath Basin resources. Additional information available for the ALRS site includes information on preliminary site planning, wetlands delineation, field investigations, and property reference materials (Reclamation, 2010a).

3.3.3.1 Site planning background synopsis

Land elevations within most of the ALRS site have subsided and currently lie below the adjacent Agency Lake water surface even at relatively low water levels in the lake. Reclamation has managed the ALRS water levels using the existing irrigation and pump systems to produce seasonal water storage.

Reclamation preliminary studies are undertaken to compile information on existing conditions, formulate potential resource options, data or information needs, and to identify viable options and important issues for more detailed investigations. Reclamation projects that involve new or additional Federal funding appropriations then, as a result of recommendations by early level planning studies, may lead to defined appraisal, feasibility, and final design engineering investigations and NEPA compliance.

In the early planning, site restoration options were identified for initial screening evaluations. For example, the site restoration and integration within the Upper Klamath National Wildlife Refuge (UKNWR) ultimately involves breaching the existing containment dikes to restore open-to-lake hydrologic conditions. Consequently, the preliminary site planning defined a basic option as: open-to-lake conditions using the minimum site work. Implications of this option include issues such as methods for breaching containment dikes along the lake, reinforcing the north dike to prevent flooding of nearby landowners, as well as site work that could be used to reduce fish entrapment.

The other site options evaluated involved methods to restore subsided lands using water control operations, or additional earthwork and water control to enhance wetlands development and restore internal site stream pathways with delayed dike breaching. In addition, staged restoration options that involved different scenarios of dike breaching, site restoration, or water storage operations were evaluated from a resource perspective including factors such as the overall effectiveness, cost-benefits, or major limitations. A managed storage option (upgraded from current condition) was also considered at preliminary level for comparison against other options.

The preliminary site planning included initial layout of major site features and details for components such as internal earthwork, pump stations, dike breaching, or dike reinforcement. The latter planning studies focused on the north dike design criteria because this dike is the main component to allow for open-to-lake conditions without flooding private lands to the north of the ALRS properties.

3.3.3.2 Recent update on ALRS site status

Recently, the ALRS properties (Agency Lake Ranch and Barnes Ranch) were transferred to the FWS for inclusion into the FWS National Wildlife Refuge system. The dikes could be breached, and the properties restored to Agency Lake. However, according to section 18.2.2.D of the KBRA, until such breaching and restoration plans are finalized and implemented, and/or historic water storage operations cease, Reclamation will continue operations and maintenance activities on the properties (KBRA, 2010). This is the reason for the existence, for UKBOS study purposes, the “future without project” scenario exists as discussed elsewhere in this IAIR, as it involves the assumption at a point in the reasonably foreseeable future that the containment levees will be breached to hydrologically connect the ALRS unit to UKL. This is an important assumption from the hydrologic operations aspect of any options developed in the UKBOS studies for comparison purposes.

Two options for the ALRS site—the minimum open-to-lake option and the managed annual storage option (upgraded from current condition)—are included in UKBOS study evaluations.

Although these recent activities pertaining to the ALRS site have defined any future planning for this site, both of these options are included in the IAIR to show the investigations completed to date and to provide a basis for comparing the option characteristics and findings with other UKBOS options. Additional information on these preliminary ALRS site planning studies is in appendix E.

3.3.4 LLV appraisal study findings

Appraisal studies were completed in 2010 for the baseline 350 TAF reservoir at the Long Lake Valley site. These studies also include optimization studies done to refine certain attributes and sensitivity studies that were done to assess possible methods to optimize the LLV reservoir configuration or operations. Even though the appraisal studies did not find a favorable benefit-cost ratio for the project, two options, one for the appraisal (baseline) LLV reservoir, and one for a water quality release option are included to provide reference information for UKBOS study evaluations. The following correspondence excerpt (Reclamation, 2010b) summarizes the status of the LLV appraisal investigations at this time.

Additional information on the Long Lake Valley Reservoir appraisal study activities and findings is available in appendix F.

Long Lake Valley Reservoir—Summary of proposed reservoir status after appraisal studies completed in 2010

An earlier draft UKBOS IAIR, as authorized under the Enhancement Act of 2000, recommended that appraisal level studies be conducted on the LLV surface-water-storage reservoir option. Studies and investigations for the LLV option have been completed and are included in the Final Long Lake Valley Offstream Storage Appraisal Report.

Some prefeasibility level studies have also been completed, including a LLV facilities configuration optimization study. Those studies addressed optimal water conveyance features (canal, tunnel), water quality and pump-generation facility configurations. Paper copies of the final appraisal and optimization study reports were provided to Mid-Pacific Regional staff on November 2, 2010, during a Regional Director's Office presentation on the LLV appraisal study findings.

Appraisal study findings include that depending on the alternative, construction cost estimates range from $548 million to $2.3 billion in 2009 dollars. As such, repayment capability would likely require development of a multiple-purpose project.

Power generation was considered as part of the project and was presented to various potential private-market and government (e.g., BPA) partners. Unfortunately none expressed interest because of the limited head created by the facility. The Klamath Basin HydroEconomics Model (KB_HEM) was used to determine the long term benefits over a 50-year period. The results were a direct annual irrigation benefit equal to $1.2 million. Qualitative analysis was conducted and showed a very small benefit for the annual fisheries improvements in the Klamath River from LLV deliveries. At this time, data was insufficient to perform quantitative analyses on fishery benefits. Overall economic analyses results show the benefit/cost ratio (B/C) for the entire range of LLV alternatives studied is 0.01 to 0.04.

Local irrigation representatives including Klamath Water Users Association and Klamath Water and Power Agency representatives, Klamath County Commissioners, and Klamath Basin Tribes were invited to participate in a LLV briefing in late November 2010. Irrigation representatives, Klamath County Commissioners, and Karuk Tribe representatives participated in the presentation. Paper copies of the final appraisal and optimization study reports were given those in attendance. They were informed that due to the low B/C ratio, further Federal planning studies for LLV are not warranted.

Source: Reclamation, 2010b

3.4 UKBOS Planning Status Summary

Storage options either have potential for further investigations, do not appear viable at this time, or are included in the IAIR for reference purposes. Eliminated options include the expanded Gerber Reservoir, On-farm Storage, Deming Creek, UKL Internal Storage, and KBWSI in-lieu groundwater pumping. Options that do not appear viable, but were still included in the IAIR for reference or comparison purposes include Future Without Storage, ALRS Storage, the LLV Reservoir (appraisal study), Raise Link River Dam, and UKL dredging.

The original source, option name, and status of all options described with respect to the current UKBOS study evaluations are summarized in table 3-4. For all options that are carried forward in this framework, the IAIR identification number (e.g., IA-1) is also indicated. This list reflects the array of options that are carried through the preliminary UKBOS study evaluations described in the subsequent IAIR sections.

Table 3-4.—Summary status of storage schemes and preliminary screening to identify options carried forward in UKBOS study evaluations.

Source	Original Name	IAIR Status Notes
UKBOS	Without Storage—Future conditions	**IA–1** Included in IAIR with 2 options; future conditions and demand reduction
KBWSI-23	Klamath River Valley GW—In-lieu groundwater pumping	**Not in IAIR** As defined, no active water storage components
KBWSI-24	Klamath River Valley GW—pumping with recharge	**IA–2** Included in IAIR with 10 options for potential ASR site applications
KBWSI-34	Agency Lake north and west (ALRS properties)	**IA–3** Included in IAIR with 2 options; open-to-lake (“future without project” scenario) and upgraded managed storage
KBWSI-40	Aspen Lake—reservoir storage	**IA–4** Included in UKBOS study evaluations
KBWSI-40	Round Lake—reservoir storage	**IA–5** Included in UKBOS study evaluations
KBWSI-40	Long Lake Valley—new reservoir storage	**IA–6** Included in IAIR with 2 options; original base reservoir and water quality (WQ) release
KBWSI-41	Swan Lake valley—new reservoir storage	**IA–7** Included in IAIR with 2 options; total capacity and water supply feed
KBWSI-60	Lower Klamath National Wildlife Refuge—storage	**IA–8** Included in UKBOS study evaluations
KBWSI-61	Tule Lake National Wildlife Refuge Sump 1A—storage	**IA–9** Included in UKBOS study evaluations
KBWSI-70	Raise Gerber Dam—to increase storage	**Not in IAIR** Failed in feasibility planning studies (Reclamation, 2005)
KBWSI-72	Raise Link River Dam—to increase storage in Upper Klamath Lake	**IA–10** Included in UKBOS study evaluations
Sponsor	Deming Creek—new reservoir in upper watershed site	**Not in IAIR** Initial screening indicated storage and water source limitations

Sponsor	On-farm storage—small storage in multiple farm ponds	**Not in IAIR** Initial screening indicated storage and water source limitations
UKBOS	Upper Klamath Lake dredging—to increase storage capacity	**IA–11** Included in UKBOS study evaluations
UKBOS	Caledonia Marsh—water storage within containment dikes	**IA–12** Included in UKBOS study evaluations
UKBOS	Wocus Marsh—pumped storage within containment dikes	**IA–13** Included in IAIR with 2 options; high and low water levels
UKBOS	Klamath Drainage District—storage	**IA–14** Included in UKBOS study evaluations
UKBOS	Whiteline Reservoir—expanded capacity of existing reservoir	**IA–15** Included in UKBOS study evaluations
UKBOS	Torrent Springs—on river reservoir	**IA–16** Included in UKBOS study evaluations
UKBOS	Williamson River—on river reservoir	**IA–17** Included in UKBOS study evaluations
UKBOS	Buck Lake—reservoir storage	**IA–18** Included in UKBOS study evaluations
UKBOS	Boundary Site—on river reservoir	**IA–19** Included in UKBOS study evaluations
UKBOS	Clear Lake—existing reservoir with water supply via J Canal	**IA–20** Included in UKBOS study evaluations
UKBOS	Clear Lake ASR—with Boundary Reservoir storage	**IA–21** Included in UKBOS study evaluations
UKBOS	Bryant Mountain—new reservoir site	**IA–22** Included in UKBOS study evaluations

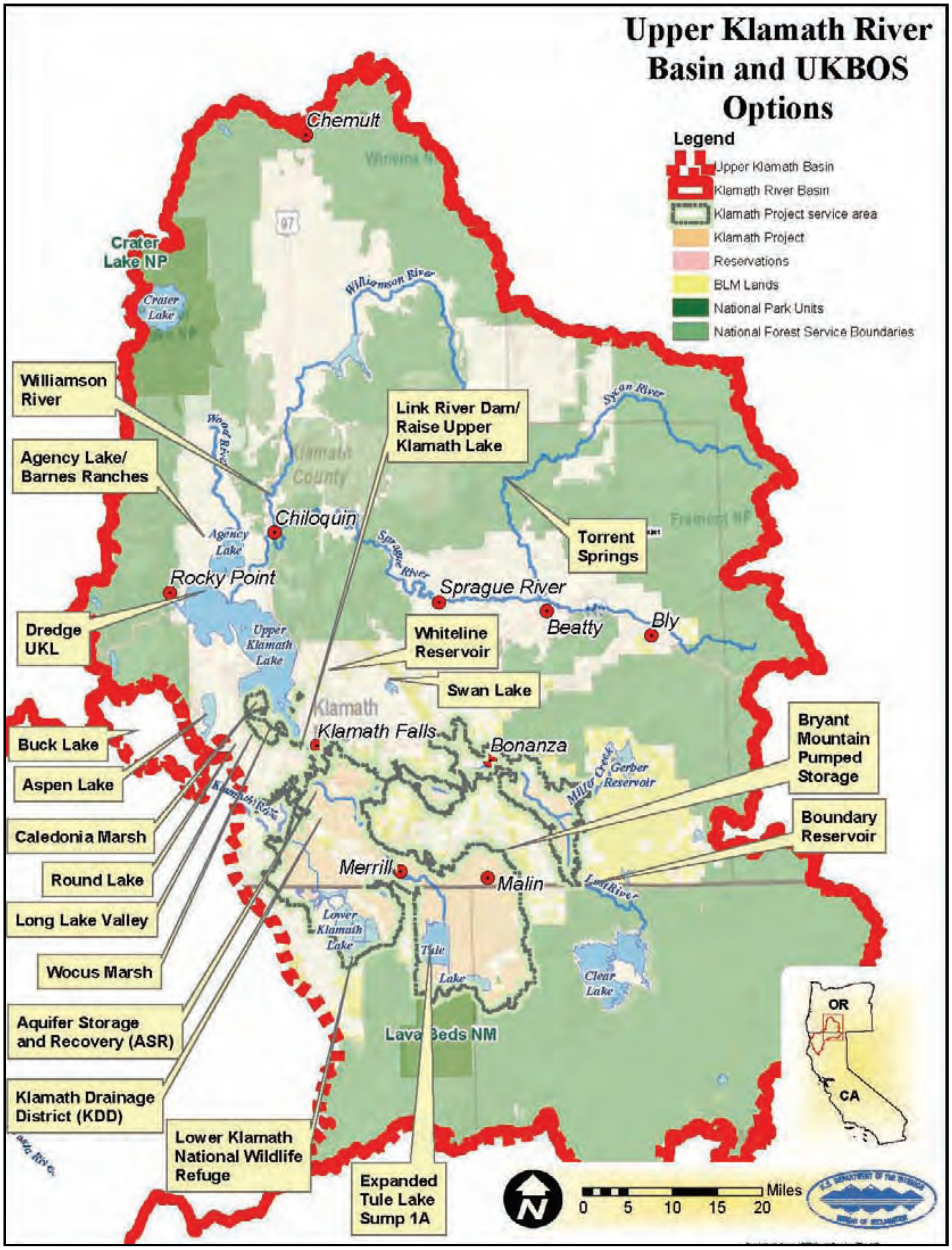


Figure 3-3.—Upper Klamath Basin study area showing the locations of the water storage options included in the current UKBOS-IAIR preliminary evaluations.

4.0 Plan Formulation Factors

The options identified previously as being evaluated through the UKBOS studies and documented in the IAIR have all undergone preliminary formulation to define the essential water storage elements and related characteristics. In keeping with the preliminary level of planning, the option plan formulation was based only on available information, without undertaking new site investigations or detailed analyses (as appropriate for preliminary studies according to Reclamation's Planning guidelines). For options that have already had some previous development or investigations done, this was a matter of compiling and adjusting information within the context of the IAIR framework. For many other options; however, this involved a series of steps to formulate the original concept into a realistic water storage plan—from assessing the amount of available water, to estimating the storage capacity and defining functional elements including existing or new water systems employed for storage and delivery operations. These features then form the basis for assessing potential economic and environmental factors associated with a given option, and in comparison between options. Certain methods and criteria were applied to develop the options consistently for the IAIR framework screening comparisons. The preliminary planning methods used to formulate the UKBOS options are described in this IAIR section. The section concludes with a complete list and synopsis of the options carried through the IAIR framework. For purposes of remaining IAIR discussion sections, the terms "IAIR" and "UKBOS studies" are used interchangeably.

Section 4 Topics:

- *Describe the methods applied to formulate storage option characteristics and establish the framework to assist future UKBOS planning efforts*
- *Describe the preliminary engineering development, hydrologic modeling, and water treatment studies used to evaluate water storage options*
- *Summarize water storage options that are carried forward in the current IAIR framework*

4.1 Framework Methods and Criteria Applied

Option plan formulation consisted of several steps that involved different types of planning methods and criteria. The preliminary option characterization activities can be grouped into the following primary planning stages:

1. Formulate the water storage mechanisms.—Water supply quantity, storage capacity, storage duration, water conveyance, and operating parameters involved to make the storage option function effectively.

2. Define major components and operations.—Infrastructure including new or existing water systems and operating requirements that are key factors for preparing preliminary level, design-life cost estimates.

3. Evaluate related implications of the option.—The above attributes are used to identify potential environmental issues or other resource considerations that could pose important barriers or warrant further studies.

4.1.1 Option formulation screening criteria

A tiered approach was applied to screen options as they are developed and refined through preliminary planning. Option screening can occur at any time, starting with the original storage concept to early information review and the preliminary plan development. For example, many storage concepts that are not included in the IAIR were eliminated early because either they were found impractical or major barriers were discovered during initial reviews. A second tier of option (or concept) screening can occur once the crucial information (e.g., site mapping, hydrologic data, water systems, non-engineering issues) have been assembled to provide enough information to assess factors such as the projected effectiveness and any prominent advantages or disadvantages for an option.

All potentially viable options included in the IAIR have passed this initial screening and were carried through preliminary plan formulation. A few selected criteria were applied to assess options that already had some planning completed (via KBWSI or other studies) and to develop the other UKBOS study identified options that had little or no prior option plan formulation.

A few of the prominent screening factors applied at the preliminary plan formulation stage include:

- Storage capacity (water volume) and duration (annual or multiyear)
- Water conveyance pumping, gravity flow, existing or new systems
- Water loss potential based on site evaporation or seepage potential
- Infrastructure footprint surface area with related impact implications
- Groundwater interactions in terms of water quantity or quality affects
- Capital and life cycle cost factors associated with storage components
- Cultural or environmental identified barriers or topics for further study
- Regulatory, permitting, land purchase, water rights, or related factors

Preliminary plan formulation was based more on a combination of factors rather than fixed numeric criteria. For example, for surface storage options, a capacity of 50 TAF was considered substantial storage; however, other factors such as the new infrastructure required, annual pumping required, or environmental attributes were considered equally important. The defined option attributes form a matrix for evaluating the overall viability and priority for a given option.

In addition, preliminary planning recognized the potential for combining options to reach an effective storage capacity in a comprehensive program. For example, two or more ASR sites could be developed to establish an integrated groundwater storage program. In addition, this approach also allows for potential conjunctive surface and groundwater resource programs.

As a result, all IAIR options were developed individually so the option attributes can be considered separately or as part of a more comprehensive or coordinated water storage program scheme.

4.1.2 Preliminary level economic considerations

Detailed thorough economic benefit-cost analysis is not appropriate at this preliminary planning level. However, the major benefit and cost factors were considered to gain some insight into potentially critical factors and to help in screening the IAIR options. For the IAIR purposes, the focus was on identifying the significant economic factors and relative comparison between options and that could influence future water resource determinations.

Major cost factors are tied to the key water infrastructure, operating requirements, and environmental or institutional factors. Major benefit factors could include the effective storage provided as well as related benefits of lesser resource impacts or factors that could provide cost reductions versus other options. Beyond this level, no methodical economic analyses were undertaken for the IAIR options.

4.1.3 Preliminary environmental review methods

A preliminary review of potential cultural or environmental resource implications was also conducted for the IAIR options. The purpose is to identify crucial issues that could pose major barriers (or significantly increase costs) or could offer some advantage (or significantly increase the benefits) for an option. This initial review was also intended to identify issues that could warrant further investigation during subsequent planning and environmental compliance investigations (Environmental [e.g., NEPA, ESA, or the National Historic Preservation Act (NHPA)] compliance is beyond the scope of these preliminary IAIR option evaluations).

The preliminary option environmental review focuses on major factors identified including existing wetland resources in the option site area, water quality issues, or related water treatment implications, and identified sensitive species—particularly fish habitat or fish screening needs that could be major benefit or cost factors for a given option. Other environmental or cultural resource issues were also identified when apparent based on the option information available. However, again these preliminary reviews do not in any way supersede full environmental compliance activities that would be required during subsequent planning stages.

4.2 Preliminary Level Engineering Development

The goals and limitations for preliminary planning investigations were discussed previously. Some preliminary level engineering was done on the IAIR options to develop realistic storage mechanisms and to define major components that represent sizeable cost factors or that are linked to any associated resource effects. It is also important to have a consistent approach in developing options to provide an equitable basis for comparing options and for identifying the most promising options for future planning.

Overall, the preliminary engineering development parallels the option formulation and the resulting option characteristics are summarized for each individual option and compared across options in the following sections.

4.2.1 Surface water storage option development

For the IAIR surface water storage options, the preliminary engineering attributes developed for each option are indicated in table 4-1. Information developed for each of these storage attributes is summarized in the left-hand column.

The storage peak capacity was limited to a maximum of approximately 350,000 acre-feet regardless of the physical site storage capacity. This upper storage limit was set to allow direct comparison with the LLV reservoir appraisal study findings. This is a useful point of reference, but it does not replace further design development that would be required for any of the preliminary IAIR options.

The other preliminary engineering attributes (cited in table 4-1) were developed through an iterative process that involved developing initial site plans based on known constraints or a range of conditions, then examining related water storage attributes using appropriate analyses, and then adjusting the preliminary features accordingly. Water supply data obtained from the Oregon Water Resources Department—Water Availability Report System (OWRD, 2002) could be evaluated with respect to relevant BO limitations to develop upper limits for storage volumes and flow rates. For some options, these water supply parameters might be developed or modified using hydrologic operations modeling (described later). The physical storage capacity at the identified site and any new or existing conveyance systems (channels, tunnels, pipelines, pump stations) could then be analyzed with respect to these water supply parameters. Ultimately, the projected water supply benefits could then be assessed using hydrologic model results, and the preliminary cost estimates could be prepared based on the major components developed for the option. For some options such as options within the Lost River watershed (e.g. Boundary Reservoir) and others (Buck Lake, Bryant Mtn pumped storage), it was difficult to model the benefits. A couple of iterations were typically completed to develop the specific IAIR storage option features at preliminary level.

Table 4-1.—Storage option attributes and preliminary engineering development basis and examples for IAIR surface water storage options.

Storage attribute	Preliminary development basis and examples
Storage peak capacity:	Site data and preliminary site plan layout were used to estimate the storage capacity based on stage-volume or existing limitations; up to a defined maximum capacity of 350,000 acre-ft. • *Example:* 350,000 acre-ft maximum
Projected storage time:	Site data and the option storage capacity, available water and flow rates were used to assess the potential for multiyear carryover or seasonal water storage and any related timing factors. • *Example:* Multiyear storage potential
Storage water supply:	Original storage conceptual development generally identified the water source and supply-related factors for the option. • *Example:* UKL surplus water
Available storage water:	OWRD-OWARS data were used to define upper limits for storage water supplies and applicable BO (1) provisions or other limitations were incorporated into preliminary plans as appropriate. • *Example:* Up to maximum UKL surplus and current BOs
Storage fill frequency:	Hydrologic modeling (2) examined a range of storage fill and release scenarios to define the storage operating parameters. • *Example:* Years when surplus water is available (spill flows)
Initial design inflow rate:	Site data, hydrologic modeling (2), and preliminary storage system layout of water controls and conveyance systems (including any existing and new components) were examined to define storage option flow rates based on preliminary sizing or timing objectives or to account for identified flow capacity limitations. • *Example:* 1,000 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	Hydrologic modeling (2) was applied to simulate the supplemental water supply benefits associated with a storage option. • *Example:* 0 to 350,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Water treatment (2) needs and components were based on the water source, storage mechanism, and stored water use or release. • *Example:* WQ group 1; UKL water supply for surface storage
Current priority status:	Relative priority ratings (2) were defined based on the overall option engineering attributes and nonengineering factors identified. • *Example:* 2nd priority potentially viable

Notes:
(1) Endangered Species Act, BO that could affect storage option functions.
(2) Additional information for these preliminary development activities is in the following sections.

4.2.2 Groundwater storage option development

As the IAIR options that involve ASR (groundwater) were developed, information was compiled based on the same storage attributes shown in table 4-1. For these cases, the initial geohydrology studies used in the preliminary option development were completed through an interagency effort with the USGS (2010). Additional information on the Klamath Basin groundwater characterization and preliminary ASR site investigations is included in appendix D.

The first two storage attributes; *storage peak capacity* and *projected storage time*, were developed from these site-specific geohydrology investigations. The next two attributes concerning; *storage water supply* and *available storage water* both refer to surface runoff supplies and were derived from the same OWRD-OWARS and hydrologic studies as for the surface water options. The following two attributes concerning *storage fill frequency* and *initial design inflow rates* were developed based on the groundwater recharge method employed. Groundwater ASR options that employ passive infiltration spreading basins or direct injection recharge, have designed target recharge cycles and rates. As a result, these recharge parameters were set based on the geohydrologic conditions. The other groundwater options that involve natural recharge had additional preliminary studies done to assess the implications of groundwater production at defined rates and recharge rates subject to the projected site hydrology and runoff conditions. The last storage attribute, *water delivery benefit range*, was developed based on the geohydrology findings and engineering parameters defined by the ASR technology.

4.2.3 Basis applied in preliminary cost estimates

Preliminary level cost estimates *only* indicate relative magnitude for comparison and ranking purposes and should not be used for funding projections. Any subsequent review of the preliminary IAIR economic findings must take into account the uncertainties, contingency factors applied, and the inherent limitations associated with early estimates. All preliminary cost estimates are subject to the conditions and context described in the Reclamation guidelines (Reclamation, 2007).

The major storage components for each IAIR option were identified based on the preliminary storage facility layout and any related parameters. These components were used to prepare preliminary level capital construction cost estimates (see the box on this page for a description of the way that this IAIR uses preliminary estimates). The corresponding storage operating requirements developed for an option were used to prepare annual cost estimates for a 50-year option infrastructure design life. These capital and annualized cost estimates were combined to prepare a total life-cycle present worth cost estimate for the option design life.

4.3 Basinwide Hydrologic Operations Modeling

Reclamation has developed a specialized computational hydrologic model for the Klamath Basin. The model system supports simulation modeling for the basin hydrology and water operations. The model incorporates input-defined climate conditions and specified scenarios based on the network of interconnected water systems, including the Klamath Project operations at a generalized level.

During the preliminary option development, a series of modeling analyses were conducted to evaluate potential water management implications of representative water storage options. This series included selected UKBOS options that were analyzed to gain more accurate understanding of the hydrologic effects on the Klamath Project and Upper Klamath Basin water operations.

4.3.1 Modeling software and hydrology data

Klamath Basin hydrologic operations simulation modeling was conducted using the Water Resources Integrated Modeling System (WRIMS)—a general-purpose river and reservoir planning and operations modeling software developed and maintained by the CDWR Modeling Support Branch. The WRIMS uses a mixed integer linear programming solver to route water through the network of water system elements. Policies and priorities for water routing are implemented through user-defined weighted conditions that are applied to flow segments and storage nodes of the network. System variables and constraints were specified using the model software scripting. The modeling system uses a 46-year period (1961-2006) of historic hydrologic data to drive computations of the Klamath Basin system including UKL water levels, Klamath River flows at Iron Gate Dam, Klamath Project water deliveries for agricultural irrigation and wildlife refuges, and water storage operations based on the existing basin conditions or defined scenarios for future operations.

As stated elsewhere and in appendix A, the model was run for a “without project scenario” and various with-project scenarios. The without project option involves doing nothing and its subsequent impacts of the continuation of demand growth and competition for water in the entire Klamath River Basin and future conflicts over water between the Upper and Lower Klamath Basins. The without project term refers to conditions without implementing water storage and/or delivery infrastructure improvements described for storage options but is also not meant to imply any changes in the current existing Klamath Project .

The “future without project” scenario is the March 2008 Proposed Action for Klamath Project operations included in Reclamation’s Biological Assessment. The “future without project” option is defined as the March 2008 Proposed Action for Klamath Project operations included in Reclamation’s Biological Assessment, occurring at the point in time (roughly the year 2016) where the Upper Klamath Basin as a system includes the breaching of the existing boundary levees of Agency Lake Ranch. It is referred to within UKBOS studies as Future Without

Project. Input data and operating rules for the Klamath Project 2008 Proposed Action are described in appendix A. If operational requirements are altered as a result of new biological opinions, new modeling inputs would result in potential changes in model outputs. Factors such as the KBRA provisions or potential future changes in BOs regarding Klamath Project water operations, coupled with any demand increases or multi-year shortages, must be studied with the scenario of ALR/Barnes being hydrologically reconnected to Agency Lake/UKL. See appendix A for more discussion regarding model parameters and the issue of use of later BOs.

4.3.2 Upper Klamath Basin model network

The Klamath Basin hydrologic operations modeling also analyzed any proposed operations of the options developed including a representation of deliveries to Klamath Project water users, with demands based on precipitation and conditions set forth in relevant Biological Opinions. Schematic diagrams of the analysis network of the model are included in appendix A.

Headwater inflows are represented for Upper Klamath Lake, Gerber Reservoir, and Clear Lake. Local gains and other inflows are represented by Lake Ewauna gain, Lost River Diversion Channel spill, Area A2 winter runoff, Klamath Straits Drain flows, and river gains from Keno to Iron Gate Dam. Diversions to meet the Klamath Project demands are represented at the A Canal, Lost River Diversion Channel, North Canal, and Ady Canal.

The UKBOS options, whether groundwater ASR or surface storage options, are represented as an offstream storage facility, connected to the system via UKL or other existing facility or as a model node for a new facility that would be constructed based on the option preliminary plans. Model simulation uses a monthly or bimonthly time-step to compute the net balance of flows between UKBOS options depending upon their location and UKL results expressed as either an identified storage inflow gain or storage water release.

4.3.3 Action operations criteria and scenarios

Delivery results for the without storage (no-action) and with storage option (action) scenarios were processed to develop information on annual deliveries for each year of the model run. The average of these annual values was used in the determination of potential benefit.

Pertinent water supply data obtained from OWRD-OWARS also constrained development of options located outside of the existing Klamath Project. It should be noted that no OWARS data has yet been developed for the Lost River system. The OWARS information was used in formulating the preliminary option capacities because water availability depends on the option geographic location. In no case could an option capacity exceed the annual water volume available based on the OWARS data. For surface storage options, preliminary stage-capacity data sets were developed for the model. For the ASR options, the model capacity used was based on the aquifer characteristics defined by the USGS (2010).

An example model analysis based on the Long Lake Valley 350 TAF reservoir at a 1,000 ft^3/s inflow is included in appendix A. Model network schematic diagrams developed for the defined UKBOS action storage scenarios are also included in appendix A. These preliminary modeling analyses were conducted and account for more recent BO or KBRA events and some new data developed for some options. The preliminary hydrological modeling would have to be updated and refined for further storage planning studies. The model system is a valuable tool that could be used for more detailed investigations.

A relative comparison was performed for LLV using the 2010 NMFS BO and 2008 FWS BO or KBRA and it showed effectively the same storage volumes as was computed for the model runs for each option.

A more detailed discussion of the hydrologic analyses is found in appendix A.

4.3.4 Water rights, permits, other considerations

Although the hydrologic operations modeling system can incorporate water rights, water allocation rules, or other known water supply provision of constraints, these factors would require detailed analysis for any options that are advanced to further planning stages. A water rights application permit would have to be submitted to OWRD or CDWR (or both) immediately after an option is identified for further planning. The determination of water availability is a critical factor and the time and costs associated with preparing rights permit applications, any necessary legal representation, and processing fees could be substantial.

Water rights do not presently exist for IAIR options. Any future water rights would also be subject to the OWRD adjudication process for major portions of the Klamath Basin, currently in progress (OWRD, 1999).

The agencies would issue Proposed Orders or a Proposed Preliminary Permit that does NOT grant the right to construct any project facilities. A preliminary permit would allow the applicant to gather additional stream flow or groundwater data; pursue the necessary use permits; assess environmental impacts of the proposed action, develop mitigation measures, complete detail design plans and associated cost estimates, and file draft and/or final water right applications. A preliminary permit also does not ensure approval of any subsequent action or permanent water right permit. The applicant must demonstrate that the proposed project (storage option) would not impair or be detrimental to the public interest.

In the case of ASR options (and possibly for surface storage options) the OWRD and/or CDWR could require a groundwater study that could include conducting a groundwater interference test. These tests must be conducted under controlled conditions and directed by a qualified hydrogeologist to determine the possible impacts of pumping any proposed well(s) on other existing wells near the proposed project. OWRD or CDWR would then review and approve plans for the proposed groundwater interference test. Generally, an interference test would be conducted during January or February before groundwater pumping for irrigation begins for the season. The OWRD/CDWR could offer assistance in selecting reference wells in the vicinity to be monitored during the drawdown and recovery periods of the test. A water level change in the test monitoring wells in a given area could imply potential for interference, but a lack of response does not absolutely mean no interference will occur. Long-term groundwater interference effects could be assessed by establishing groundwater-monitoring wells.

Any additional water rights and interference testing results could be incorporated in refining future hydrologic operations modeling. Additional geohydrology data or groundwater modeling results could also be applied directly in the basinwide hydrologic operation modeling to assess potential implications for Klamath Basin water resources. The established modeling capabilities could be an important tool for any further surface or groundwater storage investigations.

4.4 Water Treatment as Optional Storage Need

The preliminary IAIR option development also evaluated the potential need for water treatment based on the water quality of the storage water supply and the stored water use or release to UKL or the Klamath River. The options were grouped into five categories for these preliminary level water treatment assessment studies. The associated preliminary cost estimates for treatment were also factors into the option comparisons and prioritization. Refer to appendix B. Note that in section 4.4 and in appendix B, the term “alternative” is to be considered equivalent to the term “option” for UKBOS study purposes.

Water treatment scenarios evaluated for five defined WQ groups address were based on many of the contaminants flow quantities identified in a previous study conducted for the LLV option (Reclamation, 2008). The current analyses, therefore, incorporate the designs and costs from the LLV study where appropriate. The design and cost estimating assumptions used in the LLV study and incorporated herein include:

- Maximum sustained flow rate into treatment plant operations is 1,000 ft^3/s during a 60-day period of time; except for options 2A through 2D under alternative group 2, which evaluate two maximum sustained flow rates: 100 ft^3/s and 300 ft^3/s, during a 60-day period of time.

- Power cost = $0.07/kW-hr; plant operator labor rate = $33.78/hr.

- Use of Environmental Protection Agency (EPA) and TSC cost curves for water treatment plant construction and operation and maintenance costs, indexed to September 2008 using *Engineering News Record* index data, to prepare preliminary-level cost estimates.

- Cost estimates for some treatment equipment and chemicals are derived from vendor quotes and contract bid data available from the internet.

- Water quality parameters were derived from UKL for the LLV study, plus data provided by the Klamath Basin Area Office as described in each of the alternative group descriptions.

TMDL standards for both the California and Oregon portions of the Klamath River system were issued in late 2010. Impacts to options carried forward from both TMDL standards will have to be taken into account in future studies.

4.4.1 WQ group 1—UKL water supply

Alternative group 1 addresses water quality characteristics that are common to the following IAIR surface water storage options: Caledonia Marsh, Swan Lake, Klamath Drainage District, Wocus Marsh, ALRS Managed Storage, Buck Lake, Round Lake, Aspen Lake, and Whiteline Reservoir. The raised UKL option was also included in this group for preliminary planning purposes.

These storage options have the potential to increase eutrophication and water temperatures due to the nature (shallow depths for most options, other factors for other options) of these water bodies as compared to UKL. Treatment requirements and cost estimates for this alternative group assume in-lake aeration (to increase dissolved oxygen), phosphorous removal (to mitigate algae blooms), and treatment plant filtration (to remove suspended solids) as developed in the LLV study.

Additionally, treatment measures to reduce temperature, pH, and ammonia are added for storage options in this alternative group including:

- Temperature reduction.—It is assumed that temperature requirements can be met through a combination of aeration mixing technology and hydraulic reservoir management techniques. The intake hose for aerators should be set at the required depth to establish a thermocline, below which cooler temperature water extracted for discharge. Hydraulic management techniques could augment this method through temperature monitoring and selective withdrawal of reservoir water.

- pH reduction.—A sulfuric acid mixing and injection system at the filtration treatment plant will reduce the pH of the discharged water.

- Ammonia reduction.—The concentration of ammonia is reduced using a chlorine injection system to convert ammonia to nitrogen gas.

4.4.2 WQ group 2—ASR/groundwater extraction alternatives

Alternative group 2 consists of potential ASR projects using source waters similar in quality to UKL. Waters that are stored below ground surface are subject to the State of Oregon UIC program. Under this UIC program, ASR source water supplies must meet the EPA Safe Drinking Water Standards prior to underground injection for groundwater recharge.

The water treatment approach for the ASR options incorporates the conventional water treatment operations from the LLV study (coagulation with ferric chloride [$FeCl_3$], clarification, and gravity sand filtration) and adds chlorine disinfection to remove pathogens, as shown in figure 4-1.

Conventional treatment provides both solids removal and organics removal using a conservative high dose of $FeCl_3$, 7 mg/L. Solids are removed to reduce the potential for plugging or fouling of the injection wells and organics should be removed to minimize the potential of forming disinfection byproducts, which are regulated by drinking water standards. A conservative high dose of chlorine, 10 mg/L CL_2, was assumed to meet disinfection requirements.

Potential treatment needs for the ASR options were adjusted further based on the specific water quality characteristics of the source water identified for each of the groundwater ASR options.

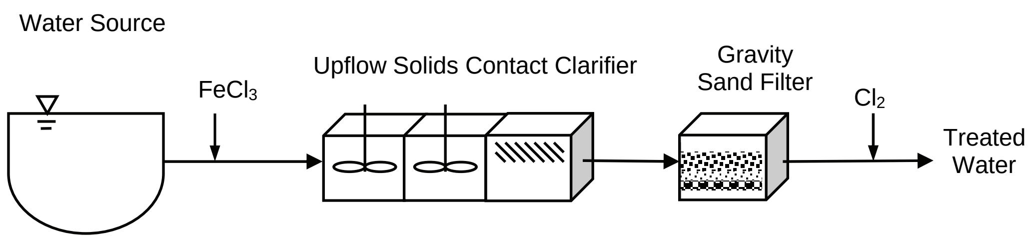


Figure 4-1.—Conventional Water Treatment Process for ASR Alternatives.

4.4.3 WQ group 3—upper tributaries

The third alternative group consists of the Williamson River and Torrent Springs tributary surface water storage options. The source water for both these upper Williamson River and Torrent Springs tributaries options likely has superior water quality compared to the LLV reference study. Although some treatment may be required for this alternative group, it is likely that treatment would be relatively minimal as compared to the LLV storage option.

The primary water impairment concern is possible stratification of reservoir water resulting in higher surface temperatures and reduced dissolved oxygen levels below the thermocline. It may be possible to adequately mitigate this potential impairment through the use of outlet works that selectively discharge waters that meet discharge requirements.

4.4.4 WQ group 4—TMDL factors

Alternative group 4 comprises surface water storage options in the Lost Basin including: Tule Lake NWR, Lower Klamath NWR, Clear Lake J Canal, Boundary Reservoir, Clear Lake ASR/Boundary Storage and Bryant Mountain Reservoir. Treatment requirements for these storage options were based on the existing water quality requirements in California and future requirements that were anticipated in Oregon for TMDL. Provisions in place during preliminary planning focused on nitrogen and biochemical oxygen demand and treatment needs were estimated based on these constituents.

The water treatment approach for the group 4 storage options incorporates the source water treatment assumed from the LLV study (aeration, phosphorous removal, and filtration) with additional treatment incorporated for removal of nitrogen constituents (ammonia and nitrate).

The projected loading estimates for discharged nitrogen were only slightly higher than the California Lost River TMDL objective. Therefore, preliminary treatment assumed only a portion of the total discharge would require treatment for nitrogen removal to meet the current TMDL.

4.4.5 WQ group 5—dredging impacts

Alternative group 5 addresses the short-term water quality impacts from dredging UKL for additional surface water storage in UKL. The purpose of dredging is to improve the long-term water quality of the UKL. Disturbance of the underlying anoxic sediments, however, could release some constituents of concern currently immobile at this time and temporarily degrade the current water quality.

Increased phosphorus loading could occur and current algae bloom conditions might be exacerbated. Since these conditions would be temporary, it would be preferable to minimize discharges until the water column has stabilized and the water quality improves.

4.5 Priority Criteria for IAIR Options

A relative priority scale was applied to interpret the collective characteristics of the preliminary IAIR options for further planning stages.

0. **Not applicable for this option**—The option would not improve storage; generally only refers to the without project options.

1. **First priority for further planning**—The most promising current priorities; best potential as initial alternatives for further planning stages.

2. **Second priority potentially viable**—Could be reviewed in future planning; could move up if higher priority options are proven not viable.

3. **Third priority additional barriers**—Need definite means to resolve issues; most likely are only viable with major changes in circumstances.

4. **Fourth tier not currently viable**—Major factors preclude further planning; are carried for reference purposes, but are not viable at this time.

These option priority criteria were developed for preliminary screening purposes only. In keeping with IAIR framework context, addition investigations and future IAIR iterations would review and update the option priority status.

A complete list of all water storage options carried forward in UKBOS study evaluations, including the respective IAIR identity numbers and basin storage mechanisms are shown in table 4-2. This table will be used as a consistent reference basis for all options in the subsequent sections of this document.

Table 4-2.—Options in the IAIR framework showing; identity number, option name, and the storage mechanism and factors.

Identity ID#	Option name	Storage mechanism and factors
IA-1 a	Without Project— Future Conditions	Baseline condition without project conditions (not no action for NEPA compliance).
b	Without Project— Nonstructural Measures	Modified baseline without project with demand reduction programs implemented
IA-2 a	ASR Passive Infiltration, Sprague Basin, Site #7a	ASR Passive infiltration spreading basins with pumped well water recovery
b	ASR Active Injection, Sprague Basin, Site #7a	ASR Direct injection with pumped well recovery
c	ASR Active Injection, North Klamath, Site #3	ASR Direct injection with pumped well recovery
d	ASR Passive Recharge, Langell Valley, Site #8	ASR recovery with passive natural recharge
e	ASR Passive Recharge, Gerber Area, Site #9	ASR recovery with passive natural recharge
f	ASR Passive Recharge, Clear Lake, Site #10	ASR recovery with passive natural recharge
g	ASR Injection/Exchange, Tule Lake, Site #11	ASR Direct injection with onsite or downstream recovery and potential water exchange
h	ASR Active Injection, South LKL, Site #12a	ASR Direct injection with pumped well recovery—optional location
i	ASR Active Injection, South LKL, Site #12b	ASR Direct injection with pumped well recovery—optional location
j	ASR Active Injection, South LKL, Site #12c	ASR Direct injection with pumped well recovery—optional location
IA-3 a	Agency Lake Ranches, Open-to-Lake	Existing containment dikes breached to restore open-to-lake conditions with minimum site work - “future without project”
b	Agency Lake Ranches, Upgraded Managed Storage	Existing dikes and pump systems upgraded to increase storage volume of UKL water with pumped release
IA-4	Aspen Lake Reservoir	UKL water pumped up to higher elevation enlarged existing lake basin with gravity release
IA-5	Round Lake Reservoir	UKL water pumped up to higher elevation existing lake basin with gravity release
IA-6 a	Long Lake Valley Reservoir, Base 350K acre-ft	UKL water pumped to higher elevation existing lake basin with gravity release—2010 Appraisal study
b	Long Lake Valley Reservoir, WQ Release	UKL water pumped storage into existing LLV lake basin—modified option with WQ release operations

IA-7 a	Swan Lake Reservoir, AB Canal Feed	UKL water conveyed and pumped to existing higher elevation lake basin with repumped release to Lost River and Klamath Project
b	Swan Lake Reservoir, Algoma Feed	UKL water pumped to existing higher elevation lake basin with gravity release to Lost River and Klamath Project
IA-8	Lower Klamath NWR Reservoir	Project water pumped and stored in enlarged existing NWR pond with gravity return to project systems
IA-9	Tule Lake NWR, Expand Sump1A	Project water pumped and stored in enlarged existing basin with gravity or pumped return to project systems
IA-10	Upper Klamath Lake, Raise Link River Dam	Raise existing dam elevation to increase the UKL storage capacity
IA-11	Upper Klamath Lake, Dredge to Expand Capacity	Dredge bottom sediments in specific areas to directly expand UKL capacity
IA-12	Caledonia Marsh Reservoir	UKL water stored by gravity feed into existing low lying basin lands with pumped return to UKL
IA-13 a	Wocus Marsh, High Reservoir	UKL water pumped and stored in existing enlarged confined basin with gravity return—high water option
b	Wocus Marsh, Low Reservoir	UKL water pumped and stored in existing enlarged confined basin with gravity return—low water option
IA-14	Klamath Drainage District Reservoir	Project water stored in existing basin with pumped return to project systems
IA-15	Whiteline Reservoir, Expanded Capacity	UKL water pumped to enlarged reservoir with gravity release back to UKL
IA-16	Torrent Springs Reservoir	Upper tributary water source flows stored in new reservoir (site to be determined [TBD]), gravity release
IA-17	Wiliamson River Reservoir	Upper tributary water source flows stored in new reservoir (TBD), gravity release
IA-18	Buck Lake Reservoir	Upper tributary flows stored in existing lake basin with gravity release to Klamath River
IA-19	Boundary Reservoir	New on-river reservoir to store surplus flows with gravity release back to Lost Basin
IA-20	Clear Lake Storage, J Canal Feed	Project water pumped and stored in existing reservoir, J Canal feed, gravity release back to project systems
IA-21	Clear Lake ASR with Boundary Reservoir	ASR recovery, natural recharge, product water stored in new reservoir, gravity release
IA-22	Bryant Mountain Reservoir	Project water stored in new reservoir, D and J Canal feeds, gravity release back to project systems

5.0 Storage Option Descriptions

A brief summary for each of the IAIR storage options are presented in this section. The abstracts contain the same identified topics to summarize attributes associated with each option in a consistent way. The purpose of these summaries is twofold. First, to distill different types of information gathered from various sources and preliminary findings adequately to characterize each option. Second, to provide an equitable basis for comparing attributes and factors between options that could suggest their priorities for consideration as initial alternatives that could potentially be developed further in future resource planning stages.

Section 5 Topics:

- *Overview of Klamath Basin water supply planning efforts and water storage needs*
- *Identify storage concepts originally cited during the Klamath Basin Water Supply Initiative*
- *Identify additional storage options developed during the initial UKBOS planning stages*
- *Summary of water storage options that are included in this IAIR evaluation framework*

Option abstracts are presented in the order of the IAIR option ID numbers (table 4-2), starting with the base without storage option and followed by the KBWSI and UKBOS options cited in this IAIR. Option features and planning factors are described in a two-page synopsis with a site location map and preliminary planning figures that illustrate the option storage strategy and major components. For all options, additional information is available in the appendices and references.

Each option abstract starts with a project description that includes an overview of the storage mechanisms involved, technology and infrastructure, water source and hydrology, and synopsis of preliminary engineering factors. These attributes also indicate the basis for preliminary cost estimates. The second part of the abstracts described the preliminary findings for the option including identified institutional and economic factors, potential issues associated with wetlands, water quality, or potential implications for existing biological or cultural resources, and a synopsis of key nonengineering factors that could warrant further investigation.

Finally, each abstract concludes with a summary of the current option status with respect to the IAIR framework. This includes brief synopsis of the status in terms of the overall option viability or the relative priority versus other options considered at this time. Any identified factors that could influence comparison to the other options are also briefly described. These key factors form the basis for the IAIR framework in which current option priorities are identified, then future iterations of UKBOS planning could reassess the priorities, incorporate additional information, and formulate updated priorities for subsequent planning.

5.1 Without Storage—Future Conditions

Storage peak capacity:	None—no additional storage provided
Projected storage time:	No changes to existing water operations
Storage water supply:	Current-future constraints including BOs
Available storage water:	Not applicable without storage projects
Storage fill frequency:	No changes to existing water operations
Initial design inflow rate:	Not applicable without storage projects
Water delivery benefit range:	None—no additional storage provided
Water treatment type:	2010 proposed TMDL to be determined
Current option status:	0—does not improve storage

Project Description

This option is a base condition for evaluating storage options and implications of future water resource conditions without providing any added water storage in the Upper Klamath Basin (UKB). Without storage improvements, Klamath Project and UKB water users will experience continued and increasing water constraints attributed to current and future BOs, the KBRA, the ongoing water rights adjudication process in Oregon, and possible future constraints from other actions such as the proposed TMDL water quality standards under review by the States of Oregon and California. These limitations will only become more restrictive during times of relatively less to severe water shortages on UKB water resources.

Technology and infrastructure—

By definition, this option does not involve new storage. However, there are even costs for the without project option. For this purpose, attributes and costs of the current AL/Barnes Ranch managed storage will be listed at the end of table 6-1. The option could have implications for the future operations and maintenance of the existing Klamath Project and UKB storage and conveyance facilities. Other non-storage treatment facilities, water system improvements, or technologies may be required to address water demands, quality standards, or other resource issues.

Water source and hydrology—

Future water supplies could be constrained by basinwide hydrological conditions, existing and future BOs (e.g., NMFS, 2010; FWS, 2008), operating agreements such as the KBRA, the operational efficiency and losses (evaporation or leakage) from existing water storage and conveyance systems, and other factors including changes in the downstream water demands or water use practices.

Preliminary engineering factors—

No new storage infrastructure would be built. Additional water resource modeling investigations would be necessary to assess future water supplies, water quality, or infrastructure under scenarios for shortage or surplus management. The potential implications of BO and TMDL changes may also warrant further investigation.

5.1 UKBOS-IAIR Option: IA-1a

Preliminary Findings

Without water storage improvements Klamath Project and UKB water users will experience continued and increasing constraints on water resources including the water available during future demand scenarios, under normal to drought water years, and related implications for water systems and operations.

Institutional and economic factors—
More detailed investigation is required to assess relevant water rights and claims involved in the adjudication process, groundwater protection from existing water operations, and benefit-cost relationships. Societal costs of continued status quo could include continued demand growth and competition for water throughout the Klamath Basin and water conflicts between the water users. In addition, factors such as the KBRA provisions or potential future changes in BOs regarding Klamath Project water operations, coupled with any demand increases or multiyear shortages, could force Reclamation to withhold or reduce contracted irrigation water deliveries. The societal and economic impacts of continuing these current water constraints within the Klamath Project/UKB are evident and could be greatly increased during times of shortage.

Wetlands and water quality—
Without implementing new storage facilities there would be no direct impacts to existing wetland areas. Water quality implications of future conditions without storage improvements—including potential TMDL requirements—would require further study and review by Oregon and California regulatory agencies.

Biological and cultural resources—
Fish species issues would continue to require mitigation or other construction of other facilities to address future water limitations. Possible implications on other biological or cultural resources would require more detailed investigation.

Key nonengineering factors—
There are prominent institutional and economic implications associated with this option. These factors and potential future implications on biological and cultural resources would require more detailed study during future planning stages.

Current Option Status

This option is not considered viable because it does meet the storage improvement objectives and has critical consequences cited above. More detailed hydrological and economic modeling could be used to assess Klamath Project and UKB water operations for comparison to any other UKBOS options that are carried forward to appraisal planning stages. Economic modeling may be able to build on studies underway for the Klamath Hydrologic Settlement Agreement. The current AL/Barnes managed storage shows a relatively good benefit/cost factor.

5.2 Without Storage—Nonstructural Measures

Storage peak capacity:	None—no additional storage provided
Projected storage time:	No changes to existing water operations
Storage water supply:	Current-future constraints including BOs
Available storage water:	Not applicable without storage projects
Storage fill frequency:	No changes to existing water operations
Initial design inflow rate:	Not applicable without storage projects
Water delivery benefit range:	None—no additional storage provided
Water treatment type:	2010 proposed TMDL to be determined
Current option status:	0—does not improve storage

Project Description

This option is a variation of the future condition without storage that addresses the concept of implementing nonstructural demand reduction measures to reduce the need for water storage in the UKB. All other attributes of this option are the same as the base option, without storage improvements. Under this option, water storage needs and future constraints on the Klamath Project and UKB water users would be addressed through nonstructural measures such as the purchase of water rights. Related implications on provisions that could influence future UKB water operations—BOs, the KBRA, water rights adjudication, and TMDL water quality standards—would all require specific investigation.

Technology and infrastructure—

By definition this option does not involve new storage infrastructure. The option could have implications for the future operations and maintenance of the existing Klamath Project and UKB storage and conveyance facilities. Other non-storage treatment facilities, water system improvements, or technologies may be required to address water demands, quality standards, or other resource issues. See option IA-3A, for “future without project” description.

Water source and hydrology—

Future water supplies could be constrained by basinwide hydrological conditions, existing and future BOs (e.g., NMFS, 2010; FWS, 2008), operating agreements such as the KBRA, the operational efficiency and losses (evaporation or leakage) from existing water storage and conveyance systems, and other factors including changes in the downstream water demands or water use practices.

Preliminary engineering factors—

No new storage infrastructure would be built. Non storage-related infrastructure engineering implications of this option are possible, although beyond the scope of storage objectives at this time. Additional water resource modeling investigations would be necessary to assess future water supplies, water quality, or infrastructure under scenarios for shortage or surplus management. The potential implications of BO and TMDL changes may also warrant further investigation.

5.2 UKBOS-IAIR Option: IA-1b

Preliminary Findings

Without water storage improvements Klamath Project and UKB water users will experience continued and increasing constraints on water resources including the water available during future demand scenarios, under normal to drought water years, and related implications for water systems and operations. These issues would be reduced to some extent by the nonstructural measures of this option.

Institutional and economic factors—
More detailed investigation is required to assess relevant water rights and claims and key benefit-cost relationships. The extent that this option would reduce the impacts and economic costs of future conditions without storage improvements would depend on the scope and specific provisions that are incorporated in the option (which have not been formulated to date). It may be possible to apply an economic modeling approach to define the optimum scope and specific objectives for this type of nonstructural water rights program. As stated elsewhere, long-term Federal funding for water demand reduction efforts and other nonstructural programs (such as water rights purchase) probably will not be viable.

Wetlands and water quality—
Without implementing new storage facilities there would be no direct impacts to existing wetland areas. Water quality implications of future conditions without storage improvements—including potential TMDL requirements—would require further study and review by Oregon and California regulatory agencies.

Biological and cultural resources—
Fish species issues would continue to require mitigation or other construction of other facilities to address future water limitations. Possible implications on other biological or cultural resources would require more detailed investigation.

Key nonengineering factors—
There are prominent institutional and economic implications associated with this option. These factors and potential future implications on biological and cultural resources would require more detailed study during future planning stages.

Current Option Status

This option is not considered viable for these water storage preliminary planning purposes, because it does meet the direct objectives and could have consequences that are beyond the scope of the UKBOS investigations. It may be possible to use detailed hydrological and economic modeling to assess Klamath Project and UKB water operations for comparison to any other storage options that are carried forward to appraisal planning stages.

5.3 ASR Passive Infiltration—Sprague Basin, Site #7a

Storage peak capacity:	7,500 acre-ft maximum
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	Sprague River
Available storage water:	271,000 acre-ft/year (OWARS, 1999)
Storage fill frequency:	Surplus water years
Initial design inflow rate:	100 ft^3/s (for 60 days to peak capacity)
Water delivery benefit:	0 to 7,500 acre-ft/year (USGS, 2010)
Water treatment type:	Group 2; ASR—infiltration needs TBD
Current option status:	2—second level priority for further planning

Project Description

This option involves passive groundwater recharge, storage, and recovery within the Sprague Basin—a tributary to UKL. The U.S. Geological Survey (USGS, 2010) developed preliminary scoping parameters. The identified Sprague site #7a is the preferred location because it is the lowest elevation of the Sprague subareas to gather water supplies at the intake using the adjacent Sprague River water and would minimize existing farmed lands impacts and distances to/from conveyance features. Water delivery would use the existing conveyance systems and channels. Stored water returned back to UKL by this option would benefit downstream water user needs during times of shortage.

Technology and infrastructure—

These ASR operations would apply recharge and retrieval within the same general site area. Supply water would be passed through a fish-screen intake and pumped to constructed infiltration beds (porous bottom ponds) to produce passive surface infiltration and percolation for groundwater recharge. Water stored underground would be recovered using a pumped well field in the same site area and released to the Sprague River for downstream use or storage in UKL. Preliminary plans are based on a pumped well field with 10 wells producing up to 15 ft^3/s each. The total peak well field extraction capacity was oversized somewhat to accommodate equipment maintenance and produce reliable retrieval flow rates.

Water source and hydrology—

Water for the recharge operations would be supplied by tributary inflows from the Sprague River watershed during times of excess runoff. Hydrological operations are defined by the infiltration rates in passive infiltration/percolation beds (ponds), evaporative water losses, underground leakage to areas outside the recovery zone, and other factors including downstream water demands.

Preliminary engineering factors—

Further planning will likely require additional geohydrologic investigations and operations modeling to develop more accurate estimates of reliable water supply, facilities and operating costs, and long-term design life storage benefits.

5.3 UKBOS-IAIR Option: IA-2a

Preliminary Findings

ASR schemes in general offer water management flexibility. They also offer relatively smaller surface infrastructure footprints and evaporation losses than do surface water storage schemes.

Institutional and economic factors—

More detailed investigations are required to evaluate water rights, water quality, and benefit/cost relationships. Preliminary planning located the option facilities to minimize impacts to private farmlands (a geographic information system [GIS] using land parcel datasets). Some land purchase or easements would be required for the ASR facilities, including the infiltration ponds, well field, water conveyance, and power systems. Oregon water law review is anticipated to consider storage in ASR projects with possible delivery for use at a different location or within a single or multipurpose water project such as the Klamath Project. Major cost elements include the spreading basins, conveyance systems, water treatment, O&M, and power use.

Wetlands and water quality—

Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS and National Wetlands Inventory dataset). Passive infiltration may not require rigorous water treatment compared to direct injection ASR; however, groundwater protection Safe Drinking Water Act provisions will require specific evaluations. Treatment after recovery is not expected although this will also require further project-specific studies and regulatory review.

Biological and cultural resources—

Fish species issues will be mitigated by construction of a fish screen at the intake pumps. Studies of seasonal flow intake would have to consider sensitive fish, aquatic, terrestrial, and avian species. Although there are no identified cultural resource issues at this site, further evaluation will be needed should this option advance to subsequent planning stages.

Key nonengineering factors—

Surface infiltration facilities generally do not produce intractable resource impacts although some wildlife may use spreading basins. Further studies should evaluate these issues, groundwater protection, and water rights issues in detail.

Current Option Status

This option is considered viable and a second level priority for further storage planning stages. Surface infiltration ASR operations have been used successfully at many locations where conditions are suitable. Water treatment and pumping power are generally less than with injection ASR. Spreading basins require periodic maintenance and reconditioning. Site-specific factors can influence benefit-cost relationships considerably and would require further study.

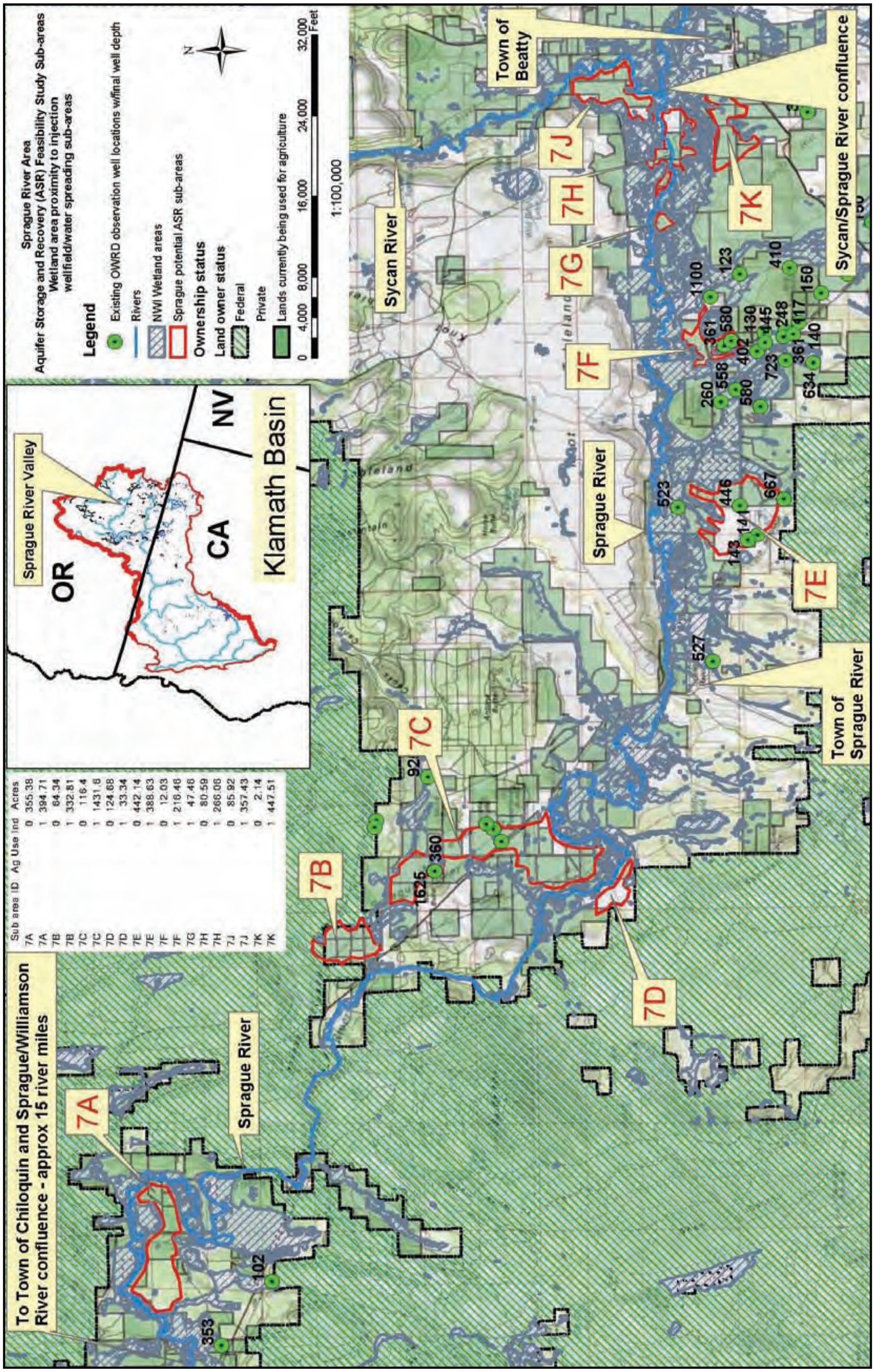


Figure 5-1.—Locations of potential ASR sites evaluated in the Sprague Basin.

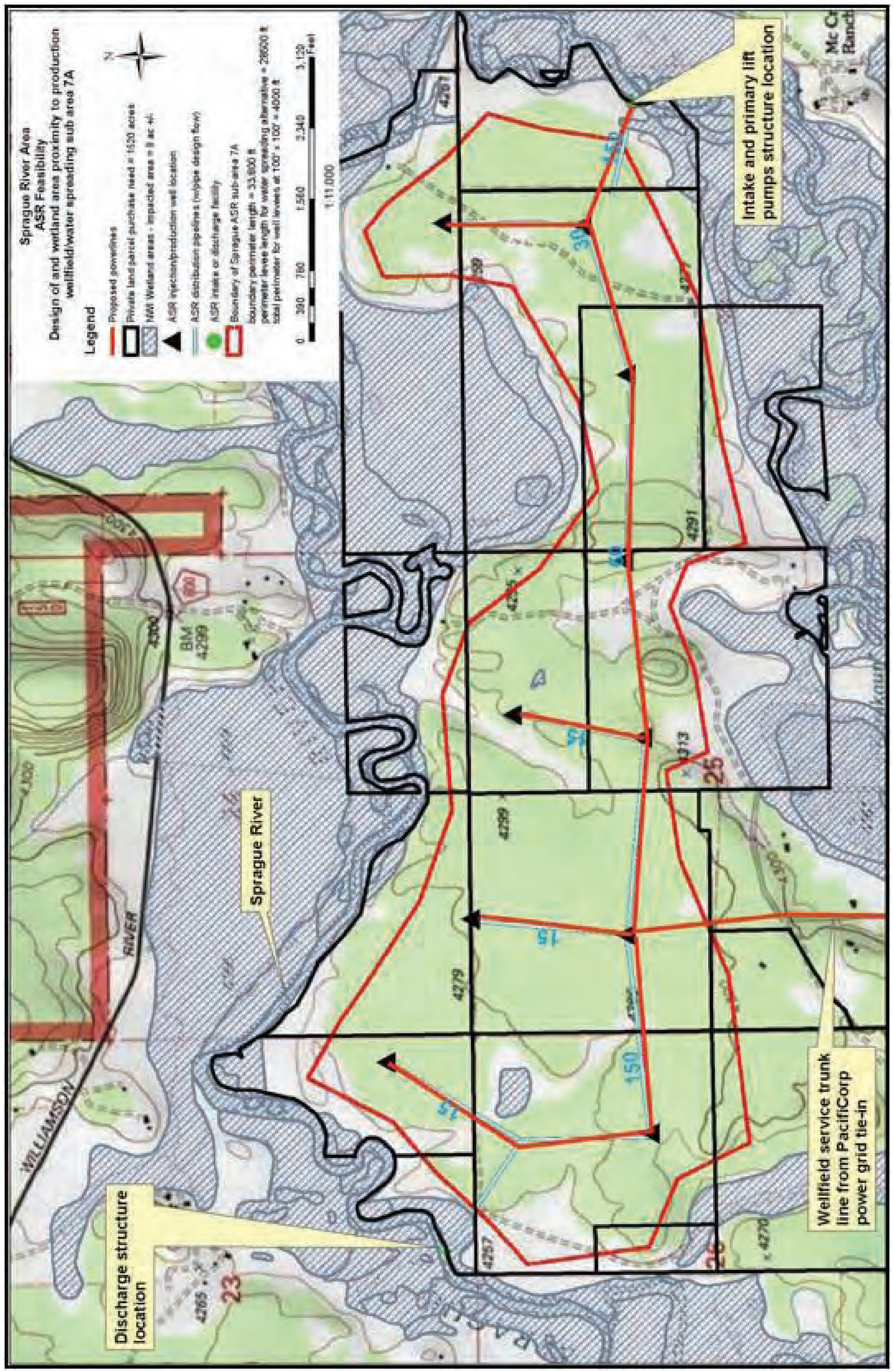


Figure 5-2.—Preliminary layout of ASR facilities within the Sprague site #7a area.

5.4 ASR Active Injection—Sprague Basin, Site #7a

Storage peak capacity:	7,500 acre-ft maximum
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	Sprague River
Available storage water:	271,000 acre-ft/year (OWARS, 1999)
Storage fill frequency:	Surplus water years
Initial design inflow rate:	100 ft^3/s (for 60 days to peak capacity)
Water delivery benefit range:	0 to 7,500 acre-ft/year (USGS, 2010)
Water treatment type:	Group 2; ASR—injection treatment
Current option status:	2—second level priority for further planning

Project Description

This option involves active well injection for ASR in the Sprague Basin tributary to UKL. The USGS (2010) developed preliminary scoping parameters. The identified Sprague site #7a is the preferred location for these ASR operations because it has the lowest elevations in the Sprague area to gather water supplies at intake using Sprague River water and would minimize existing farmed lands impacts. Water delivery to and from the site would use existing conveyance systems and channels. Stored water returned to UKL would benefit downstream water user needs during times of shortage.

Technology and infrastructure—

Groundwater ASR operations would apply integrated direct well injection and recovery systems. Supply water would be passed through a fish-screened intake and pumped to through pressurized injection wellheads to recharge the underlying groundwater aquifer. Water stored underground would be recovered by reversing the same wellhead pumps to extract and release stored water to the Sprague River for downstream uses or storage at UKL. Preliminary plans are based on 10 wells producing up to 15 ft^3/s each. The extraction capacity was oversized to allow for equipment reliability and to achieve estimated retrieval flows.

Water source and hydrology—

Sprague River tributary flows would supply the ASR operations during times of excess runoff. Hydrological operations would be defined by the injection rate capacities of the wells, underground leakage to areas outside of the well field recovery zone, and other factors including downstream water demands and water use practices. Preliminary planning applied a 60-day duration for both river water supply diversion rates and the groundwater recovery extraction period.

Preliminary engineering factors—

Further planning will require additional geohydrologic investigations and water operations modeling to develop accurate estimates of water supply and delivery reliability, groundwater recovery implications, ASR facilities and operating costs, and design life storage benefits for this option.

5.4 UKBOS-IAIR Option: IA-2b

Preliminary Findings

Active ASR schemes have been used successfully at many locations nationwide and offer water management flexibility. They also have a smaller infrastructure footprints and evaporation losses than surface water storage schemes.

Institutional and economic factors—
Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon water law review is anticipated to consider storage in ASR projects with possible delivery for use at a different location or for use within a single or multipurpose water project such as currently accommodated within the Klamath Project operations. For preliminary planning purposes, the option facilities were located to minimize impacts to existing private lands (GIS, land parcel datasets). Minor land purchase is expected for installation of ASR wells, water conveyance, and service infrastructure. Major cost elements include ASR facilities, water treatment, ongoing O&M, and power usage.

Wetlands and water quality—
Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS, National Wetlands Inventory dataset). Active injection operations often require water treatment for groundwater protection under the Safe Drinking Water Act provisions. Treatment after recovery is not expected although this will require further project specific studies and regulatory review.

Biological and cultural resources—
Construction of a fish screen at the intake pump will mitigate fish species issues. Studies of seasonal flow intake into this option would have to consider sensitive fish, aquatic, terrestrial, and avian species issues. Although there are no currently identified cultural resource issues at this site, further evaluation will be necessary should this option advance to further planning stages.

Key nonengineering factors—
Once installed, direct injection ASR facilities including ASR wellheads, pipelines, and power systems, have fairly minor affects on surface resources accept to allow for repairs or maintenance. Further studies should assess potential groundwater interactions, water treatment needs, and water rights issues.

Current Option Status

This option is considered viable and a second level priority for further storage planning stages. Direct injection ASR operations have been used successfully at many locations where conditions are suitable. Water treatment is often required for injection recharge operations. Pumping power for both injection and recovery operations is a primary life cycle cost. Site-specific factors can influence benefit-costs relationships considerably and would require further study.

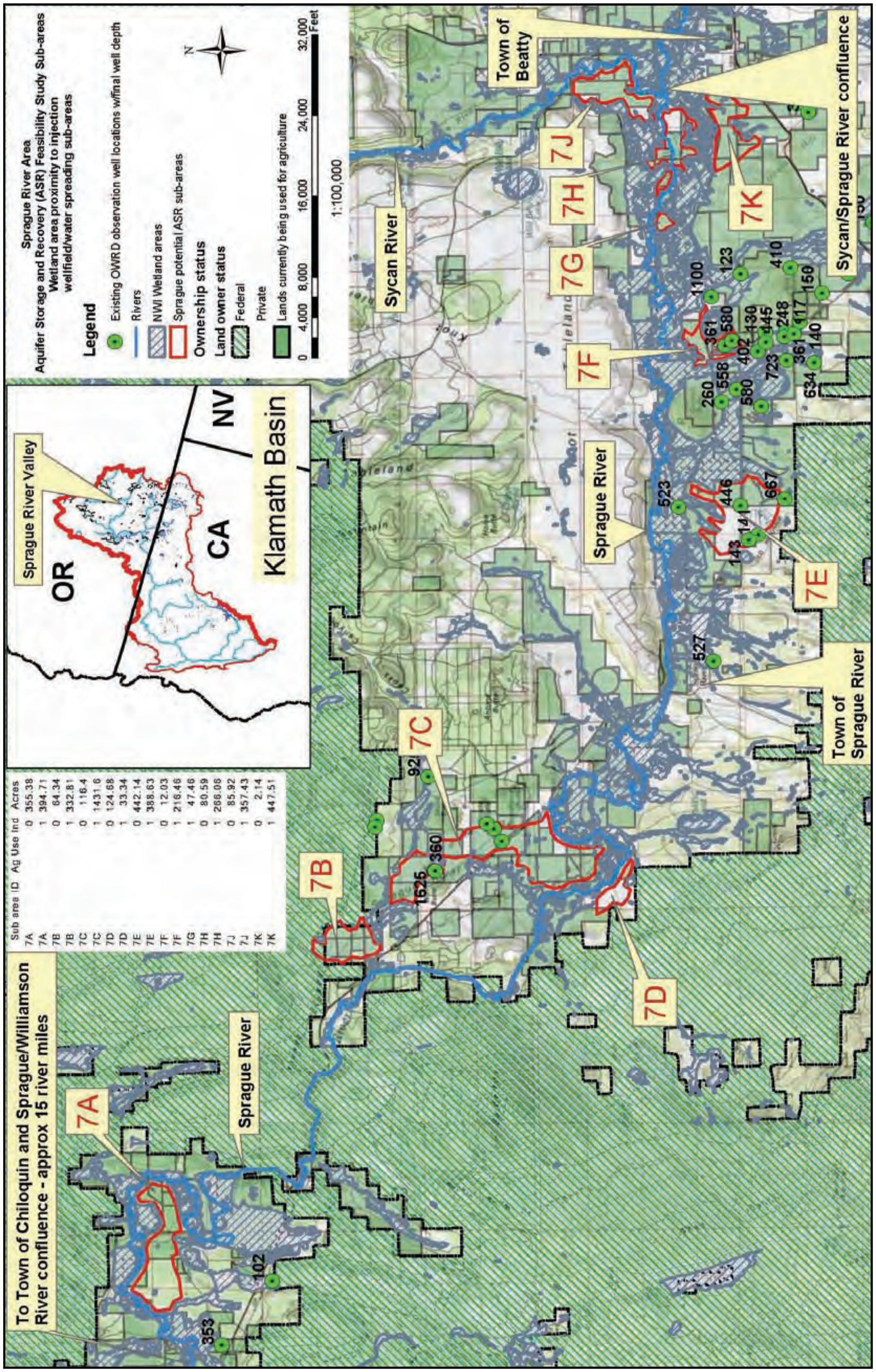


Figure 5-3.—Locations of potential ASR sites evaluated in the Sprague Basin.

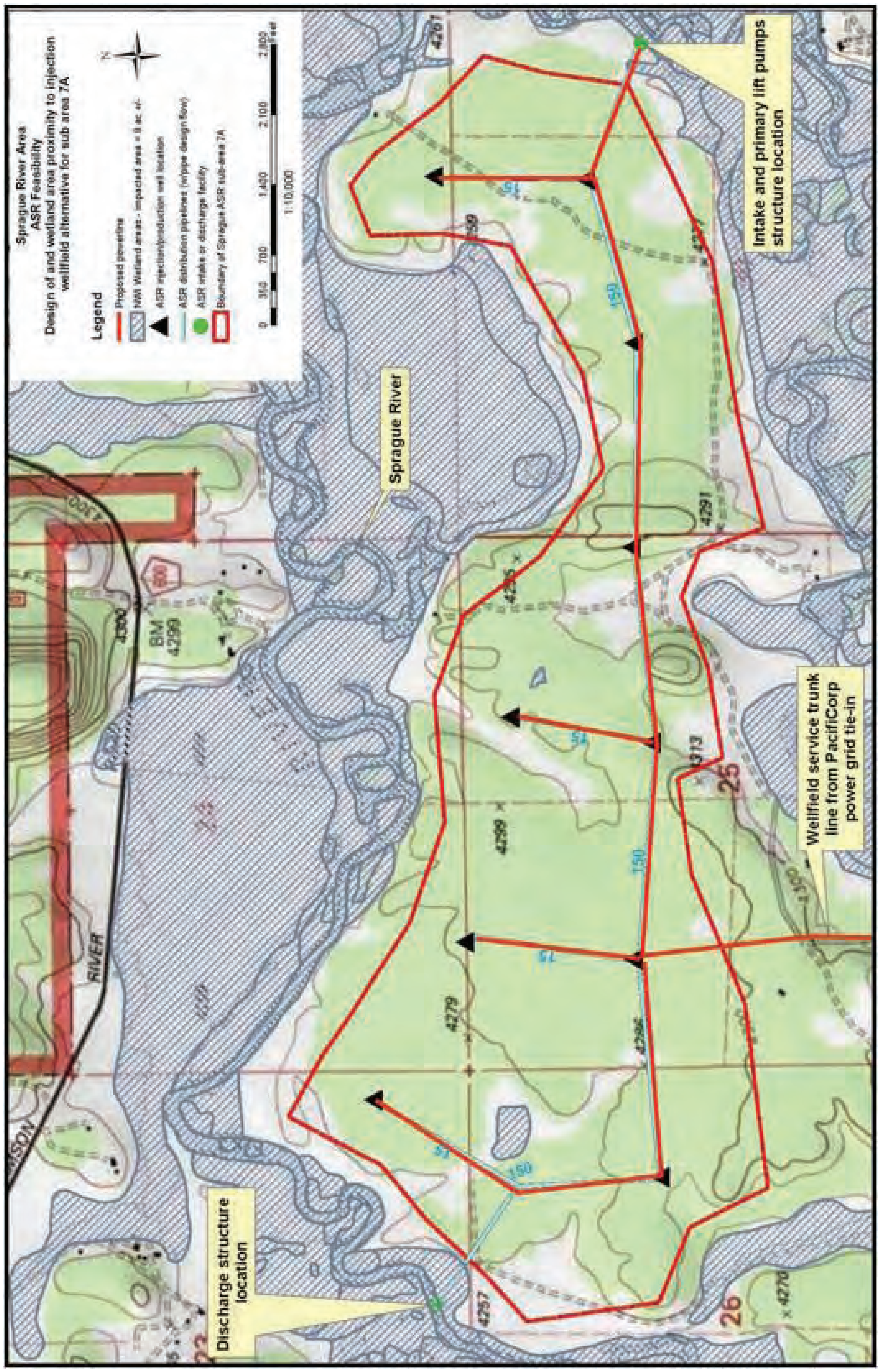


Figure 5-4.—Preliminary layout of injection ASR facilities in the Sprague site #7a area.

5.5 ASR Active Injection—North Klamath, Site #3

Storage peak capacity:	9,500 acre-ft maximum
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	Klamath River and Lost River
Available storage water:	803,000 acre-ft/year (OWARS, 1999)
Storage fill frequency:	Surplus water years
Initial design inflow rate:	100 ft^3/s (for 60 days to peak capacity)
Water delivery benefit range:	0 to 9,500 acre-ft/year (USGS, 2010)
Water treatment type:	Group 2; ASR—injection operations
Current option status:	2—second level priority for further planning

Project Description

This option involves active well injection for ASR in the Northern Klamath Valley. Preliminary scoping parameters were developed by the USGS (2010). The identified Northern Klamath Valley site #3 area is preferred for ASR operations because of the close proximity to the Lost River Diversion Canal. Water delivery to and from the site would use existing Klamath Project conveyance systems and stream channels. Water users would benefit from the additional water available during times of shortage.

Technology and infrastructure—

Groundwater ASR operations would apply an integrated direct well injection and recovery system. Supply water would be passed through a fish-screened intake and pumped to through pressurized injection wellheads to recharge the underlying groundwater aquifer. Stored water would be recovered by reversing the wellhead pumps to release water to the Lost River Diversion Canal for distribution through Klamath Project systems or to the Klamath River. Preliminary plans are based on 10 wells producing up to 15 ft^3/s each. The ASR extraction capacity was oversized to allow for equipment reliability and to achieve estimated retrieval flows.

Water source and hydrology—

These ASR operations would be supplied by Klamath River and Lost River flows during times of excess runoff. Hydrological operations would be defined by the injection well recharge rates, underground leakage outside of the recovery zone, and other factors including Klamath Project and downstream water demands and water use practices. Preliminary planning applied a 60-day duration for both river water supply diversion rates and the groundwater recovery extraction period.

Preliminary engineering factors—

Further planning will require additional geohydrologic investigations and water operations modeling to develop accurate estimates of water supply, recharge rates, water delivery reliability, facility design details, and design life benefit and cost relationships. Potential implications of surface and groundwater interactions will also require further investigation.

5.5 UKBOS-IAIR Option: IA-2c

Preliminary Findings

Active ASR schemes have been used successfully at many locations nationwide and offer water management flexibility. They also have a smaller infrastructure footprints and evaporation losses than surface water storage schemes.

Institutional and economic factors—
Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon water law review is anticipated to consider storage in ASR projects with possible delivery for use at a different location or for use within a single or multipurpose water project such as currently accommodated within the Klamath Project operations. For preliminary planning purposes, the option facilities were located to minimize impacts to existing private lands (GIS, land parcel datasets). Minor land purchase is expected for installation of ASR wells, water conveyance, and service infrastructure. Major cost elements include ASR facilities, water treatment, ongoing O&M, and power usage.

Wetlands and water quality—
Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS, National Wetlands Inventory dataset). Active injection operations often require water treatment for groundwater protection under the Safe Drinking Water Act provisions. Treatment after recovery is not expected although this will require further project specific studies and regulatory review.

Biological and cultural resources—
Fish species issues will be mitigated by construction of a fish screen at the intake pump. Studies of seasonal flow intake into this option would have to consider sensitive fish, aquatic, terrestrial, and avian species issues. Although there are no currently identified cultural resource issues at this site, further evaluation will be necessary should this option advance to further planning stages.

Key nonengineering factors—
Once installed, direct injection ASR facilities including ASR wellheads, pipelines, and power systems, have fairly minor affects on surface resources accept to allow for repairs or maintenance. Further studies should assess potential groundwater interactions, water treatment needs, and water rights issues.

Current Option Status

This option is considered viable and a second level priority for further storage planning stages. Direct injection ASR operations have been used successfully at many locations where conditions are suitable. Water treatment is often required for injection recharge operations. Pumping power for both injection and recovery operations is a primary life cycle cost. Site-specific factors can influence benefit-costs relationships considerably and would require further study.

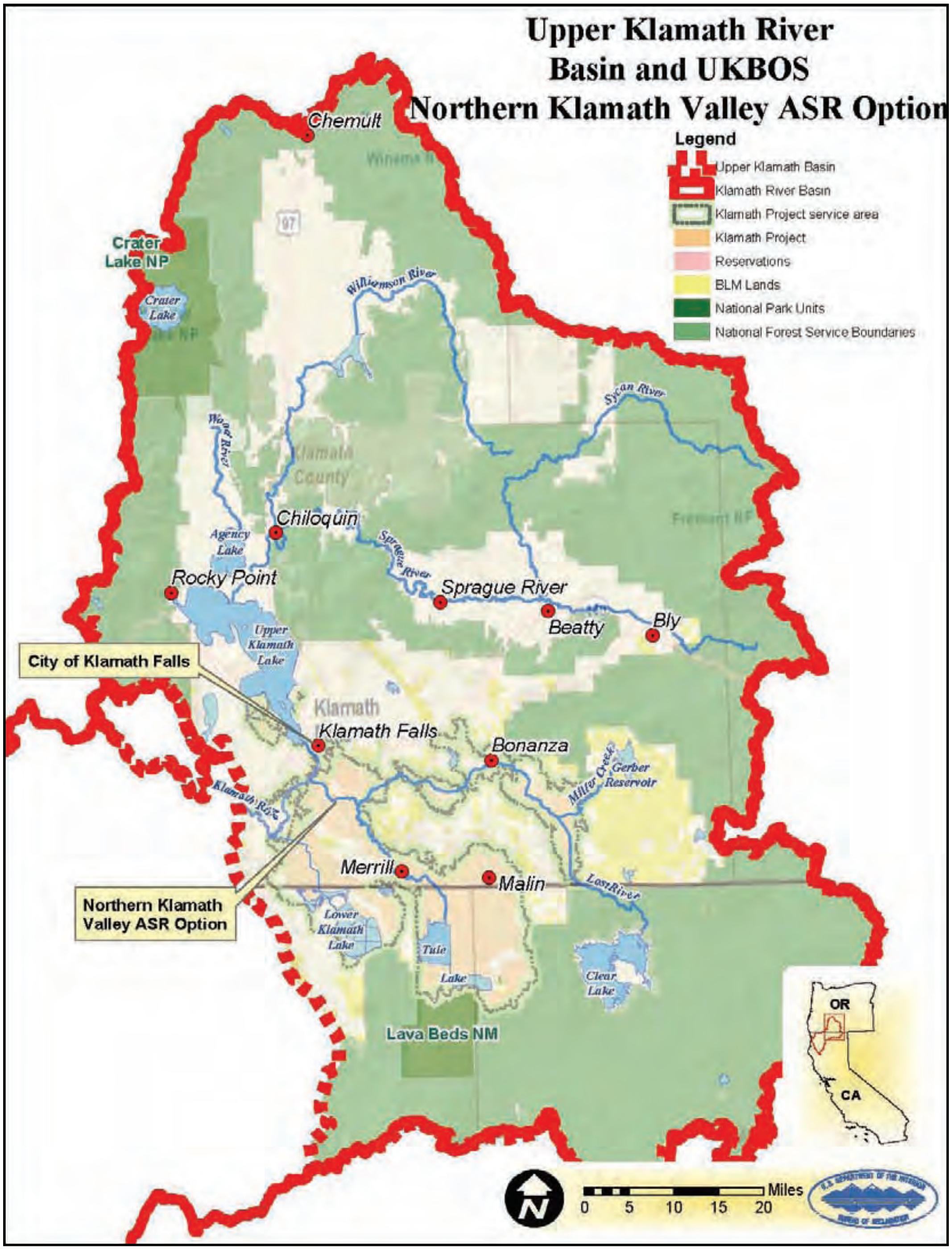


Figure 5-5.—ASR at Northern Klamath site #3—location map.

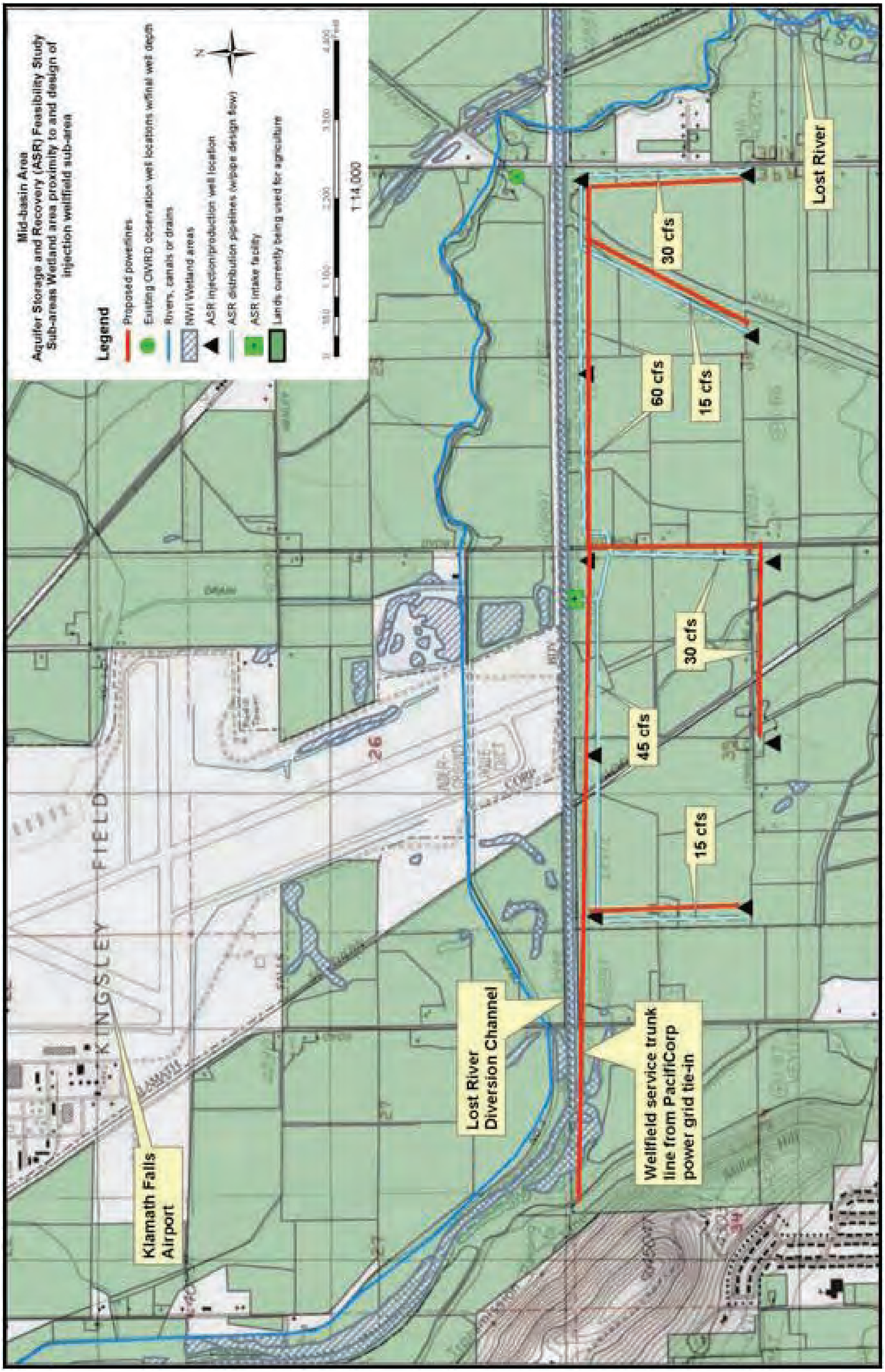


Figure 5-6.—Preliminary layout of ASR facilities in the Northern Klamath site #3 area.

5.6 ASR Passive Recharge—Langell Valley, Site #8

Storage peak capacity:	6,400 acre-ft maximum
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	Production (groundwater pumping) only from aquifer
Available storage water:	Production/extraction only—no active injection
Storage fill frequency:	Passive regional aquifer natural recharge
Initial design inflow rate:	Varies (pending detailed studies)
Water delivery benefit range:	0 to 6,400 acre-ft/year (USGS, 2010)
Water treatment type:	Group 4; Potential TMDL needs
Current option status:	2—second level priority for further planning

Project Description

This option involves groundwater recovery within the Langell Valley area of the Lost River watershed. Preliminary scoping parameters were developed by the USGS (2010). The identified Langell Valley site #8 is preferred to minimize existing farmed lands impacts and the distance to the North Canal and Langell Valley Klamath Project water systems. Water delivery would use the existing Klamath Project conveyance systems and stream channels. Water users would benefit from the additional water available during times of shortage.

Technology and infrastructure—

Groundwater retrieval would be accomplished using pumped wells with passive natural recharge to replenish groundwater supplies. As a result, this represents a modified ASR strategy. A wellhead pump system would extract groundwater and deliver it to the North Canal for downstream use or Klamath Project water users supplied by the North Canal. Preliminary plans are based on 10 wells at up to 15 ft^3/s each. The extraction capacity was oversized to allow for equipment reliability and to achieve estimated retrieval flows.

Water source and hydrology—

Water for recharge of the larger regional aquifer is supplied by local groundwater in the Miller Creek watershed. The hydrological operations would be defined by the extraction rate capacities, underground leakage to areas outside the well field recovery zone, and other factors including downstream water demands and water use practices. The water supply reliability depends on the surplus recharge rates. Preliminary plans applied a 60-day annual extraction period to estimate facilities needed to deliver supplemental water for downstream uses.

Preliminary engineering factors—

Further planning will require additional geohydrologic investigations and water operations modeling to develop accurate estimates of the aquifer recharge rates, water supply and delivery reliability, facility design details, and design life cost and benefit relationships. The potential implications of surface and groundwater resource interactions will also require further investigation.

5.6 UKBOS-IAIR Option: IA-2d

Preliminary Findings

ASR schemes in general offer water management flexibility. They can also offer relatively smaller surface infrastructure footprints and evaporation losses than do surface water storage schemes.

Institutional and economic factors—
Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon water law review is anticipated to consider surface and groundwater rights implications and possible delivery for use at a different location or within a single or multipurpose water project such as within the Klamath Project. For preliminary planning, the option facilities were located to minimize impacts to private lands (GIS, land parcel datasets); however, minor land purchase is expected for installation of new wells, water conveyance systems, and service infrastructure. Major cost elements include the groundwater extraction facilities, ongoing O&M, and power usage.

Wetlands and water quality—
Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS, National Wetlands Inventory dataset). Passive aquifer recharge eliminates the need for pretreatment. Treatment after extraction is not expected although this will require project specific studies and regulatory review.

Biological and cultural resources—
Major effects on fish, birds, or terrestrial wildlife are not expected because for the groundwater production operations. Possible implications associated with surface and groundwater exchanges will likely require further study. Although there are no currently identified cultural resource issues at this site, further evaluation will be necessary should this option advance to further planning stages.

Key nonengineering factors—
Once installed, ASR facilities including wellheads, pipelines, and power systems, generally have fairly minor affects on surface resources accept to allow for repairs or maintenance. Further studies should assess possible economic implications of groundwater extraction, water rights issues, and potential impacts of groundwater movement and transfers to surface hydrologic features.

Current Option Status

This option is considered viable and a second level priority for further storage planning stages. Water treatment is not applicable to natural recharge and power costs are only required for production well operations. Additional investigations will be necessary to assess recharge rates, supply reliability, and potential surface water interactions. Site-specific factors could influence benefit-cost relationships considerably and would require further investigation.

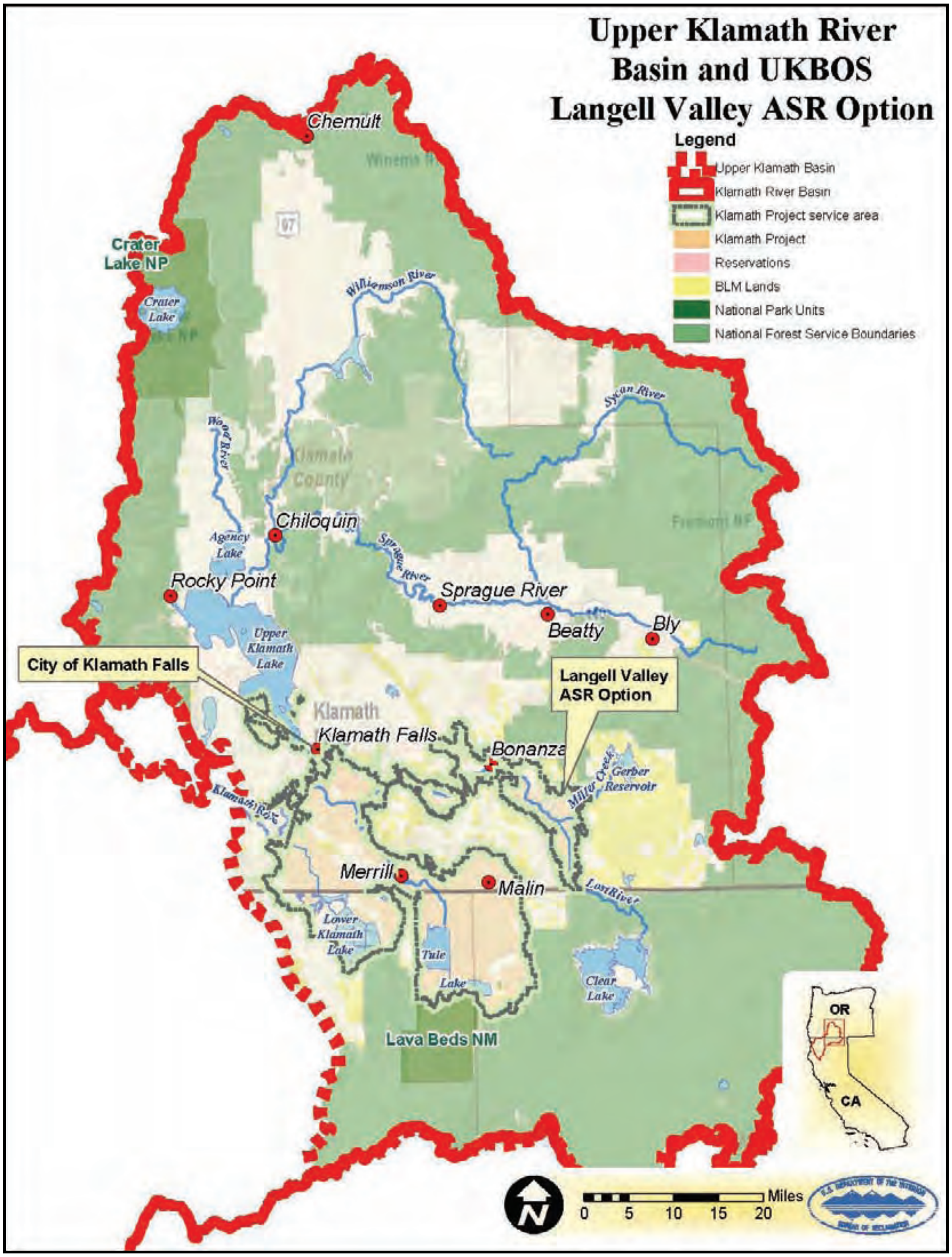


Figure 5-7.—ASR at the Langell Valley site #8—location map.

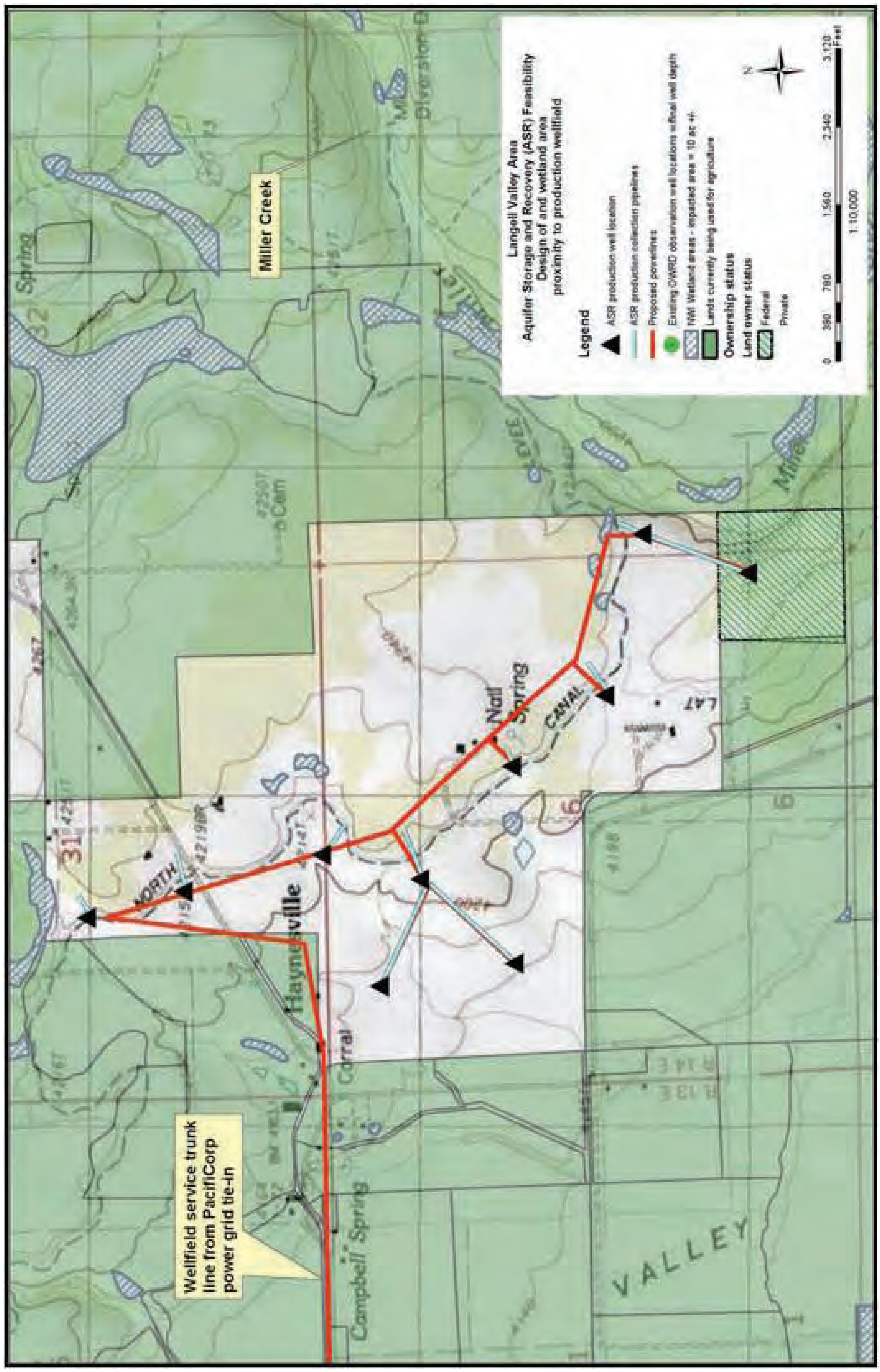


Figure 5-8.—Preliminary layout of ASR facilities at the Langell Valley site #8.

5.7 ASR Passive Recharge —Gerber Basin, Site #9

Storage peak capacity:	Storage peak capacity: 8,000 acre-ft maximum
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	Production (groundwater pumping) only from aquifer
Available storage water:	Production/extraction only—no active injection
Storage fill frequency:	Passive regional aquifer natural recharge
Initial design inflow rate:	Varies (pending detailed studies)
Water delivery benefit range:	0 to 8,000 acre-ft/year (USGS, 2010)
Water treatment type:	Group 4; Potential TMDL needs
Current option status:	1—High priority for further planning

Project Description

This option involves groundwater recovery within the Gerber Reservoir area of the Lost River watershed. Preliminary scoping parameters were developed by the USGS (2010). The identified Gerber Reservoir site #9 is preferred to minimize wetland areas impacts and distance to the Gerber Reservoir and Klamath Project water systems. Water delivery would use existing Klamath Project conveyance systems and stream channels. Water users would benefit from the additional water available during times of shortage.

Technology and infrastructure—

Groundwater retrieval would be accomplished using pumped wells with passive natural recharge to replenish groundwater supplies. As a result, this represents a modified ASR strategy. A wellhead pump system would extract groundwater and deliver it to Gerber Reservoir for downstream use or Klamath Project water users. Preliminary plans are based on 10 wells at up to 15 ft^3/s each. The well field capacity was oversized to allow for some equipment reliability and to achieve estimated retrieval flows.

Water source and hydrology—

Water for recharge of the larger regional aquifer is supplied by groundwater in the Gerber Reservoir watershed. The hydrological operations would be defined by the extraction rate capacities, underground leakage to areas outside the well field recovery zone, and other factors including downstream water demands and water use practices. The water supply reliability depends on the surplus recharge rates. Preliminary plans applied a 60-day annual extraction period to estimate facilities needed to deliver supplemental water for downstream uses.

Preliminary engineering factors—

Further planning will require additional geohydrologic investigations and water operations modeling to develop accurate estimates of the aquifer recharge rates, water supply and delivery reliability, facility design details, and design life cost and benefit relationships. The potential implications of surface and groundwater resource interactions will also require further investigation.

5.7 UKBOS-IAIR Option: IA-2e

Preliminary Findings

ASR schemes in general offer water management flexibility. They can also offer relatively smaller surface infrastructure footprints and evaporation losses than do surface water storage schemes.

Institutional and economic factors—
Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon water law review is anticipated to consider water rights implications. The distance between Gerber Reservoir and the nearest potable wells may limit local groundwater exchanges. For preliminary planning, facilities were located to minimize impacts to private lands (GIS, land parcel datasets); however, some land purchase is expected for installation of new wells, conveyance, and service systems. Major cost elements include the pumped well groundwater extraction facilities, ongoing O&M, and power usage.

Wetlands and water quality—
Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS, National Wetlands Inventory dataset). Passive aquifer recharge eliminates the need for pretreatment. Treatment after extraction is not expected although this will require project specific studies and regulatory review.

Biological and cultural resources—
Major effects on fish, birds, or terrestrial wildlife are not expected because for the groundwater production operations. Possible implications associated with surface and groundwater exchanges will likely require further study. Although there are no currently identified cultural resource issues at this site, further evaluation will be necessary should this option advance to further planning stages.

Key nonengineering factors—
Once installed, ASR facilities including wellheads, pipelines, and power systems, generally have fairly minor affects on surface resources accept to allow for repairs or maintenance. Further studies should assess possible economic implications of groundwater extraction, water rights issues, and potential impacts of groundwater movement and transfers to surface hydrologic features.

Current Option Status

This option is considered viable and a relatively higher priority for further storage planning stages. Water treatment is not applicable to natural recharge and power costs are only required for production well operations. Additional investigations will be necessary to assess recharge rates, supply reliability, and potential surface water interactions. Site-specific factors could influence benefit-cost relationships considerably and would require further investigation.

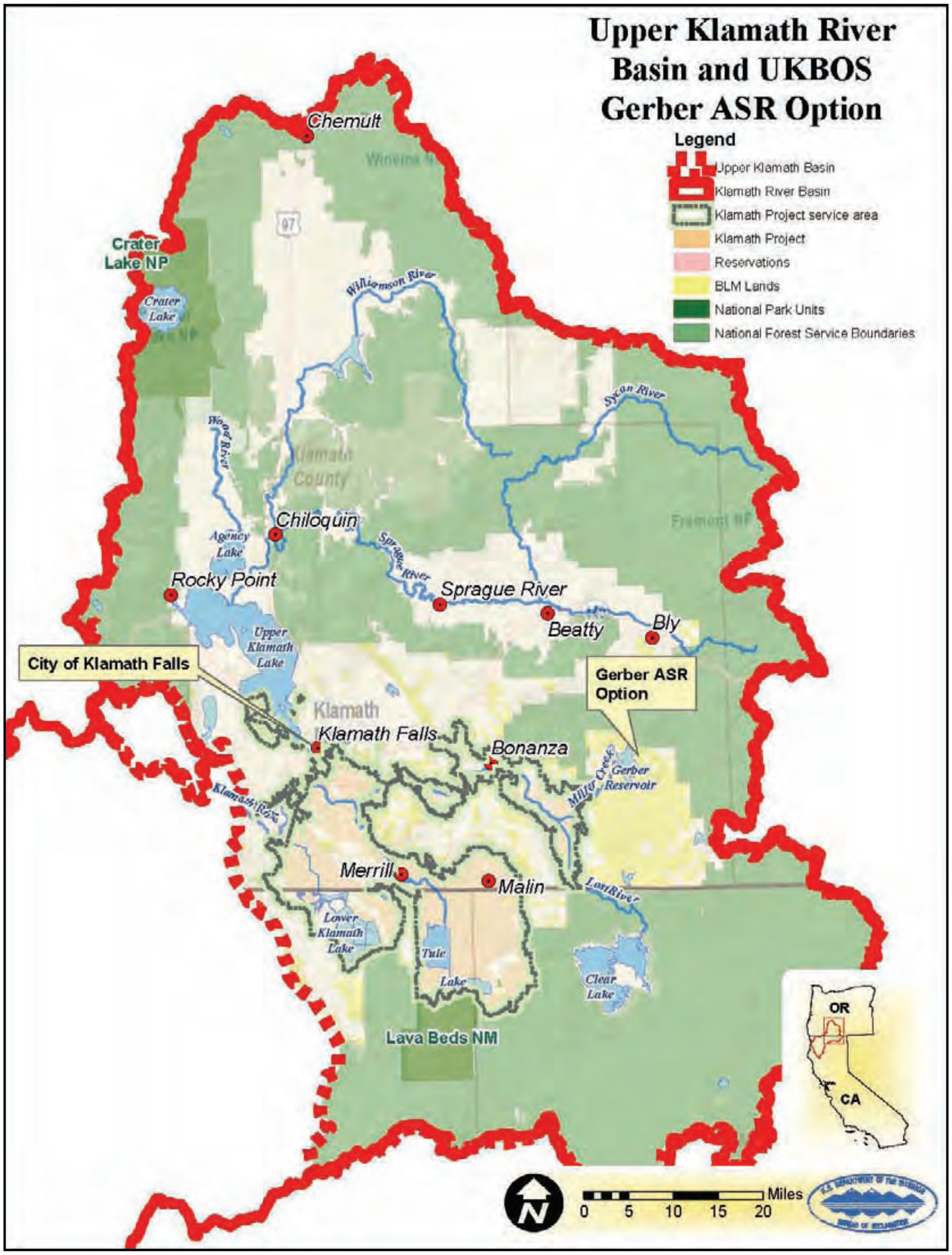


Figure 5-9.—ASR at the Gerber Reservoir site #9—location map.

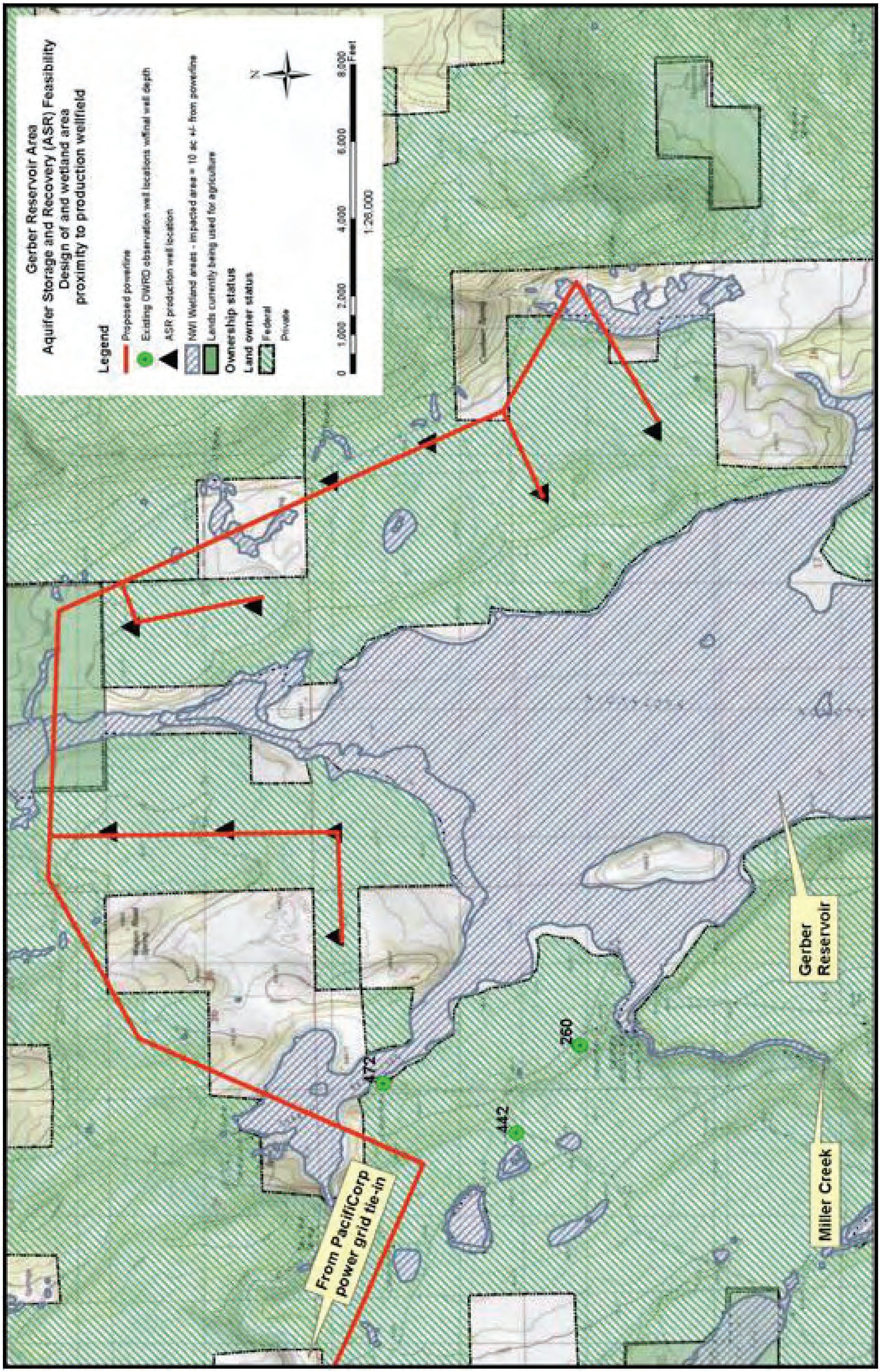


Figure 5-10.—Preliminary layout of ASR facilities at the Gerber Reservoir site #9.

5.8 ASR Passive Recharge—Clear Lake, Site #10

Storage peak capacity:	8,000 acre-ft maximum
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	Production (groundwater pumping) only from aquifer
Available storage water:	Production/extraction only—no active injection
Storage fill frequency:	Passive regional aquifer natural recharge
Initial design inflow rate:	Varies (pending detailed studies)
Water delivery benefit range:	0 to 8,000 acre-ft/year (USGS, 2010)
Water treatment type:	Group 4; Potential TMDL needs
Current option status:	1—High priority for further planning

Project Description

This option involves groundwater recovery within the Clear Lake Reservoir area of the Lost River watershed. Preliminary scoping parameters were developed by the USGS (2010). The identified Clear Lake Reservoir site #10 is preferred to minimize wetland areas impacts and distance to the Clear Lake Reservoir and Klamath Project water systems. Water delivery would use existing Klamath Project conveyance systems and stream channels. Water users would benefit from the additional water available during times of shortage.

Technology and infrastructure—
Groundwater retrieval would be accomplished using pumped wells with passive natural recharge to replenish groundwater supplies. As a result, this represents a modified ASR strategy. A wellhead pump system would extract groundwater and deliver it to Clear Lake Reservoir for downstream use or Klamath Project water users. Preliminary plans are based on 10 wells at up to 15 ft^3/s each. The well field extraction capacity was oversized to allow for some equipment reliability and to achieve estimated retrieval flows.

Water source and hydrology—
Water for recharge of the larger regional aquifer is supplied by groundwater in the Clear Lake Reservoir watershed. The hydrological operations would be defined by the extraction rate capacities, underground leakage to areas outside the well field recovery zone, and other factors including downstream water demands and water use practices. The water supply reliability depends on the surplus recharge rates. Preliminary plans applied a 60-day annual extraction period to estimate facilities needed to deliver supplemental water for downstream uses.

Preliminary engineering factors—
Further planning will require additional geohydrologic investigations and water operations modeling to develop accurate estimates of the aquifer recharge rates, water supply and delivery reliability, facility design details, and design life cost and benefit relationships. The potential implications of surface and groundwater resource interactions will also require further investigation.

5.8 UKBOS-IAIR Option: IA-2f

Preliminary Findings

ASR schemes in general offer water management flexibility. They can also offer relatively smaller surface infrastructure footprints and evaporation losses than do surface water storage schemes.

Institutional and economic factors—
Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon water law review is anticipated to consider water rights implications. The distance between Clear Lake Reservoir and the nearest potable wells may limit groundwater exchanges. For preliminary planning, facilities were located to minimize impacts to private lands (GIS, land parcel datasets); however, some land purchase is expected for installation of new wells, conveyance, and service systems. Major cost elements include the pumped well groundwater extraction facilities, ongoing O&M, and power usage.

Wetlands and water quality—
Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS, National Wetlands Inventory dataset). Passive aquifer recharge eliminates the need for pretreatment. Treatment after extraction is not expected although this will require project specific studies and regulatory review.

Biological and cultural resources—
Major effects on fish, birds, or terrestrial wildlife are not expected because for the groundwater production operations. Possible implications associated with surface and groundwater exchanges will likely require further study. Although there are no currently identified cultural resource issues at this site, further evaluation will be necessary should this option advance to further planning stages.

Key nonengineering factors—
Once installed, ASR facilities including wellheads, pipelines, and power systems, generally have fairly minor affects on surface resources accept to allow for repairs or maintenance. Further studies should assess possible economic implications of groundwater extraction, water rights issues, and potential impacts of groundwater movement and transfers to surface hydrologic features.

Current Option Status

This option is considered viable and a relatively higher priority for further storage planning stages. Water treatment is not applicable to natural recharge and power costs are only required for production well operations. Additional investigations will be necessary to assess recharge rates, supply reliability, and potential surface water interactions. Site-specific factors could influence benefit-cost relationships considerably and would require further investigation.

Figure 5-11.—ASR at the Clear Lake Reservoir site #10—location map.

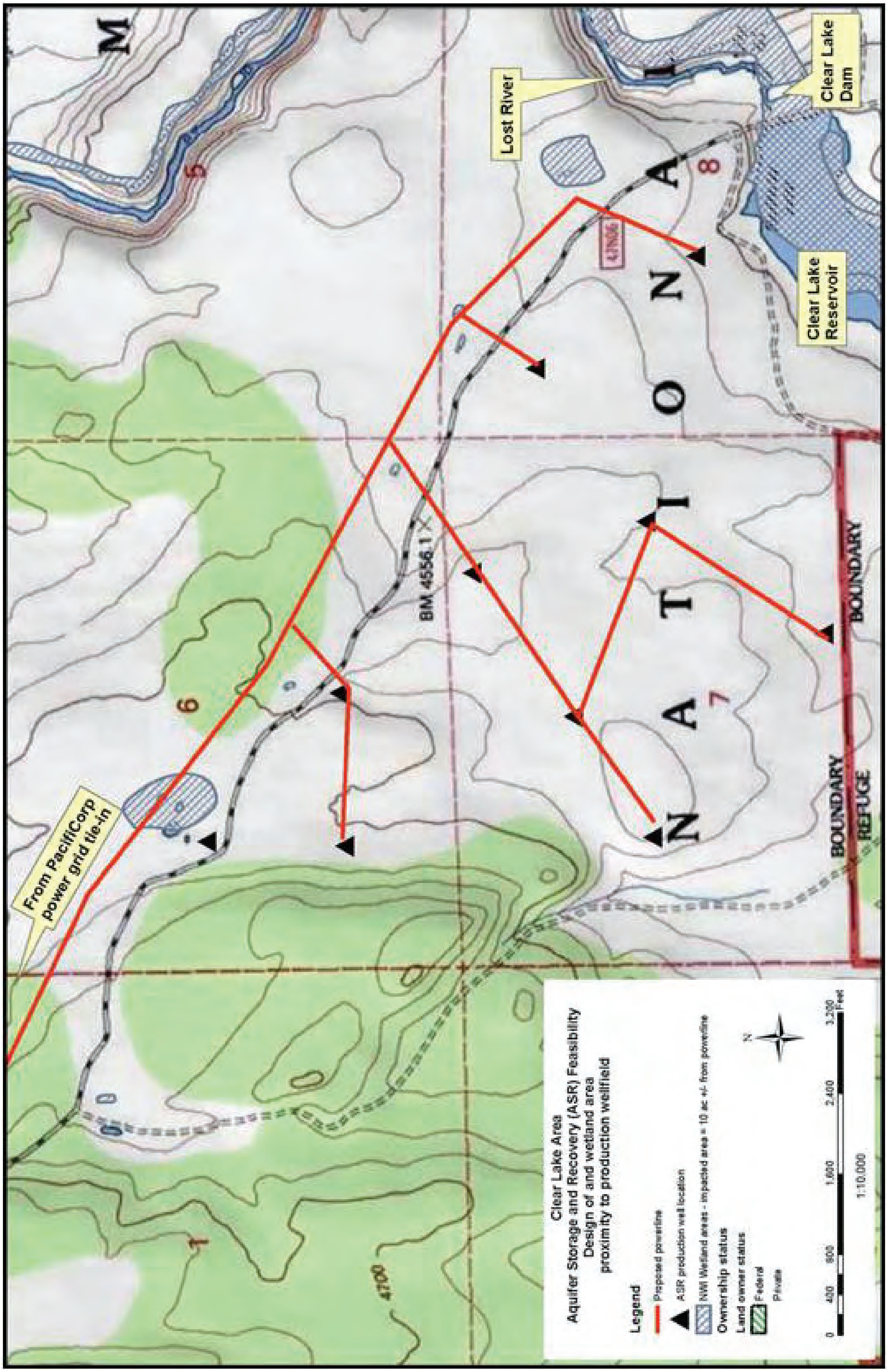


Figure 5-12.—Preliminary layout of ASR facilities at the Clear Lake Reservoir site #10.

5.9 ASR Injection/Exchange—Tule Lake, Site #11

Storage peak capacity:	15,900 acre-ft maximum aquifer storage space
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	Tule Lake basin surface and groundwater resources
Available storage water:	Up to maximum Tule Lake conservation volume
Storage fill frequency:	When surplus inflows or for Tule Lake drawdown
Initial design inflow rate:	100 ft^3/s (for 90 days to peak capacity)
Water delivery benefit range:	0 to 15,900 acre-ft/year (USGS, 2010)
Water treatment type:	Group 2; ASR—injection operations
Current option status:	2—second level priority for further planning

Project Description

This option involves active well injection for ASR in the Tule Lake basin area. Preliminary scoping parameters were developed by the USGS (2010). Two well fields within the Tule Lake basin site #11 area were identified to account for southeast underground aquifer flow. Recovery operations at the south end of the basin would maximize potential aquifer gain and are in close proximity to Sump 1B for flexibility as an adjunct to Sump 1A. Water delivery would use the existing Klamath Project D Pumping Plant, conveyance systems, and stream channels. Water users would benefit from the additional water available during times of shortage.

Technology and infrastructure—

Separate injection-extraction and extraction-only well fields would be constructed to allow two alternate operations. Water would be supplied for recharge using the D Pumping Plant and then recovered at the same north location using reversible wellheads and using the J Canal, P Canal, and a new tunnel for delivery to the Klamath Project. Water recovered at the southern extraction well field would be released into the Tule Lake Sump 1B. Preliminary plans assumed 10 wells with capacity up to 15 ft^3/s each at both well fields. Capacities were oversized to allow for some equipment malfunction and to achieve estimated retrieval flows.

Water source and hydrology—

Water for recharge is supplied by surface and groundwater water in the Tule Lake basin area. Hydrological operations would be defined by injection recharge rates, underground leakage outside the recovery zone, and other factors including water demands and water use practices. Preliminary planning applied a 60-day duration for both the injection water supply rates and recovery extraction period.

Preliminary engineering factors—

Further planning will require additional geohydrologic investigations and water operations modeling to develop accurate estimates of water supply and delivery reliability, groundwater recovery implications, ASR facilities and operating costs, and design life storage benefits for this option.

5.9 UKBOS-IAIR Option: IA-2g

Preliminary Findings

Active ASR schemes have been used successfully at many locations nationwide and offer water management flexibility. They also have a smaller infrastructure footprints and evaporation losses than surface water storage schemes.

Institutional and economic factors—

Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon or California water law review is anticipated to consider storage in ASR projects with possible delivery for use at a different location or for use within a single or multipurpose water project such as the Klamath Project operations. The preliminary facility layout was developed to minimize impacts to existing private lands (GIS, land parcel datasets). Minor land purchase is expected to install ASR wells, water conveyance, and servicing infrastructure. Major cost elements include ASR facilities, water treatment, fish screening, ongoing O&M, and power usage.

Wetlands and water quality—

Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS and National Wetlands Inventory [NWI] dataset). ASR injection operations often require water treatment for groundwater protection under the Safe Drinking Water Act. Second treatment after recovery is not expected although this could require further project specific studies and regulatory review.

Biological and cultural resources—

Fish species issues would be mitigated by installing a fish screen at the intake to the D Pumping Plant. Studies of seasonal flow operations would have to consider sensitive fish/aquatic, terrestrial and avian species. Although there are no currently identified cultural resource issues at this site, further evaluation will be necessary should this option advance to further planning stages.

Key nonengineering factors—

Once installed, ASR facilities including wellheads, pipelines, and power systems, generally have fairly minor affects on surface resources accept to allow for repairs or maintenance. Further studies should assess possible economic implications of groundwater extraction, water rights issues, and potential impacts of groundwater movement and transfers to surface hydrologic features.

Current Option Status

This option is considered viable and a mid level priority for further storage planning stages. Direct injection ASR operations have been used successfully at locations where conditions are suitable. Water treatment is often required for well injection operations. Pumping power is a primary life cycle cost. Site-specific factors can influence benefit-cost relationships considerably and require further study.

Figure 5-13.—ASR injection/exchange at Tule Lake, site #11—location map.

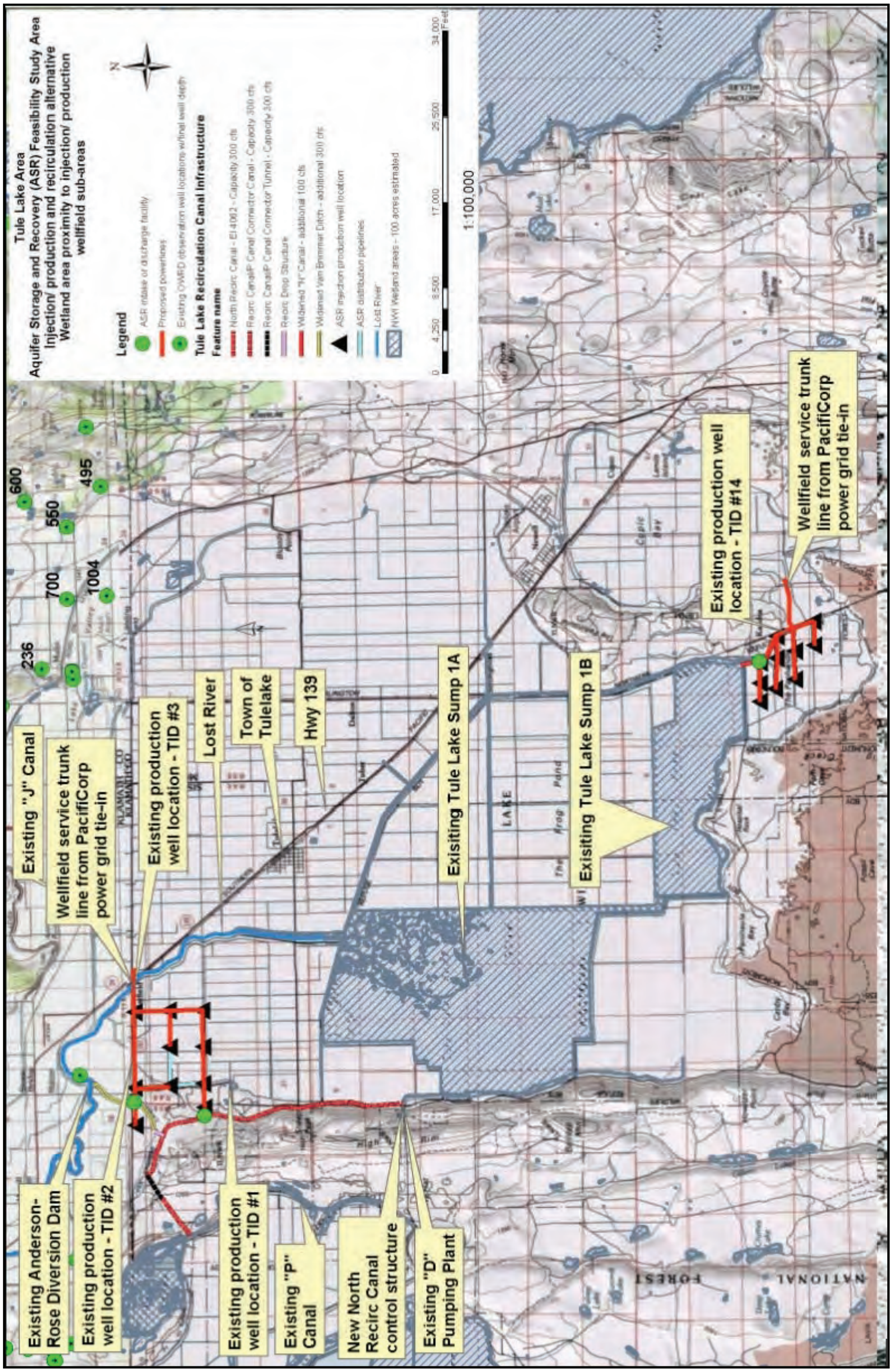


Figure 5-14.—Preliminary layout of ASR injection/exchange facilities at Tule Lake, site #11.

5.10 ASR Injection—South Lower Klamath Lake, Site #12a

Storage peak capacity:	8,000 acre-ft maximum
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	UKL / Klamath River via ADY Canal
Available storage water:	803,000 acre-ft/year (OWARS, 2010)
Storage fill frequency:	Surplus water years
Initial design inflow rate:	100 ft^3/s (for 60 days to peak capacity)
Water delivery benefit range:	0 to 8,000 acre-ft/yr (USGS, 2010)
Water treatment type:	Group 2; ASR—injection operations
Current option status:	2—second level priority for further planning

Project Description

This option involves active well injection for ASR in the southern LKL area. Preliminary scoping parameters were developed by the USGS (2010). The identified location for a well field at the north end of the basin is in close proximity to ADY Canal and Klamath Straits Drain (KSD) to reduce conveyance distances to and from the well field. Water delivery from the well field would use existing Klamath Project conveyance systems and stream channels. Water users would benefit from the additional water available during times of shortage.

Technology and infrastructure—

Groundwater ASR operations would apply an integrated direct well injection and recovery system. Water would be supplied via the ADY Canal, passed through a fish-screened intake, and pumped to through pressurized injection wellheads to recharge the underlying groundwater aquifer. Stored water would be recovered by reversing the wellhead pumps and releasing the water into KSD for delivery to Klamath Project uses. Preliminary planning assumed 10 wells with capacity for up to 15 ft^3/s each. Well field capacities were oversized to allow some equipment malfunction scenarios and to achieve estimated retrieval flows.

Water source and hydrology—

Water for recharge of the larger aquifer is supplied by groundwater and surface water in the south LKL subbasin watershed area. Hydrological operations would be defined by injection well recharge rates, underground leakage outside of the recovery zone, and other factors including Klamath Project and downstream water demands and water use practices. Preliminary planning applied a 60-day duration for both the injection water supply rates and recovery extraction period.

Preliminary engineering factors—

Further planning will require additional geohydrologic investigations and water operations modeling to develop accurate estimates of water supply and delivery reliability, groundwater recovery implications, ASR facilities and operating costs, and design life storage benefits for this option.

5.10 UKBOS-IAIR Option: IA-2h

Preliminary Findings

Active ASR schemes have been used successfully at many locations nationwide and offer water management flexibility. They also have a smaller infrastructure footprints and evaporation losses than surface water storage schemes.

Institutional and economic factors—

Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon or California water law review is anticipated to consider storage in ASR projects with possible delivery for use at a different location or for use within a single or multipurpose water project such as the existing Klamath Project operations. For preliminary planning, a facility layout was developed to minimize impacts to existing private lands (GIS, land parcel datasets). Minor land purchase is expected for installation of ASR wells, water conveyance, and service infrastructure. Major cost elements include ASR facilities, water treatment, fish screening, ongoing O&M, and power usage.

Wetlands and water quality—

This option could provide some water quality benefits by releasing added dilution water to the KSD. Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS and NWI dataset). Active injection operations often require water treatment for groundwater protection under the Safe Drinking Water Act provisions. Treatment after recovery is not expected although this will require further project specific studies and regulatory review.

Biological and cultural resources—

Fish species issues will be mitigated by installing a fish screen at the ADY Canal intake. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are no currently identified cultural resource issues at this site, further evaluation will be necessary should this option advance to further planning stages.

Key nonengineering factors—

Once installed, direct injection ASR facilities including ASR wellheads, pipelines, and power systems, have fairly minor affects on surface resources accept to allow for repairs or maintenance. Further studies should assess potential groundwater interactions, water treatment needs, and water rights issues.

Current Option Status

This option is considered viable and a mid level priority for further storage planning stages. Direct injection ASR operations have been used successfully at locations where conditions are suitable. Water treatment is often required for well injection operations. Pumping power is a primary life cycle cost. Site-specific factors can influence benefit-cost relationships considerably and require further study.

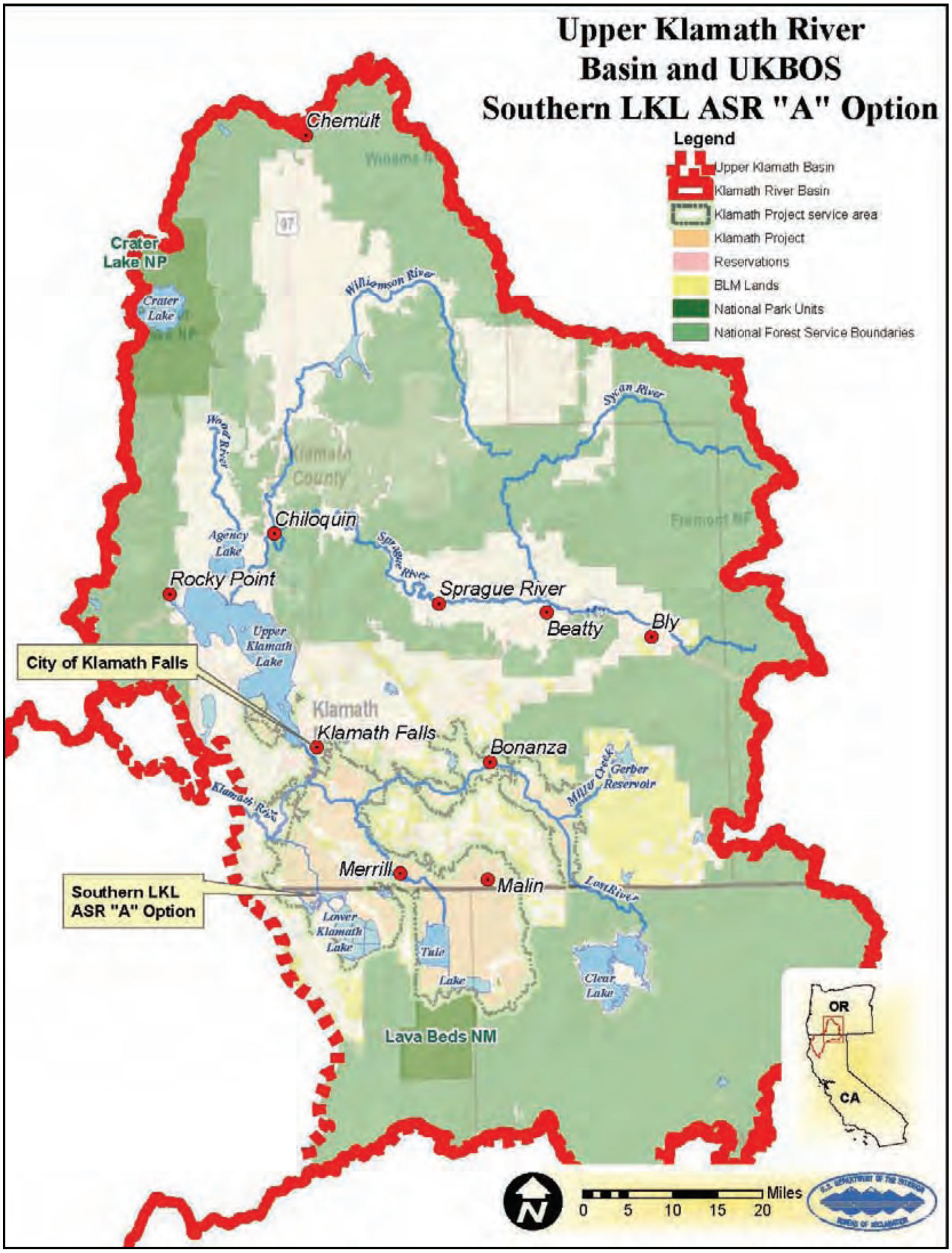


Figure 5-15.—ASR injection at South Lower Klamath Lake, site #12a—location map.

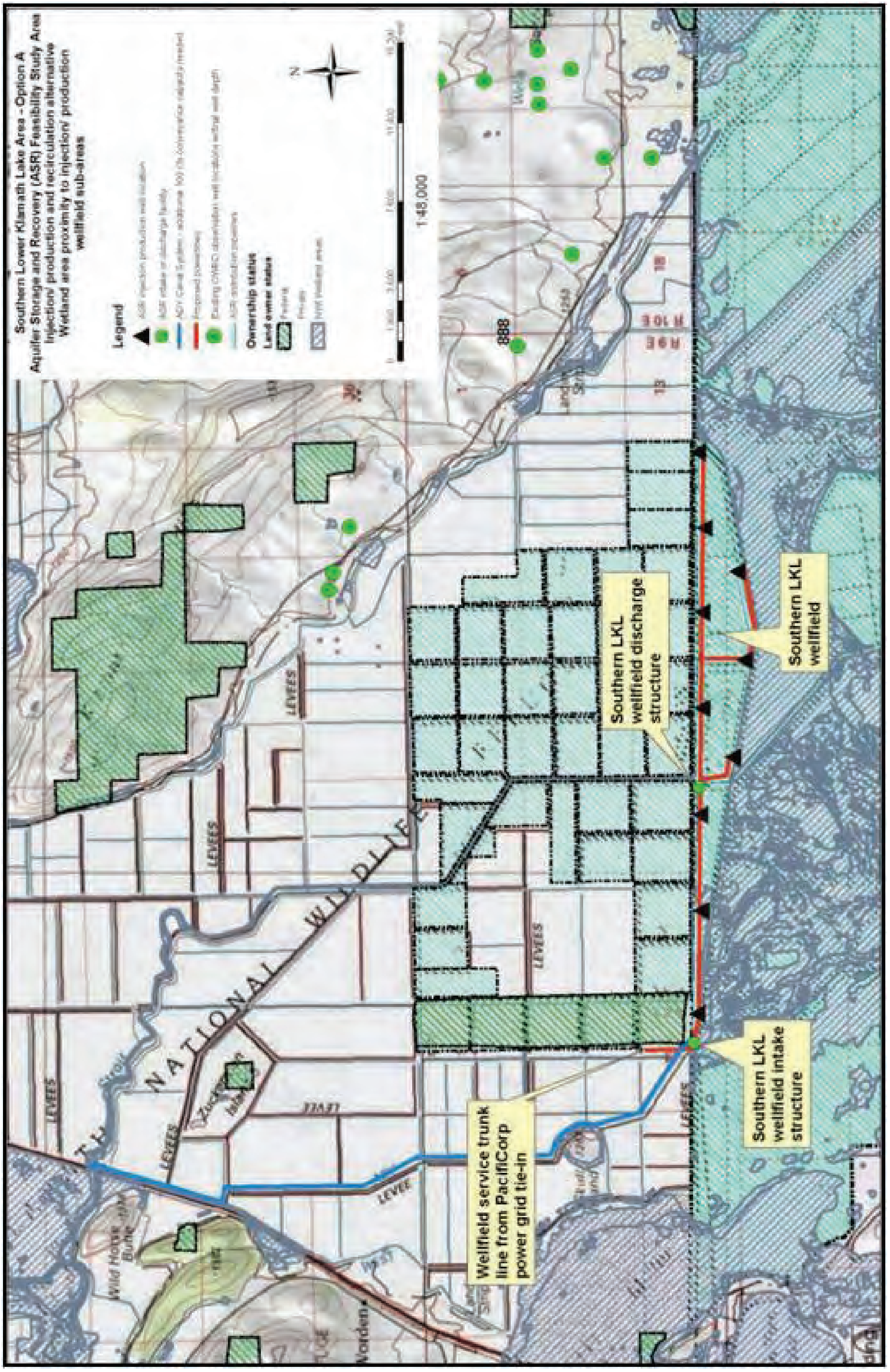


Figure 5-16.—Preliminary layout of ASR injection facilities at South Lower Klamath Lake, site #12a.

5.11 ASR Injection—South Lower Klamath Lake, Site #12b

Storage peak capacity:	8,000 acre-ft maximum
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	Tule Lake or UKL / Klamath River
Available storage water:	803,000 acre-ft/year (OWARS, 2010)
Storage fill frequency:	Surplus water years
Initial design inflow rate:	100 ft^3/s (for 60 days to peak capacity)
Water delivery benefit range:	0 to 8,000 acre-ft/yr (USGS, 2010)
Water treatment type:	Group 2; ASR—injection operations
Current option status:	2—second level priority for further planning

Project Description

This option involves active well injection for ASR in the southern LKL area. Preliminary scoping parameters were developed by the USGS (USGS, 2010). The location for a well field at the southwest end of the basin is in close proximity to P Canal to reduce water conveyance distances. Water delivery from the well field would use existing Klamath Project conveyance systems and stream channels. Water users would benefit from the additional water available during times of shortage.

Technology and infrastructure—

Groundwater ASR operations would apply an integrated direct well injection and recovery system. Water would be supplied via the New North Canal and/or the P Canal, through fish-screened intakes and pumped using pressurized injection wellheads to recharge the underlying groundwater aquifer. Stored water would be recovered by reversing wellhead pumps and returning the water to the New North or P Canal for delivery to Klamath Project uses. A short canal would be built to convey water between the New North and P Canals. Preliminary plans assume 10 wells with capacity for up to 15 ft^3/s each. Capacities were oversized to allow for some equipment malfunction and to achieve estimated retrieval flows.

Water source and hydrology—

Water for recharge of the larger aquifer is supplied by groundwater and surface water in the south LKL subbasin watershed area. Hydrological operations would be defined by injection well recharge rates, underground leakage outside of the recovery zone, and other factors including Klamath Project and downstream water demands and water use practices. Preliminary planning applied a 60-day duration for both the injection water supply rates and recovery extraction period.

Preliminary engineering factors—

Further planning will require additional geohydrologic investigations and water operations modeling to develop accurate estimates of water supply and delivery reliability, groundwater recovery implications, ASR facilities and operating costs, and design life storage benefits for this option.

5.11 UKBOS-IAIR Option: IA-2i

Preliminary Findings

Active ASR schemes have been used successfully at many locations nationwide and offer water management flexibility. They also have a smaller infrastructure footprints and evaporation losses than surface water storage schemes.

Institutional and economic factors—

Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon or California water law review is anticipated to consider storage in ASR projects with possible delivery for use at a different location or for use within a single or multipurpose water project such as the existing Klamath Project operations. For preliminary planning, a facility layout was developed to minimize impacts to existing private lands (GIS, land parcel datasets). Minor land purchase is expected for installation of ASR wells, water conveyance, and service infrastructure. Major cost elements include ASR facilities, water treatment, fish screening, ongoing O&M, and power usage.

Wetlands and water quality—

Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS and NWI dataset). Active injection operations often require water treatment for groundwater protection under Safe Drinking Water Act provisions. Treatment after recovery is not expected although this will require further project specific studies and regulatory review. Extracted groundwater could also have geothermal temperature implications at the proposed well field location.

Biological and cultural resources—

Fish species issues would be mitigated by installing a fish screen at the intake to the New North Canal. Studies of seasonal flow operations would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are no currently identified cultural resource issues at this site, further evaluation will be necessary should this option advance to further planning stages.

Key nonengineering factors—

Once installed, direct injection ASR facilities including ASR wellheads, pipelines, and power systems, have fairly minor affects on surface resources accept to allow for repairs or maintenance. Further studies should assess potential groundwater interactions, water treatment needs, and water rights issues.

Current Option Status

This option is considered viable and a mid level priority for further storage planning stages. Direct injection ASR operations have been used successfully at locations where conditions are suitable. Water treatment is often required for well injection operations. Pumping power is a primary life cycle cost. Site-specific factors can influence benefit-cost relationships considerably and require further study.

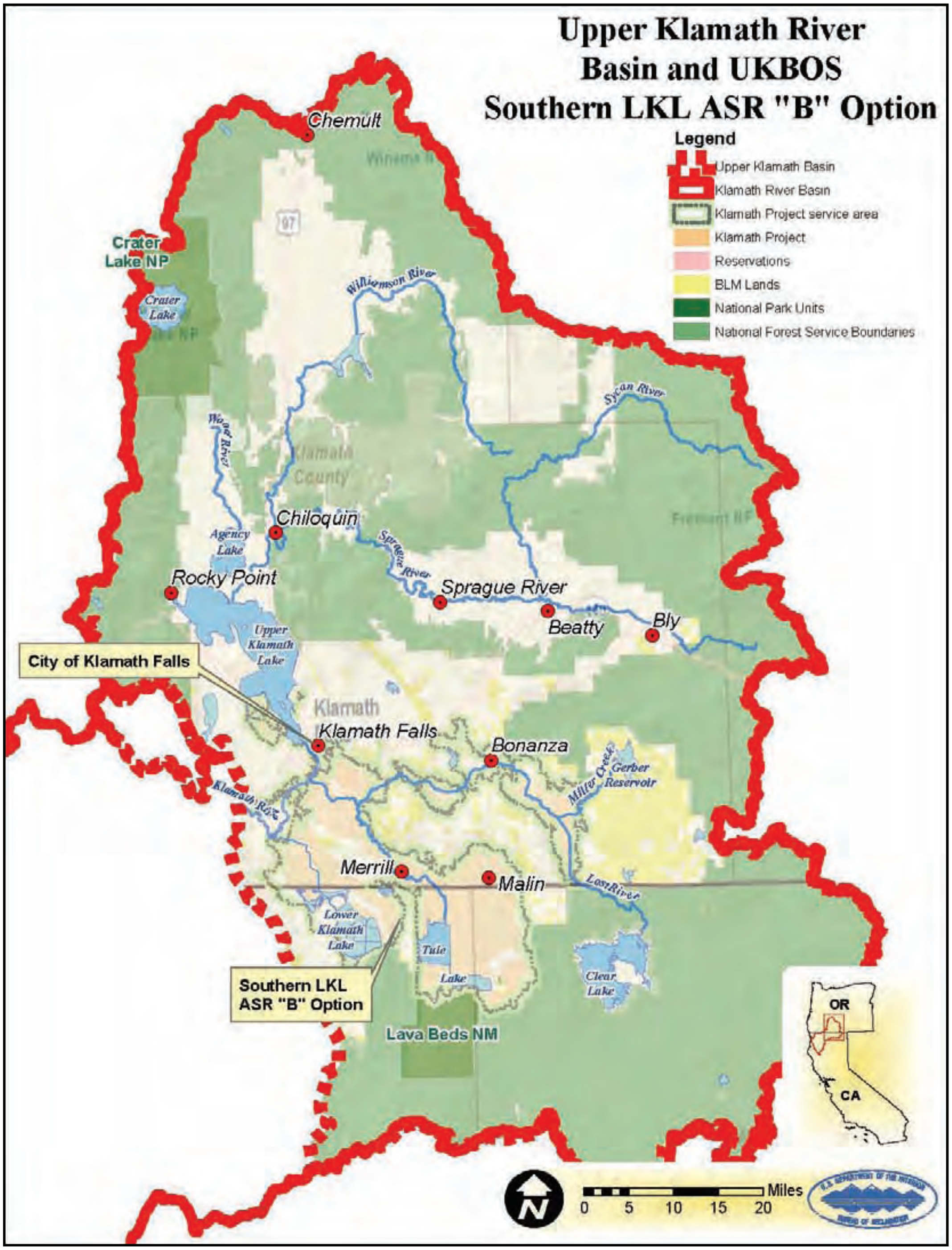


Figure 5-17.—ASR injection at South Lower Klamath Lake, site #12b—location map.

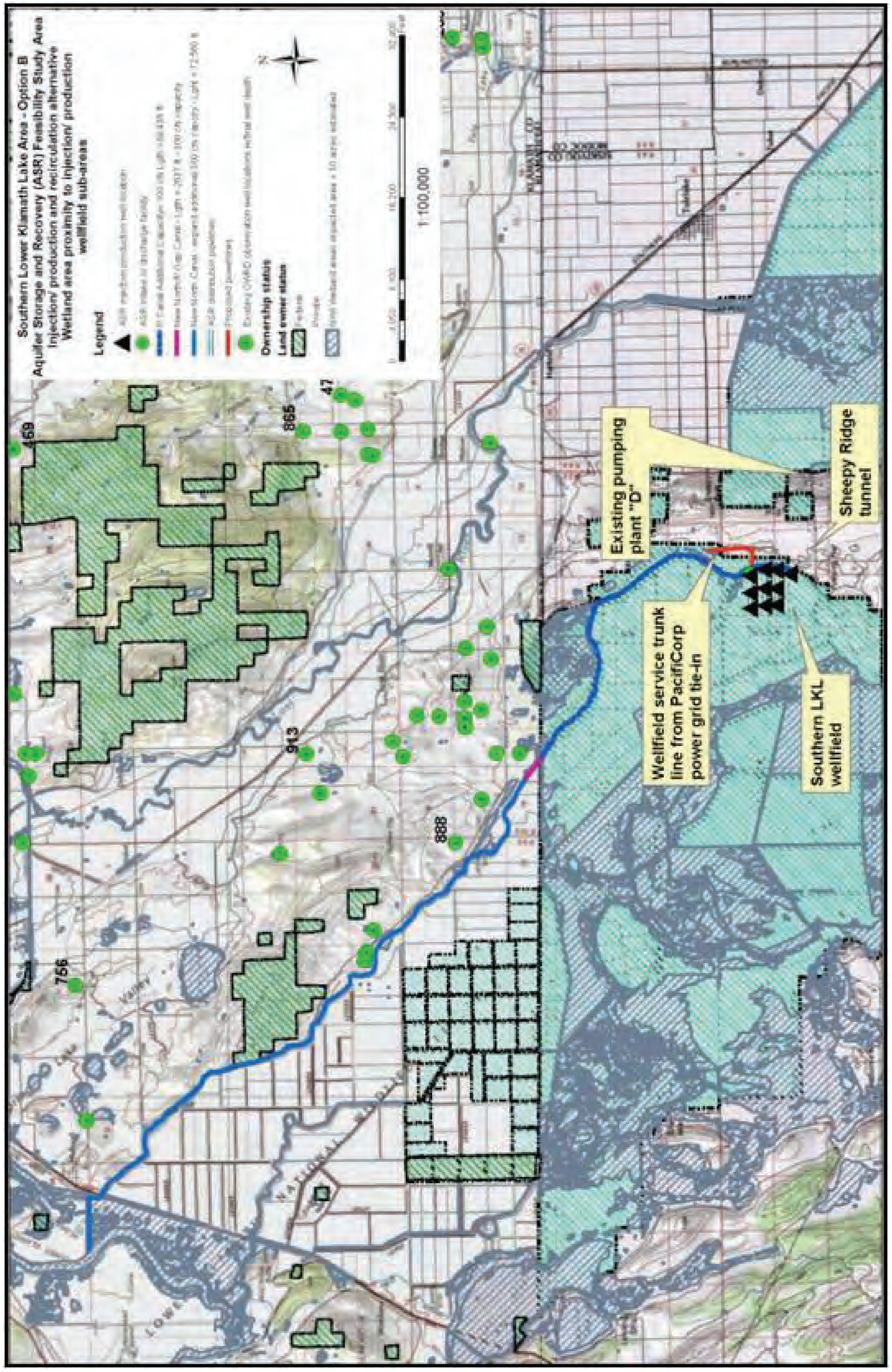


Figure 5-18.—Preliminary layout of ASR injection facilities at South Lower Klamath Lake, site #12b.

5.12 ASR Injection—South Lower Klamath Lake, Site #12c

Storage peak capacity:	8,000 acre-ft maximum
Projected storage time:	Multiyear (USGS, 2010)
Storage water supply:	UKL to Klamath River via ADY Canal
Available storage water:	803,000 acre-ft/year (OWARS, 2010)
Storage fill frequency:	Surplus water years
Initial design inflow rate:	100 ft^3/s (for 60 days to peak capacity)
Water delivery benefit range:	0 to 8,000 acre-ft/yr (USGS, 2010)
Water treatment type:	Group 2; ASR—injection operations
Current option status:	2—second level priority for further planning

Project Description

This option involves active well injection for ASR in the southern LKL area. Preliminary scoping parameters were developed by the USGS (2010). The location for a well field at the north end of the basin is in close proximity to the KSD to reduce conveyance distances. Water delivered from the well field would use the existing Klamath Project conveyance systems and stream channels and water users would benefit from the additional water available during times of shortage. Additional water quality benefits to KSD are possible.

Technology and infrastructure—

Groundwater ASR operations would apply an integrated direct well injection and recovery system. Water would be supplied via KSD, passed through fish-screen intakes, and pumped using pressurized injection wells to recharge the underlying groundwater aquifer. Stored water would be recovered by reversing the wellhead pumps and releasing the water back to the KSD for delivery to Klamath Project uses. Preliminary planning assumed 10 ASR wells with capacity of up to 15 ft^3/s each. These well field capacities were oversized to allow for some equipment malfunction scenarios and to achieve estimated retrieval flows.

Water source and hydrology—

Water for recharge of the larger aquifer is supplied by groundwater and surface water in the south LKL subbasin watershed area. Hydrological operations would be defined by injection well recharge rates, underground leakage outside of the recovery zone, and other factors including Klamath Project and downstream water demands and water use practices. Preliminary planning applied a 60-day duration for both the injection water supply rates and recovery extraction period.

Preliminary engineering factors—

Further planning will require additional geohydrologic investigations and water operations modeling to develop accurate estimates of water supply and delivery reliability, groundwater recovery implications, ASR facilities and operating costs, and design life storage benefits for this option.

5.12 UKBOS-IAIR Option: IA-2j

Preliminary Findings

ASR schemes in general offer water management flexibility. They also offer relatively smaller surface infrastructure footprints and evaporation losses than do surface water storage schemes.

Institutional and economic factors—
Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon or California water law review is anticipated to consider storage in ASR projects with possible delivery for use at a different location or for use within a single or multipurpose water project such as the existing Klamath Project operations. For preliminary planning, a facility layout was developed to minimize impacts to existing private lands (GIS, land parcel datasets). Minor land purchase is expected for installation of ASR wells, water conveyance, and service infrastructure. Major cost elements include ASR facilities, water treatment, fish screening, ongoing O&M, and power usage.

Wetlands and water quality—
This option could provide some water quality benefits by releasing added dilution water to the KSD. Preliminary sites for option facilities were located to minimize impacts to existing wetlands (GIS and NWI dataset). Active injection operations often require water treatment for groundwater protection under the Safe Drinking Water Act provisions. Treatment after recovery is not expected although this will require further project specific studies and regulatory review.

Biological and cultural resources—
Fish species issues will be mitigated by construction of a fish screen at an intake on KSD near Highway 97. Studies of seasonal flow operations would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although no cultural resource issues are currently identified at this site, further evaluation will be necessary should this option advance to further planning stages.

Key nonengineering factors—
Once installed, direct injection ASR facilities including ASR wellheads, pipelines, and power systems, have fairly minor affects on surface resources accept to allow for repairs or maintenance. Further studies should assess potential groundwater interactions, water treatment needs, and water rights issues.

Current Option Status

This option is considered viable and a mid level priority for further storage planning stages. Direct injection ASR operations have been used successfully at locations where conditions are suitable. Water treatment is often required for well injection operations. Pumping power is a primary life cycle cost. Site-specific factors can influence benefit-cost relationships considerably and require further study.

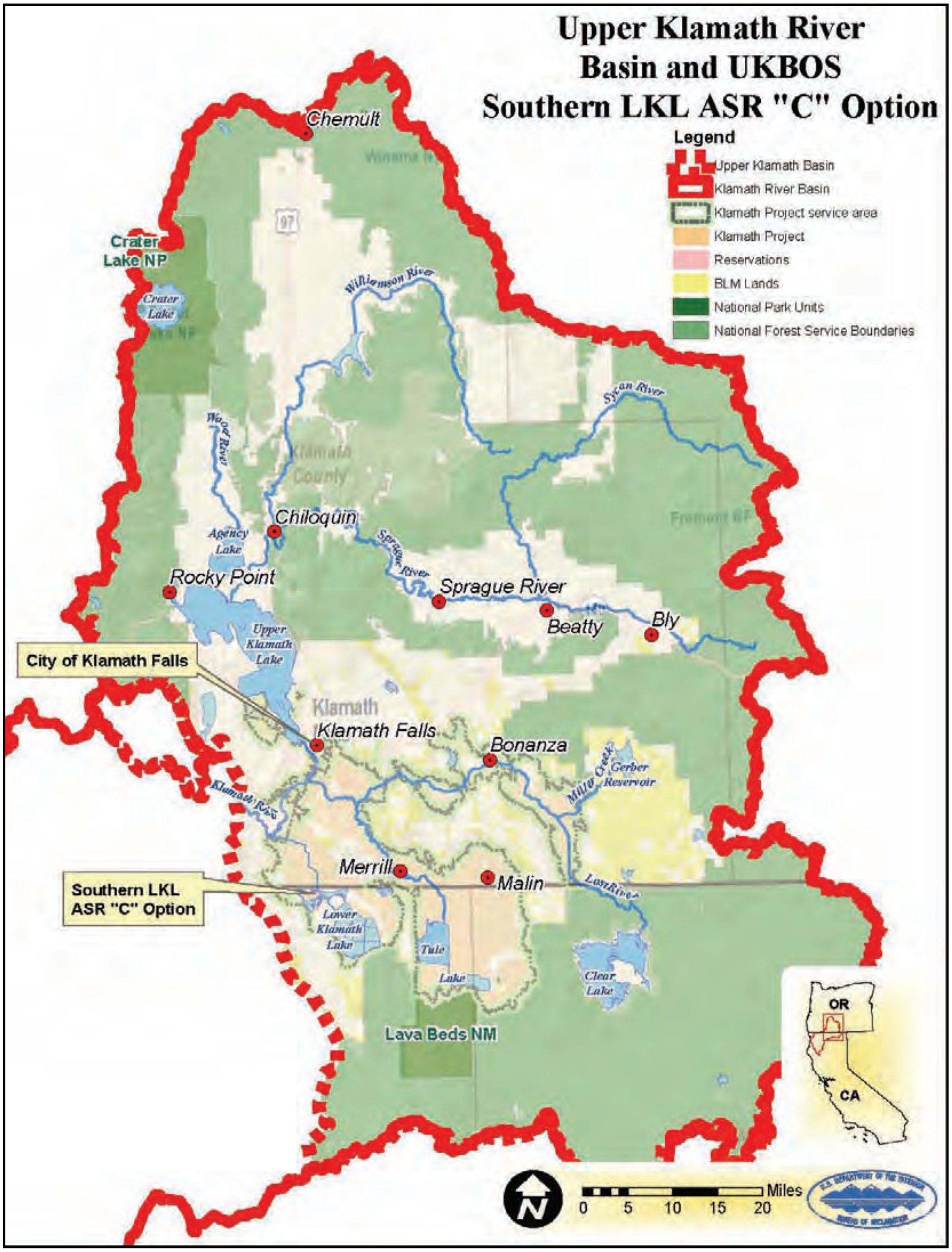


Figure 5-19.—ASR injection at South Lower Klamath Lake, site #12c—location map.

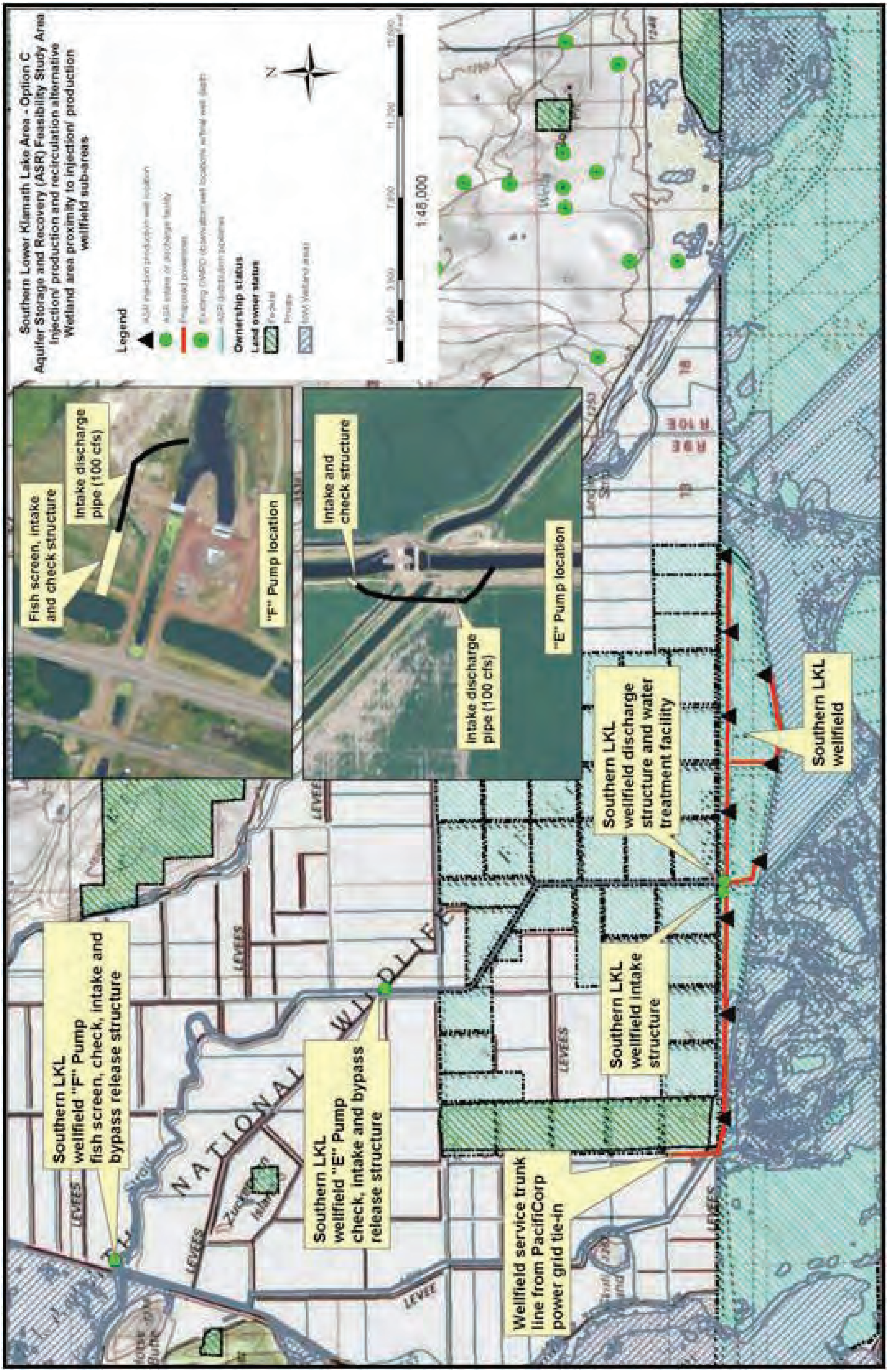


Figure 5-20.—Preliminary layout of ASR injection facilities at South Lower Klamath Lake, site #12c.

5.13 Agency Lake Ranches—Open-to-Lake

Storage peak capacity:	None—No additional storage provided
Projected storage time:	Annual cycle—same as without storage
Storage water supply:	UKL surplus water supply
Available storage water:	Up to maximum UKL surplus w/ BO constraints
Storage fill frequency:	No changes to existing water operations
Initial design inflow rate:	Not applicable for open-to-lake conditions
Water delivery benefit:	Minor incremental unmanaged storage
Water treatment type:	Not applicable for open-to-lake conditions
Current priority status:	4—fourth tier not currently viable

Project Description

This option involves unmanaged water storage within previously drained lands of the Barnes Ranch and ALRS site. Reclamation purchased the ALRS properties under agreements with FWS and The Nature Conservancy to ultimately breach the perimeter containment dikes and open the lands to seasonal flooding by UKL high waters. The potential for storage at ALRS was identified by the KBWSI and Reclamation has conducted preliminary through appraisal studies to assess water storage and other resource characteristics. Although the Agency Lake and UKL total water volume is increased, the open-to-lake storage cannot be regulated to provide benefits when water is needed. As a result, the ALRS water volume was incorporated into the base without storage condition for evaluating other UKBOS options, with the same implications for future conditions, without storage improvements. This option/scenario is known as "future without project."

Technology and infrastructure—
Preliminary planning evaluated scenarios for restoring the site lands and identified a possible need to reinforce the north dike to prevent offsite flooding during high UKL water levels. Once the open-to-lake conditions are restored, further major construction work or active storage operations is not expected and the ALRS site area will be incorporated into the Upper Klamath NWR programs.

Water source and hydrology—
Implications of the option ultimate open-to-lake conditions on the Upper Klamath Basin water supplies were evaluated by initial hydrological operations modeling conducted for the UKBOS preliminary studies. The end result is that this option provides only an incremental unmanaged storage and the open-to-lake condition was incorporated into the without project computations for all subsequent water storage operations modeling.

Preliminary engineering factors—
Further planning is expected to focus on methods to breach the dikes and address habitat or fish access issues. Any nonstorage implications are as described for the base future, without storage conditions.

5.13 UKBOS-IAIR Option: IA-3a

Preliminary Findings

This option does not provide effective water storage that could help to address the water supply problems. Klamath Basin water users will experience continued and increasing constraints on water under future demands for normal to shortage water years and related impacts on water systems and operations.

Institutional and economic factors—

The ALRS site properties are being transferred to the FWS for incorporation into the Upper Klamath NWR. Interagency coordination is expected through future planning and beyond the current site management. Without storage improvement, the benefit-cost relationships could shift toward characteristics associated with the optimal site restoration approach and the resulting habitat and long-term resource management. These considerations are not within the current UKBOS objectives and would require separate investigation.

Wetlands and water quality—

Breaching the containment dikes around the ALRS site would produce significant impacts to the existing wetlands based on a jurisdictional wetland delineation completed. At the same time, the open-to-lake conditions could restore or restore new wetlands functions and values that may offset the existing wetlands impacts if substantial planning and restoration efforts were properly conducted. Water quality implications of this option could require further study and review by appropriate regulatory agencies.

Biological and cultural resources—

The potential for fish access or entrapment at the site are important considerations for further site planning. Potential implications for other biological or cultural resources could also require more detailed investigations.

Key nonengineering factors—

The important resource implications for this option will likely depend on specific objectives for restoring and managing the site as part of the NWR (determined by the FWS) and potential future implications for biological and cultural resources would likely require additional review during future planning stages.

Current Option Status

This option is not considered viable and a low priority for these water storage preliminary planning purposes, because it does meet the direct objectives and could have consequences that are beyond the scope of the UKBOS investigations. It may be possible to use detailed hydrological and economic modeling to assess the Upper Klamath Basin water operations for comparison to other storage options that are carried forward to appraisal planning stages.

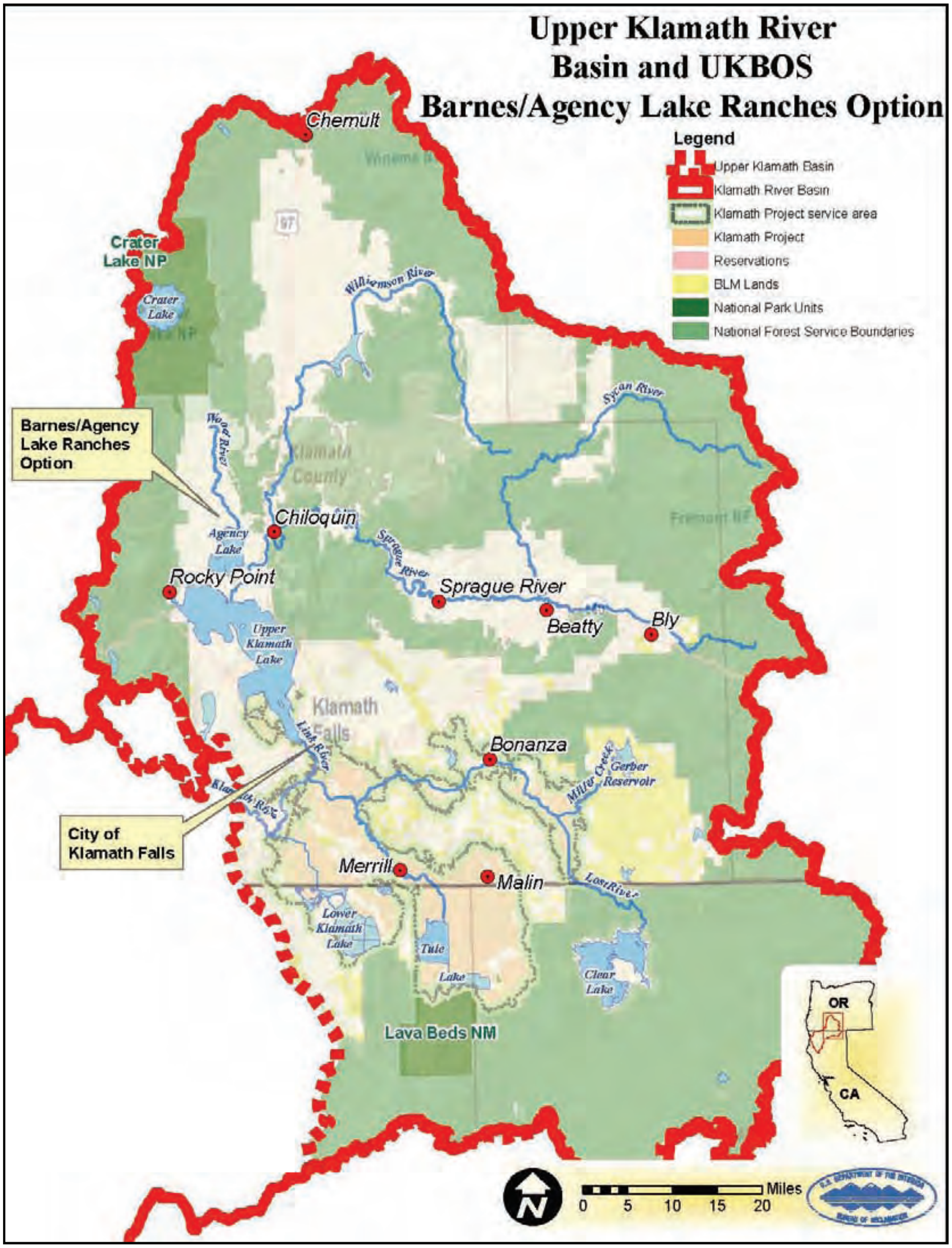


Figure 5-21.—BR and ALR preliminary site layout showing Option 1—Open to lake with minimum site work required to breach perimeter dikes and construct internal site restoration features.

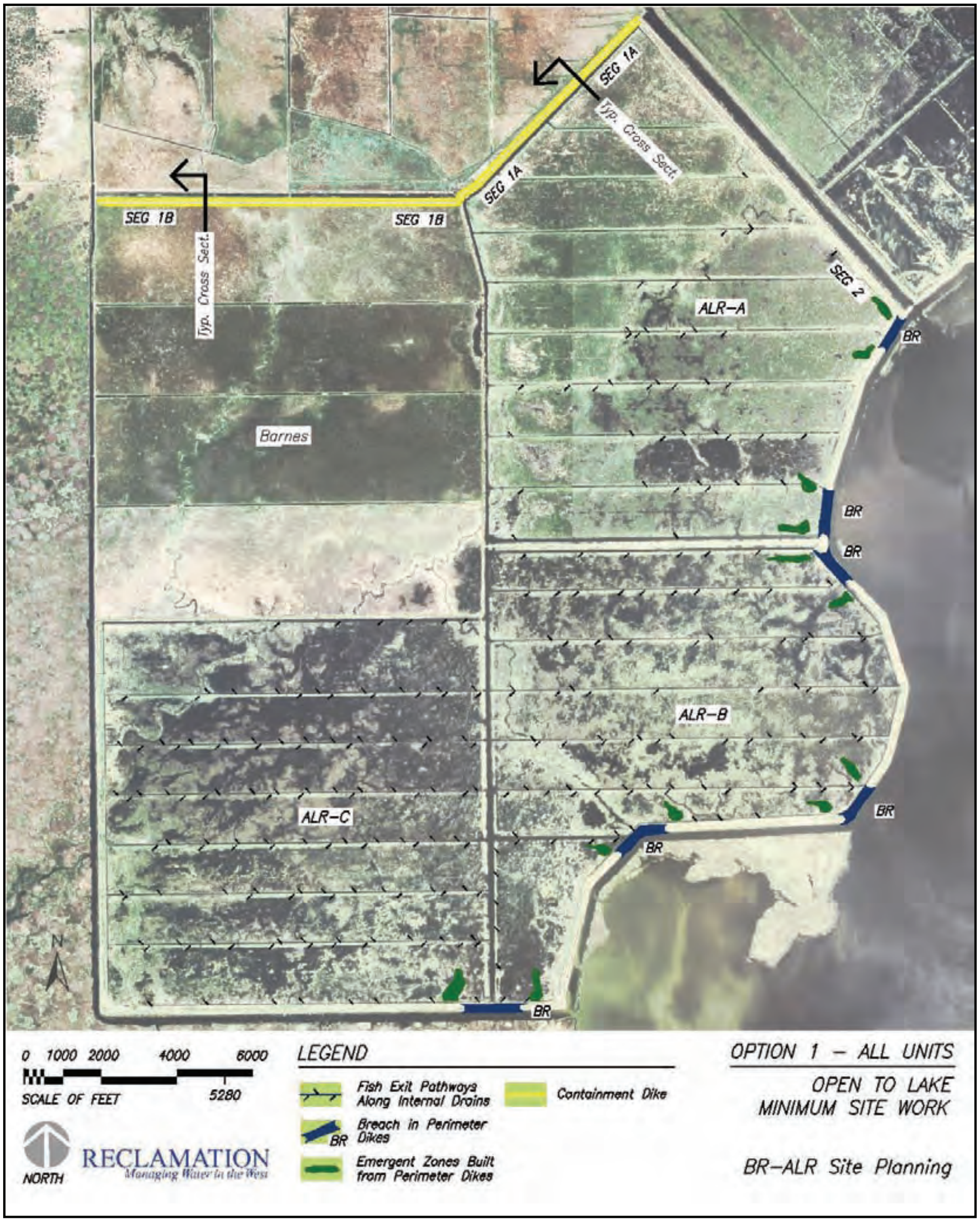


Figure 5-22.—Location showing the BR and ALR sites in relation to other properties and features in the UKL and Agency Lake basin in south-central Oregon.

5.14 Agency Lake Ranches—Upgraded Managed Storage

Storage peak capacity:	65,700 acre-ft maximum (below UKL drawdown)
Projected storage time:	Single-year annual refill storage operations
Storage water supply:	UKL surplus water supply
Available storage water:	Up to maximum UKL surplus w/ BO constraints
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	250 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	0 to 65,700 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	4—fourth tier not currently viable

Project Description

This option involves upgrading the existing the Barnes Ranch and ALRS site as an enhanced storage reservoir. Water would enter the reservoir by gravity flow at high water levels in UKL with pumped releases back to UKL to meet downstream water demands. However, the properties are currently owned under interagency agreements that call for restoring open-to-lake conditions in the reasonably foreseeable future and this would directly eliminate the use for managed storage operations.

Technology and infrastructure—

Preliminary plans are based on reconstructing the existing ALRS perimeter dikes to contain the active water storage volume and upgrading the site into an enhanced managed storage reservoir. A new pump station would be used to release water back into UKL systems for water delivery. The reservoir volume was estimated based on the site topography and UKL water levels. Seepage and ability to retain water at UKL drawdown would require further studies.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning could require additional investigations to assess future BO or other constraints on water supply, water quality, and delivery reliability.

Preliminary engineering factors—

Reclamation has completed preliminary through appraisal planning investigations for this option (Reclamation, 2009a) that indicated significant construction would be required to raise and reinforce containment dikes for long-term storage operations. Other possible engineering factors could include construction of fish screens, wetlands mitigation features, or treatment facilities as needed.

5.14 UKBOS-IAIR Option: IA-3b

Preliminary Findings

This option was identified by the KBWSI effort and some planning investigations have been completed. The option is no longer considered viable due to relatively lower benefit-costs and existing interagency agreements for property transfer a restoring open-to-lake conditions that preclude active storage operations.

Institutional and economic factors—

The ALRS site properties were transferred to the FWS in 2010 for incorporation into the Upper Klamath NWR and restoring open-to-lake conditions. Current managed storage operations will continue until planning efforts are completed as to the ultimate fate of this site. Economic benefit-cost relationships would require further investigation once the specific site management plans are developed. These considerations are not within the current UKBOS objectives and would require separate investigation.

Wetlands and water quality—

Upgrading the ALRS site for long-term storage operations would produce significant impacts to the extensive existing wetlands identified based on jurisdictional wetland delineation. This would likely require significant offsite mitigation and high associated costs. Water quality implications of storage would require further study and review by appropriate regulatory agencies. The site currently supports a seasonal wetland community developed from the past years of storage operations.

Biological and cultural resources—

The potential for fish access or entrapment would be critical considerations for any future storage plans at this site. Potential implications for other biological or cultural resources could also require more detailed investigations.

Key nonengineering factors—

Under the option storage operations, fish entrapment issues, extensive wetlands impacts, and potential water quality and water treatment are critical factors that could have significant costs and would require more detailed investigations.

Current Option Status

This option is not considered viable and a low priority for the UKBOS planning purposes because of the current agreements for property planning and restoration. Even without theses constraints, the apparent biological considerations and associated mitigation costs appear to pose significant parries to further planning.

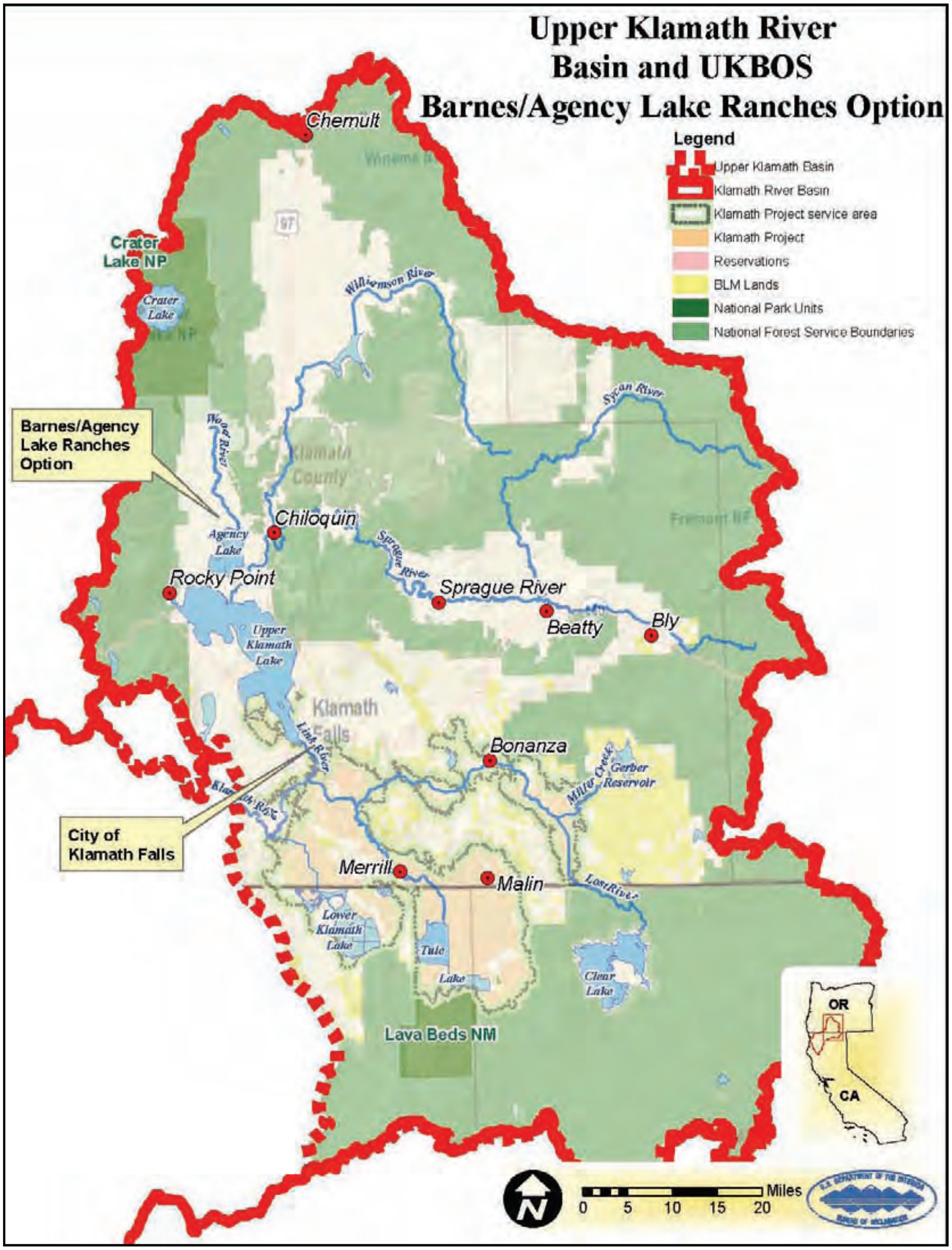


Figure 5-23.—Location showing the BR and ALR sites in relation to other properties and features in the UKL and Agency Lake basin in south-central Oregon.

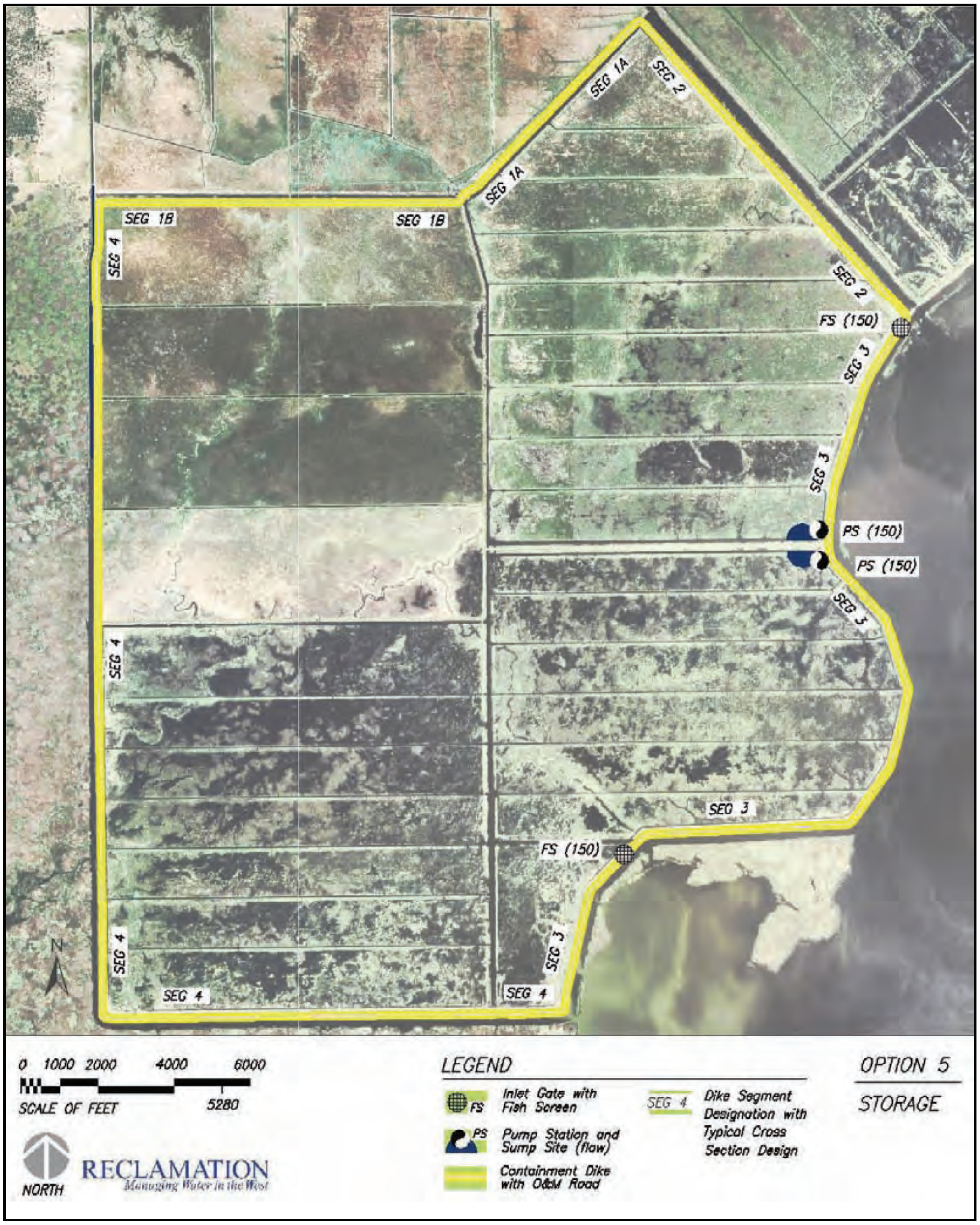


Figure 5-24.—BR and ALR preliminary site layout showing Option 5—Permanent seasonal managed storage operations with site construction work required to reinforce and raise the existing perimeter dikes.

5.15 Aspen Lake Reservoir

Storage peak capacity:	350,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	1,000 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	0 to 350,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

Surplus UKL water would be stored in the existing Aspen Lake basin using new pumped storage facilities. Water delivery would involve gravity release and use existing Klamath Project infrastructure including UKL, canals, and river channels. Downstream water users could benefit from additional water supplies available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on using the Aspen Lake basin to reduce the reservoir and related facility footprint impacts. An embankment dam would be constructed at the north end of the lake to achieve the target storage capacity. Two new pump stations were estimated to pump water to the Aspen Lake reservoir. Stored water would be released through both new and existing conveyance systems for water delivery. The preliminary reservoir design volume was based on BO constraints (NMFS, 2002; FWS 2008) on surplus UKL water. The latest NMFS BO (2010) could further constrain available water supplies. Seepage losses and the potential need for an impervious lining to retain stored water will require further studies.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—

Aspen Lake is one of four basins located southwest of UKL that could be used for water storage. It is one of the closest to UKL and thus could have relatively lower costs. Several factors require additional study to refine the option features and develop an accurate assessment of storage benefit-cost relationships.

5.15 UKBOS-IAIR Option: IA-4

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. Using an existing water body reduces newly inundated surface area. This option was recommended for preliminary study as part of the KBWSI effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option uses some existing UKL and Klamath Project conveyance systems. Major cost elements include the reservoir, conveyance and pump system construction, and annual power use and O&M requirements.

Wetlands and water quality—

Preliminary review indicates the potential for impacts to existing wetlands in the option site area (analyzed by GIS and the National Wetlands Inventory dataset). Wetlands mitigation is considered a strong possibility. Water treatment for stored release flows is also likely although specific requirements will require thorough investigation and review by appropriate regulatory agencies.

Biological and cultural resources—

Fish species protection would include incorporating fish screens into the intake of the conveyance system at UKL. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Preliminary evaluation indicated mitigation requirements for wetlands within the Aspen Lake basin could pose a significant cost factor. Other resource issues will require more detailed study during future planning and design stages.

Current Option Status

This option is considered a potentially viable second level priority for further planning stages. Preliminary planning indicates Aspen Lake is similar to pumped storage options at Whiteline Reservoir, Swan Lake, and LLV. Conveyance distance is a key factor in comparing these options. Additional planning studies including geotechnical assessment of reservoir seepage containment potential and detailed hydrologic water operations modeling are needed to assess whether this option should advance to appraisal investigations.

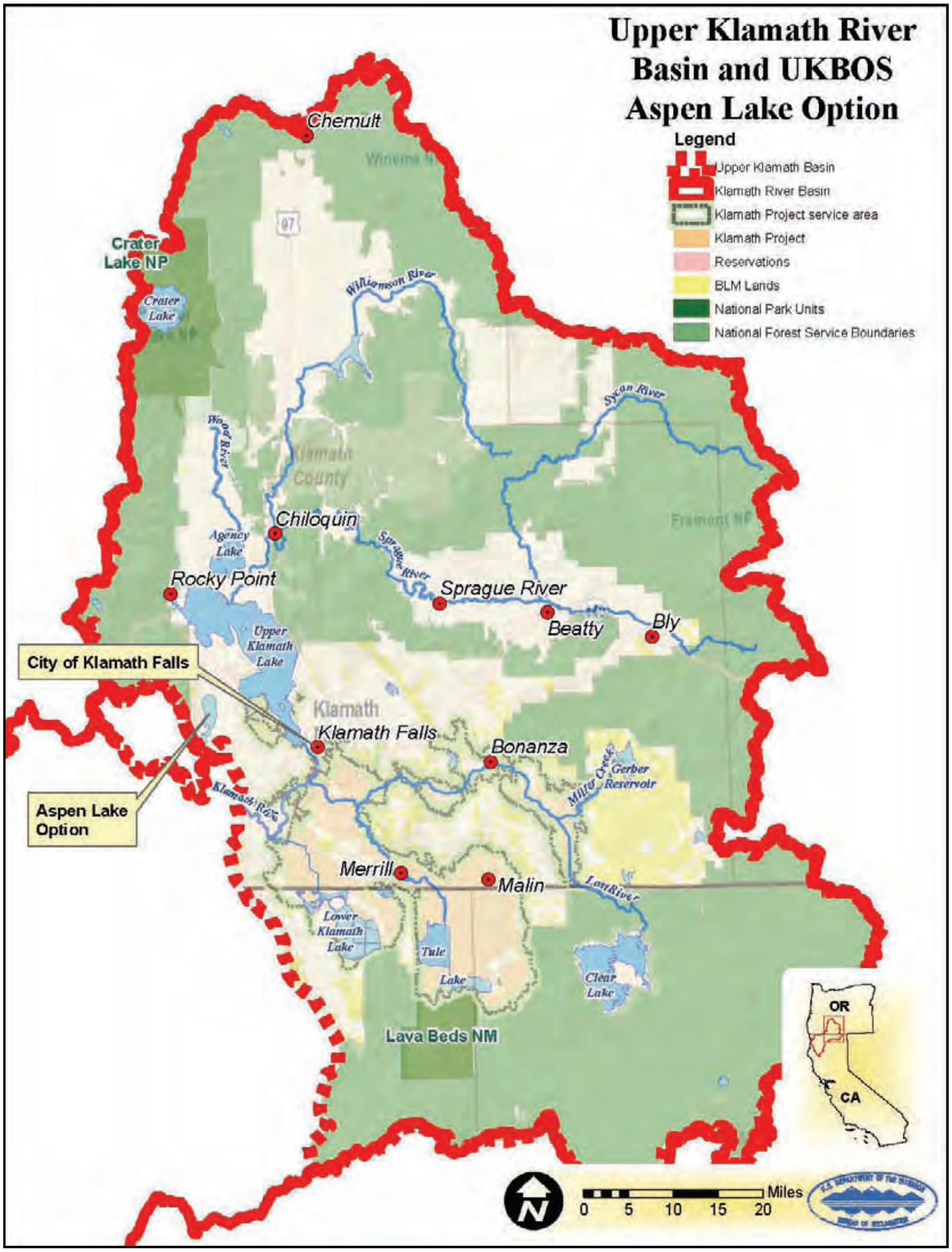


Figure 5-25.—Aspen Lake option location in the Upper Klamath Basin study area.

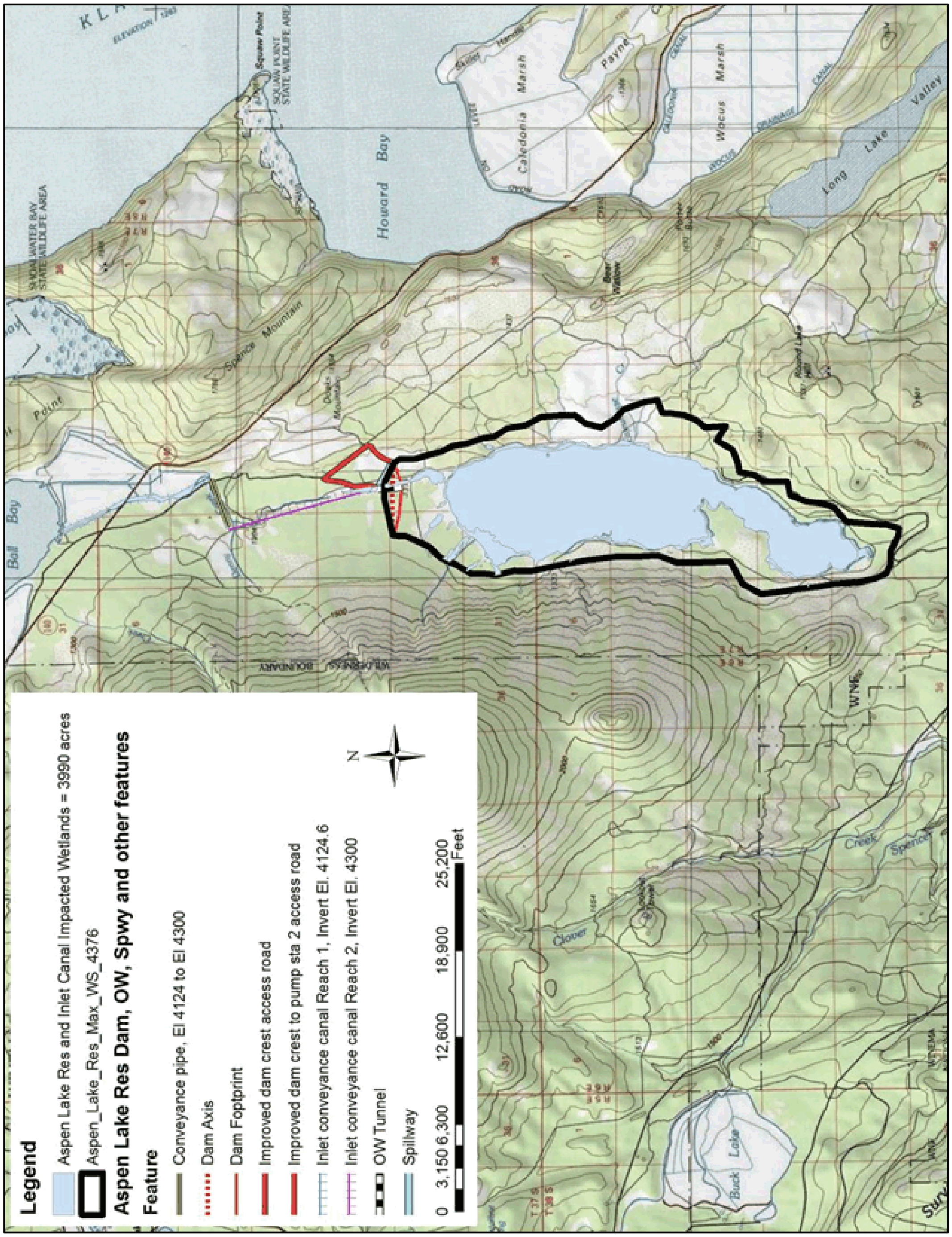


Figure 5-26.—Aspen Lake option—Preliminary layout showing major facilities.

5.16 Round Lake Reservoir

Storage peak capacity:	350,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	1,000 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	0 to 350,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	4—fourth tier not currently viable

Project Description

This option would consist of a pumped storage reservoir at the Round Lake basin southwest of the LLV site. Preliminary planning was not developed because initial review indicted the option life-cycle costs would be larger than for the reservoir options at LLV. Round Lake would require the similar reservoir facilities as LLV, except with longer conveyance systems.

Technology and infrastructure—

Option facilities would include a new reservoir at Round Lake with conveyance and pumping systems. Water would be conveyed to and from the reservoir via new constructed canals, tunnels and conduits connecting to UKL. The reservoir would be created by constructing tunnel inlet/outlet works allowing water flow into and out of the existing Round Lake basin. Storage capacity and embankment requirements would be refined during further planning according to the potential BO limitations on surface water supplies or lake levels in UKL.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—

Round Lake is one of four basins located southwest of UKL that could be used for water storage. It is farther from UKL than either LLV or Aspen Lake and thus could have relatively higher costs than those options. Several factors will require additional study to refine the option features and develop an accurate assessment of the potential water storage benefit-cost relationships.

5.16 UKBOS-IAIR Option: IA-5

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. Using an existing water body reduces newly inundated surface area. This option was recommended for preliminary study as part of the KBWSI effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option uses some existing UKL and Klamath Project conveyance systems. Major cost elements include the reservoir, conveyance and pump system construction, and annual power use and O&M requirements.

Wetlands and water quality—

Preliminary review indicates the potential for impacts to existing wetlands in the option site area (assessed by GIS using NWI datasets). Wetlands mitigation is considered a strong possibility. Water treatment for stored release flows is also likely although specific requirements will require thorough investigation and review by appropriate regulatory agencies.

Biological and cultural resources—

Fish species protection would include incorporating fish screens into the intake of the conveyance system at UKL. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Preliminary evaluation indicated mitigation requirements for wetlands within the Round Lake basin could pose a significant cost factor. Other resource issues will require more detailed study during future planning and design stages.

Current Option Status

This option is considered a lower priority for further planning primarily because of the relatively greater infrastructure and operational costs anticipated compared to other similar storage option sites. Implications for the existing residential and commercial development near Round Lake would require evaluation. Subsurface seepage and hydrologic modeling would be needed as part of any further planning stages. This modeling could also require additional field exploration and testing studies including drilling for seepage study verification in the site area.

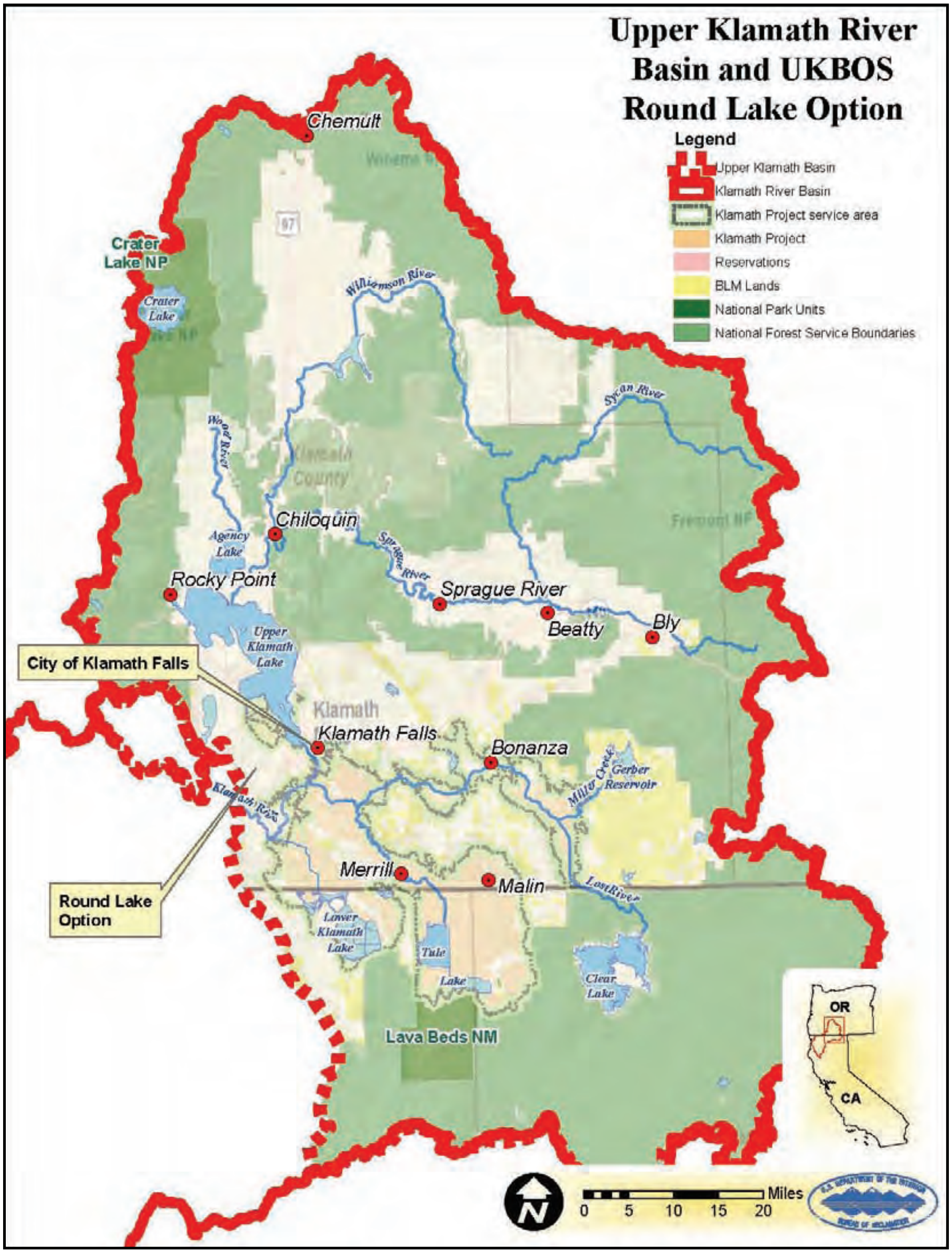


Figure 5-27.—Round Lake Reservoir location map.

Figure 5-28.—Preliminary layout at Round Lake Reservoir.

5.17 Long Lake Valley Reservoir—Base 350K Acre-Ft

Storage peak capacity:	350,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	1,000 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	0 to 350,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	3—third priority additional barriers

Project Description

This option involves storing surplus UKL water in a new reservoir in the LLV basin. Stored water would be returned to UKL for use in existing Klamath Project delivery systems. Appraisal planning was completed in early 2010 for this 350,000 acre-ft reservoir capacity. This option was not advanced to further planning because economic factors were determined unfavorable for the proposed project facilities at that time.

Technology and infrastructure—

Preliminary and appraisal plans were based on constructing embankment dams at low points along the basin ridgeline. Water would be conveyed to and from the LLV reservoir and UKL using new conveyance and pump systems. The capacity was based on BO constraints (NMFS, 2002; FWS 2008) on surplus UKL water and the latest NMFS BO (2010) could further limit storage supplies. Areas of the LLV site may require an impervious liner to control seepage or potential for drainage interactions near the Round Lake and Wocus Marsh areas.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—

Although this option was determined not viable based on economic relationships for the LLV reservoir facilities identified at this time, it could be reconsidered to incorporate engineering design adjustments or to account for changes in prevalent benefit or cost factors. More detailed description of the LLV reservoir facilities is available in the full appraisal report.

5.17 UKBOS-IAIR Option: IA-6a

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage schemes. This option was recommended as part of the KBWSI effort and remains potentially viable if the constraints and economic factors can be addressed.

Institutional and economic factors—
More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option uses some existing UKL and Klamath Project conveyance systems. Major cost elements include the reservoir, conveyance and pump system construction, and annual power use and O&M requirements.

Wetlands and water quality—
Preliminary review indicates the potential for impacts to existing wetlands in the option site area (GIS and NWI datasets). Wetlands mitigation requirements are a strong possibility and an important economic factor. Water treatment for stored release flows is also likely although specific requirements will require thorough investigation and review by appropriate regulatory agencies.

Biological and cultural resources—
Fish species protection would include incorporating fish screens into the intake of the conveyance system at UKL. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—
Preliminary evaluation indicated mitigation requirements for wetlands within the inundated LLV reservoir area could pose a significant cost factor. Other resource issues will require more detailed study during future planning and design stages.

Current Option Status

Although this option is potentially viable, barriers identified in appraisal planning make it a third priority that would require some modification to reconsider as part of further storage planning. The option is similar to other pumped storage options at the Whiteline and Swan Lake sites or nearby Aspen Lake or Round Lake sites. Although the option could have lower conveyance costs than sites farther from the UKL supply water, other engineering features or hydrological operations would warrant further studies to address the major benefit and cost factors. At this time is appears that modification to the facilities or operating schemes are necessary to raise the economic viability and the current option priority status.

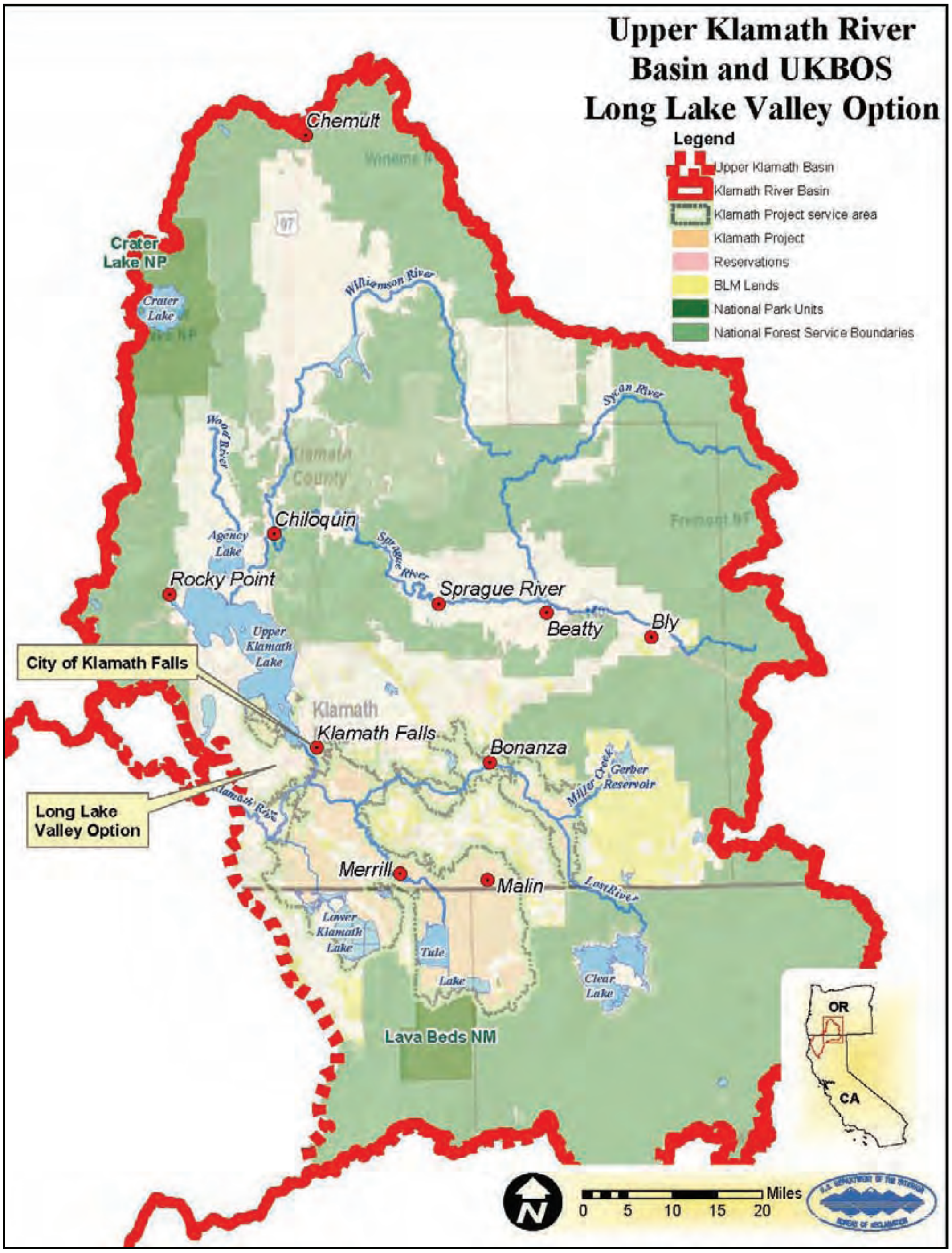


Figure 5-29.—Long Lake Valley Reservoir—base 350K acre-ft—location map.

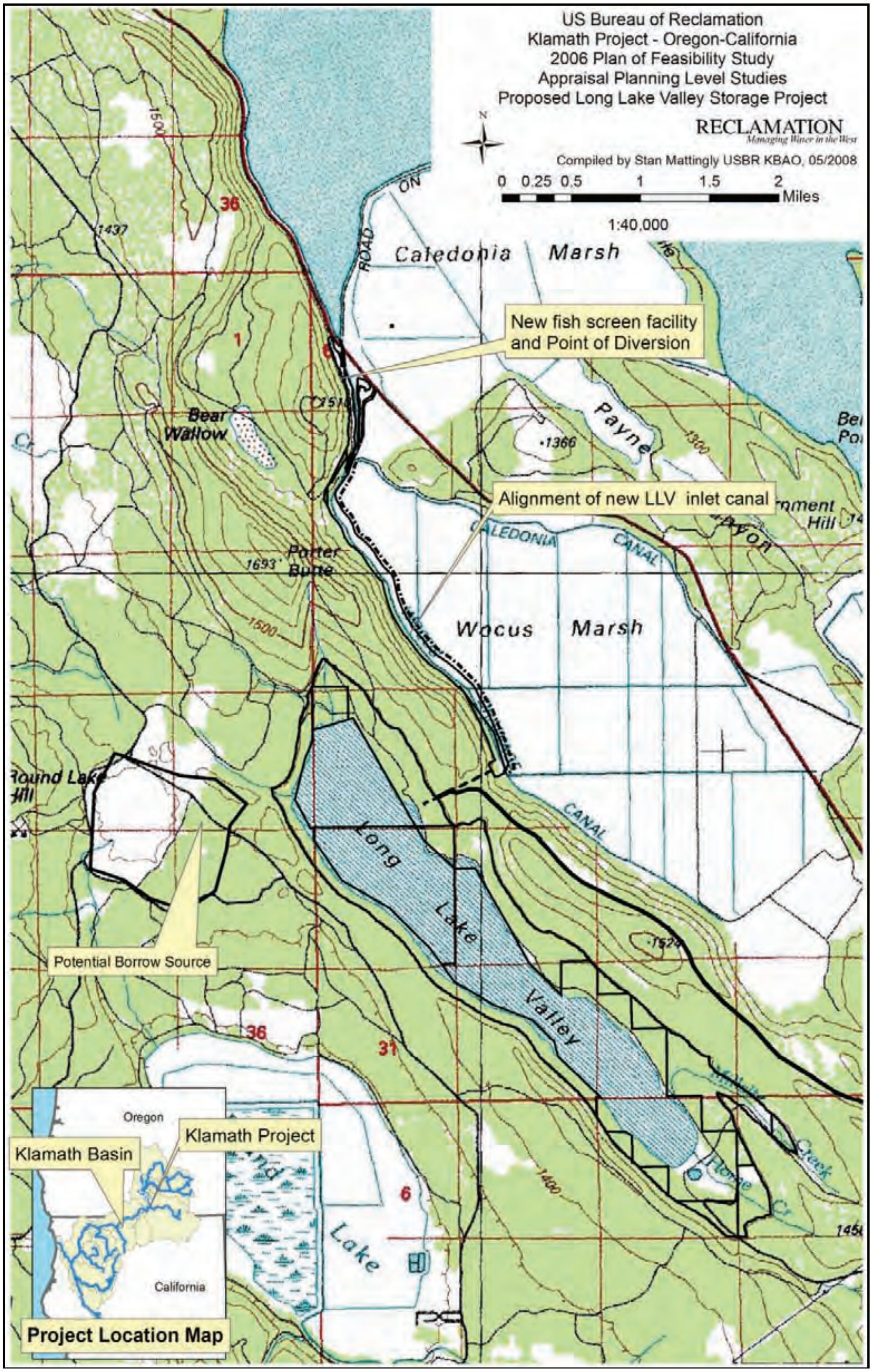


Figure 5-30.—Preliminary layout at Long Lake Valley Reservoir—base 350K acre-ft option.

5.18 Long Lake Valley Reservoir—WQ Release

Storage peak capacity:	350,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	1,000 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	0 to 350,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	3—third priority potentially viable

Project Description

This option involves storing surplus UKL water in a new reservoir in the LLV basin. This option is a variation of the LLV reservoir planning that has an additional tunnel and pipeline to allow direct release of stored water to the Klamath River near Keno. Downstream water users could benefit from additional water supplied during times of shortage.

Technology and infrastructure—

Preliminary and appraisal plans were based on constructing embankment dams at two points at the basin perimeter. Water would be conveyed to the LLV reservoir using new pump conveyance systems. Stored water could be returned to UKL for delivery via existing Klamath Project systems or released through the additional pipeline to the Klamath River near Keno. The LLV reservoir capacity was based on BO constraints (NMFS, 2002; FWS 2008) on UKL water. The latest NMFS BO (2010) could further limit available water supplies. Areas of the LLV site may require an impervious liner to control seepage losses or drainage interactions near the Round Lake and Wocus Marsh areas.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning would require additional hydrological modeling to develop accurate estimates of the water supply, delivery reliability, and groundwater interactions.

Preliminary engineering factors—

This option has similar engineering and economic attributes as the original LLV reservoir with added flexibility for releasing water directly to the Klamath River and the potential to improve water quality in the LLV reservoir by periodic flow through operations. Additional studies are necessary to refine the option features and develop an accurate assessment of storage benefit-cost relationships.

5.18 UKBOS-IAIR Option: IA-6b

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage schemes. The LLV reservoir was first recommended as part of the KBWSI effort and remains viable if key economic factors and issues can be addressed.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option entails using some existing UKL and Klamath Project water systems. Major cost elements include the reservoir, conveyance and pump system construction, and annual power use and O&M requirements.

Wetlands and water quality—

Preliminary review indicates the potential for impacts to existing wetlands in the option site area (GIS and NWI datasets). Wetlands mitigation requirements are a strong possibility and an important economic factor. Water treatment for stored outflows would require further investigation and regulatory review. Preliminary studies indicate potential temperature benefits in the Klamath River are not likely to persist downstream, although this could also warrant further studies.

Biological and cultural resources—

Fish species protection would include incorporating fish screens into the intake of the conveyance system at UKL. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Preliminary evaluation indicated mitigation requirements for wetlands within the inundated LLV reservoir area could pose a significant cost factor. Other resource issues would require more detailed study during any future planning stages.

Current Option Status

The potential for improved operational flexibility to manage LLV reservoir water quality or direct Klamath River releases could offer additional benefits over the original LLV reservoir. Although the LLV location could have lower conveyance costs than sites farther from the UKL water supply, engineering and hydrological operations details would require further development. Future planning studies including geotechnical assessment of reservoir seepage containment potential and detailed hydrologic water operations modeling are needed to evaluate whether this option should advance to appraisal investigations.

Figure 5-31.—Long Lake Valley Reservoir with WQ release—location map.

Figure 5-32.—Preliminary layout at Long Lake Valley Reservoir—WQ release option.

5.19 Swan Lake Reservoir—AB Canal Feed

Storage peak capacity:	188,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	330 ft^3/s via canals, pumping plant and new tunnel
Water delivery benefit:	0 to 188,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves storing surplus UKL water within the Swan Lake basin using new pumped storage facilities. Water conveyance to and from the reservoir would utilize existing Klamath Project infrastructure including the A Canal, B Canal, UKL, and connected stream channels. Water users would benefit from the additional water available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on using the existing Swan Lake basin to reduce new reservoir footprint impacts. This option has a smaller capacity of the two options identified at this site. Existing A and B Canals would convey UKL supply water close to the site and then pumped into the reservoir basin. Stored water would be delivered via new and existing conveyance systems. The reservoir capacity was based on BO constraints (NMFS, 2002; FWS 2008) on surplus UKL water and the latest NMFS BO (2010) could further limit available supplies. Potential for evaporation losses could be significant and portions of the site area may need to be lined to control seepage losses.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for interactions with existing groundwater wells.

Preliminary engineering factors—

Between the two identified Swan Lake options, this A-B supply option has lower capacity. Although preliminary planning did not identify significant engineering barriers, several factors require additional study to refine the option features and develop an accurate assessment of storage benefit-cost relationships.

5.19 UKBOS-IAIR Option: IA-7a

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. Using an existing water body reduces newly inundated surface area. This option was recommended for preliminary study as part of the KBWSI effort and remains potentially viable for future planning.

Institutional and economic factors—
More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option uses some existing UKL and Klamath Project conveyance systems. Major cost elements include the reservoir, conveyance and pump system construction, and annual power use and O&M requirements.

Wetlands and water quality—
Preliminary review indicates the potential for impacts to existing wetlands in the option site area (GIS and NWI datasets). Wetlands mitigation requirements are a strong possibility and an important economic factor. Water treatment for stored release flows is also possible although specific requirements will require thorough investigation and review by appropriate regulatory agencies.

Biological and cultural resources—
Fish species hazards would be reduced by using the existing fish screen that is on the A Canal intake from UKL. Further studies to assess seasonal flow operations for this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—
Preliminary evaluation indicated mitigation requirements for wetlands within the Swan Lake basin could be significant. Other possible resource issues will require more detailed study during future planning and design stages.

Current Option Status

This option is considered a potentially viable second priority for further storage planning stages. At this time, it appears that the larger capacity Algoma supply option offers benefit and cost advantages over this option. Additional planning studies including geotechnical assessment of the reservoir seepage containment and detailed hydrologic water operations modeling are needed to assess whether this option should advance to appraisal investigations.

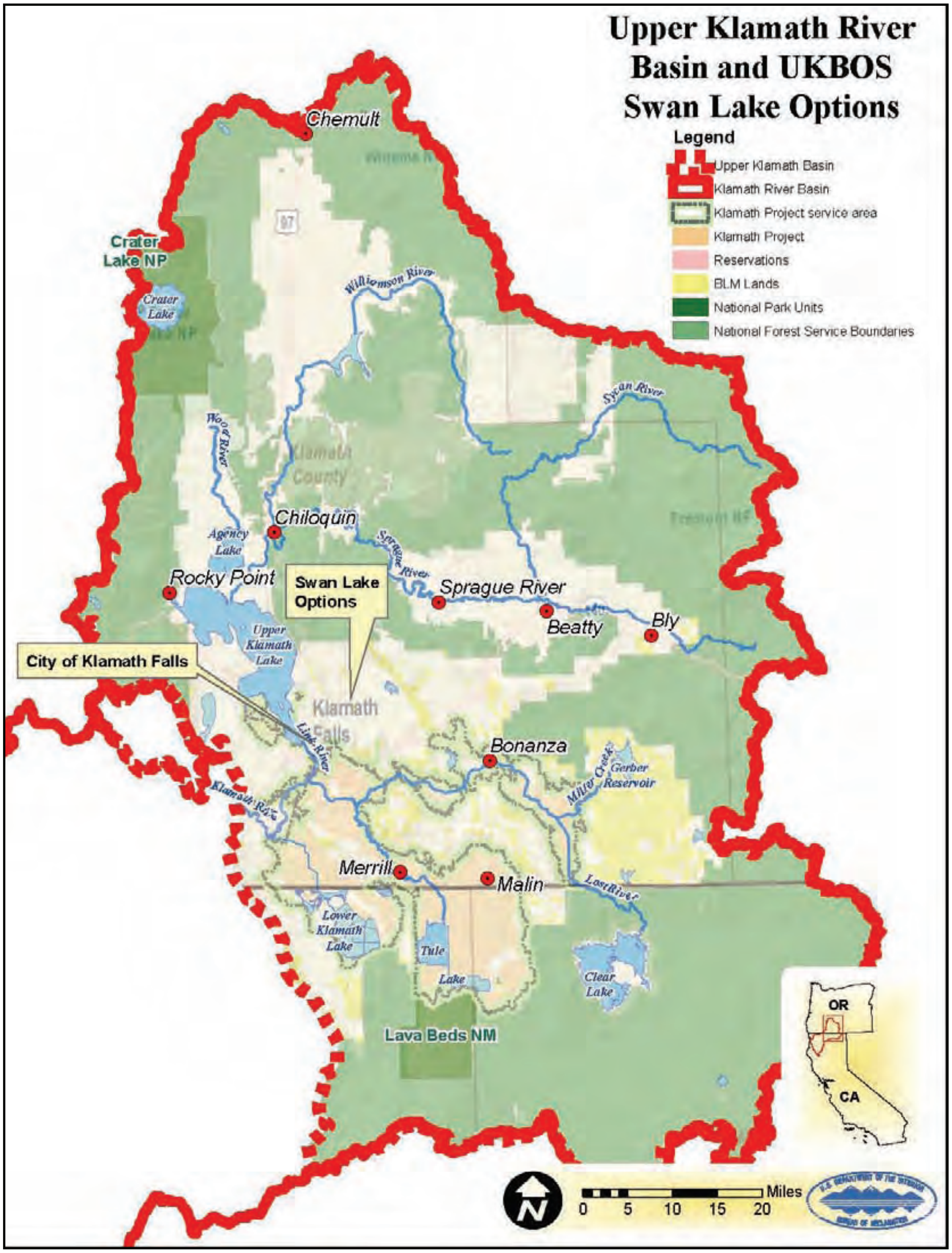


Figure 5-33.—Swan Lake Reservoir with AB Canal feed—location map.

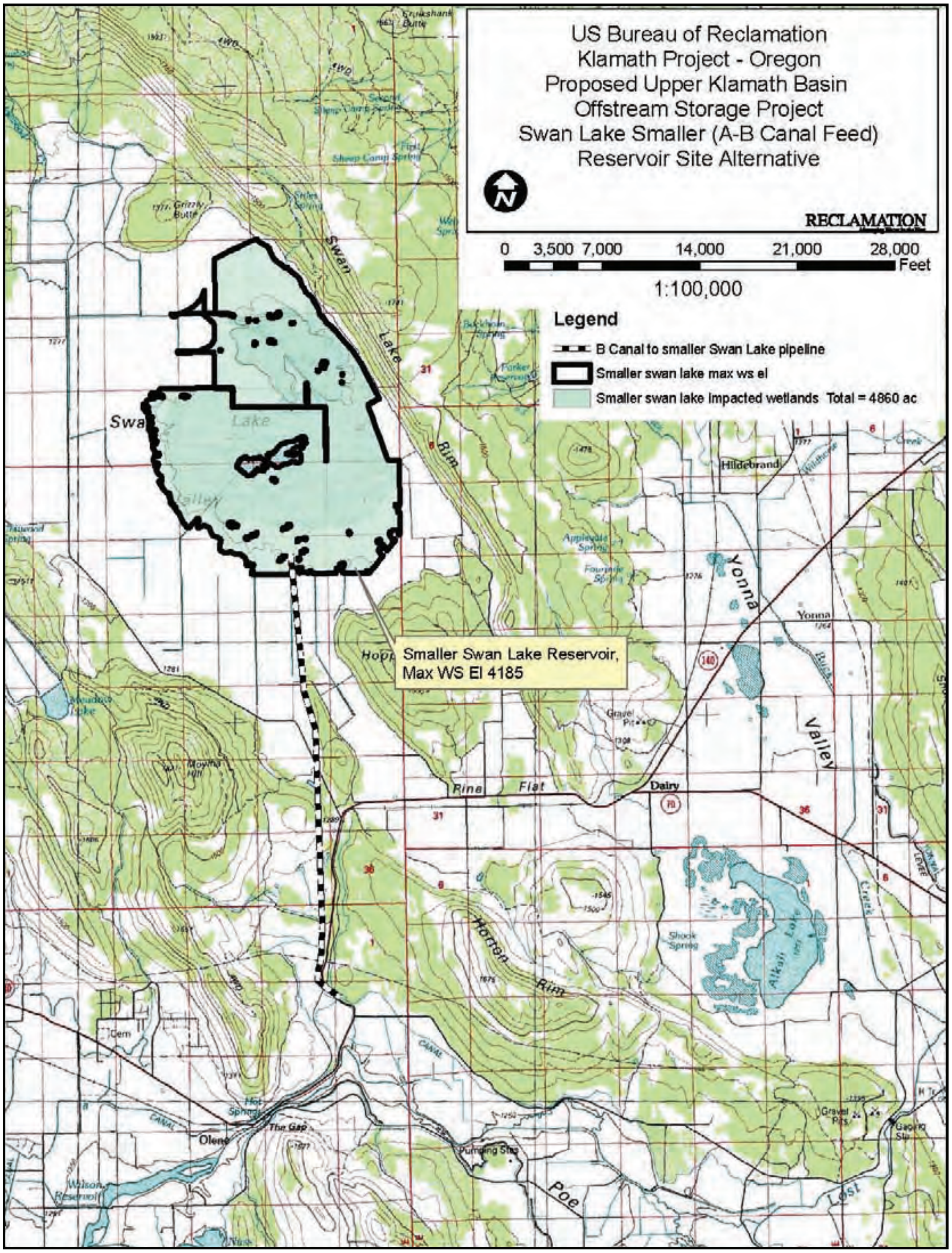


Figure 5-34.—Preliminary layout at Swan Lake Reservoir with AB Canal feed.

5.20 Swan Lake Reservoir—Algoma Feed

Storage peak capacity:	350,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	1,000 ft^3/s via canals, pumping plant and tunnel
Water delivery benefit:	0 to 350,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves storing surplus UKL water within the Swan Lake basin using new pumped storage facilities. The location was selected for the potential storage volume with a relatively smaller impoundment structure and the proximity to the UKL water supply. Water conveyance to and from the reservoir would utilize existing and new conveyance systems and stream channels. Water users supplied by this option would benefit from the additional water available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on using the existing Swan Lake basin to reduce new reservoir footprint impacts. Water would be conveyed via the new Algoma canal, pump station, and tunnel (Algoma Ridge) and passed through the existing Whiteline Reservoir into the Swan Lake reservoir. Stored water would be delivered via new and existing Klamath Project water conveyance systems. The reservoir capacity was based on BO constraints (NMFS, 2002; FWS 2008) on surplus UKL water and the latest NMFS BO (2010) could further limit available supplies.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for interactions with existing groundwater wells.

Preliminary engineering factors—

Between the two identified Swan Lake reservoir options, this Algoma feed option has greater capacity. Although preliminary planning did not identify significant engineering barriers, several factors require additional study to refine the option features and accurately assess storage benefit-cost relationships.

5.20 UKBOS-IAIR Option: IA-7b

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. Using an existing water body reduces newly inundated surface area. This option was recommended for preliminary study as part of the KBWSI effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option uses some existing UKL and Klamath Project conveyance systems. Major cost elements include the reservoir, conveyance and pump system construction, and annual power use and O&M requirements.

Wetlands and water quality—

Preliminary review indicates the potential for impacts to existing wetlands in the option site area (GIS and NWI datasets). Wetlands mitigation requirements are a strong possibility and an important economic factor. Water treatment for stored release flows is also possible although specific requirements will require thorough investigation and review by appropriate regulatory agencies.

Biological and cultural resources—

Fish species risks would be mitigated by installing a fish screen at the UKL intake into the Algoma Canal. Further studies of seasonal flow operations for this option would have to consider sensitive aquatic, terrestrial, and avian species. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Preliminary evaluation indicated mitigation requirements for wetlands within the Swan Lake basin could be significant. Resource issues associated with conveying water through Whiteline Reservoir and other possible resource issues will require more detailed study during any subsequent planning and design stages.

Current Option Status

This option is considered a potentially viable second priority for further storage planning stages. At this time, it appears that the larger capacity Algoma supply option offers greater storage benefits over the smaller Swan Lake storage option although operating costs require further study. Further planning studies including geotechnical assessment of reservoir seepage containment and detailed hydrologic water operations modeling are necessary to determine whether this option should advance to appraisal investigations.

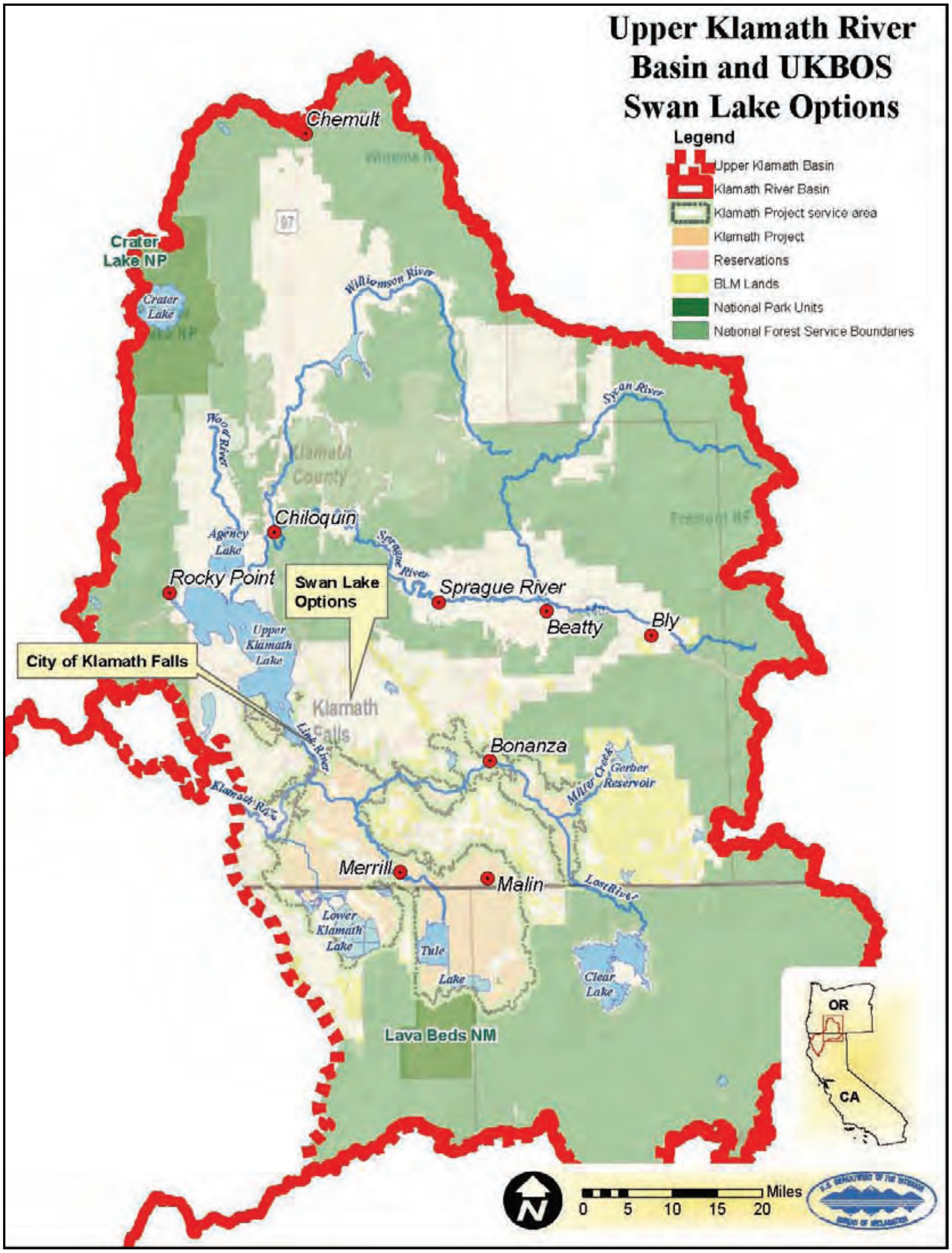


Figure 5-35.—Swan Lake Reservoir with Algoma feed—location map.

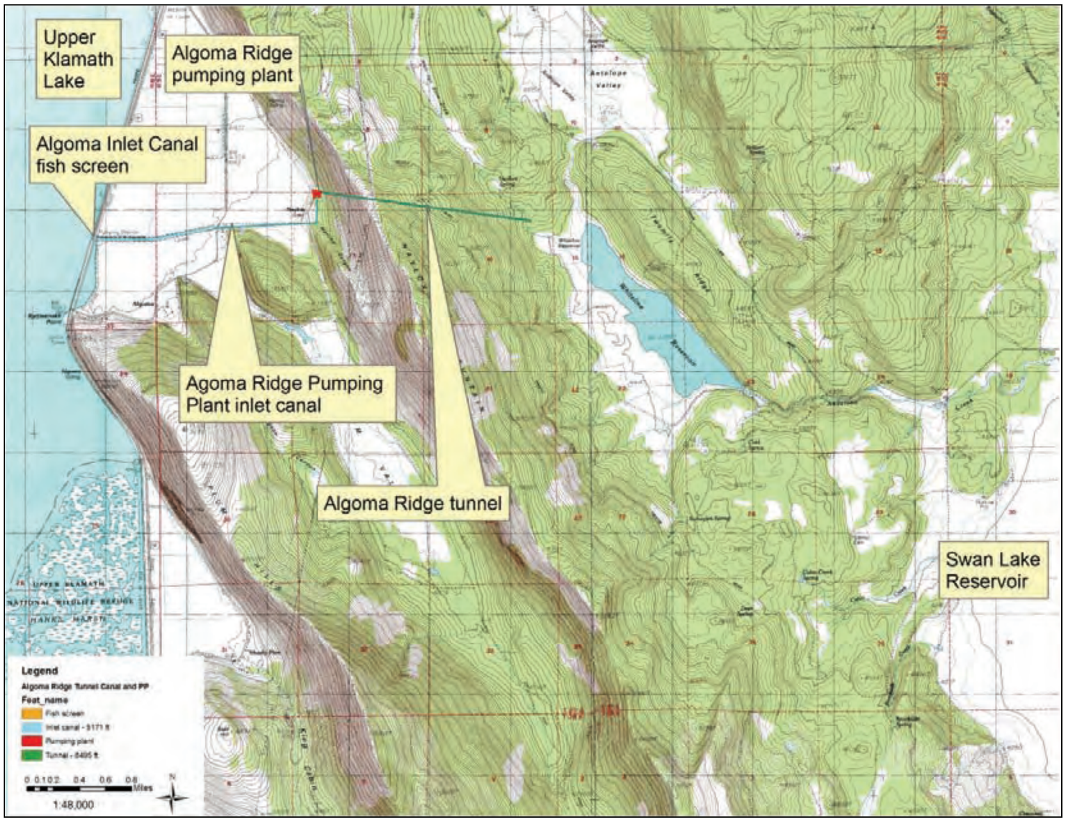
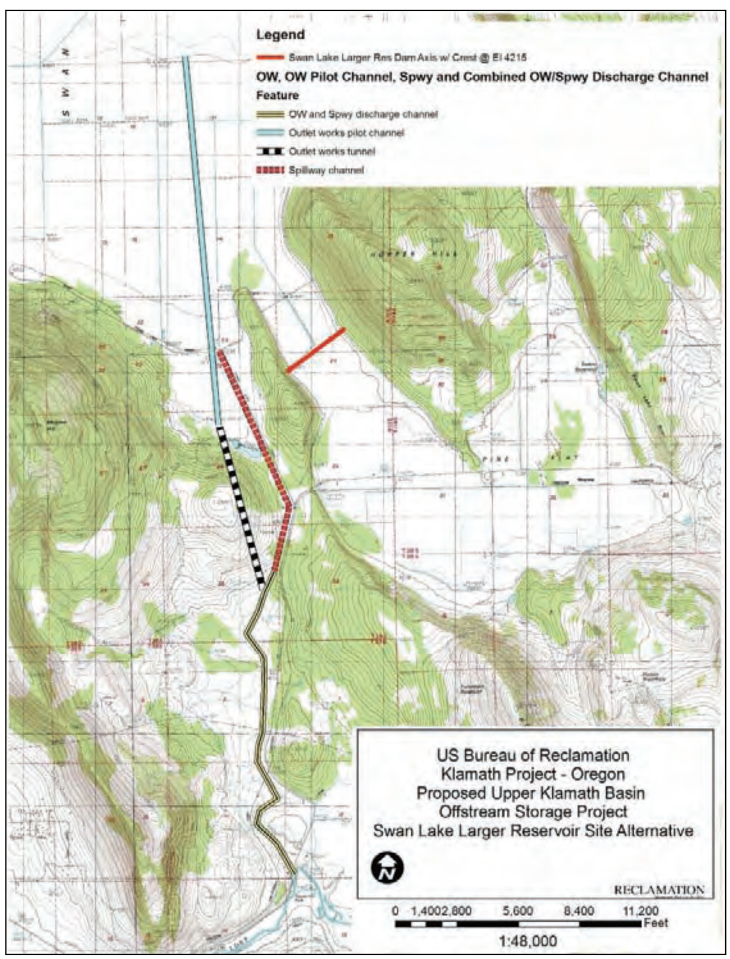


Figure 5-36.—
Preliminary layout at Swan Lake Reservoir with Algoma feed.



5.21 Lower Klamath NWR Reservoir

Storage peak capacity:	80,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	Tule Lake surplus water
Available storage water:	Up to maximum Tule Lake conservation capacity
Storage fill frequency:	Years when surplus Tule Lake water is available
Initial design inflow rate:	320 ft^3/s via Sheepy Tunnel and D pumping plant
Water delivery benefit:	0 to 80,000 acre-ft/yr to Klamath River through KSD
Water treatment type:	Group 4; Lost River source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves storing surplus water from the Tule Lake basin in Unit 13 of the LK-NWR. Preliminary reservoir location at the south end of LK-NWR Unit 13 was based on the close proximity to the Sheepy Tunnel for conveying water to the reservoir. Water deliveries would utilize existing Klamath Project infrastructure including the KSD and existing river channels. Downstream and refuge water users would benefit from the additional water made available during times of shortage.

Technology and infrastructure—
Preliminary planning is based on converting the existing Unit 13 pond into a dual-purpose reservoir. The reservoir would be created by a constructed embankment dam located along the boundaries of Unit 13 and the outlet works could provide discharge into KSD for delivery to Klamath Project users. The reservoir volume was sized to match a target 120-day supply rate. Water would be conveyed to the reservoir via a constructed canal and tunnel from the existing Sheepy Tunnel outlet by constructing a bifurcation to allow flows to the existing P Canal.

Water source and hydrology—
Water for storage in this option would be obtained when surplus Tule Lake water is available. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from Tule Lake; the estimated water budget including evaporation rates, precipitation, and underground leakage; and factors including water demands and water use practices. An estimated duration of 120 days was applied for both the storage diversions and later delivery flow rates.

Preliminary engineering factors—
Further planning would require additional site studies and hydrologic operations modeling to develop accurate estimates of water supply, water quality, delivery reliability, and potential groundwater interactions. These factors would require further investigation to refine storage features and accurately assess storage the benefit-cost relationships.

5.21 UKBOS-IAIR Option: IA-8

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. Using an existing water body reduces newly inundated surface area. This option was recommended for preliminary study as part of the KBWSI effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site is located on Federally owned and managed land and requires no private land purchase. Cooperation with the FWS would be necessary to undertake this option, although the LK-NWR could benefit from the additional water supplied to the refuge. Operators of water infrastructure, such as the D Pumping Plant, would have to agree on pumping cost distribution. Major cost elements include reservoir facilities, pumping power use, and O&M.

Wetlands and water quality—

Preliminary review indicates potential for direct impacts to existing wetlands in the site area (GIS and NWI datasets) and wetlands mitigation is expected. This option could provide some water quality benefits by releasing freshwater flows to the KSD to dilute drainage water during low flow periods. Water treatment prior to releasing stored water to the Lost River is unknown and standards—including potential TMDL requirements—would require study and review by appropriate Oregon and California regulatory agencies.

Biological and cultural resources—

Fish species issues would be mitigated by installing a fish screen at the intake at the D Pumping Plant. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. There are currently no known cultural resource issues at this site, although further study would be for any subsequent planning stages.

Key nonengineering factors—

Preliminary evaluation indicated the potential wetlands mitigation requirements is a potential cost factor. The potential for KSD water quality improvement and the potential benefits or changes to fish and wildlife habitat from the additional water storage within the NWR require further investigation.

Current Option Status

This option is considered viable as a second priority for further storage planning stages. Cooperation with the FWS pertaining to NWR management and among stakeholders in regards to pumping costs are key benefit cost factors to evaluate whether this option should advance to appraisal planning.

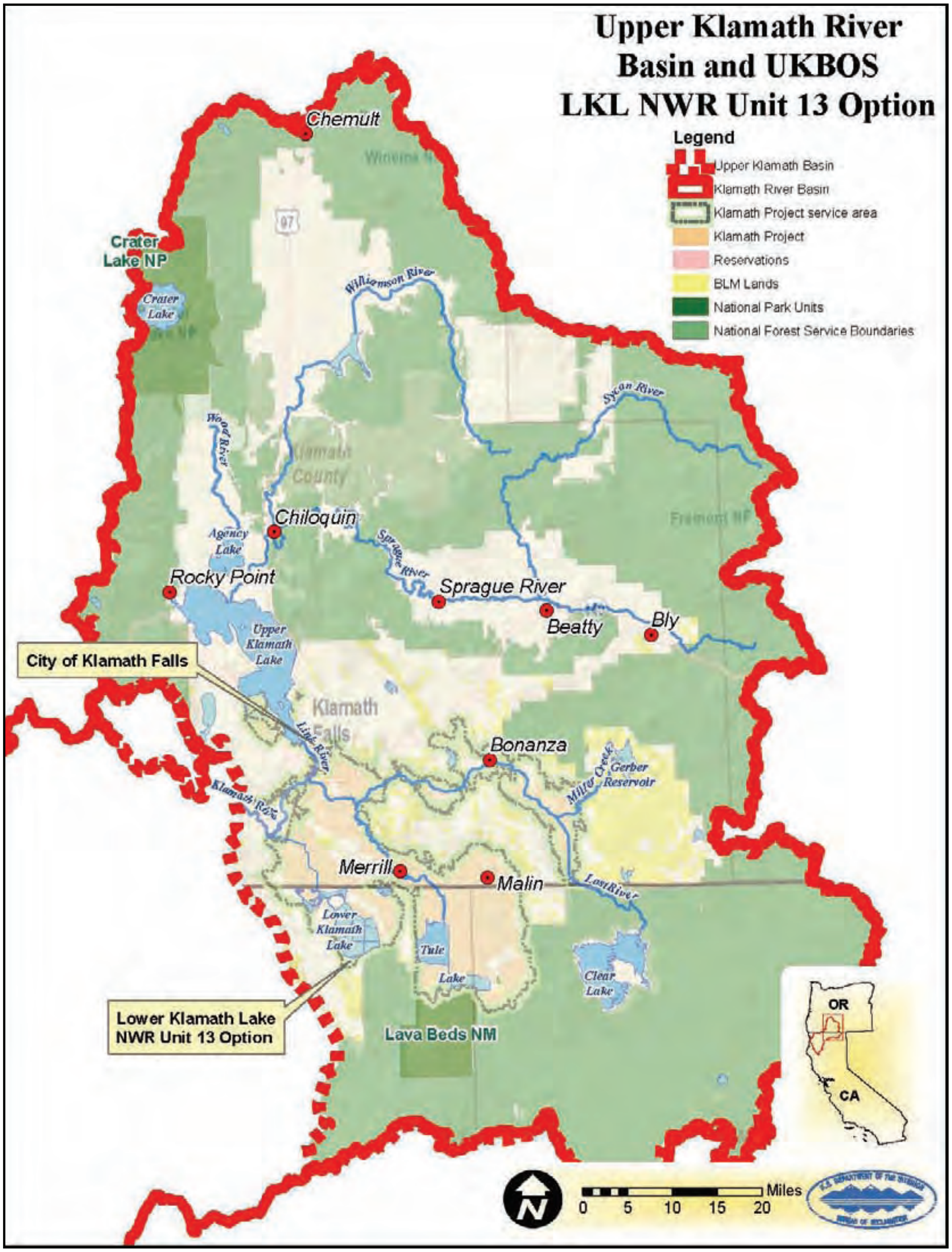


Figure 5-37.—Lower Klamath NWR Reservoir location map.

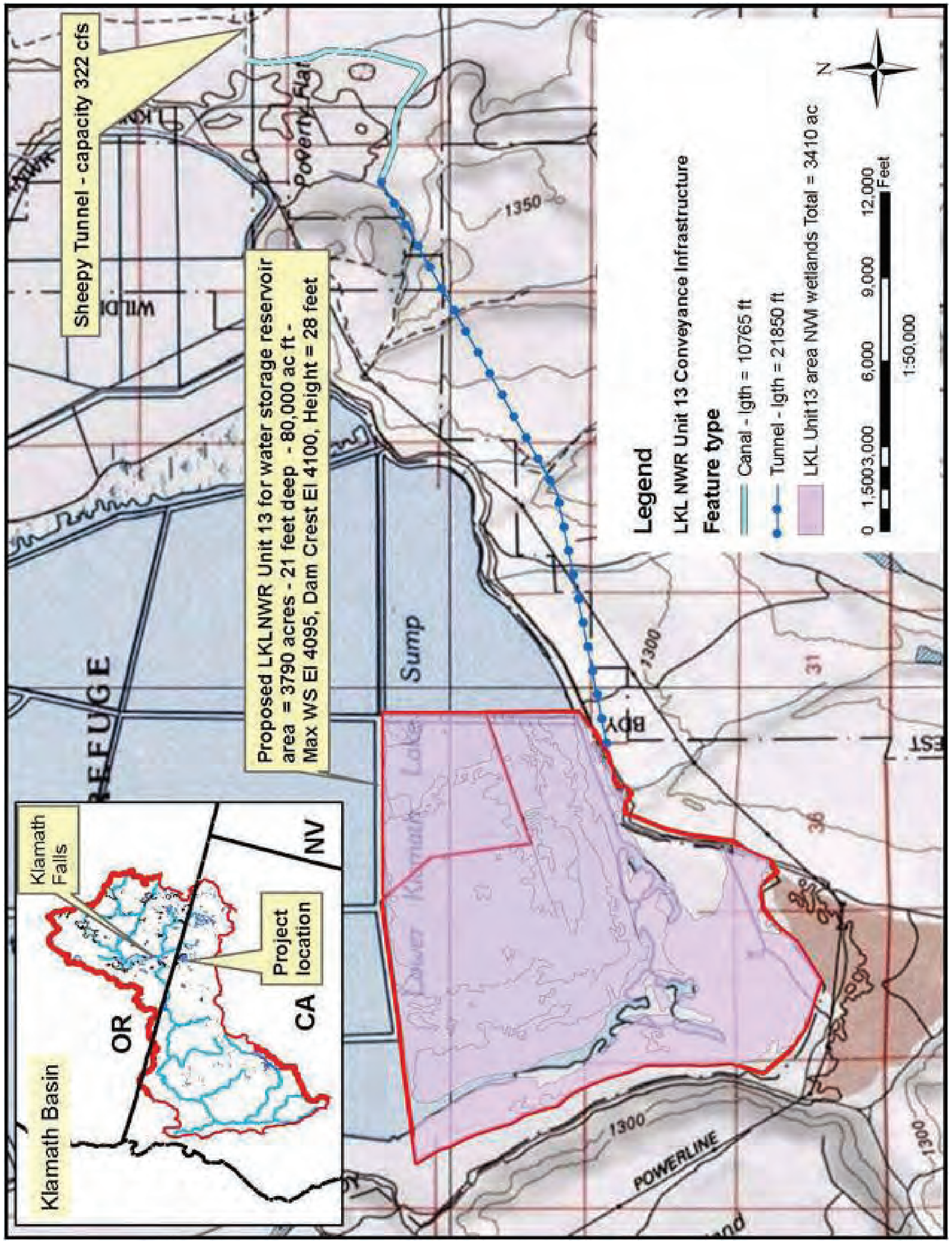


Figure 5-38.—Preliminary layout at Lower Klamath NWR Reservoir.

5.22 Tule Lake—Expanded Sump 1A

Storage peak capacity:	48,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	Tule Lake surplus inflows from UKL
Available storage water:	Maximum surplus, return flows, and current BOs
Storage fill frequency:	When surplus UKL / Tule Lake water is available
Initial design inflow rate:	1,000 ft^3/s depending on irrigation return flow rates
Water delivery benefit:	0 to 48,000 acre-ft/yr to Klamath River through KSD
Water treatment type:	Group 4; Lost River source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves storing surplus water from UKL and irrigation return flows in the Tule Lake basin Sump 1A. This site is part of the Tule Lake National Wildlife Refuge. Water deliveries would use existing Klamath Project systems including the KSD and existing river channels and downstream and refuge water users could benefit from additional water supplies available during times of shortage.

Technology and infrastructure—
Preliminary planning is based on converting the existing Sump 1A into a storage reservoir. The reservoir would be created by constructing raised levees along the boundaries of Sump 1A. The reservoir volume was sized to match a target 24-day supply flow duration. Water would be conveyed to the reservoir in the Lost River and existing conveyance infrastructure including the numerous agricultural drains in the Tule Lake basin. The existing D Pumping Plant could discharge stored water into the P Canal and the KSD for Klamath Project users.

Water source and hydrology—
Storage water would be obtained using surplus UKL water or by irrigation return flows. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimated water budget including evaporation rates, precipitation, and underground leakage; and other factors including water demands and water use practices. An estimated duration of 30 days was applied for both the storage diversions and later delivery flow rates.

Preliminary engineering factors—
Further planning would require additional site studies and hydrologic operations modeling to develop accurate estimates of water supply, water quality, delivery reliability, and potential groundwater interactions. These factors would require further investigation to refine storage features and accurately assess storage the benefit-cost relationships.

5.22 UKBOS-IAIR Option: IA-9

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage schemes. Using an existing water body reduces the newly inundated surface area. This option was recommended for preliminary study as part of the KBWSI effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site is located on Federally owned and managed land and requires no private land purchase. Cooperation with the FWS would be necessary to undertake this option, although the LK-NWR could benefit from the additional water supplied to the refuge. Operators of water infrastructure, such as the D Pumping Plant, would have to agree on pumping cost distribution. Major cost elements include the reservoir facilities, pumping power use, and O&M.

Wetlands and water quality—

Preliminary review indicates potential for direct impacts to existing wetlands in the site area (GIS and NWI datasets) and wetlands mitigation is expected. This option could provide some water quality benefits by releasing freshwater flows to the KSD to dilute drainage water during low flow periods. Water treatment prior to releasing stored water to the Lost River is unknown and standards—including potential TMDL requirements—would require study and review by appropriate Oregon and California regulatory agencies.

Biological and cultural resources—

Fish species issues would be mitigated by installing a fish screen at the intake at the D Pumping Plant. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. There are currently no known cultural resource issues at this site, although further study would be necessary for any subsequent planning stages.

Key nonengineering factors—

Preliminary evaluation indicated the potential wetlands mitigation requirements is a potential cost factor. The potential for KSD water quality improvement and the potential benefits or changes to fish and wildlife habitat from the additional water storage within the NWR require further investigation.

Current Option Status

This option is considered viable as a second priority for further storage planning stages. Cooperation with the FWS pertaining to NWR management and among stakeholders in regards to pumping costs are key benefit-cost factors to evaluate whether this option should advance to appraisal planning.

Figure 5-39.—Tule Lake with expanded sump 1A—location map.

Figure 5-40.—Preliminary layout at Tule Lake with expanded sump 1A.

5.23 UKL—Raise Link River Dam

Storage peak capacity:	350,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	Sprague, Williamson, and Wood Rivers inflows
Available storage water:	803,000 acre-ft (OWARS, 2010) and current BOs
Storage fill frequency:	Years of surplus water in Upper Klamath basin
Initial design inflow rate:	Run of the river flows into Upper Klamath Lake
Water delivery benefit:	0 to 350,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 3; Williamson source (need to be determined)
Current priority status:	3—third priority additional barriers

Project Description

Additional water could be stored within UKL by raising the existing Link River Dam outlet controls and building containment levees at key locations around the UKL perimeter. The option was originally developed as part of the KBWSI planning because of the potential large water storage capacity with moderate dam structure modifications. Water delivery could utilize existing Klamath Project infrastructure and water users could benefit from the additional water supplies available during times of shortage.

Technology and infrastructure—

Preliminary plans are based raising the existing Link River Dam and related water control systems and raising UKL perimeter levees to accommodate a higher water surface elevation. The raised reservoir would lie within the existing UKL bounds and would use existing water supply and delivery infrastructure. The preliminary reservoir volume was estimated based on current BO constraints (NMFS, 2002; FWS 2008) on surplus UKL water and the latest NMFS BO (2010) or future changes could further constrain available water supplies.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—

Preliminary findings indicate significant lengths of the UKL perimeter levees and the existing A Canal water controls and fish screen would require modification or new construction to implement this option. The potential implications for local communities, roads, and utilities would require more detailed investigations.

5.23 UKBOS-IAIR Option: IA-10

Preliminary Findings

Storage in this large central reservoir would offer exceptional water management flexibility. Using an existing water body generally reduces the newly inundated surface area; however, in this case extensive levee construction would be required to contain water within the existing UKL area. This option was recommended for preliminary study as part of the KBWSI effort and remains potentially viable with certain economic and practical barriers.

Institutional and economic factors—

More detailed investigation is required to evaluate water rights, reservoir seepage, groundwater interactions, and benefit/cost relationships. The option facilities are located on currently private and Federally owned lands that would require some land purchase to construct raised containment levees, water controls, and service facilities. Major cost elements include construction work on raising Link River Dam, related water control systems, and containment levees around UKL.

Wetlands and water quality—

Preliminary review indicates significant potential for impacts to existing wetlands (GIS and NWI datasets), especially within the Upper Klamath NWR. Extensive wetlands mitigation requirements would be expected. Water treatment of water stored in UKL is not expected, although subject to further studies and review by appropriate regulatory agencies.

Biological and cultural resources—

Direct fish species risks could be mitigated by modifying the existing fish ladder at the Link River Dam and the existing fish screen at the A Canal headworks (if needed). Studies of seasonal flow operations would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues associated with this option, further study would be necessary for any subsequent planning stages.

Key nonengineering factors—

Preliminary evaluation indicated the potential wetlands mitigation requirements is a substantial cost barrier. Other resource issues will require more detailed study during future planning and design stages.

Current Option Status

This option is considered viable although with potentially significant limitations and economic barriers that would have to be addressed in any future storage planning stages. These factors would require further investigation to refine storage features and accurately assess storage the benefit-cost relationships.

Figure 5-41.—Location map for the UKL—Raise Link River Dam option.

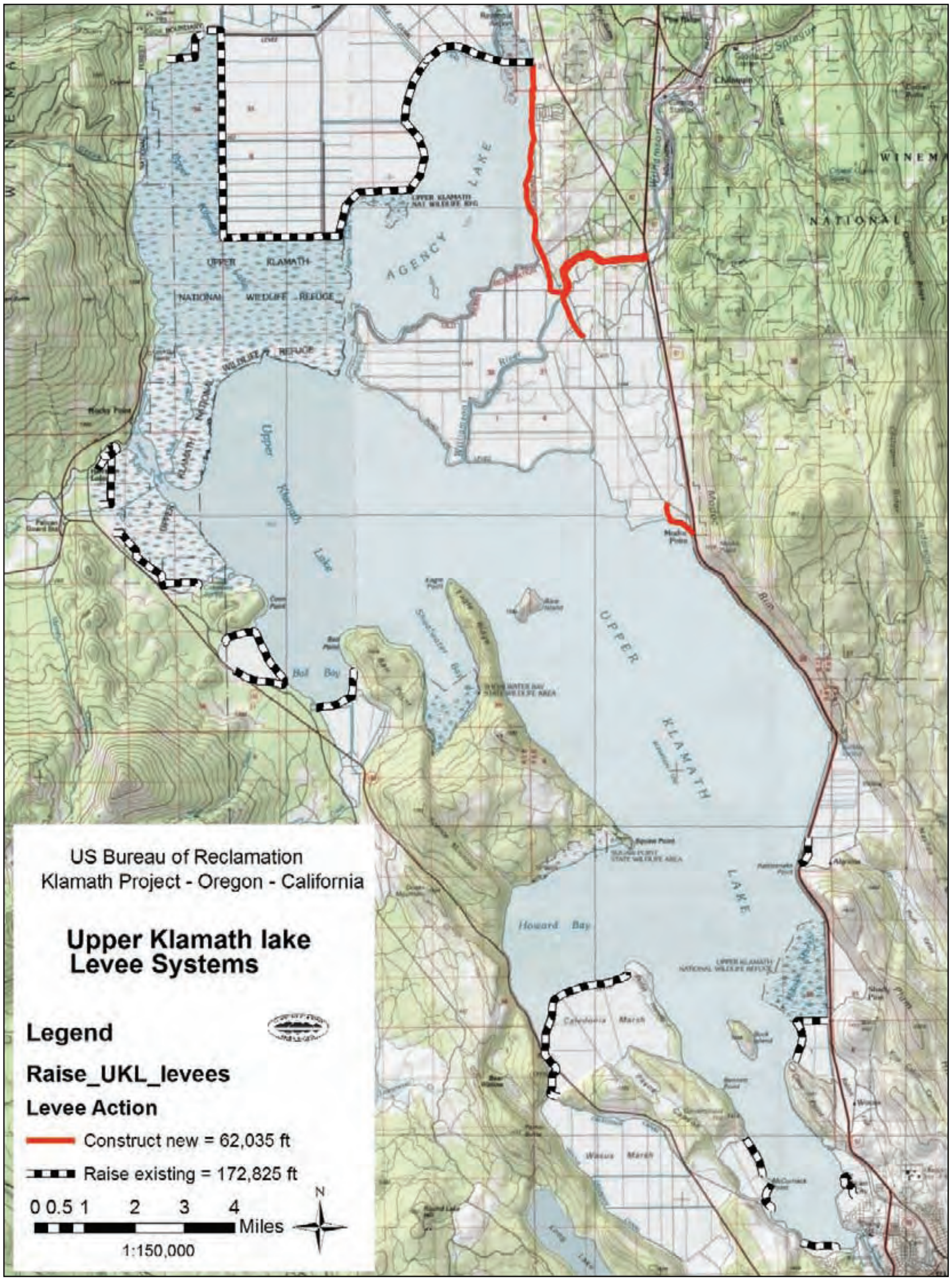


Figure 5-42.—Preliminary layout for the UKL-Raise Link River Dam option.

5.24 UKL—Dredge to Expand Capacity

Storage peak capacity:	Not determined—Depends on dredge volume
Projected storage time:	Permanent (expands minimum pool volume)
Storage water supply:	Upper Klamath Lake annual water supply
Available storage water:	Up to UKL capacity and BO constraints
Storage fill frequency:	Annual basin runoff water balance into UKL
Initial design inflow rate:	Not applicable to normal runoff inflow rates
Water delivery benefit:	None—Added bottom capacity not available
Water treatment type:	Group 5; Short term UKL dredging treatment
Current option status:	4—fourth tier not currently viable

Project Description

This strategy involves dredged removal of bottom sediments in selected areas of UKL where bottom elevations are above the established minimum pool elevation 4137 and would increase the UKL useable storage.

Technology and infrastructure—

Previous studies suggested the possibility of dredging in the Howard Bay area of UKL. However, current Reclamation datum bathymetry surveys indicate bottom elevations in that area are below the minimum pool and although dredging could increase the total lake storage volume it would not increase the amount of usable water (active storage) in the system. An alternative area was identified at the northwest end of UKL, south of the Upper Klamath National Wildlife Refuge (figure 5-19). Removing an average one-foot sediment layer from approximately 1,420 acres in this area could yield a fairly small additional active storage volume of about 1,420 acre-feet (2000 acre-feet maximum).

Water source and hydrology—

Oregon Water Resources Department data (OWRD, 2010) indicate surplus water for storage is available in UKL watershed. However, the current BO provisions (FWS, 2008) governing the Klamath Project operations require a minimum UKL water surface elevation of 4137.5 (Reclamation datum) and higher monthly minimum water levels can be required at certain times of the year. In addition, the existing UKL outlet works for the A canal currently restrict minimum UKL water levels to elevation 4137. As a result, dredged storage is also physically restricted to areas within UKL that have bottom substrates above elevation 4137.

Preliminary engineering factors—

The feasibility of gaining additional active water storage from UKL dredging is limited by physical controls and operational requirements. A primary concern with UKL dredging is also the expectation that over time, the dredged volume would progressively refill with sediment materials. Dredging work generally has higher unit water volume costs compared to other storage options.

5.24 UKBOS-IAIR Option: IA-11

Preliminary Findings

This option was recommended for preliminary study by the KBWSI. Preliminary UKBOS planning studies using more current and accurate reservoir bathymetry survey topography based on Reclamation datum revealed the critical operational and infrastructure limitations to this option described above.

Institutional and economic factors—

Relevant water rights implications and accurate benefit/cost relationships would require more detailed investigations. No permanent new facility construction is involved in this option. All dredging work would be conducted on the Federally owned and managed lands and would not require private land purchase. Dredging in the northern area (if pursued as a new option) could require right-of-way across nearby lands and access routes. Coordination with the FWS is expected for any work near the UKNWR lands or wetlands. Major cost elements would center on the dredging operations and disposal of removed sediment.

Wetlands and water quality—

The implications of in-lake dredging including removing excavated materials or wetland impacts would require more detailed studies. Dredging operations would require dredge and fill permits according to Section 404 of the Clean Water Act and Oregon Department of State Lands. Dredging could have adverse short term impacts on water quality in the lake or connected waters that would likely require specialized investigations based on more detailed plans for any proposed dredging activities. Although increasing the lake water volume might offer aquatic biota or lake water quality benefits, this is uncertain at this time.

Biological and cultural resources—

Dredging work would be within open waters of UKL. Disturbance to local areas around the UKL perimeter could occur for transport of excavated lake sediment materials. Although there could be local disturbance of sediments near dredging operations in within UKL it appears that fish would have ample habitat to move away for the dredging area. Other issues associated with biological or cultural resources require additional investigations based on specific plans.

Key nonengineering factors—

Any further planning would require more detailed investigation to assess potential impacts to water quality, species of concern, wildlife habitats, wetland resources, and other possible cultural, environmental, or water resource issues.

Current Option Status

This option is considered lowest priority. It does not appear to have the potential to contribute significantly to the UKBOS objectives; it raises important questions regarding potential impacts and does not appear cost effective at this time.

Figure 5-43.—UKL Dredging option location in the Upper Klamath Basin study area.

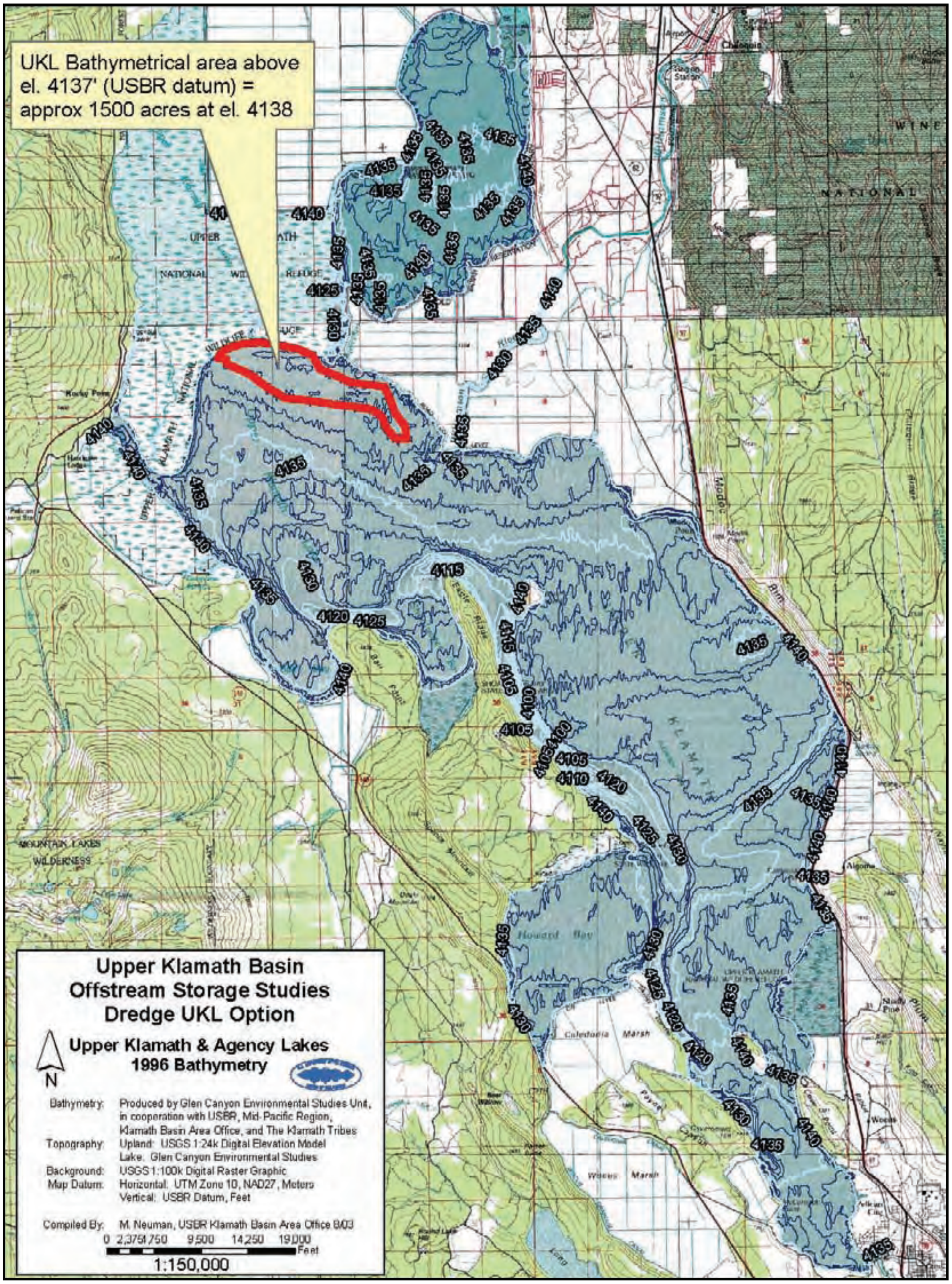


Figure 5-44.—UKL dredging option showing northern area (red outline) with bottom sediments that are above elevation 4137 (Reclamation datum).

5.25 Caledonia Marsh Reservoir

Storage peak capacity:	21,532 acre-ft maximum
Projected storage time:	Annual seasonal storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	250 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	0 to 21,500 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

Surplus water could be stored within the existing Caledonia Marsh area by using new and existing infrastructure. The site is close to UKL, which could minimize water conveyance. Water delivery from this option would utilize existing Klamath Project water systems including UKL and existing river channels Water users supplied by this option could benefit from additional water made available during times of shortage.

Technology and infrastructure—
Preliminary plans include some new levee construction and reinforcing of existing levees to store water within the site area. At high UKL water levels, water would enter the reservoir by gravity through a new inlet. Stored water would be pumped back to UKL using new pump systems. The preliminary capacity estimated was based on preliminary evaluation of existing levees and practical factors that could affect the height of any new or reinforced containment levees.

Water source and hydrology—
The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—
The Caledonia Marsh area is similar to other low-lying lands around UKL that have potential to store water. The storage capacity is limited by practical ability to raise containment dikes around the proposed reservoir site. Annual hydrologic patterns and UKL water levels could affect practical operations and actual storage benefits. These factors would require more detailed study to better define storage features and accurately assess storage benefit-cost relationships.

5.25 UKBOS-IAIR Option: IA-12

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option would entail using some existing UKL and Klamath Project conveyance systems. Major cost factors include the reservoir, conveyance, pump systems, levee construction, and annual power and O&M requirements.

Wetlands and water quality—

Preliminary review indicates significant potential for impacts to existing wetlands in the site area (GIS and NWI datasets). Wetlands mitigation requirements are an expected factor. Water treatment for stored release flows also appears very likely although specific requirements would require a thorough investigation and review by appropriate regulatory agencies.

Biological and cultural resources—

Fish species protection would include incorporating fish screens into the intake of the UKL water supply conveyance systems. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Preliminary evaluation indicated the potential wetlands mitigation requirements in the Caledonia Marsh area could pose a major cost factor. Other resource issues will require more detailed study during future planning and design stages.

Current Option Status

This option is considered viable as a second priority for further storage planning stages. Preliminary results indicate this option has similar benefit-cost factors to other low lying leveed storage sites near UKL such as Agency Lake Ranches and the Wocus Marsh sites. Additional studies including geotechnical assessment of reservoir seepage containment potential and detailed hydrologic water operations modeling are needed to assess whether this option should advance to appraisal investigations.

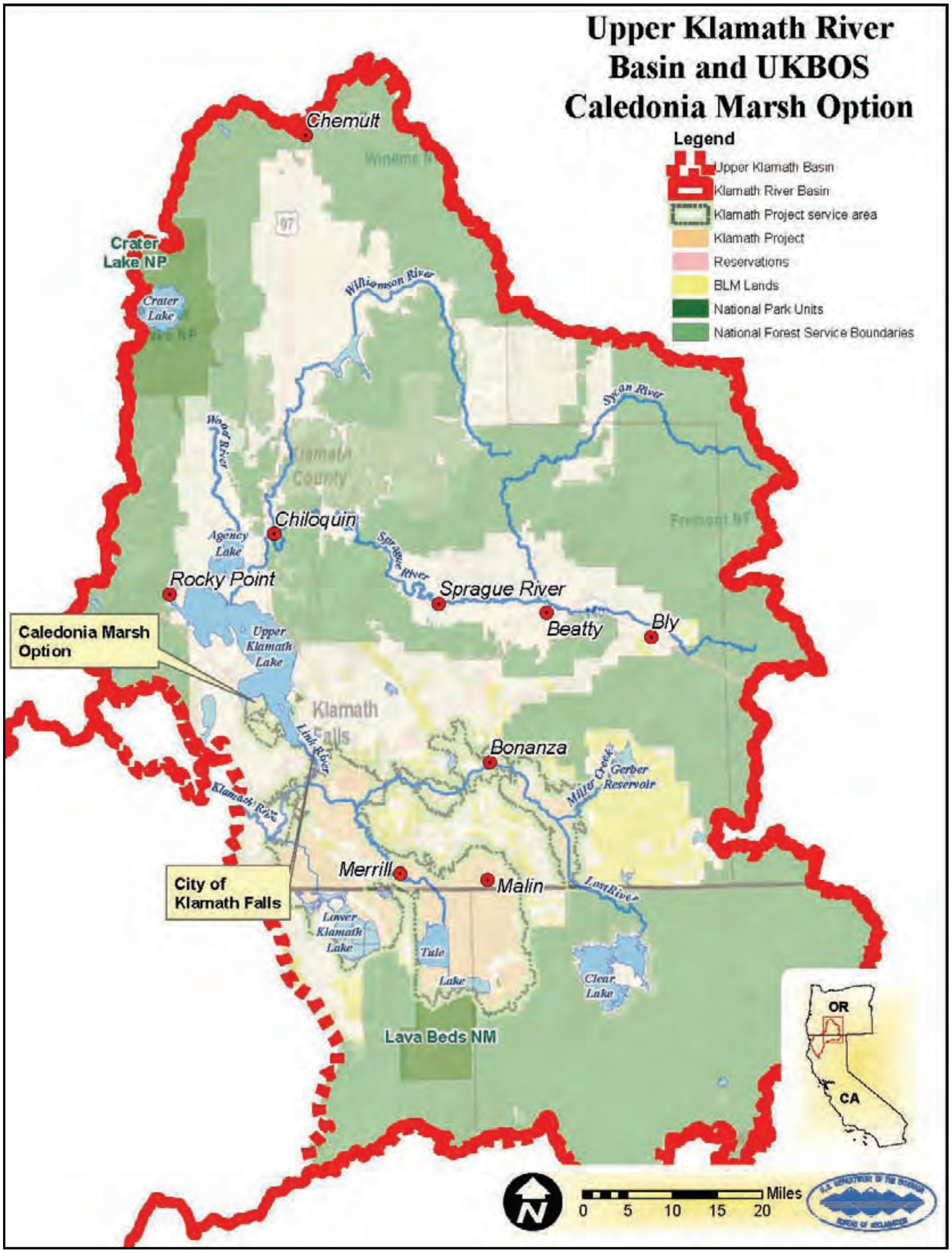


Figure 5-45.—Caledonia Marsh Reservoir location map.

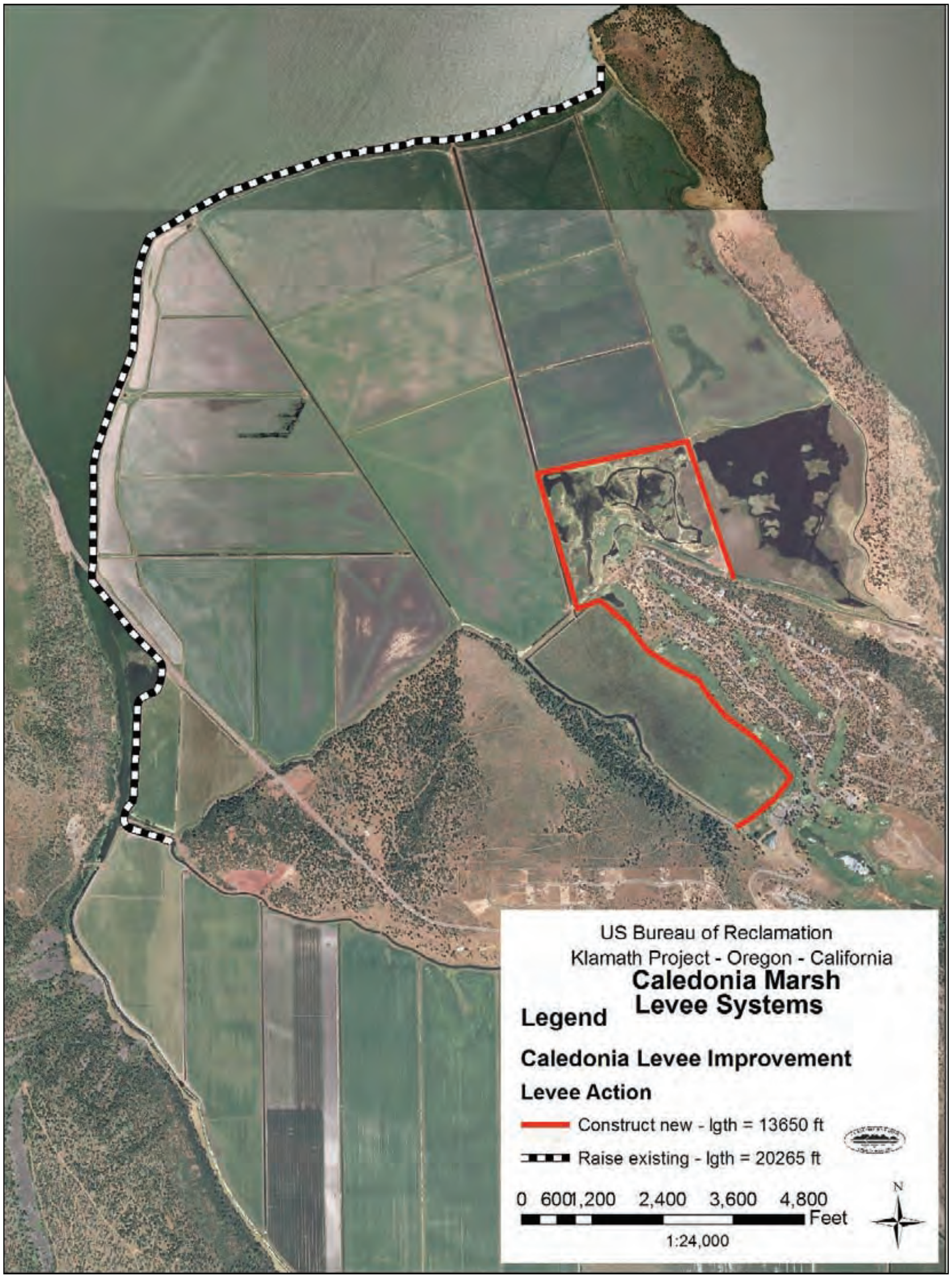


Figure 5-46.—Preliminary layout at Caledonia Marsh Reservoir.

5.26 Wocus Marsh—High Reservoir

Storage peak capacity:	350,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	1,000 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	0 to 350,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

Surplus water from the UKL basin water would be stored at the Wocus Marsh high reservoir option. The site is very close to UKL, which could minimize water conveyance facilities. Water delivery would use existing Klamath Project systems including UKL and connected river channels. Water users supplied by this option could benefit from additional water available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on an impoundment dam and raising lateral levees to store water in the Wocus Marsh basin. Water would be conveyed to and from the reservoir via a constructed inlet/outlet works and pumping plant from UKL. The preliminary capacity estimated was based on BO constraints (NMFS, 2002; FWS 2008) on surplus UKL water. The latest NMFS BO (2010) or future changes could further constrain available water supplies. Seepage losses and the potential need for an impervious lining to retain stored water require further studies.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—

The high reservoir Wocus Marsh option requires more extensive dike construction and reinforcement work to contain the reservoir waters without inundating nearby lands. The site is close to the UKL water supply and could have relatively lower conveyance costs versus other sites. Several factors require additional studies to refine the features and accurately assess the benefit-cost relationships.

5.26 UKBOS-IAIR Option: IA-13a

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option would entail using some existing UKL and Klamath Project conveyance systems. Major cost factors include the reservoir, conveyance, pump systems, levee construction, and annual power and O&M requirements.

Wetlands and water quality—

Preliminary review indicates significant potential for impacts to existing wetlands in the site area (GIS and NWI datasets). Wetlands mitigation requirements are an expected factor. Water treatment of stored release flows is also possible although specific requirements require a thorough investigation and review by appropriate regulatory agencies.

Biological and cultural resources—

Fish species protection would include fish screens installed at the UKL intake to water supply conveyance systems. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Preliminary evaluation indicated the potential wetlands mitigation requirements in the Wocus Marsh area could be a significant cost factor. Other potential resource issues require more detailed study during future planning or design stages.

Current Option Status

This option is considered viable as a second priority for further storage planning stages. Preliminary plans indicate this option has a relatively higher priority than the Wocus Marsh low reservoir because it would not inundate nearby residential communities. The storage capacity benefits could also be limited by UKL water level fluctuations. Although the proximity to UKL offers apparent advantages, land acquisition and mitigation could have significant costs. Additional studies including geotechnical evaluations of reservoir seepage potential and hydrologic operations modeling are necessary to assess whether this option should advance to appraisal planning.

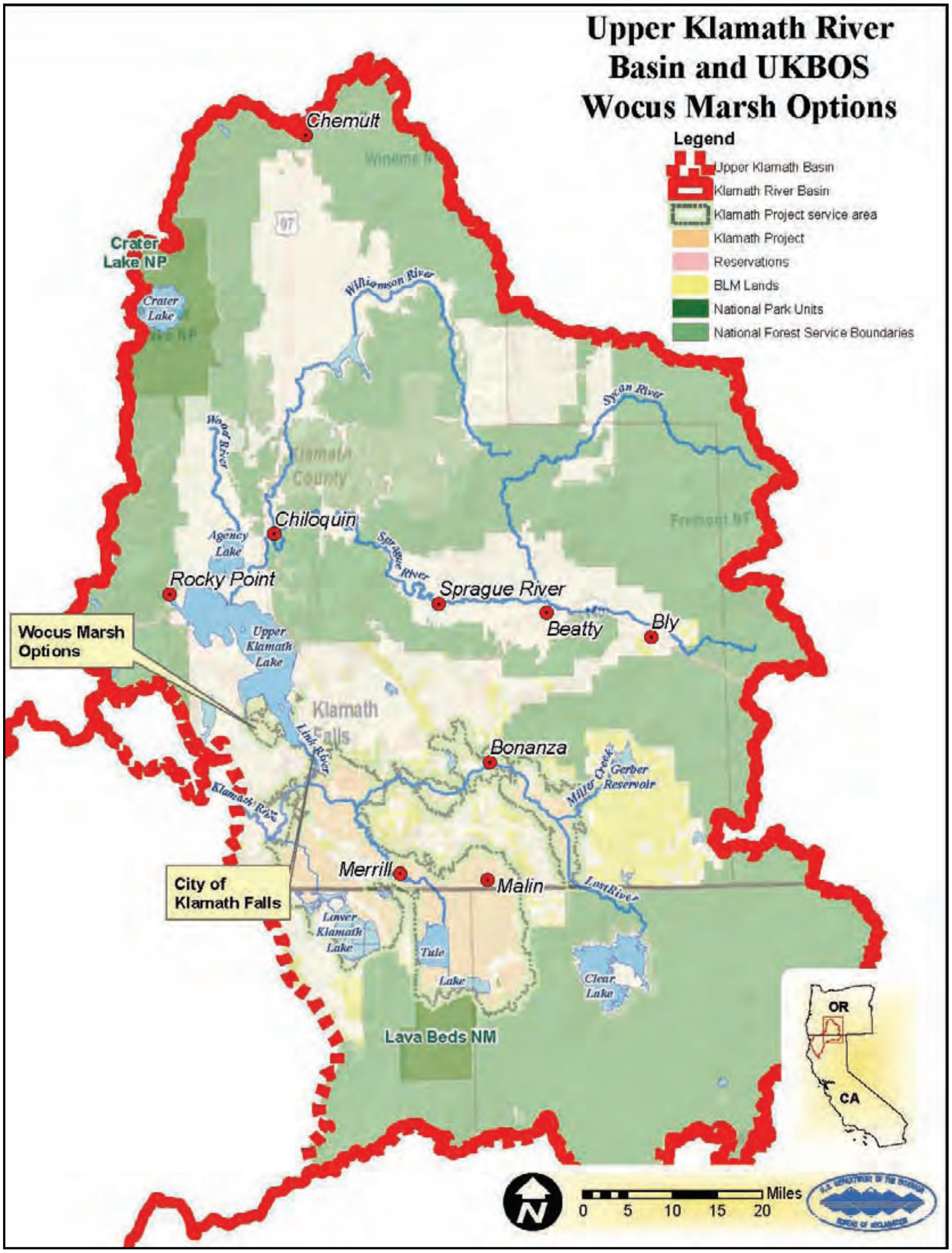


Figure 5-47.—Wocus Marsh with high reservoir—location map.

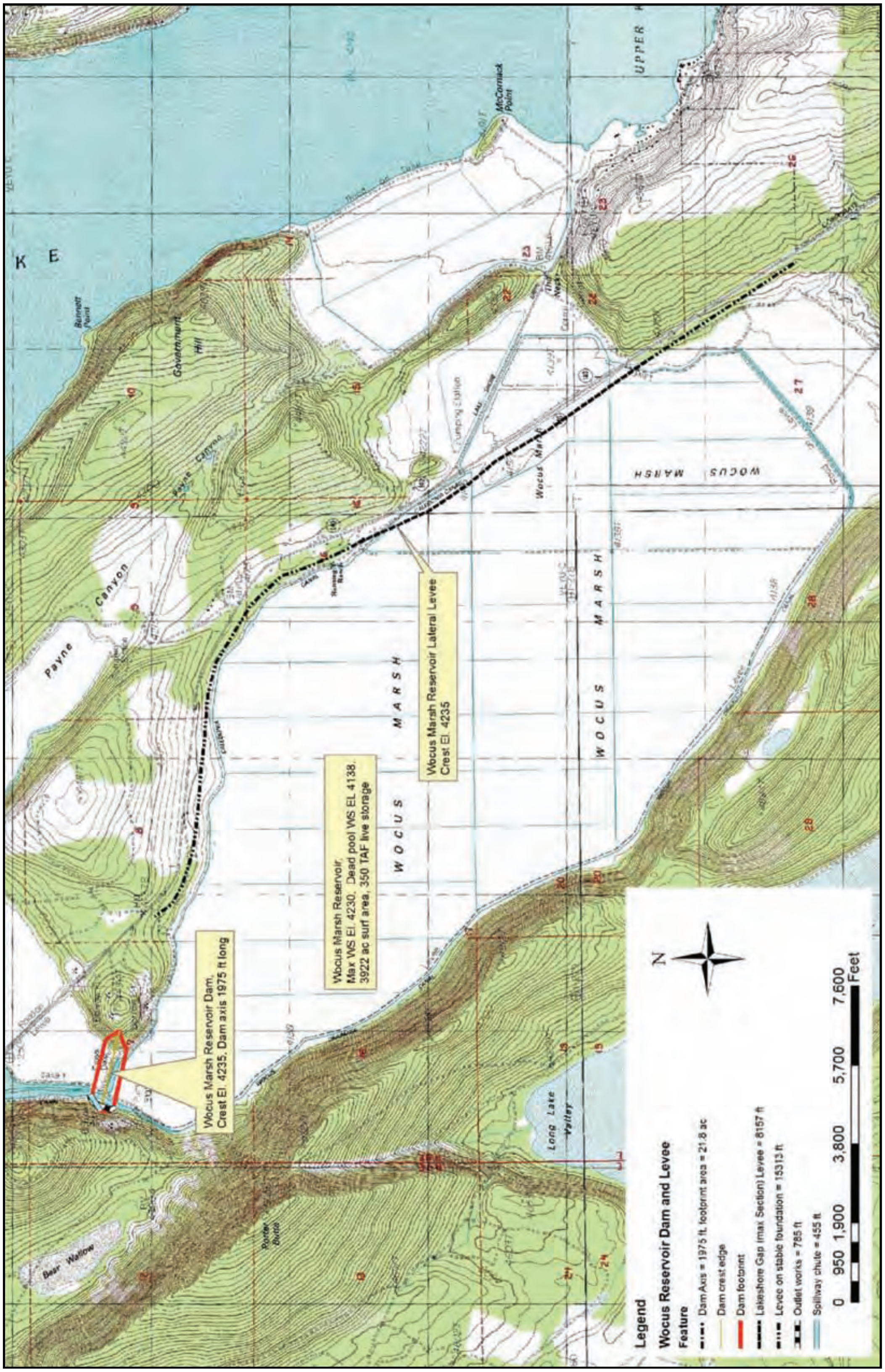


Figure 5-48.—Preliminary layout at Wocus Marsh, high reservoir.

5.27 Wocus Marsh—Low Reservoir

Storage peak capacity:	350,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	1,000 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	0 to 350,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	3—third priority additional barriers

Project Description

Surplus water from the UKL basin water would be stored at the Wocus Marsh low reservoir option. The site is very close to UKL, which could minimize water conveyance facilities. Water delivery would use existing Klamath Project systems including UKL and connected river channels. Water users supplied by this option could benefit from additional water available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on an impoundment dam and raised lateral levees to store water in the Wocus Marsh basin. Water would be conveyed to and from the reservoir via a constructed inlet/outlet works and pumping plant from UKL. The preliminary capacity estimated was based on BO constraints (NMFS, 2002; FWS 2008) on surplus UKL water. The latest NMFS BO (2010) or future changes could further constrain available water supplies. Seepage losses and the potential need for an impervious lining to retain stored water require further studies.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—

The site is very close to the UKL water supply and would have relatively lower conveyance costs versus other sites. The low reservoir option could affect nearby development that could pose practical barriers or additional costs. Several factors require additional study to refine the features and accurately assess the storage benefit-cost relationships.

5.27 UKBOS-IAIR Option: IA-13b

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—
More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option would entail using some existing UKL and Klamath Project conveyance systems. Major cost factors include the reservoir, conveyance, pump systems, levee construction, and annual power and O&M requirements.

Wetlands and water quality—
Preliminary review indicates significant potential for impacts to existing wetlands in the site area (GIS and NWI datasets). Wetlands mitigation requirements are an expected factor. Water treatment of stored release flows is also possible although specific requirements require a thorough investigation and review by appropriate regulatory agencies.

Biological and cultural resources—
Fish species protection would include fish screens installed at the UKL intake to water supply conveyance systems. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—
Preliminary evaluation indicated the potential wetlands mitigation requirements in the Wocus Marsh area could be a significant cost factor. Other potential resource issues require more detailed study during future planning or design stages.

Current Option Status

This option is considered a viable third priority because of the additional barriers attributed to potential impacts to nearby residential communities and major highways. In addition the storage benefits could be limited by UKL water level fluctuations. Although the proximity to UKL offers apparent advantages, the land acquisition and mitigation could have significant costs. Additional studies including geotechnical evaluation of the potential reservoir seepage and detailed hydrologic operations modeling are necessary to assess whether this option should advance to appraisal planning.

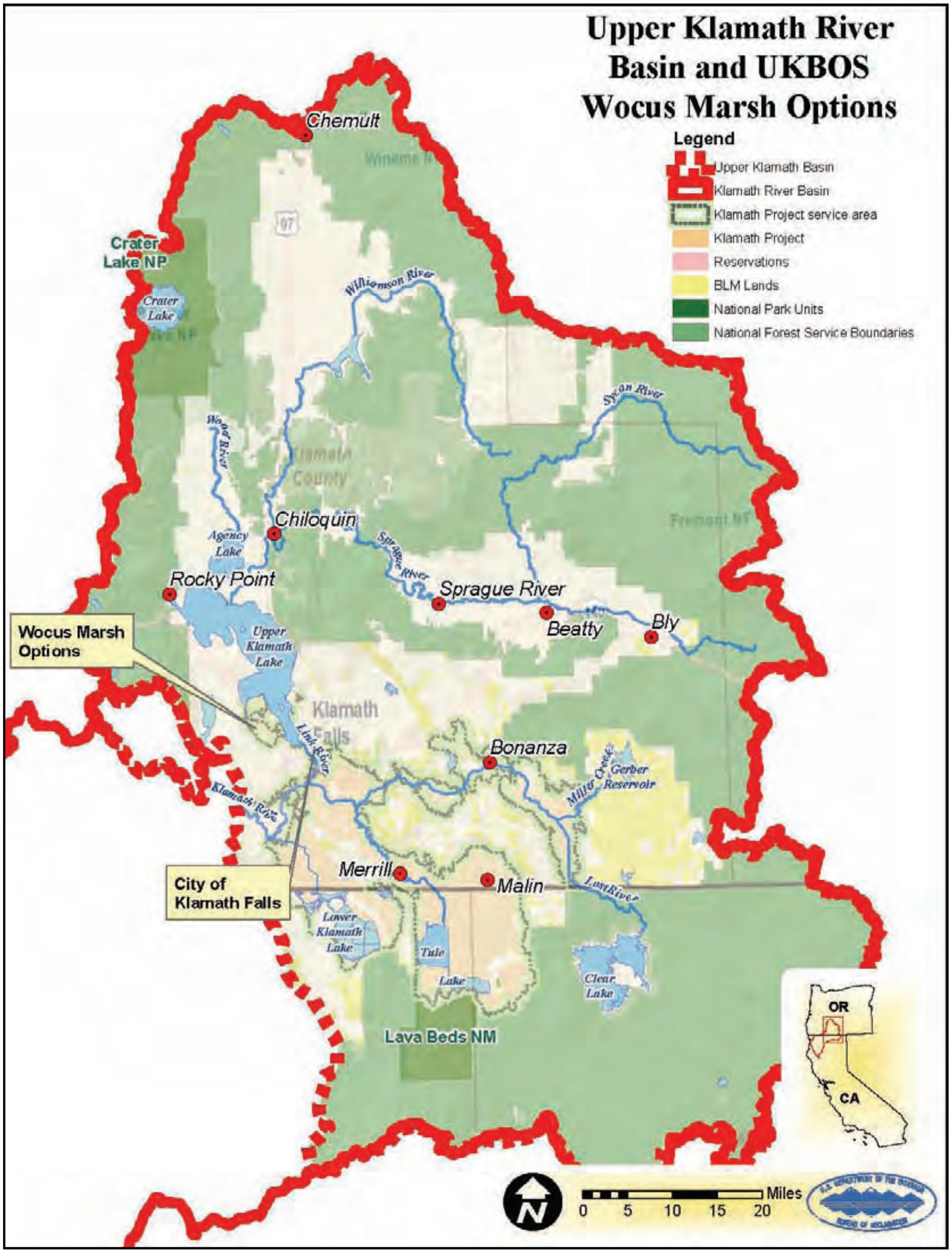


Figure 5-49.—Wocus Marsh with low reservoir—location map.

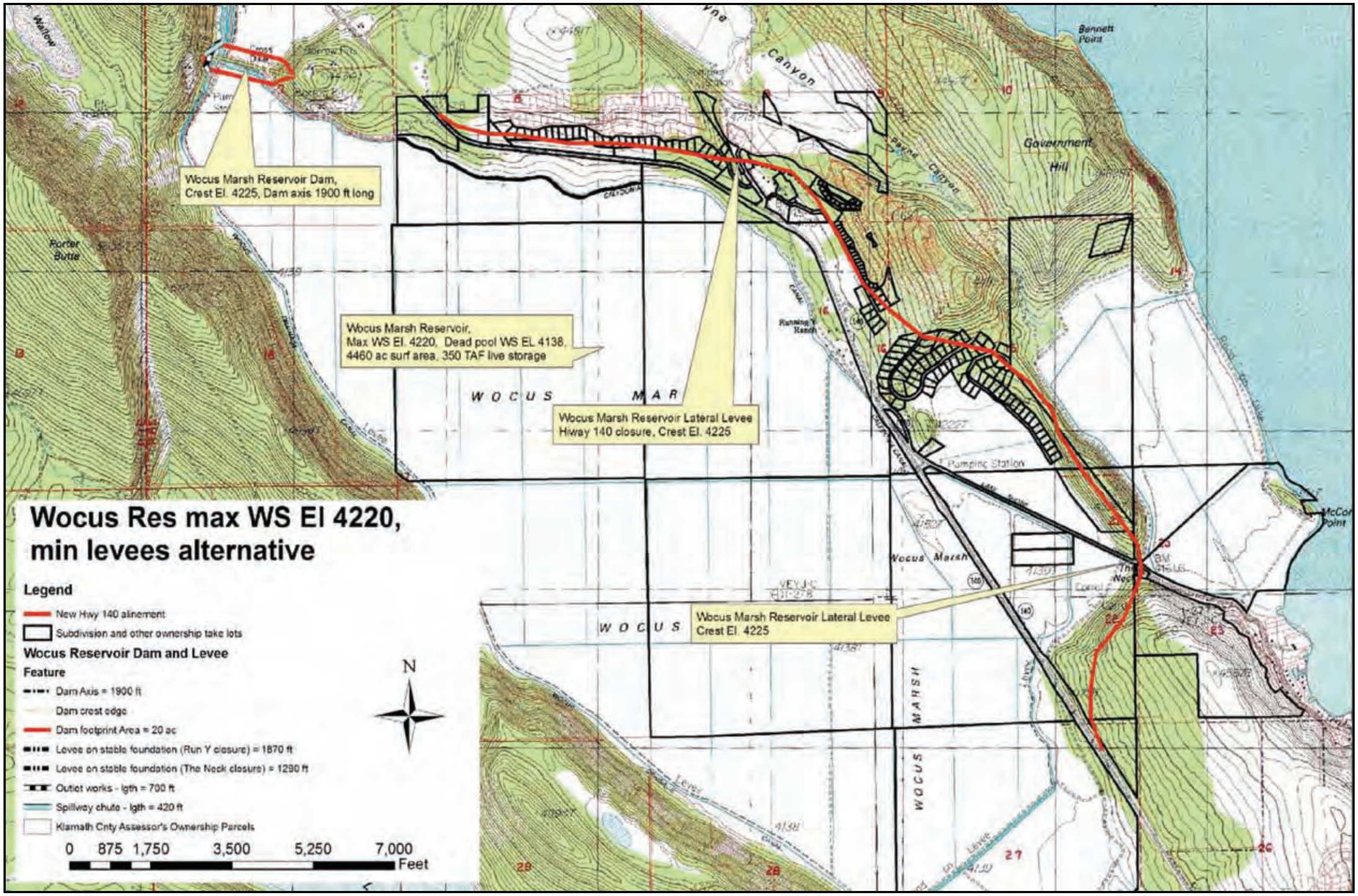


Figure 5-50.—Preliminary layout at Wocus Marsh, low reservoir.

5.28 Klamath Drainage District Reservoir

Storage peak capacity:	97,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	725 ft^3/s via new and existing conveyance systems
Water delivery benefit:	0 to 97,000 acre-ft/yr Klamath River via KSD
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

Surplus water from UKL basin could be stored within the existing Klamath Drainage District area. The KDD reservoir proximity to the Klamath River reduces water conveyance distances. Water delivery would utilize existing Klamath Project canal infrastructure including the KSD and existing river channels Downstream water users would benefit from the additional water available during times of shortage.

Technology and infrastructure—

Preliminary planning is based on establishing a reservoir within the KDD shallow basin areas using existing levees. No new impoundment infrastructure needs to be constructed. Supply water would be conveyed to the reservoir via new inlets on existing canals and to the Klamath River via the existing pumping plants on the KSD. The inflow rate of 725 ft^3/s would be split between the 200 ft^3/s North Canal and 525ft^3/s ADY Canal existing flow capacities. The reservoir volume was based on the area within the existing levees used for lateral impoundment.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential surface and groundwater interactions.

Preliminary engineering factors—

The geotechnical conditions and suitability of the existing perimeter levees for the intended reservoir containment is uncertain. Evaporation could be significant for this shallow reservoir. These factors would require further investigation to refine storage features and accurately assess storage the benefit-cost relationships.

5.28 UKBOS-IAIR Option: IA-14

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option would entail using some existing UKL and Klamath Project conveyance systems. Major cost factors include the reservoir, conveyance, pump systems upgrades, levee construction, and annual power and O&M requirements.

Wetlands and water quality—

Preliminary review indicates significant potential for impacts to existing wetlands in the site area (GIS and NWI datasets) and wetlands mitigation requirements are expected. Water treatment of stored release flows is not expected, although this requires investigation and review by appropriate regulatory agencies. This option could also provide some water quality benefits by releasing more freshwater flow to the KSD to dilute the drainage water during low flow periods.

Biological and cultural resources—

Fish species issues would be mitigated by construction of fish screen at intakes at the existing ADY and New North Canals. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species issues. Although there are currently no known cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Preliminary evaluation indicated the potential wetlands mitigation requirements is a potential cost factor. Potential for water quality improvement in the KSD down to the Klamath River is an important potential added benefit.

Current Option Status

This option is considered viable as a second priority for further storage planning stages. Site-specific condition and practical factors could influence benefit-cost relationships considerably and require further study. Additional studies including geotechnical assessment of levee structures, reservoir seepage, and hydrological operations modeling are important factors to evaluate whether this option should advance to appraisal investigations. Potential benefits for fish and wildlife from water storage and delivery also require further investigation.

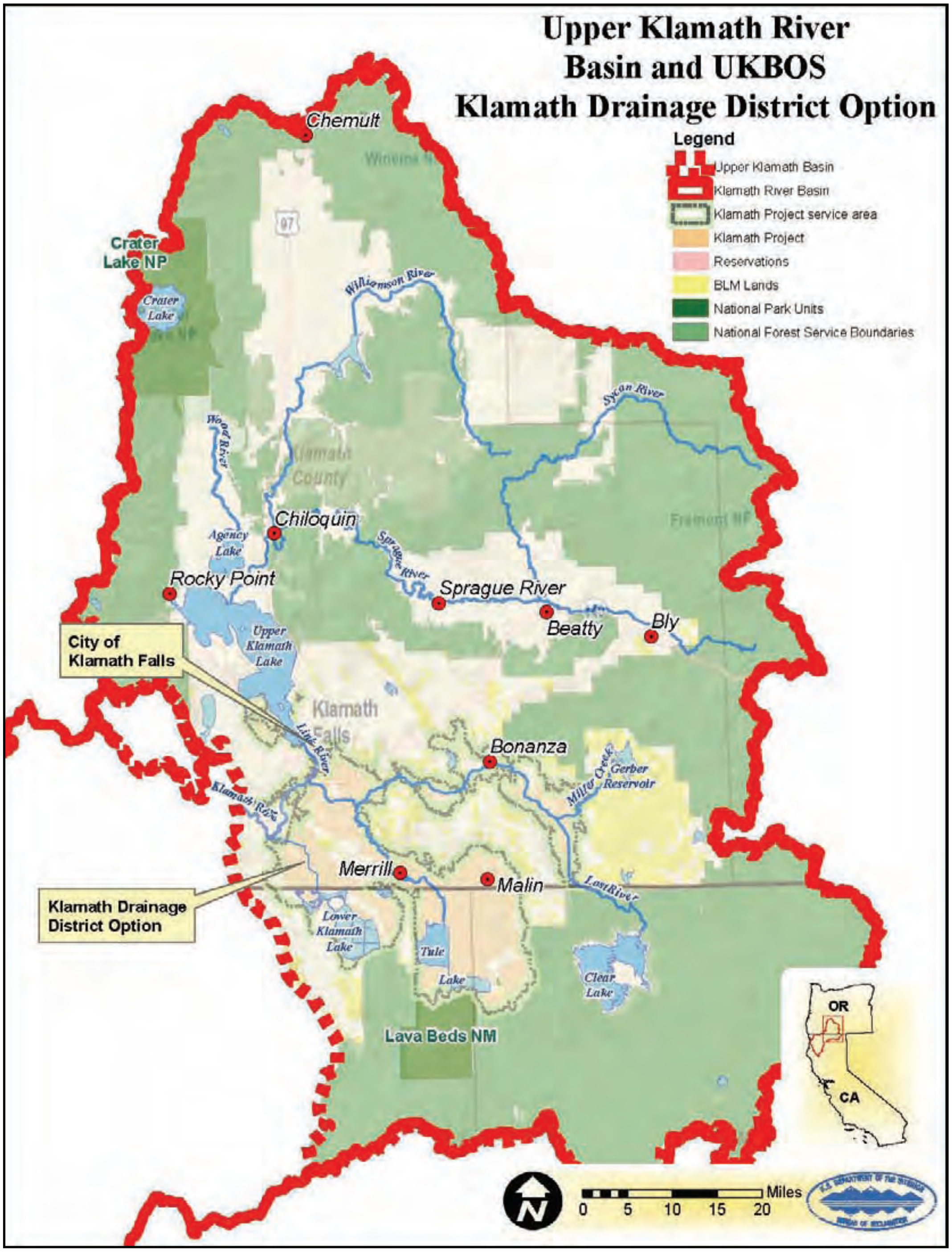


Figure 5-51.—Klamath Drainage District Reservoir location map.

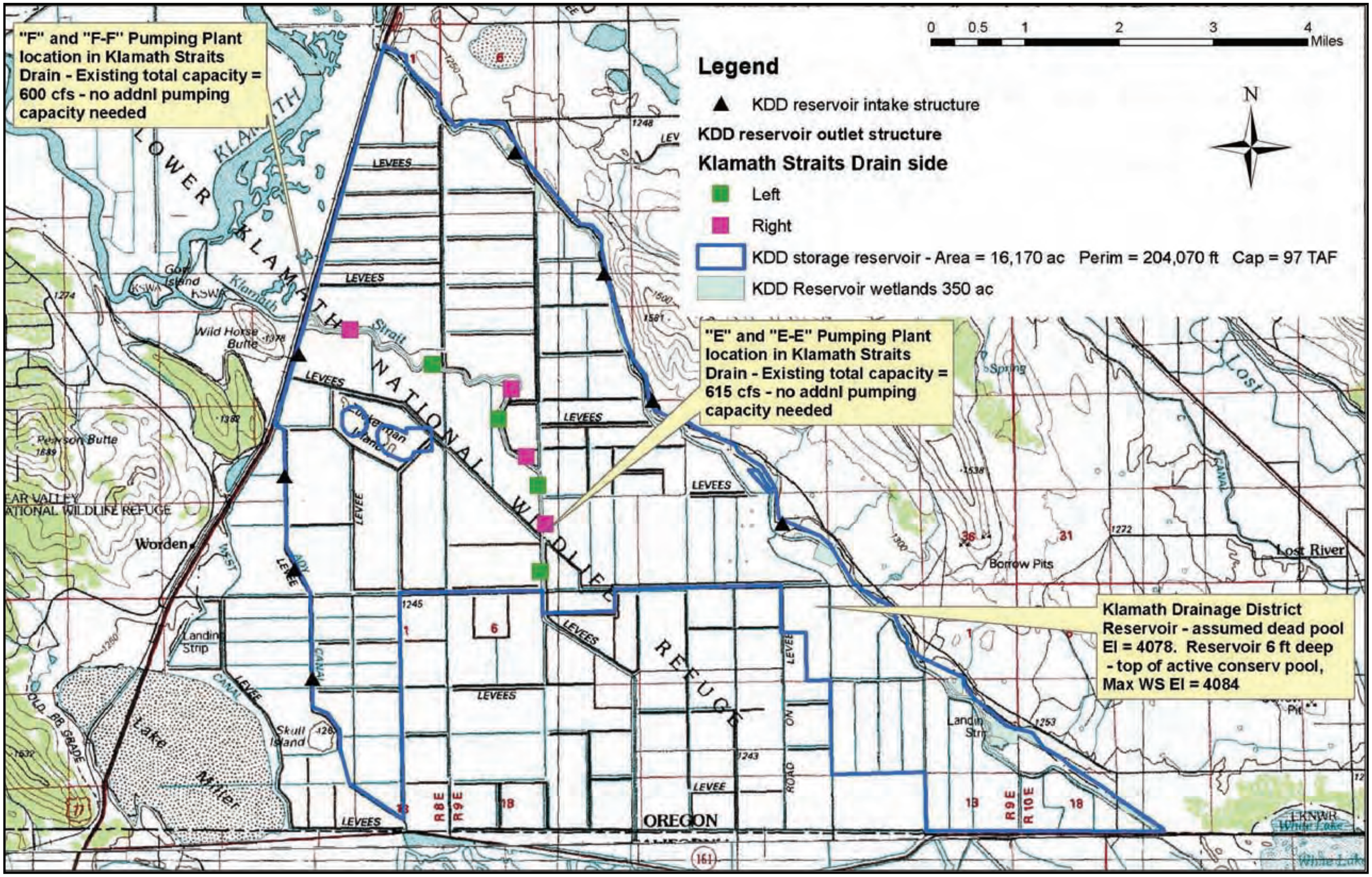


Figure 5-52.—Preliminary layout at Klamath Drainage District Reservoir.

5.29 Whiteline Reservoir—Expanded

Storage peak capacity:	350,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	UKL surplus water
Available storage water:	Up to maximum UKL surplus and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	1,000 ft^3/s via new pumping and conveyance systems
Water delivery benefit:	0–350,000 acre-ft/yr Klamath Project or Klamath R.
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

The option involves storing surplus water from UKL in the existing Whiteline Reservoir. The storage capacity at Whiteline Reservoir could be expanded to accommodate additional storage. The reservoir it is also relatively proximity to the UKL water supply to reduce conveyance needs. Water delivery could utilize existing Klamath Project infrastructure and water users could benefit from the additional water supplies available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on using the existing Whiteline Reservoir for storage by increasing the dam height to expand the capacity. Water would be conveyed to and from the reservoir using some existing and newly constructed canal, tunnel and pump systems. The preliminary reservoir volume was sized based on current BO constraints (NMFS, 2002; FWS 2008) on surplus UKL water. The recent NMFS BO (2010) or other future changes could further constrain the available water supplies. The reservoir would be subject to significant evaporation losses and may need to be lined to prevent significant seepage losses.

Water source and hydrology—

The storage water available is governed by hydrologic conditions in the watershed contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; estimates of the water budget including evaporation rates, precipitation, and underground leakage; and factors including downstream water demands and water use practices. Further planning for this option will require additional hydrological operations modeling to develop accurate estimates of the water supply, water quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—

Using the existing reservoir could minimize new construction and related facility impacts. Preliminary planning has indicated the Whiteline dam and related water systems could be modified to accommodate higher water levels without requiring additional containment levees around the reservoir perimeter.

5.29 UKBOS-IAIR Option: IA-15

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. Additional lands would be inundated by the higher storage levels and land purchase would be required to construct the larger dam, water controls, and service facilities. The option would entail using some existing UKL and Klamath Project conveyance systems. Major cost elements include the larger dam, conveyance (including a tunnel), and pump system construction, and the annual power use and O&M requirements.

Wetlands and water quality—

Preliminary review indicates the potential for impacts to existing wetlands around the reservoir perimeter lands (GIS and NWI datasets) and mitigation is considered a strong possibility. Water treatment for stored water flows is expected, although actual requirements would require more detailed study and review by appropriate regulatory agencies.

Biological and cultural resources—

Fish species protection would include incorporating fish screens into the intake of the conveyance system at UKL. Studies of the potential seasonal flow operations would have to consider sensitive aquatic, terrestrial, and avian species. Although there are currently no identified cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Using the existing reservoir could reduce resource impacts compared to building a new reservoir. Potential wetlands mitigation requirements could be a significant cost factor. Other resource issues will require more detailed study during future planning and design stages.

Current Option Status

This option is considered potentially viable as a second priority for further storage planning stages. This option is similar to other pumped storage reservoir options at LLV and Aspen Lake. Using the existing reservoir could minimize initial construction costs; however annual conveyance costs would be higher than for other locations closer to the UKL source water. Additional planning studies including geotechnical assessment of reservoir seepage containment potential and detailed hydrologic water operations modeling are needed to assess whether this option should advance to appraisal investigations.

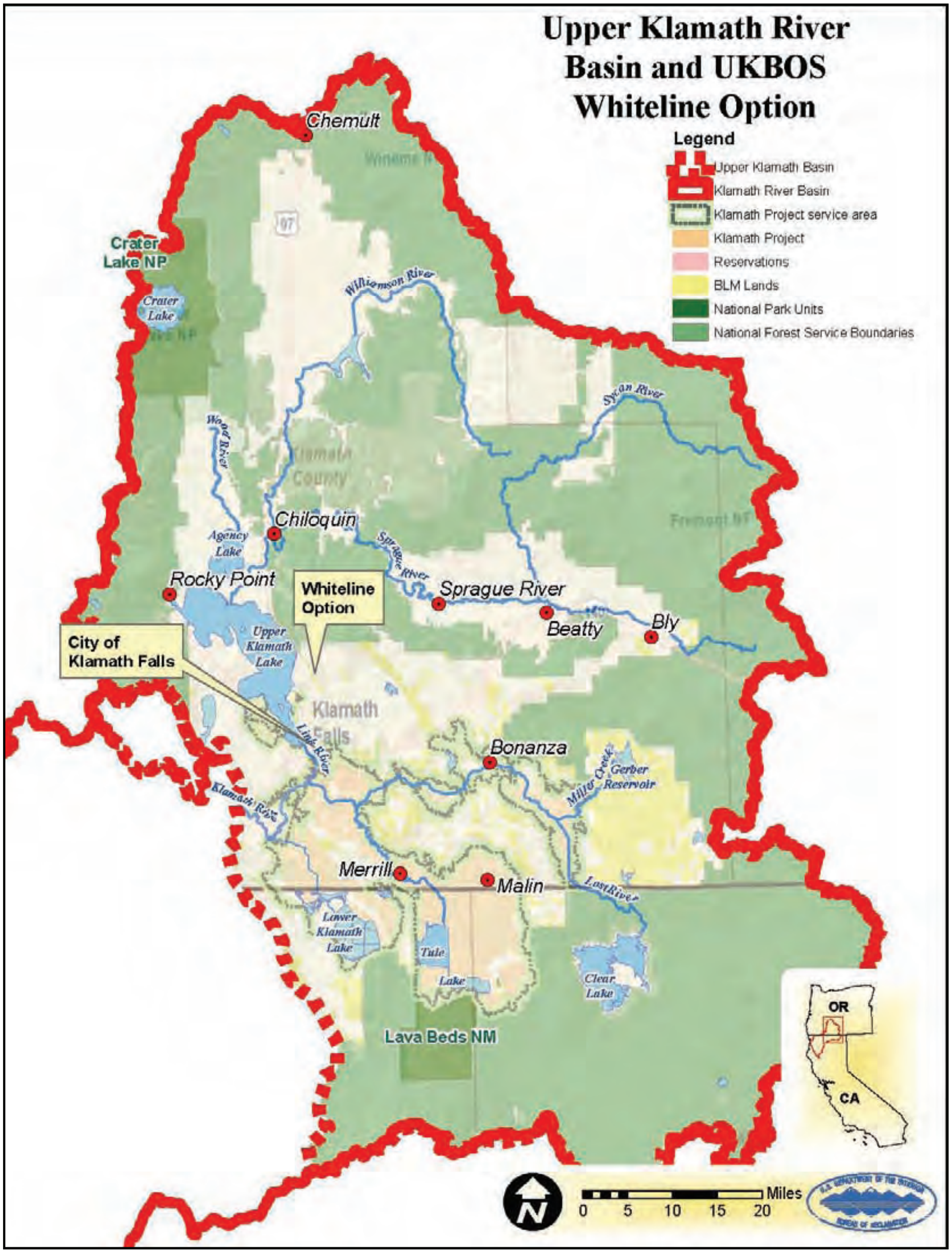


Figure 5-53.—Whiteline Reservoir, expanded—location map.

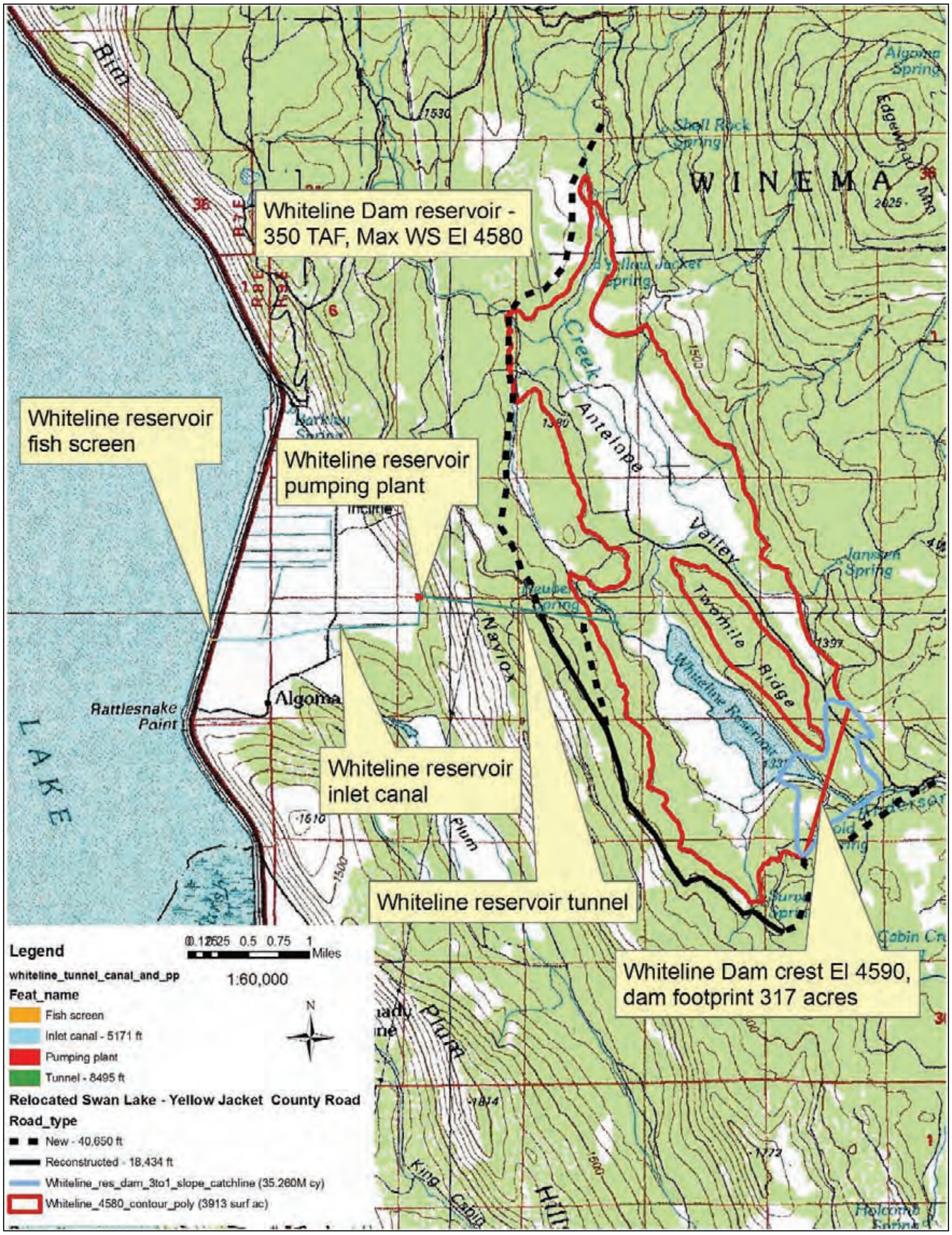


Figure 5-54.—Preliminary layout at Whiteline Reservoir, expanded.

5.30 Torrent Springs Reservoir

Storage peak capacity:	Storage peak capacity: 421,800 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	Sycan River watershed surplus water
Available storage water:	46,800 acre-ft (OWARS) maximum and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	Run of the river flows
Water delivery benefit:	0–421,800 acre-ft/yr Klamath Project or Klamath R.
Water treatment type:	Group 3; Williamson Basin (to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves building a new reservoir at the Torrent Springs site to store surplus water diverted from the Sycan River, a tributary to the Sprague River and UKL. The option offers the potential to store a fairly large water volume with relatively small impoundment dam structure. Water delivery could utilize existing Klamath Project infrastructure and water users could benefit from the additional water supplies available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on a new dam and related facilities constructed at the Torrent Springs site. The reservoir is located on the Sycan River and would not require water conveyance infrastructure. The reservoir could store surplus river flows in the upper Sycan River watershed while maintaining required downstream flows. The preliminary reservoir volume was based hydrologic estimates of water available and current BO constraints (NMFS, 2002; FWS 2008) on UKL water operations. The recent NMFS BO (2010) or other future changes could further constrain available water supplies. The reservoir would be subject to significant evaporation losses and may require lining to control seepage losses.

Water source and hydrology—

Storage water would be obtained at times when the Sycan River surplus flows are available. Available storage water is governed by hydrologic conditions in this subbasin contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; the reservoir water budget including evaporation rates, precipitation, and leakage; and other factors including downstream water demands and water use practices. Further planning would involve additional studies to assess the water supply and quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—

Any potential new reservoir construction at this site would require more detailed planning investigations to refine the necessary project features and develop more accurate analyses of the storage benefit-cost relationships.

5.30 UKBOS-IAIR Option: IA-16

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—
More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option would entail using some existing UKL and Klamath Project conveyance systems. Major cost elements include the reservoir and water control system, and fish ladder construction and annual O&M requirements.

Wetlands and water quality—
Preliminary review indicates this option could affect significant areas of existing wetlands, especially within the existing Sycan Marsh (GIS and NWI datasets). As a result, the need for wetlands mitigation is a strong possibility. Water treatment for releasing stored water back to the Sycan River are unknown; however, actual stream standards and treatment requirements would require more detailed studies and review by appropriate regulatory agencies.

Biological and cultural resources—
Fish species mitigation could require a fish ladder to assist fish passage at the new reservoir dam. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species. Although there are currently no identified cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—
Potential for impacts to existing wetlands and mitigation requirements could be a key cost factor. Other resource issues would require more detailed study during any subsequent planning and design stages.

Current Option Status

This option is considered potentially viable as a second priority for further storage planning stages. The option is similar to other run-of-river impoundment options at Williamson River Canyon or the Buck Lake sites. Although the option would have little or no conveyance costs, the potential resource impacts and mitigation requirements could be a major benefit-cost factor. Additional studies including geotechnical assessment of reservoir seepage containment potential and detailed hydrologic water operations modeling are needed to assess whether this option should advance to appraisal investigations.

Figure 5-55.—Torrent Springs Reservoir location map.

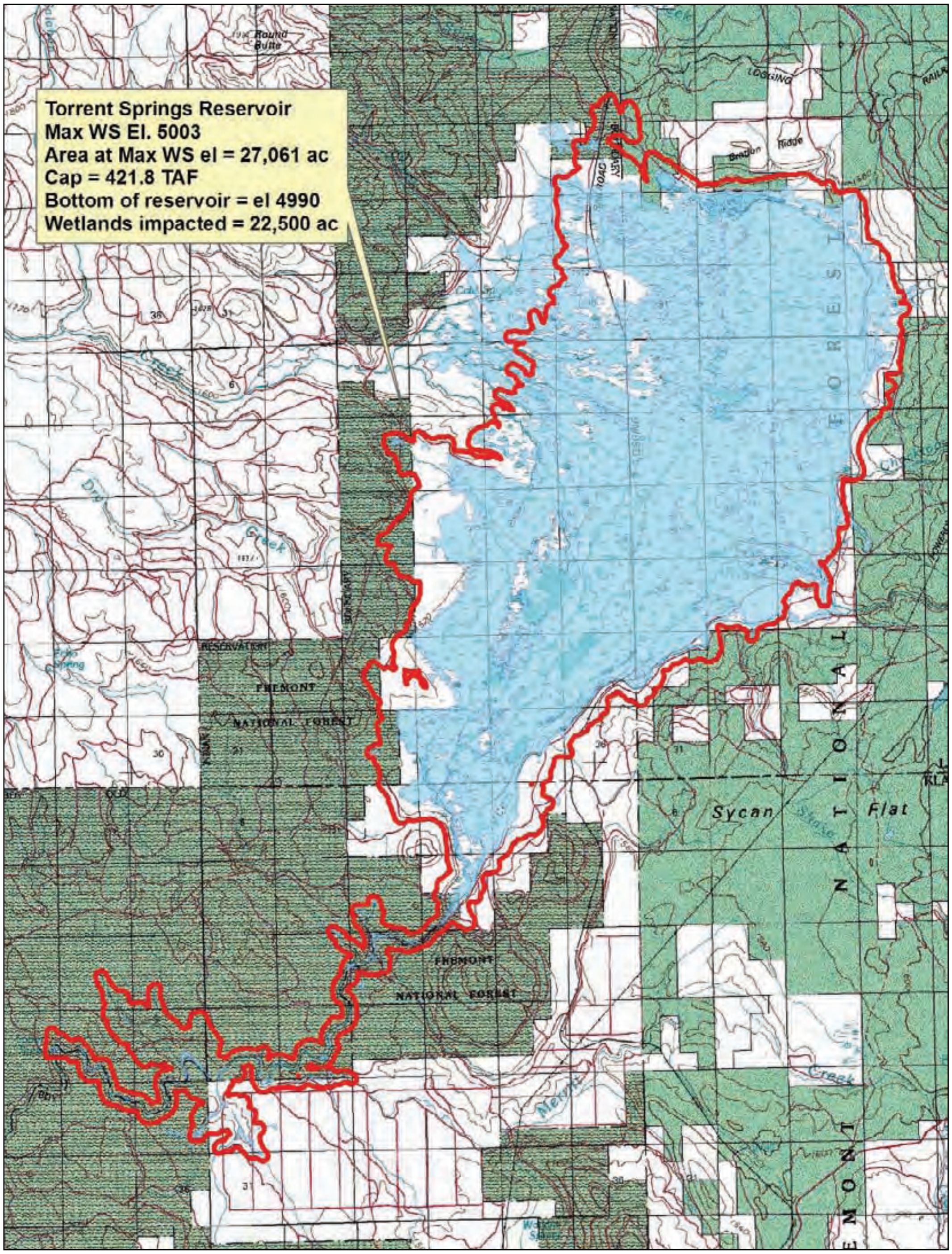


Figure 5-56.—Preliminary layout at Torrent Springs Reservoir.

5.31 Williamson River Canyon Reservoir

Storage peak capacity:	150,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	Upper Williamson Basin surplus water
Available storage water:	Up to maximum capacity and current BOs
Storage fill frequency:	Years when surplus water is available (spill flows)
Initial design inflow rate:	Run of the river diversion flows
Water delivery benefit:	0-50,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 3; Williamson River (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves building a new reservoir on the upper Williamson River site near Kirk, Oregon above the Sprague River confluence and above UKL. The option offers the potential to store a fairly large water volume with relatively small impoundment dam structure. Water delivery could utilize existing Klamath Project infrastructure and water users could benefit from the additional water supplies available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on a new dam and related facilities constructed at the upper Williamson River site. The reservoir is located on the river and would not require water conveyance infrastructure. The reservoir could store surplus flows in the upper Williamson Basin while maintaining downstream flows. The preliminary reservoir volume was based hydrologic estimates of water available and current BO constraints (NMFS, 2002; FWS 2008). The recent NMFS BO (2010) or other future changes could further constrain water storage. A reservoir at this location could be subject to significant evaporation losses and may require an impervious lining to control seepage losses.

Water source and hydrology—

Available storage water is governed by hydrologic conditions in the Williamson Basin contributing to UKL. Preliminary hydrologic modeling was used to estimate the frequency and water volume available from UKL; the reservoir water budget including evaporation rates, precipitation, and leakage; and other factors including downstream water demands and water use practices. Further planning would involve additional studies to assess the water supply and quality, delivery reliability, and the potential for surface and groundwater interactions.

Preliminary engineering factors—

Any potential new reservoir construction at this site would require more detailed planning investigations to refine the necessary project features and develop more accurate analyses of the storage benefit-cost relationships.

5.31 UKBOS-IAIR Option: IA-17

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. The site area is located on private lands and would require land purchase to construct the reservoir, water control systems and service facilities. The option would entail using some existing UKL and Klamath Project conveyance systems. Major cost elements include the reservoir and water control system, and fish ladder construction and annual O&M requirements.

Wetlands and water quality—

Preliminary review indicates this option could affect significant areas of existing wetlands (GIS and NWI datasets), especially within the existing Klamath Marsh NWR area. As a result, wetlands mitigation is a strong possibility and potential major cost factor. Water treatment needs prior to releasing stored water back into the Williamson River are unknown and the applicable standards and requirements would require detailed studies and review by appropriate regulatory agencies.

Biological and cultural resources—

Fish species mitigation could require a fish ladder to assist fish passage at the new reservoir dam. Studies of seasonal flow operations of this option would have to consider sensitive fish/aquatic, terrestrial and avian species. Although there are currently no identified cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Potential for impacts to existing wetlands and mitigation requirements could be a key cost factor. Other resource issues would require more detailed study during any subsequent planning and design stages.

Current Option Status

This option is considered potentially viable as a second priority for further storage planning stages. The option is similar to another run-of-river impoundment option: the Torrent Springs site. Although the option would require no conveyance or pumping systems, the potential resource impacts and mitigation requirements are key benefit-cost factors. Additional planning studies including geotechnical assessment of reservoir seepage containment potential, and detailed hydrologic water operations modeling are needed to assess whether this option should advance to appraisal investigations.

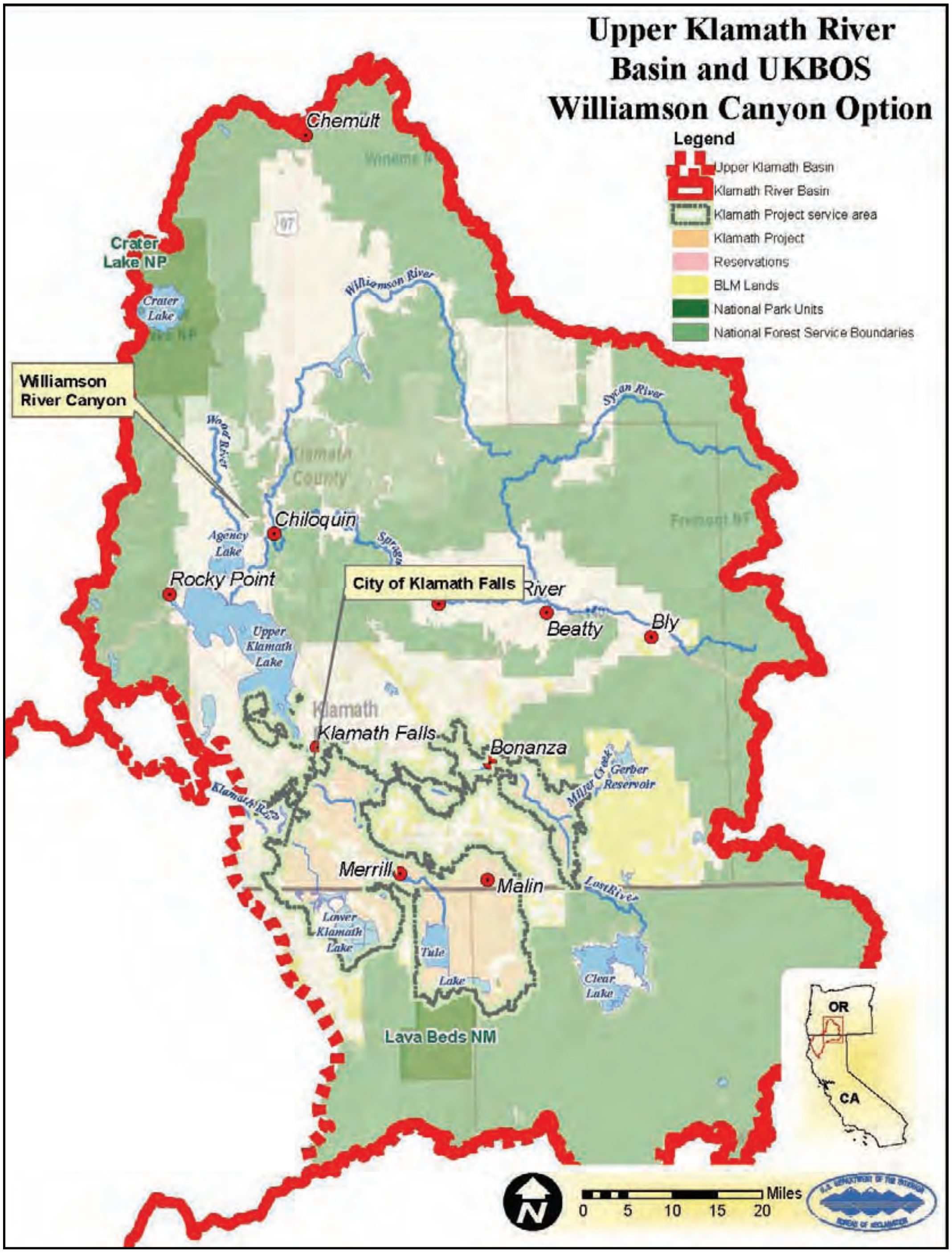


Figure 5-57.—Williamson River Canyon Reservoir location map.

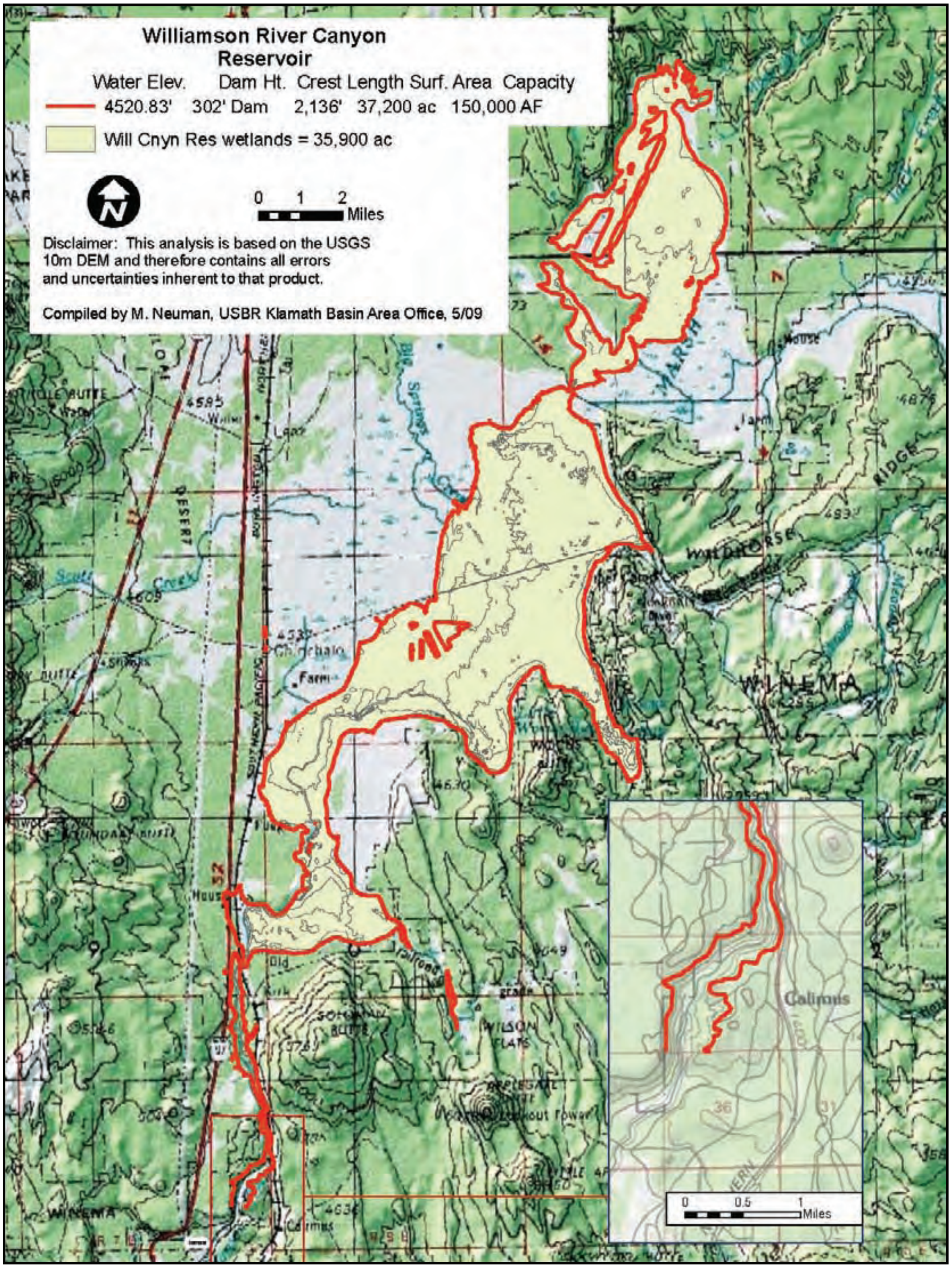


Figure 5-58.—Preliminary layout at Williamson River Canyon Reservoir.

5.32 Buck Lake Reservoir

Storage peak capacity:	9,300 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	Clover Creek and Spencer Creek surplus water
Available storage water:	Up to maximum capacity (OWARS, 2010)
Storage fill frequency:	Years when surplus water is available
Initial design inflow rate:	75 ft^3/s via new diversion and conveyance systems
Water delivery benefit:	0-9,300 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 1; UKL source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves water storage in the existing Buck Lake, which lies within the Spencer Creek drainage, a tributary to the Klamath River at the existing JC Boyle Reservoir. Water delivery from this option would use the existing Spencer Creek and Clover Creek to release stored water to the Klamath River. Downstream fish and wildlife and irrigation water users in the Klamath Project (via exchange) could benefit from the additional water available during times of shortage.

Technology and infrastructure—
Preliminary plans are based on using the existing Buck Lake basin to reduce the reservoir and related facility construction requirements. The current Buck Lake storage capacity would be enlarged by constructing an impoundment (dam) and outlet works to regulate stored water as needed. Clover Creek and Spencer Creek surplus flows would be collected at upper reaches using fish passable diversion structures and a gravity flow tunnel to convey water to the reservoir. Stored water would be released to Spencer Creek for downstream water uses. The preliminary reservoir volume was based on hydrologic estimates of water available (OWARS, 2010). The reservoir would be subject to significant evaporation losses and may require an impervious lining to control seepage losses.

Water source and hydrology—
Storage water would be obtained at times when surplus flows are available in the Clover Creek and Spencer Creek basins. Preliminary hydrologic modeling was not performed to estimate the water volume available; the reservoir water budget including evaporation rates, precipitation, and leakage; and factors such as the downstream water demands and water use practices.

Preliminary engineering factors—
Using the existing Buck Lake basin could minimize new facility construction and related impacts. Any potential storage planning at this site would require detailed investigations to refine the necessary project features and develop more accurate determinations of the overall storage benefit-cost relationships.

5.32 UKBOS-IAIR Option: IA-18

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. Preliminary planning is based on facilities located to minimize impacts to currently farmed private lands; however, some land purchase could be necessary to construct the reservoir impoundments, water controls, and service facilities. The option would entail using some streams as and constructing new conveyance systems. Major cost elements include the reservoir and water control system construction and annual O&M requirements.

Wetlands and water quality—

Preliminary review indicated potential for direct impacts to the existing wetlands around the reservoir site (GIS and NWI datasets) and mitigation is considered a strong possibility. Water treatment of stored water prior to releasing back to the Spencer Creek is not expected although specific regulatory requirements require further investigation and review by appropriate regulatory agencies.

Biological and cultural resources—

Sensitive fish species would be mitigated by installing fish screens or fish passage facilities where needed on the Clover and Spencer Creek facilities. Although no cultural resource issues were identified during preliminary review, more detailed study is required for any further planning.

Key nonengineering factors—

Using the existing reservoir could reduce resource impacts compared to building a new reservoir. Potential for wetlands impacts and mitigation requirements could be a key cost factor. Other potential resource issues would require more detailed study during any subsequent planning and design stages.

Current Option Status

This option is considered potentially viable as a second priority for further storage planning stages. Although this option could take advantage of the existing lake to reduce dam construction, the storage benefits are limited to downstream water users. Additional studies including geotechnical assessment of reservoir containment needs, detailed hydrologic water operations modeling, and more accurate estimates of benefit/cost relationships are needed to assess whether this option should advance to appraisal planning stages.

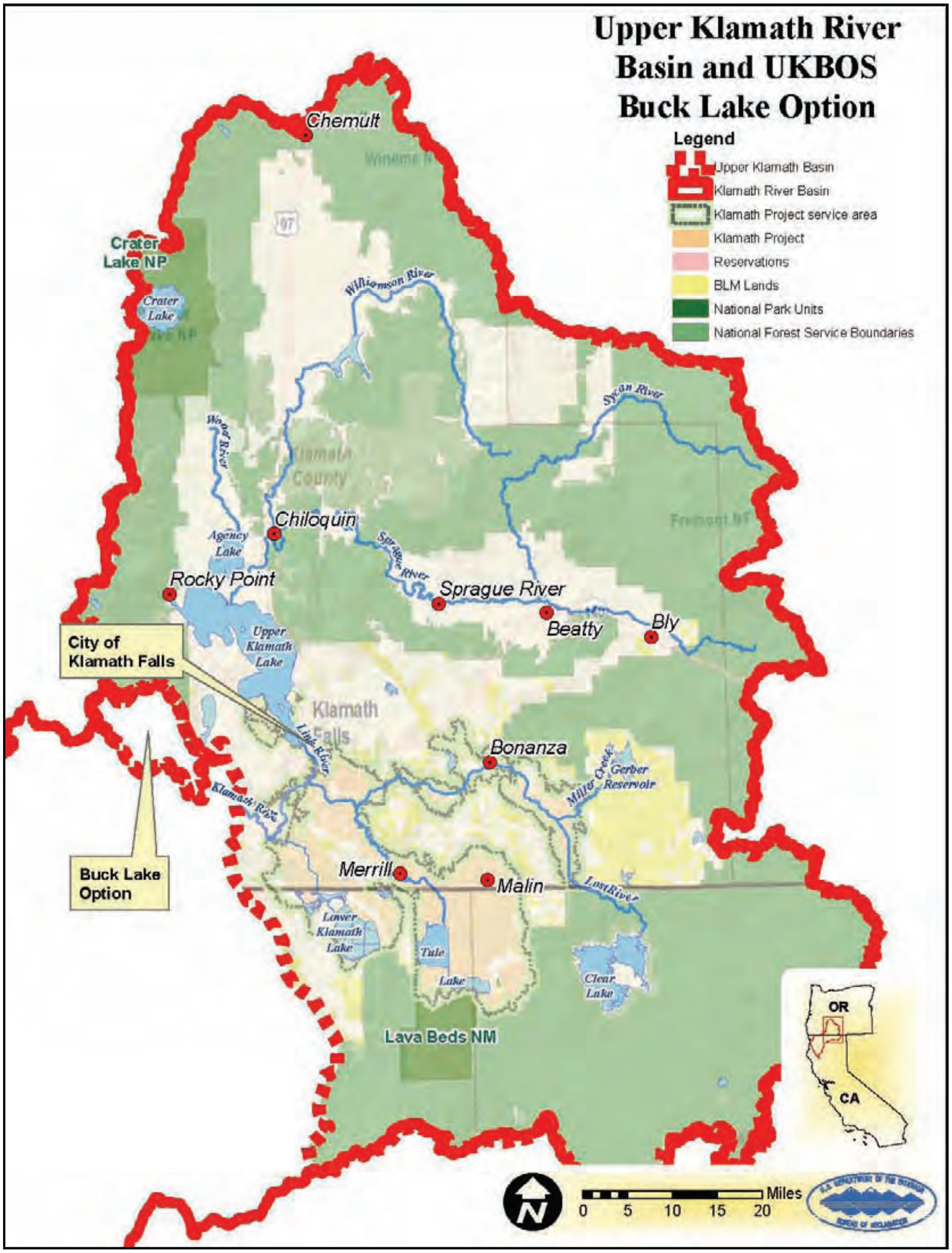
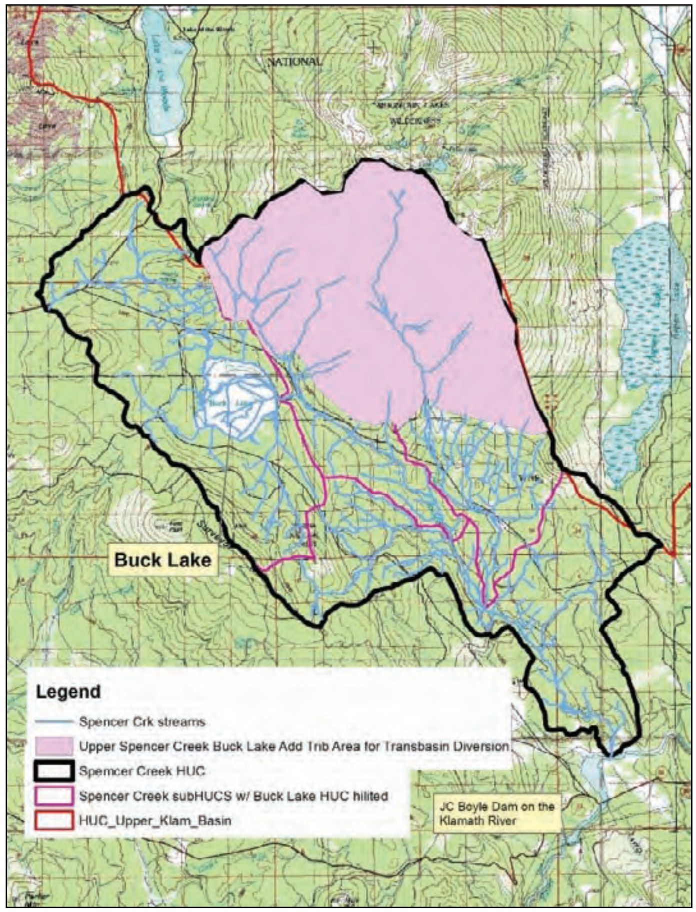
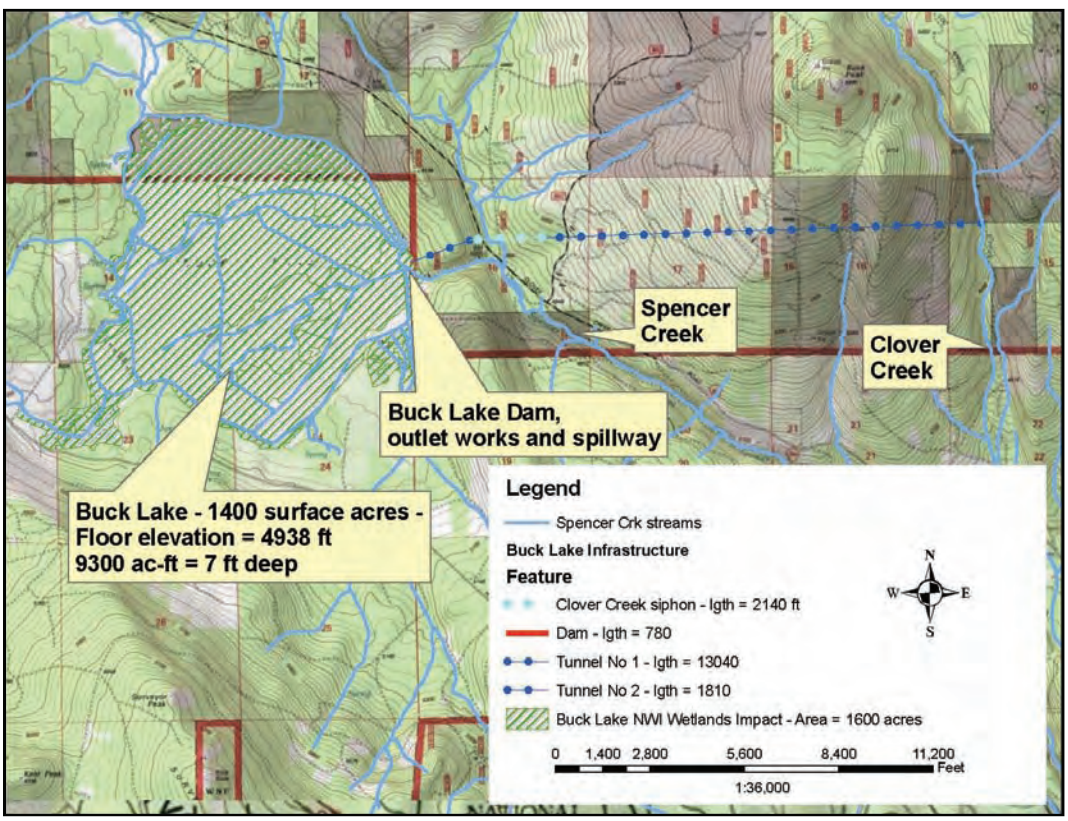


Figure 5-59.—Buck Lake Reservoir location map.

Figure 5-60.—Preliminary layout at Buck Lake Reservoir.





5.33 Boundary Reservoir

Storage peak capacity:	72,000 acre-ft maximum
Projected storage time:	Multiyear storage
Storage water supply:	Upper Lost River watershed surplus water
Available storage water:	Up to maximum capacity and current BOs
Storage fill frequency:	When surplus water is available
Initial design inflow rate:	Run of the river diversion flows
Water delivery benefit:	0-72,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 4; Lost River source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves building a reservoir on the Lost River near the Oregon and California boundary—the Boundary Reservoir site. The location allows storage of river flows and released spilling flows from Clear Lake. Water delivery could use existing Klamath Project conveyance systems and water users could benefit from the additional water supplies available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on a new dam and related facilities constructed at the identified Boundary Reservoir site. The reservoir is on the river and would not require conveyance or pumping facilities. The stored water would be released to Lost River for the Klamath Project eastern service area or for downstream water users. The preliminary reservoir volume was based on the physical site capacity conditions under current BO provisions although future changes could further affect potential water storage and use patterns.

Water source and hydrology—

Storage water could be supplied by river flows, the East Branch of the Lost River and Rock Creek in the upper Lost River watershed area and by spills from Clear Lake. Preliminary hydrologic modeling was used to estimate the water volume available; the reservoir water budget including evaporation, precipitation, and leakage; and other factors including downstream water demands and water use practices. Further planning would include additional studies to assess the water supply and quality, delivery reliability, and groundwater interactions. A reservoir at this location could be subject to significant evaporation losses and could require an impervious lining to control seepage losses.

Preliminary engineering factors—

The reservoir could store surplus flows in the Lost Basin while maintaining downstream flows. Plans for new reservoir construction at this site would require more detailed investigations to refine the necessary project features and develop more accurate analyses of the storage benefit-cost relationships.

5.33 UKBOS-IAIR Option: IA-19

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. For preliminary planning, the facilities were located to avoid currently farmed lands, although some private land purchase is expected to construct the dam, water controls, and service facilities. The option would use some existing UKL and Klamath Project conveyance systems. Major cost factors include the reservoir construction and annual O&M requirements.

Wetlands and water quality—

Preliminary review indicates this option could have direct impacts on small areas of existing wetlands (GIS and NWI datasets) and minimal wetlands mitigation is expected. Water treatment prior to releasing stored water into the Lost River is uncertain at this time and the applicable standards—including potential for TMDL requirements—would require more detailed planning investigations and review by appropriate Oregon and California regulatory agencies.

Biological and cultural resources—

There are no sensitive fish/aquatic, terrestrial and avian species issues at this site but further study would be needed should this option advance to higher planning level. Although there are currently no identified cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Preliminary review suggests potential impacts to existing wetlands and wildlife resources are somewhat limited factors, whereas water quality standards could be a significant consideration for this option. All resource issues will require more detailed study during any subsequent planning and design stages.

Current Option Status

This option is considered potentially viable as a second priority for further storage planning stages. Although the Boundary Reservoir initial construction would be a significant cost factor, the facilities would have no added conveyance or pumping costs. Relatively lower resource implications could also improve the benefit-cost relationships. Additional planning studies including geotechnical evaluation of reservoir seepage and containment needs, detailed water operations modeling, and water quality regulatory implications are needed to determine whether this option should advance to further appraisal planning stages.

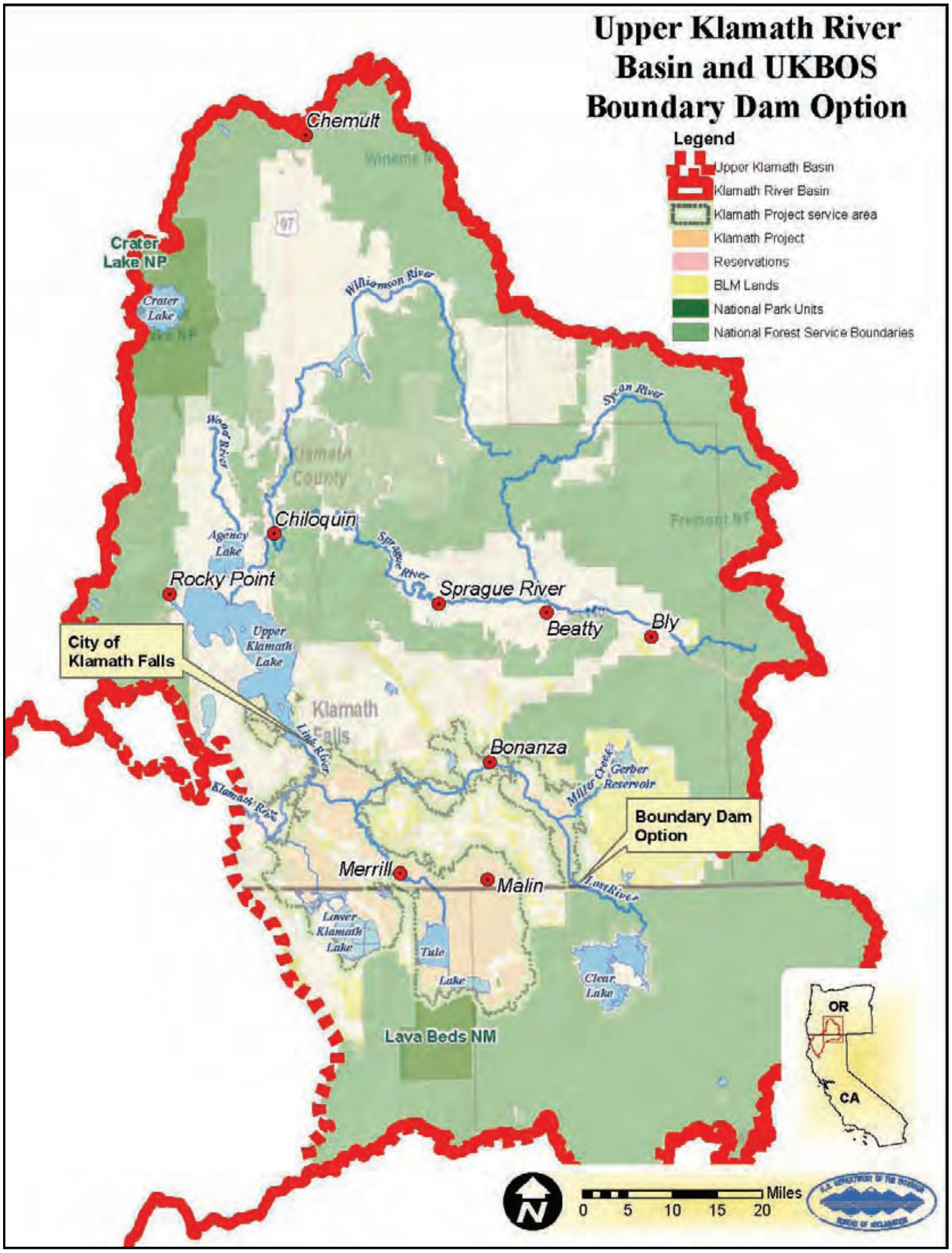


Figure 5-61.—Boundary Reservoir location map.

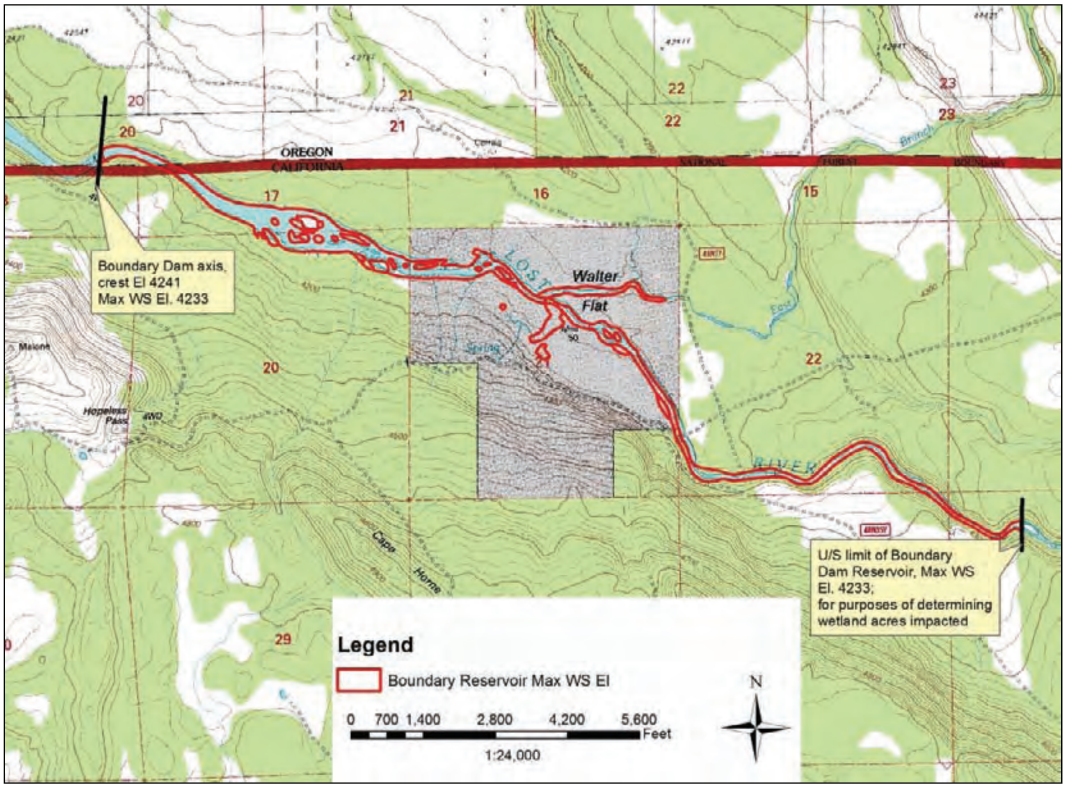


Figure 5-62.—Preliminary layout at Boundary Reservoir.

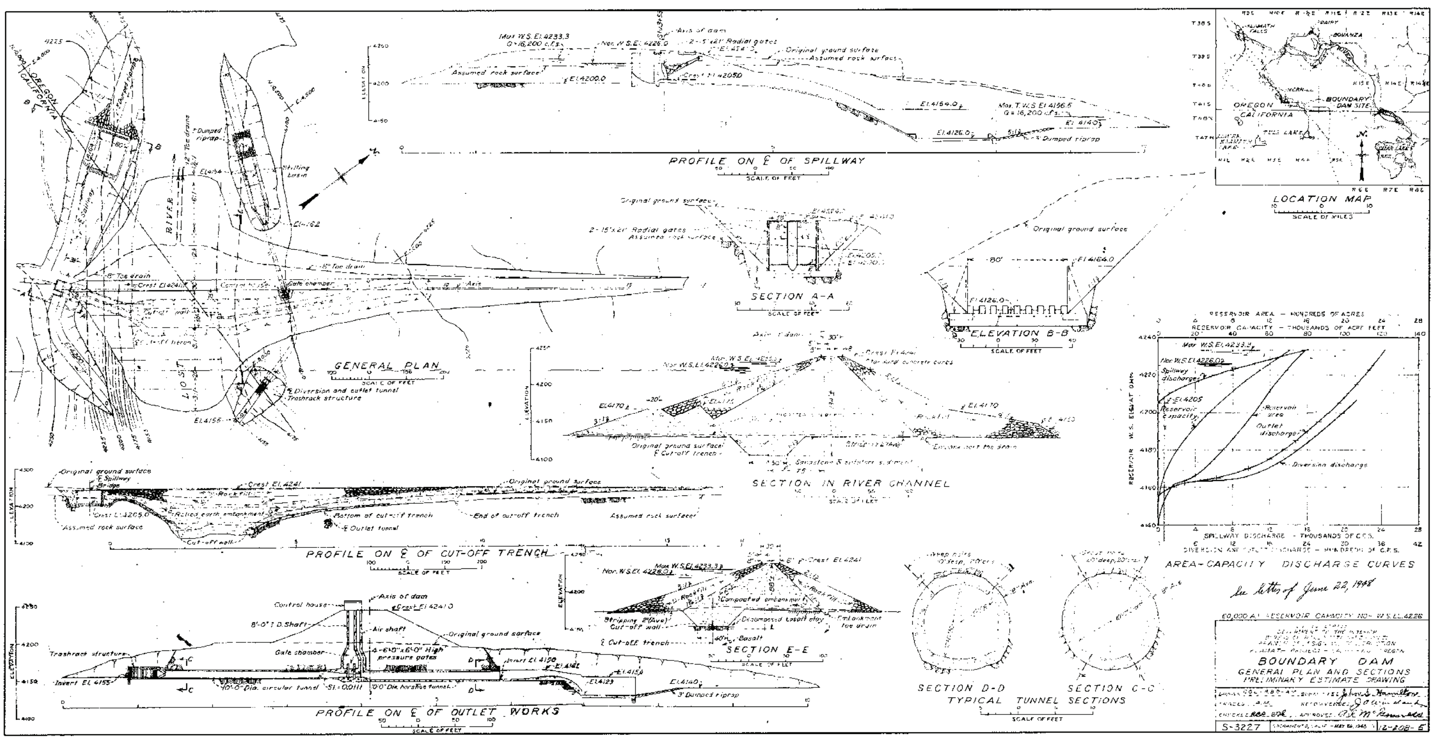


Figure 5-63.—Boundary Reservoir general plan and sections.

5.34 Clear Lake—J Canal Feed

Storage peak capacity:	513,330 acre-ft maximum (existing Clear Lake)
Projected storage time:	Multiyear storage
Storage water supply:	Lost Basin, Klamath Project return flows
Available storage water:	54,000 acre-ft at 90 days estimated surplus duration
Storage fill frequency:	Times of surplus runoff or return flows available
Initial design inflow rate:	300 ft^3/s (upsized from 262 ft^3/s J Canal capacity)
Water delivery benefit:	0-54,000 acre-ft/yr Klamath Project or Klamath River
Water treatment type:	Group 4; Lost River source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves using the existing Clear Lake reservoir to provide additional water storage. The option would allow diversion of flows in the lower Lost River (Klamath Project return flows) into the existing J Canal and then pumped through a new tunnel into Clear Lake. Water delivery could use existing Klamath Project conveyance systems and water users could benefit from the additional water made available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on using the existing J Canal and constructing a new pumping and tunnel system for conveyance infrastructure. Stored water would be released to the upper Lost River reach for downstream water uses and supplement the eastern service areas of the Klamath Project.

Water source and hydrology—

This option would essentially allow recirculation reuse of lower Lost River water (largely produced by Klamath Project irrigation returns) that currently flows down to the Tule Sump 1A and is not available for reuse. Preliminary plans indicate the existing Clear Lake capacity could be adequate to store this excess water and the capacity estimates are based on pumping rates, potential water volume available; the reservoir water budget including evaporation, precipitation, and leakage; and other factors including downstream water use practices. Further investigation for this option would likely require additional hydrological operations modeling to develop accurate estimates of water supply and delivery reliability and potential for interactions with other surface or groundwater resources.

Preliminary engineering factors—

Clear Lake could store these excess returns flows to provide a supplemental reuse water supply with relatively minor infrastructure required. Further plans for this option would more detailed investigations to refine the necessary project features and develop more accurate analyses of the storage benefit-cost relationships.

5.34 UKBOS-IAIR Option: IA-20

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. For preliminary planning, the facilities were located to avoid currently farmed lands, although some private land purchase is expected to construct the dam, water controls, and service facilities. The option would use some existing UKL and Klamath Project conveyance systems. Major cost factors include the new pumping, tunnel, and service infrastructure; and long term annual pumping power and O&M costs over the storage design life

Wetlands and water quality—

Preliminary review indicates the option facilities could be located to minimize direct impacts on existing wetlands (GIS and NWI datasets) and little wetlands mitigation is expected. Water treatment prior to releasing stored water into the Lost River is unknown at this time and applicable standards—including potential for TMDL requirements—would require more detailed planning investigations and review by appropriate Oregon and California regulatory agencies.

Biological and cultural resources—

Potential implications for sensitive fish/aquatic, terrestrial, or avian species would require further study. There are also some identified cultural resource issues that would need further study if this option proceeds to subsequent planning stages.

Key nonengineering factors—

Preliminary review suggests the potential implications for biological and cultural resources would require further investigation. In addition, relevant water quality standards could be a significant consideration for this option and these resource issues require detailed study as part of any subsequent planning stages.

Current Option Status

This option is considered potentially viable as a second priority for further storage planning stages. Preliminary findings indicate the option infrastructure features could have relatively lower implementation costs. However, biological or cultural resource issues and water quality regulatory requirements could influence overall benefit-cost relationships and require further investigation to assess whether this option should advance to further appraisal planning stages.

Figure 5-64.—Clear Lake with J Canal feed—location map.

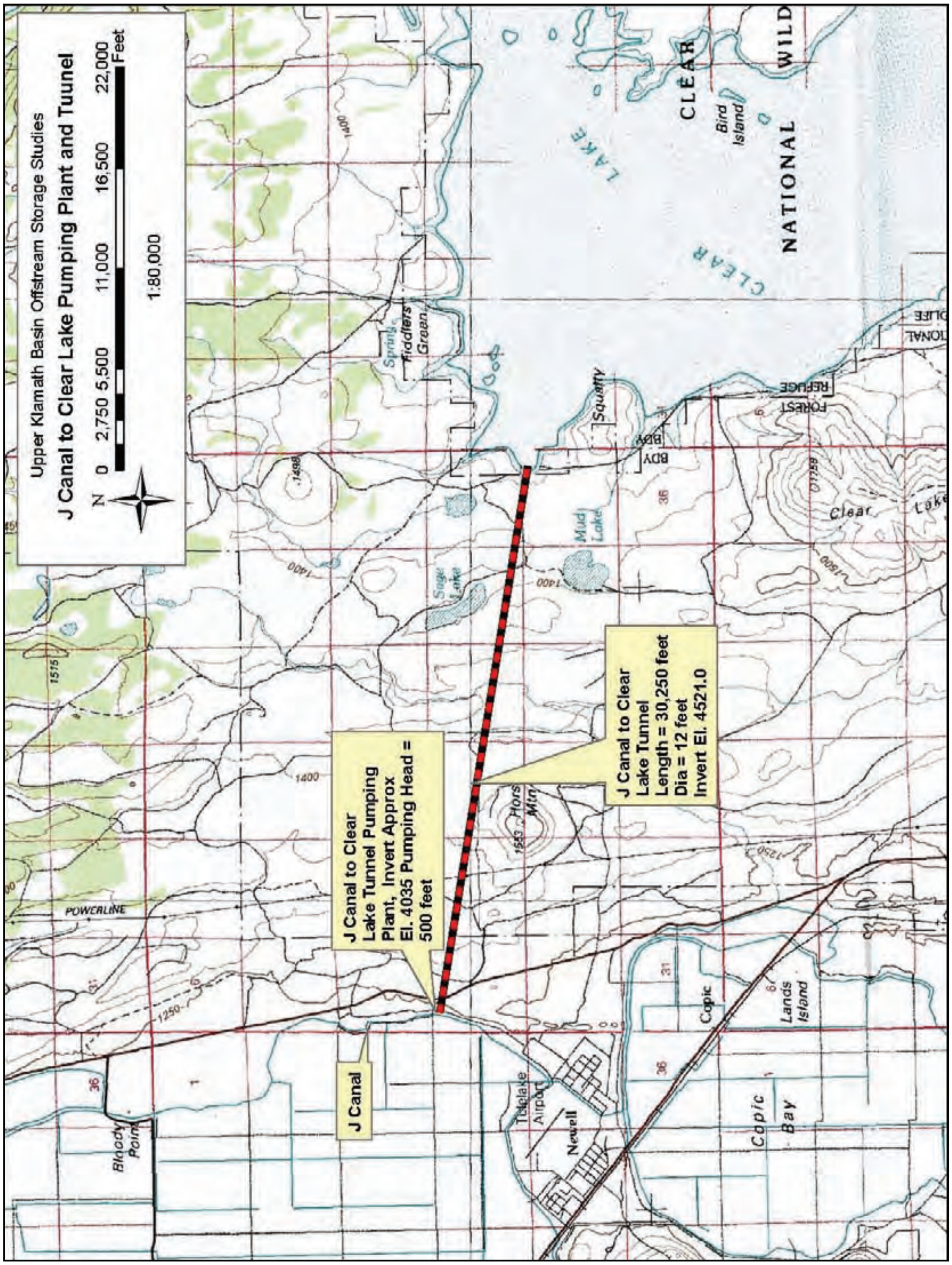


Figure 5-65.—Preliminary layout at Clear Lake with J Canal feed.

5.35 Clear Lake ASR—Boundary Storage

Storage peak capacity:	72,000 acre-ft maximum (at Boundary Reservoir)
Projected storage time:	Multiyear storage (USGS, 2010)
Storage water supply:	Lost Basin, groundwater well production
Available storage water:	≤72,000 acre-ft (8,000 groundwater; USGS, 2010)
Storage fill frequency:	Times of surplus runoff and groundwater production
Initial design inflow rate:	Run of the river via new pumping and conveyance
Water delivery benefit:	0–72,000 acre-ft/yr total both sources (USGS, 2010)
Water treatment type:	Group 4; Lost River source (need to be determined)
Current priority status:	1—first priority potentially viable

Project Description

This option involves groundwater recovery in the Clear Lake Reservoir basin with water storage in a new reservoir on the Lost River near the Oregon and California border—at the option Boundary Reservoir. Preliminary scoping parameters were developed by the USGS (2010). The identified well field site is preferred to avoid potential wetland areas and reduce conveyance distances to the Boundary Reservoir site and Klamath Project points of use. Water delivery could use existing Klamath Project conveyance systems and the water users could benefit from the additional water available during times of shortage.

Technology and infrastructure—
Groundwater retrieval would be accomplished using pumped wells with passive natural recharge to replenish groundwater supplies. As a result, this represents a modified ASR strategy. Groundwater would be extracted by a pumped well field system and passed through Clear Lake Reservoir for storage in the proposed Boundary Reservoir. Clear Lake storage constraints are not applicable to storage at Boundary Reservoir. Preliminary plans are based on 10 wells with up to 15 ft^3/s each. The capacity was oversized to allow for some equipment reliability and to achieve estimated retrieval flows.

Water source and hydrology—
Hydrological operations would be defined by aquifer recharge and extraction rate capacities and storage operational factors. The water supply reliability depends on surplus recharge rates. Preliminary plans applied a 60-day annual extraction period to estimate facilities needed to deliver supplemental water for downstream uses. Storage at the Boundary Reservoir site could be subject to evaporation and could require an impervious lining to control seepage losses.

Preliminary engineering factors—
This option is a combination of the Clear Lake ASR and the Boundary Reservoir options. Plans for the well field installation reservoir construction would require more detailed investigations to refine the necessary project features and develop more accurate analyses of the storage benefit-cost relationships.

5.35 UKBOS-IAIR Option: IA-21

Preliminary Findings

This option combines groundwater ASR with conventional surface water storage schemes and could offer greater water delivery reliability and water management flexibility. The option was identified for preliminary investigation as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—
Detailed investigations are required to evaluate relevant water rights, groundwater protection, and benefit/cost relationships. Oregon water law review is anticipated to assess potential implications for surface and groundwater rights. Preliminary planning is based on option facilities located to minimize impacts to private lands although some land purchase is expected to construct the option facilities. Major cost factors include the reservoir, conveyance systems, and well construction and the long-term power use and O&M requirements.

Wetlands and water quality—
Preliminary review indicates this option could have direct impacts on small areas of existing wetlands (GIS and NWI datasets) and may require mitigation. Water treatment is not required for natural passive recharge. However, water treatment prior to releasing stored water into the Lost River is uncertain at this time and the applicable standards—including potential TMDL requirements—require further planning investigations and review by regulatory agencies.

Biological and cultural resources—
There are no sensitive fish/aquatic, terrestrial and avian species issues at this site but further study would be needed should this option advance to higher planning level. Although there are currently no identified cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—
Preliminary review suggests potential impacts to existing wetlands and wildlife resources are somewhat limited factors, whereas water quality standards could be a significant consideration for this option. All resource issues will require more detailed study during any subsequent planning and design stages.

Current Option Status

This option is considered viable as a high priority for further storage planning stages. It may be possible to offset some of the initial Boundary Reservoir costs if the reservoir storage could provide multiple purpose benefits. Additional studies including geotechnical analysis of reservoir seepage and containment, surface and groundwater operations, and water quality regulatory implications are necessary to assess whether this option should advance to appraisal planning stages.

Figure 5-66.—Clear Lake ASR—Boundary storage option—location map.

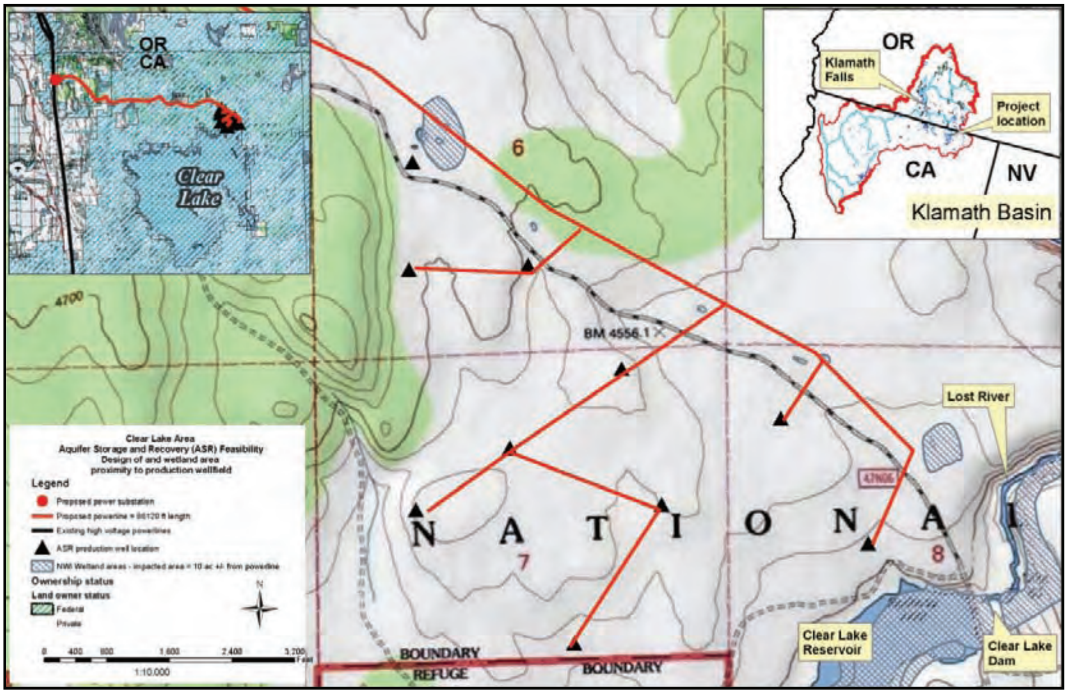


Figure 5-67.—Design of the Clear Lake ASR—Boundary storage option and wetland area proximity to production well field.

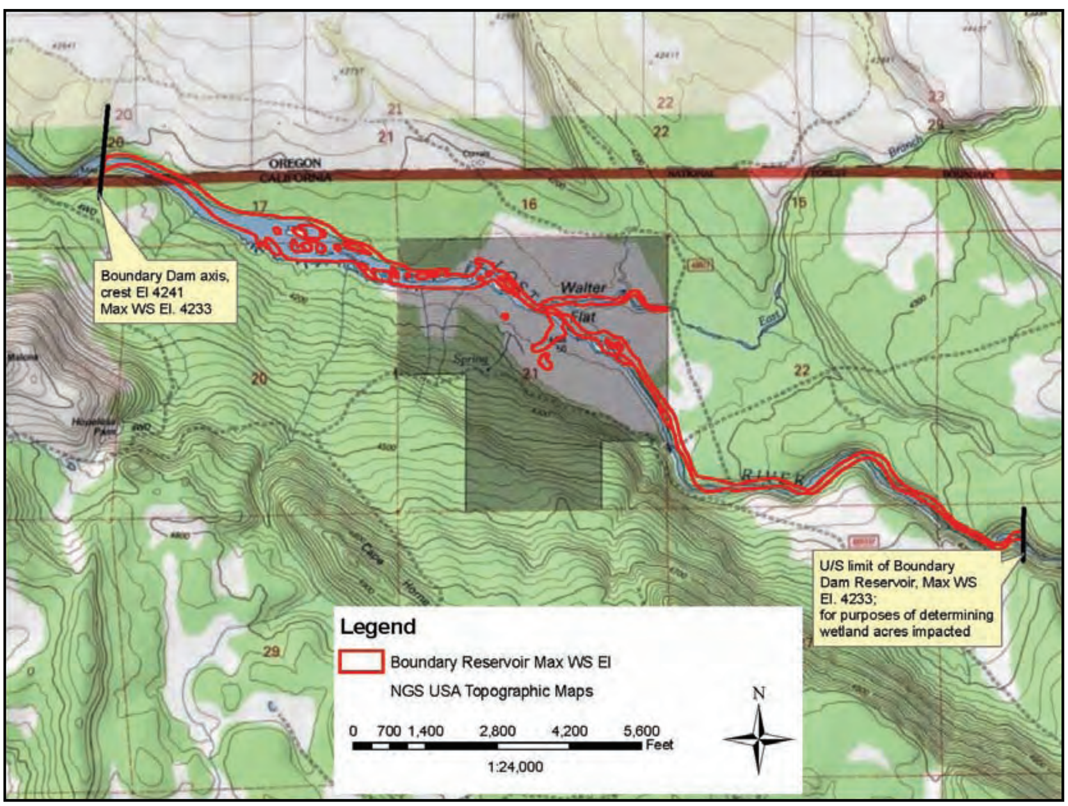


Figure 5-68.—Preliminary layout at the Clear Lake ASR—Boundary storage option.

5.36 Bryant Mountain Reservoir

Storage peak capacity:	103,200 acre-ft maximum (at new lower reservoir)
Projected storage time:	Multiyear storage
Storage water supply:	Surplus UKL, Lost River watershed, return flows
Available storage water:	Up to maximum capacity (and BO constraints)
Storage fill frequency:	Times of surplus runoff and drainage return flows
Initial design inflow rate:	610 ft^3/s (based on 90-day surplus up to 54,000 acre-ft)
Water delivery benefit:	0–103,200 acre-ft/yr (w/12,400 acre-ft for peak power)
Water treatment type:	Group 4; Lost River source (need to be determined)
Current priority status:	2—second priority potentially viable

Project Description

This option involves building a reservoir at the identified Bryant Mountain site to store surplus lower Lost River water (Klamath Project drain return flows or other flows). Water would be diverted into the existing J and C Canals and pumped via a new conduit to a peaking power lower reservoir forebay. Water delivery could use existing Klamath Project conveyance systems and water users could benefit from the additional water supplies available during times of shortage.

Technology and infrastructure—

Preliminary plans are based on a new dam and related facilities constructed at the identified Bryant Mountain Reservoir site. Existing J Canal and C Canal systems would be utilized and new pumped storage, impoundment, and conveyance tunnel infrastructure would be constructed. The stored water would be released back to the J Canal or C Canal for use in the Tule Lake basin and eastern service areas of the Klamath Project. The preliminary reservoir volume was based on the physical site capacity limitations under current BO provisions.

Water source and hydrology—

This option would essentially allow recirculation reuse of lower Lost River water (largely produced by Klamath Project irrigation returns) that currently flows down to Tule Sump 1A and is not available for reuse. Preliminary hydrologic modeling was applied to assess the storage volume available, storage and releases; reservoir water budget including evaporation, precipitation, and leakage; and other factors including downstream water demands and water use practices. Further planning would include additional studies to assess the water supply and quality, delivery reliability, and groundwater interactions.

Preliminary engineering factors—

The reservoir could store surplus flows in the Lost Basin while maintaining downstream flows. Plans for new reservoir construction at this site would require more detailed investigations to refine the necessary project features and develop more accurate analyses of the storage benefit-cost relationships.

5.36 UKBOS-IAIR Option: IA-22

Preliminary Findings

Surface storage generally offers water management flexibility although it also has a larger infrastructure footprint and evaporation losses than underground storage and extraction schemes. This option was formulated for preliminary study as part of the UKBOS effort and remains potentially viable for future planning.

Institutional and economic factors—

More detailed studies are needed to evaluate water rights, groundwater protection, and key benefit-cost factors. For preliminary planning, the option facilities were located to avoid currently farmed lands, although some land purchase is expected to construct the reservoir, water controls, and service facilities. Major cost factors include facility construction and mitigation implementation and long term O&M, pumping, and power use requirements.

Wetlands and water quality—

Preliminary plans located option facilities to minimize direct impacts on existing wetlands (GIS and NWI datasets), although some wetlands mitigation could be required. Water treatment prior to releasing stored water into the Lost River is uncertain at this time and the applicable standards—including potential for TMDL requirements—would require more detailed planning investigations and review by appropriate Oregon and California regulatory agencies.

Biological and cultural resources—

Sensitive fish species concerns would be mitigated by installing fish screens at the intakes at J and C Canals. Other possible biological resource issues would require further study should this option advance to higher planning level. Although there are currently no identified cultural resource issues at this site, more detailed study is required for any further planning.

Key nonengineering factors—

Preliminary review suggests potential impacts to existing wetlands and wildlife resources are somewhat limited factors, whereas water quality standards could be a significant consideration for this option. All resource issues will require more detailed study during any subsequent planning and design stages.

Current Option Status

This option is considered potentially viable as a second priority for further storage planning stages. Additional planning studies including geotechnical evaluation of reservoir seepage and containment needs, detailed water operations modeling, and water quality regulatory implications are needed to determine whether this option should advance to further appraisal planning stages.

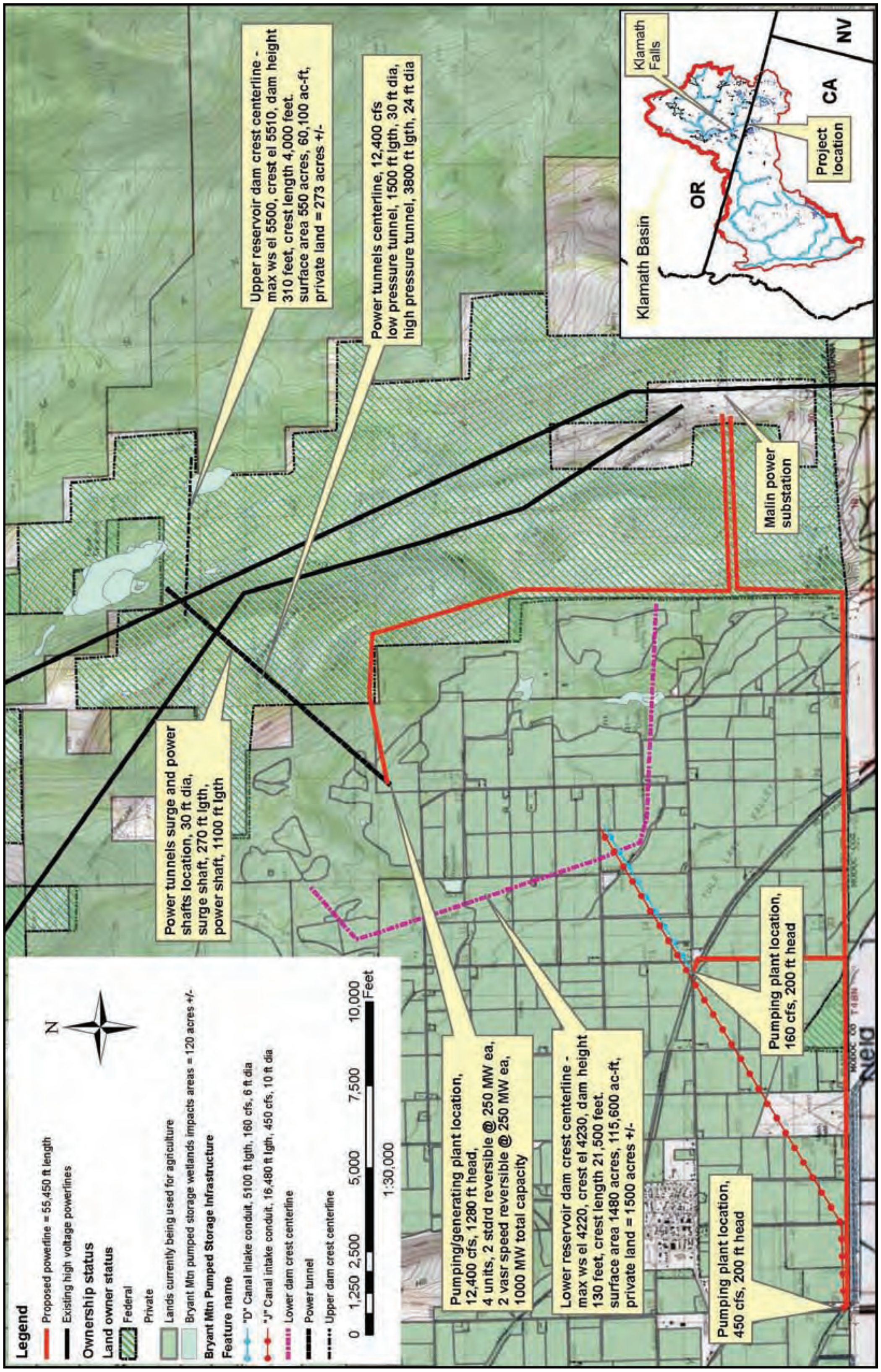


Figure 5-69.—Preliminary layout at Bryant Mountain Reservoir.

6.0 Preliminary Costs, Benefits, and Issues

Important findings from the preliminary options development and evaluations are summarized in this section and these findings are cross-compared between all of the IAIR options. In particular, preliminary cost estimates, water supply benefits, environmental and socioeconomic factors are used as relative screening factors to compare option attributes. This relative screening is applied to narrow the range of IAIR options and identify a short list of the more promising options that could be formulated into initial alternatives and carried forward into further planning stages. Considerations for combining options or formulating a more comprehensive basinwide approach for improving water storage in the Upper Klamath Basin are also discussed.

Section 6 Topics:

- *Comparison of preliminary capital construction and design life-cycle cost estimates for all options*
- *Comparison of maximum year and average annual water supply benefit factors for all options*
- *Comparison of environmental and socioeconomic considerations identified for all options*
- *Description of a selected short list of priority options as initial alternatives for further planning*

Reclamation could select one or more of the identified priority IAIR water storage options to undertake more comprehensive appraisal-level investigations. This option selection would consider the technical engineering requirements and projected costs, the option performance in meeting storage objectives, and other institutional (water rights, regulatory, permitting), environmental (fish and wildlife, wetlands, water quality), or other resource issues (cultural, social, land uses, economics) associated with the option. These option-screening comparisons relied on existing available data and information and only represent the preliminary level assessment of possible issues. The without storage option is considered a baseline reference and the option comparisons focus on the developed action storage options.

6.1 Estimated Capital and Life-Cycle Costs

Preliminary storage capacity, estimated capital construction and total life-cycle cost factors, and water supply benefit factors for the array of IAIR water storage options are shown in table 6-1. Estimated cost numbers are divided into groups that show the capital construction and total life-cycle costs. Capital costs represent the first costs required to construct the storage facilities associated with a given option. The total life-cycle costs include the capital costs, plus associated operations and maintenance costs over a 50-year design life. Future annual and periodic life-cycle costs are converted into a present worth value using standard economic time-value accounting procedures.

6.1.1 Preliminary cost estimates for options

The estimates are also separated into the total cost and a unit cost that is based on the water storage capacity indicated in the left-hand column. The unit cost gives additional insight into the relative cost-effectiveness for a given option.

Each of these is then further broken down to show estimates that are based on the without and with water treatment included. Water treatment costs could be a significant factor in storage planning, yet the exact requirements are not refined at preliminary level. Consequently, this range allows the potential water treatment needs to be evaluated independently and updated or refined separately.

The estimating was performed to preliminary planning level standards according to the Reclamation Manual standards FAC 09-01, FAC 09-02, and FAC 09-03. Additional information on the cost estimating procedures and preliminary level estimating limitations is included in appendix C.

6.1.2 Cost comparison between options

Collectively the cost estimate breakdown was used to compare different aspects across the complete array of options. For example, power costs are a considerable portion of the life-cycle costs for options that involve pumping. Other options may not require water treatment associated costs.

Among the groundwater ASR options, the Clear Lake ASR and Gerber Reservoir ASR options hold the most promise with the least construction and lifecycle costs per unit volume of water delivered. Other ASR options are somewhat more costly to construct but may hold promise to address various water supply issues in the immediate vicinity of their location. For example, Tule Lake ASR recirculation option would cost more to construct and pumping costs may become substantial in the future; however, this option could offer benefits that are difficult to obtain otherwise (such as reusing water within the Tule Lake subbasin). Life-cycle costs for ASR options increase, for example, relative to run of the river (on stream) type surface storage options because of their need for pumping infrastructure and the pertinent operations power costs.

Among the surface storage options, some on-stream options such as raising UKL, Torrent Springs, and Williamson River, do not require pumping construction and operations power costs. Other surface storage options including Wocus Marsh, Swan Lake, Whiteline Reservoir, and Bryant Mountain that involve pumped storage have greater construction and operations power costs over the projected design life cycle. The Wocus Marsh option involves pumped storage, although it is close to UKL, and thus would have relatively lower operating costs than other pumped storage options. The Buck Lake option has substantial estimated costs attributed to constructing water supply conveyance tunnels; however, this option would not require any pumping facilities because the water would flow into and out of the reservoir by gravity flow and therefore this option has relatively lower annual operating requirement and associated total life-cycle costs.

6.2 Klamath Basin Water Supply Benefits

Preliminary storage capacity, estimated costs, water delivery, projected total water delivery valuation, and relative benefit-cost rating factors for the array of IAIR water storage options are shown in table 6-1. For the water supply benefit factors, the maximum year values (upper value) and average annual values (lower value) are shown in each cell of the table. Potential water supply constraints that were evident from the OWRD-OWARS data are also noted. Total water delivery values are based on a $100/acre-ft unit value applied to the annual deliveries projected over the 50-year option design life-cycle period. All values indicated are expressed in total present worth derived by standard economic accounting procedures.

6.2.1 Groundwater ASR option benefits

The ASR options offer generally smaller available supply volumes than do the surface storage options but a general advantage to the ASR options is that they will experience far less losses due to evaporation. The active recharge options generally have higher operating costs for injection well pumping that can limit the cost effectiveness to only annual storage. Passive recharge options do not have this apparent limitation as reflected in the relative benefit-cost ratings.

The potential effects of groundwater well extraction at the rates proposed for the Langell Valley ASR, Clear Lake ASR, or Gerber ASR options can be inferred from the current understanding of the basic groundwater hydrology of the region (as outlined in the USGS 2007 groundwater hydrology report) as well as the observed response of the basin since 2001. During the first few years of pumping, much of the pumped water will come from aquifer storage, resulting in hydraulic head (water level) declines within a few miles of the wells. As time goes by, the water level effects will expand. This behavior has been observed in association with historic supplemental pumping in the upper Klamath Basin. The changes in hydraulic head propagate outward from the pumping centers, net fluxes of groundwater discharge to hydrologic boundaries, such as streams, springs, lakes, and drains, will diminish to offset the pumped volume. Groundwater pumping impacts on spring flows have been reported at multiple locations within the upper Klamath Basin. The timing and proportion of these impacts generally depends on the radial distance from the well pumping center.

Accurate numbers describing the potential hydrologic boundaries and drawdown magnitudes from the ASR options are not available at this time. The USGS was requested to provide an in-depth assessment of potential groundwater extraction effects at the Langell Valley, Clear Lake and Gerber ASR options because these options appear more cost-effective than other ASR options. Provisional review indicated there could be significant drawdown within 2 miles, tapering rapidly off to fairly minor drawdown beyond 5 miles of the well fields. However, at this time, the simulation modeling results have not been finalized and released, and must be considered provisional (USGS, 2010 personal communication).

Developing more precise estimates for the Clear Lake and Gerber Reservoir areas will be difficult given the lack of wells for monitoring in these areas. It may be possible to refine the Langell Valley area drawdown estimates by incorporating aquifer tests into the analysis; however, this would be a rigorous effort and the results would still have uncertainty. Alternatively, some additional data could be derived from test drilling and long term pumping tests.

Each ASR option could offer water supply benefits within the immediate vicinity or to other parts of the Klamath Project by releasing water to be stored in surface storage facilities for subsequent release for Klamath Project or other needs.

6.2.2 Surface storage option benefits

Surface storage options generally offer larger volumes of potential water supply benefits but also tend to have greater evaporation losses than groundwater ASR options. Surface storage option capacities and average annual water deliveries for all uses were estimated based on (a) WRIMS hydrologic simulation modeling as described previously (appendix A) or (b) a limiting infrastructure approach that is based on the conveyance system limitations (e.g., Swan Lake A-B Canal feed, LK NWR constrained by Sheepy Tunnel), or (c) by the absolute quantities available under the OWARS data (OWARS, 2010). Of all the option storage facilities, only Torrent was allowed to exceed the OWARS water supply limitations.

The largest potential storage volumes are found among the Raise UKL, Wocus, Whiteline, Swan Lake and Torrent options. Raise UKL, Wocus and Whiteline would serve as storage adjuncts to the existing UKL with the added advantage of the need to construct and O&M minimal or no conveyance infrastructure. Buck Lake could offer some advantages because it is located higher in elevation, could collect the runoff water close to its source in the Cascade Mountains and could release water directly to the Klamath River via Spencer Creek. This flow could help the Upper Klamath Basin meet the Klamath River fishery operations BO, thereby freeing the Upper Basin to capture an equivalent amount of water in UKL for delivery to Klamath Project water users.

The surface storage options that involve NWR ponds could provide an additional water supply benefit to meet refuge water needs. Boundary Dam is strategically located and is of a volume such that it offers potential benefits to the east side of the Klamath Project, an area that has experienced water limitations during the last two decades. The Boundary Dam option would be located on-stream and would not require and pump-storage facilities.

In several instances, the larger surface storage options capacity does not translate into more water available indicated by the WRIMS modeling results. Water for reservoir filling is available only in certain limited years. More detailed planning should include specialized studies to optimize the storage sizing and configuration characteristics for the surface water storage options.

Inspection of table 6-1 shows that for many surface storage alternatives, there is a large difference between design capacity and the average annual delivery. For purposes of UKBOS studies, a facility was initially purposefully designed to a size that was anticipated not to be undersized. No attempt at facility sizing optimization for any of these options has been performed and such an activity needs to be accomplished should an option in this category be advanced to higher level planning studies.

6.3 Environmental and Socioeconomic Factors

Preliminary environmental and socioeconomic considerations associated with IAIR water storage options are shown in table 6-2. The environmental category is further divided to identify potential implications concerning existing wetlands, endangered fish species, or water treatment needs. The socioeconomic category includes cultural resources, local or regional factors, and land ownership considerations. These topics are intended to encompass major costs or potential barriers for a given option at preliminary level. More detailed studies will likely be required for environmental (i.e., NEPA, NHPA, ESA, etc.) compliance during further planning for selected options.

6.3.1 Environmental resources considerations

Potential environmental resource issues were identified for each option using readily available data. Much of the information described here was obtained from GIS databases developed by Reclamation or other agencies or in consultation with other agencies. The information provided is preliminary and some databases do not encompass the entire study area. No environmental surveys were conducted at this level and would have to be performed in the future further study phases to verify the resources and assess potential effects. The information summarized is appropriate at preliminary level to identify major constraints to implementing an option or issues that make an option impractical or cost prohibitive.

6.3.1.1 Existing wetlands impacts

Potential impacts to existing wetlands were characterized primarily by evaluating the surface area footprint of the storage operations with respect to geospatial data sets available from the NWI. Significant wetlands areas and the potential need for building mitigation wetlands were noted. These issues would ultimately have to be studied in more detail, including the potential need to conduct a site-specific jurisdictional wetlands delineation and develop a corresponding mitigation plans as part of further storage planning.

6.3.1.2 Fish and wildlife issues

Reclamation conducted a preliminary-level overview of potential fish and wildlife issues for each option. The potential to affect wildlife-related recreation, such as hunting, fishing, and wildlife observation, was also considered. Much of the data were compiled from readily available GIS datasets. However, these datasets may not cover the entire study area and consequently, these preliminary reviews may not accurately represent species occurrence. More thorough surveys of sensitive, threatened, or endangered species would be required for further planning.

Potential fish and wildlife issues associated with proposed water supply options include loss of terrestrial habitat due to inundation by proposed surface storage reservoirs. Habitats of particular concern are likely in the study area and scope of the storage option because many Species of Concern depend on aquatic habitat or use related natural resources. Other potential issues include loss of fish-rearing habitat, predation, and loss of primary productivity.

Reservoir drawdown that is necessary from surface storage options can increase the density of all aquatic species relative to the amount of habitat remaining, potentially changing predator-prey dynamics. As overall aquatic habitat volume decreases during a drawdown, encounters between predator and prey species can increase and the lower water levels could also reduce productivity or the extent of suitable fishery spawning grounds. Spawning fish nests could be dewatered and rearing habitat could be lost. Over time, continuous drawdown could diminish both littoral and riparian vegetation, and bank erosion could increase.

For the preliminary option comparisons, the potential for fish screening needed to protect the known threatened and endangered fish species was quantified by way of inclusion in an option’s construction cost estimate where appropriate, and was noted and cited in table 6-2. Existing species-specific data for the proposed water storage sites consist primarily of casual observations, rather than standardized surveys. Further studies will be needed to assess habitat and wildlife resources as well as human use of these resources for any storage options.

6.3.1.3 Water quality factors

Water quality factors were defined by the preliminary water treatment assessment studies described previously. The overall need and extent of treatment is cited in the option summaries and noted in table 6-3. The estimated treatment costs were also included as a range factor in the cost estimates.

6.3.2 Socioeconomic considerations

Some of the IAIR identified water storage options could have important implications for cultural resources, economic conditions in local communities or the regional area. They could also involve private land ownership or have affects on the land uses in the area.

6.3.2.1 Cultural resource issues

Detailed cultural resource inventories or investigations were not conducted for the preliminary storage evaluations. For screening purposes, option sites that have known or probable cultural considerations were noted. The study area has not been surveyed and more detailed surveys would be conducted for defined areas that could be affected by the option facilities or operations.

Changes in reservoir configuration and operations such as found for Raise UKL and dredge UKL could potentially affect cultural resources located along the UKL perimeter. Drawing down UKL may expose additional cultural resource sites or add to the cumulative amount of time that resources are exposed, making them susceptible to damage from recreational activities. Water operations could also increase bank erosion and slumping that could bury cultural sites. Constructing new reservoirs could inundate significant cultural resources with later exposure as reservoir water levels fluctuate. Options with proposed reservoirs likely have a higher probability for cultural impacts than the ASR options.

6.3.2.2 Regional economic considerations

The only economic factors that were considered for this preliminary level review of all options were with regard to social issues. These could be important considerations in detailed economic analysis of the without storage future conditions versus any active storage options. Without implementing storage improvements would result in continuing water conflicts in the basin whereas the action options offer the potential for some relief from those conflicts.

6.3.2.3 Land use and ownership

The preliminary option assessments considered land uses that occurred within the footprint of proposed reservoirs for surface storage options and surface facilities for ASR options. These inventories relied on available GIS datasets that identify landownership (such as Klamath County Assessor’s parcel dataset) and structures such as residences, roads, and railroads.

Modifying operations at existing reservoir facilities such as at UKL could affect the current recreation access and quality, as well as other infrastructure and uses surrounding the UKL shoreline. New reservoirs would inundate existing lands and structures. Potential land use issues associated with each storage option are also cited in table 6-2. This is not meant to be a comprehensive list of issues, as comprehensive land use surveys have not yet been made. The estimated land purchase costs for the options’ facility and mitigation wetlands footprints were also included in the cost estimates.

6.4 Preliminary Screening Comparisons

Collectively, the information summarized in tables 6-1 and 6-2 provides a basis for screening comparisons between the individual option characteristics and to consider strategic approaches that focus on a part of the Upper Klamath Basin water supply issues. The estimated costs and benefit parameters are important to gain insight into the major factors at this stage, even within preliminary planning limitations. Environmental and socioeconomic factors indicate important issues and influence the relative benefit-cost comparisons to a certain extent.

Table 6-1 shows a measure of an option's carryover storage effectiveness (total storage capacity to annual evaporation ratio column). The higher the ratio the higher the option's effectiveness and is an indication of the relative effort required to deal with annual evaporation losses. Deep canyon reservoir location options such as Torrent or Williamson score high while options with a large area of shallow storage that suffer from relatively high annual evaporation such as Caledonia do not. The last column indicates whether pumping is involved in the option. At a certain point in an option's annual operations where pumping is involved, expensive pumping costs may be experienced just to replace water lost to evaporation. The optimal option in this regard would therefore be interpreted to be one with a high carryover effectiveness ratio coupled with no pumping involved such as run of the river in a deep canyon such as Williamson or Torrent. This optimality characteristic must in turn be weighed against an option's other factors listed in tables 6-1 and 6-2 (such as B/C ratio and potential environmental impacts).

The preliminary estimated capital costs and life-cycle costs reflect major factors associated with initial construction and annual operating requirements. Water delivery maximum and average annual values give insight into the potential for water supply reliability and management flexibility benefits. The corresponding relative benefit-cost factors provide a rational basis for comparing and screening between the storage options. However, the preliminary context is a crucial aspect and the numbers estimated for these purposes are ***only*** considered appropriate for screening these options developed at an equitable level. The estimates presented are not suitable outside of this IAIR and the stated intended purposes.

6.4.1 Primary objectives comparison

The primary UKBOS objectives center on water storage capacity, maximum and average annual water delivery, water management flexibility and the relative cost or benefit valuations estimated for these factors. Reclamation could fully develop one or a combination of storage options in the future. All options are conducive to phased implementation or a coordinated subbasin approach.

Among all UKBOS options, ASR options would provide the greatest water supply per ideal unit of water stored due to the low evaporation losses. Additionally, among all options, ASR options could have fewer direct environmental impacts because they rely on the existing conveyance systems and smaller facilities than would surface storage options. ASR options would also rank the highest among options considered in terms of the amount of funding and time required to study aquifer characteristics and storage implications, although aquifer model studies involve greater uncertainty than surface hydrologic water operations and delivery analysis models. Of the ASR options, Gerber and Clear Lake hold the greatest promise with the best relative B-C values. If these ASR options move to higher planning level, more in depth investigations are needed to determine losses due to aquifer drift and neighboring well draft volumes.

A number of surface storage options entail construction of conveyance systems with significant distances for new major canals, tunnels, and siphons, number of pumping plants, and the potential need for a reregulating reservoir, as is the case for the Bryant Mountain pumped storage option. The new construction required would entail potentially greater study time, resources, and effort to complete the necessary level of engineering and environmental analyses. Despite this, surface storage could be designed and implemented in stages, potentially by expediting water delivery to some Klamath Projector basin areas more quickly.

Options which serve as storage adjuncts to UKL, namely Raise UKL, Whiteline reservoir, Wocus Marsh, Caledonia Marsh, and Aspen Lake offer the greatest ability to use existing conveyance infrastructure. These options also appear to have more significant environmental effects because they involve larger surface area of disturbance. They would also entail relatively extensive reservoir facility construction. The on-stream and other gravity fed options, such as Williamson River, Torrent Springs, and Buck Lake as configured, would deliver water by gravity and some options by pumping would not need to pump water as high as other options such as the smaller Swan Lake option.

Additional information was used to assess a few options. For example, for the Gerber ASR option, the value range for water delivery, water delivery value, and relative benefit-cost represent two suboptions that involve running power lines (higher cost) or installing a diesel generation onsite (lower cost), and therefore the range reflects a without and with diesel power. Another example involves the Wocus Marsh and Aspen Lake options. Results for these options indicate a fairly positive relative benefit-cost rating, although this is attributed to an assumption of not requiring an impervious liner—which may not be accurate in either case. The Aspen Lake site is located at a higher elevation mountains valley, predominantly on fractured volcanic deposits that could suggest greater potential for seepage losses. The Wocus Marsh site is lower elevation and overlies mostly older lakebed sediments. A lower surface elevation with higher groundwater levels could tend to reduce seepage potential; although the peat composed lakebed sediments common in the UKL area could still require an impervious lining.

AL/Barnes current management is not an UKBOS option (and thus not given an UKBOS option designation number) but characteristics for it are included in tables 6-1 and 6-3 for comparison purposes. Hydrologically, all non-AL/Barnes options include the hydrologic aspects of the AL/Barnes open to the lake scenario (this is an action that is reasonably foreseeable to occur at time of this IAIR development) and delivery benefits are as compared to the no action scenario.

AL/Barnes options of open to the lake and upgraded offstream storage as "future no action/future without project" scenarios are included as stand-alone UKBOS options for which benefits and costs have been determined also for comparison purposes and are included in the UKBOS studies and table 6-1. The future options at AL/Barnes described in this IAIR would be paid for by the Federal government (FWS) and construction and life-cycle costs would not be the responsibility of Klamath Project water user entities. However, for purposes of table 6-1 and 6-3, the non-AL/Barnes options include AL/Barnes open to the lake scenario delivery benefits as explained elsewhere in this report and appendix A (which when included are relatively small), but do not include the AL/Barnes open to the lake option costs.

6.4.2 Nonengineering option comparison factors

The most prominent environmental factor affecting the option screening was the presence of existing wetlands, and primarily associated with options that involve new reservoir construction. This is consistent with the LLV appraisal findings in which wetlands mitigation was a significant cost factor. Water quality and the potential need for treatment could become a significant cost factor; however, the actual requirements would require further study for any option carried further and therefore the potential implications of treatment are reflected in the preliminary estimated cost ranges.

The majority of the other nonengineering biological, cultural, and economic factors will require more specific studies for options selected for further appraisal level alternative investigations. For biological resources, additional information regarding fish screening needs and design detail could be developed during further planning stages. Although fish screens can be a significant design element, screening facilities were included as scoped at a preliminary level because the cost implications for a majority of the options were expected to be relatively minor compared to the other components. These issues are identified for future consideration and planning purposes; however, they were not deciding factors in the preliminary-level option screening.

6.4.3 Comprehensive water storage strategies

The categories and corresponding characteristics for the storage options suggest the potential for developing a comprehensive approach that could incorporate a staged development scheme or to target different storage strategies for different water resource aspects throughout the Klamath Basin.

Comprehensive storage strategy examples—

It appears that the most effective basinwide planning approach might integrate multiple options in a strategic plan that contributes toward the overall UKBOS objectives. For example, options above UKL could take advantage of the UKL storage and reregulation operations. On-stream reservoirs might offer the potential for less water treatment, although at possible trade-off with the mitigation often associated with new reservoir construction.

6.5 Option Priority Results and Discussion

The preliminary evaluation findings and resulting option priorities were used to narrow the range of options considered in the IAIR into a smaller group of options that appear the most promising as initial alternatives for subsequent appraisal and feasibility planning stages. IAIR options identified as the most promising (short list) to carry forward as initial alternatives are shown in table 6-3.

It is worth noting that these options that currently appear to offer best potential for further development do not necessarily preclude further review and planning for other viable options. As additional information is obtained, the IAIR framework should be reviewed and updated with potentially new identified priorities.

6.5.1 Discussion of the identified priority options

The IAIR short list includes Gerber ASR, Clear Lake ASR, Boundary Reservoir, Clear Lake ASR with Boundary Storage, Buck Lake Reservoir, Wocus Marsh low option, Torrent Springs Reservoir and the two options at the Agency Lake Ranches site. These options appear most favorable for further planning because they have relatively lower preliminary estimated costs per average annual water delivered and similar nonengineering factors. The short list options also appear to require fewer resources to complete subsequent engineering development and environmental analyses.

These nine options bracket a range of potential storage mechanisms and locations throughout the Klamath Basin. Major attributes of these options include:

- Gerber ASR (diesel powered).—Groundwater recovery at upper area of the Lost Basin uses Gerber Reservoir for regulation and could provide supplemental water for Klamath Project during water shortages. Potential TMDL issues could be alleviated by direct irrigation delivery or by diluting river water quality as an added TMDL benefit.

- Clear Lake ASR.—Groundwater recovery in upper Lost Basin with (or without) storage in Clear Lake. The location has with lower potential to affect other water wells and similar TMDL attributes to Gerber ASR.

- Boundary Reservoir.—A surface reservoir at this site is more economical to construct and has fewer environmental issues compared to other surface storage sites because it is physically smaller in volumetric capacity. Boundary Reservoir is in a strategic water supply location and could expand water operations flexibility for the Klamath Project.

- Clear Lake ASR and Boundary Reservoir.—Combining these options could be a more cost-effective means to achieve the storage benefits and offers greater overall water supply reliability and flexibility.

- Buck Lake Reservoir.—This storage site could offer effective operational benefits by releasing stored water to the Klamath River below the Klamath Project to meet Klamath River BO water demands thus allowing more water to be retained in UKL for meeting the UKL lake water levels BO. As such it offers the potential to provide a dedicated water supply source that could be integrated for more effective overall water management.

- Wocus Marsh (low option).—Preliminary results indicated a comparatively favorable relative B-C rating among surface storage options. This is partly attributed to no impervious lining included in costs. In this level of study, the need for a lining was not determined and may be a major cost element should this option be advanced to higher level planning studies. It is located close to UKL, which reduces conveyance systems and offers more direct, efficient interaction with the UKL water operations.

- Torrent Springs Reservoir.—An on-stream reservoir located high in the basin has better potential to address water quality without or at least with relatively lesser treatment requirements. The location in the upper reaches above UKL might also have relatively better socioeconomic attributes.

  Agency Lake Ranches (open-to-lake).—This option has a comparatively favorable relative B-C rating. However, the storage benefits provided cannot be easily determined and thus the actual benefits will require further investigation and hydrological modeling.

- Agency Lake Ranches (upgrade managed storage).—The added costs for storage at the site reduce the relative B-C rating somewhat. Multiyear carryover storage could require further study. The FWS owns this property, and the ultimate site land use remains to be determined.

6.5.2 Future water storage planning considerations

It is again worth noting that these current priority options do not preclude further review and planning for other viable options. The IAIR framework is intended to provide a basis for updating option information and priorities. Further planning for any options carried forward in subsequent planning stages would involve more detailed engineering design development (appraisal and feasibility), resulting in a refinement of the option design features, economic analyses, water rights or other institutional issues, and associated environmental and resource factors.

It appears that there may not be any one single option that can accomplish all the UKBOS objectives. In fact, potential advantages of developing a comprehensive staged or targeted strategy are apparent. The array of different surface water and groundwater options with different storage mechanisms employed illustrates this potential for meeting different aspects of the Klamath Basin water resource needs with a combination of measures that could meet water needs in the most practical and cost-effective manner. Future planning should consider the comprehensive or staged water storage strategies discussed previously.

6.5.3 Preliminary benefit and cost factor considerations

The preliminary level capital and life cycle cost estimates and the maximum and average annual benefit values provide an equitable basis for comparison between the IAIR options. This is consistent with the overall IAIR perspective to compile data and information on storage options, evaluate and screen options to identify to the better opportunities for detailed planning, and provide an effective framework to facilitate current and future water supply improvement activities. The benefit and cost estimates in this section should be reviewed from this context and within the stated goals and inherent constraints of preliminary level investigations.

Table 6-1.—Preliminary level capital construction and total life-cycle cost estimates and related engineering criteria and comparison factors for the array of IAIR water storage options.

ID #	Option	Total water storage capacity (acre-ft)	Capital construction				Total life-cycle				Water supply benefit				Carryover storage effectiveness	
			Total cost ($ millions)		**Unit cost** ($/acre-ft x1000)		**Total cost** ($ millions)		**Unit cost** ($/acre-ft x1000)		**Annual water delivery** [7] (acre-ft) Maximum / Average	**Total water delivery value** (PW$ x1000) [1] Maximum / Average annual	**Available water supply constrained by OWARS?** [2]	**Relative B-C** [3] **rating factor** Maximum / Average annual	**Total water storage capacity to annual evaporation ratio** [8]	**Pumping involved?**
			Without water treatment	With water treatment	Without water treatment	With water treatment	Without water treatment	With water treatment	Without water treatment	With water treatment						
IA-1a	w/o Project Future Cond.	0	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	N/A	No
IA-1b	w/o Project Nonstructural	0	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	N/A	No
IA-2a	ASR Passive Sprague #7a	7,500	59.1	63.1	7.88	8.41	63	76	8.40	10.13	7,500 890	37,500 4,450	No	0.493 0.059	Brief evap N/A	Yes
IA-2b	ASR Active Sprague #7a	7,500	57.1	67.1	7.61	NA	67	81	8.93	NA	7,500 890	37,500 4,450	No	0.463 0.055	N/A	Yes
IA-2c	ASR Active N Klamath #3	9,500	40	120	4.21	12.63	51	150	5.37	15.79	9,500 890	47,500 4,450	No	0.317 0.030	N/A	Yes
IA-2d	ASR Passive Langell #8	6,400	26.6	NA	4.16	NA	36	NA	5.63	NA	6,400 720	32,000 3,600	No	0.889 0.100	N/A	Yes
IA-2e	ASR Passive Gerber #9	8,000	34 / 12.5	NA	4.25 / 1.56	NA	44 / 32	NA	5.50 / 4.00	NA	8,000 3,720	40,000 18,600	No	0.92—1.25 [4] 0.42—0.58 [4]	N/A	Yes
IA-2f	ASR Passive Clear Lk #10	8,000	31	NA	3.88	NA	41	NA	5.13	NA	8,000 3,720	40,000 18,600	No	0.976 0.454	N/A	Yes
IA-2g	ASR Active Tule Lk #11	16,000	230.2	NA	14.39	NA	250	NA	15.63	NA	16,000 12,000	80,000 60,000	No	0.320 0.240	N/A	Yes
IA-2h	ASR Active So LKL #12a	8,000	49	130	6.13	16.25	59	160	7.38	20.00	8,000 890	40,000 4,450	No	0.250 0.028	N/A	Yes
IA-2i	ASR Active So LKL #12b	8,000	39	NA	4.88	NA	49	NA	6.13	NA	8,000 890	40,000 4,450	No	0.816 0.091	N/A	Yes
IA-2j	ASR Active So LKL #12c	8,000	50	130	6.25	16.25	60	160	7.50	20.00	8,000 3,720	40,000 18,600	No	0.250 0.028	N/A	Yes
IA-3a	ALRS Open Lake	56,200	69	NA	1.38	NA	69	NA	1.38	NA	44,200 21,750	221,000 108,750	No	3.20 1.57	4.47	No
IA-3b	ALRS Upgraded Storage	65,700	155	NA	2.36	NA	155	NA	2.36	NA	53,700 -21,000	268,500 Neg number	No	1.73 Neg number	5.22	Yes
IA-4	Aspen Lake	350,000	660.2	780.2	1.98	2.33	740	950	2.21	2.84	334,140 26,440	1,670,700 132,200	No	1.759 0.139	22.07	Yes
IA-5	Round Lake	TBD	Not evaluated—similar to Aspen Lake (or higher cost)				Not evaluated—similar to Aspen Lake (or higher cost)				Not evaluated—similar to Aspen Lake (or higher cost)				Not evaluated	
IA-6a	LLV Base 350 TAF	350,000	1,320.6	1,470.6	3.84	4.28	1,400	1,600	4.07	4.65	344,000 28,120	1,720,000 140,600	No	1.075 0.088	50.61	Yes
IA-6b	LLV WQ Release	350,000	1,670.3	1,770.3	4.86	5.15	1750	1,900	5.09	5.52	344,000 28,120	1,720,000 140,600	No	0.905 0.075	50.61	Yes
IA-7a	Swan Lake AB Feed	188,000	359.4	429.4	2.81	3.35	420	510	3.28	3.98	128,000 1,060	640,000 5,300	No	1.255 0.010	5.74	Yes
IA-7b	Swan Lake Algoma	350,000	662	802	2.20	2.67	720	950	2.40	3.16	300,600 22,080	1,503,000 110,400	No	1.582 0.116	7.09	Yes
IA-8	L Klamath NWR	80,000	287	NA	4.09	NA	310	NA	4.42	NA	70,146 5,590	350,730 27,950	No	1.046 0.090	8.12	Yes

ID #	Option	Total water storage capacity (acre-ft)	Capital construction				Total life-cycle				Water supply benefit				Carryover storage effectiveness	
			Total cost ($ millions)		**Unit cost** ($/acre-ft x1000)		**Total cost** ($ millions)		**Unit cost** ($/acre-ft x1000)		**Annual water delivery** [7] (acre-ft) Maximum / Average	**Total water delivery value** (PW$ x1000) [1] Maximum / Average annual	**Available water supply constrained by OWARS?** [2]	**Relative B-C** [3] **rating factor** Maximum / Average annual	**Total water storage capacity to annual evaporation ratio** [8]	**Pumping involved?**
			Without water treatment	With water treatment	Without water treatment	With water treatment	Without water treatment	With water treatment	Without water treatment	With water treatment						
IA-9	Tule Lake NWR	48,000	178.9	313.9	7.68	13.47	230	440	9.87	18.88	23,300 3,740	116,500 18,700	No	0.265 0.043	1.94	Yes
IA-10	UKL Raise Link R Dam	350,000	530	660	3.73	4.65	530	750	3.73	0.01	142,000 17,860	710,000 89,300	No	0.947 0.119	1.68	No
IA-11	UKL Dredge to Expand	2,000	150	NA	75	NA	170	NA	85	NA	2,000	5,000	No	.059	0.01	No
IA-12	Caledonia Marsh	21,500	92.7	169.7	6.05	11.08	105	200	6.85	13.05	15,321 2,970	76,605 14,850	No	0.383 0.074	3.47	Yes
IA-13a	Wocus Marsh High	350,00	598.1	738.1	1.76	2.17	630	860	1.85	2.53	339,802 26,440	1,699,010 132,200	No	1.976 0.154	34.32	Yes
IA-13b	Wocus Marsh Low	350,000	309.2	449.2	0.91	1.33	340	570	1.00	1.68	338,404 26,440	1,692,020 132,200	No	2.968 0.232	30.18	Yes
IA-14	Klamath DD	97,000	208	283	3.78	5.15	280	370	5.09	6.73	54,958 5,620	274,790 28,100	No	0.743 0.076	2.31	Yes
IA-15	Whiteline Reservoir	350,000	1,055.6	1,205.7	3.09	3.53	1,100	1,350	3.22	3.96	341,200 26,440	1,706,000 132,200	No	1.264 0.098	39.77	Yes
IA-16	Torrent Springs	421,800	389	399	1.06	1.09	390	410	1.06	1.12	367,600 19,210	1,838,000 96,050	No	4.483 0.234	7.78	No
IA-17	Williamson River	150,000	568	578	5.92	6.02	570	590	5.94	6.15	96,000 11,950	480,000 59,750	No	0.814 0.101	2.78	No
IA-18	Buck Lake	9,300	131.1	216	23.16	38.16	150	250	26.50	44.17	7,480 7,480	37,400 37,400	No	0.150 0.150	5.11	No
IA-19	Boundary	72,000	NA	240	NA	7.57	NA	320	NA	0.01	31,700 5,580	158,500 27,900	No	0.495 0.087	11.79	No
IA-20	Clear Lake J Canal	54,000	360	430	10.00	11.94	420	510	11.67	14.17	54,000 3,740	270,000 18,700	No	0.529 0.037	5.02	Yes
IA-21	Clr Lk ASR w/ Boundary	80,000	115	NA	2.90	NA	125	NA	3.15	NA	39,700 9,300	198,500 46,500	No	1.588 0.372	1.99	Yes
IA-22	Bryant Mountain (6)	103,200	4,903.8	5,003.8	43.80	44.70	5,200	5,400	46.45	48.23	99,552 3,740	497,760 18,700	No	0.092 0.003	30.09	Yes
	ALRS Mng'ed Storage (5)	27,800	NA	NA	NA	NA	20	NA	NA	NA	27,800 17,480	139,000 87,400	No	6.95 4.37	2.21	Yes

Notes:
(1) Total valuation derived at $100/acre-ft per year, over the 50-year storage project design life (unit price escalation and present value discounting assumed offsetting).
(2) Constraints based on data obtained from the Oregon Department of Water Resources—Water Availability Report System (OWARS, 2010).
(3) Relative B-C rating factors do not reflect thorough economic analysis and are only suitable for comparison between these options (developed on the same basis).
(4) Gerber ASR ranges reflect costs with onsite diesel power facilities and without diesel power (installing power transmission lines to this site).
(5) The current scenario of Agency Lake Barnes Ranches managed as offstream storage is shown for comparison purposes—average water delivery for 2004-2010. Maximum is set equal to average for purposes of this report.
(6) Total capacity = 115,600 ac-ft for lower reservoir but 12,400 ac-ft of pool space is to be reserved for daily power generation fluctuation. Estimated annual evaporation losses expected to be 3648 ac-ft.
(7) After annual evaporation losses (2.6 ft/surface acre/year) deducted from total storage capacity. Evaporation losses for Agency Lake options estimated for 9680 surface acres @ 1.24 ft/surface acre/year (12,600 ac-ft annual loss) due to typical operation of facility by spring refill with pumping of entire capacity before warmest summer months with highest evap rates occurs. This means very small or no effective carryover.
(8) ASR options (1-2 a thru 1-2j) do not have evaporation loss from stored water. Ratio only given for surface storage options or surface facility portion of hybrid ASR/surface storage options. Conveyance or evap losses for conveyed water to/from storage are neglected.
(9) Figure could be greatly reduced due to large evaporation rates and volumes if water is not passed thru Clear Lake Dam immediately and stored for any length of time.

Table 6-2.—Preliminary level potential environmental, cultural, and land resource considerations identified for the array of IAIR water storage options.

ID #	Option	Environmental resources			Socioeconomic considerations		
		Existing wetlands	**Fish species**	**Water treatment**	**Cultural resources**	**Regional factors**	**Land ownership**
IA-1a	w/o Project Future Cond.	No impacts	No impacts	No	No impacts	Continued water conflicts	No impacts
IA-1b	w/o Project Nonstructural	Minor direct impacts	No impacts	No	No impacts		No impacts
IA-2a	ASR Passive Sprague #7a	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Minimal	Not known—potential significant impacts further study required for surface facility impacts	Minor effects possible to nearby domestic or irrigation water supply wells	Some private land acquisition needed for surface facilities and mitigation wetlands
IA-2b	ASR Active Sprague #7a	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes	Not known—potential significant impacts further study required for surface facility impacts	Minor effects possible to nearby domestic or irrigation water supply wells	Some private land acquisition needed for surface facilities and mitigation wetlands
IA-2c	ASR Active N Klamath #3	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes	Minor impacts from surface facilities—further study required	Potential effects for nearby domestic or irrigation water supply wells	Minor private land acquisition needed—uses some existing conveyance infrastructure
IA-2d	ASR Passive Langell #8	Minor measurable impacts	No fish screening needed	Minimal	Minor impacts from surface facilities—further study required	Potential effects for nearby domestic or irrigation water supply wells	Minor private land acquisition needed—uses some existing conveyance infrastructure
IA-2e	ASR Passive Gerber #9	Minor measurable impacts—possible impacts to springs	No fish screening needed	Minimal	Minor impacts from surface facilities—further study required	Potential effects for nearby domestic or irrigation water supply wells	No private lands involved—uses only existing conveyance infrastructure
IA-2f	ASR Passive Clear Lk #10	Minor measurable impacts—possible impacts to springs	No fish screening needed	Minimal	Minor impacts from surface facilities—further study required	Minor effects possible to nearby domestic or irrigation water supply wells	No private lands involved—uses only existing conveyance infrastructure
IA-2g	ASR Active Tule Lk #11	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes	Not known—potential significant impacts further study required for surface facility impacts	Potential effects for nearby domestic or irrigation water supply wells	Some private land acquisition needed for surface facilities and mitigation wetlands—uses some existing conveyance infrastructure
IA-2h	ASR Active So LKL #12a	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes	Minor impacts from surface facilities—further study required	Minor effects for nearby domestic wells and potential effects for irrigation water supply wells	No private lands involved—requires land for mitigation wetlands—uses existing conveyance infrastructure
IA-2i	ASR Active So LKL #12b	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes	Minor impacts from surface facilities—further study required	Minor effects for nearby domestic wells and potential effects for irrigation water supply wells	No private lands involved—requires land for mitigation wetlands—uses existing conveyance infrastructure
IA-2j	ASR Active So LKL #12c	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes	Minor impacts from surface facilities—further study required	Minor effects for nearby domestic wells and potential effects for irrigation water supply wells	No private lands involved—requires land for mitigation wetlands—uses existing conveyance infrastructure
IA-3a	ALRS Open Lake	Minor measurable impacts—possible impacts to springs	No fish screening needed	Minimal	Minor impacts from surface facilities—further study required	Potential effects for nearby domestic or irrigation water supply wells	No private lands involved—uses only existing conveyance infrastructure
IA-3b	ALRS Upgraded Storage	Measurable Impacts—mitigation included in capital cost estimates	No fish screening needed		Uses previously disturbed or inundated lands—new facilities have minor footprint	Unknown—need further studies	No private lands involved
IA-4	Aspen Lake	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out		Uses previously disturbed or inundated lands—new facilities have minor footprint	Unknown—need further studies	No private lands involved
IA-5	Round Lake	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes—assumed to come under TMDL	Not known—potential significant impacts further study required for facility impacts	Unknown—need further studies—impacts private forested products lands	Requires acquisition of private forest products lands for reservoir and mitigation wetlands and minor private lands for canal and tunnel
IA-6a	LLV Base 350 TAF	Not scoped—see Table 6-1					
IA-6b	LLV WQ Release	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes—assumed to come under TMDL	Not known—potential significant impacts further study required for facility impacts	Impacts one private family ranch and one other landowner along canal right-of-way (ROW)	Requires acquisition of private land for reservoir, mitigation wetlands, and canal

ID #	Option	Environmental resources			Socioeconomic considerations		
		Existing wetlands	**Fish species**	**Water treatment**	**Cultural resources**	**Regional factors**	**Land ownership**
IA-7a	Swan Lake AB Feed	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes—assumed to come under TMDL	Not known—potential significant impacts further study required for facility impacts	Impacts one private family ranch and some landowners along canal and pipeline ROWs	Requires acquisition of private land for reservoir, mitigation wetlands, and canal and pipeline ROWs
IA-7b	Swan Lake Algoma	Measurable Impacts—mitigation included in capital cost estimates	Receives water supply from A Canal where fish screen already exists	Yes—assumed to come under TMDL	Not known—potential significant impacts further study required for facility impacts	Impacts private family ranches in Swan Lake Valley	Requires acquisition of private land for reservoir, wetlands, pipeline ROW
IA-8	L Klamath NWR	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes	Not known—potential significant impacts further study required for facility impacts	Impacts private family ranches in Swan Lake Valley	Requires acquisition of private land for reservoir, mitigation wetlands, pumping plant and canal and pipeline ROWs
IA-9	Tule Lake NWR	Measurable Impacts—mitigation included in capital cost estimates	Fish screening not needed—uses Lower Lost River water supplies which are presumed to be screened in the future	No—assumed to release internal to NWR	Not known—potential significant impacts further study required for facility impacts	NWR impacts—no private land impacted—NWR tourism could be enhanced	Minor private land acquisition needed for mitigation wetlands
IA-10	UKL Raise Link R Dam	Measurable Impacts—mitigation included in capital cost estimates	Fish screening not needed—uses Lower Lost River water supplies which are presumed to be screened in the future	No	Uses previously disturbed or inundated lands—new facilities have minor footprint	NWR impacts—no private land impacted—NWR tourism could be enhanced	Minor private land acquisition needed for mitigation wetlands
IA-11	UKL Dredge to Expand	Measurable Impacts—mitigation included in capital cost estimates	Existing fish screen at A Canal would need to be modified—fish ladder already available at existing Link River Dam	Yes—assumed to come under TMDL	Not known—potential significant impacts further study required for facility impacts	Minor private land impacts—mostly utilizes existing UKL footprint	Minor private land acquisition needed for mitigation wetlands
IA-12	Caledonia Marsh	Measurable Impacts—mitigation included in capital cost estimates	Existing fish screen at A Canal would need to be modified—fish ladder already available at existing Link River Dam	Yes—assumed to come under TMDL	Uses previously disturbed or inundated lands—new facilities have minor footprint	No private land impacts	No private land needed
IA-13a	Wocus Marsh High	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes—assumed to come under TMDL		Impacts one private farm and ranch	Requires acquisition of private land for reservoir and pumping plant
IA-13b	Wocus Marsh Low	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes—assumed to come under TMDL	Not known—potential significant impacts further study required for facility impacts	Impacts one private farm and ranch	Requires acquisition of private land for reservoir, mitigation wetlands, and pumping plant
IA-14	Klamath DD	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes—assumed to come under TMDL	Not known—potential significant impacts further study required for facility impacts	Impacts one private farm and ranch, and high-value subdivision residences and related infrastructure	Requires acquisition of private land for reservoir, mitigation wetlands, and pumping plant
IA-15	Whiteline Reservoir	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes—assumed to come under TMDL	Uses previously disturbed or inundated lands—new facilities have minor footprint	Impacts several private farm and ranch operations	Requires acquisition of private land for reservoir, mitigation wetlands, and pumping plant
IA-16	Torrent Springs	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out	Yes—assumed to come under TMDL	Not known—potential significant impacts further study required for facility impacts	Impacts several private farm and ranch operations	Requires acquisition of private land for reservoir, mitigation wetlands, and pumping plant
IA-17	Williamson River	Measurable Impacts—mitigation included in capital cost estimates	No fish screening needed—fish ladder required and included in costs	Yes	Not known—potential significant impacts further study required for facility impacts	Impacts several private farm and ranch operations	Requires acquisition of private land for reservoir and mitigation wetlands
IA-18	Buck Lake	Measurable Impacts—mitigation included in capital cost estimates	No fish screening needed—fish ladder required and included in costs	Yes	Not known—potential significant impacts further study required for facility impacts	Impacts several private farm and ranch operations	Requires acquisition of private land for reservoir and mitigation wetlands
IA-19	Boundary	Measurable Impacts—mitigation included in capital cost estimates	Fish screening needed to keep endangered aquatic species out—fish ladder required and included in costs	Yes—assumed to come under TMDL	Uses previously disturbed or inundated lands—new facilities have minor footprint	Impacts one private farm and ranch operation	Requires acquisition of private land for reservoir and mitigation wetlands
IA-20	Clear Lake J Canal	Measurable Impacts—mitigation included in capital cost estimates	Fish screening not needed—uses Upper Lost River water supplies which are screened at existing Clear Lake Dam	No—release to Upper Lost River	Not known—potential significant impacts further study required for facility impacts	No private lands impacted	Potentially requires acquisition of private land for mitigation wetlands
IA-21	Clr Lk ASR w/ Boundary	Minor measurable impacts	No impacts	No—release to Upper Lost River	No impacts	Minor private land impacts	Requires acquisition of private land for mitigation wetlands and pumping plant
IA-22	Bryant Mountain	Measurable Impacts—mitigation included in capital cost estimates	Fish screening not needed—uses Upper Lost River water supplies which are screened at existing Clear Lake Dam	No—release to Upper Lost River	Not known—potential significant impacts further study required for facility impacts	No private lands impacted	Potentially requires acquisition of private land for mitigation wetlands

Table 6-3.—Important characteristics of the high priority storage options identified in preliminary investigations for the array of IAIR water storage options

Options / factors	**Gerber ASR** (diesel powered)	**Clear Lake ASR**	**Boundary Reservoir**	**Clear Lake ASR / Boundary Storage**	**Buck Lake Reservoir**	**Wocus Marsh** (low option)	**Torrent Springs Reservoir**	**Agency Lk Ranches** (open-to-lake)	**Agency Lk Ranches** (current managed storage)
Engineering attributes									
Storage capacity (acre-ft)	8,000	8,000	31,700	39,700	5,660	350,000	421,800	56,200 (UKL WSEL Control)	27,800 (ALR AC Table)
Maximum yearly water delivery (acre-ft)	8,000	8,000	31,700	39,700	7,480	338,404	367,600	56,200 (UKL WSEL control)	27,800 (Controlled release)
Average annual water delivery (acre-ft)	3,720	3,720	5,580	9,300	7,480	26,400	19,200	21,750	17,400
Maximum total LC relative B-C rating	1.25	0.98	0.495	1.597	0.14	2.97	4.49	3.20	6.95—pumping life-cycle costs only
Average annual LC relative B-C rating	0.58	0.45	0.087	0.372	0.14	0.232	0.234	1.57	4.37—pumping life-cycle costs only
Relative carryover storage effectiveness	N/A subject to natural aquifer recharge rate	N/A subject to natural aquifer recharge rate	Moderate	Moderate	Low to moderate	High	High	Low	Low
Environmental resources									
Existing wetlands	Minor measurable impacts—springs could be affected	Minor measurable impacts—springs could be affected	Potential impacts & mitigation costs are expected	Potential impacts & mitigation costs are expected	Potential impacts & mitigation costs are expected	Potential impacts & mitigation costs are expected	Potential impacts & mitigation costs are expected	Extensive impacts & mitigation costs are expected	No impacts & mitigation costs are expected
Fish species	Fish screening not needed	Fish screening not needed	Fish screening not needed—upper Lost River supply is already screened at Clear Lake Dam	Fish screening not needed—upper Lost River supply is already screened at Clear Lake Dam	Fish screening is needed—required fish ladder included in preliminary cost estimates	Fish screening needed to keep endangered aquatic species out	Fish screening needed to keep endangered aquatic species out	Fish passage and access features are needed to minimize potential entrapment during drawdown	No fish screens needed to keep out endangered species during water storage cycles
Water treatment	Minimal	Minimal	No—release to upper Lost River	No—release to upper Lost River	Yes—assumed to come under TMDL	Yes—assumed to come under TMDL	Yes—assumed to come under TMDL	No—fill and release is direct to UKL	No—fill and release is direct to UKL
Socioeconomic considerations									
Cultural resources	Potential impacts for surface water facilities—requires further study	Potential impacts for surface water facilities—requires further study	Not known at this time—impacts of proposed facilities will require further study	Not known at this time—impacts of proposed facilities will require further study	Impacts are not expected—would inundate existing lands with small footprint	Not known at this time—impacts of proposed facilities will require further study	Not known at this time—impacts of proposed facilities will require further study	Not expected given existing land use is already in annual flooding	Not expected given existing land use is already in annual flooding
Regional factors	Potential impacts to nearby domestic and irrigation water supply wells	Minor impacts to nearby domestic and irrigation water supply wells	No private lands impacted	No private lands impacted	Impacts one private farm and ranch operation	Impacts one private farm and ranch operation	Impacts to several private farms and ranch operations	No impacts expected to nearby to lands or other resources	No impacts expected to nearby to lands or other resources
Land ownership	No private lands involved—uses existing canals or stream channels for water delivery	No private lands involved—uses existing canals or stream channels for water delivery	Potentially requires acquisition of some private lands for mitigation wetlands	Potentially requires acquisition of some private lands for mitigation wetlands	Likely acquisition of some private lands for reservoir and mitigation wetlands	Requires acquisition of some private lands for reservoir, mitigation wetlands, and pump station	Requires acquisition of some private lands for reservoir, mitigation wetlands, and pump station	Site properties were transferred to the FWS to incorporate into UKNWR	Site properties were transferred to the FWS to incorporate into UKNWR
Preliminary priority assessment									
Overall priority	**Most favorable**	**Most favorable**	**Lower priority as stand alone**	**Most favorable**	**Could be dedicated to lower river**	**Most favorable**	**Most favorable**	**Annual storage is not managed**	**Current managed storage has no wetland impacts**

7.0 Findings, Conclusions, and Future Actions

Many offstream storage options in the Upper Klamath Basin have been examined over time and formalized within the KBWSI and UKBOS processes as described in this IAIR framework. UKBOS study evaluations indicate the two leading groundwater and surface water storage options are the diesel powered ASR option at Gerber Reservoir, and the combined Clear Lake ASR with Boundary Reservoir storage option. The IAIR findings indicate that there is a compelling justification to proceed with the next phase of UKBOS planning investigations as authorized by the Enhancement Act. The specific recommendations for future action involve carrying these two priorities forward to the next level of the authorized planning process—formulating the selected storage options into detailed alternatives for an appraisal study. The recommended appraisal investigation is required to obtain additional specific information and develop more detailed plans for the Gerber ASR and Clear Lake ASR/Boundary Reservoir alternatives as appropriate to refine the economic analyses before proceeding with potential feasibility design planning and environmental compliance investigations.

Section 7 Topics:

- *Conclusions regarding the current priority storage options recommended for development as initial alternatives for further planning stages*
- *Plan formulation considerations to fully develop and define alternatives and investigation requirements for appraisal level storage planning*
- *Specific recommendations for future IAIR planning and potential advantages of a coordinated strategic storage implementation approach*

As was seen in the previous discussion, preliminary groundwork has been laid but more work remains to be done to determine the proper course of action. It would also be necessary to answer questions regarding the opportunity for, and possible use of, power generation or other related factors or specific alternatives that could potentially enhance the overall cost effectiveness of any storage alternatives that were to proceed with project design and implementation stages.

7.1 Priority Alternatives for Future Investigations

The IAIR findings indicated that the Gerber ASR and hybrid Clear Lake ASR / Boundary Reservoir could be viable alternatives to improve water storage conditions in the Klamath Basin with effective capacity and carryover storage to alleviate moderate water shortages in the most cost effective means available at

UKBOS-IAIR current storage priority synopsis—

Two of the water storage options assessed in this IAIR are recommended as initial alternatives for appraisal level planning investigations. These options—Gerber ASR and Clear Lake ASR with Boundary Reservoir storage—were selected from a short list of priority options. A total of 36 water storage options were developed at preliminary level and screened to identify the most promising opportunities to address the goals of the Enhancement Act. Current option priorities were based on preliminary estimated costs, water supply benefit factors, and consideration for potential environmental, socioeconomic, regulatory, and institutional issues.

The identified priority options both involve groundwater production with subsequent storage in surface reservoirs. Preliminary studies indicated the natural rate of recharge would exceed the target groundwater production during an average annual cycle—a passive ASR strategy. Secondary storage in surface reservoirs allows for reregulation and conveyance directly to Klamath Project water systems to improve water delivery reliability while allowing flexibility for integrating surface and groundwater resource operations.

These options do not preclude other measures that could be combined for greater overall water supply improvement. For example, upper basin priority options—Torrent Springs Reservoir and Wocus Marsh—could add to the UKL basin storage. The UKBOS-IAIR summarizes the current findings and importantly, it also provides framework for updating and reevaluating water supply measures in the future as more information is available or circumstances change.

this time. These alternatives represent the current priorities for future action via continuation to the authorized next planning process investigation stages.

Reclamation determined that all options examined in section 5 are technically feasible. Preliminary cost estimates indicate that options that require constructing major infrastructure are more expensive, but when compared per water delivered for all uses, all options are within a comparable range of costs. Because these costs estimates are preliminary and entail different costing methods, additional design data and analysis are required to refine the construction costs.

Costs associated with O&M, land acquisition, mitigation, and relocating utilities will also need to be studied more fully comprehend impacts and subsequently calculated to fully understand the costs associated with implementation of any option selected for construction. These data will be compiled in the next Study phase. However, the information developed for this investigation does allow general comparisons between options and justification for determining which options will then be moved forward into appraisal planning studies.

In addition, all of the options examined are expected to have some potential for environmental effects. Reclamation would need to undertake data collection and analyses in coordination with State and Federal agencies to fully identify specific effects and measures to mitigate effects where possible and appropriate.

Although none of the entire UKBOS list of options had a 50-year average annual water delivery benefit to cost relationship nearing or above unity, Reclamation supports the conversion of any two of the 7 options cited previously (table 6-3) into alternatives for purposes of the appraisal studies. At this point it appears to be advantageous to select one surface storage option and one ASR related option to advance to appraisal studies. Storage option(s) carried forward could depend on needs and opportunities jointly developed in consultation with the water user and stakeholder community in the Klamath Basin.

In addition, there could be greater strategic benefits in meeting Klamath Basin water supply needs by implementing a combination of options to target certain conditions and enhance overall benefits versus implementing any one storage option alone. For example, if having a water reserve for downstream fishery flows is a critical need, then surface storage at Buck Lake Reservoir, could be a preferred surface storage priority even though it would not be large enough for effective carryover storage.

Torrent Springs Reservoir or a Wocus Marsh option could become higher priority to provide an additional headwater surface supply to supplement UKL. Similarly, the Boundary Reservoir option is another example of strategically located storage that could be pursued to provide water storage for a strategic area of the existing Klamath Project. Torrent Springs also offers the highest carryover relative effectiveness among the UKBOS options in table 6-1. Although water supply and hydrologic data are scarce and the recent climate conditions in the region raise uncertainties for Boundary Reservoir as a stand-alone reservoir, the combined option of incorporating Clear Lake ASR could improve the overall cost-effectiveness and provide additional water management flexibility involving surface and groundwater operations.

If a surface storage adjunct to UKL is still sought, storage at Wocus Marsh could be investigated. It should be noted that reservoir lining was a major cost element for the Long Lake Valley option; it was not included or scoped and could be a major cost element as well for both Wocus Marsh options, Whiteline Reservoir, both Swan Lake options, Caledonia Marsh, or Aspen Lake options.

One of the groundwater ASR options might be used to serve as a critical reserve to alleviate future water shortages and the preferred ASR option is Gerber ASR w/diesel engine drive pump wells. ASR recovery (passive recharge) options have higher preliminary relative B-C ratings among all options but still have relatively low yields with no large volume effective carryover storage. Modeling studies might help to address the concept of obtaining groundwater supplies to serve as a water shortage reserve that would only be tapped into to alleviate short-term serious water shortages. Water rights for ASR are a remaining question.

Given the significant economic costs associated with any of the identified storage options, Reclamation will continue to work with local water users and stakeholder community to examine lower cost alternatives such as water conservation, water measurement, water markets, dry-land farming conversion, and reconstruction of wells. Conversely, for some communities, the storage construction costs may not pose barriers with respect to the economic benefits of sustaining the agricultural production in the area. In addition, carryover storage is a major goal under the Enhancement Act. The nonstructural mechanisms described do not offer longer-term carryover storage capability. In addition, issues concerning the potential impacts to fish, wildlife, recreation, infrastructure, and private property were cited for almost all options presented in this IAIR.

Overall, it is readily apparent that it is not simply a relative B-C rating that could favor one option versus another. It is important to avoid an overemphasis on using only the relative B-C at preliminary screening level. This IAIR framework has compiled a substantial amount of information and provides a useful database for further discussion and investigations. Stakeholder review of IAIR findings could generate interest in collecting more detailed data or in refining the analysis numbers. Narrowing down current priorities is only considered a first step and a means to facilitate future water storage improvement actions.

7.2 Alternatives Compared to Without Project

Reclamation appraisal studies are required to measure project benefits according to established principles and guidelines (P&Gs). These Federal P&Gs also specify procedures for determining the National Economic Development (NED) benefits of Federal actions for project implementation (Reclamation, 1983). For example, an analysis of NED agricultural benefits is a “with” and “without” project comparison that identifies the change in net farm income related to a change in crop acreage under the same cropping pattern. The Klamath Basin HydroEconomics model (KB_HEM) is currently used to measure the cropping pattern for defined with and without project *scenarios*, based on hydrologic conditions. Net farm income is then estimated using a farm budget methodology. The agricultural benefits would be based on (1) the average annual water supply, (2) the cropping pattern for both with and without offstream storage, and (3) the benefit unit value per acre for each crop. The KB_HEM model measures cropping pattern effects for alternatives, including the without project alternative, based on the annual average water supply. The benefit unit values, estimated using a farm budget methodology, are applied to the cropping patterns, incremental to the without project alternative to estimate the NED agricultural benefits for both the with and without alternatives. This model could be used for alternatives being analyzed at planning ;levels higher than the UKBOS studies.

The model used to analyze hydrologic implications of proposed options includes a representation of deliveries to Klamath Project water users, and demands based on precipitation conditions. The model uses a 46-year historical hydrology database (1961-2006) to simulate operations of the Klamath River system, UKL elevations, flows at Iron Gate Dam, agricultural and wildlife refuge deliveries in accordance with present and assumed future operating criteria. Delivery results for both the with and without project scenarios were applied to calculate water deliveries for each year of the simulated model run. The average of these annual values was used to determine the total water delivery benefits for a given UKBOS storage option and is used for purposes of tables 6-1 and 6-3..

7.2.1 Current priority groundwater ASR option

The Gerber ASR option with diesel driven pumps would involve groundwater recovery within the Gerber Reservoir area of the Lost River watershed and is a preferred ASR option for subsequent appraisal studies. The USGS (2010) developed preliminary scoping parameters. The identified Gerber Reservoir (site #9) is preferred to minimize existing wetland areas and to have reduced distance to the Gerber Reservoir and Klamath Project water systems. Water delivery could use existing Klamath Project conveyance systems and water users would benefit from the water available during times of moderate water shortages.

Groundwater retrieval would use diesel generator-powered pumped wells with passive natural recharge to replenish the groundwater supplies. As a result, this represents a modified ASR strategy. Simulation modeling studies were conducted to assess aquifer extraction and recharge rates to evaluate the sustainability as an effective natural recharge ASR strategy.

Wellhead pumps would extract groundwater and deliver it to Gerber Reservoir for downstream use or Klamath Project water users. Preliminary plans are based on 10 wells at up to 15 ft^3/s each. The well field capacity was oversized to allow for some equipment reliability and to achieve estimated retrieval flows. The diesel powered motorized pumps, although costly themselves, would eliminate higher costs of lengthy electric power supply infrastructure to supply each well in the well field and the main trunk line from the local power supply grid.

Groundwater in the Gerber Reservoir watershed supplies water for recharge of the larger regional aquifer. Hydrologic analysis results (appendix D) estimated average annual water supplied by this option would be 2.5 TAF, although initial modeling only allowed water to be extracted two months a year. The modeling analysis results imply this option is only supplying supplemental water in July and August in shortage years (60 days of pumping). This conservative pumping basis was applied in the preliminary modeling evaluations.

Model sensitivity analyses were also conducted to assess if the full 8,000 acre-feet of the aquifer supply could be utilized. This volume more closely corresponds to a four-month total period (July through October) to maximize delivery benefits. For either pumping scenario, two or four months, the modeling results indicated the natural aquifer recharge rate in nonpumping months was sufficient to refill the aquifer groundwater supply use within each annual cycle.

Reclamation believes the relative benefit-cost factor for this option could range from about 0.5 to 1.0 for the average annual or maximum annual delivery water volumes respectively, and this is comparatively more favorable than most surface storage options. Appraisal studies would include optimization of well field design and size (size and number of wells and pumps). The option also requires minimal water treatment and would have less potential for wetlands impacts than surface storage options. These factors reduce construction and annual O&M costs.

The Gerber ASR (diesel-powered) option accommodates further planning studies and implementation in phases, using various possible configurations. This design flexibility could help to expedite required planning, implementation, and effective water delivery operations faster than other options evaluated.

7.2.2 Current priority surface water storage option

The hybrid Clear Lake ASR with Boundary Reservoir storage option was selected as a recommended priority because it improves the cost effectiveness for the most advantageous surface reservoir option (Boundary Reservoir) and adds flexibility for different ways to integrate surface and groundwater operations. As the name suggests, it is a combination of separate IAIR options for Clear Lake ASR (IA-2f) and Boundary Reservoir (IA-19) that were evaluated individually. The combined option could take produce greater identified benefits at comparable costs.

This option involves groundwater recovery in the Clear Lake Reservoir basin with water storage in a new reservoir on the Lost River at the Boundary Reservoir site near the Oregon-California border. Groundwater would be extracted at a pumped well field (at ASR site #10) and passed through Clear Lake Dam for storage in Boundary Reservoir. Preliminary results indicated the natural recharge rates in this area would replenish aquifer supplies during each annual cycle and therefore, this represents a passive ASR mechanism. Storage constraints at Clear Lake would not be affected, although excess spill flows from Clear Lake Dam could be stored in Boundary Reservoir to enhance the total surface storage water budget. Water delivery would use the existing Klamath Project conveyance systems and provide additional water available during times of shortages.

Aquifer recharge and extraction rate capacities and surface storage operational factors would define hydrological operations. Preliminary plans are based on 10 wells with up to 15 ft^3/s applied over a 60-day extraction period, yielding a total recovery of 8,000 acre-feet per year. The proposed Boundary Reservoir would have an estimated storage capacity of up to 72,000 acre-feet, which could provide for carryover storage from year to year. Reservoir storage would be subject to evaporation and could require an impervious lining to control seepage losses. Appraisal studies would further refine the reservoir design configuration, conveyance systems, and the groundwater recovery and surface storage operating parameters.

Boundary Reservoir estimated construction and life-cycle costs were lower than the other surface storage options, and the Boundary location could also improve the operational flexibility and delivery reliability for the Klamath Project. Initial review of potential environmental issues indicated the Boundary Reservoir site would have less complex issues than other surface storage options. The capacity could also potentially be augmented by excess flows from the Lost River or the Rock Creek tributary. The design features to integrate surface and groundwater storage would require more detailed planning investigations.

The estimated relative benefit-cost factor is about 1.59 based on maximum annual delivery benefits to 0.37 for the average annual delivery. Appraisal investigations are necessary to define the infrastructure design and operating parameters for the Clear Lake ASR groundwater facilities and the Boundary Reservoir as appropriate to develop more accurate benefit and cost relationships.

7.3 Additional Plan Formulation Considerations

Investigations conducted at Appraisal-level project planning require more detailed formulation of specific alternatives. These alternatives are frequently formulated to capture the major technical considerations or project related implications as a means of refining the project engineering features, cost and benefit estimates, and environmental cultural, or socioeconomic issues.

7.3.1 Unresolved issues and investigation needs

Provisions and costs for facilities to address water quality issues and any potential need for treating the stored water were investigated but not included in table 6-3 because a preliminary indication in formal correspondence from Oregon Department of Environmental Quality (ODEQ, 2007) stated that no treatment would be needed for UKL water stored offstream elsewhere and returned to UKL and would not require a National Pollutant Discharge Elimination System permit. In the IAIR, water quality issues were addressed from a preliminary standpoint, based on specific issues associated with each identified water storage option. Future option variations would require further examination during subsequent appraisal and feasibility investigations.

For appraisal and feasibility studies purposes, a more complete investigation of any leading offstream storage project alternatives will need to involve characterizing how to use the stored water. For example, the following determinations should be made after addressing all pertinent questions:

- How should water storage operations be balanced between the studied option and UKL be maintained? Just store UKL spills or make explicit withdrawals in anticipation of spills? Would economic costs of pumping be considered?

- What are the intended uses of the offstream storage? Are uses for agriculture, lake levels management, instream flows, or all three? Under what conditions? And does this mean that no flow above minimum requirements ever goes past Iron Gate Dam?

- For surface water storage options, what are the anticipated losses due to evaporation and groundwater seepage? This will depend on the connectivity of the groundwater model with the river and how this can be characterized in the surface water model or through use of a hydrogeologic modeling process that would study the interaction of the surface and groundwater domains in the Upper Klamath Basin both with and without the proposed storage option.

- What are the actual benefit(s) for the Klamath Project of implementing the studied option facilities?

- What are the impacts to Klamath Project operations with or without the construction of the studied option considering the latest Biological Opinion?

7.3.2 Study management and public involvement

If the appraisal studies of the alternatives determine that one and/or the other alternatives is financially and environmentally viable, Reclamation would then conduct scoping meetings to initiate compliance with NEPA. These meetings would identify environmental issues and concerns and assist in defining the scope of analyses that Reclamation would conduct to determine environmental effects and possible mitigation.

Reclamation would also initiate consultation with Tribal governments, as well as ESA consultation with the FWS and NMFS, as appropriate to address all other appropriate environmental rules and regulations.

A planning report and appropriate NEPA report would be prepared to document the investigation and recommendations. This planning report document would then provide supporting information for any requests to Congress for construction funding for any selected alternative(s).

7.4 Investigation Process and Schedule Factors

Reclamation could initiate appraisal investigations for the priority Gerber ASR and Clear Lake ASR / Boundary Reservoir options as soon as these future actions are approved. Additional data collection and analyses would be necessary to further develop engineering designs and improve the accuracy of cost estimates according to Reclamation planning process policies and guidelines.

Economic analyses will occur to determine if the alternatives are economically justified and financially feasible. Reclamation will begin data collection and surveys to determine the presence of fish, wildlife, plants, and cultural resources in areas potentially affected by the selected alternatives. Additional geologic and hydrologic investigations are expected for the priority options. Reclamation will also continue aquifer-monitoring activities that began in 2006.

In keeping with the IAIR objectives, selected options carried forward in appraisal planning would first require additional formulation to define specific alternative attributes in greater detail. For example, if carried forward, the Gerber ASR and Clear Lake / Boundary Reservoir characteristics would be developed into defined alternatives for the appraisal planning and investigation process.

7.5 Specific Recommendations for Future Action

Reclamation will continue to work with the local water user and stakeholder community to examine less expensive alternatives such as water conservation, water measurement, water markets, conversion to dryland farming, and reconstruction of wells, given the significant economic costs associated with constructing any of the options. In some instances, the construction costs may not appear significant when considering the current economic benefits of sustaining current agricultural production in the Klamath Basin. In addition, Reclamation is seeking carryover storage solutions as one of the charges under the Enhancement Act. Lower cost nonstructural options described previously cannot offer that.

Reclamation has identified potential for fish, wildlife, recreation, infrastructure, and private property issues associated with many options in this IAIR. It is very obvious that it is not appropriate to simply view the relative B-C ratings that could favor one option over another. Overemphasis on using only relative B-C ratings at this preliminary screening level should be avoided.

The IAIR serves as a framework to assist in future planning discussions and initial reviews could generate some interest in refining the numbers. Narrowing down current priorities is considered a key step in this process and the IAIR framework priorities could be periodically reviewed, updated, and adjusted as additional data and information are obtained or progress is made on improving storage within the Klamath Basin. The current priority Gerber ASR option, Clear Lake / Boundary Reservoir option, and other options could be combined or incorporated into more comprehensive plans to enhanced benefits of individual options or apply specific strategies in improving the water supply conditions within the Klamath Basin. Narrowing down current priorities is still valid and useful.

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** All maps created by Bureau of Reclamation personnel using Arc-GIS programming and shape files

Appendices

A—UKBOS Water Operations Modeling

B—UKBOS Water Treatment Assessment Report

C—Preliminary Costs and Estimating Guidelines

D—ASR Studies

E—Agency Lake Ranches Site Planning Studies

F—Long Lake Valley Reservoir Appraisal Studies

G—Deming Creek Initial Reconnaissance Studies

H—Sycan River–Torrent Spring Dam Site–Preliminary Geologic Investigation, August 2007

I—Williamson River Canyon–Proposed Water Storage Site–Preliminary Geologic Investigation, August 2007

APPENDIX A

UKBOS Water Operations Modeling

- **Summary report on operations modeling for Options**
- **Model network diagrams for Options**

UKBOS OPTIONS HYDROLOGIC MODELING SUMMARY

A limited number of the UKBOS options, including Long Lake Valley (LLV), have been analyzed through modeling to understand their hydrologic impacts to Klamath Project and Upper Klamath Basin operations. After 2008, a new Biological Opinion was rendered by NMFS which requires more water to be released for downstream Klamath River uses.

Modeling Software

Modeling has been conducted using the Water Resources Integrated Modeling System (WRIMS) – general purpose river and reservoir planning and operations modeling software developed and maintained by the California Department of Water Resources Modeling Support Branch. The Klamath Project Simulation (KPSIM) model was originally a spreadsheet model. Development of the WRIMS KPSIM model began in 2004 and by 2006 had replaced the old KPSIM spreadsheet model as the analytical tool of choice to address increasingly complex water management scenarios and strategies in the basin.

WRIMS uses a mixed integer linear programming solver to route water through a network. Policies and priorities for water routing are implemented through user-defined weights applied to flow arcs and storage nodes in the network. System variables and the constraints on them are specified with a scripting language called the "water resources engineering simulation language" (wresl). Wresl code is developed in simple ascii text files. Time series input data and model results are stored in HEC-DSS files. Relational data (lookup tables) is stored in ascii text files.

Hydrology Data

The current representation of the Klamath Project uses a 46 year period of hydrology, encompassing water years 1961 through 2006. A full set of data is available from the USGS for key streamflow gages for this period, and it includes the dry period of record as well as some of the wettest years recorded for the Upper Klamath Basin. Hydrologic input to the model includes historical net inflow to Upper Klamath Lake, Lost River Diversion Canal spills to the Klamath River, local gains between Link River and Keno Dam, runoff from agricultural lands above Lower Klamath Lake, gains between USGS gages at Keno and Iron Gate, and returns from the Klamath Straits Drain.

Each water year is divided into 17 timesteps – full months in August-February and half-months in March-July. This temporal scale is necessary to represent some operational requirements for UKL elevation and Iron Gate flow.

System Description and Model Network

Figures in the following section show the schematic diagram of the model used in the analysis. Headwaters inflows are represented for Upper Klamath Lake, Gerber Reservoir, and Clear Lake. Local gains and other inflows are represented by Lake Ewauna gain, Lost River Diversion Channel Spill, Area A2 Winter Runoff, Klamath Straits Drain inflows, and Keno to Iron Gate Gain. Diversions to Project demands are represented at A Canal, Lost River Diversion Channel, North Canal, and Ady Canal. Long Lake Valley (LLV) or the other UKBOS options are represented as an offstream storage facility, connected to the system via Upper Klamath Lake or other existing facility or a new facility that would need to be constructed. With a monthly/bi-monthly timestep, the net balance of flow between LLV or other UKBOS options depending upon their location and Upper Klamath Lake is either inflow or release. For purposes of the UKBOS options hydrologic modeling studies, options are referred to as “projects.” These projects are the stand alone options implemented.

Proposed Action Operations Criteria

The following discussion is based on the modeling of those options based on the BOs in place prior to 2009. The model was run for a “without project” scenario and various with-project (implementation of options) scenarios. The “without project” option involves doing nothing and its subsequent impacts of the continuation of demand growth and competition for water in the entire Klamath River Basin and future conflicts over water between the Upper and Lower Klamath Basins. The “without project” term refers to conditions without implementing water storage and/or delivery infrastructure improvements described for storage options but is also not meant to imply any changes in the current existing Klamath Project . This does imply a “no action” for the purposes of the National Environmental Policy Act. The “without project” scenario, for purposes of the UKBOS studies, is the same as “no action” even though it is the March 2008 Proposed Action for Klamath Project operations included in Reclamation’s Biological Assessment is termed as the “future no action” scenario as explained later. Input data and operating rules for the Klamath Project 2008 Proposed Action are described below. If operational requirements are altered in the model as a result of post-2008 biological opinions, new modeling inputs would result in potential changes in model outputs.

- Priorities for water use are:
    - meet or exceed the minimum Iron Gate Dam flows.

- meet or exceed the minimum Upper Klamath Lake elevations.
- sustain water diversions to meet contractual agreements between Reclamation and water users.
- meet Upper Klamath Lake Refill Targets.
- Remaining water supply is split between flow in the Klamath River at Iron Gate Dam and storage in Upper Klamath Lake according to an interactive management process that is described below.

- Base flows at Iron Gate Dam and base water surface elevations for Upper Klamath Lake are shown in Table 1.

Month	Klamath River	Upper Klamath Lake	
	Proposed Minimum Flows below Iron Gate Dam	Proposed Minimum Elevation (ft)	Proposed Lake Refill Targets (ft)
October	1300		4139.1
November	1300		4139.9
December	1300		4140.8
January	1300		4141.7
February	1300	4141.5	4142.5
March	1450	4142.2	4143.0
April	1500	4142.2	
May	1500	4141.6	
June	1400	4140.5	
July	1000	4139.3	
August	1000	4138.1	
September	1000	4137.5	4138.0

Table 1. Flow and lake elevation criteria.

- Klamath Project demand for irrigation and refuge water users are based on a precipitation index that defines annual demand and its monthly distribution. A1 deliveries include diversion from UKL to the A Canal and diversion from Lake Ewauna to the Lost River Diversion Channel. A2 deliveries include diversions from the Klamath River to irrigation uses through the North and Ady Canals. Refuge deliveries as modeled are the Ady Canal deliveries to the Lower Klamath Lake National Wildlife Refuge. Tule Lake National Wildlife Refuge, D-pump operations, and distribution of Lost River water is not explicitly represented in the model. Annual demands based on the precipitation conditions are shown in Table 2.

Feb-Mar Precipitation Index (in)	A1 Demand Apr-Mar (TAF)	Refuge Demand Apr-Mar (TAF)	Oct-Jan Precipitation Index (in)	A2 Demand Apr-Mar (TAF)
0.00 – 1.999	340	30	0.00 - 3.99	105
2.00 – 2.749	310	25	4.00 - 6.99	95
2.75 – 3.299	300	20	7.00 - 9.99	90
>= 3.30	275	15	>= 10.00	80

Table 2. Project demand as a function of precipitation.

- Expanded storage capacity in Upper Klamath Lake includes Agency Lake/Barnes and the Tulana Farms/Goose Bay areas. Evaporation and changes to consumptive use for these new storage areas are represented specifically in the model.

- Flood control rules are adjusted from the original Pacific Power and Light levels to reflect the same amount of available storage space given the modified storage capacity.

- Interactive management of "surplus water". Surplus water is identified water supply that is above and beyond that required to meet the base criteria for project operations. The interactive management process provides a method for sharing that surplus between additional flow at Iron Gate and higher carryover storage in UKL. Augmentation of spring and summer flows at Iron Gate Dam above base levels is based on the computed surplus water supply likely to occur by the end of September. Surplus water supply is calculated in April as:

Surplus Water Supply = A + B – C – D + E – F where:

A = End-of-March storage in Upper Klamath Lake.
B = Upper Klamath Lake inflow, April through September (perfect foresight).
C = September target carryover storage.
D = Iron Gate minimum flow requirement, April through September.
E = Link River to Iron Gate Dam gain, April through September (perfect foresight).
F = Agriculture and National Wildlife Refuge demand, April through September.

A portion of the surplus water is allocated to increasing Iron Gate Dam flows above the minimum levels. This portion is based on a seasonal water supply factor, which evolves as water supply conditions change through the year. This factor is calculated in each time period April through September as:

Seasonal Water Supply Factor = G + H – I where:

G = End-of-previous time period storage in Upper Klamath Lake.
H = The Upper Klamath Lake inflow, "now" through September, (perfect foresight).
I = September target carryover storage.

The percentage of the April through September surplus water supply allocated to flow augmentation, interpolated relative to this continually updated seasonal water supply, is shown in Table 3. Note that there is not an explicit allocation of the surplus to UKL. Whatever portion of the surplus is not specifically targeted for Iron Gate flow augmentation will remain in storage in UKL, and is considered de facto "lake level augmentation".

Semimonthly or Monthly Period [1]	**If Seasonal Supply Factor in TAF was:**	**If Seasonal Supply Factor in TAF was:**	**If Seasonal Supply Factor in TAF was:**	**If Seasonal Supply Factor in TAF was:**
May 1 – 15	0 to 790	790 to 920	920 to 1181	above 1181
May 16 – 31	0 to 728	728 to 850	850 to 1069	above 1069
June 1 – 15	0 to 661	661 to 775	775 to 949	above 949
June 15 – 30	0 to 579	579 to 687	687 to 853	above 853
July 1 – 15	0 to 501	501 to 604	604 to 756	above 756
July 16 – 31	0 to 434	434 to 530	530 to 685	above 685
August	0 to 363	363 to 458	458 to 609	above 609
September	0 to 256	256 to 349	349 to 498	above 498
Percent of Surplus Water Supply to augmentation the Iron Gate Discharge Flow is:	**20%**	**20% to 36%**	**36% to 35%**	**35%**

[1] In modeling, no flow augmentation above Iron Gate Dam minimum flows in April exists. However, flows in excess of minimums did occur during spill events. Spills have historically occurred in April.

Table 3. Percent of surplus water supply allocated to Iron Gate flow augmentation.

Monthly distribution of the bulk seasonal flow augmentation is shown in Table 4. The distribution is also a function of the seasonal supply factor. Water that is not specifically targeted for flow at Iron Gate Dam remains in Upper Klamath Lake, and is considered de facto "lake level augmentation".

Time Period	Seasonal Supply Factor in TAF	Dist of IG Flow Aug.	Seasonal Supply Factor in TAF	Dist of IG Flow Aug.	Seasonal Supply Factor in TAF	Dist of IG Flow Aug.	Seasonal Supply Factor in TAF	Dist of IG Flow Aug.
May 1 - 15	0 to 790	.33	790 to 920	.26	920 to 1181	.15	above 1181	.15
May 16 - 31	0 to 728	.33	728 to 850	.25	850 to 1069	.15	above 1069	.15
June 1 - 15	0 to 661	.1	661 to 775	.135	775 to 949	.22	above 949	.20
June 15 - 30	0 to 579	.1	579 to 687	.135	687 to 853	.22	above 853	.20
July 1 - 15	0 to 501	.03	501 to 604	.055	604 to 756	.065	above 756	.075
July 16 - 31	0 to 434	.03	434 to 530	.055	530 to 685	.065	above 685	.075
August	0 to 363	.03	363 to 458	.035	458 to 609	.04	above 609	.05
September	0 to 256	.05	256 to 349	.075	349 to 498	.09	above 498	.1

Table 4. Distribution of Iron Gate Dam flow augmentation.

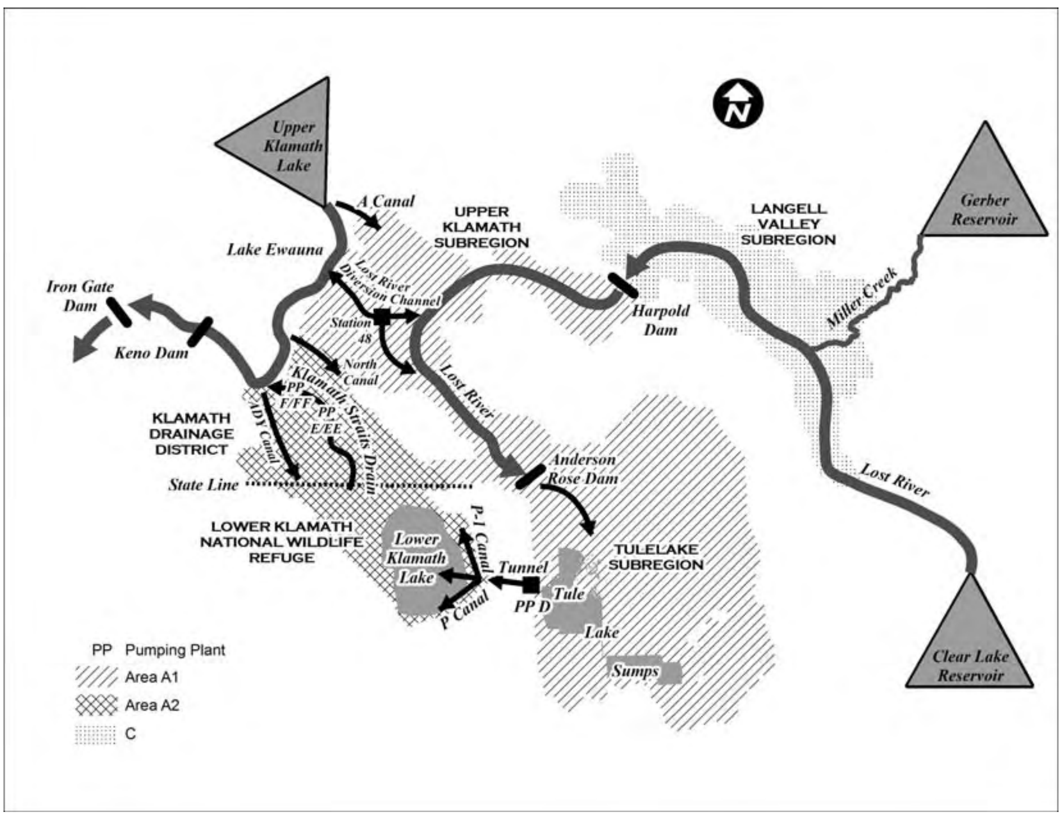

Figure 1 - Schematized diagram of current Klamath Project and related Upper Klamath Basin hydrologic features

Options Operations Criteria

The "without project" option or the "no action" scenario is defined as doing nothing. It does not include consideration of future actions. "Future without project" or "future no action." is referred to within UKBOS studies as the March 2008 Proposed Action for Klamath Project operations included in Reclamation's Biological Assessment, occurring at the point in time (roughly the year 2016) where the Upper Klamath Basin as a system includes the breaching of the existing boundary levees of Agency Lake/Barnes Ranches (AL/Barnes Ranches, ALR/BR or ALR/Barnes).
The with-project (action) options are consistent with the proposed action assumptions but include various scenarios of Long Lake Valley or other UKBOS options and use the additional stored water in meeting project operating goals. The with-project options differ in option storage capacity and conveyance capacities between option storage facilities and UKL, and LLV seepage. All of the non- AL/Barnes Ranches options include AL/Barnes Ranches combined with UKL and Agency Lake. All non-LLV options were operated without seepage considered. All options were operated with the following criteria:

- Inflows to the option being analyzed:
  - Limited to spill from UKL that would otherwise have occurred in the absence of option reservoir.
  - Limited to flows above Stateline water right (Table 5).
  - Limited to Oregon Water Resources Department (OWRD) stateline instream flow restrictions (Table 5).

Month	Stateline water instream flow right in CFS	OWRD Inflow Restrictions
OCT	1260	No Inflow
NOV	1500	No Inflow
DEC	1500	No Inflow
JAN	1500	Inflow Allowed
FEB	1500	No Inflow
MAR	1500	Inflow Allowed
APR	1500	Inflow Allowed
MAY	1500	Inflow Allowed
JUN	1500	No Inflow
JUL	1500	No Inflow
AUG	1330	No Inflow
SEP	1160	No Inflow

Table 5. OWRD water rights and inflow restrictions.

- Releases:

- Encouraged to meet shortages to other system constraints (UKL minimum elevation, Iron Gate Flow, or delivery targets) that would have occurred in absence of LLV. Otherwise discouraged.
- Use of LLV storage to further augment Iron Gate flow was implemented as follows:
  - 50 TAF/yr in the drier 60% of years when flow augmentation is scheduled
  - Distributed 60%/40% in April/May in the drier of these years and 40%/40%/20% April/May/June otherwise
  - Triggered only if end-of-March storage in LLV was at least 150 TAF
  - Triggered in April and May if flow would otherwise have been below 3000 cfs

Feasibility level studies for LLV or the other UKBOS options could include the simulation of offstream storage benefits given a range of scenarios for climate change in the basin. Climate change scenarios would be input to rainfall/runoff scenarios for watershed hydrology, providing altered inflow data sets that would drive the operations model used for this appraisal level study.

UKBOS options that were studied via WRIMS model analysis include:

1. Enlarged UKL (Upper Klamath Lake)
2. Small Swan Lake
3. Large Swan Lake
4. KDD Storage (Klamath Drainage District Storage)
5. LKL Storage (Lower Klamath Lake Refuge Storage)
6. Enlarged Tule Lake
7. Williamson Reservoir
8. Torrent Reservoir
9. Agency Lake/Barnes Ranches used as a managed offstream storage facility – upgraded from the current facility – a possible option to AL/Barnes Ranches open to the lake
10. Sprague ASR
11. Langell ASR
12. Gerber ASR
13. Boundary Reservoir

Data used for the area-capacity tables of the reservoirs is rough and was estimated by KBAO staff and adjusted by TSC staff. The hydrology used for the reservoirs is common to the LLV model except Williamson and Torrent Reservoirs which are upstream of UKL. Inflows were developed for Williamson and Torrent, then subtracted from UKL historic inflows to compute the accretion (gain) from the upstream reservoir to UKL.

Inflows for Williamson Reservoir are based upon USGS gage 11493500 – Williamson River Near Klamath Agency, Oregon. This gage is also referred to as "Williamson River At Kirk Bridge". Data for this gage exist for the entire study period of the model (water years 1961 through 2006). Historic data are the same data as available at Oregon Water Resources Department (OWRD). The gage has an average annual value of 101.0 TAF. The ORWD water availability analysis for Klamath at Kirk is 102.0 TAF/year. The USGS data are available at:

http://waterdata.usgs.gov/nwis/dv?site_no=11493500&cb_00060=on&format=rdb&&begin_date=10/01/1960&end_date=09/30/2008&date_format=YYYY-MM-DD

Data for Torrent Reservoir are based on a United State Forest Service gage, 614202010, Sycan At Road Bridge Below Sycan Marsh, that only existed from 1993 through 1998. Data for this gage were obtained from the Oregon Water Resources Department (OWRD) at:

http://apps2.wrd.state.or.us/apps/sw/hydro_report/data_Results.aspx?station_nbr=61420210&start_date=10/1/1992&end_date=9/30/1999&record_type=mdfDaily_time_series&tolerance=0&fdcCase=usgs&record_status=PUB&nbr_days=1&nbr_max=

Torrent Reservoir inflows were extended to 1974 through 2007 by monthly regressions to USGS gage 11490101 – Upper Sycan Below Snake River Near Beatty. These data are available at:

http://waterdata.usgs.gov/nwis/dv?site_no=11499100&cb_00060=on&format=rdb&&begin_date=10/01/1960&end_date=09/30/2008&date_format=YYYY-MM-DD

Sycan Beatty flows were extended by monthly regression to UKL inflows and those extended flows were used to extend Torrent Reservoir inflows back to water year 1961. Although is it not desirable use regressions of regressions for extending data, only one other data source is available which are data developed by OWRD. However, OWRD recommended that those data not be used because they exclude Sycan Marsh. Given the level of this analysis, it was determined that the regressed data were sufficient for this study. The extended data for Torrent Reservoir has an average annual value of 79.9 TAF.

The OWRD water availability analysis (WARS) for Sycan at Sycan Marsh has an average annual value of 46.8 TAF. The OWRD was contacted to request these data as a time-series for use in this study. Rick Cooper of the OWRD indicated that the 46.8 TAF reflects an adjustment that assumes that Sycan Marsh does not exist. Because of this adjustment, he recommended that we not use OWRD data for our Sycan data development.

Use of upstream reservoir inflow hydrology is explained below. The other options all use historic UKL hydrology as per the LLV model.

The LLV model operates with two decision passes. The first pass uses the same operating criteria as the UKL without project scenario. This pass establishes the amount of spill water that is available for supplemental storage. The second pass stores water in supplemental storage if spill water is available, stateline instream flow requirement have been meant, and it is a storable month (January, March, April, or May) as specified by the draft permit issued by the OWRD (aka inflow restrictions). The second pass releases water from supplemental storage for project demands and for extra Iron Gate flows as discussed in the next paragraph. In addition, LLV model inflows and releases are governed by the pumping capacity.

The LLV model has two release criteria which are supplemental releases for project users and extra Iron Gate flows. Extra Iron Gate flows, aka augmentation flows, consist of two elements, a primary extra release for Iron Gate and a supplemental extra release for Iron Gate. The augmentation flows are in addition to the minimum flow requirements at Iron Gate which are made by the first pass. The primary extra Iron Gate release is made during the first pass and uses the same criteria that the without project scenario uses.

The extra Iron Gate flow releases are made using LLV water passed through UKL. Availability of water for extra Iron Gate flow releases is determined by a seasonal water supply factor that is a function of UKL storage, May through September forecasted inflow, and expected end of September carryover storage. The seasonal supply of water made available for extra Iron Gate flow releases is distributed from May through September.

Fundamentally, model operations for the non-LLV option reservoirs are the same as LLV. However, most of the non-LLV option reservoirs do not move water directly between the option reservoir and UKL. All storage in options' reservoirs is limited by the OWRD inflow restrictions, surplus water, and the stateline instream flow requirement. In addition, inflows to options' reservoirs downstream of UKL are limited by their delivery canal capacity less deliveries being made through the canal. Storage in reservoirs of options upstream of UKL is also limited by inflow. Table 6 summarizes lists the inflow and outflow limits for the given analyzed option.

Several of the option reservoirs can not physically deliver extra flows to Iron Gate. However, UKL will make these releases if supply is available. Small Swan Lake, KDD Storage, LKL Storage, and Enlarged Tule Lake were modeled to respect their delivery canal capacities. Except for Enlarged Tule Lake, which has site specific inflow and release capacities, the inflow and release capacities are determined by the delivery canal.

In the case of the reservoirs for options downstream of UKL, preference is given to releases from these reservoirs over UKL. Then UKL attempts to deliver the remaining demand. The models were reconfigured as a pseudo delivery and release because a full reconfiguration would take considerable time to implement in the operation. Instead, the supply from the reservoir was used to reduce the demand of the service area so that UKL did not over delivery. The total delivery is computed in the output spreadsheets.

The LKL option model reduces refuge depletions by the area of LKL. Small Swan Lake respects the A canal, B canal, and C canal capacities and deliveries. The B canal restriction severely limits the ability of Small Swan Lake to store and deliver water.

Enlarged UKL model was operated as a separate reservoir because UKL inflow includes evaporation and the enlarged reservoir will produce additional evaporation. In addition, this saved having to modify a number of targets and related operations of UKL. The inflow and releases capacities for enlarged UKL are unlimited should emulate one large reservoir. Enlarged UKL and Large Swan Lake are operated identically to LLV with only the area-capacity tables revised.

Scenario	Reservoir Inflow Capacity (cfs)	Reservoir Release Capacity (cfs)
Enlarged UKL[1]	None	None
Small Swan Lake[2]	290	290
Large Swan Lake	1000	1000
KDD Storage[3]	550	615
LKL Storage[7]	322	300
Enlarged Tule Lake[4]	300	322
Williamson Reservoir[1]	None	500
Torrent Reservoir[1]	None	500
Sprague ASR[4]	100	100
Langell ASR[5]	100	100
Gerber ASR[6]	100	100
Boundary Dam[4]	25000	3600
Buck Lake Dam[4]	75	100
Bryant Mtn Pumped Storage[4]	610	610
1. Upstream reservoirs and enlarged UKL inflow is only limited by hydrologic conditions. Williamson and Torrent normal releases are thru an outlet works with an available spillway for higher flood flows.		

2. Small Swan Lake is limited to capacity of B Canal (290 cfs) less B Canal deliveries from other sources.
3. KDD Storage inflow is limited to combined capacity of Ady, West and North Canals (525 + 200 cfs) less their deliveries from other sources. Outflow is limited to Klamath Straits drain pump capacity (600 cfs at F/F-F plant)
4. Limited by hydrologic conditions and inflow and outflow capacities.
5. Limited by hydrologic conditions, inflow and outflow capacities, and month.
6. Limited by inflow and outflow capacities, and month.
7. LKL Storage inflow is limited to Sheepy Tunnel capacity (322 cfs) less the deliveries to other needs (P Canal). Outflow designed for 300 cfs

Table 6. Reservoir Inflow and Outflow Limits

The models for options' reservoirs upstream of UKL were reconfigured (rather than cloning LLV). The model's first pass sends all water (the upstream reservoir's plus the accretion) through to UKL so that UKL inflows are the same as the without project scenarios for the first pass. The upstream reservoirs are then allowed to store with the same criteria (surplus exists, Stateline is respected, and Oregon monthly limits) but are also limited by their respective inflows. Releases from the upstream reservoirs are made with the same criteria as LLV runs.

Gerber Lake ASR (ground water reservoir) is supplied by ground water inflow whereas Langell ASR and Sprague ASR are supplied by excess surface water inflow. Because Gerber ASR and Langell ASR are connected hydrologically to the Klamath River, they do not restrict inflows by stateline requirements and OWRD inflow diversion months. Alternatively, they are allowed to supply water in July through August and to refill in all other months. Sprague ASR is governed by stateline requirements and OWRD inflow diversion months as per other Klamath River reservoirs.

The data used in this study should be characterized as preliminary/reconnaissance level data. In particular, the area-capacity tables of the reservoirs are rough estimates. The hydrology is common to the LLV studies for six of the options but was developed for the two upstream reservoirs. The hydrology for Williamson Reservoir is of typical USGS quality with an accuracy of plus or minus 5 percent.

The hydrology for Torrent Reservoir is problematic because of the short period of record, the source of the data (USFS), and the use of two regressions to extend the data. At best, it has an accuracy of plus or minus 25 percent.

For the ALR/Barnes (ALR/BR) upgraded managed storage stand alone option “future without project” scenario, the following modeling criteria were used:

Management goals: The ALR/Barnes properties options reservoir shall be managed to 1) optimize water storage for beneficial use 2) to maximize wildlife benefits i.e. wetlands, etc. so the modeling parameters are as follows:

1. Storage begins in fall and winter after the UKL refill curve line has been reached.
2. Storage diversions are managed to ensure that UKL refill curve line is maintained.
3. Storage diversions require that a head differential for gravity deliveries exists between UKL and ALR/Barnes.
4. Storage diversions can only occur if a spill exists and it is February through May.
5. Removal of stored water from ALR/Barnes can begin as soon as UKL elevations drop below the refill curves.
6. Several inflow and outflow scenarios were modeled. The ones reported in this document as assumed are with an inflow rate of 250 cfs, release rate of 300 cfs. The 150 cfs release rate is the current capacity. The 300 cfs release rate would double the release capacity. This is assuming that additional screened intakes could be installed, additional pumps could be added, and existing pump facilities would be raised.

Other options investigated but not modeled are Whiteline, Wocus Marsh, Aspen Lake, Round Lake, Clear Lake J Canal Feed, Bryant Mtn Pumped Storage, and Buck Lake. Although model runs were not completed, Whiteline, Wocus Marsh, Aspen Lake, Round Lake options’ reservoirs were considered hydrological equivalents of LLV. Therefore, the study results for LLV were used for those options.

Caledonia Marsh would be operated in similar manner to Agency Lake Ranch/Barnes Ranch and so the hydrologic results were proportioned from ALR/BR by area to that of the smaller Caledonia storage capacity area.

Although the above options were not modeled and analyzed, their schematic diagrams are included in the following section. The water supply for both the Clear Lake J Canal water supply option and the Bryant Mtn shall be set as equivalent to the analyses results for the Raise Tule Lake option multiplied by a factor which is ratioed for the option’s storage volume available vs the storage volume available for the Raise Tule Lake option.

The above options were not modeled but their schematic diagrams are included to show the reader how and where the option would fit into the Klamath Project

Buck Lake – storage in enlarged existing lake basin
Clear Lake – water storage in existing reservoir via J Canal water supply
Bryant Mtn – Malin Pumped Storage scheme

and/or the Upper Klamath Basin.

Only the Sprague, Gerber, and Langell Valley ASR options were modeled. The average annual delivery for the N. Klamath and S. LKL ASR options was inferred to be equivalent to Sprague modeled results. Table 1 from the USGS report is included to show ASR option capacities.

Summary of Results

Average Annual Values for Hydrology and Demand Elements in Klamath Basin Modeling - 1961 through 2009 - TAF								
Item	Appraisal LLV Without Project	2009 LLV Without Project	Appraisal LLV 350K Lake 1K Pump	Appraisal LLV 350K Lake 2K Pump	2009 LLV 350K Lake 1K Pump	2009 LLV 350K Lake 2K Pump	2010 BO	KBRA
UKL Inflow	1299.0	1299.0	1299.0	1299.0	1299.0	1299.0	1299.0	1329.0
Assumed recovery of consumptive use on reclaimed marsh areas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.9
Precipitation Assumption	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.4
Other Inflows, Including Klamath Straits Drain	556.5	556.5	556.5	556.5	556.5	556.5	556.5	526.1
A2 Returns	32.6	32.6	32.6	32.8	33.3	33.4	33.4	31.6
Ag Delivery	378.8	378.9	385.4	386.7	386.8	388.6	366.3	369.3
Refuge Delivery	19.9	19.9	21.9	21.9	21.4	21.7	15.7	67.4
Evaporation from reclaimed marsh areas of UKL	50.3	50.3	50.4	50.4	50.4	50.4	50.1	57.7
Iron Gate Flow	1456.4	1456.2	1436.0	1433.6	1437.3	1432.6	1471.3	1446.2
Total UKL inflow	1310.1	1310.1	1310.1	1310.1	1310.1	1310.1	1310.1	1376.4
Incremental Project Delivery From LLV Relative To LLV No Action	N/A	N/A	8.6	9.9	9.3	11.4	N/A	N/A
Incremental Project Delivery From LLV Relative To BO 2010	N/A	N/A	8.2	9.5	8.9	10.9	N/A	N/A
KBRA and BO 2010 are set up as per Klamath Dam Removal Study with dynamic allocations using synthetic forecast errors. All other setups use historic forecasts.								
BO 2010 incremental supply is estimated as a function of previous No Action and BO 2010 supplies.								

Table 7 – 2010 analysis of LLV option with respect to post-2008 BO and KBRA flow requirements

Table 7 displays the analysis of the 1000 cfs 350K LLV option showing several columns of information for comparison and reference purposes. The Appraisal LLV columns analysis did not take into account in-stream flow deductions and the additional month of February UKL inflows being able to be stored as was determined by OWRD after the Appraisal runs had been done. This issue/comparison description is further discussed below. The 2009 analysis results column did add these considerations into the analyses.

Tables 8 through 11 summarize results pre-2009 analyses of several LLV scenarios and non-LLV options. These runs results would use the same inputs and constraints as described in the above introductory sections. This would aline with the information found in the two Appraisal LLV columns in Table 7 above. All scenarios have some incremental benefit to project deliveries. In addition, most options also have an incremental benefit for Iron Gate flows. However, the Agency Lake Ranch Barnes Ranches upgraded managed storage option scenario does not have an incremental benefit for Iron Gate flows. In fact, this ALR/BR scenario can deliver less water for the benefit of Iron Gate than the without project/no action option. The reason this ALR/BR scenario takes a hit with Iron Gate in this scenario is that pumping and releases have periods when they are allowed to pump or release, the model rules constrains operations such that it cannot pump and release in same time step, and subsequently, water gets stuck in Agency Lake that might otherwise get released to Iron Gate. The AL/Barnes Ranches scenarios of either “open to the lake” (future no action) or upgraded managed storage would happen in the foreseeable future but the only way you can compare them individually is to the “no action” scenario as shown in Table 10. For purposes of Table 10 – Future No Action With Existing UKL includes no AL/Barnes storage. All other scenarios include the “future no-action” scenario operations. This setup, also known as the “Open Water” scenario, assumes that UKL, Agency Lake Ranch, and Barnes Ranches are combined to become one large reservoir.

Non-LLV UKBOS options were not reanalyzed using the 2009 updated inputs (instream flow deductions and the additional month of February for UKL inflow) but as one can see from Table 7, a relative comparison shows that when taking the 2010 BO or KBRA into account that effectively the same storage volumes as was computed for the pre-2009 runs can be considered for each option. Thus the pre-2009 run results will be used for each option for the final options comparison table.

Initial model runs for ASR options studied, Sprague and Gerber, were only allowed to divert in July and August. So Gerber is only supplying supplemental water in July and August in shortage years. The modeled reservoir (aquifer in this case) is allowed to fill in other months, but because it isn’t extracting that much, it refills quickly after diversions. The model could easily be changed to allow extractions in more months.

For Gerber ASR, the model was set up for extraction only (no inflow/ouflow only). Even though the modeled reservoir size was given at 8000 af the results showed that 2.75 TAF is available for all uses (Total Incremental Project Delivery Plus Iron Gate). That means that the 8 TAF is not used every year.

A quick model run was made for Gerber and Langell ASR’s changed to allow extractions in July thru October. This had a negative impact on Langell because the model did not allow inflows in same months as extractions and reservoir does not fill as frequently. Gerber water is used every year. In non shorted years, all water would be used for extra Iron Gate flows. In shorted years, it would reduce ag shortages. The extra Iron Gate flows do not necessarily show up in same time step because model may need to keep the water in UKL. However, the extra carryover will help in subsequent time steps for both ag and extra Iron Gate flows.

Such a scenario was not used in the scoping of the design for the ASR options nor determination of construction and life-cycle costs.

Item	Total Project Delivery							
Scenario	Unlined 350K Long Lake 1K Pump	Fully Lined 350K Long Lake 1K Pump	Half Lined 350K Long Lake 1K Pump	Northeast Lined 350K Long Lake 1K Pump	Unlined 500K Long Lake 1K Pump	Fully Lined 500K Long Lake 1K Pump	Half Lined 500K Long Lake 1K Pump	Northeast Lined 500K Long Lake 1K Pump
Units	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	412.28	413.60	414.61	414.58	414.23	414.56	414.61	414.58
Item	Incremental Project Delivery							
Scenario	Unlined 350K Long Lake 1K Pump	Fully Lined 350K Long Lake 1K Pump	Half Lined 350K Long Lake 1K Pump	Northeast Lined 350K Long Lake 1K Pump	Unlined 500K Long Lake 1K Pump	Fully Lined 500K Long Lake 1K Pump	Half Lined 500K Long Lake 1K Pump	Northeast Lined 500K Long Lake 1K Pump
Units	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	9.72	11.04	12.05	12.02	11.67	12.00	12.05	12.02
Item	Extra Iron Gate Instream Flow							
Scenario	Unlined 350K Long Lake 1K Pump	Fully Lined 350K Long Lake 1K Pump	Half Lined 350K Long Lake 1K Pump	Northeast Lined 350K Long Lake 1K Pump	Unlined 500K Long Lake 1K Pump	Fully Lined 500K Long Lake 1K Pump	Half Lined 500K Long Lake 1K Pump	Northeast Lined 500K Long Lake 1K Pump
Units	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	9.72	11.04	12.05	12.02	18.64	19.95	19.89	19.91
Item	Total Incremental Project Delivery Plus Iron Gate							
Scenario	Unlined 350K Long Lake 1K Pump	Fully Lined 350K Long Lake 1K Pump	Half Lined 350K Long Lake 1K Pump	Northeast Lined 350K Long Lake 1K Pump	Unlined 500K Long Lake 1K Pump	Fully Lined 500K Long Lake 1K Pump	Half Lined 500K Long Lake 1K Pump	Northeast Lined 500K Long Lake 1K Pump
Units	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	26.44	28.12	31.94	31.93	30.31	31.94	31.94	31.93

Table 8. Summary of 1000 cfs Pump Long Lake Options (pre-2009 analyses runs).

Item	Total Project Delivery							
Scenario	Unlined 350K Long Lake 2K Pump	Fully Lined 350K Long Lake 2K Pump	Half Lined 350K Long Lake 2K Pump	Northeast Lined 350K Long Lake 2K Pump	Unlined 500K Long Lake 2K Pump	Fully Lined 500K Long Lake 2K Pump	Half Lined 500K Long Lake 2K Pump	Northeast Lined 500K Long Lake 2K Pump
Units	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	414.15	415.77	417.88	417.99	415.98	418.22	417.88	417.99
Item	Incremental Project Delivery							
Scenario	Unlined 350K Long Lake 2K Pump	Fully Lined 350K Long Lake 2K Pump	Half Lined 350K Long Lake 2K Pump	Northeast Lined 350K Long Lake 2K Pump	Unlined 500K Long Lake 2K Pump	Fully Lined 500K Long Lake 2K Pump	Half Lined 500K Long Lake 2K Pump	Northeast Lined 500K Long Lake 2K Pump
Units	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	11.59	13.21	15.32	417.99	13.43	15.66	15.32	15.43
Item	Extra Iron Gate Instream Flow							
Scenario	Unlined 350K Long Lake 2K Pump	Fully Lined 350K Long Lake 2K Pump	Half Lined 350K Long Lake 2K Pump	Northeast Lined 350K Long Lake 2K Pump	Unlined 500K Long Lake 2K Pump	Fully Lined 500K Long Lake 2K Pump	Half Lined 500K Long Lake 2K Pump	Northeast Lined 500K Long Lake 2K Pump
Units	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	11.59	13.21	15.32	15.43	19.83	19.92	19.91	19.91
Item	Total Incremental Project Delivery Plus Iron Gate							
Scenario	Unlined 350K Long Lake 2K Pump	Fully Lined 350K Long Lake 2K Pump	Half Lined 350K Long Lake 2K Pump	Northeast Lined 350K Long Lake 2K Pump	Unlined 500K Long Lake 2K Pump	Fully Lined 500K Long Lake 2K Pump	Half Lined 500K Long Lake 2K Pump	Northeast Lined 500K Long Lake 2K Pump
Units	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	28.64	30.65	35.23	35.34	33.26	35.58	35.23	35.34

Table 9. Summary of 2000 cfs Pump Long Lake Options.(pre-2009 analyses runs)

Agency Lake Alternatives			
Item	Total Project Delivery		
Scenario	Future No Action With Existing UKL	Future No Action Open To Water UKL	Managed Agency Lake Ranch and Barned Ranch
Units	taf	taf	taf
Average Annual Supply	396.13	402.56	412.59
Item	Incremental Project Delivery		
Scenario	Future No Action With Existing UKL	Future No Action Open To Water UKL	Managed Agency Lake Ranch and Barned Ranch
Units	taf	taf	taf
Average Annual Supply	N/A	6.43	16.46
Item	Incremental Extra Iron Gate Instream Flow		
Scenario	Future No Action With Existing UKL	Future No Action Open To Water UKL	Managed Agency Lake Ranch and Barned Ranch
Units	taf	taf	taf
Average Annual Supply	N/A	15.32	-37.50
Item	Total Incremental Project Delivery Plus		
Scenario	Future No Action With Existing UKL	Future No Action Open To Water UKL	Managed Agency Lake Ranch and Barned Ranch
Units	taf	taf	taf
Average Annual Supply	N/A	21.75	-21.04

Table 10. Summary of Agency Lake/Barnes Ranches Options

UKBOS Alternatives

Item	Total Project Delivery													
Scenario	Future No Action Open To Water UKL	Large Swan Lake	Enlarged UKL	Williamson Reservoir	Torrent Reservoir	Small Swan Lake	Tule Lake	KDD Storage	LKL Storage	Langell ASR	Gerber ASR	Sprague ASR	Boundary Dam	Caledonia Marsh
Units	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	402.56	410.68	413.26	408.75	411.69	402.99	403.72	404.92	404.90	402.95	407.41	403.09	404.24	404.49
Item	Incremental Project Delivery													
Scenario	Future No Action With Existing UKL	Large Swan Lake	Enlarged UKL	Williamson Reservoir	Torrent Reservoir	Small Swan Lake	Tule Lake	KDD Storage	LKL Storage	Langell ASR	Gerber ASR	Sprague ASR	Boundary Dam	Caledonia Marsh
Units	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	N/A	8.12	10.70	6.19	9.13	0.43	1.16	2.36	2.35	0.39	3.17	0.53	1.68	1.94
Item	Incremental Extra Iron Gate Instream Flow													
Scenario	Future No Action With Existing UKL	Large Swan Lake	Enlarged UKL	Williamson Reservoir	Torrent Reservoir	Small Swan Lake	Tule Lake	KDD Storage	LKL Storage	Langell ASR	Gerber ASR	Sprague ASR	Boundary Dam	Caledonia Marsh
Units	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	N/A	13.97	7.16	5.75	10.09	0.63	2.58	3.26	3.24	0.33	0.55	0.36	3.89	1.04
Item	Total Incremental Project Delivery Plus Iron Gate													
Scenario	Future No Action With Existing UKL	Large Swan Lake	Enlarged UKL	Williamson Reservoir	Torrent Reservoir	Small Swan Lake	Tule Lake	KDD Storage	LKL Storage	Langell ASR	Gerber ASR	Sprague ASR	Boundary Dam	Caledonia Marsh
Units	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf	taf
Average Annual Supply	N/A	22.08	17.86	11.95	19.21	1.06	3.74	5.62	5.59	0.72	3.72	0.89	5.58	2.97

Table 11. Summary of UKBOS Options.

Table 1. Summary of key criteria for assessment of potential for managed underground storage of water for 14 candidate areas in the upper Klamath Basin.

	Number of large-capacity wells in area	Median yield (GPM)	Median depth to water (ft)	Median depth of large-capacity wells (ft)	Assumed injection rate per well (GPM)*	Potential volume assuming 10 wells injecting for 90 days (AF)	Comments	Potential for application of surface infiltration	Status of consideration for injection/ASR	Major reason(s) for removal from consideration for injection/ASR
1. Long/Aspen Lake area	6	2,025	94	388	--	--		Possible	Area no longer under consideration	No obvious water source. Area close to discharge boundaries.
2. Swan Lake Valley	11	2,150	51	320	--	--		Low	Area no longer under consideration	No obvious water source. Area close to discharge boundaries.
3. Northern Klamath Valley	15	2,400	29	480	2,400	9,546		Low		
4. Northern Lower Klamath Lake subbasin	0	**	--	No large capacity wells in area	--	--		Low	Area no longer under consideration	Available storage unlikely.
5. Wood River Valley	0	**	0	No large capacity wells in area	--	--		No	Area no longer under consideration	Available storage highly unlikely.
6. Klamath Marsh area	9	2,400	5	300	--	--		Low	Area no longer under consideration	Available storage unlikely. Area close to discharge features (springs, flowing artesian wells, and wetlands)
7. Sprague River Valley	41	1,900	33	439	1,900	7,557		Low		
8. Langell Valley	25	1,600	26	423	1,600	6,364		Low		
9. Gerber Reservoir area	0	**	374	409****	2,000	7,955	Theoretical injection rate based on geology	Possible		
10. Clear Lake area	0	**	100	No large capacity wells, median depth of stock wells is 257 ft	2,000	7,955	Theoretical injection rate based on geology	Possible		
11. Tule Lake subbasin	38	2,300	35***	452	4,000	15,910	Theoretical Injection rate based on TID wells	Possible		
12. Southern Lower Klamath Lake subbasin	Several	**	28***	Median depth of 5 large-capacity wells is 800 ft	2,000	7,955	Theoretical injection rate based on pump tests	Low		
13. Butte Valley	50 (Q > 3,000 GPM	**	32	408	--	--		Possible	Area no longer under consideration	No obvious source of water, considerable conveyance costs.
14. Buck Lake/upper Spencer Creek area	0	**	--	No wells in the area	--	--		Unknown	Area no longer under consideration	No obvious source of water, considerable conveyance costs.

* Injection rate based on median pumping rate for large-capacity wells unless otherwise noted
** Median pumping not calculated
*** Large-capacity wells only
**** Single 1,200 gpm well near area.

Table 1 from USGS, 2010 for scoped ASR options storage/supply volumes

UKBOS Options
WRIMS KPSIM Model Schematic Diagrams

Note: The word "option" should be substituted for the word "alternative" in the diagrams

Upper Klamath Basin Offstream Storage Studies

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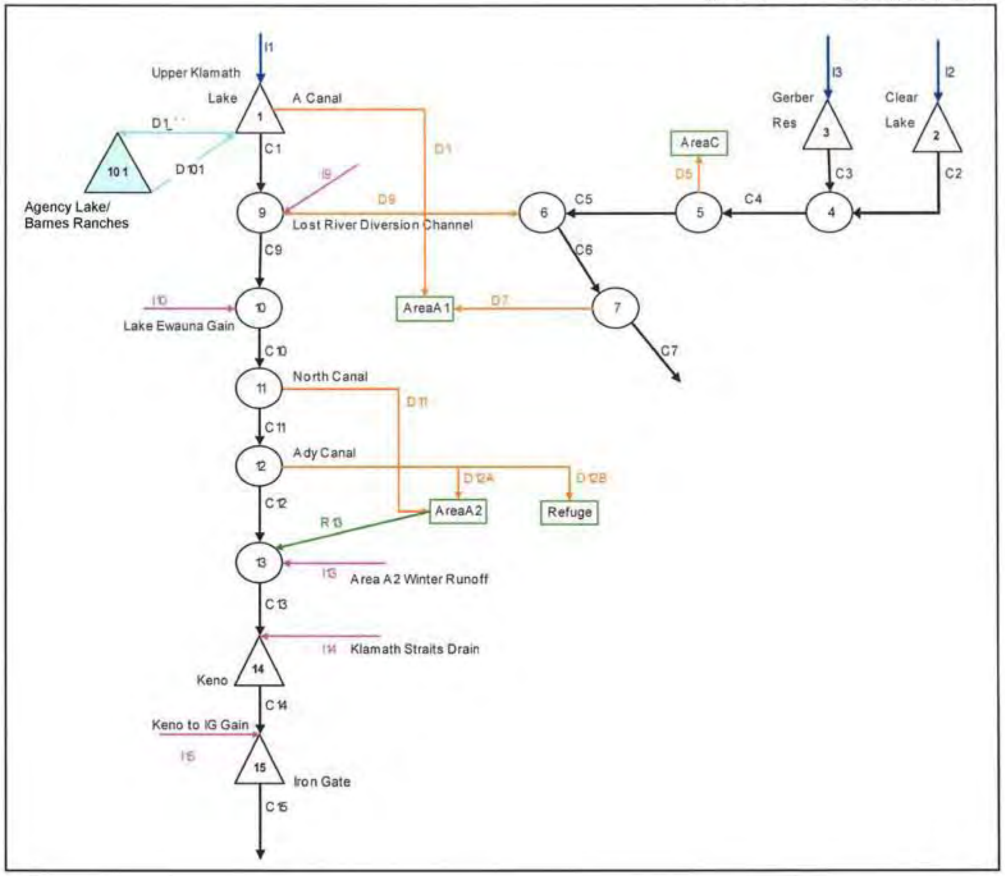
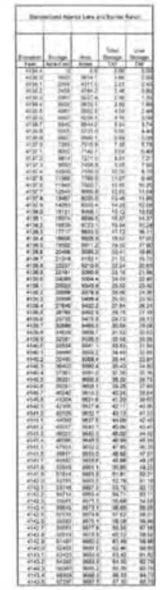
Agency Lake/Barnes Ranches managed storage (not open to UK/Agency Lakes) alternatives



Area-Capacity Table



Hydrologic Modeling Criteria for use of ALR/Barnes as Off-Stream Storage

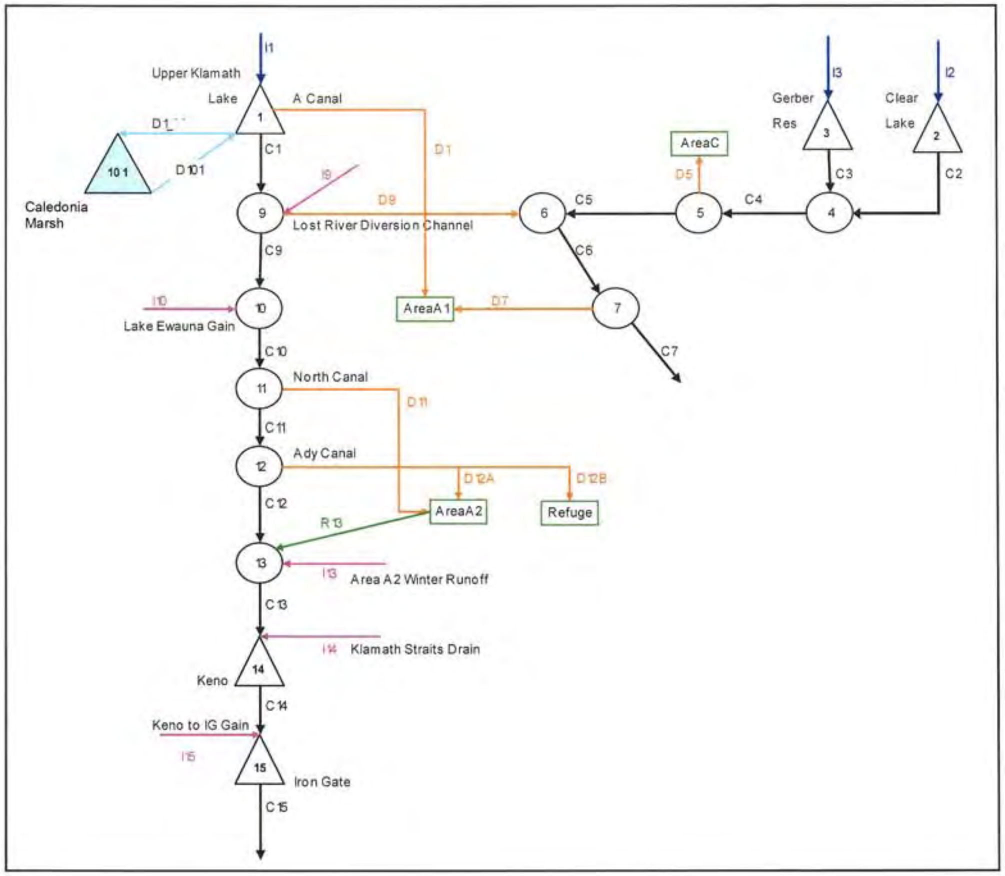
Management goals: The ALR/Barnes properties shall be managed to 1) optimize water storage for beneficial use 2) to maximize wildlife benefits i.e. wetlands, etc.

1. Storage would begin in the fall and winter after the UKL refill curve line has been reached.
2. Storage diversions should be managed to ensure that UKL refill curve line is maintained.
3. If additional runoff above the UKL refill curve is experienced in the months of February through May, some of this additional runoff can be stored for later release.
4. Removal of stored water from ALR/Barnes shall begin as soon as UKL elevations begin a downward decent and drop below elevation 4142.5.
5. If removal of stored water has began but increased inflows into UKL show a rise in elevations, removal of stored water may stop and storage may resume.
6. Modeling shall assume a fill rate of 300 CFS and a removal (pump off) rate of 500 CFS. Fill and removal rates may be slightly modified by the modeler to better optimize the storage and removal of water. (This is assuming that additional screened intakes could be installed, additional pumps could be added, and existing pump facilities would be raised.)

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Caledonia Marsh alternative



Depth (ft)	Volume (acre-ft)
9.0	21,532
5.0	11,945
0.0	0

Hydrologic Modeling Criteria for use of Caledonia as Off-Stream Storage

Management goals: The Caledonia properties would be managed to 1) optimize water storage for beneficial use 2) to maximize wildlife benefits i.e. wetlands, etc.

1. Storage would begin in the fall and winter after the UKL refill curve line has been reached.
2. Storage diversions should be managed to ensure that UKL refill curve line is maintained.
3. If additional runoff above the UKL refill curve is experienced in the months of February through May, some of this additional runoff can be stored for later release.
4. Removal of stored water from Caledonia would begin as soon as UKL elevations begin a downward decent and drop below elevation 4142.5.
5. If removal of stored water has begun but increased inflows into UKL show a rise in elevations, removal of stored water may stop and storage may resume.
6. Modeling shall assume a fill rate of 300 CFS and a removal (pump off) rate of 500 CFS. Fill and removal rates may be slightly modified by the modeler to better optimize the storage and removal of water. (This is assuming that additional screened intakes could be installed, additional pumps could be added, and existing pump facilities would be raised.)

Upper Klamath Basin Offstream Storage Studies

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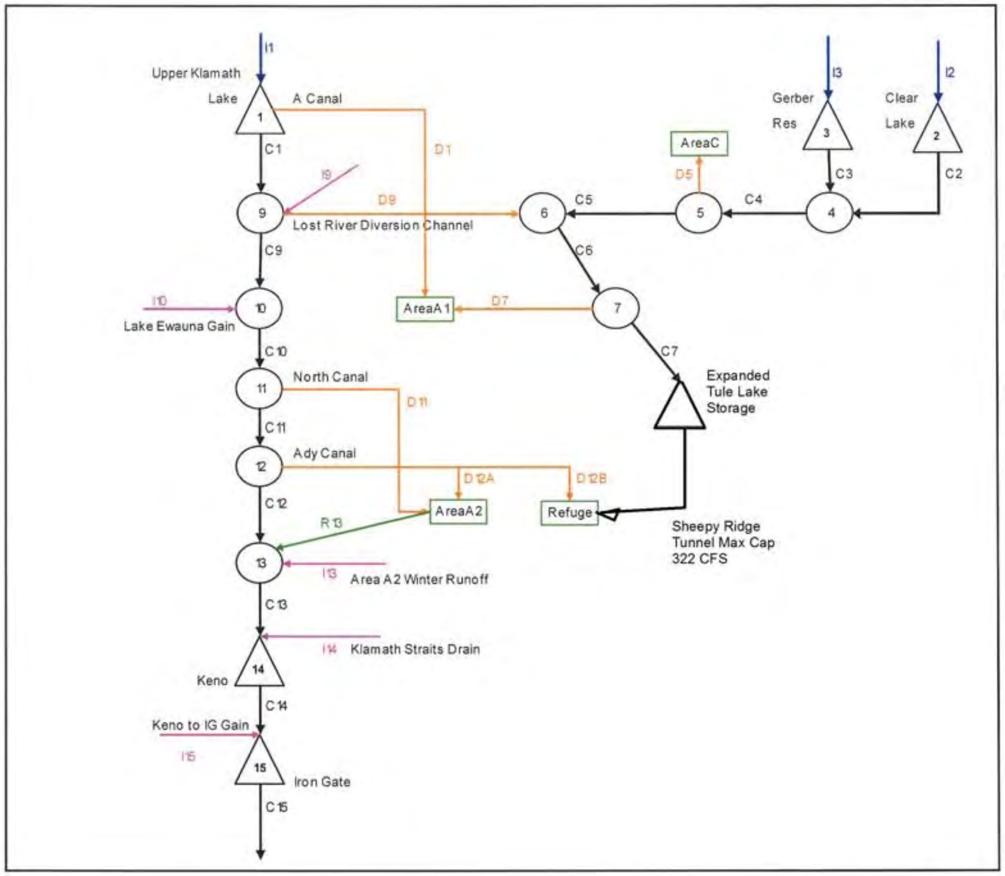
Expanded Tule Lake storage alternative



Area-Capacity Table

Additional Depth (ft)	Additional Volume (acre-ft)
5.0	47,500
2.5	23,750
0.0	0

Upper Klamath Basin Offstream Storage Studies

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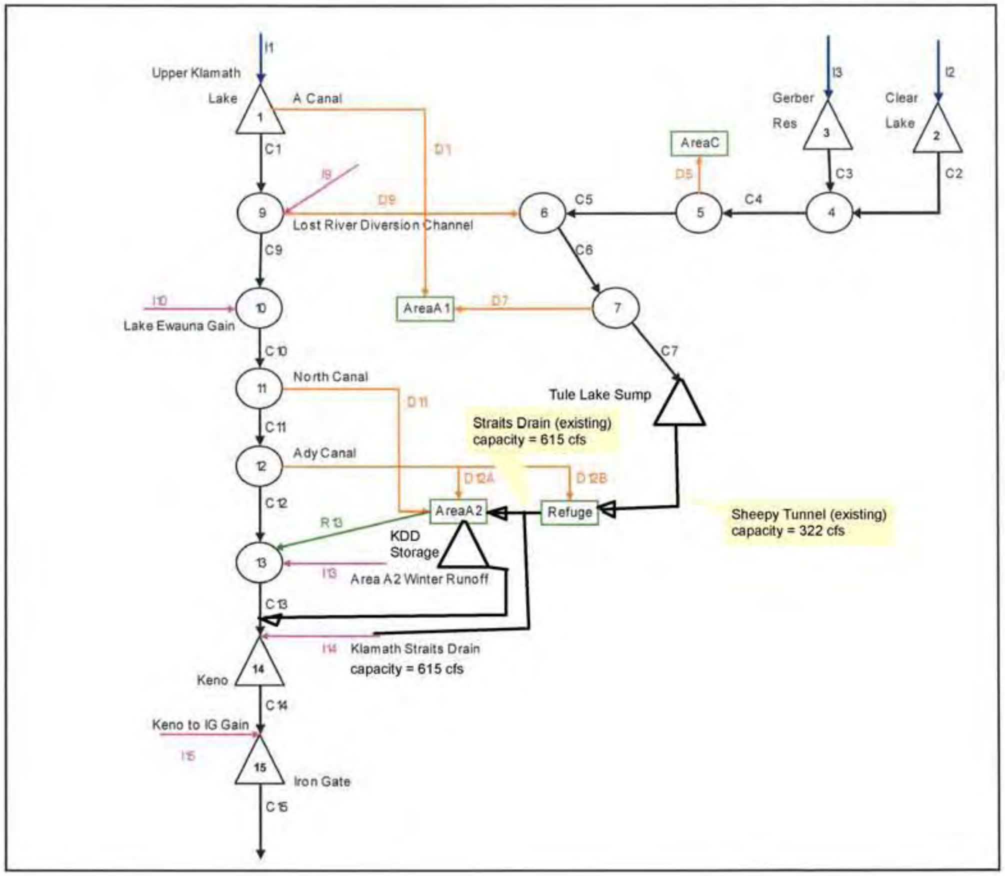
Klamath Drainage District storage alternative



Klamath Drainage District Storage facility
Inlet capacity = 550 cfs
Outlet capacity = 615 cfs

Depth (ft)	Volume (acre-ft)
8.0	97,000
5.0	80,850
3.0	48,500
0	0

Upper Klamath Basin Offstream Storage Studies

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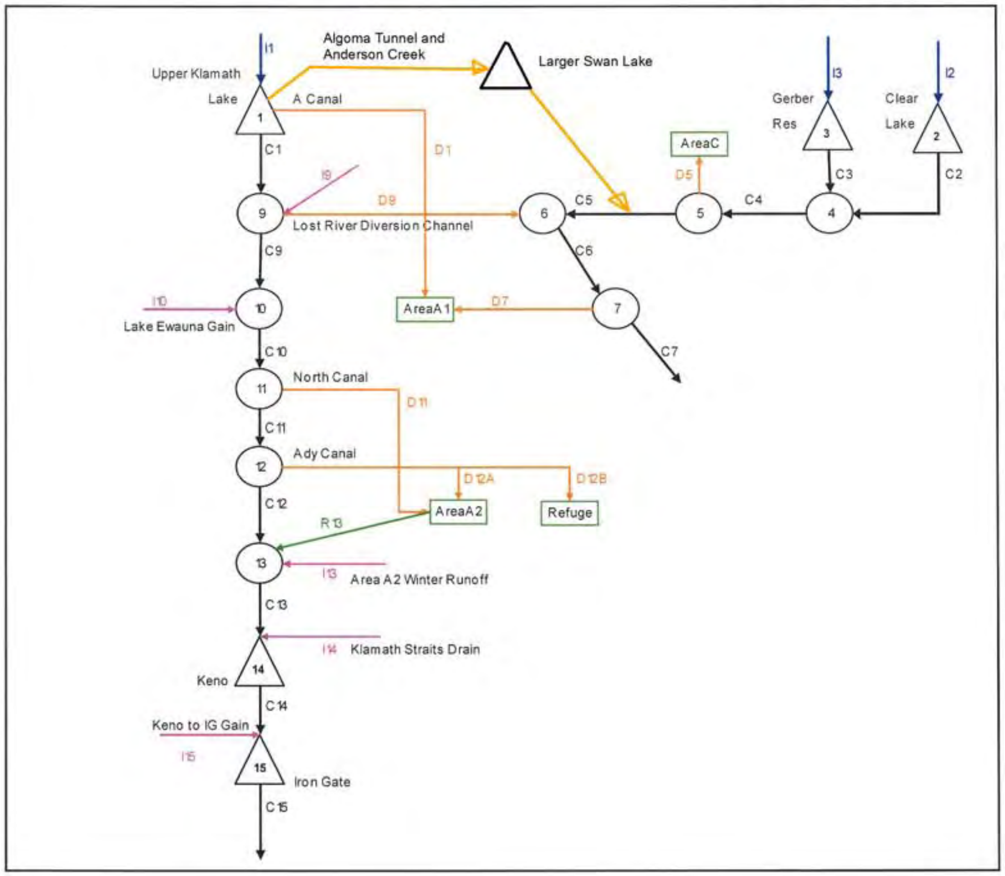
Larger Swan Lake alternative



Area-Capacity Table

Depth (ft)	Volume (acre-ft)
0	0
10	114,250
20	286,075
23	350,000

Upper Klamath Basin Offstream Storage Studies

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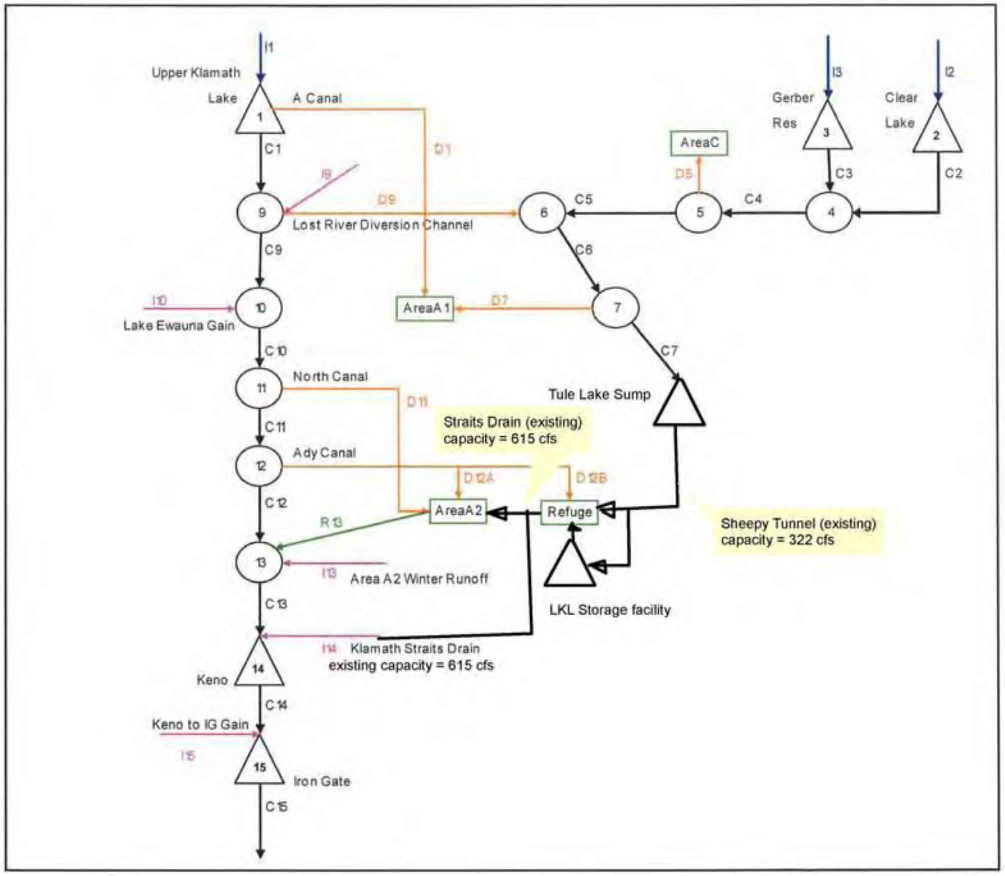
Lower Klamath Lake Refuge alternative



LKL Storage facility
Inlet/Outlet capacity = 300 cfs

Total Depth (ft)	Additional Volume (acre-ft)
21	80,000
7.0	26,500
0.0	0

Upper Klamath Basin Offstream Storage Studies

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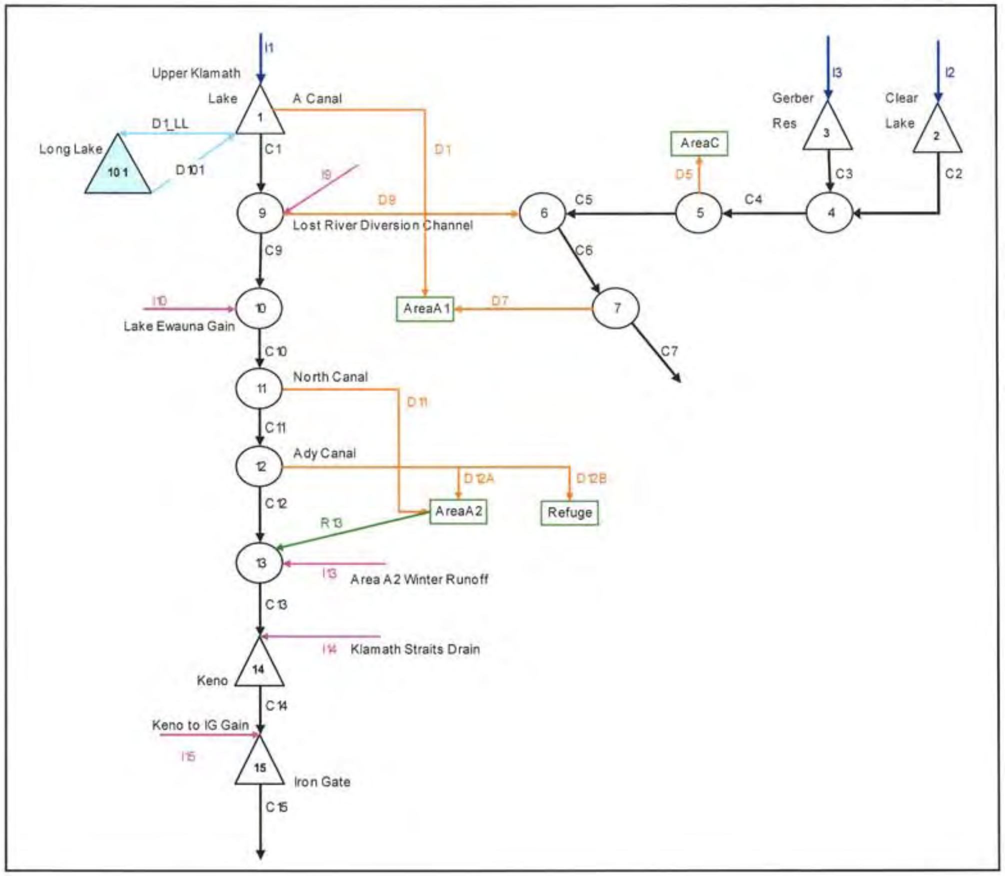
Long Lake Valley alternative



Area-Capacity Table

Elevation (ft)	Depth (ft)	Volume (acre-ft)
4262	0	0
4300	38	56427
4350	88	154602
4400	138	268133
4433	171	352089
4450	188	398906
4485	223	502507

Upper Klamath Basin Offstream Storage Studies

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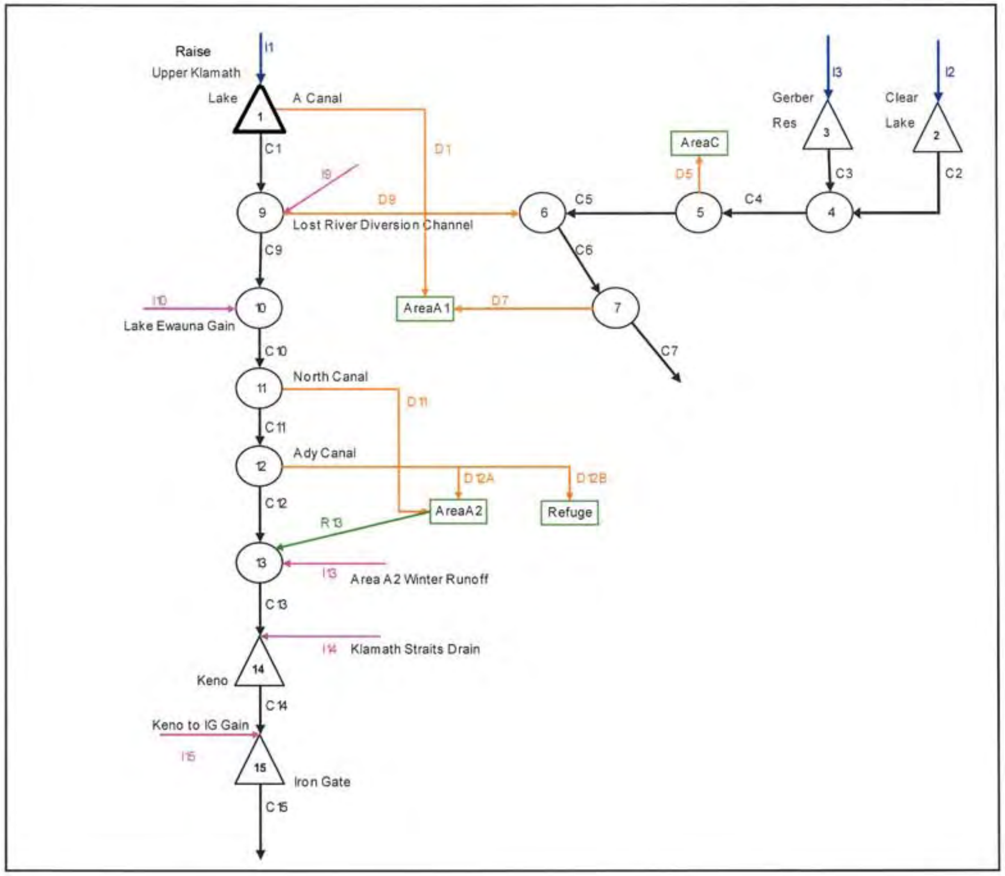
Raise Link River Dam and Upper Klamath Lake Lake alternative



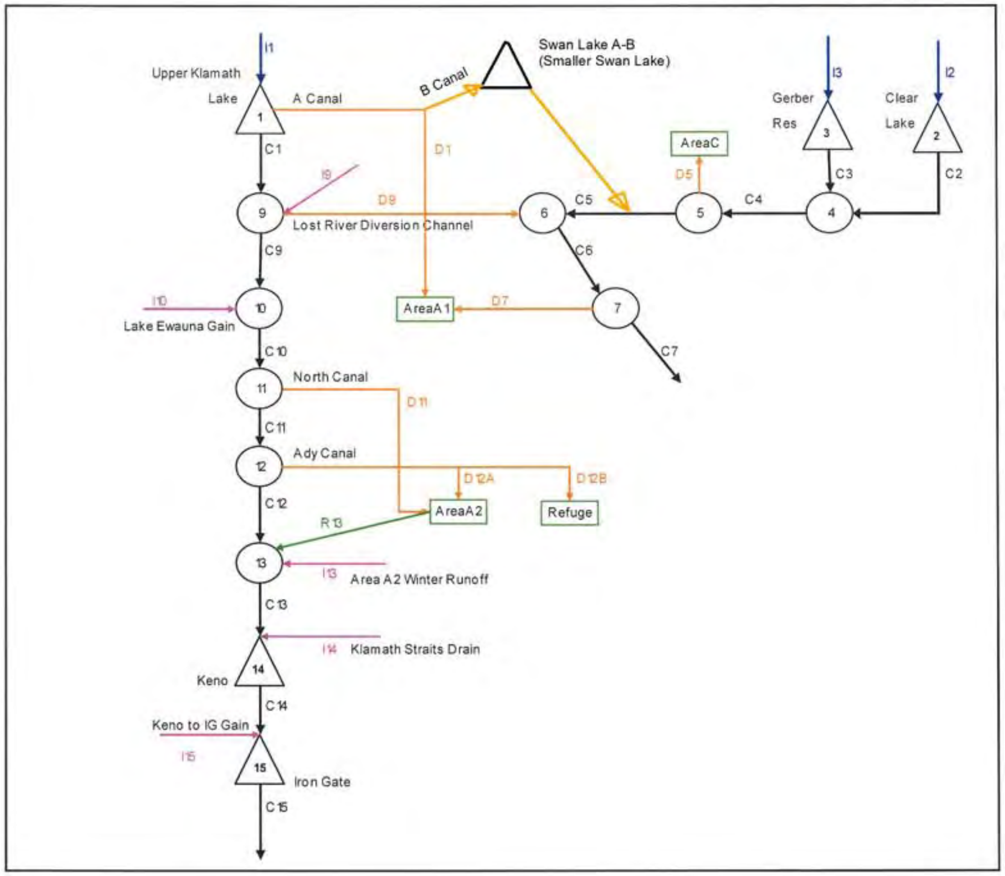
Area-Capacity Table

Elevation (ft)	Additional Volume (acre-ft)
4148.3	387,965
4145.8	193,982
4143.3	0

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Swan Lake A-B (Smaller Swan Lake) alternative



Area-Capacity Table

Depth (ft)	Volume (acre-ft)
12	188,000
8	100,000
3	37,000
0	0

Upper Klamath Basin Offstream Storage Studies

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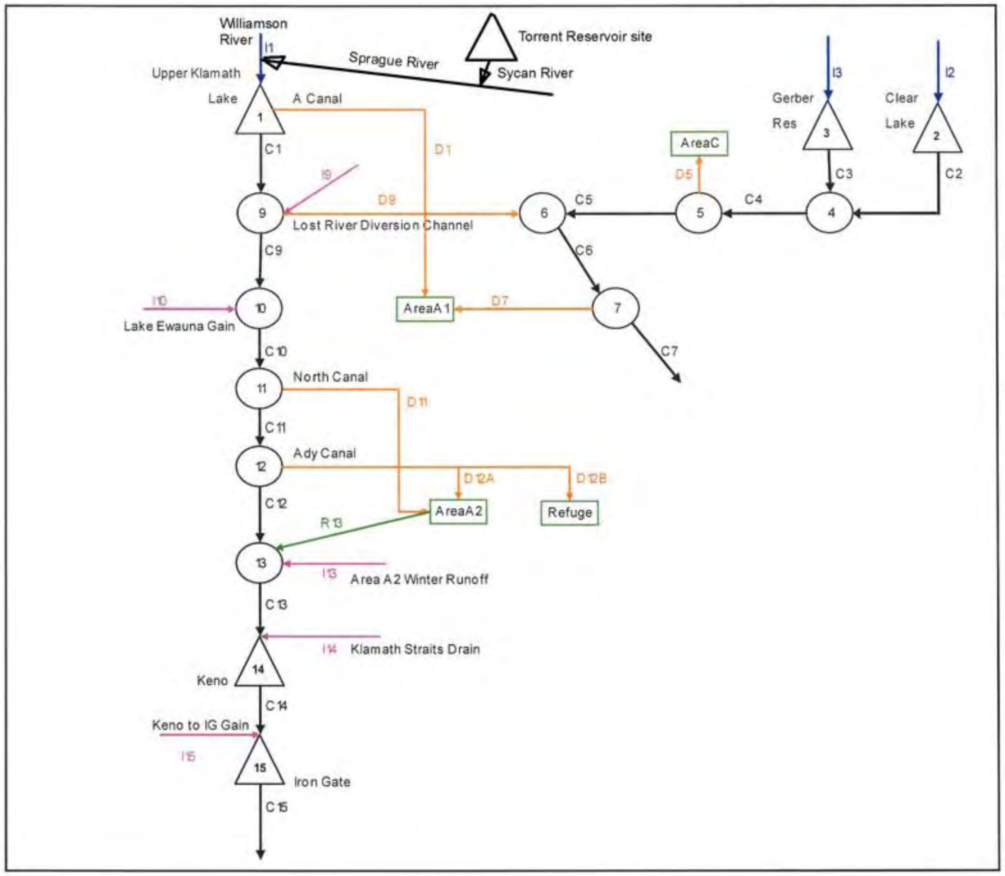
Torrent Reservoir alternative



Area-Capacity Table

Elevation (ft)	Depth (ft)	Volume (acre-ft)
5003.0	113.0	421,800
4945.0	55.0	210,900
4890.0	0.0	0

Upper Klamath Basin Offstream Storage Studies

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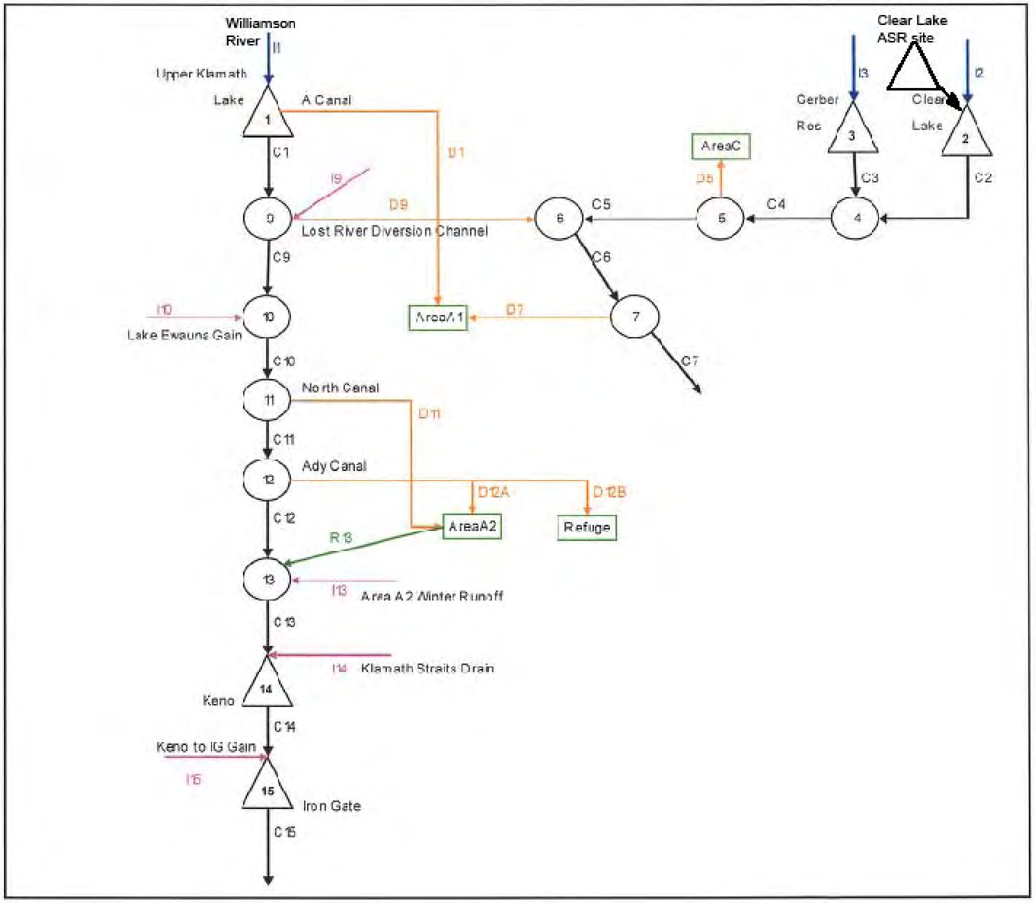
Clear Lake ASR alternative - production only



Clear Lake ASR production facility
Outlet capacity = 100 cfs

Storage capacity = 8000 af

Upper Klamath Basin Offstream Storage Studies

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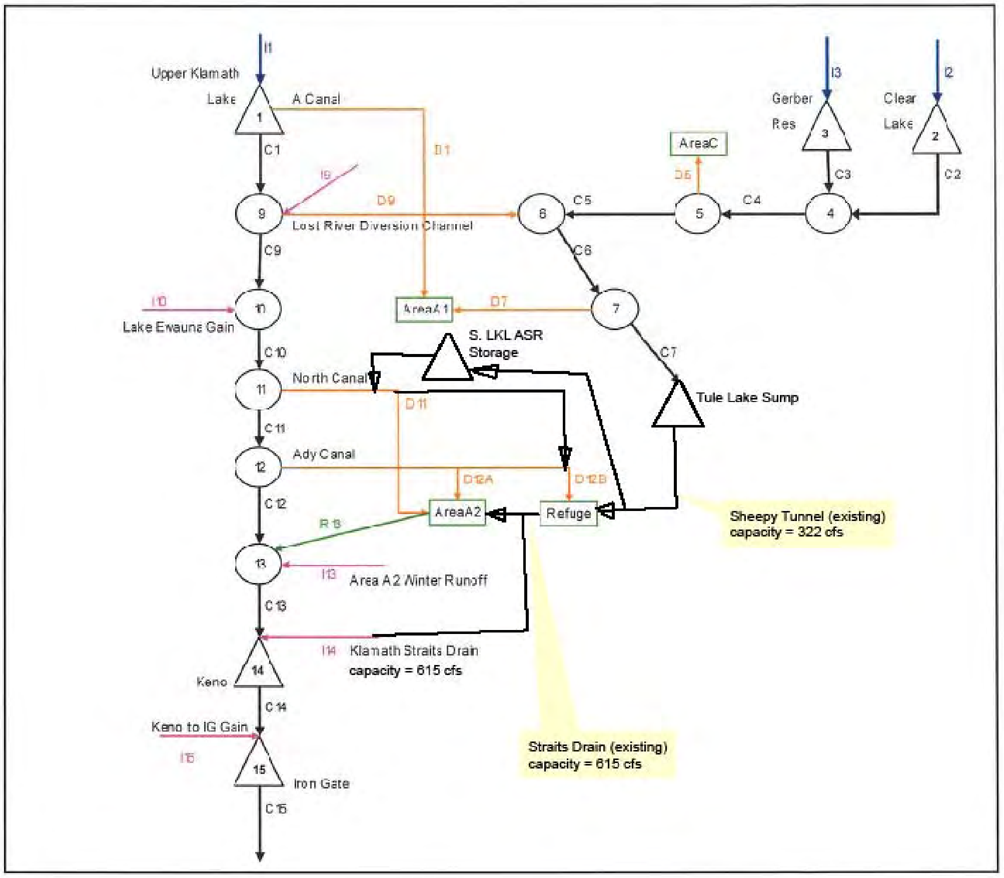
Southern Lower Klamath Lake ASR storage alternative
Suboption B



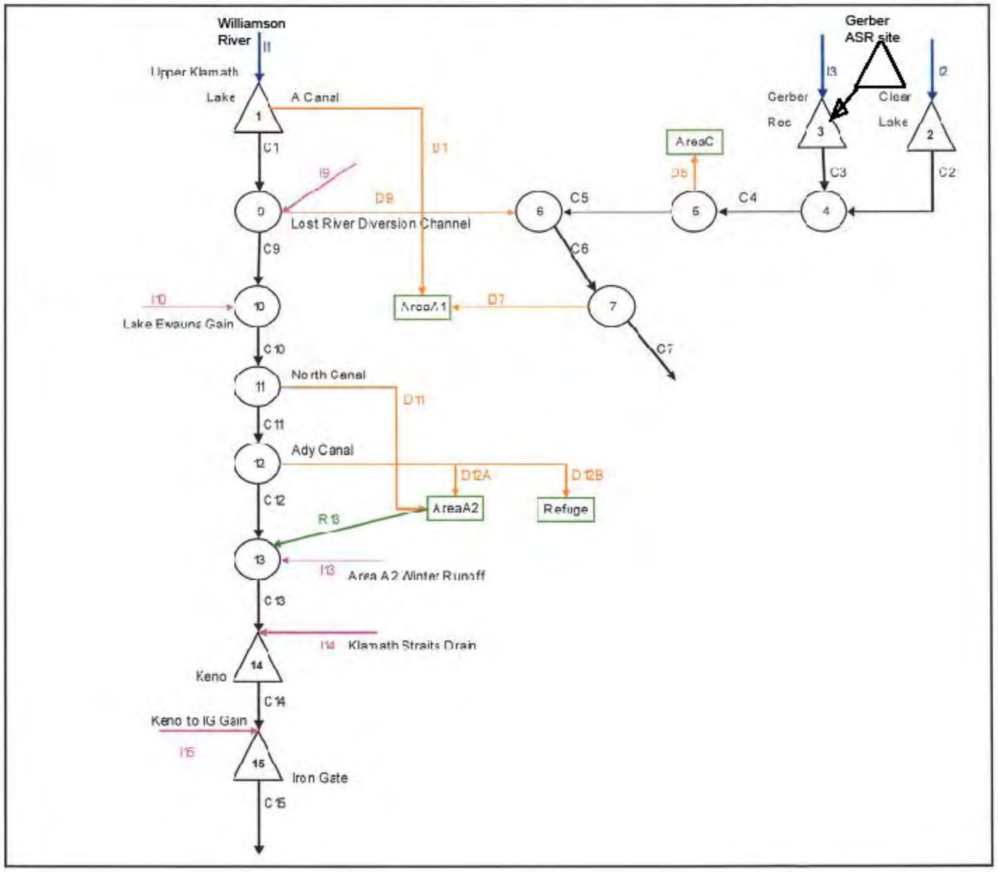
Southern Lower Klamath Lake ASR Storage facility
Inlet/Outlet capacity = 100 cfs

Storage capacity = 8000 af

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Gerber ASR alternative - production only



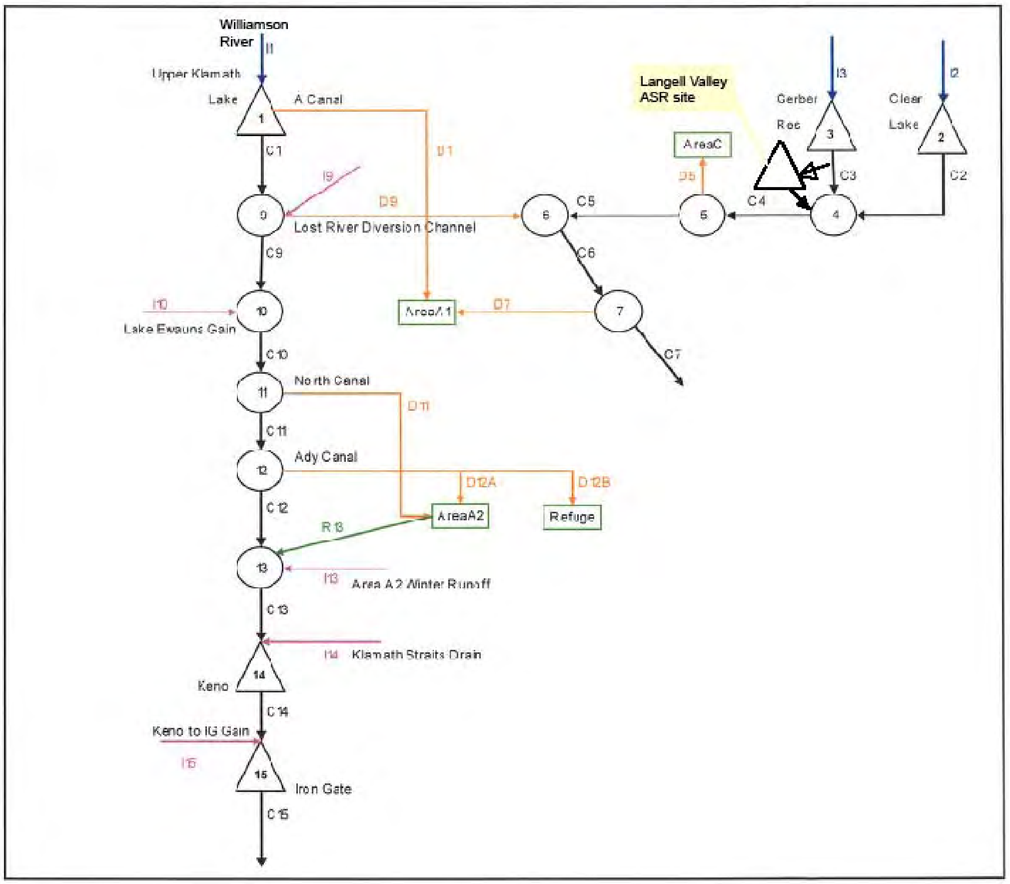
Gerber ASR production facility
Outlet capacity = 100 cfs

Storage capacity = 8000 af

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Langell Valley ASR alternative



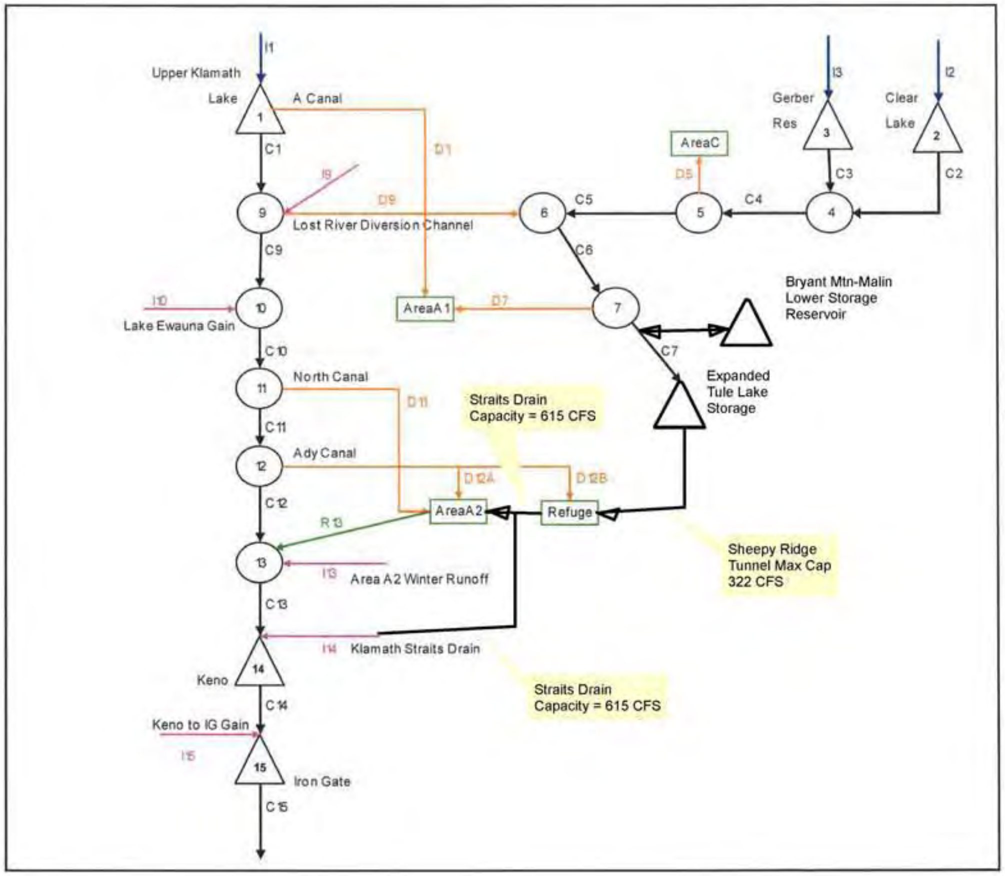
Langell Valley ASR facility
Inlet/outlet capacity = 100 cfs

Storage capacity = 6400 af

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Bryant Mtn - Malin storage alternative



Bryant Mtn - Malin lower reservoir
storage facility
Inlet/outlet capacity = 610 cfs

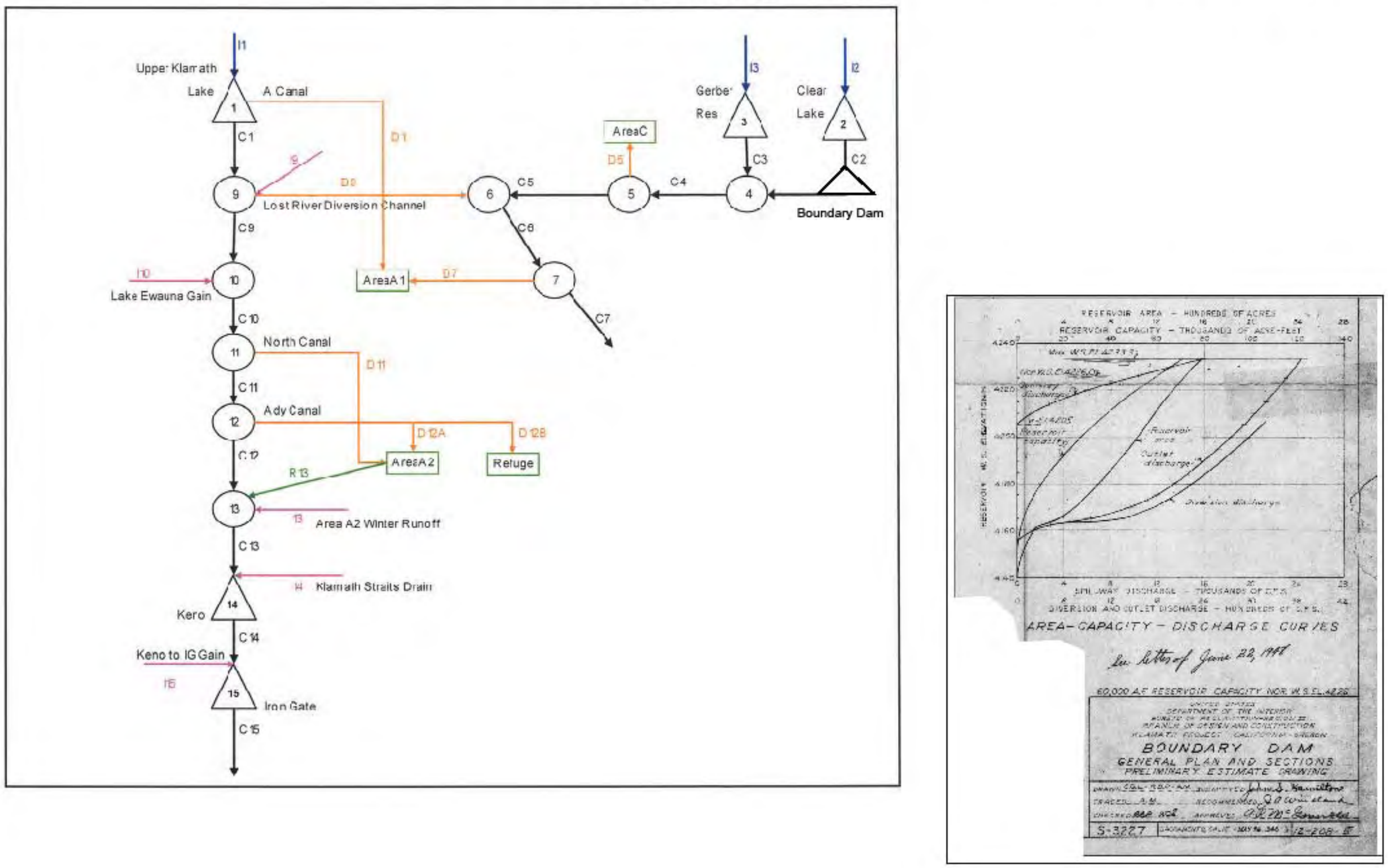
Depth (ft)	Storage (ac-ft)
0	0
50	50,000
120	115,600

Lower reservoir capacity table is shown for water conservation pool only. This pool would be available during non-power generaation season only.
12,400 ac-ft of space in the lower reservoir would be needed for daily power generation during power generation season.

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

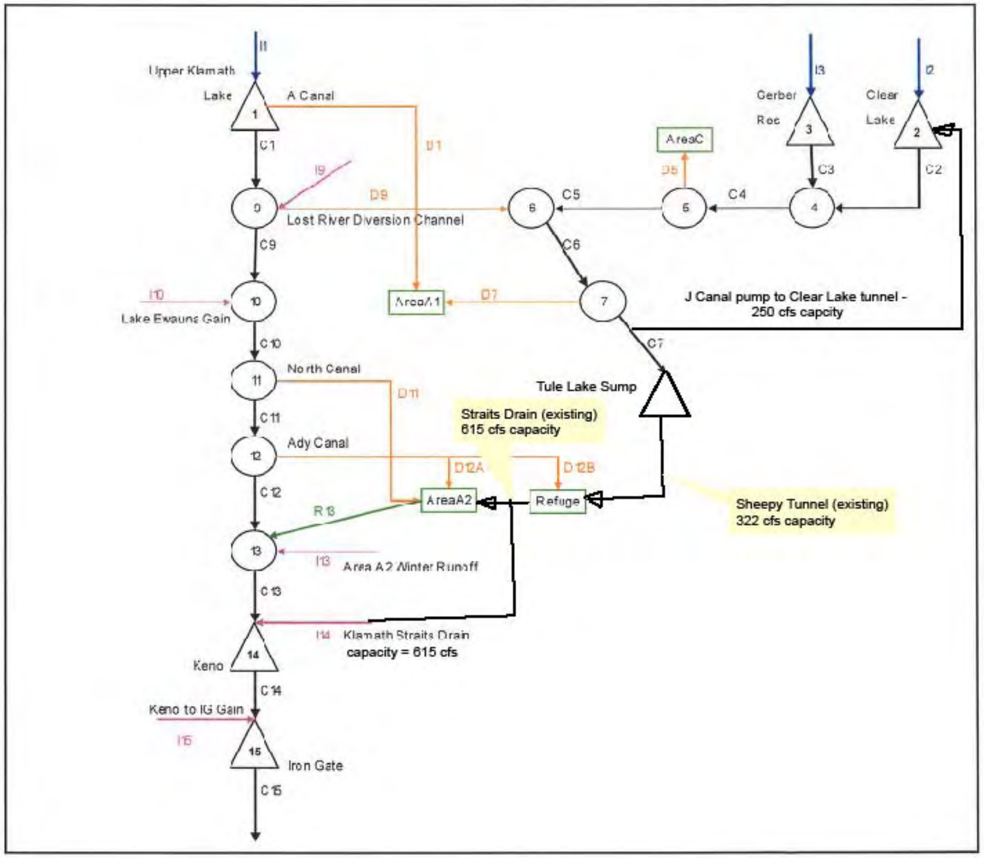
Boundary Dam storage alternative



Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

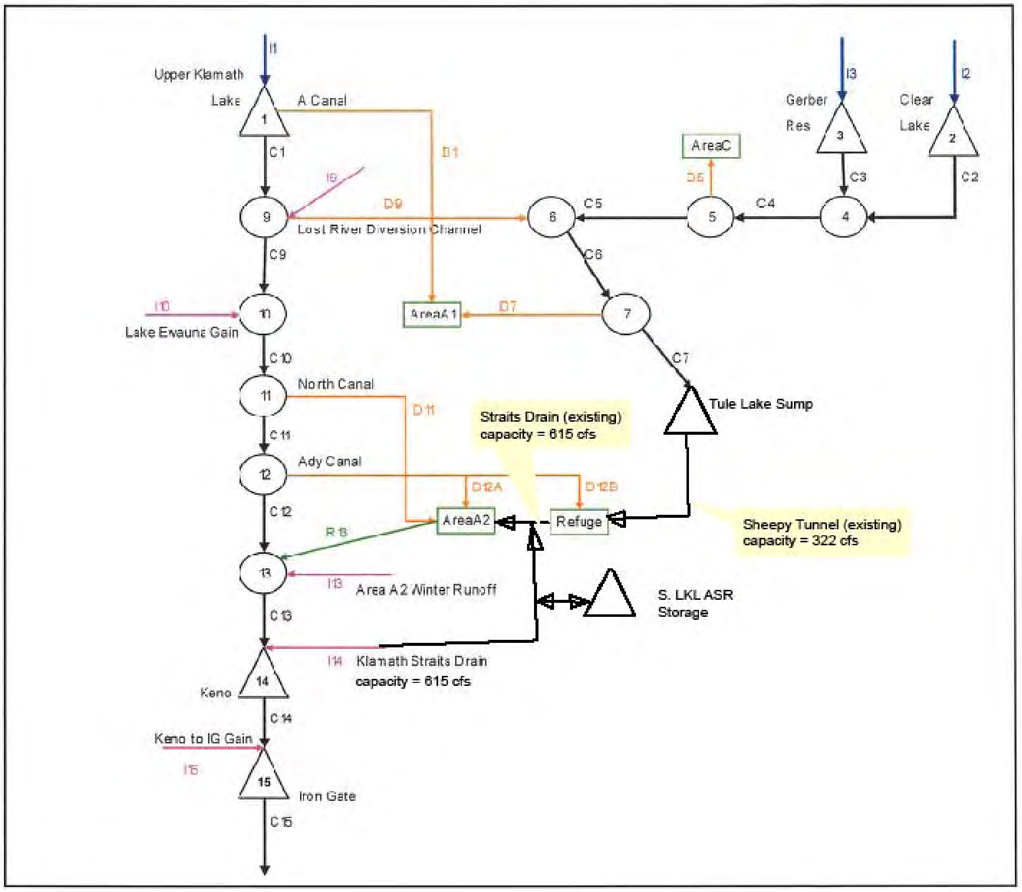
J Canal pump to Clear Lake alternative



Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Southern Lower Klamath Lake ASR storage alternative
Suboption C



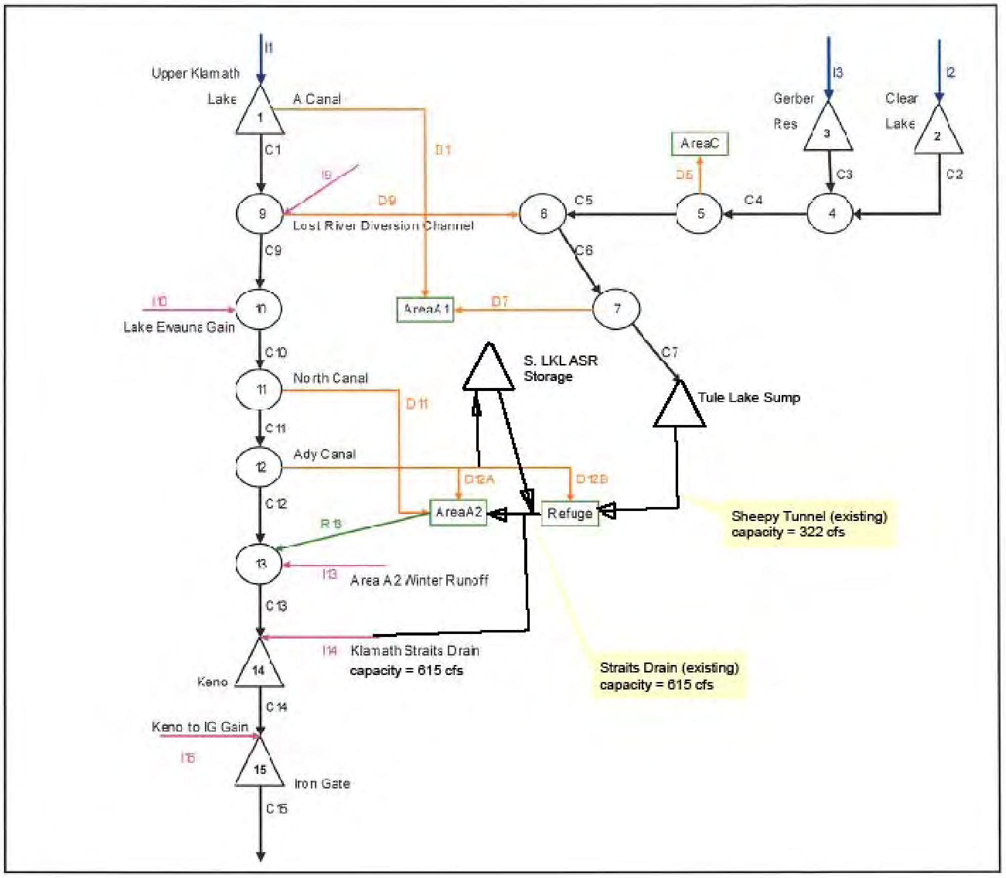
Southern Lower Klamath Lake ASR Storage facility
Inlet/Outlet capacity = 100 cfs

Storage capacity = 8000 af

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Southern Lower Klamath Lake ASR storage alternative
Suboption A



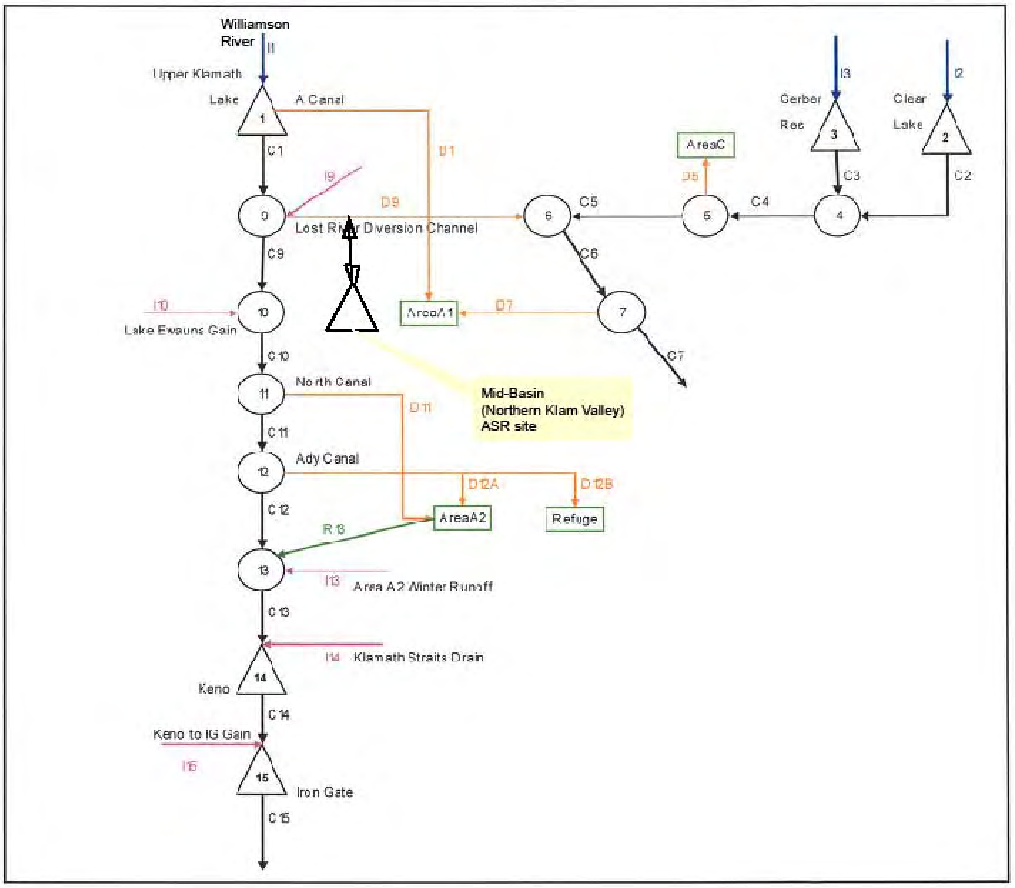
Southern Lower Klamath Lake ASR Storage facility
Inlet/Outlet capacity = 100 cfs

Storage capacity = 8000 af

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Mid-Basin (Northern Klamath Valley) ASR alternative



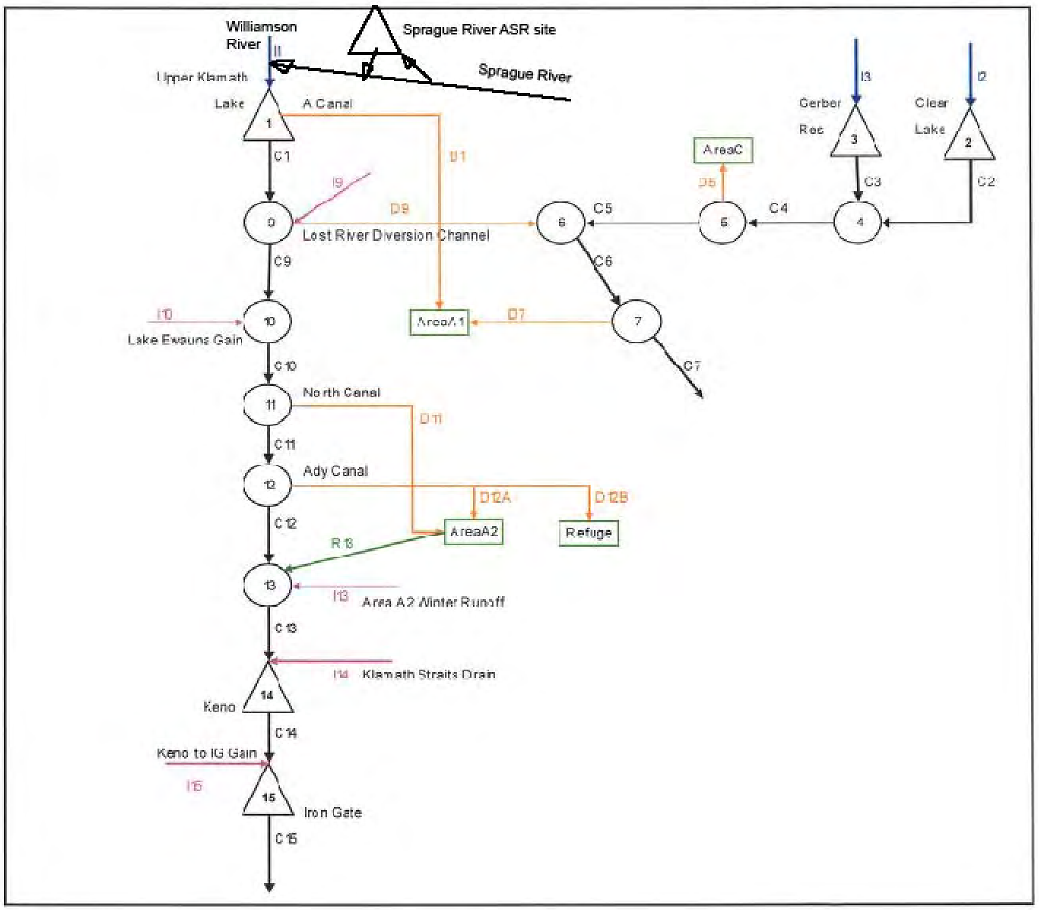
Mid-Basin (N. Klamath Valley) ASR facility
Inlet/outlet capacity = 100 cfs

Storage capacity = 9600 af

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Sprague River ASR alternatives - injection and infiltrated



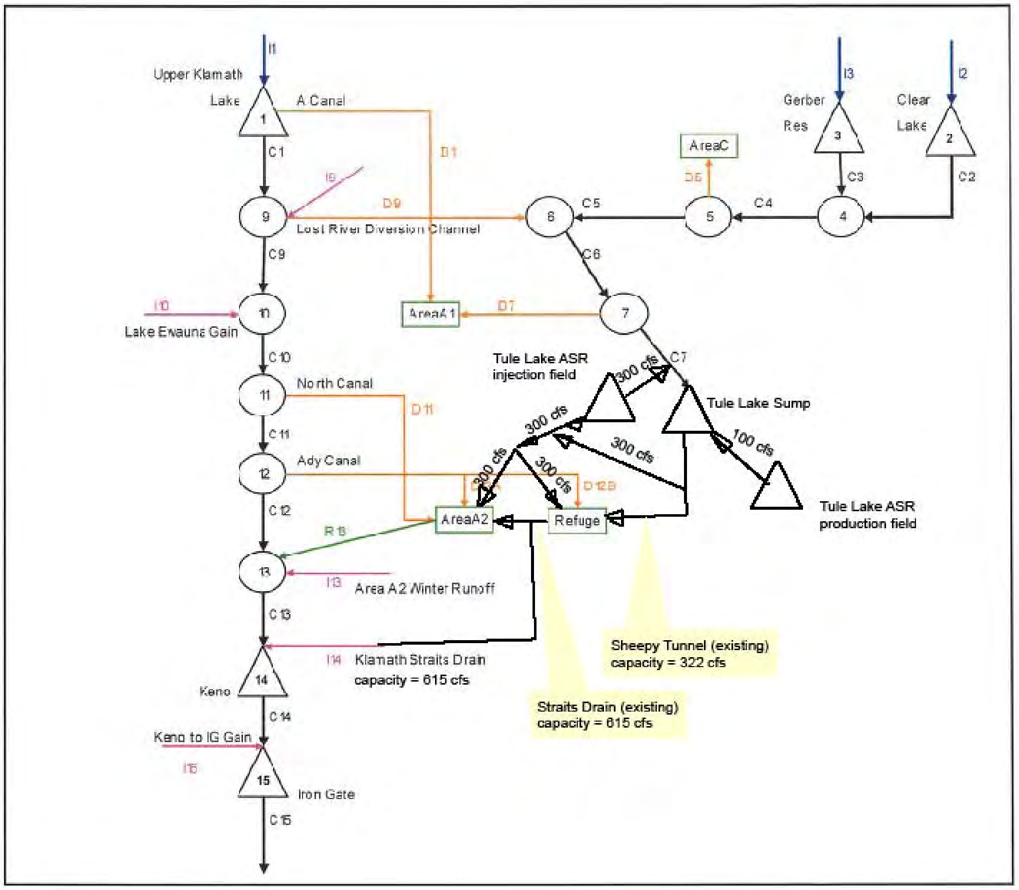
Sprague River ASR storage facility
Inlet/outlet capacity = 100 cfs

Storage capacity = 7600 af

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Tule Lake ASR storage alternative



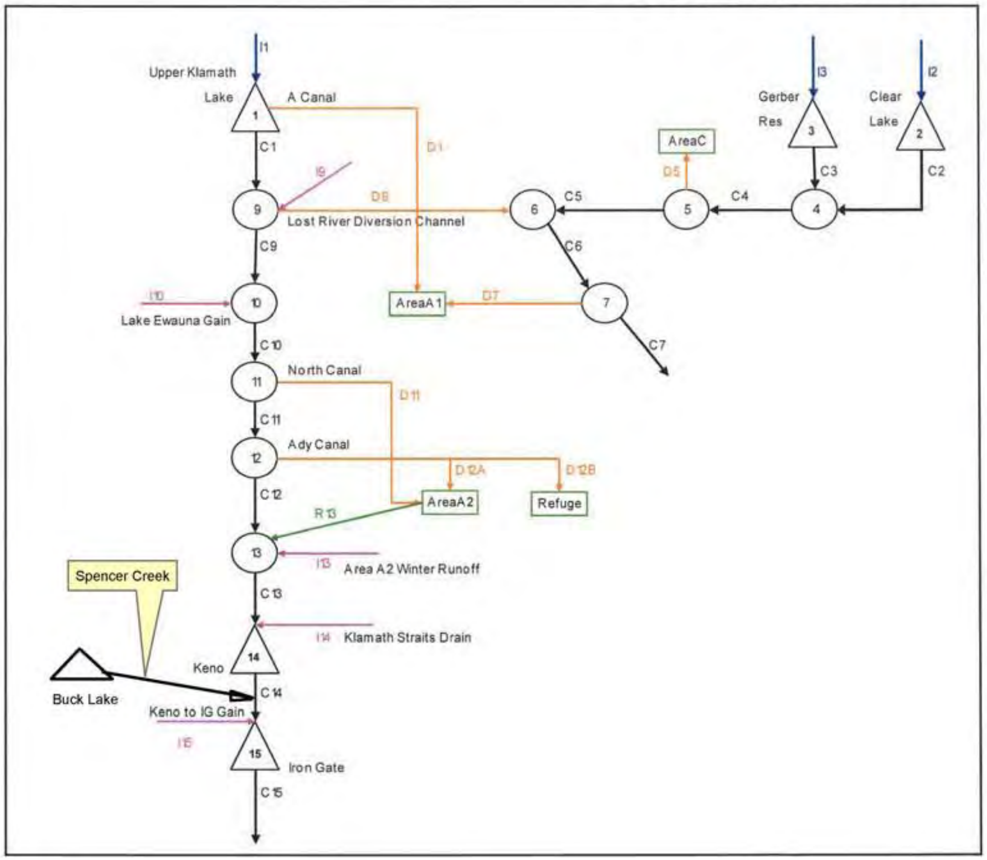
Tule Lake ASR Storage facility
Inlet/Outlet capacity = 100 cfs

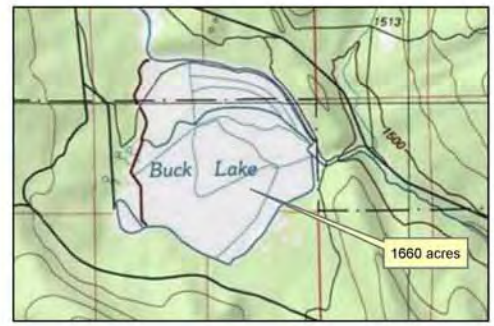
Storage capacity = 16000 af

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Buck Lake storage alternative





Buck Lake
Outlet Capacity = 100 cfs

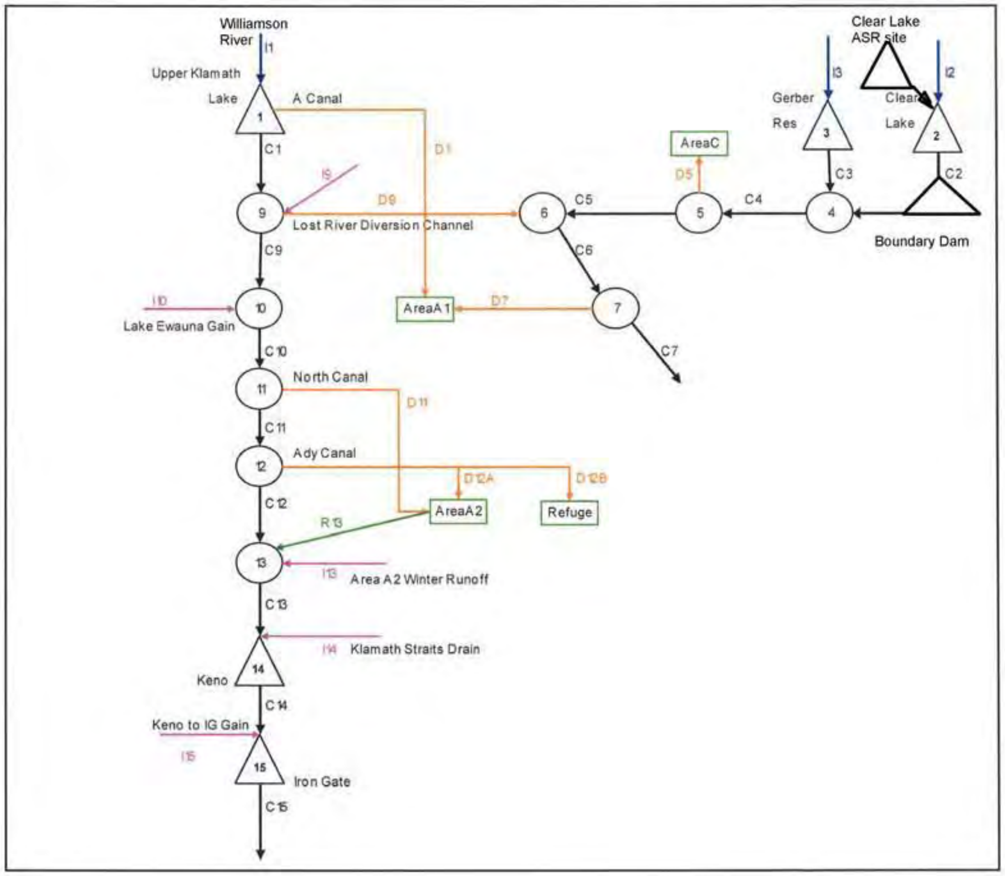
AC Table

Depth	Volume
0	0
5	8300
7	9300

Upper Klamath Basin Offstream Storage Studies

WRIMS Hydrology Study Model Water Delivery System Schematic and Model Inputs

Clear Lake ASR site - production only
with storage of production at Boundary Reservoir

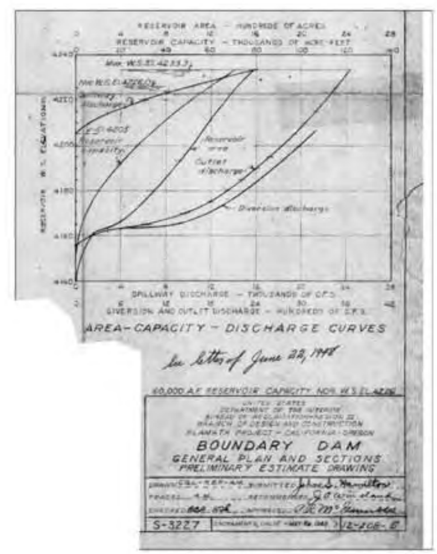


Clear Lake ASR production facility
Outlet capacity = 100 cfs

Storage capacity = 8000 af

Boundary Dam - Outlet capacity = 3600 cfs

Combined ASR/surface stroage capacity = 39,700 af



APPENDIX B

UKBOS Water Treatment Assessment Report

- **Summary report on preliminary water treatment assessment**
- **Supplemental water quality and water treatment data**

PRELIMINARY-LEVEL EVALUATION OF UKBOS WATER TREATMENT OPTIONS

The Upper Klamath Basin Offstream Storage (UKBOS) investigations developed a variety of water storage scenarios for the Basin's future water supply. The Klamath Basin Area Office (KBAO) and the MP Regional Office requested preliminary-level analyses and cost estimates for potential water treatment options to address contaminants of concern for five groups of off-stream storage alternatives presented in the *UKBOS Initial Alternatives Information Report*, June 2009 (UKBOS initial report). Reclamation's Technical Service Center (TSC) previously completed a similar evaluation for one of the UKBOS alternatives – *Preliminary Design and Cost Estimate for Water Treatment, UKBOS Study at Long Lake Valley*, November 2008 (LLV study).

The water treatment scenarios evaluated for the five groups of alternatives address many of the same contaminants of concern and utilize the same treatment flow quantities that were presented in the LLV study. The current analyses, therefore, incorporate the designs and costs from the LLV study where appropriate, and all cost estimates are presented at the September 2008 price level to enable comparison with the LLV off-stream storage alternative. The design and cost estimating assumptions used in the LLV study and incorporated herein include:

- Maximum sustained flow rate into treatment plant operations is 1,000 cfs during a 60-day period of time; except for Options 2A – 2D under Alternative Group 2, which evaluate two maximum sustained flow rates: 100 cfs and 300 cfs, during a 60-day period of time.
- Power cost = $0.07/kW-hr; plant operator labor rate = $33.78/hr.
- Use of EPA and TSC cost curves for water treatment plant construction and operation and maintenance costs, indexed to September 2008 using ENR index data, to prepare preliminary-level cost estimates.
- Cost estimates for some treatment equipment and chemicals are derived from vendor quotes and contract bid data available from the internet.
- Water quality parameters derived from Upper Klamath Lake (UKL) for the LLV study shown in Table 1, plus data provided by KBAO as described in each of the alternative group descriptions.

Table 1. Water Quality Parameters from LLV Study			
Parameter	**Raw average**	**Raw maximum**	**Effluent (water quality goal) to UKL**
pH	9.0	10.6	9.0
Total phosphorus (mg/L)	0.2	1.0	0.5
Ammonia (mg/L)	0.4	7.6	0.36
TSS (mg/L)	10	100	30
Temperature (°F)	61	79	61
Dissolved oxygen (mg/L)	8.6	18.6	5.0

Alternative Group 1

Alternative Group 1 addresses water quality concerns that are common to the following off-stream surface water storage options, which are described in the UKBOS initial report: Caledonia Marsh Offstream Storage, Swan Lake Storage, Raise Upper Klamath Lake, Klamath Drainage District Storage, Wocus Marsh, Fully-Levied ALR/Barnes Ranch, Buck Lake, Round Lake, Aspen Lake, and Whiteline.

These storage options have the potential to increase eutrophication and water temperatures due to the shallow depths of these water bodies as compared to UKL. Treatment requirements and cost estimates for this alternative group assume in-lake aeration (to increase dissolved oxygen), phosphorous removal (to mitigate algae blooms), and treatment plant filtration (to remove suspended solids) as developed in the LLV study. The cost for SolarBee aeration was modified from the LLV study to account for the increment of change in the total volume of storage of the Group 1 storage options as compared to the volume of storage of the proposed LLV reservoir. Additionally, treatment measures to reduce temperature, pH, and ammonia are added for storage options in this alternative group, as described below and shown in Table 2.

- Temperature reduction: It is assumed that temperature reduction requirements can be met through a combination of SolarBee mixing technology and hydraulic reservoir management techniques. The intake hose for SolarBee aerators can be set at the required depth to establish a thermocline, below which cooler temperature water may be extracted for discharge. Hydraulic management techniques can augment this method through temperature monitoring and selective withdrawal of reservoir water.

- pH reduction: A sulfuric acid mixing and injection system at the filtration treatment plant will reduce the pH of the discharged water.
- Ammonia reduction: The concentration of ammonia is reduced using a chlorine injection system to convert ammonia to nitrogen gas.

Table 2. Water Treatment Cost Estimates for Alternative Group 1.

	Treatment Technologies	**Treatment Goals**	**Capital Cost**	**Annual O&M Cost**
1	SolarBee aeration	DO ≥ 5 mg/L Temperature ≤ 61°F	$ 4,300,000	$ 230,000
2	In-lake phosphorus precipitation	phosphorus ≤ 0.5 mg/L	$ 5,400,000	$2,200,000
3	Filtration	TSS ≤ 30 mg/L	$50,000,000	$ 320,000
4	Acid addition	pH ≤ 9	$ 300,000	$ 530,000
5	Chlorine addition	NH_3 ≤ 0.36 mg/L	$ 3,800,000	$1,000,000
	Total Treatment Costs		$63,800,000	$4,280,000

Alternative Group 2

Alternative Group 2 consists of potential aquifer storage and recovery (ASR) projects using source waters similar in quality to UKL. Waters that are discharged and stored below ground surface are subject to the State of Oregon Underground Injection Control Program. Under this program, ASR waters must meet the EPA Safe Drinking Water Standards prior to underground injection. The water treatment approach for the ASR options incorporates the conventional water treatment operations from the LLV study (coagulation with ferric chloride [$FeCl_3$], clarification, and gravity sand filtration) and adds chlorine disinfection to remove pathogens, as shown in Figure 1.

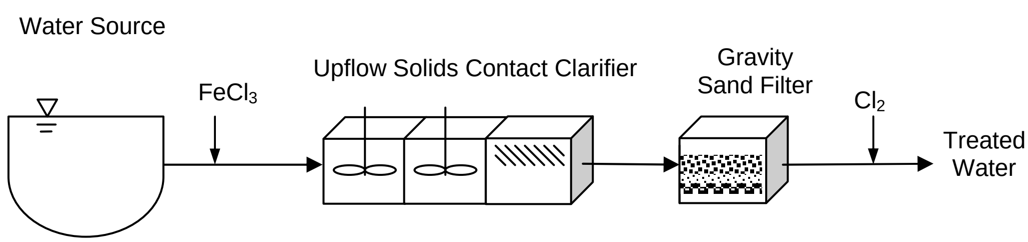


Figure 1. Conventional Water Treatment Process for ASR Alternatives

Conventional treatment provides both solids removal and organics removal using a conservative high dose of $FeCl_3$, 7 mg/L. Solids are removed to reduce the potential for plugging or fouling of the injection wells, and organics should be removed to minimize the potential of forming disinfection by-products, which are regulated by drinking water standards. A conservative high dose of chlorine, 10 mg/L CL_2, is assumed to meet disinfection requirements; the resulting cost estimates are shown in Table 3.

Table 3. Water Treatment Cost Estimates for Alternative Group 2.

	Treatment Technologies	Treatment Goals	Capital Cost	Annual O&M Cost
1	$FeCl_3$ coagulation	TSS ≤ 30 mg/L Organics removal	$15,000,000	$1,500,000
2	UFSCC	TSS ≤ 30 mg/L Organics removal	$14,000,000	$ 60,000
3	Filtration	TSS ≤ 30 mg/L Organics removal	$50,000,000	$ 320,000
4	Chlorine addition	Bacteria = 0 CFU	$ 3,800,000	$1,000,000
	Total Treatment Costs		$82,800,000	$2,880,000

Options 2A – 2D

Options 2A – 2D are a subset of Alternative Group 2; they are all ASR projects, however, they are based upon a flow rate of 100 cfs and 300 cfs and utilize different source waters, storage assumptions, or treatment configurations.

Option 2A: The source water is similar in quality to the Williamson River and Torrent Springs, which are likely superior in quality as compared to the water quality parameters for Alternative Group 2. This option uses the conventional treatment process (Figure 1); however, the chemical dosing requirements for both coagulation and disinfection are reduced (2.25 mg/L of $FeCl_3$, and 7 mg/L of Cl_2) as compared to Alternative Group 2. The cost estimates are provided in Table 4a and 4b.

Table 4a. Water Treatment Cost Estimates for Option 2A at 100 cfs.

	Treatment Technologies	Treatment Goals	Capital Cost	Annual O&M Cost
1	$FeCl_3$ coagulation	TSS ≤ 30 mg/L Organics removal	$ 280,000	$ 40,000
2	UFSCC	TSS ≤ 30 mg/L Organics removal	$ 2,400,000	$ 9,200
3	Filtration	TSS ≤ 30 mg/L Organics removal	$ 8,900,000	$ 59,000
4	Chlorine addition	Bacteria = 0 CFU	$ 400,000	$ 80,000
	Total Treatment Costs		$ 11,980,000	$188,200

Table 4b. Water Treatment Cost Estimates for Option 2A at 300 cfs.				
	Treatment Technologies	**Treatment Goals**	**Capital Cost**	**Annual O&M Cost**
1	$FeCl_3$ coagulation	TSS ≤ 30 mg/L Organics removal	$ 870,000	$ 120,000
2	UFSCC	TSS ≤ 30 mg/L Organics removal	$ 6,000,000	$ 20,000
3	Filtration	TSS ≤ 30 mg/L Organics removal	$21,000,000	$ 140,000
4	Chlorine addition	Bacteria = 0 CFU	$ 840,000	$ 220,000
	Total Treatment Costs		$28,710,000	$2,880,000

<u>Option 2B</u>: The source water for Option 2B as the same water quality as Tule Lake, which has high levels of phosphorus, nitrate, and ammonia. The concentrations of these constituents as described under the Group 4 Alternatives are lower than the drinking water standards. The required treatment process, therefore, is the same conventional treatment shown in Figure 1. It is likely that high levels of suspended solids and organics are present, so conservative chemical dosing requirements are assumed: 7 mg/L of $FeCl_3$ and 10 mg/L of Cl_2. Cost estimates are shown in Table 5a and 5b.

Table 5a. Water Treatment Cost Estimates for Option 2B at 100 cfs.				
	Treatment Technologies	**Treatment Goals**	**Capital Cost**	**Annual O&M Cost**
1	$FeCl_3$ coagulation	TSS ≤ 30 mg/L Organics removal	$ 820,000	$ 120,000
2	UFSCC	TSS ≤ 30 mg/L Organics removal	$ 2,400,000	$ 9,200
3	Filtration	TSS ≤ 30 mg/L Organics removal	$8,900,000	$ 59,000
4	Chlorine addition	Bacteria = 0 CFU	$ 570,000	$ 120,000
	Total Treatment Costs		$12,690,000	$ 308,200

Table 5b. Water Treatment Cost Estimates for Option 2B at 300 cfs.				
	Treatment Technologies	**Treatment Goals**	**Capital Cost**	**Annual O&M Cost**
1	$FeCl_3$ coagulation	TSS ≤ 30 mg/L Organics removal	$ 6,800,000	$ 380,000
2	UFSCC	TSS ≤ 30 mg/L Organics removal	$ 6,000,000	$ 20,000
3	Filtration	TSS ≤ 30 mg/L Organics removal	$21,000,000	$ 140,000
4	Chlorine addition	Bacteria = 0 CFU	$ 1,200,000	$ 320,000
	Total Treatment Costs		$35,000,000	$ 860,000

Option 2C: The source water for Option 2C is assumed to not require treatment prior to injection in the ASR project. Ground water that is subsequently extracted from the ASR is required to have the same water quality as the injected water or meet drinking water quality standards if they are more stringent. Extracted water is not likely to be degraded during underground storage and the pumped retrieval would impart natural filtration from aquifer soils. Pumped ground waters commonly require only disinfection to meet drinking water standards. The cost estimates for Option 2C, therefore, are based upon disinfection treatment using a moderate Cl_2 dose of 5 mg/L, and are shown in Table 6a and 6b.

Table 6a. Water Treatment Cost Estimates for Option 2C at 100 cfs.				
	Treatment Technologies	**Treatment Goals**	**Capital Cost**	**Annual O&M Cost**
1	Chlorine addition	Bacteria = 0 CFU	$ 290,000	$ 56,000
	Total Treatment Costs		$ 290,000	$ 56,000

Table 6b. Water Treatment Cost Estimates for Option 2C at 300 cfs				
	Treatment Technologies	**Treatment Goals**	**Capital Cost**	**Annual O&M Cost**
1	Chlorine addition	Bacteria = 0 CFU	$ 580,000	$ 160,000
	Total Treatment Costs		$ 580,000	$ 160,000

Option 2D: The source water for Option 2D has the same water quality as Alternative Group 1, which would likely have high levels of solids and organics. Pre-injection treatment for ASR would require the conventional treatment process (Figure 1) to meet drinking water standards and conservative chemical dosages: 7 mg/L of $FeCl_3$ and 10 mg/L of Cl_2. The cost estimates for Option 2D are provided in Table 7a and 7b.

Table 7a. Water Treatment Cost Estimates for Option 2D at 100 cfs.

	Treatment Technologies	Treatment Goals	Capital Cost	Annual O&M Cost
1	$FeCl_3$ coagulation	TSS ≤ 30 mg/L Organics removal	$ 820,000	$ 120,000
2	UFSCC	TSS ≤ 30 mg/L Organics removal	$ 2,400,000	$ 9,200
3	Filtration	TSS ≤ 30 mg/L Organics removal	$8,900,000	$ 59,000
4	Chlorine addition	Bacteria = 0 CFU	$ 570,000	$ 120,000
	Total Treatment Costs		$12,690,000	$ 308,200

Table 7b. Water Treatment Cost Estimates for Option 2D at 300 cfs.

	Treatment Technologies	Treatment Goals	Capital Cost	Annual O&M Cost
1	$FeCl_3$ coagulation	TSS ≤ 30 mg/L Organics removal	$ 6,800,000	$ 380,000
2	UFSCC	TSS ≤ 30 mg/L Organics removal	$ 6,000,000	$ 20,000
3	Filtration	TSS ≤ 30 mg/L Organics removal	$21,000,000	$ 140,000
4	Chlorine addition	Bacteria = 0 CFU	$ 1,200,000	$ 320,000
	Total Treatment Costs		$35,000,000	$ 860,000

Alternative Group 3

The third alternative group consists of damming Williamson River Canyon and Torrent Springs for surface water storage. The source water for both Williamson River Canyon and Torrent Springs is likely of superior water quality as compared to the parameters used for the LLV study. Although some treatment may be required for this alternative group, it is likely that treatment will be relatively minimal as compared to the LLV storage option.

The primary water impairment concern is possible stratification of reservoir water resulting in higher surface temperatures and reduced dissolved oxygen levels below the thermocline. It may be possible to adequately mitigate this potential impairment through the use of outlet works that selectively discharge waters that meet discharge requirements. If additional measures are required, it is likely that SolarBee aerators can provide the mixing and oxygenation needed to meet discharge requirements. SolarBee pond aeration units can also prevent or minimize the mobilization of contaminants from sediment, including iron, manganese, and sulfides as shown in Figure 2. Cost estimates for SolarBee installation and operation and maintenance are based upon the LLV study but modified to account for the difference in reservoir storage parameters (Table 8).

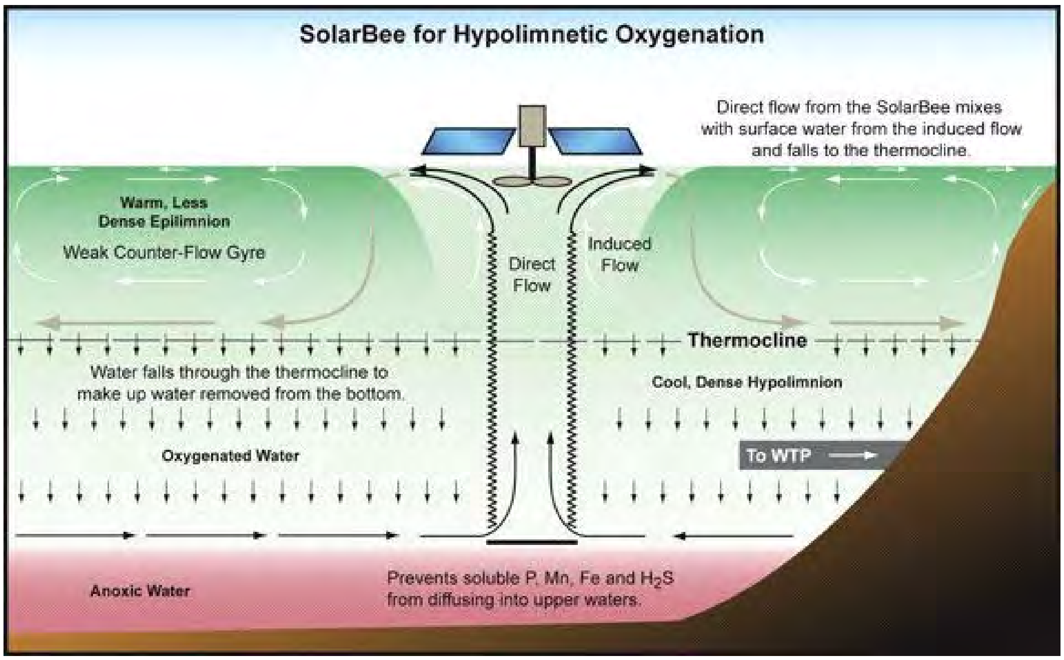


Figure 2. Hypolimnetic Oxygenation Using a SolarBee

Table 8. Water Treatment Cost Estimates for Alternative Group 3.

	Treatment Technologies	Treatment Goals	Capital Cost	Annual O&M Cost
1	SolarBee aeration	DO ≥ 5 mg/L Temperature ≤ 61°F	$2,200,000	$120,000
	Total Treatment Costs		$2,200,000	$120,000

Alternative Group 4

Alternative Group 4 is comprised of three surface water storage sites (Tule Lake, Lower Klamath Lake, and Boundary Dam) with existing requirements in California and future requirements in Oregon for total maximum daily loads (TMDLs). Currently, TMDLs in these areas are focused on nitrogen and biochemical oxygen demand. As such, it is likely that California would require treatment for these constituents. The water treatment approach for the Group 4 storage options incorporates the source water treatment operations from the LLV study (aeration, phosphorous removal, and filtration) and adds treatment steps for the removal of nitrogen constituents (ammonia and nitrate).

The current estimates of discharged nitrogen quantities, 22.3 metric tons/yr, are only slightly higher than the California Lost River TMDL, 21.7 metric tons/yr. Therefore, only a portion of the total discharge would require treatment for nitrogen removal to meet the TMDL. Assuming average concentrations of 1 mg/L of ammonia and 1 mg/L of nitrate in the raw water, approximately 6 metric tons of nitrogen can be removed using chlorination and ion exchange treatment for a 20 cfs portion of the total discharge flow. The treated flow (20 cfs) would be blended with the bypass flow (980 cfs) at the point of discharge. The treatment costs for Alternative Group 4 are summarized in Table 9.

Table 9. Water Treatment Cost Estimates for Alternative Group 4.

	Treatment Technologies	Treatment Goals	Capital Cost	Annual O&M Cost
1	SolarBee aeration	DO ≥ 5 mg/L Temperature ≤ 61^{o}F	$ 4,600,000	$ 240,000
2	In-lake phosphorus precipitation	phosphorus ≤ 0.5 mg/L	$ 5,700,000	$2,300,000
3	Filtration	TSS ≤ 30 mg/L	$50,000,000	$ 320,000
4	Ion Exchange	NO_3^- removal, N ≤ 21.7 m-tons/yr	$ 6,000,000	$ 800,000
5	Chlorine addition	NH_3 removal, N ≤ 21.7 m-tons/yr	$ 300,000	$ 50,000
	Total Treatment Costs		$66,600,000	$3,710,000

Alternative Group 5

Alternative Group 5 addresses the short term water quality impacts from dredging UKL for additional surface water storage in UKL. The purpose of dredging is to improve the long-term water quality of the UKL. Disturbance of the underlying anoxic sediments, however, could release some constituents of concern currently immobile at this time and temporarily degrade the current water quality.

Increased phosphorus loading could occur and current algae bloom conditions might be exacerbated. Since these conditions would be temporary, it would be preferable to minimize discharges until the water column has stabilized and the water quality improves. If treatment measures are required to address these temporary impacts, installation of SolarBee aerators and in-lake phosphorous removal can be employed to increase dissolved oxygen and reduce potential algae blooms. Cost estimates derived from the LLV study are provided in Table 10 to address these temporary treatment measures.

Table 10. Water Treatment Cost Estimates for Alternative Group 5.

	Treatment Technologies	Treatment Goals	Capital Cost	Annual O&M Cost
1	SolarBee aeration	DO ≥ 5 mg/L Temperature ≤ 61^{o}F	$ 4,600,000	$ 240,000
2	In-lake phosphorus precipitation	phosphorus ≤ 0.5 mg/L	$ 5,700,000	$2,300,000
	Total Treatment Costs		$10,300,000	$2,540,000

APPENDIX C

Preliminary Costs and Estimating Guidelines

- **Itemized capital cost estimating worksheets for alternatives**
- **Total life-cycle cost estimating worksheet for alternatives**
- **Cost estimating and project planning guidelines reference**

IA-1. Without Water Storage projects alternative.

No construction or life-cycle costs are associated with this option.

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ of _8_

FEATURE: **ASR - Sprague infiltrated** **Q = 100 cfs)** **Summary Sheet by Feature** **- with water treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study**
	WOID: AF329 — **ESTIMATE LEVEL:** Preliminary
	REGION: MP — **UNIT PRICE LEVEL:** Oct-10
	FILE: H:\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOSS\28 Alts Working\A-2 - Aquifer Storage & Recovery-New\Dec-10\A-2a Sprague infilt\A-2a ASR Sprague Infiltr w WT.xlsx]FeatureSum ftz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$102,525.00
	3	Construct Wellfield levees and O&M Roads					$8,683,403.00
	4	Construct Intake and Discharge Structures					$1,065,030.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$2,738,620.00
	7	Fish screening facility					$3,986,800.00
	8	Electric Installations					$8,930,000.00
	9	Water Treatment facility					$580,000.00
		Subtotal 1					$29,250,287.00
		Mobilization	5%	+/-			$1,450,000.00
		Subtotal 1 with Mobilization					**$30,700,287.00**
		Design Contingencies	25%	+/-			$7,675,072.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$38,375,359.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$38,375,359.00
		CONTRACT COST					**$38,000,000.00**
		Construction Contingencies	25%	+/-			$10,000,000.00
		FIELD COST					**$48,000,000.00**
		Non-Contract Costs	25%	+/-			$12,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$60,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY S Mattingly	**REVIEWED**	**BY** L. Zlomke	**CHECKED** 12/17/10
DATE PREPARED 11/17/10	**PEER REVIEW / DATE** S. Mattingly 11/17/10	**DATE PREPARED** 12/16/10	**PEER REVIEW / DATE** 12/20/10

BUREAU OF RECLAMATION			ESTIMATE WORKSHEET			SHEET _1_ of _8_	
FEATURE: ASR - Sprague infiltrated Q = 100 cfs) Summary Sheet by Feature - without water treatment			**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study				
			WOID:	AF329	**ESTIMATE LEVEL:**		Preliminary
			REGION:	MP	**UNIT PRICE LEVEL:**		Oct-10
			FILE:	H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 2 - Aquifer Storage & Recovery-New\Dec-10\IA-2a Sprague Infil\[IA-2a ASR Sprague Infiltr WO WT.xlsx]Life-Cycle Costs Analysis			
PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$102,525.00
	3	Construct Wellfield levees and O&M Roads					$8,683,403.00
	4	Construct Intake and Discharge Structures					$1,065,030.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$2,738,620.00
	7	Fish screening facility					$3,986,800.00
	8	Electric Installations					$4,830,000.00
		Subtotal 1					$24,570,287.00
		Mobilization	5%	+/-			$1,250,000.00
		Subtotal 1 with Mobilization					**$25,820,287.00**
		Design Contingencies	25%	+/-			$6,455,072.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$32,275,359.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$32,275,359.00
		CONTRACT COST					**$32,000,000.00**
		Construction Contingencies	25%	+/-			$8,000,000.00
		FIELD COST					**$40,000,000.00**
		Non-Contract Costs	25%	+/-			$10,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$50,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	REVIEWED	BY L. Ziomke	CHECKED KMB 1/14/11
DATE PREPARED 11/17/10	PEER REVIEW / DATE S. Mattingly 11/17/10	DATE PREPARED 01/13/11	PEER REVIEW / DATE DLM 1/14/11

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET 1 of 8

FEATURE: ASR - Sprague Injected Q = 100 cfs)	**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study
Summary Sheet by Feature Water Treatment	WOID: AF329 — ESTIMATE LEVEL: Preliminary
	REGION: MP — UNIT PRICE LEVEL: Oct-10
	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-2 - Aquifer Storage & Recovery-New\Dec-10\IA-2b Sprague Inject\[IA-2b ASR Sprague Injected W WT.xlsx]FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$102,525.00
	3	Construct Wellfield levees and O&M Roads					$8,683,403.00
	4	Construct Intake and Discharge Structures					$1,065,030.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$4,559,936.00
	7	Fish screening facility					$4,025,118.00
	8	Electric Installations					$8,930,000.00
	9	Water Treatment facillity					$580,000.00
		Subtotal 1					$31,109,921.00
		Mobilization	5%	+/-			$1,550,000.00
		Subtotal 1 with Mobilization					**$32,659,921.00**
		Design Contingencies	25%	+/-			$8,164,980.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$40,824,901.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$40,824,901.00
		CONTRACT COST					**$41,000,000.00**
		Construction Contingencies	25%	+/-			$10,000,000.00
		FIELD COST					**$51,000,000.00**
		Non-Contract Costs	25%	+/-			$13,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$64,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY: S Mattingly	REVIEWED	BY: L. Zlomke	CHECKED: KMB 1/10/11
DATE PREPARED: 11/17/10	PEER REVIEW / DATE: S. Mattingly 11/17/10	DATE PREPARED: 01/10/11	PEER REVIEW / DATE: DCM 1/10/11

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ of _8_

FEATURE:	PROJECT:
ASR - Sprague Injected Q = 100 cfs) Summary Sheet by Feature - without water treatment	UPPER KLAMATH BASIN Offstream Storage Study WOID: AF329 — ESTIMATE LEVEL: Preliminary REGION: MP — UNIT PRICE LEVEL: Oct-10 FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-2 - Aquifer Storage & Recovery-New\Dec-10\IA-2b Sprague Inject\[IA-2b ASR Sprague Injected WO WT-R1.xlsx]Life-Cycle Costs Analysis

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$102,525.00
	3	Construct Wellfield levees and O&M Roads					$8,683,403.00
	4	Construct Intake and Discharge Structures					$1,065,030.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$4,559,936.00
	7	Fish screening facility					$4,025,118.00
	8	Electric Installations					$4,830,000.00
		Subtotal 1					$26,429,921.00
		Mobilization	5%	+/-			$1,300,000.00
		Subtotal 1 with Mobilization					**$27,729,921.00**
		Design Contingencies	25%	+/-			$6,932,480.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$34,662,401.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$34,662,401.00
		CONTRACT COST					**$35,000,000.00**
		Construction Contingencies	25%	+/-			$8,000,000.00
		FIELD COST					**$43,000,000.00**
		Non-Contract Costs	25%	+/-			$11,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$54,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY S Mattingly	REVIEWED	BY L. Zlomke	CHECKED KMB 1/14/11
DATE PREPARED 11/17/10	PEER REVIEW / DATE S. Mattingly 11/17/10	DATE PREPARED 01/13/11	PEER REVIEW / DATE DL 1/14/11

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _8_

FEATURE: **ASR - Mid-basin injected** **Q = 100 cfs)** **Summary Sheet by Feature** **- with water treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 **ESTIMATE LEVEL:** Preliminary **REGION:** MP **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-2 - Aquifer Storage & Recovery-New\Dec-10\IA-2c N Klamath Inject - Mid Basin\[IA-2c ASR Mid Basin_N. Klamath_ w WT.xlsx]FeatureSum

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$83,234.00
	3	Roads For service and O&M					$1,520,640.00
	4	Construct Intake and Discharge Structures					$1,040,580.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$5,292,780.00
	7	Fish screening facility					$4,025,118.00
	8	Electric Installations					$8,680,000.00
	9	Water Treatment facility					$35,000,000.00
		Subtotal 1					$58,806,261.00
		Mobilization	5%	+/-			$2,900,000.00
		Subtotal 1 with Mobilization					**$61,706,261.00**
		Design Contingencies	25%	+/-			$15,426,565.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$77,132,826.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$77,132,826.00
		CONTRACT COST					**$77,000,000.00**
		Construction Contingencies	25%	+/-			$19,000,000.00
		FIELD COST					**$96,000,000.00**
		Non-Contract Costs	25%	+/-			$24,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$120,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	**REVIEWED**	**BY** L. Zlomke	**CHECKED** 12/18/10
DATE PREPARED 11/17/10	**PEER REVIEW / DATE** S. Mattingly 11/17/10	**DATE PREPARED** 12/16/10	**PEER REVIEW / DATE** For DLM 12/20/10

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _8_

FEATURE: ASR - Mid-basin injected Q = 100 cfs)			**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study				
			WOID:	AF329	**ESTIMATE LEVEL:**		Preliminary
Summary Sheet by Feature - without water treatment			**REGION:**	MP	**UNIT PRICE LEVEL:**		Oct-10
			FILE:	H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 2 - Aquifer Storage & Recovery-New\Dec-10\IA-2c N Klamath Inject - Mid Basin\[IA-2c ASR Mid Basin_N. Klamath WO WT-R1.xlsx]FeatureSum			

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$83,234.00
	3	Roads For service and O&M					$1,520,640.00
	4	Construct Intake and Discharge Structures					$1,040,580.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$5,292,780.00
	7	Fish screening facility					$4,025,118.00
	8	Electric Installations					$4,580,000.00
		Subtotal 1					$19,706,261.00
		Mobilization	5%	+/-			$990,000.00
		Subtotal 1 with Mobilization					**$20,696,261.00**
		Design Contingencies	25%	+/-			$5,174,065.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$25,870,326.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$25,870,326.00
		CONTRACT COST					**$26,000,000.00**
		Construction Contingencies	25%	+/-			$6,000,000.00
		FIELD COST					**$32,000,000.00**
		Non-Contract Costs	25%	+/-			$8,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$40,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY S Mattingly	**REVIEWED**	**BY** L Zlomke	**CHECKED** KMB 4/14/11
DATE PREPARED 11/17/10	**PEER REVIEW / DATE** S. Mattingly 11/17/10	**DATE PREPARED** 01/14/11	**PEER REVIEW / DATE** DLG 1/18/11

BUREAU OF RECLAMATION			ESTIMATE WORKSHEET			SHEET _1_ OF _6_	
FEATURE: ASR - Langell Valley - production only Wetlands construction costs			**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study				
			WOID:	AF329	ESTIMATE LEVEL:		Preliminary
Summary Sheet by Feature			REGION:	MP	UNIT PRICE LEVEL:		Oct-10
- without water treatment			FILE:	H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 2 - Aquifer Storage & Recovery-New\Dec-10\IA-2d Langell Inject\[IA-2d ASR Langell inject WO WT-R1.xlsx]Life-Cycle Costs Analysis			
PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$113,232.00
	3	Roads For service and O&M					$400,752.00
	4	Furnish and install wellfield					$3,047,500.00
	5	Steel pipe					$381,892.00
	6	Electric Installations					$8,830,000.00
		Subtotal 1					$12,889,785.00
		Mobilization	5%	+/-			$640,000.00
		Subtotal 1 with Mobilization					**$13,529,785.00**
		Design Contingencies	25%	+/-			$3,382,446.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$16,912,231.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$16,912,231.00
		CONTRACT COST					**$17,000,000.00**
		Construction Contingencies	25%	+/-			$4,000,000.00
		FIELD COST					**$21,000,000.00**
		Non-Contract Costs	25%	+/-			$5,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$26,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	REVIEWED	BY L. Zlomke	CHECKED KMB 1/14/11
DATE PREPARED 11/17/10	PEER REVIEW / DATE S. Mattingly 11/17/10	DATE PREPARED 01/14/11	PEER REVIEW / DATE DL 1/18/11

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET 1 OF 3

FEATURE:
ASR - Gerber - production only
Q = 100 cfs)
Diesel Pumps
Summary Sheet by Feature
- without water treatment

PROJECT:
UPPER KLAMATH BASIN
Offstream Storage Study

WOID:	AF329	ESTIMATE LEVEL:	Preliminary
REGION:	MP	UNIT PRICE LEVEL:	Oct-10

FILE: H:\D8170\EST\Spreadsheet\Zumke\C-Work Files\MP\Klamath\UKBOS\28 Alts Working\A 2 - Aquifer Storage & Recovery New\Dec-10\A-2e Gerber Inject\A-2e ASR Gerber inject diesel WO WT.xls]FeatureSum

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Roads For service and O&M					$3,117,312.00
	2	Furnish and install wellfield					$3,094,500.00
		Subtotal 1					$6,211,812.00
		Mobilization	5%	+/-			$310,000.00
		Subtotal 1 with Mobilization					**$6,521,812.00**
		Design Contingencies	25%	+/-			$1,630,453.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$8,152,265.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$8,152,265.00
		CONTRACT COST					**$8,000,000.00**
		Construction Contingencies	25%	+/-			$2,000,000.00
		FIELD COST					**$10,000,000.00**
		Non-Contract Costs	25%	+/-			$2,500,000.00
		CONSTRUCTION COST (does not include land costs)					**$12,500,000.00**

Ref: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY S Mattingly	REVIEWED	BY L Zbmke	CHECKED 12/17/10
DATE PREPARED 11/17/10	PEER REVIEW / DATE S Mattingly 11/17/10	DATE PREPARED 12/17/10	PEER REVIEW / DATE

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET 1 OF 5

FEATURE:
ASR - Gerber - production only
Q = 100 cfs)

Summary Sheet by Feature
- without water treatment

PROJECT: **UPPER KLAMATH BASIN Offstream Storage Study**

WOID:	AF329	**ESTIMATE LEVEL:**	Preliminary
REGION:	MP	**UNIT PRICE LEVEL:**	Oct-10
FILE:	H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 2 - Aquifer Storage & Recovery-New\Dec-10\IA-2e Gerber Inject\[IA-2e ASR Gerber inject WO WT-R1.xlsx]FeatureSum		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$113,232.00
	3	Construct Roads For service and O&M					$3,117,312.00
	4	Furnish and install wellfield					$3,047,500.00
	5	Electric Installations					$10,330,000.00
		Subtotal 1					$16,724,453.00
		Mobilization	5%	+/-			$840,000.00
		Subtotal 1 with Mobilization					**$17,564,453.00**
		Design Contingencies	25%	+/-			$4,391,113.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$21,955,566.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$21,955,566.00
		CONTRACT COST					**$22,000,000.00**
		Construction Contingencies	25%	+/-			$5,000,000.00
		FIELD COST					**$27,000,000.00**
		Non-Contract Costs	25%	+/-			$7,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$34,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY: S Mattingly	REVIEWED	BY: L Zlomke	CHECKED: KMB 1/14/11
DATE PREPARED: 11/17/10	PEER REVIEW / DATE: S.Mattingly 11/17/10	DATE PREPARED: 01/14/11	PEER REVIEW / DATE: DLA 1/18/11

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _5_

FEATURE:
ASR - Clear Lake - production only

Q = 100 cfs)
Summary Sheet by Feature
- no water treatment

PROJECT: **UPPER KLAMATH BASIN Offstream Storage Study**

WOID:	**AF329**	**ESTIMATE LEVEL:**	**Preliminary**
REGION:	**MP**	**UNIT PRICE LEVEL:**	**Oct-10**
FILE:	H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 2 - Aquifer Storage & Recovery-New\Dec-10\IA-2f Clear Lake Inject\[IA-2f Clear Lake ASR Qty WO WT-R1.xlsx]Life-Cycle Costs Analysis		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,167.00
	2	Construct embankment levee for wetlands					$113,340.00
	3	Construct O&M Roads					$801,504.00
	4	Furnish and install wellfield					$3,047,500.00
	5	Electric Installations					$11,330,000.00
		Subtotal 1					$15,407,511.00
		Mobilization	5%	+/-			$770,000.00
		Subtotal 1 with Mobilization					**$16,177,511.00**
		Design Contingencies	25%	+/-			$4,044,378.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$20,221,889.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$20,221,889.00
		CONTRACT COST					**$20,000,000.00**
		Construction Contingencies	25%	+/-			$5,000,000.00
		FIELD COST					**$25,000,000.00**
		Non-Contract Costs	25%	+/-			$6,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$31,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY S Mattingly	**REVIEWED**	**BY** L. Zlomke	**CHECKED** KMB 1/14/11
DATE PREPARED 11/17/10	**PEER REVIEW / DATE** S. Mattingly 11/17/10	**DATE PREPARED** 01/14/11	**PEER REVIEW / DATE** DLM 1/18/11

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _9_

FEATURE: **ASR - Tule Lake injected** **2 Wellfields - Q (each) = 100 cfs** **& (E) 300 cfs from "D" Plant** **Summary Sheet by Feature** **- no water treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 — **ESTIMATE LEVEL:** Preliminary **REGION:** MP — **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 2 - Aquifer Storage & Recovery-New\Dec-10\IA-2g Tule Inject\[IA-2g ASR Tule Lake Inject WO WT-R1.xlsx]Life-Cycle Costs Analysis

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$356,145.00
	3	Construct levees & other earthen works					$78,322,878.00
	4	Construct Roads For service and O&M					$1,520,640.00
	5	Construct Intake, Discharge and Recirc Canal Control Structure					$2,877,490.00
	6	Furnish and install wellfield					$6,095,000.00
	7	Steel pipe					$7,054,040.00
	8	Fish Screen Facility					$4,015,118.00
	9	Electrical Installations					$9,130,000.00
		Subtotal 1					$109,487,720.00
		Mobilization	5%	+/-			$5,500,000.00
		Subtotal 1 with Mobilization					**$114,987,720.00**
		Design Contingencies	25%	+/-			$28,746,930.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$143,734,650.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$143,734,650.00
		CONTRACT COST					**$145,000,000.00**
		Construction Contingencies	25%	+/-			$35,000,000.00
		FIELD COST					**$180,000,000.00**
		Non-Contract Costs	25%	+/-			$50,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$230,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY S Mattingly	REVIEWED	BY L Ziomke	CHECKED KMB 1/14/11
DATE PREPARED 11/17/10	PEER REVIEW / DATE Smattingly 11/17/10	DATE PREPARED 01/14/11	PEER REVIEW / DATE DLA 1/18/11

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ of _8_

FEATURE: **ASR - So LKL Opt A injected** **Q = 100 cfs)** **Summary Sheet by Feature** **Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 **ESTIMATE LEVEL:** Preliminary **REGION:** MP **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-2 - Aquifer Storage & Recovery-New\Dec-10\IA-2h S LKL-a Inject\[IA-2h ASR S LKL-a Inject w WT.xlsx]FeatureSum.ltz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$83,234.00
	3	Construct Wellfield levees and O&M Roads					$3,341,552.00
	4	Construct Intake and Discharge Structures					$1,065,030.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$5,382,032.00
	7	Fish screening facility					$4,025,118.00
	8	Electric Installations					$10,930,000.00
	9	Water Treatment facillity					$35,000,000.00
		Subtotal 1					$62,990,875.00
		Mobilization	5%	+/-			$3,100,000.00
		Subtotal 1 with Mobilization					**$66,090,875.00**
		Design Contingencies	25%	+/-			$16,522,719.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$82,613,594.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$82,613,594.00
		CONTRACT COST					**$83,000,000.00**
		Construction Contingencies	25%	+/-			$22,000,000.00
		FIELD COST					**$105,000,000.00**
		Non-Contract Costs	25%	+/-			$25,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$130,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	**REVIEWED**	**BY** L. Zlomke	**CHECKED** 12/13/10
DATE PREPARED 11/17/10	**PEER REVIEW / DATE** S Mattingly 11/17/10	**DATE PREPARED** 12/16/10	**PEER REVIEW / DATE** For DLM 12/20/10

BUREAU OF RECLAMATION			ESTIMATE WORKSHEET			SHEET _1_ of _8_	
FEATURE: ASR - So LKL Opt A injected Q = 100 cfs)			**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study				
			WOID:	AF329	**ESTIMATE LEVEL:**		Preliminary
Summary Sheet by Feature			**REGION:**	MP	**UNIT PRICE LEVEL:**		Oct-10
No Water Treatment			**FILE:**	H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 2 - Aquifer Storage & Recovery-New\Dec-10\IA-2h S LKL-a Inject\[IA-2h ASR S LKL-a Inject WO WT-R1.xlsx]Life-Cycle Costs Analysis			
PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$83,234.00
	3	Construct Wellfield levees and O&M Roads					$3,341,552.00
	4	Construct Intake and Discharge Structures					$1,065,030.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$5,382,032.00
	7	Fish screening facility					$4,025,118.00
	8	Electric Installations					$6,830,000.00
		Subtotal 1					$23,890,875.00
		Mobilization	5%	+/-			$1,200,000.00
		Subtotal 1 with Mobilization					**$25,090,875.00**
		Design Contingencies	25%	+/-			$6,272,719.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$31,363,594.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$31,363,594.00
		CONTRACT COST					**$31,000,000.00**
		Construction Contingencies	25%	+/-			$8,000,000.00
		FIELD COST					**$39,000,000.00**
		Non-Contract Costs	25%	+/-			$10,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$49,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY: S Mattingly	REVIEWED	BY: L. Zlomke	CHECKED: KMB 1/14/11
DATE PREPARED: 11/17/10	PEER REVIEW / DATE: S Mattingly 11/17/10	DATE PREPARED: 01/14/11	PEER REVIEW / DATE: DLM 1/18/11

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ of _7_

FEATURE:

ASR - So LKL Opt B injected
Wellfield (Q = 100 cfs)

Summary Sheet by Feature
- no water treatment

PROJECT:
UPPER KLAMATH BASIN
Offstream Storage Study

WOID: AF329 | **ESTIMATE LEVEL:** Preliminary
REGION: MP | **UNIT PRICE LEVEL:** Oct-10

FILE: H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-2 - Aquifer Storage & Recovery-New\Dec-10\IA-2i S LKL-b Inject\[IA-2i ASR S LKL-b Inject WO WT-R1.xlsx]FeatureSum Ilz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$187,972.00
	3	Construct Wellfield levees and O&M Roads					$9,485,920.00
	4	Construct Discharge Structures					$289,675.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$1,503,188.00
	7	Electric Installations					$4,330,000.00
		Subtotal 1					$18,960,664.00
		Mobilization	5%	+/-			$950,000.00
		Subtotal 1 with Mobilization					**$19,910,664.00**
		Design Contingencies	25%	+/-			$4,977,666.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$24,888,330.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$24,888,330.00
		CONTRACT COST					**$25,000,000.00**
		Construction Contingencies	25%	+/-			$6,000,000.00
		FIELD COST					**$31,000,000.00**
		Non-Contract Costs	25%	+/-			$8,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$39,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	**REVIEWED**	**BY** L. Ziomke [signature]	**CHECKED** KMB 1/14/11
DATE PREPARED 11/19/10	**PEER REVIEW / DATE** S Mattingly 11/19/10	**DATE PREPARED** 01/14/11	**PEER REVIEW / DATE** [signature] 1/18/11

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET 1 of 8

FEATURE: ASR - So LKL Opt C injected Q = 100 cfs)	**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — **ESTIMATE LEVEL:** Preliminary
Summary Sheet by Feature	**REGION:** MP — **UNIT PRICE LEVEL:** Oct-10
Water Treatment	**FILE:** H:\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-2 - Aquifer Storage & Recovery-New\Dec-10\IA-2) S LKL-c Inject\[IA-2) ASR S LKL-c Inject w WT.xlsx]FeatureSum ltz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$83,234.00
	3	Construct Service & O&M Roads					$1,520,640.00
	4	Construct Intake and Discharge Structures					$4,076,050.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$4,479,868.00
	7	Fish screening facility					$4,025,118.00
	8	Electric Installations					$10,930,000.00
	9	Water Treatment facillity					$35,000,000.00
		Subtotal 1					$63,278,819.00
		Mobilization	5%	+/-			$3,200,000.00
		Subtotal 1 with Mobilization					**$66,478,819.00**
		Design Contingencies	25%	+/-			$16,619,705.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$83,098,524.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$83,098,524.00
		CONTRACT COST					**$83,000,000.00**
		Construction Contingencies	25%	+/-			$22,000,000.00
		FIELD COST					**$105,000,000.00**
		Non-Contract Costs	25%	+/-			$25,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$130,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY: S Mattingly	REVIEWED	BY: L. Zlomke	CHECKED 12/18/10
DATE PREPARED: 11/19/10	PEER REVIEW / DATE: S. Mattingly 11/19/10	DATE PREPARED: 12/16/10	PEER REVIEW / DATE: for DLM 12/20/10

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ of _8_

FEATURE:	PROJECT:			
ASR - So LKL Opt C injected Q = 100 cfs)	UPPER KLAMATH BASIN Offstream Storage Study			
	WOID:	AF329	ESTIMATE LEVEL:	Preliminary
Summary Sheet by Feature	REGION:	MP	UNIT PRICE LEVEL:	Oct-10
No Water Treatment	FILE:	H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 2 - Aquifer Storage & Recovery-New\Dec-10\IA-2) S LKL-c Inject\[IA-2) ASR S LKL-c Inject WO WT-R1.xlsx]FeatureSum llz		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$116,409.00
	2	Construct embankment levee for wetlands					$83,234.00
	3	Construct Service & O&M Roads					$1,520,640.00
	4	Construct Intake and Discharge Structures					$4,076,050.00
	5	Furnish and install wellfield					$3,047,500.00
	6	Steel pipe					$4,479,868.00
	7	Fish screening facility					$4,025,118.00
	8	Electric Installations					$6,830,000.00
		Subtotal 1					$24,178,819.00
		Mobilization	5%	+/-			$1,200,000.00
		Subtotal 1 with Mobilization					**$25,378,819.00**
		Design Contingencies	25%	+/-			$6,344,705.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$31,723,524.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$31,723,524.00
		CONTRACT COST					**$32,000,000.00**
		Construction Contingencies	25%	+/-			$8,000,000.00
		FIELD COST					**$40,000,000.00**
		Non-Contract Costs	25%	+/-			$10,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$50,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	REVIEWED	BY L. Zlomke	CHECKED KAB 1/14/11
DATE PREPARED 11/19/10	PEER REVIEW / DATE S. Mattingly 11/19/10	DATE PREPARED 01/14/11	PEER REVIEW / DATE DLM 1/18/11

IA-2. Aquifer Storage and Recovery – 10 priority options.
Preliminary-level capital construction cost estimate worksheets.

Summary of Life Cycle Costs

UKBOS Studies
ASR – Infiltration Sprague Valley Site #7A
100 cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Infiltration Sprague Valley Site #7A	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$60,000,000	$60,000,000
Real estate costs				
Private land purchase costs			$3,040,000	$3,040,000
Mitigation wetlands costs @ 8 acres estimated			$16,000	$16,000
Subtotal 1				**$63,056,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$19,582	$411,809
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$15,798	$332,232
WT Maint Costs	PWA Factor	21.03	$160,000	$3,364,800
Subtotal 3				**$9,039,282**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$76,318,642**
Total Present Worth Costs Rounded				**$76,000,000**
Assumptions: Shown on Page 2				
BY:	Kelly Brom		CHECKED:	
DATE PREPARED:	27-Dec-10		PEER REVIEW:	

IA-2a ASR Sprague Infiltr w WT.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:	
50	= n = year analysis period.
4.125%	= i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).	
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) =	21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.	
Input to the Pumping Plant Operation and Maintenance Program:	
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes	
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr	
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr	
Interest Rate 4.125% for water storage projects	
Assume wellfield is not manned.	
Operating 4-weeks/year	
100 cfs with a total of 8,000 acre-feet/year	
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.	

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Infiltration Sprague Valley Site #7A
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Infiltration Sprague Valley Site #7A	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$50,000,000	$50,000,000
Real estate costs				
Private land purchase costs			$3,040,000	$3,040,000
Mitigation wetlands costs @ 8 acres estimated			$16,000	$16,000
Subtotal 1				**$53,056,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$19,582	$411,809
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$15,798	$332,232
Subtotal 3				**$5,674,482**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$62,953,842**
Total Present Worth Costs Rounded				**$63,000,000**
Assumptions:	**Shown on Page 2**			
BY:	L Zlomke		CHECKED: KMB 1/14/11	
DATE PREPARED:	13-Jan-11		PEER REVIEW: [signature] 1/14/11	

IA-2a ASR Sprague Infiltr WO WT.xlsx Life-Cycle Costs Analysis

Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 4 weeks/year
100 cfs with a total of 8,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 = 0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 = 0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR - Sprague Injected
100 cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection Sprague area, Site #7	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$64,000,000	$64,000,000
Real estate costs				
Private land purchase costs			$3,040,000	$3,040,000
Mitigation wetlands costs @ 8 acres estimated			$16,000	$16,000
Subtotal 1				**$67,056,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$28,027	$589,408
WT Maint Costs	PWA Factor	21.03	$160,000	$3,364,800
Subtotal 3				**$9,405,878**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$80,685,238**
Total Present Worth Costs Rounded				**$81,000,000**
Assumptions: Shown on Page 2				
BY:	Kelly Brom KMB 1/11/11		CHECKED:	
DATE PREPARED:	27-Dec-10		PEER REVIEW:	1/12/11

IA-2b ASR Sprague Injected W WT-R1.xlsx Life-Cycle Costs Analysis

Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR - Sprague Injected
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection Sprague area, Site #7	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$54,000,000	$54,000,000
Real estate costs				
Private land purchase costs			$3,040,000	$3,040,000
Mitigation wetlands costs @ 8 acres estimated			$16,000	$16,000
Subtotal 1				**$57,056,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$15,798	$332,232
Subtotal 3				**$5,783,902**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$67,063,262**
Total Present Worth Costs Rounded				**$67,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: RMB 1/14/11	
DATE PREPARED:	13-Jan-11		PEER REVIEW: 1/14/11	

IA-2b ASR Sprague Injected WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 = 0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 = 0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection North Klamath, Site #3 (Mid Basin)
100 cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection North Klamath, Site #3 (Mid Basin)	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$120,000,000	$120,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs @ 5 acres estimated			$10,000	$10,000
Subtotal 1				**$120,010,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$252,429	$5,308,582
Energy Costs	PWA Factor	21.03	$28,027	$589,408
WT Maint Costs	PWA Factor	21.03	$860,000	$18,085,800
Subtotal 3				**$24,505,019**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$148,738,379**
Total Present Worth Costs Rounded				**$150,000,000**
Assumptions: Shown on Page 2				
BY:	Kelly Brom KMB		CHECKED:	
DATE PREPARED:	27-Dec-10		PEER REVIEW:	1/4/10

IA-2c ASR Mid Basin_N. Klamath_ w WT.xlsx Life-Cycle Costs Analysis   Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 9,500 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 = 0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 = 0.2974

IA-2c ASR Mid Basin_N. Klamath_ w WT.xlsx Life-Cycle Costs Analysis Page 2 of 2

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection North Klamath, Site #3 (Mid Basin)
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection North Klamath, Site #3 (Mid Basin)	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$40,000,000	$40,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs @ 5 acres estimated			$10,000	$10,000
Subtotal 1				**$40,010,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$252,429	$5,308,582
Energy Costs	PWA Factor	21.03	$28,027	$589,408
Subtotal 3				**$6,419,219**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$50,652,579**
Total Present Worth Costs Rounded				**$51,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KnB 1/14/11	
DATE PREPARED:	14-Jan-11		PEER REVIEW: [signature] 1/19/11	

IA-2c ASR Mid Basin_N. Klamath WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 9,500 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection Langell Valley, Site #8
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection Langell Valley, Site #8	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$26,000,000	$26,000,000
Real estate costs				
Private land purchase costs			$560,000	$560,000
Mitigation wetlands costs @ 10 acres estimated			$20,000	$20,000
Subtotal 1				**$26,580,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$212,998	$4,479,348
Energy Costs	PWA Factor	21.03	$28,027	$589,408
Subtotal 3				**$5,589,985**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$36,393,345**
Total Present Worth Costs Rounded				**$36,000,000**
Assumptions: Shown on Page 2				
BY:	L. Zlomke		CHECKED: KMB 1/14/11	
DATE PREPARED:	14-Jan-11		PEER REVIEW: 1/19/11	

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 6,400 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 = 0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 = 0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection Gerber area, Site #9
100 cfs
No Water Treatment - Diesel Pump
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection Gerber area, Site #9	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$12,500,000	$12,500,000
Real estate costs				
Federal land (no purchase costs)			$0	$0
Mitigation wetlands costs			$0	$0
Subtotal 1				**$12,500,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$1,650,000**	$899,745
Year 30	PW Factor	0.2974	**$2,600,000**	$773,240
Subtotal 2				**$1,672,985**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$5,484	$115,329
Maintenance Costs	PWA Factor	21.03	$21,719	$456,751
Diesel Costs	PWA Factor	21.03	$814,200	$17,122,626
Subtotal 3				**$17,694,706**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$31,867,691**
Total Present Worth Costs Rounded				**$32,000,000**
Assumptions: Shown on Page 2				
BY:	Lzlomke		CHECKED:	
DATE PREPARED:	6-Jan-11		PEER REVIEW: 1/7/11	

IA-2e ASR Gerber inject _diesel WO WT.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year
Diesel Costs: Consumption 21.44 gal/hr @ 80% load (230,000gal/yr * $3.54/gallon delivered = $814,200/year)

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection Gerber area, Site #9
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection Gerber area, Site #9	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$34,000,000	$34,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs @ 10 acres estimated			$20,000	$20,000
Subtotal 1				**$34,020,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$28,027	$589,408
Subtotal 3				**$6,041,078**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$44,284,438**
Total Present Worth Costs Rounded				**$44,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED:	[illegible] 1/14/11
DATE PREPARED:	14-Jan-11		PEER REVIEW:	[illegible] 1/19/11

IA-2e ASR Gerber inject WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
Clear Lake ASR
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Clear Lake ASR	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$31,000,000	$31,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs @ 10 acres estimated			$20,000	$20,000
Subtotal 1				**$31,020,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$28,027	$589,408
Subtotal 3				**$6,041,078**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$41,284,438**
Total Present Worth Costs Rounded				**$41,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KMB 1/14/11	
DATE PREPARED:	14-Jan-10		PEER REVIEW: 1/19/11	

IA-2f Clear Lake ASR Qty WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection Tule Lake, Site #11
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection Tule Lake, Site #11	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$230,000,000	$230,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs			$200,000	$200,000
Subtotal 1				**$230,200,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$8,400,000**	$4,580,520
Year 30	PW Factor	0.2974	**$13,000,000**	$3,866,200
Subtotal 2				**$8,446,720**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$56,898	$1,196,565
Maintenance Costs	PWA Factor	21.03	$631,714	$13,284,945
Energy Costs	PWA Factor	21.03	$80,512	$1,693,167
Subtotal 3				**$16,174,677**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$254,821,397**
Total Present Worth Costs Rounded				**$250,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED:	KMB 1/14/11
DATE PREPARED:	14-Jan-11		PEER REVIEW:	1/19/11

IA-2g ASR Tule Lake Inject WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 3

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 12 weeks/year
100 cfs with a total of 16,000 acre-feet/year developed from/injected into wellfields-300cfs flow is lifted at the existing D pump location-78 feet of lift
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 = 0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 = 0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection South LKL, Site #12a
100 cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection South LKL, Site #12a	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$130,000,000	$130,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs @ 5 acres estimated			$10,000	$10,000
Subtotal 1				**$130,010,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$28,027	$589,408
WT Maint Costs	PWA Factor	21.03	$860,000	$18,085,800
Subtotal 3				**$24,126,878**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$158,360,238**
Total Present Worth Costs Rounded				**$160,000,000**
Assumptions: Shown on Page 2				
BY:	Kelly Brom		CHECKED:	
DATE PREPARED:	27-Dec-10		PEER REVIEW:	1/5/11

IA-2h ASR S LKL-a Inject w WT.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year-this flow is also lifted at existing E and F pump locations, both with 20 feet of lift each
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 = 0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 = 0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection South LKL, Site #12a
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection South LKL, Site #12a	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$49,000,000	$49,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs @ 5 acres estimated			$10,000	$10,000
Subtotal 1				**$49,010,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$28,027	$589,408
Subtotal 3				**$6,041,078**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$59,274,438**
Total Present Worth Costs Rounded				**$59,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KMB 1/14/11	
DATE PREPARED:	14-Jan-11		PEER REVIEW: 1/19/11	

IA-2h ASR S LKL-a Inject WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year-this flow is also lifted at existing E and F pump locations, both with 20 feet of lift each
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection South LKL, Site #12b
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection South LKL, Site #12b	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$39,000,000	$39,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs			$10,000	$10,000
Subtotal 1				**$39,010,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$28,027	$589,408
Subtotal 3				**$6,041,078**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$49,274,438**
Total Present Worth Costs Rounded				**$49,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KMB 1/14/11	
DATE PREPARED:	14-Jan-11		PEER REVIEW: 1/18/11	

IA-2i ASR S LKL-b Inject WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year developed from wellfield - 300 cfs flow is lifted at the existing D pump location - 78 ft of lift
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection South LKL, Site #12c
100 cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection South LKL, Site #12c	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$130,000,000	$130,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs			$10,000	$10,000
Subtotal 1				**$130,010,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$28,027	$589,408
WT Maint Costs	PWA Factor	21.03	$860,000	$18,085,800
Subtotal 3				**$24,126,878**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$158,360,238**
Total Present Worth Costs Rounded				**$160,000,000**
Assumptions: Shown on Page 2				
BY:	Kelly Brom KMB		CHECKED:	
DATE PREPARED:	20-Dec-10		PEER REVIEW: 1/5/11	

IA-2j ASR S LKL-c Inject w WT.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year - this flow is also lifted at the existing E and F pump locations - both with 20 ft of lift each
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 = 0.5453

PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 = 0.2974

Summary of Life Cycle Costs

UKBOS Studies
ASR – Injection South LKL, Site #12c
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			ASR – Injection South LKL, Site #12c	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$50,000,000	$50,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs			$10,000	$10,000
Subtotal 1				**$50,010,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$28,027	$589,408
Subtotal 3				**$6,041,078**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$60,274,438**
Total Present Worth Costs Rounded				**$60,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KMB 1/14/10	
DATE PREPARED:	14-Jan-11		PEER REVIEW: 1/19/11	

IA-2j ASR S LKL-c Inject WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year - this flow is also lifted at the existing E and F pump locations - both with 20 ft of lift each
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

IA-2j ASR S LKL-c Inject WO WT-R1.xlsx Life-Cycle Costs Analysis Page 2 of 2

IA-2. Aquifer Storage and Recovery – 10 priority options.
Preliminary-level Life-cycle cost estimate worksheet tables.

BUREAU OF RECLAMATION — **ESTIMATE WORKSHEET** — SHEET _1_ OF _2_

FEATURE:
Long Lake Valley Appraisal Design - No Action
Barnes - Agency Lake Ranch
Option 1 - (Open to Lake -
Minimum Site Work)

No Water Treatment

PROJECT:
UPPER KLAMATH BASIN
Offstream Storage Study

WOID:	**AF329**	**ESTIMATE LEVEL:**	Preliminary
REGION:	**MP**	**UNIT PRICE LEVEL:**	**Oct-10**

FILE: H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-3 - Barnes & Agency Lake Ranch-NEW - WARNING ADDED WORK\Dec-10\[IA-3 AL-BR Option 1 WO WT.xls]Option 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Mobilization and Prepartory Work		1	LS		Shown in Summary
	2	Excavation for Fish Exit Pathways		30,000	yd3	$23.00	$690,000.00
		Wet Excavation. Waste on site.					
	3	Cut Existing dike Tops & Excavate for North					
		containment Dike Base. Waste on site.		222,000	yd3	$4.00	$888,000.00
	4	Breach Existing Lake Dikes. Build Adjacent					
		Embankments with Waste		640,000	yd3	$34.00	$21,760,000.00
	5	Import & Place Embankment - North Containment					
		Dike. Gov. Furnish. Haul Distance 7 to 10 Miles					
		Dike Segments 1A & 1B, Total		476,000	yd3	$15.00	$7,140,000.00
	6	Import & Place Rip-rap - North containment Dike					
		Gov. Furnish. Haul Distance 7 to 10 Miles					
		6-18 in. D50 of 11 in.					
		Dike Segments 1A & 1B, Total		38,000	yd3	$60.00	$2,280,000.00
	7	Furnish & Place Rip-rap Bedding. North Dike.					
		Fine to coarse Gravel (#4 (0.19 in.) -3 in.					
		Dike Segments 1A & 1B, Total		12,500	yd3	$40.00	$500,000.00
	8	Furnish & Place 6" thick X 20' wide					
		Aggregate O & M Road Surfacing Base					
		Dike Segments 1A & 1B, Total		9,900	yd3	$40.00	$396,000.00
		Subtotal This Page					$33,654,000.00

QUANTITIES		PRICES	
BY JF Pattie	CHECKED Al Bernstein	BY Lonnie Ziomke	CHECKED 12/17/10
DATE PREPARED 08/26/09	PEER REVIEW / DATE Al Bernstein 8/28/09	DATE PREPARED 12/17/10	PEER REVIEW / DATE DLM 12/17/10

IA-3a. Barnes and Agency Lake Ranch – Option 1; Open-to-lake; Minimum site work. Preliminary-level capital construction cost estimate worksheet, Page 1.

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET 2 OF 2

FEATURE: **Long Lake Valley Appraisal Design - No Action** **Barnes - Agency Lake Ranch** **Option 1 - (Open to Lake - Minimum Site Work)** **No Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 **ESTIMATE LEVEL:** Preliminary **REGION:** MP **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-3 - Barnes & Agency Lake Ranch-NEW - WARNING ADDED WORK\Dec-10\[IA-3 AL-BR Option 1 WO WT.xls]Option 1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Page 1					$33,654,000.00
		Subtotal 1					$33,654,000.00
		Mobilization	5%	+/-			$1,700,000.00
		Subtotal 1 with Mobilization					**$35,354,000.00**
		Design Contingencies	25%	+/-			$8,838,500.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$44,192,500.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$44,192,500.00
		CONTRACT COST					**$44,000,000.00**
		Construction Contingencies	25%	+/-			$11,000,000.00
		FIELD COST					**$55,000,000.00**
		Non-Contract Costs	25%	+/-			$14,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$69,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY JF Pattie	**REVIEWED** Al Bernstein	**BY** Lonnie Zlomke	**CHECKED** S. S. 12/17/10
DATE PREPARED 08/26/09	**PEER REVIEW / DATE** Al Bernstein 8/28/09	**DATE PREPARED** 12/17/10	**PEER REVIEW / DATE** DLM 12/17/10

IA-3a. Barnes and Agency Lake Ranch – Option 1; Open-to-lake; Minimum site work. Preliminary-level capital construction cost estimate worksheet, Page 2.

Note: Life cycle cost estimates are considered the same as the without project basis – specific estimates would have to be developed from that standpoint.

BUREAU OF RECLAMATION **ESTIMATE WORKSHEET** SHEET _3_ OF _3_

FEATURE:
Restoration and Potential for Enhancing Wetland Values at the Barnes Ranch and Agency Lake Ranch Sites
Option 5R1 - Storage
All Sites
No Water Treatment

PROJECT:
UPPER KLAMATH BASIN
Offstream Storage Study

WOID: AF329 | **ESTIMATE LEVEL:** Preliminary
REGION: MP | **UNIT PRICE LEVEL:** Oct-10
FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-3 - Barnes & Agency Lake Ranch-NEW - WARNING ADDED WORK\Dec-10\[IA-3 AL-BR Option 5R1 WO WT.xls]Option 5R1

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
		Subtotal Page 1					$31,850,118.00
		Subtotal Page 2					$44,280,000.00
		Subtotal 1					$76,130,118.00
		Mobilization	5%	+/-			$3,800,000.00
		Subtotal 1 with Mobilization					**$79,930,118.00**
		Design Contingencies	25%	+/-			$19,982,530.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$99,912,648.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$99,912,648.00
		CONTRACT COST					**$100,000,000.00**
		Construction Contingencies	25%	+/-			$25,000,000.00
		FIELD COST					**$125,000,000.00**
		Non-Contract Costs	25%	+/-			$30,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$155,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY JF Pattie	**REVIEWED** Ribha Dham	**BY** Lonnie Zlomke	**CHECKED** 12/17/10
DATE PREPARED 06/03/09	**PEER REVIEW / DATE** 06/03/09	**DATE PREPARED** 12/17/10	**PEER REVIEW / DATE** DLM 12/17/10

IA-3b. Barnes and Agency Lake Ranch – Option 5; Managed water storage. Preliminary-level capital construction cost estimate worksheet, summary page.

Summary of Life Cycle Costs

UKBOS Studies
Barnes Ranch - Agency Lake Option 5R1
150 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Barnes Ranch - Agency Lake Option 5R1	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$155,000,000	$155,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs @ 8 acres			$0	$0
Subtotal 1				**$155,000,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$1,300,000**	$708,890
Year 25	PW Factor	0.3640	**$220,000**	$80,080
Year 30	PW Factor	0.2974	**$1,950,000**	$579,930
Subtotal 2				**$1,368,900**
Annual Costs		P/A (n = 50)		
Pump Operations Costs	PWA Factor	21.030	$6,100	$128,283
Pump Maintenance Costs	PWA Factor	21.030	$14,000	$294,420
Other Annual O&M Costs	PWA Factor	21.030	$2,000	$42,060
Energy Costs	PWA Factor	21.030	$12,550	$263,927
Subtotal 3				**$728,690**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$157,097,590**
Total Present Worth Costs Rounded				**$155,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KMB 1/13/11	
DATE PREPARED:	12-Jan-11		PEER REVIEW: [signature] 1/13/11	

IA-3B AL-BR Option 5R1 WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.030
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume pump station is not manned.
Operating 21 weeks/year
150 cfs with a total of 6200 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.
Assume all work is performed by Government Work Force Personnel for all Non-pump life cycle calcs.
Assume 25% non-contract costs are added to any periodic cost to procurement, admin support, etc.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,25yrs) = 1/(1 + 4.125%)^25 =	0.3640
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

IA-3B AL-BR Option 5R1 WO WT-R1.xlsx Life-Cycle Costs Analysis Page 2 of 2

IA-3b. Barnes and Agency Lake Ranch – Option 5; Managed water storage. Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _12_

FEATURE:

Aspen Lake Reservoir (350 TAF)
- with Pumping Capacity of 1,000 cfs
Summary Sheet by Feature

Water Treatment

PROJECT:
UPPER KLAMATH BASIN
Offstream Storage Study

WOID: AF329 | **ESTIMATE LEVEL:** Preliminary
REGION: MP | **UNIT PRICE LEVEL:** Oct-10
FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-4 Aspen Lake Storage-Old\Dec-10\[IA-4 Aspen Lake Storage w WT_kmb11192010.xlsx]FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System					$70,049,420.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen and Check Structure					$16,350,416.00
	4	Pumping plant - 1000 cfs 1@186 ft head & 1@76 ft head					$79,700,000.00
	5	Construct Surge Shaft					$650,750.00
	6	Construct embankment dam (Crest 4225 - 350 TAF)					$67,666,170.00
	7	Construct emergency spillway chute, stilling basin, & bridge					$13,186,800.00
	8	Construct Spillway Crest Bridge					$998,175.00
	9	Construct Tunnel					$20,614,810.00
	10	Construct Outlets Work Tower and Access Bridge					$20,627,570.00
	11	Electrical					$12,651,000.00
	12	Access Roads					$4,373,700.00
	13	Water Treatment					$63,800,000.00
		Subtotal 1					$372,466,811.00
		Mobilization	5%	+/-			$18,500,000.00
		Subtotal 1 with Mobilization					**$390,966,811.00**
		Design Contingencies	25%	+/-			$97,741,703.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$488,708,514.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$488,708,514.00
		CONTRACT COST					**$490,000,000.00**
		Construction Contingencies	25%	+/-			$120,000,000.00
		FIELD COST					**$610,000,000.00**
		Non-Contract Costs	25%	+/-			$150,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$760,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	REVIEWED Paul Ruchti 8/3/09	BY L Zlomke	CHECKED S. [signature] 12/16/10
DATE PREPARED 06/12/08	PEER REVIEW / DATE	DATE PREPARED 12/15/10	PEER REVIEW / DATE DLM 12/17/10

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _12_

FEATURE: **Aspen Lake Reservoir (350 TAF)** **- with Pumping Capacity of 1,000 cfs** **Summary Sheet by Feature** **No Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 — **ESTIMATE LEVEL:** Preliminary **REGION:** MP — **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-4 Aspen Lake Storage-Old\Dec-10\[IA-4 Aspen Lake Storage WO WT.xlsx]FeatureSum ll

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System					$70,049,420.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen and Check Structure					$16,350,416.00
	4	Pumping plant - 1000 cfs 1@186 ft head & 1@76 ft head					$79,700,000.00
	5	Construct Surge Shaft					$650,750.00
	6	Construct embankment dam (Crest 4225 - 350 TAF)					$67,666,170.00
	7	Construct emergency spillway chute, stilling basin, & bridge					$13,186,800.00
	8	Construct Spillway Crest Bridge					$998,175.00
	9	Construct Tunnel					$20,614,810.00
	10	Construct Outlets Work Tower and Access Bridge					$20,627,570.00
	11	Electrical Installations					$12,651,000.00
	12	Access Roads					$4,373,700.00
		Subtotal 1					$308,666,811.00
		Mobilization	5%	+/-			$15,000,000.00
		Subtotal 1 with Mobilization					**$323,666,811.00**
		Design Contingencies	25%	+/-			$80,916,703.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$404,583,514.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$404,583,514.00
		CONTRACT COST					**$400,000,000.00**
		Construction Contingencies	25%	+/-			$110,000,000.00
		FIELD COST					**$510,000,000.00**
		Non-Contract Costs	25%	+/-			$130,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$640,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Paul Ruchti 8/3/09	**BY** L.L. Zlomke	**CHECKED** 12/16/10
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/14/10	**PEER REVIEW / DATE** DLM 12/17/10

IA-4. Aspen Lake water storage.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Aspen Lake Reservoir - Offstream Storage
350 TAF Capacity; 1000cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Aspen Lake Reservoir - Offstream Storage	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$760,000,000	$760,000,000
Land purchase costs				
Land for reservoir and facilities			$14,200,000	$14,200,000
Mitigation wetlands			$5,980,000	$5,980,000
Subtotal 1				**$780,180,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$140,583	$2,956,460
Maintenance Costs	PWA Factor	21.03	$3,455,352	$72,666,053
Energy Costs	PWA Factor	21.03	$153,374	$3,225,455
Replacement Costs	PWA Factor	21.03	$127,475	$2,680,799
WT Maint Costs	PWA Factor	21.03	$4,280,000	$90,008,400
Subtotal 2				**$171,537,167**
Total Present Worth Costs = Subtotal 1 + 2				**$951,717,167**
Total Present Worth Costs Rounded				**$950,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 4 weeks/year

1000 cfs with a total of 50,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom [illegible]	CHECKED:	[illegible] 12/23/10
DATE PREPARED:	22-Dec-10	PEER REVIEW:	[illegible] 12/23/10

File Name: IA-4 Aspen Lake Storage w WT_kmb11192010.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Aspen Lake Reservoir - Offstream Storage
350 TAF Capacity; 1000cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Aspen Lake Reservoir - Offstream Storage	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$640,000,000	$640,000,000
Land purchase costs				
Land for reservoir and facilities			$14,200,000	$14,200,000
Mitigation wetlands			$5,980,000	$5,980,000
Subtotal 1				**$660,180,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$140,583	$2,956,460
Maintenance Costs	PWA Factor	21.03	$3,455,352	$72,666,053
Energy Costs	PWA Factor	21.03	$153,374	$3,225,455
Replacement Costs	PWA Factor	21.03	$127,475	$2,680,799
Subtotal 2				**$81,528,767**
Total Present Worth Costs = Subtotal 1 + 2				**$741,708,767**
Total Present Worth Costs Rounded				**$740,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 4 weeks/year

1000 cfs with a total of 50,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom KMB	CHECKED:	JW 12/23/10
DATE PREPARED:	22-Dec-10	PEER REVIEW:	[signature] 12/23/10

File Name: IA-4 Aspen Lake Storage WO WT.xlsx Tab: App A Life-Cycle Costs Analysis   Page 1 of 1

IA-4. Aspen Lake water storage.
Preliminary-level life-cycle cost estimate worksheet table.

Not included – see below

IA-5. Round Lake water storage.
Preliminary-level capital construction cost estimate worksheet.

Not included – see below

IA-5. Round Lake water storage.
Preliminary-level Life-cycle cost estimate worksheet table.

Note: Preliminary cost estimates not developed for the Round Lake alternative because is considered similar to Aspen Lake, except more costly due to farther distance conveyance costs – these factors are explained in report.

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _33_

FEATURE:	PROJECT:			
Long Lake Valley Canal - Tunnel & Power Optimization Study Alternative 1: Option A: 1,000 cfs - Pumping Only *Canal from Klamath Lake to Long Lake Valley* *Earthen Lined - 19,000 ft long* Water Treatment	UPPER KLAMATH BASIN Offstream Storage Study			
	WOID:	AF329	ESTIMATE LEVEL:	Preliminary
	REGION:	MP	UNIT PRICE LEVEL:	Oct-10
	FILE:	H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 6A Long Lake Valley Reservoir Option A -Old\Dec-10\[IA-6A LLV_A1-OA lined w WT xlsx]FeatureSum feh		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Canal ID: A1-1K-EC-19K (4 sheets)					$174,170,000.00
	2	Tunnel ID: A1-1K-T (1 sheet)					$20,030,050.00
	3	UK Intake/Fish Screen Eq ID: A1345-1K-PO&PG-IntFS Eq (3 sheets)					$6,574,980.00
	4	UK Intake/Fish Screen Hyd Eq ID: A1-5-1K-All-IntFS HydEq (1 sheet)					$4,052,000.00
	5	Fish Screen Pipe ID: A1-5-All-FSPipe (1 sheet)					$376,684.00
	6	UK Intake/Fish Screen Structure ID: A134-1K-All-FS Struct (1 sheet)					$15,753,408.00
	7	UK Intake/Fish Screen Cofferdams ID: A124-All-Coff-Rev1 (1 sheet)					$4,756,500.00
	8	UK Plant CS ID: A134-1K-PO&P-T-CSPlt (3 sheets)					$46,469,325.00
	9	UK Plant Mech Eq ID: A1-5-1K-PO-MEqPlt (3 sheets)					$8,339,000.00
	10	UK Plant Hyd Eq ID: A1-5-1K-PO-Plt HydEq (1 sheet)					$12,600,000.00
	11	UK Plant Pipe ID: A1-5-1K-PO-Plt Pipe (2 sheets)					$22,468,184.00
	12	UK Plant Electric ID: A1-5-1K-PO-Eplt (3 sheets)					$12,089,400.00
	13	Switch Yard & T-Line ID: A1&3-1K-All-SY (1 sheet)					$7,554,000.00
	14	Plant Penstock ID: A1-1K-All-PltPen (1 sheet)					$1,306,500.00
	15	LLV Intake Tower CS ID: A1&3-1K-All-T CS (2 sheets)					$12,624,750.00
	16	LLV Intake Tower Mech Eq ID: A1-5-1K-PO&PG-T-MEq (1 sheet)					$8,065,000.00
	17	LLV Intake Structure Hydraulic Eq ID: A1-5-1K-All-T HydEq (1 sheet)					$2,030,000.00
	18	Non Plant Structures Electrical ID: A1&3-All-NonPlt Elec (1 sheet)					$1,354,100.00
	19	350 TAF Full Clay Liner (1 sheet)					$317,373,000.00
	20	Water Treatment facillity					$63,800,000.00
		Subtotal 1					$741,786,881.00
		Mobilization	5%	+/-			$37,000,000.00
		Subtotal 1 with Mobilization					**$778,786,881.00**
		Design Contingencies	20%	+/-			$155,757,376.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$934,544,257.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$934,544,257.00
		CONTRACT COST					**$930,000,000.00**
		Construction Contingencies	25%	+/-			$220,000,000.00
		FIELD COST					**$1,150,000,000.00**
		Non-Contract Costs	25%	+/-			$300,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$1,450,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	REVIEWED Paul Ruchti 8/3/09	BY T. Hanke	CHECKED 12/10/10
DATE PREPARED 06/12/08	PEER REVIEW / DATE	DATE PREPARED 12/17/10	PEER REVIEW / DATE DLM 12/17/10

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _33_

FEATURE:	PROJECT:
Long Lake Valley	UPPER KLAMATH BASIN
Canal - Tunnel & Power Optimization Study	Offstream Storage Study
Alternative 1: Option A: 1,000 cfs - Pumping Only	WOID: AF329 — ESTIMATE LEVEL: Preliminary
Canal from Klamath Lake to Long Lake Valley	REGION: MP — UNIT PRICE LEVEL: Oct-10
Earthen Lined - 19,000 ft long	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\26 Alts-Working\IA-6A Long Lake Valley Reservoir Option A -Old\Dec-10\[IA-6A LLV_A1-OA lined WO WT xlsx]FeatureSum teh
No Water Treatment	

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Canal ID: A1-1K-EC-19K (4 sheets)					$174,170,000.00
	2	Tunnel ID: A1-1K-T (1 sheet)					$20,030,050.00
	3	UK Intake/Fish Screen Eq ID: A1345-1K-PO&PG-IntFS Eq (3 sheets)					$6,574,980.00
	4	UK Intake/Fish Screen Hyd Eq ID: A1-5-1K-All-IntFS HydEq (1 sheet)					$4,052,000.00
	5	Fish Screen Pipe ID: A1-5-All-FSPipe (1 sheet)					$376,684.00
	6	UK Intake/Fish Screen Structure ID: A134-1K-All-FS Struct (1 sheet)					$15,753,408.00
	7	UK Intake/Fish Screen Cofferdams ID: A124-All-Coff-Rev1 (1 sheet)					$4,756,500.00
	8	UK Plant CS ID: A134-1K-PO&P-T-CSPlt (3 sheets)					$46,469,325.00
	9	UK Plant Mech Eq ID: A1-5-1K-PO-MEqPlt (3 sheets)					$8,339,000.00
	10	UK Plant Hyd Eq ID: A1-5-1K-PO-Plt HydEq (1 sheet)					$12,600,000.00
	11	UK Plant Pipe ID: A1-5-1K-PO-Plt Pipe (2 sheets)					$22,468,184.00
	12	UK Plant Electric ID: A1-5-1K-PO-Eplt (3 sheets)					$12,089,400.00
	13	Switch Yard & T-Line ID: A1&3-1K-All-SY (1 sheet)					$7,554,000.00
	14	Plant Penstock ID: A1-1K-All-PltPen (1 sheet)					$1,306,500.00
	15	LLV Intake Tower CS ID: A1&3-1K-All-T CS (2 sheets)					$12,624,750.00
	16	LLV Intake Tower Mech Eq ID: A1-5-1K-PO&PG-T-MEq (1 sheet)					$8,065,000.00
	17	LLV Intake Structure Hydraulic Eq ID: A1-5-1K-All-T HydEq (1 sheet)					$2,030,000.00
	18	Non Plant Structures Electrical ID: A1&3-All-NonPlt Elec (1 sheet)					$1,354,100.00
	19	350 TAF Full Clay Liner (1 sheet)					$317,373,000.00
		Subtotal 1					$677,986,881.00
		Mobilization	5%	+/-			$34,000,000.00
		Subtotal 1 with Mobilization					**$711,986,881.00**
		Design Contingencies	20%	+/-			$142,397,376.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$854,384,257.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$854,384,257.00
		CONTRACT COST					**$850,000,000.00**
		Construction Contingencies	25%	+/-			$200,000,000.00
		FIELD COST					**$1,050,000,000.00**
		Non-Contract Costs	25%	+/-			$250,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$1,300,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY: Stan Mattingly	REVIEWED: Paul Ruchti 8/3/09	BY: T. Hanke (signature)	CHECKED: (signature) 12/17/10
DATE PREPARED: 06/12/08	PEER REVIEW / DATE	DATE PREPARED: 12/17/10	PEER REVIEW / DATE: DLM 12/17/10

IA-6a. Long Lake Valley Reservoir – 350K AF option (Appraisal Study). Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
LLV Option A (LLV Reservoir; 350KAF)
350 TAF Capacity; 1000cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			LLV Option A (LLV Reservoir; 350KAF)	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$1,450,000,000	$1,450,000,000
Land purchase costs				
Land for reservoir and facilities			$6,000,000	$6,000,000
Mitigation wetlands			$14,616,000	$14,616,000
Subtotal 1				**$1,470,616,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$90,503	$1,903,278
Maintenance Costs	PWA Factor	21.03	$2,598,031	$54,636,592
Energy Costs	PWA Factor	21.03	$196,103	$4,124,046
Replacement Costs	PWA Factor	21.03	$114,415	$2,406,147
WT Maint Costs	PWA Factor	21.03	$4,280,000	$90,008,400
Subtotal 2				**$153,078,463**
Total Present Worth Costs = Subtotal 1 + 2				**$1,623,694,463**
Total Present Worth Costs Rounded				**$1,600,000,000**

Assumptions:

50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year with 335ft head.
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	
DATE PREPARED:	23-Dec-10	PEER REVIEW:	12/30/10

File Name: IA-6A LLV_A1-OA lined w WT.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
LLV Option A (LLV Reservoir; 350KAF)
350 TAF Capacity; 1000cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			LLV Option A (LLV Reservoir; 350KAF)	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$1,300,000,000	$1,300,000,000
Land purchase costs				
Land for reservoir and facilities			$6,000,000	$6,000,000
Mitigation wetlands			$14,616,000	$14,616,000
Subtotal 1				**$1,320,616,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$90,503	$1,903,278
Maintenance Costs	PWA Factor	21.03	$2,598,031	$54,636,592
Energy Costs	PWA Factor	21.03	$196,103	$4,124,046
Replacement Costs	PWA Factor	21.03	$114,415	$2,406,147
Subtotal 2				**$63,070,063**
Total Present Worth Costs = Subtotal 1 + 2				**$1,383,686,063**
Total Present Worth Costs Rounded				**$1,400,000,000**

Assumptions:

50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50)
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010 Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year with 335ft head.
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	12/23/10
DATE PREPARED:	16-Dec-10	PEER REVIEW:	12/30/10

File Name: IA-6A LLV_A1-OA lined WO WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

IA-6a. Long Lake Valley Reservoir – 350K AF option (Appraisal Study). Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _35_

FEATURE:
Long Lake Valley
Canal - Tunnel & Power Optimization Study
Alternative 1: Option A: 1,000 cfs - Pumping Only
Canal from Klamath Lake to Long Lake Valley
Earthen Lined - 19,000 ft long
Water Treatment

PROJECT: **UPPER KLAMATH BASIN Offstream Storage Study**

WOID:	**AF329**	**ESTIMATE LEVEL:**	Preliminary
REGION:	**MP**	**UNIT PRICE LEVEL:**	**Oct-10**
FILE:	H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\2B Alts-Working\IA-6B (was C) LLV Option A plus ROW at Keno-Revised\Dec-10\[IA-6B LLV A1-OA plus ROW at Keno w WT xlsx]FeatureSum teh		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Canal ID: A1-1K-EC-19K (4 sheets)					$174,170,000.00
	2	Tunnel ID: A1-1K-T (1 sheet)					$20,030,050.00
	3	UK Intake/Fish Screen Eq ID: A1345-1K-PO&PG-IntFS Eq (3 sheets)					$6,574,980.00
	4	UK Intake/Fish Screen Hyd Eq ID: A1-5-1K-All-IntFS HydEq (1 sheet)					$4,052,000.00
	5	Fish Screen Pipe ID: A1-5-All-FSPipe (1 sheet)					$376,684.00
	6	UK Intake/Fish Screen Structure ID: A134-1K-All-FS Struct (1 sheet)					$15,753,408.00
	7	UK Intake/Fish Screen Cofferdams ID: A124-All-Coff-Rev1 (1 sheet)					$4,756,500.00
	8	UK Plant CS ID: A134-1K-PO&P-T-CSPlt (3 sheets)					$46,469,325.00
	9	UK Plant Mech Eq ID: A1-5-1K-PO-MEqPlt (3 sheets)					$8,339,000.00
	10	UK Plant Hyd Eq ID: A1-5-1K-PO-Plt HydEq (1 sheet)					$12,600,000.00
	11	UK Plant Pipe ID: A1-5-1K-PO-Plt Pipe (2 sheets)					$22,468,184.00
	12	UK Plant Electric ID: A1-5-1K-PO-Eplt (3 sheets)					$12,089,400.00
	13	Switch Yard & T-Line ID: A1&3-1K-All-SY (1 sheet)					$7,554,000.00
	14	Plant Penstock ID: A1-1K-All-PltPen (1 sheet)					$1,306,500.00
	15	LLV Intake Tower CS ID: A1&3-1K-All-T CS (2 sheets)					$12,624,750.00
	16	LLV Intake Tower Mech Eq ID: A1-5-1K-PO&PG-T-MEq (1 sheet)					$8,065,000.00
	17	LLV Intake Structure Hydraulic Eq ID: A1-5-1K-All-T HydEq (1 sheet)					$2,030,000.00
	18	Non Plant Structures Electrical ID: A1&3-All-NonPlt Elec (1 sheet)					$1,354,100.00
	19	350 TAF Full Clay Liner (1 sheet)					$317,373,000.00
	20	ROW at Keno					$141,782,460.00
	21	Water Treatment facillity					$63,800,000.00
		Subtotal 1					$883,569,341.00
		Mobilization	5%	+/-			$44,000,000.00
		Subtotal 1 with Mobilization					**$927,569,341.00**
		Design Contingencies	20%	+/-			$185,513,868.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$1,113,083,209.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$1,113,083,209.00
		CONTRACT COST					**$1,100,000,000.00**
		Construction Contingencies	25%	+/-			$300,000,000.00
		FIELD COST					**$1,400,000,000.00**
		Non-Contract Costs	25%	+/-			$350,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$1,750,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Paul Ruchti 8/3/09	**BY** T. Hanke	**CHECKED** 12/16/10
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/17/10	**PEER REVIEW / DATE** DLM 12/17/10

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _35_

FEATURE:
Long Lake Valley
Canal - Tunnel & Power Optimization Study
Alternative 1: Option A: 1,000 cfs - Pumping Only
Canal from Klamath Lake to Long Lake Valley
Earthen Lined - 19,000 ft long
No Water Treatment

PROJECT:
UPPER KLAMATH BASIN
Offstream Storage Study

WOID:	**AF329**	**ESTIMATE LEVEL:**	Preliminary
REGION:	**MP**	**UNIT PRICE LEVEL:**	**Oct-10**
FILE:	H:\D8170\EST\Spreadsheet\Ziomkek\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-6B (was C) LLV Option A plus ROW at Keno-Revised\Dec-10\[IA-6B LLV A1-OA plus ROW at Keno WO WT xlsx]FeatureSum teh		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Canal ID: A1-1K-EC-19K (4 sheets)					$174,170,000.00
	2	Tunnel ID: A1-1K-T (1 sheet)					$20,030,050.00
	3	UK Intake/Fish Screen Eq ID: A1345-1K-PO&PG-IntFS Eq (3 sheets)					$6,574,980.00
	4	UK Intake/Fish Screen Hyd Eq ID: A1-5-1K-All-IntFS HydEq (1 sheet)					$4,052,000.00
	5	Fish Screen Pipe ID: A1-5-All-FSPipe (1 sheet)					$376,684.00
	6	UK Intake/Fish Screen Structure ID: A134-1K-All-FS Struct (1 sheet)					$15,753,408.00
	7	UK Intake/Fish Screen Cofferdams ID: A124-All-Coff-Rev1 (1 sheet)					$4,756,500.00
	8	UK Plant CS ID: A134-1K-PO&P-T-CSPlt (3 sheets)					$46,469,325.00
	9	UK Plant Mech Eq ID: A1-5-1K-PO-MEqPlt (3 sheets)					$8,339,000.00
	10	UK Plant Hyd Eq ID: A1-5-1K-PO-Plt HydEq (1 sheet)					$12,600,000.00
	11	UK Plant Pipe ID: A1-5-1K-PO-Plt Pipe (2 sheets)					$22,468,184.00
	12	UK Plant Electric ID: A1-5-1K-PO-Eplt (3 sheets)					$12,089,400.00
	13	Switch Yard & T-Line ID: A1&3-1K-All-SY (1 sheet)					$7,554,000.00
	14	Plant Penstock ID: A1-1K-All-PltPen (1 sheet)					$1,306,500.00
	15	LLV Intake Tower CS ID: A1&3-1K-All-T CS (2 sheets)					$12,624,750.00
	16	LLV Intake Tower Mech Eq ID: A1-5-1K-PO&PG-T-MEq (1 sheet)					$8,065,000.00
	17	LLV Intake Structure Hydraulic Eq ID: A1-5-1K-All-T HydEq (1 sheet)					$2,030,000.00
	18	Non Plant Structures Electrical ID: A1&3-All-NonPlt Elec (1 sheet)					$1,354,100.00
	19	350 TAF Full Clay Liner (1 sheet)					$317,373,000.00
	20	ROW at Keno					$141,782,460.00
		Subtotal 1					$819,769,341.00
		Mobilization	5%	+/-			$41,000,000.00
		Subtotal 1 with Mobilization					**$860,769,341.00**
		Design Contingencies	20%	+/-			$172,153,868.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$1,032,923,209.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$1,032,923,209.00
		CONTRACT COST					**$1,050,000,000.00**
		Construction Contingencies	25%	+/-			$250,000,000.00
		FIELD COST					**$1,300,000,000.00**
		Non-Contract Costs	25%	+/-			$350,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$1,650,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Paul Ruchti 8/3/09	**BY** T. Hanke	**CHECKED**
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/17/10	**PEER REVIEW / DATE** DLM 12/17/10

IA-6b. Long Lake Valley Reservoir alternative – Water quality release option. Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-6B LLVR; WQ Release option Keno
350 TAF Capacity; 1000cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-6C LLVR; WQ Release option	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$1,750,000,000	$1,750,000,000
Land purchase costs				
Land for reservoir and facilities			$5,400,000	$5,400,000
Mitigation wetlands			$14,916,000	$14,916,000
Subtotal 1				**$1,770,316,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$90,503	$1,903,278
Maintenance Costs	PWA Factor	21.03	$2,598,031	$54,636,592
Energy Costs	PWA Factor	21.03	$196,103	$4,124,046
Replacement Costs	PWA Factor	21.03	$114,415	$2,406,147
WT Maint Costs	PWA Factor	21.03	$4,280,000	$90,008,400
Subtotal 2				**$153,078,463**
Total Present Worth Costs = Subtotal 1 + 2				**$1,923,394,463**
Total Present Worth Costs Rounded				**$1,900,000,000**

Assumptions:

50 = n = year analysis period
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year with 335ft head.
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	12/23/10
DATE PREPARED:	23-Dec-10	PEER REVIEW:	12/29/10

File Name: IA-6B LLV A1-OA plus ROW at Keno w WT.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-6B LLVR; WQ Release option Keno
350 TAF Capacity; 1000cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-6C LLVR; WQ Release option	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$1,650,000,000	$1,650,000,000
Land purchase costs				
Land for reservoir and facilities			$5,400,000	$5,400,000
Mitigation wetlands			$14,916,000	$14,916,000
Subtotal 1				**$1,670,316,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$90,503	$1,903,278
Maintenance Costs	PWA Factor	21.03	$2,598,031	$54,636,592
Energy Costs	PWA Factor	21.03	$196,103	$4,124,046
Replacement Costs	PWA Factor	21.03	$114,415	$2,406,147
Subtotal 2				**$63,070,063**
Total Present Worth Costs = Subtotal 1 + 2				**$1,733,386,063**
Total Present Worth Costs Rounded				**$1,750,000,000**

Assumptions:

50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year with 335ft head.
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	12/23/10
DATE PREPARED:	23-Dec-10	PEER REVIEW:	12/29/10

File Name: IA-6B LLV A1-OA plus ROW at Keno WO WT.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

IA-6b. Long Lake Valley Reservoir alternative – Water quality release option. Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET 1 OF 5

FEATURE:	PROJECT:
Swan A B Canal Feed with Pumping from "B" Canal to Swan Lake	UPPER KLAMATH BASIN Offstream Storage Study
Summary Sheet by Feature	WOID: AF329 / ESTIMATE LEVEL: Preliminary
	REGION: MP / UNIT PRICE LEVEL: Oct-10
Water Treatment	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 7A Swan Lake AB Canal Feed-Old\Dec-10\[IA-7A Swan Lake AB Canal w WT.xlsx]FeatureSum ltz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Canal Rework, Raising Levees, F & P Pipeline					$135,117,230.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Pump Plant					$17,700,000.00
	4	Electrical					$9,580,000.00
	5	Water Treatment					$35,000,000.00
		Subtotal 1					$199,195,230.00
		Mobilization	5%	+/-			$10,000,000.00
		Subtotal 1 with Mobilization					**$209,195,230.00**
		Design Contingencies	25%	+/-			$52,298,808.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$261,494,038.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$261,494,038.00
		CONTRACT COST					**$260,000,000.00**
		Construction Contingencies	25%	+/-			$70,000,000.00
		FIELD COST					**$330,000,000.00**
		Non-Contract Costs	25%	+/-			$80,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$410,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY Stan Mattingly	REVIEWED Paul Ruchti 8/5/09	BY L.L.Zlomke	CHECKED KMB 1/10/11
DATE PREPARED 06/12/08	PEER REVIEW / DATE	DATE PREPARED 01/07/11	PEER REVIEW / DATE DLA 1/10/11

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET 1 OF 5

FEATURE:	PROJECT:
Swan A B Canal Feed with Pumping from "B" Canal to Swan Lake	UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — ESTIMATE LEVEL: Preliminary
Summary Sheet by Feature	REGION: MP — UNIT PRICE LEVEL: Oct-10
No Water Treatment	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 7A Swan Lake AB Canal Feed-Old\Dec-10\[IA-7A Swan Lake AB Canal WO WT.xlsx]FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Canal Rework, Raising Levees, F & P Pipeline					$135,117,230.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Pump Plant					$17,700,000.00
	4	Electrical					$9,580,000.00
		Subtotal 1					$164,195,230.00
		Mobilization	5%	+/-			$8,200,000.00
		Subtotal 1 with Mobilization					**$172,395,230.00**
		Design Contingencies	25%	+/-			$43,098,808.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$215,494,038.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$215,494,038.00
		CONTRACT COST					**$220,000,000.00**
		Construction Contingencies	25%	+/-			$50,000,000.00
		FIELD COST					**$270,000,000.00**
		Non-Contract Costs	25%	+/-			$70,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$340,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY: Stan Mattingly	REVIEWED: Paul Ruchti 8/5/09	BY: L.L.Zlomke	CHECKED: KMB 1/10/11
DATE PREPARED: 06/12/08	PEER REVIEW / DATE	DATE PREPARED: 01/07/11	PEER REVIEW / DATE: DLM 1/10/11

IA-7a. Swan Lake – AB Canal water supply option.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-7A Swan Lake AB Canal
290 cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-7A Swan Lake AB Canal	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$410,000,000	$410,000,000
Land purchase costs				
Land for reservoir and facilities			$9,720,000	$9,720,000
Mitigation wetlands			$9,720,000	$9,720,000
Subtotal 1				**$429,440,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$238,537	$5,016,433
Maintenance Costs	PWA Factor	21.03	$2,468,050	$51,903,092
Energy Costs	PWA Factor	21.03	$51,332	$1,079,512
Replacement Costs	PWA Factor	21.03	$98,722	$2,076,124
WT Maint Costs	PWA Factor	21.03	$860,000	$18,085,800
Subtotal 2				**$78,160,961**
Total Present Worth Costs = Subtotal 1 + 2				**$507,600,961**
Total Present Worth Costs Rounded				**$510,000,000**

Assumptions:

50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor =
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 8 weeks/year
290 cfs with a total of 32,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	
DATE PREPARED:	11-Jan-11	PEER REVIEW:	1/12/11

File Name: IA-7A Swan Lake AB Canal w WT-R1.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-7A Swan Lake AB Canal
290 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-7A Swan Lake AB Canal	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$340,000,000	$340,000,000
Land purchase costs				
Land for reservoir and facilities			$9,720,000	$9,720,000
Mitigation wetlands			$9,720,000	$9,720,000
Subtotal 1				**$359,440,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$238,537	$5,016,433
Maintenance Costs	PWA Factor	21.03	$2,468,050	$51,903,092
Energy Costs	PWA Factor	21.03	$51,332	$1,079,512
Replacement Costs	PWA Factor	21.03	$98,722	$2,076,124
Subtotal 2				**$60,075,161**
Total Present Worth Costs = Subtotal 1 + 2				**$419,515,161**
Total Present Worth Costs Rounded				**$420,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 8 weeks/year

290 cfs with a total of 32,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	
DATE PREPARED:	11-Jan-11	PEER REVIEW:	1/12/11

File Name: IA-7A Swan Lake AB Canal WO WT-R1.xlsx Tab: App A Life-Cycle Costs Analysis   Page 1 of 1

IA-7a. Swan Lake – AB Canal water supply option.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _12_

FEATURE: **Swan Lake Algoma Reservoir (350 TAF)** **- with Pumping Capacity of 1,000 cfs** **Summary Sheet by Feature** **Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 **ESTIMATE LEVEL:** Preliminary **REGION:** MP **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\A 6A Long Lake Valley Reservoir Option A -Old\Dec-10\[IA-6A LLV_A1-OA lined w WT.xlsx]FeatureSum teh

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System (~ 1 mile)					$15,840,340.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen and Check Structure					$16,350,416.00
	4	Pumping plant					$59,300,000.00
	5	Access Roads					$4,373,700.00
	6	Electrical					$10,451,000.00
	7	Construct embankment dam					$18,469,020.00
	8	Construct emergency spillway, stilling basin, & bridge					$42,974,175.00
	9	Construct Tunnel, Tower, Bridge, & OW Channel					$80,458,920.00
	10	Construct Surge Shaft (OW)					$2,518,738.00
	11	Construct Tunnel (OW)					$48,709,900.00
	12	Water Treatment					$63,800,000.00
		Subtotal 1					$365,044,209.00
		Mobilization	5%	+/-			$18,500,000.00
		Subtotal 1 with Mobilization					**$383,544,209.00**
		Design Contingencies	25%	+/-			$95,886,052.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$479,430,261.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$479,430,261.00
		CONTRACT COST					**$480,000,000.00**
		Construction Contingencies	25%	+/-			$120,000,000.00
		FIELD COST					**$600,000,000.00**
		Non-Contract Costs	25%	+/-			$150,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$750,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Paul Ruchti 8/3/09	**BY** L. L. Zlomke	**CHECKED** KMB 12/15/10
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/15/10	**PEER REVIEW / DATE** DLM 12/15/10

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _12_

FEATURE:	PROJECT:			
Swan Lake Algoma Reservoir (350 TAF) - with Pumping Capacity of 1,000 cfs	UPPER KLAMATH BASIN Offstream Storage Study			
	WOID:	AF329	ESTIMATE LEVEL:	Preliminary
	REGION:	MP	UNIT PRICE LEVEL:	Oct-10
Summary Sheet by Feature No Water Treatment	FILE:	H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 20 Clear Lake Storage-J Canal Feed-New\Dec-10\[IA-20 J_Canal to Clear Lake WO WT.xlsx]FeatureSum ltz		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System (~ 1 mile)					$15,840,340.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen and Check Structure					$16,350,416.00
	4	Pumping plant					$59,300,000.00
	5	Access Roads					$4,373,700.00
	6	Electrical					$10,451,000.00
	7	Construct embankment dam					$18,469,020.00
	8	Construct emergency spillway, stilling basin, & bridge					$42,974,175.00
	9	Construct Tunnel, Tower, Bridge, & OW Channel					$80,458,920.00
	10	Construct Surge Shaft (OW)					$2,518,738.00
	11	Construct Tunnel (OW)					$48,709,900.00
		Subtotal 1					$301,244,209.00
		Mobilization	5%	+/-			$15,000,000.00
		Subtotal 1 with Mobilization					**$316,244,209.00**
		Design Contingencies	25%	+/-			$79,061,052.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$395,305,261.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$395,305,261.00
		CONTRACT COST					**$400,000,000.00**
		Construction Contingencies	25%	+/-			$90,000,000.00
		FIELD COST					**$490,000,000.00**
		Non-Contract Costs	25%	+/-			$120,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$610,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	REVIEWED Paul Ruchti 8/3/09	BY L. L. Ziomke	CHECKED KMB 12/15/10
DATE PREPARED 06/12/08	PEER REVIEW / DATE	DATE PREPARED 12/15/10	PEER REVIEW / DATE DLM 12/15/10

IA-7b. Swan Lake – Algoma water supply option.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Swan Lake Algoma Reservoir
350 TAF Capacity; 1000cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Swan Lake Algoma Reservoir	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$750,000,000	$750,000,000
Land purchase costs				
Land for reservoir and facilities			$42,340,000	$42,340,000
Mitigation wetlands			$9,720,000	$9,720,000
Subtotal 1				**$802,060,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$85,752	$1,803,365
Maintenance Costs	PWA Factor	21.03	$2,378,127	$50,012,011
Energy Costs	PWA Factor	21.03	$158,056	$3,323,918
Replacement Costs	PWA Factor	21.03	$99,725	$2,097,217
WT Maint Costs	PWA Factor	21.03	$4,280,000	$90,008,400
Subtotal 2				**$147,244,911**
Total Present Worth Costs = Subtotal 1 + 2				**$949,304,911**
Total Present Worth Costs Rounded				**$950,000,000**

Assumptions:

50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor =
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	
DATE PREPARED:	18-Dec-10	PEER REVIEW:	

File Name: IA-7B Swan Lake Algoma w WT.xlsx Tab: App A Life-Cycle Costs Analysis — Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Swan Lake Algoma Reservoir
350 TAF Capacity; 1000cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Swan Lake Algoma Reservoir	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$610,000,000	$610,000,000
Land purchase costs				
Land for reservoir and facilities			$42,340,000	$42,340,000
Mitigation wetlands			$9,720,000	$9,720,000
Subtotal 1				**$662,060,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$85,752	$1,803,365
Maintenance Costs	PWA Factor	21.03	$2,378,127	$50,012,011
Energy Costs	PWA Factor	21.03	$158,056	$3,323,918
Replacement Costs	PWA Factor	21.03	$99,725	$2,097,217
Subtotal 2				**$57,236,511**
Total Present Worth Costs = Subtotal 1 + 2				**$719,296,511**
Total Present Worth Costs Rounded				**$720,000,000**

Assumptions:	
50	= n = year analysis period.
4.125%	= i = FY2011 planning interest rate for the year 50 year period.
PWA Factor =	
P/A = (((1+i)^n) - 1)/(i*((1+i)^n))	21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23

BY	Kelly Brom	CHECKED	
DATE PREPARED	18-Dec-10	PEER REVIEW	

File Name: IA-7B Swan Lake Algoma WO WT.xlsx Tab: App A Life-Cycle Costs Analysis — Page 1 of 1

IA-7b. Swan Lake – Algoma water supply option.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _11_

FEATURE: **Surface storage - Lower Klamath Lake Nat Wildlife Refuge (LKL NWR), Unit 13** **Q = 322 cfs inflow, 300 cfs outflow** **Summary Sheet by Feature** **No Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 **ESTIMATE LEVEL:** Preliminary **REGION:** MP **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-8 Lower Klamath Storage-Revised\Dec-10\[IA-8 LKL Refuge WO WT.xlsx]Dam_OW_and_Spwy

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Canal					$1,468,020.00
	2	Service Roads					$801,550.00
	3	Construct Inlet Canal Control structure and Stilling Basin					$1,182,600.00
	4	Discharge structure for tunnel into Unit 13					$4,300.00
	5	Construct Unit 13 Inlet Tunnel					$59,275,400.00
	6	Construct fish screen and headwork structure					$16,350,416.00
	7	Construct Surge Shaft for Unit 13 Inlet tunnel					$475,950.00
	8	Construct embankment dam					$49,109,090.00
	9	Construct emergency spillway chute and stilling basin					$672,560.00
	10	Construct Spillway Crest Bridge					$85,450.00
	11	Construct Outlet Works					$191,050.00
	12	Construct Outlet Works Tower and Access Bridge					$2,124,680.00
	13	Electrical					$2,830,000.00
	14	Construct mitigation wetlands outlet works					$115,167.00
	15	Construct embankment levee for wetlands					$2,062,840.00
		Subtotal 1					$136,749,073.00
		Mobilization	5%	+/-			$6,800,000.00
		Subtotal 1 with Mobilization					**$143,549,073.00**
		Design Contingencies	25%	+/-			$35,887,268.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$179,436,341.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$179,436,341.00
		CONTRACT COST					**$180,000,000.00**
		Construction Contingencies	25%	+/-			$40,000,000.00
		FIELD COST					**$220,000,000.00**
		Non-Contract Costs	25%	+/-			$60,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$280,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	**REVIEWED**	**BY** L.L. Zlomke	**CHECKED** KMB 12/15/10
DATE PREPARED 11/19/10	**PEER REVIEW / DATE** S. Mattingly 11/19/10	**DATE PREPARED** 12/15/10	**PEER REVIEW / DATE** DLM 12/16/10

IA-8. Lower Klamath National Wildlife Refuge storage.
Preliminary-level capital construction cost estimate worksheet.

Summary of Life Cycle Costs

UKBOS Studies
IA-8 LKL NW Refuge Storage-Revised
322 cfs, 17,880 ac-ft/year
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-8 LKL NW Refuge Storage-Revised	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$280,000,000	$280,000,000
Real estate costs				
Private land purchase costs				$0
Mitigation wetlands costs @ 3410 acres estimated impacted from powerline			$6,820,000	$6,820,000
Subtotal 1				**$286,820,000**
Periodic Replacement Costs		P/F		
Year 25	PW Factor	0.3640	**$12,200,000**	$4,440,800
Subtotal 2				**$4,440,800**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$130,000	$2,733,900
Maintenance Costs	PWA Factor	21.03	$640,000	$13,459,200
Energy Costs	PWA Factor	21.03	$14,707	$309,288
Subtotal 3				**$16,502,388**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$307,763,188**
Total Present Worth Costs Rounded				**$310,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KMB 1/13/11	
DATE PREPARED:	13-Jan-11		PEER REVIEW: [illegible] 1/13/11	

Assumptions are shown on Page 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
322 cfs with a total of 17,880 acre-feet/year pumped thru Sheepy Tunnel with 78 feet of lift from "D" pumping plant
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.
Since D pumping plant is an existing pump, assume replacement pump is not included with these life cycle costs, but energy costs are based on usage of pumping plant. Assume energy costs will be passed through to client.
Reference Hard Dollar file for developed life cycle costs

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,25yrs) = 1/(1 + 4.125%)^30 =	0.3640
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

IA-8 LKL Refuge WO WT-R1.xlsx Life-Cycle Costs Analysis

Page 2 of 2

IA-8. Lower Klamath National Wildlife Refuge storage.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _4_

FEATURE:

Raised Tule Lake Sump 1A
- with Pumping from Lost River

Summary Sheet By Feature

Water Treatment

PROJECT: **UPPER KLAMATH BASIN** **Offstream Storage Study**

WOID: AF329 | **ESTIMATE LEVEL:** Preliminary

REGION: MP | **UNIT PRICE LEVEL:** Oct-10

FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-9 Tule Lake Storage-Old\Dec-10\[IA-9 Tule Lake w WT.xlsx] FeatureSum ltz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Compacted Embankment at Tule Sump					$36,880,000.00
	2	Compacted Embankment Lost River Diversion					$1,296,500.00
	3	Pump Plants					$30,500,000.00
	4	Electric Installations					$13,073,000.00
	5	Water Treatment					$66,600,000.00
		Subtotal 1					$148,349,500.00
		Mobilization	5%	+/-			$7,400,000.00
		Subtotal 1 with Mobilization					**$155,749,500.00**
		Design Contingencies	30%	+/-			$46,724,850.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$202,474,350.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$202,474,350.00
		CONTRACT COST					**$200,000,000.00**
		Construction Contingencies	25%	+/-			$50,000,000.00
		FIELD COST					**$250,000,000.00**
		Non-Contract Costs	25%	+/-			$60,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$310,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Mike O'Shea 8/3/09	**BY** L. Zlomke	**CHECKED** KMB 12/15/10
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/14/10	**PEER REVIEW / DATE** DLH 12/15/10

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET 1 OF 4

FEATURE: Raised Tule Lake Sump 1A - with Pumping from Lost River; Summary Sheet By Feature; No Water Treatment	**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — **ESTIMATE LEVEL:** Preliminary
	REGION: MP — **UNIT PRICE LEVEL:** Oct-10
	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-9 Tule Lake Storage-Old\Dec-10\[IA-9 Tule Lake WO WT.xlsx] FeatureSum itz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Compacted Embankment at Tule Sump					$36,880,000.00
	2	Compacted Embankment Lost River Diversion					$1,296,500.00
	3	Pump Plants					$30,500,000.00
	4	Electric Installations					$13,073,000.00
		Subtotal 1					$81,749,500.00
		Mobilization	5%	+/-			$4,100,000.00
		Subtotal 1 with Mobilization					**$85,849,500.00**
		Design Contingencies	30%	+/-			$25,754,850.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$111,604,350.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$111,604,350.00
		CONTRACT COST					**$110,000,000.00**
		Construction Contingencies	25%	+/-			$30,000,000.00
		FIELD COST					**$140,000,000.00**
		Non-Contract Costs	25%	+/-			$35,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$175,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY: Stan Mattingly	REVIEWED: Mike O'Shea 8/3/09	BY: L. Zlomke	CHECKED: YMB 12/15/10
DATE PREPARED: 06/12/08	PEER REVIEW / DATE	DATE PREPARED: 12/14/10	PEER REVIEW / DATE: DLM 12/15/10

IA-9. Tule Lake water storage.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Tule Lake Storage
1000cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Tule Lake Storage	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$310,000,000	$310,000,000
Land purchase costs				
Land for reservoir and facilities (Fed Land No Cost)			$0	$0
Mitigation wetlands			$3,860,000	$3,860,000
Subtotal 1				**$313,860,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$96,508	$2,029,563
Maintenance Costs	PWA Factor	21.03	$2,145,664	$45,123,314
Energy Costs	PWA Factor	21.03	$20,194	$424,680
Replacement Costs	PWA Factor	21.03	$85,827	$1,804,942
WT Maint Costs	PWA Factor	21.03	$3,710,000	$78,021,300
Subtotal 2				**$127,403,799**
Total Present Worth Costs = Subtotal 1 + 2				**$441,263,799**
Total Present Worth Costs Rounded				**$440,000,000**

Assumptions:	
50	= n = year analysis period.
4.125%	= i = FY2011 planning interest rate for the year 50 year period.
PWA Factor =	
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) =	21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	
DATE PREPARED:	18-Dec-10	PEER REVIEW:	12/22/10

File Name: IA-9 Tule Lake w WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Tule Lake Storage
1000cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Tule Lake Storage	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$175,000,000	$175,000,000
Land purchase costs				
Land for reservoir and facilities (Fed Land No Cost)			$0	$0
Mitigation wetlands			$3,860,000	$3,860,000
Subtotal 1				**$178,860,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$96,508	$2,029,563
Maintenance Costs	PWA Factor	21.03	$2,145,664	$45,123,314
Energy Costs	PWA Factor	21.03	$20,194	$424,680
Replacement Costs	PWA Factor	21.03	$85,827	$1,804,942
Subtotal 2				**$49,382,499**
Total Present Worth Costs = Subtotal 1 + 2				**$228,242,499**
Total Present Worth Costs Rounded				**$230,000,000**

Assumptions:	
50	= n = year analysis period.
4.125%	= i = FY2011 planning interest rate for the year 50 year period.
PWA Factor =	
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) =	21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	
DATE PREPARED:	18-Dec-10	PEER REVIEW:	

File Name: IA-9 Tule Lake WO WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

IA-9. Tule Lake water storage.
Preliminary-level Life-cycle cost estimate worksheet table.

IA-10

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _3_

FEATURE:

Raised UKL and Link River Dam

Summary Sheet by Feature

Water Treatment

PROJECT:

UPPER KLAMATH BASIN
Offstream Storage Study

WOID:	AF329	**ESTIMATE LEVEL:**	Preliminary
REGION:	MP	**UNIT PRICE LEVEL:**	Oct-10

FILE: H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-10 UKL-Raising Link River Dam-Old\Dec-10\[IA-10 UKL-Raising Link River Dam w WT.xlsx]FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Compacted Embankments for levees					$129,265,500.00
	2	Excavation at borrow site					$45,524,000.00
	3	Levee Raise Riprap with bedding					$70,660,000.00
	4	Concrete Work					$642,700.00
	5	Water Treatment					$63,800,000.00
		Subtotal 1					$309,892,200.00
		Mobilization	5%	+/-			$15,500,000.00
		Subtotal 1 with Mobilization					**$325,392,200.00**
		Design Contingencies	30%	+/-			$97,617,560.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$423,009,860.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$423,009,860.00
		CONTRACT COST					**$420,000,000.00**
		Construction Contingencies	25%	+/-			$110,000,000.00
		FIELD COST					**$530,000,000.00**
		Non-Contract Costs	25%	+/-			$130,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$660,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		**PRICES**	
BY Stan Mattingly	**REVIEWED** Al Bernstein 8/4/09	**BY** L. L. Ziomke	**CHECKED** KimB 12/14/10
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/14/10	**PEER REVIEW / DATE** DLM 12/14/10

IA-10

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET 1 OF 3

FEATURE: Raised UKL and Link River Dam

Summary Sheet by Feature

No Water Treatment

PROJECT: UPPER KLAMATH BASIN Offstream Storage Study

WOID:	AF329	**ESTIMATE LEVEL:**	Preliminary
REGION:	MP	**UNIT PRICE LEVEL:**	Oct-10

FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-10 UKL-Raising Link River Dam-Old\Dec-10\[IA-10 UKL-Raising Link River Dam WO WT.xlsx]FeatureSum ifz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Compacted Embankments for levees					$129,265,500.00
	2	Excavation at borrow site					$45,524,000.00
	3	Levee Raise Riprap with bedding					$70,660,000.00
	4	Concrete Work					$642,700.00
		Subtotal 1					$246,092,200.00
		Mobilization	5%	+/-			$12,500,000.00
		Subtotal 1 with Mobilization					**$258,592,200.00**
		Design Contingencies	30%	+/-			$77,577,660.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$336,169,860.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$336,169,860.00
		CONTRACT COST					**$340,000,000.00**
		Construction Contingencies	25%	+/-			$80,000,000.00
		FIELD COST					**$420,000,000.00**
		Non-Contract Costs	25%	+/-			$110,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$530,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Al Bernstein 8/4/09	**BY** L. L. Zlomke	**CHECKED** YMB 12/14/10
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/14/10	**PEER REVIEW / DATE** DLM 12/14/10

IA-10. Upper Klamath Lake – Raise Link River Dam.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-10 UKL-Raising Link River Dam
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

				IA-10 UKL-Raising Link River Dam	
				Estimated Costs	Present Worth
Initial Capital Costs					
Initial Construction and Other Costs					
Construction Costs				$660,000,000	$660,000,000
Land purchase costs					
Land for reservoir and facilities				$0	$0
Mitigation wetlands				$0	$0
Subtotal 1					**$660,000,000**
Annual Costs		P/A (n = 50)			
Operations Costs	PWA Factor	21.03		$0	$0
Maintenance Costs	PWA Factor	21.03		$0	$0
WT Maint Costs	PWA Factor	21.03		$4,280,000	$90,008,400
Subtotal 2					**$90,008,400**
Total Present Worth Costs = Subtotal 1 + 2					**$750,008,400**
Total Present Worth Costs Rounded					**$750,000,000**

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor =
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03
These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Only significant feature, except water treatment, is the levee & no life cycle costs
are developed for this feature at this level.

BY:	L. Zlomke	CHECKED:	KMB 1/10/11
DATE PREPARED:	10-Jan-11	PEER REVIEW:	[illegible] 1/12/11

File Name: IA-10 UKL-Raising Link River Dam w WT.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-10 UKL-Raising Link River Dam
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-10 UKL-Raising Link River Dam	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$530,000,000	$530,000,000
Land purchase costs				
Land for reservoir and facilities			$0	$0
Mitigation wetlands			$0	$0
Subtotal 1				**$530,000,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$0	$0
Maintenance Costs	PWA Factor	21.03	$0	$0
Subtotal 2				**$0**
Total Present Worth Costs = Subtotal 1 + 2				**$530,000,000**
Total Present Worth Costs Rounded				**$530,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Only significant feature is the levee & no life cycle costs are developed for this feature at this level.

BY:	L.Zlomke	CHECKED:	KmB 1/10/11
DATE PREPARED:	10-Jan-11	PEER REVIEW:	[signature] 1/13/11

File Name: IA-10 UKL-Raising Link River Dam WO WT.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

IA-10. Upper Klamath Lake – Raise Link River Dam.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _4_

FEATURE:	PROJECT:
Dredge UKL (200 AF of volume)	UPPER KLAMATH LAKE - Offstream Storage Study
	WOID: AF329 — ESTIMATE LEVEL: Preliminary
	REGION: MP — UNIT PRICE LEVEL: Oct-10
	FILE: V:\ENHANCEMENT ACT (P.L. 106-498)\UKBOS_Studies\Dredge_UKL\[Dredge_UKL_quantity_20110218.xlsx] FeatureSumllz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Dredge, haul and handle spoil at spoil site					$74,221,000.00
	2	Construct mitigation wetlands					$1,187,100.64
		Subtotal 1					$75,408,100.64
		Mobilization	5%	+/-			$3,800,000.00
		Subtotal 1 with Mobilization					**$79,208,100.64**
		Design Contingencies	25%	+/-			$19,802,025.36
		Subtotal 2 = Subtotal 1 + Design Contingencies					$99,010,126.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$99,010,126.00
		CONTRACT COST					**$100,000,000.00**
		Construction Contingencies	25%	+/-			$20,000,000.00
		FIELD COST					**$120,000,000.00**
		Non-Contract Costs	25%	+/-			$30,000,000.00
		CONSTRUCTION COST					**$150,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY	REVIEWED	BY	CHECKED
Stan Mattingly	Al Bernstien 8/5/09	L. L. Zlomke	
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED	PEER REVIEW / DATE
06/12/08		08/05/09	

IA-11. Upper Klamath Lake – Dredge lake bottom.
Preliminary-level capital construction cost estimate worksheet.

Summary of Life Cycle Costs

UKBOS Studies
Dredge UKL
200 AF Capacity
Estimate Level: Preliminary
Price Level: Oct-09
WOID: AF329

			Dredge UKL	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$150,000,000	$150,000,000
Land purchase costs				
Dredge spoil land footprint			$800,000	$800,000
Wetlands			$800,000	$800,000
Subtotal 1				**$150,000,000**
Periodic Costs		P/A (n = 50)		
Redredge in 25th year costs	PWA Factor	0.3	$74,221,000	$22,266,300
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	19.36679	$0	$0
Maintenance Costs	PWA Factor	19.36679	$5,000	$96,834
Energy Costs	PWA Factor	19.36679	$0	$0
Subtotal 2				**$22,363,134**
Total Present Worth Costs = Subtotal 1 + 2				**$172,363,134**
Total Present Worth Costs Rounded				**$170,000,000**

Assumptions:
50-year analysis period.
FY2009 planning interest rate 4.625% per year for 50 years.
PW Factor = P/F = $(1+ i)^{-n}$ = Single Payment Present Worth (P/F, 4.625%, 50).
PWA Factor = P/A = ((1+i)n - 1)/(i*((1+i)n) = Uniform Series Present Worth Factor (P/A, 4.625%, 50).
Interest Rate 4.625% for water storage projects

BY: S Mattingly	CHECKED:
DATE PREPARED: 4-Oct-10	PEER REVIEW:

File Name: Dredge_UKL_quantity_20110218.xlsx Tab: App A Life-Cycle Costs Analysis — Page 1 of 1

IA-11. Upper Klamath Lake – Dredge lake bottom.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _4_

FEATURE: **Caledonia Marsh Reservoir** **- with Pumping from UKL** **Summary Sheet by Feature** **Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 **ESTIMATE LEVEL:** Preliminary **REGION:** MP **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 12 Caledonia Marsh Storage-Old\Dec-10\[IA-12 Caledonia Marsh w WT.xlsx]FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Compacted embankment on levees					$23,920,000.00
	2	Pump Plant					$10,100,000.00
	3	Electrical Istallation					$7,180,000.00
	4	Water Treatment					$35,000,000.00
		Subtotal 1					$76,200,000.00
		Mobilization	5%	+/-			$3,800,000.00
		Subtotal 1 with Mobilization					**$80,000,000.00**
		Design Contingencies	30%	+/-			$24,000,000.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$104,000,000.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$104,000,000.00
		CONTRACT COST					$105,000,000.00
		Construction Contingencies	25%	+/-			$25,000,000.00
		FIELD COST					$130,000,000.00
		Non-Contract Costs	25%	+/-			$35,000,000.00
		CONSTRUCTION COST (does not include land costs)					$165,000,000.00

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Mike O'Shea 08/04/09	**BY** E. L. Zlomke	**CHECKED** RMB 1/9/11
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 01/07/11	**PEER REVIEW / DATE** DLM 1/10/11

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _4_

FEATURE: **Caledonia Marsh Reservoir** **- with Pumping from UKL** **Summary Sheet by Feature** **No Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **WOID:** AF329 **ESTIMATE LEVEL:** Preliminary **REGION:** MP **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-12 Caledonia Marsh Storage-Old\Dec-10\[IA-12 Caledonia Marsh WO WT.xlsx]FeatureSum.ltz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Compacted embankment on levees					$23,920,000.00
	2	Pump Plant					$10,100,000.00
	3	Electrical Istallation					$7,180,000.00
		Subtotal 1					$41,200,000.00
		Mobilization	5%	+/-			$2,100,000.00
		Subtotal 1 with Mobilization					**$43,300,000.00**
		Design Contingencies	30%	+/-			$12,990,000.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$56,290,000.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$56,290,000.00
		CONTRACT COST					**$56,000,000.00**
		Construction Contingencies	25%	+/-			$14,000,000.00
		FIELD COST					**$70,000,000.00**
		Non-Contract Costs	25%	+/-			$18,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$88,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY Stan Mattingly	REVIEWED Mike O'Shea 08/04/09	BY L. L. Zlomke	CHECKED LMB 1/7/11
DATE PREPARED 06/12/08	PEER REVIEW / DATE	DATE PREPARED 01/07/11	PEER REVIEW / DATE DLM 1/10/11

IA-12. Caledonia Marsh storage.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-12 Caledonia Marsh Storage
28 TAF Capacity; 500 cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-12 Caledonia Marsh Storage	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$165,000,000	$165,000,000
Land purchase costs				
Land for reservoir and facilities			$4,400,000	$4,400,000
Mitigation wetlands			$340,000	$340,000
Subtotal 1				**$169,740,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$36,337	$764,167
Maintenance Costs	PWA Factor	21.03	$522,693	$10,992,234
Energy Costs	PWA Factor	21.03	$2,931	$61,639
Replacement Costs	PWA Factor	21.03	$20,908	$439,695
WT Maint Costs	PWA Factor	21.03	$860,000	$18,085,800
Subtotal 2				**$30,343,535**
Total Present Worth Costs = Subtotal 1 + 2				**$200,083,535**
Total Present Worth Costs Rounded				**$200,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 4 weeks/year

500 cfs with a total of 28,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	1-11-11
DATE PREPARED:	11-Jan-11	PEER REVIEW:	1/12/11

File Name: IA-12 Caledonia Marsh w WT-R1.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-12 Caledonia Marsh Storage
28 TAF Capacity; 500 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-12 Caledonia Marsh Storage	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$88,000,000	$88,000,000
Land purchase costs				
Land for reservoir and facilities			$4,400,000	$4,400,000
Mitigation wetlands			$340,000	$340,000
Subtotal 1				**$92,740,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$36,337	$764,167
Maintenance Costs	PWA Factor	21.03	$522,693	$10,992,234
Energy Costs	PWA Factor	21.03	$2,931	$61,639
Replacement Costs	PWA Factor	21.03	$20,908	$439,695
Subtotal 2				**$12,257,735**
Total Present Worth Costs = Subtotal 1 + 2				**$104,997,735**
Total Present Worth Costs Rounded				**$105,000,000**

Assumptions:

50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor =
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
500 cfs with a total of 28,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	[illegible]
DATE PREPARED:	11-Jan-11	PEER REVIEW:	[illegible] 1/12/11

File Name: IA-12 Caledonia Marsh WO WT-R1.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

IA-12. Caledonia Marsh storage.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _12_

FEATURE:
Wocus Marsh Reservoir (350 TAF) Elev 4235
- with Pumping Capacity of 1,000 cfs
- shorter levees - Max WS EL 4230

Summary Sheet by Feature
Water Treatment

PROJECT: **UPPER KLAMATH BASIN**
Offstream Storage Study

WOID:	AF329	ESTIMATE LEVEL:	Preliminary
REGION:	MP	UNIT PRICE LEVEL:	Oct-10
FILE:	H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\A-13A Wocus Marsh Storage 4235-Old\Dec-10\[A-13A Wocus Marsh High w WT.xlsx] FeatureSum.ilz		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System					$9,443,500.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen					$16,350,416.00
	4	Pumping plant					$33,700,000.00
	5	Construct Surge Shaft					$475,950.00
	6	Construct embankment dam					$16,550,680.00
	7	Construct lateral levees					$179,170,400.00
	8	Construct emergency spillway chute, and stilling basin					$2,395,300.00
	9	Construct Spillway Crest Bridge					$501,870.00
	10	Construct Tunnel					$2,015,200.00
	11	Construct Outlets Work Tower and Access Bridge					$12,379,310.00
	12	Electrical					$12,851,000.00
	13	Access Roads					$978,500.00
	14	Water Treatment					$63,800,000.00
		Subtotal 1					$352,410,126.00
		Mobilization	5%	+/-			$17,500,000.00
		Subtotal 1 with Mobilization					**$369,910,126.00**
		Design Contingencies	25%	+/-			$92,477,532.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$462,387,658.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$462,387,658.00
		CONTRACT COST					**$460,000,000.00**
		Construction Contingencies	25%	+/-			$120,000,000.00
		FIELD COST					**$580,000,000.00**
		Non-Contract Costs	25%	+/-			$150,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$730,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	REVIEWED Al Bernstien 8/5/09	BY L. L. Zlomke	CHECKED KMB 12/16/10
DATE PREPARED 06/12/08	PEER REVIEW / DATE	DATE PREPARED 12/16/10	PEER REVIEW / DATE DLH 12/16/10

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _12_

FEATURE:	PROJECT:
Wocus Marsh Reservoir (350 TAF) Elev 4235 - with Pumping Capacity of 1,000 cfs - shorter levees - Max WS EL 4230	UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — ESTIMATE LEVEL: Preliminary
	REGION: MP — UNIT PRICE LEVEL: Oct-10
Summary Sheet by Feature No Water Treatment	FILE: H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-13A Wocus Marsh Storage 4235-Old\Dec-10\[IA-13A Wocus Marsh High WO WT.xlsx]FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System					$9,443,500.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen					$16,350,416.00
	4	Pumping plant					$33,700,000.00
	5	Construct Surge Shaft					$475,950.00
	6	Construct embankment dam					$16,550,680.00
	7	Construct lateral levees					$179,170,400.00
	8	Construct emergency spillway chute, and stilling basin					$2,395,300.00
	9	Construct Spillway Crest Bridge					$501,870.00
	10	Construct Tunnel					$2,015,200.00
	11	Construct Outlets Work Tower and Access Bridge					$12,379,310.00
	12	Electrical					$12,851,000.00
	13	Access Roads					$978,500.00
		Subtotal 1					$288,610,126.00
		Mobilization	5%	+/-			$14,500,000.00
		Subtotal 1 with Mobilization					**$303,110,126.00**
		Design Contingencies	25%	+/-			$75,777,532.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$378,887,658.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$378,887,658.00
		CONTRACT COST					**$380,000,000.00**
		Construction Contingencies	25%	+/-			$90,000,000.00
		FIELD COST					**$470,000,000.00**
		Non-Contract Costs	25%	+/-			$120,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$590,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	REVIEWED Al Bernstien 8/5/09	BY L. Ziomke	CHECKED KMB 12/16/10
DATE PREPARED 06/12/08	PEER REVIEW / DATE	DATE PREPARED 12/16/10	PEER REVIEW / DATE DLM 12/17/10

IA-13a. Wocus Marsh storage – high water level option.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Wocus Marsh Storage; High concept (4235)
350 TAF Capacity; 1000cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Wocus Marsh Storage; High concept (4235)	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$730,000,000	$730,000,000
Land purchase costs				
Land for reservoir and facilities			$7,844,000	$7,844,000
Mitigation wetlands			$280,000	$280,000
Subtotal 1				**$738,124,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$65,157	$1,370,252
Maintenance Costs	PWA Factor	21.03	$1,515,707	$31,875,318
Energy Costs	PWA Factor	21.03	$52,689	$1,108,050
Replacement Costs	PWA Factor	21.03	$52,182	$1,097,387
WT Maint Costs	PWA Factor	21.03	$4,280,000	$90,008,400
Subtotal 2				**$125,459,407**
Total Present Worth Costs = Subtotal 1 + 2				**$863,583,407**
Total Present Worth Costs Rounded				**$860,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 4 weeks/year

1000 cfs with a total of 50,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	12/21/10
DATE PREPARED:	18-Dec-10	PEER REVIEW:	12/22/10

File Name: IA-13A Wocus Marsh High w WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Wocus Marsh Storage; High concept (4235)
350 TAF Capacity; 1000cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Wocus Marsh Storage; High concept (4235)	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$590,000,000	$590,000,000
Land purchase costs				
Land for reservoir and facilities			$7,844,000	$7,844,000
Mitigation wetlands			$280,000	$280,000
Subtotal 1				**$598,124,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$65,157	$1,370,252
Maintenance Costs	PWA Factor	21.03	$1,515,707	$31,875,318
Energy Costs	PWA Factor	21.03	$52,689	$1,108,050
Replacement Costs	PWA Factor	21.03	$52,182	$1,097,387
Subtotal 2				**$35,451,007**
Total Present Worth Costs = Subtotal 1 + 2				**$633,575,007**
Total Present Worth Costs Rounded				**$630,000,000**

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor =
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS
Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	12/21/10
DATE PREPARED:	18-Dec-10	PEER REVIEW:	12/[illegible]/10

File Name: IA-13A Wocus Marsh High WO WT.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

IA-13a. Wocus Marsh storage – high water level option.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _12_

FEATURE: **Wocus Marsh Reservoir (350 TAF) Elev 4225** **- with Pumping Capacity of 1,000 cfs** **- shorter levees - Max WS EL 4220** **Summary Sheet by Feature** **Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 **ESTIMATE LEVEL:** Preliminary **REGION:** MP **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-13B Wocus Marsh Storage 4225-Old\Dec-10\[IA-13B Wocus Marsh Storage Low w WT xlsx]Dam_OW_and_Spwy llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System					$9,443,500.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen					$16,350,416.00
	4	Pumping plant					$33,700,000.00
	5	Construct Surge Shaft					$475,950.00
	6	Construct embankment dam					$14,433,900.00
	7	Construct lateral levees					$23,815,880.00
	8	Construct emergency spillway chute, and stilling basin					$2,219,850.00
	9	Construct Spillway Crest Bridge					$501,870.00
	10	Construct Tunnel					$1,796,600.00
	11	Construct Outlets Work Tower and Access Bridge					$12,379,310.00
	12	Electrical					$12,851,000.00
	13	Access Roads					$18,572,500.00
	14	Water Treatment					$63,800,000.00
		Subtotal 1					$212,138,776.00
		Mobilization	5%	+/-			$10,500,000.00
		Subtotal 1 with Mobilization					**$222,638,776.00**
		Design Contingencies	25%	+/-			$55,659,694.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$278,298,470.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$278,298,470.00
		CONTRACT COST					**$280,000,000.00**
		Construction Contingencies	25%	+/-			$70,000,000.00
		FIELD COST					**$350,000,000.00**
		Non-Contract Costs	25%	+/-			$90,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$440,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Al Bernstien 8/5/09	**BY** L. L. Zlomke	**CHECKED** 12/16/10
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/15/10	**PEER REVIEW / DATE** DLH 12/16/10

BUREAU OF RECLAMATION ESTIMATE WORKSHEET SHEET _1_ OF _12_

FEATURE:
Wocus Marsh Reservoir (350 TAF) Elev 4225
- with Pumping Capacity of 1,000 cfs
- shorter levees - Max WS EL 4220

Summary Sheet by Feature
No Water Treatment

PROJECT:
UPPER KLAMATH BASIN
Offstream Storage Study

WOID:	AF329	**ESTIMATE LEVEL:**	Preliminary
REGION:	MP	**UNIT PRICE LEVEL:**	Oct-10

FILE: H:\D6170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 13B Wocus Marsh Storage 4225-Old\Dec-10\[IA-13B Wocus Marsh Storage Low WO WT.xlsx] FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System					$9,443,500.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen					$16,350,416.00
	4	Pumping plant					$33,700,000.00
	5	Construct Surge Shaft					$475,950.00
	6	Construct embankment dam					$14,433,900.00
	7	Construct lateral levees					$23,815,880.00
	8	Construct emergency spillway chute, and stilling basin					$2,219,850.00
	9	Construct Spillway Crest Bridge					$501,870.00
	10	Construct Tunnel					$1,796,600.00
	11	Construct Outlets Work Tower and Access Bridge					$12,379,310.00
	12	Electrical					$12,851,000.00
	13	Access Roads					$18,572,500.00
		Subtotal 1					$148,338,776.00
		Mobilization	5%	+/-			$7,400,000.00
		Subtotal 1 with Mobilization					**$155,738,776.00**
		Design Contingencies	25%	+/-			$38,934,694.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$194,673,470.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$194,673,470.00
		CONTRACT COST					**$195,000,000.00**
		Construction Contingencies	25%	+/-			$50,000,000.00
		FIELD COST					**$240,000,000.00**
		Non-Contract Costs	25%	+/-			$60,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$300,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Al Bernstien 8/5/09	**BY** L. L. Zlomke	**CHECKED** S. E. 12/16/10
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/15/10	**PEER REVIEW / DATE** DLM 12/16/10

IA-13b. Wocus Marsh storage – low water level option.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Wocus Reservoir Low - Elev 4225
350 TAF Capacity; 1000cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Wocus Reservoir Low - Elev 4225	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$440,000,000	$440,000,000
Land purchase costs				
Land for reservoir and facilities			$8,920,000	$8,920,000
Mitigation wetlands			$280,000	$280,000
Subtotal 1				**$449,200,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$65,157	$1,370,252
Maintenance Costs	PWA Factor	21.03	$1,515,707	$31,875,318
Energy Costs	PWA Factor	21.03	$52,689	$1,108,050
Replacement Costs	PWA Factor	21.03	$52,182	$1,097,387
WT Maint Costs	PWA Factor	21.03	$4,280,000	$90,008,400
Subtotal 2				**$125,459,407**
Total Present Worth Costs = Subtotal 1 + 2				**$574,659,407**
Total Present Worth Costs Rounded				**$570,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 4 weeks/year

1000 cfs with a total of 50,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	12/22/10
DATE PREPARED:	18-Dec-10	PEER REVIEW:	12/22/10

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Wocus Reservoir Low - Elev 4225
350 TAF Capacity; 1000cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Wocus Reservoir Low - Elev 4225	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$300,000,000	$300,000,000
Land purchase costs				
Land for reservoir and facilities			$8,920,000	$8,920,000
Mitigation wetlands			$280,000	$280,000
Subtotal 1				**$309,200,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$65,157	$1,370,252
Maintenance Costs	PWA Factor	21.03	$1,515,707	$31,875,318
Energy Costs	PWA Factor	21.03	$52,689	$1,108,050
Replacement Costs	PWA Factor	21.03	$52,182	$1,097,387
Subtotal 2				**$35,451,007**
Total Present Worth Costs = Subtotal 1 + 2				**$344,651,007**
Total Present Worth Costs Rounded				**$340,000,000**

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor =
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03
These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume plant is partially manned.
Operating 4 weeks/year
1000 cfs with a total of 50,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom KMB	CHECKED:	[illegible] 12/21/10
DATE PREPARED:	18-Dec-10	PEER REVIEW:	[illegible] 12/22/10

File Name: IA-13B Wocus Marsh Storage Low WO WT.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

IA-13b. Wocus Marsh storage – low water level option.
Preliminary-level Life-cycle cost estimate worksheet table.

IA-14

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _10_

FEATURE: Klamath Drainage District (KDD) - with supply from Klamath River and pumping from Klamath Straits Drain Summary Sheet by Feature	**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — ESTIMATE LEVEL: Preliminary
	REGION: MP — UNIT PRICE LEVEL: Oct-10
Water Treatment	FILE: H:\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-14 Klamath Drainage District-Revised\Dec-10\[IA-14 KDD Existing Canals w WT.xlsx] FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,167.00
	2	Construct embankment levee for wetlands					$659,521.00
	3	Riprapping Levees					$38,619,420.00
	4	Access and Levee Crest Roads					$9,245,762.00
	5	Construct Intake and Discharge Structures					$10,210,880.00
	6	Construct ADY/West Canal Intake fish screen FS1					$16,077,416.00
	7	ADY/West Canal Check Structure					$273,000.00
	8	Construct fish screen FS2 @ New North Canal Intake					$4,025,118.00
	9	New North Canal Intake Check Structure					$273,000.00
	10	Pumping Plants					$4,500,000.00
	11	Electric Installations					$1,932,000.00
	12	Water Treatment facillity					$35,000,000.00
		Subtotal 1					$120,931,284.00
		Mobilization	5%	+/-			$6,000,000.00
		Subtotal 1 with Mobilization					$126,931,284.00
		Design Contingencies	25%	+/-			$31,732,821.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$158,664,105.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$158,664,105.00
		CONTRACT COST					$160,000,000.00
		Construction Contingencies	25%	+/-			$40,000,000.00
		FIELD COST					$200,000,000.00
		Non-Contract Costs	25%	+/-			$50,000,000.00
		CONSTRUCTION COST (does not include land costs)					$250,000,000.00

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC: 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY: Stan Mattingly	CHECKED	BY: L. Zlomke	CHECKED: S. Cy 12/15/10
DATE PREPARED: 11/17/10	PEER REVIEW / DATE: S.Mattingly 11/17/10	DATE PREPARED: 12/15/10	PEER REVIEW / DATE: DLM 12/15/10

IA-14

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _10_

FEATURE: **Klamath Drainage District (KDD)** **- with supply from Klamath River** **and pumping from Klamath Straits Drain** **Summary Sheet by Feature** **No Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 — **ESTIMATE LEVEL:** Preliminary **REGION:** MP — **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\[2010 Pumping Plant Breakdown Tab.xlsx]Pump Plt Brkdn ltz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,167.00
	2	Construct embankment levee for wetlands					$659,521.00
	3	Riprapping Levees					$38,619,420.00
	4	Access and Levee Crest Roads					$9,245,762.00
	5	Construct Intake and Discharge Structures					$10,210,880.00
	6	Construct ADY/West Canal Intake fish screen FS1					$16,077,416.00
	7	ADY/West Canal Check Structure					$273,000.00
	8	Construct fish screen FS2 @ New North Canal Intake					$4,025,118.00
	9	New North Canal Intake Check Structure					$273,000.00
	10	Pumping Plants					$4,500,000.00
	11	Electric Installations					$1,932,000.00
		Subtotal 1					$85,931,284.00
		Mobilization	5%	+/-			$4,300,000.00
		Subtotal 1 with Mobilization					**$90,231,284.00**
		Design Contingencies	25%	+/-			$22,557,821.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$112,789,105.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$112,789,105.00
		CONTRACT COST					**$115,000,000.00**
		Construction Contingencies	25%	+/-			$25,000,000.00
		FIELD COST					**$140,000,000.00**
		Non-Contract Costs	25%	+/-			$35,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$175,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	CHECKED	BY L Zlomke	CHECKED J. G. 12/15/10
DATE PREPARED 11/17/10	PEER REVIEW / DATE S.Mattingly 11/17/10	DATE PREPARED 12/15/10	PEER REVIEW / DATE DLM 12/15/10

IA-14. Klamath Drainage District storage.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-14 KDD Existing Canals

Use existing ADY and North Canals - Minimal new infrastructure - 97 TAF reservoir - with water treatment - 400 cfs inflow in Dec - Feb - 400 cfs outflow - July/Aug

Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-14 KDD Existing Canals	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$250,000,000	$250,000,000
Land purchase costs				
Land for reservoir and facilities			$32,340,000	$32,340,000
Mitigation wetlands			$700,000	$700,000
Subtotal 1				**$283,040,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$200,615	$4,218,933
Maintenance Costs	PWA Factor	21.03	$2,984,824	$62,770,849
Energy Costs	PWA Factor	21.03	$14,412	$303,084
Replacement Costs	PWA Factor	21.03	$119,393	$2,510,835
WT Maint Costs	PWA Factor	21.03	$860,000	$18,085,800
Subtotal 2				**$87,889,501**
Total Present Worth Costs = Subtotal 1 + 2				**$370,929,501**
Total Present Worth Costs Rounded				**$370,000,000**

Assumptions:

50 = n = year analysis period

4.125% = i = FY2011 planning interest rate for the year 50 year period

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs

Input to the Pumping Plant Operation and Maintenance Program

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned

Operating 8 weeks/year

400 cfs with a total of 97,000 acre-feet/year 10/50 years

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23

BY	Kelly Brum	CHECKED	
DATE PREPARED	16 Dec 10	PEER REVIEW	12/23/10

File Name: IA-14 KDD Existing Canals w WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies

IA-14 KDD Existing Canals

Use existing ADY and North Canals - Minimal new infrastructure - 97 TAF reservoir - with water treatment - 400 cfs inflow in Dec - Feb - 400 cfs outflow - July/Aug

No Water Treatment

Estimate Level: Preliminary

Price Level: Oct-10

			IA-14 KDD Existing Canals	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$175,000,000	$175,000,000
Land purchase costs				
Land for reservoir and facilities			$32,340,000	$32,340,000
Mitigation wetlands			$700,000	$700,000
Subtotal 1				**$208,040,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$200,615	$4,218,933
Maintenance Costs	PWA Factor	21.03	$2,984,824	$62,770,849
Energy Costs	PWA Factor	21.03	$14,412	$303,084
Replacement Costs	PWA Factor	21.03	$119,393	$2,510,835
Subtotal 2				**$69,803,701**
Total Present Worth Costs = Subtotal 1 + 2				**$277,843,701**
Total Present Worth Costs Rounded				**$280,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects.

Assume plant is partially manned

Operating 8 weeks/year

400 cfs with a total of 97,000 acre-feet/year 10/50 years

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23

BY:	Kelly Brom	CHECKED:	12/22/10
DATE PREPARED:	16-Dec-10	PEER REVIEW:	12/22/10

File Name: IA-14 KDD Existing Canals WO WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

IA-14. Klamath Drainage District storage.
Preliminary-level Life-cycle cost estimate worksheet table.

IA-15

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _13_

FEATURE: **Whiteline Reservoir (350 TAF)** **- with Pumping Capacity of 1,000 cfs** **Summary Sheet by Feature** **Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 — **ESTIMATE LEVEL:** Preliminary **REGION:** MP — **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-15 Whiteline Reservoir-Old\Dec-10\[IA-15 Whiteline Reservoir w WT.xlsx]FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System					$15,840,340.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen and Check Structure					$16,350,416.00
	4	Pumping plant					$70,100,000.00
	5	Construct Tunnel (Canal_OW)					$48,714,250.00
	6	Construct Surge Shaft (Canal_OW)					$2,917,200.00
	7	Construct Outlets Work Tower and Access Bridge (Canal_OW)					$20,627,570.00
	8	Access Roads					$4,373,700.00
	9	Electrical					$10,651,000.00
	10	Construct embankment dam					$212,958,000.00
	11	Construct emergency spillway chute and stilling basin					$52,382,000.00
	12	Construct Spillway Crest Bridge					$998,175.00
	13	Construct Tunnel					$30,947,550.00
	14	Construct Outlets Work Tower and Access Bridge					$20,596,370.00
	15	Water Treatment					$63,800,000.00
		Subtotal 1					$573,054,571.00
		Mobilization	5%	+/-			$29,000,000.00
		Subtotal 1 with Mobilization					**$602,054,571.00**
		Design Contingencies	25%	+/-			$150,513,643.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$752,568,214.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$752,568,214.00
		CONTRACT COST					**$750,000,000.00**
		Construction Contingencies	25%	+/-			$190,000,000.00
		FIELD COST					**$940,000,000.00**
		Non-Contract Costs	25%	+/-			$260,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$1,200,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	REVIEWED Al Bernstein 8/19/09	BY L. L. Zlomke	CHECKED S. G. 12/17/10
DATE PREPARED 06/12/08	PEER REVIEW / DATE	DATE PREPARED 12/17/10	PEER REVIEW / DATE DLM 12/17/10

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _13_

FEATURE: **Whiteline Reservoir (350 TAF)** **- with Pumping Capacity of 1,000 cfs** **Summary Sheet by Feature** **No Water Treatment**	**PROJECT:** **UPPER KLAMATH BASIN** **Offstream Storage Study** **WOID:** AF329 — **ESTIMATE LEVEL:** Preliminary **REGION:** MP — **UNIT PRICE LEVEL:** Oct-10 **FILE:** H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-15 Whiteline Reservoir-Old\Dec-10\[IA-15 Whiteline Reservoir WO WT.xlsx]Dam_OW_and_Spwy llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Conveyance Canal System					$15,840,340.00
	2	Construct Intake Channel and Bypass Release Structures					$1,798,000.00
	3	Fish Screen and Check Structure					$16,350,416.00
	4	Pumping plant					$70,100,000.00
	5	Construct Tunnel (Canal_OW)					$48,714,250.00
	6	Construct Surge Shaft (Canal_OW)					$2,917,200.00
	7	Construct Outlets Work Tower and Access Bridge (Canal_OW)					$20,627,570.00
	8	Access Roads					$4,373,700.00
	9	Electrical					$10,651,000.00
	10	Construct embankment dam					$212,958,000.00
	11	Construct emergency spillway chute and stilling basin					$52,382,000.00
	12	Construct Spillway Crest Bridge					$998,175.00
	13	Construct Tunnel					$30,947,550.00
	14	Construct Outlets Work Tower and Access Bridge					$20,596,370.00
		Subtotal 1					$509,254,571.00
		Mobilization	5%	+/-			$25,000,000.00
		Subtotal 1 with Mobilization					**$534,254,571.00**
		Design Contingencies	25%	+/-			$133,563,643.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$667,818,214.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$667,818,214.00
		CONTRACT COST					**$670,000,000.00**
		Construction Contingencies	25%	+/-			$160,000,000.00
		FIELD COST					**$830,000,000.00**
		Non-Contract Costs	25%	+/-			$220,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$1,050,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Al Bernstein 8/19/09	**BY** L. L. Ziomke	**CHECKED** S. S. 12/17/10
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 12/17/10	**PEER REVIEW / DATE** DLM 12/17/10

IA-15. Whiteline Reservoir.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Whiteline Reservoir
350 TAF Capacity; 1000cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Whiteline Reservoir	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$1,200,000,000	$1,200,000,000
Land purchase costs				
Land for reservoir and facilities			$4,000,000	$4,000,000
Mitigation wetlands			$1,684,000	$1,684,000
Subtotal 1				**$1,205,684,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$90,503	$1,903,278
Maintenance Costs	PWA Factor	21.03	$2,598,031	$54,636,592
Energy Costs	PWA Factor	21.03	$196,103	$4,124,046
Replacement Costs	PWA Factor	21.03	$135,084	$2,840,817
WT Maint Costs	PWA Factor	21.03	$4,280,000	$90,008,400
Subtotal 2				**$153,513,133**
Total Present Worth Costs = Subtotal 1 + 2				**$1,359,197,133**
Total Present Worth Costs Rounded				**$1,350,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) : 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 4 weeks/year

1000 cfs with a total of 50,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom KMB	CHECKED:	12/22/10
DATE PREPARED:	18-Dec-10	PEER REVIEW:	12/22/10

File Name: IA-15 Whiteline Reservoir w WT.xlsx Tab: App A Life-Cycle Costs Analysis   Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
Whiteline Reservoir
350 TAF Capacity; 1000cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Whiteline Reservoir	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$1,050,000,000	$1,050,000,000
Land purchase costs				
Land for reservoir and facilities			$4,000,000	$4,000,000
Mitigation wetlands			$1,684,000	$1,684,000
Subtotal 1				**$1,055,684,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$90,503	$1,903,278
Maintenance Costs	PWA Factor	21.03	$2,598,031	$54,636,592
Energy Costs	PWA Factor	21.03	$196,103	$4,124,046
Replacement Costs	PWA Factor	21.03	$135,084	$2,840,817
Subtotal 2				**$63,504,733**
Total Present Worth Costs = Subtotal 1 + 2				**$1,119,188,733**
Total Present Worth Costs Rounded				**$1,100,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) : 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 4 weeks/year

1000 cfs with a total of 50,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	
DATE PREPARED:	18-Dec-10	PEER REVIEW:	

File Name: IA-15 Whiteline Reservoir WO WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

IA-15. Whiteline Reservoir.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET 1 OF 6

FEATURE: Torrent Springs Reservoir Dam

Summary Sheet by Feature
Water Treatment

PROJECT: UPPER KLAMATH BASIN, Offstream Storage Study

WOID:	AF329	ESTIMATE LEVEL:	Preliminary
REGION:	MP	UNIT PRICE LEVEL:	Oct-10

FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\26 Alts-Working\IA-16 Torrent Springs Reservoir-Old\Dec-10\[IA-16 Torrent Springs Reservoir w WT-R1.xlsx]FeatureSum liz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,317.00
	2	Construct Embankment levee for Wetlands					$9,164,878.00
	3	Construct embankment dam					$26,797,780.00
	4	Construct emergency spillway and bridge					$16,183,900.00
	5	Construct Spillway Crest Bridge					$998,175.00
	6	Construct Tunnel					$2,221,500.00
	7	Construct Outlet Work Tower and Access Bridge					$10,312,900.00
	8	Electrical Installations					$9,830,000.00
	9	Access Roads					$713,000.00
	10	Fish Ladder					$20,000,000.00
	11	Water Treatment					$2,200,000.00
		Subtotal 1					$98,537,450.00
		Mobilization	5%	+/-			$4,900,000.00
		Subtotal 1 with Mobilization					**$103,437,450.00**
		Design Contingencies	30%	+/-			$31,031,235.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$134,468,685.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$134,468,685.00
		CONTRACT COST					**$135,000,000.00**
		Construction Contingencies	25%	+/-			$35,000,000.00
		FIELD COST					**$170,000,000.00**
		Non-Contract Costs	25%	+/-			$40,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$210,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY	REVIEWED	BY	CHECKED
Stan Mattingly	Mike O'Shea 8/4/09	L. L. Zlomke	KMB 1/12/11
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED	PEER REVIEW / DATE
06/12/08		01/11/11	DLM 1/13/11

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _6_

FEATURE:	PROJECT:
Torrent Springs Reservoir Dam	UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 / ESTIMATE LEVEL: Preliminary
	REGION: MP / UNIT PRICE LEVEL: Oct-10
Summary Sheet by Feature No Water Treatment	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-16 Torrent Springs Reservoir-Old\Dec-10\[IA-16 Torrent Springs Reservoir WO WT-R1.xlsx]Rd&Res liz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,317.00
	2	Construct Embankment levee for Wetlands					$9,164,878.00
	3	Construct embankment dam					$26,797,780.00
	4	Construct emergency spillway and bridge					$16,183,900.00
	5	Construct Spillway Crest Bridge					$998,175.00
	6	Construct Tunnel					$2,221,500.00
	7	Construct Outlet Work Tower and Access Bridge					$10,312,900.00
	8	Electrical Installations					$5,730,000.00
	9	Access Roads					$713,000.00
	10	Fish Ladder					$20,000,000.00
		Subtotal 1					$92,237,450.00
		Mobilization	5%	+/-			$4,600,000.00
		Subtotal 1 with Mobilization					**$96,837,450.00**
		Design Contingencies	30%	+/-			$29,051,235.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$125,888,685.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$125,888,685.00
		CONTRACT COST					**$125,000,000.00**
		Construction Contingencies	25%	+/-			$35,000,000.00
		FIELD COST					**$160,000,000.00**
		Non-Contract Costs	25%	+/-			$40,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$200,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY Stan Mattingly	REVIEWED Mike O'Shea 8/4/09	BY L. L. Zlomke	CHECKED KMB 1/12/11
DATE PREPARED 06/12/08	PEER REVIEW / DATE	DATE PREPARED 01/11/11	PEER REVIEW / DATE DLM 1/13/11

IA-16. Torrent Springs Reservoir.
Preliminary-level capital construction cost estimate worksheet.

Summary of Life Cycle Costs

UKBOS Studies
Torrent Springs Reservoir Dam
421 TAF Capacity; OW 500 cfs, Spillway
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Torrent Springs Reservoir Dam	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$210,000,000	$210,000,000
Real estate costs				
Private land purchase costs			$54,000,000	$54,000,000
Mitigation wetlands			$135,000,000	$135,000,000
Subtotal 1				**$399,000,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$40,000	$841,200
Maintenance Costs	PWA Factor	21.03	$190,000	$3,995,700
WT Maint Costs	PWA Factor	21.03	$120,000	$2,523,600
Subtotal 2				**$7,360,500**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$406,360,500**
Total Present Worth Costs Rounded				**$410,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KMB 1/14/11	
DATE PREPARED:	14-Jan-11		PEER REVIEW: 1/14/11	

Summary of Life Cycle Costs

Assumptions:	
50 = n = year analysis period.	
4.125% = i = FY2011 planning interest rate for the year 50 year period.	
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).	
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) =	21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.	
Input to the Pumping Plant Operation and Maintenance Program:	
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes	
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr	
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr	
Interest Rate 4.125% for water storage projects	
Assume all work is performed by Government Work Force Personnel for all Non-pump life cycle calcs.	
Reference Hard Dollar file for developed life cycle costs	

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,25yrs) = 1/(1 + 4.125%)^30 =	0.3640
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
Torrent Springs Reservoir Dam
421 TAF Capacity; OW 500 cfs, Spillway
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Torrent Springs Reservoir Dam	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$200,000,000	$200,000,000
Real estate costs				
Private land purchase costs			$54,000,000	$54,000,000
Mitigation wetlands			$135,000,000	$135,000,000
Subtotal 1				**$389,000,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$40,000	$841,200
Maintenance Costs	PWA Factor	21.03	$190,000	$3,995,700
Subtotal 2				**$4,836,900**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$393,836,900**
Total Present Worth Costs Rounded				**$390,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED:	1/14/11
DATE PREPARED:	14-Jan-11		PEER REVIEW:	1/14/11

Summary of Life Cycle Costs

Assumptions:	
50	= n = year analysis period.
4.125%	= i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).	
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) =	21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.	
Input to the Pumping Plant Operation and Maintenance Program:	
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes	
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr	
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr	
Interest Rate 4.125% for water storage projects	
Assume all work is performed by Government Work Force Personnel for all Non-pump life cycle calcs.	
Reference Hard Dollar file for developed life cycle costs	

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,25yrs) = 1/(1 + 4.125%)^30 =	0.3640
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

IA-16. Torrent Springs Reservoir.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _6_

FEATURE: Williamson River Canyon Reservoir	**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — **ESTIMATE LEVEL:** Preliminary
	REGION: MP — **UNIT PRICE LEVEL:** Oct-10
Summary Sheet by Feature Water Treatment	**FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA 17 Williamson River Canyon-Old\Dec-10\[IA-17 Williamson River Canyon w WT.xlsx]Life-Cycle Costs Analysis

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,317.00
	2	Construct Embankment levee for Wetlands					$1,577,073.00
	3	Construct embankment dam					$134,398,600.00
	4	Construct emergency spillway and bridge					$21,992,650.00
	5	Construct Spillway Crest Bridge					$998,175.00
	6	Construct Tunnel					$8,282,480.00
	7	Construct Outlet Work Tower and Access Bridge					$10,312,900.00
	8	Electrical Installations					$8,230,000.00
	9	Access Roads					$4,373,700.00
	10	Fish Ladder					$50,000,000.00
	11	Water Treatment					$2,200,000.00
		Subtotal 1					$242,480,895.00
		Mobilization	5%	+/-			$12,000,000.00
		Subtotal 1 with Mobilization					**$254,480,895.00**
		Design Contingencies	30%	+/-			$76,344,269.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$330,825,164.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$330,825,164.00
		CONTRACT COST					**$330,000,000.00**
		Construction Contingencies	25%	+/-			$80,000,000.00
		FIELD COST					**$410,000,000.00**
		Non-Contract Costs	25%	+/-			$100,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$510,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY: Stan Mattingly	REVIEWED: Mike O'Shea 8/4/09	BY: L. Zlomke	CHECKED: KMB 4/12/11
DATE PREPARED: 06/12/08	PEER REVIEW / DATE	DATE PREPARED: 01/12/11	PEER REVIEW / DATE: DLM 1/13/11

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _6_

FEATURE: Williamson River Canyon Reservoir	**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — **ESTIMATE LEVEL:** Preliminary
	REGION: MP — **UNIT PRICE LEVEL:** Oct-10
Summary Sheet by Feature **No Water Treatment**	**FILE:** H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-17 Williamson River Canyon-Old\Dec-10\[IA-17 Williamson River Canyon WO WT.xlsx]FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,317.00
	2	Construct Embankment levee for Wetlands					$1,577,073.00
	3	Construct embankment dam					$134,398,600.00
	4	Construct emergency spillway and bridge					$21,992,650.00
	5	Construct Spillway Crest Bridge					$998,175.00
	6	Construct Tunnel					$8,282,480.00
	7	Construct Outlet Work Tower and Access Bridge					$10,312,900.00
	8	Electrical Installations					$4,130,000.00
	9	Access Roads					$4,373,700.00
	10	Fish Ladder					$50,000,000.00
		Subtotal 1					$236,180,895.00
		Mobilization	5%	+/-			$12,000,000.00
		Subtotal 1 with Mobilization					**$248,180,895.00**
		Design Contingencies	30%	+/-			$74,454,269.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$322,635,164.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$322,635,164.00
		CONTRACT COST					**$320,000,000.00**
		Construction Contingencies	25%	+/-			$80,000,000.00
		FIELD COST					**$400,000,000.00**
		Non-Contract Costs	25%	+/-			$100,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$500,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	**REVIEWED** Mike O'Shea 8/4/09	**BY** L. L. Zlomke	**CHECKED** KMB 1/12/11
DATE PREPARED 06/12/08	**PEER REVIEW / DATE**	**DATE PREPARED** 01/12/11	**PEER REVIEW / DATE** DLM 1/13/11

IA-17. Williamson River Reservoir.
Preliminary-level capital construction cost estimate worksheet.

Summary of Life Cycle Costs

UKBOS Studies
Williamson River Canyon Reservoir
100 TAF Capacity; OW 500 cfs, Spillway
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Williamson River Canyon Reservoir	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$510,000,000	$510,000,000
Real estate costs				
Private land purchase costs			$54,000,000	$54,000,000
Mitigation wetlands			$4,000,000	$4,000,000
Wetlands Construction			$10,000,000	$10,000,000
Subtotal 1				**$578,000,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$40,000	$841,200
Maintenance Costs	PWA Factor	21.03	$230,000	$4,836,900
WT Maint Costs	PWA Factor	21.03	$120,000	$2,523,600
Subtotal 2				**$8,201,700**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$586,201,700**
Total Present Worth Costs Rounded				**$590,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED:	KMB 1/14/11
DATE PREPARED:	14-Jan-11		PEER REVIEW:	1/14/11

IA-17 Williamson River Canyon w WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:	
50	= n = year analysis period.
4.125%	= i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).	
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) =	21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.	
Input to the Pumping Plant Operation and Maintenance Program:	
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes	
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr	
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr	
Interest Rate 4.125% for water storage projects	
Assume all work is performed by Government Work Force Personnel for all Non-pump life cycle calcs.	
Reference Hard Dollar file for developed life cycle costs	

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,25yrs) = 1/(1 + 4.125%)^30 =	0.3640
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
Williamson River Canyon Reservoir
100 TAF Capacity; OW 500 cfs, Spillway
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			Williamson River Canyon Reservoir	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$500,000,000	$500,000,000
Real estate costs				
Private land purchase costs			$54,000,000	$54,000,000
Mitigation wetlands			$4,000,000	$4,000,000
Wetlands Construction			$10,000,000	$10,000,000
Subtotal 1				**$568,000,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$40,000	$841,200
Maintenance Costs	PWA Factor	21.03	$230,000	$4,836,900
Subtotal 2				**$5,678,100**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$573,678,100**
Total Present Worth Costs Rounded				**$570,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KMB 1/14/11	
DATE PREPARED:	14-Jan-11		PEER REVIEW: 1/14/11	

IA-17 Williamson River Canyon WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume all work is performed by Government Work Force Personnel for all Non-pump life cycle calcs.
Reference Hard Dollar file for developed life cycle costs

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,25yrs) = 1/(1 + 4.125%)^30 =	0.3640
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

IA-17 Williamson River Canyon WO WT-R1.xlsx Life-Cycle Costs Analysis

Page 2 of 2

IA-17. Williamson River Reservoir.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _11_

FEATURE:
Buck Lake Dam and Reservoir
- 75 cfs inflow capacity,
100 cfs outlet works cap

Summary Sheet by Feature
Water Treatment

PROJECT:
UPPER KLAMATH BASIN
Offstream Storage Study

WOID: AF329 | **ESTIMATE LEVEL:** Preliminary
REGION: MP | **UNIT PRICE LEVEL:** Oct-10
FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-19 Buck Lake Storage-New\Dec-10\[IA-19 Buck Lake w WT.xlsx] FeatureSum Itz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Tunnel and siphon					$43,119,400.00
	2	Construct Intake Channels					$856,100.00
	3	Construct Bypass Release Structures					$54,256.00
	4	Construct Wetlands outlet works					$115,317.00
	5	Construct embankment levee for wetlands					$1,413,406.00
	6	Construct Surge Shaft					$264,860.00
	7	Construct embankment dam					$1,636,627.00
	8	Construct emergency spillway chute and stilling basin					$957,120.00
	9	Construct Spillway Crest Bridge					$45,500.00
	10	Construct Outlet works conduit					$107,700.00
	11	Construct Outlet Work Tower and Access Bridge					$555,670.00
	12	Fish Screen 1					$4,721,531.00
	13	Fish Screen 2					$4,721,531.00
	14	Electric Installations					$6,370,500.00
	15	Access Roads					$1,102,500.00
	16	Water Treaatment facility					$35,000,000.00
		Subtotal 1					$101,042,018.00
		Mobilization	5%	+/-			$5,100,000.00
		Subtotal 1 with Mobilization					**$106,142,018.00**
		Design Contingencies	25%	+/-			$26,535,505.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$132,677,523.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$132,677,523.00
		CONTRACT COST					**$135,000,000.00**
		Construction Contingencies	25%	+/-			$30,000,000.00
		FIELD COST					**$165,000,000.00**
		Non-Contract Costs	25%	+/-			$45,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$210,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	CHECKED	BY Lonnie Zlomke	CHECKED KMB 12/22/10
DATE PREPARED 11/17/10	PEER REVIEW / DATE S.Mattingly 11/17/10	DATE PREPARED 12/20/10	PEER REVIEW / DATE RA 12/22/10

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _11_

FEATURE:	PROJECT:
Buck Lake Dam and Reservoir - 75 cfs inflow capacity, 100 cfs outlet works cap	UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 / ESTIMATE LEVEL: Preliminary
	REGION: MP / UNIT PRICE LEVEL: Oct-10
Summary Sheet by Feature No Water Treatment	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-19 Buck Lake Storage-New\Dec-10\[IA-19 Buck Lake WO WT-R1.xlsx] FeatureSum ltz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Tunnel and siphon					$43,119,400.00
	2	Construct Intake Channels					$856,100.00
	3	Construct Bypass Release Structures					$54,256.00
	4	Construct Wetlands outlet works					$115,317.00
	5	Construct embankment levee for wetlands					$1,413,406.00
	6	Construct Surge Shaft					$264,860.00
	7	Construct embankment dam					$1,636,627.00
	8	Construct emergency spillway chute and stilling basin					$957,120.00
	9	Construct Spillway Crest Bridge					$45,500.00
	10	Construct Outlet works conduit					$107,700.00
	11	Construct Outlet Work Tower and Access Bridge					$555,670.00
	12	Fish Screen 1					$4,721,531.00
	13	Fish Screen 2					$4,721,531.00
	14	Electric Installations					$2,270,500.00
	15	Access Roads					$1,102,500.00
		Subtotal 1					$61,942,018.00
		Mobilization	5%	+/-			$3,100,000.00
		Subtotal 1 with Mobilization					**$65,042,018.00**
		Design Contingencies	25%	+/-			$16,260,505.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$81,302,523.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$81,302,523.00
		CONTRACT COST					**$81,000,000.00**
		Construction Contingencies	25%	+/-			$19,000,000.00
		FIELD COST					**$100,000,000.00**
		Non-Contract Costs	25%	+/-			$25,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$125,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	CHECKED	BY Lonnie Zlomke	CHECKED KMB 1/11/11
DATE PREPARED 11/17/10	PEER REVIEW / DATE S.Mattingly 11/17/10	DATE PREPARED 01/11/11	PEER REVIEW / DATE DLH 1/11/11

IA-18. Buck Lake water storage.
Preliminary-level capital construction cost estimate worksheet.

Summary of Life Cycle Costs

UKBOS Studies
IA-19 Buck Lake
9.3 TAF Capacity; 75 cfs inflow,100 cfs outlet works capacity
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-19 Buck Lake	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$210,000,000	$210,000,000
Real estate costs				
Private land purchase costs			$2,900,000	$2,900,000
Mitigation wetlands costs @ 8 acres estimated			$3,200,000	$3,200,000
Subtotal 1				**$216,100,000**
Periodic Replacement Costs		P/F		
Year 25	PW Factor	0.3640	**$4,700,000**	$1,710,800
Subtotal 2				**$1,710,800**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$590,000	$12,407,700
Maintenance Costs	PWA Factor	21.03	$175,000	$3,680,250
WT Maint Costs	PWA Factor	21.03	$860,000	$18,085,800
Subtotal 3				**$34,173,750**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$251,984,550**
Total Present Worth Costs Rounded				**$250,000,000**

Assumptions: Shown on Page 2

BY:	L Zlomke	CHECKED:	KMB 2/9/11
DATE PREPARED:	9-Feb-11	PEER REVIEW:	2/9/11

IA-19 Buck Lake w WT-R1.xlsx Life-Cycle Costs Analysis — Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume reservoir is infrequently manned.
pumps operate 2 weeks/year (80 man hours)
75 cfs inflow,100 cfs outlet works capacity
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.
Assume all work is performed by Government Work Force Personnel for all Non-pump life cycle calcs.
Reference Hard Dollar file for developed life cycle costs

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,25yrs) = 1/(1 + 4.125%)^30 =	0.3640
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

Summary of Life Cycle Costs

UKBOS Studies
IA-19 Buck Lake
9.3 TAF Capacity; 75 cfs inflow,100 cfs outlet works capacity
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-19 Buck Lake	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$125,000,000	$125,000,000
Real estate costs				
Private land purchase costs			$2,900,000	$2,900,000
Mitigation wetlands costs @ 8 acres estimated			$3,200,000	$3,200,000
Subtotal 1				**$131,100,000**
Periodic Replacement Costs		P/F		
Year 25	PW Factor	0.3640	**$4,700,000**	$1,710,800
Subtotal 2				**$1,710,800**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$590,000	$12,407,700
Maintenance Costs	PWA Factor	21.03	$175,000	$3,680,250
Subtotal 3				**$16,087,950**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$148,898,750**
Total Present Worth Costs Rounded				**$150,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: KMB 2/9/11	
DATE PREPARED:	9-Feb-11		PEER REVIEW:	

IA-19 Buck Lake WO WT-R1.xlsx Life-Cycle Costs Analysis

Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume reservoir is infrequently manned.
pumps operate 2 weeks/year (80 man hours)
75 cfs inflow,100 cfs outlet works capacity
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.
Assume all work is performed by Government Work Force Personnel for all Non-pump life cycle calcs.
Reference Hard Dollar file for developed life cycle costs

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,25yrs) = 1/(1 + 4.125%)^30 =	0.3640
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

IA-19 Buck Lake WO WT-R1.xlsx Life-Cycle Costs Analysis

Page 2 of 2

IA-18. Buck Lake water storage.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _6_

FEATURE:
Boundary Dam
Crest of Dam El: 4241.0
N.W.S.El: 4226.0 Storage 60,000 A.F.
Crest length 1650 ft.
Water Treatment

PROJECT:
UPPER KLAMATH BASIN
Offstream Storage Study

WOID:	**AF329**	**ESTIMATE LEVEL:**	**Preliminary**
REGION:	**MP**	**UNIT PRICE LEVEL:**	**Oct-10**
FILE:	H:\D8170\EST\Spreadsheet\Ziomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-18 Boundary Dam & Reservoir-New\Dec-10\[IA-18 Boundary Dam w WT-R1.xlsx]Wetlands-llz		

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Dam Construction					$15,956,000.00
	2	Spillway Construction					$13,634,360.00
	3	Outlet Works Construction					$9,632,950.00
	4	Construct Wetlands outlet works					$115,317.00
	5	Construct Embankment levee for Wetlands					$386,919.00
	6	Electric Installations					$9,980,000.00
	7	Water Treatment					$66,600,000.00
		Subtotal 1					$116,305,546.00
		Mobilization	5%	+/-			$5,800,000.00
		Subtotal 1 with Mobilization					**$122,105,546.00**
		Design Contingencies	25%	+/-			$30,526,387.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$152,631,933.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$152,631,933.00
		CONTRACT COST					**$155,000,000.00**
		Construction Contingencies	25%	+/-			$35,000,000.00
		FIELD COST					**$190,000,000.00**
		Non-Contract Costs	25%	+/-			$50,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$240,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	**CHECKED**	**BY** L. Ziomke	**CHECKED** KMB 1/11/11
DATE PREPARED 09/24/10	**PEER REVIEW / DATE** S. Mattingly 11/17/10	**DATE PREPARED** 01/11/11	**PEER REVIEW / DATE** DLM 1/10/11

IA-19. Boundary Dam and Reservoir .
Preliminary-level capital construction cost estimate worksheet.

Summary of Life Cycle Costs

UKBOS Studies
IA-18 Boundary Dam
Spillway Capacity 16,200 cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-18 Boundary Dam	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$240,000,000	$240,000,000
Real estate costs				
Federal land (no purchase req'd)			$0	$0
Mitigation wetlands - Federal land			$0	$0
Subtotal 1				**$240,000,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$99,000	$2,081,970
Maintenance Costs	PWA Factor	21.03	$7,600	$159,828
WT Maint Costs	PWA Factor	21.03	$3,710,000	$78,021,300
Subtotal 2				**$80,263,098**
Total Present Worth Costs = Subtotal 1 + 2				**$320,263,098**
Total Present Worth Costs Rounded				**$320,000,000**
Assumptions: Shown on Page 2				
BY:	L Zlomke		CHECKED: CMB 1/13/11	
DATE PREPARED:	13-Jan-11		PEER REVIEW:	

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) : 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume all work is performed by Government Work Force Personnel for all Non-pump life cycle calcs.
Reference Hard Dollar file for developed life cycle costs

IA-18 Boundary Dam w WT-R1.xlsx Life-Cycle Costs Analysis Page 2 of 2

IA-19. Boundary Dam and Reservoir.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _7_

FEATURE:	PROJECT:
J Canal to Clear Lake PP and Tunnel Pumping Plant (Q = 300 cfs) - with water treatment Uses Swan Lake A-B as example	UPPER KLAMATH BASIN Offstream Storage Study WOID: AF329 — ESTIMATE LEVEL: Preliminary REGION: MP — UNIT PRICE LEVEL: Oct-10 FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-20 Clear Lake Storage-J Canal Feed-New\Dec-10\[IA-20 J_Canal to Clear Lake WO WT.xlsx]FeatureSum liz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,167.00
	2	Construct embankment levee for wetlands					$113,340.00
	3	Tunnel, Surge Shaft, and O&M Roads					$136,079,255.00
	4	Construct Intake Channel and Clear Lake Release Structures					$1,884,518.00
	5	Pumping Plant					$30,200,000.00
	6	Electric Installations					$6,630,000.00
	7	Water Treatment facillity (see Erik Jorgensen 8/10 report - Option 2B, Table 5B)					$35,000,000.00
		Subtotal 1					$210,022,280.00
		Mobilization	5%	+/-			$10,500,000.00
		Subtotal 1 with Mobilization					$220,522,280.00
		Design Contingencies	25%	+/-			$55,130,570.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$275,652,850.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$275,652,850.00
		CONTRACT COST					$280,000,000.00
		Construction Contingencies	25%	+/-			$60,000,000.00
		FIELD COST					$340,000,000.00
		Non-Contract Costs	25%	+/-			$90,000,000.00
		CONSTRUCTION COST (does not include land costs)					$430,000,000.00

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY S Mattingly	REVIEWED	BY Kelly Brom KMB	CHECKED 12/17/10
DATE PREPARED 11/17/10	PEER REVIEW / DATE S Mattingly 11/17/10	DATE PREPARED 12/17/10	PEER REVIEW / DATE DLM 12/17/10

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ OF _6_

FEATURE:	PROJECT:
J Canal to Clear Lake PP and Tunnel Pumping Plant (Q = 300 cfs) Uses Swan Lake A-B as example Summary Sheet by Feature - no water treatment	UPPER KLAMATH BASIN Offstream Storage Study WOID: AF329 — ESTIMATE LEVEL: Preliminary REGION: MP — UNIT PRICE LEVEL: Oct-10 FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-20 Clear Lake Storage-J Canal Feed-New\Dec-10\[IA-20 J_Canal to Clear Lake WO WT.xlsx]FeatureSum llz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,167.00
	2	Construct embankment levee for wetlands					$113,340.00
	3	Tunnel, Surge Shaft, and O&M Roads					$136,079,255.00
	4	Construct Intake Channel and Clear Lake Release Structures					$1,884,518.00
	5	Pumping Plant					$30,200,000.00
	6	Electric Installations					$6,630,000.00
		Subtotal 1					$175,022,280.00
		Mobilization	5%	+/-			$8,800,000.00
		Subtotal 1 with Mobilization					$183,822,280.00
		Design Contingencies	25%	+/-			$45,955,570.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$229,777,850.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$229,777,850.00
		CONTRACT COST					$230,000,000.00
		Construction Contingencies	25%	+/-			$60,000,000.00
		FIELD COST					$290,000,000.00
		Non-Contract Costs	25%	+/-			$70,000,000.00
		CONSTRUCTION COST (does not include land costs)					$360,000,000.00
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	REVIEWED	BY KMB Kelly Brom	CHECKED 12/17/10
DATE PREPARED 11/17/10	PEER REVIEW / DATE S Mattingly 11/17/10	DATE PREPARED 12/17/10	PEER REVIEW / DATE DLM 12/17/10

IA-20. Clear Lake – J Canal water supply option.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-20 J_Canal to Clear Lake
300 cfs
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-20 J_Canal to Clear Lake	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$430,000,000	$430,000,000
Land purchase costs				
Land for reservoir and facilities			$0	$0
Mitigation wetlands			$20,000	$20,000
Subtotal 1				**$430,020,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$188,378	$3,961,589
Maintenance Costs	PWA Factor	21.03	$2,681,865	$56,399,621
Energy Costs	PWA Factor	21.03	$87,808	$1,846,602
Replacement Costs	PWA Factor	21.03	$53,229	$1,119,406
WT Maint Costs	PWA Factor	21.03	$860,000	$18,085,800
Subtotal 2				**$81,413,018**
Total Present Worth Costs = Subtotal 1 + 2				**$511,433,018**
Total Present Worth Costs Rounded				**$510,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 8 weeks/year

300 cfs with a total of 50,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	12/22/10
DATE PREPARED:	22-Dec-10	PEER REVIEW:	12/22/10

File Name: IA-20 J_Canal to Clear Lake w WT.xlsx Tab: App A Life-Cycle Costs Analysis Page 1 of 1

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-20 J_Canal to Clear Lake
300 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-20 J_Canal to Clear Lake	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$360,000,000	$360,000,000
Land purchase costs				
Land for reservoir and facilities			$0	$0
Mitigation wetlands			$20,000	$20,000
Subtotal 1				**$360,020,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$188,378	$3,961,589
Maintenance Costs	PWA Factor	21.03	$2,681,865	$56,399,621
Energy Costs	PWA Factor	21.03	$87,808	$1,846,602
Replacement Costs	PWA Factor	21.03	$53,229	$1,119,406
Subtotal 2				**$63,327,218**
Total Present Worth Costs = Subtotal 1 + 2				**$423,347,218**
Total Present Worth Costs Rounded				**$420,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Operating 8 weeks/year

300 cfs with a total of 50,000 acre-feet/year

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

BY:	Kelly Brom	CHECKED:	
DATE PREPARED:	22-Dec-10	PEER REVIEW:	

File Name: IA-20 J_Canal to Clear Lake WO WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

IA-20. Clear Lake – J Canal water supply option.
Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION | ESTIMATE WORKSHEET | SHEET _1_ of _8_

FEATURE:	PROJECT:
ASR - Clear Lake - production only with water storage in Boundary Reservoir Q = 100 cfs) Summary Sheet by Feature No Water Treatment	UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — ESTIMATE LEVEL: Preliminary
	REGION: MP — UNIT PRICE LEVEL: Oct-10
	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-21 Clear Lake ASR Boundary Storage-New\Dec-10\[IA-21 Clear Lake ASR Bndry Storage WO WT-R1.xlsx]FeatureSum

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$115,167.00
	2	Construct embankment levee for wetlands					$113,340.00
	3	Construct Dam					$15,956,000.00
	4	Construct Spillway					$13,634,360.00
	5	Construct Outlet Works					$9,632,950.00
	6	Construct O&M Roads					$801,504.00
	7	Furnish and install wellfield					$3,047,500.00
	8	Electric Installations					$11,330,000.00
		Subtotal 1					$54,630,821.00
		Mobilization	5%	+/-			$2,700,000.00
		Subtotal 1 with Mobilization					**$57,330,821.00**
		Design Contingencies	25%	+/-			$14,332,705.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$71,663,526.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$71,663,526.00
		CONTRACT COST					**$72,000,000.00**
		Construction Contingencies	25%	+/-			$18,000,000.00
		FIELD COST					**$90,000,000.00**
		Non-Contract Costs	25%	+/-			$25,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$115,000,000.00**
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY S Mattingly	REVIEWED	BY L Zlomke	CHECKED KMB 1/14/11
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED 01/14/11	PEER REVIEW / DATE DLM 1/18/11

IA-21. Clear Lake ASR with Boundary Reservoir water storage option. Preliminary-level capital construction cost estimate worksheet.

Summary of Life Cycle Costs

UKBOS Studies
IA-21 Clear Lake ASR Bndry Storage
100 cfs
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-21 Clear Lake ASR Bndry Storage	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$115,000,000	$115,000,000
Real estate costs				
Private land purchase costs			$0	$0
Mitigation wetlands costs			$20,000	$20,000
Subtotal 1				**$115,020,000**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.5453	**$4,200,000**	$2,290,260
Year 30	PW Factor	0.2974	**$6,500,000**	$1,933,100
Subtotal 2				**$4,223,360**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$24,785	$521,229
Maintenance Costs	PWA Factor	21.03	$234,448	$4,930,441
Energy Costs	PWA Factor	21.03	$28,027	$589,408
Subtotal 3				**$6,041,078**
Total Present Worth Costs = Subtotal 1 + 2 + 3				**$125,284,438**
Total Present Worth Costs Rounded				**$125,000,000**

Assumptions: Shown on Page 2

BY:	L Zlomke	CHECKED:	MB 1/14/11
DATE PREPARED:	14-Jan-11	PEER REVIEW:	1/19/11

IA-21 Clear Lake ASR Bndry Storage WO WT-R1.xlsx Life-Cycle Costs Analysis Page 1 of 2

Summary of Life Cycle Costs

Assumptions:
50 = n = year analysis period.
4.125% = i = FY2011 planning interest rate for the year 50 year period.
PWA Factor = P/A = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03
These Life Cycle Annual Costs were developed using the pumping operations and maintenance and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.
Input to the Pumping Plant Operation and Maintenance Program:
2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes
Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr
Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr
Interest Rate 4.125% for water storage projects
Assume wellfield is not manned.
Operating 8 weeks/year
100 cfs with a total of 8,000 acre-feet/year
Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

PW Factor = P/F(4.125%,15yrs) = 1/(1 + 4.125%)^15 =	0.5453
PW Factor = P/F(4.125%,30yrs) = 1/(1 + 4.125%)^30 =	0.2974

IA-21 Clear Lake ASR Bndry Storage WO WT-R1.xlsx Life-Cycle Costs Analysis Page 2 of 2

IA-21. Clear Lake ASR with Boundary Reservoir water storage option. Preliminary-level Life-cycle cost estimate worksheet table.

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _18_

FEATURE: Bryant Mtn Dams, Reservoirs and Pump/Gen Plant - 610 cfs inflow capacity, 12,400 cfs pump/gen cap Water Treatment	**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — **ESTIMATE LEVEL:** Preliminary
	REGION: MP — **UNIT PRICE LEVEL:** Oct-10
	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\IA-22 Bryant Mtn-Main Pumped Storage-New\Dec-10\[IA-22 Bryant_Mtn_w_WT.xlsx] FeatureSum-tz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$476,250.00
	2	Construct embankment dam for wetlands					$387,110.00
	3	Construct embankment upper dam					$94,691,500.00
	4	Construct Upper Dam Intake Channel and Bypass Release Structures					$8,002,180.00
	5	Construct Upper Dam emergency spillway chute and stilling basin					$3,483,900.00
	6	Construct Upper Dam Spillway Crest Bridge					$422,500.00
	7	Construct Upper Dam Outlet works					$3,285,600.00
	8	Construct Upper Dam Outlet Work Tower and Access Bridge					$9,325,720.00
	9	Construct J-Canal fish screen and headwork structure					$16,350,416.00
	10	Construct D-Canal fish screen and headwork structure					$4,638,596.00
	11	Pumping/generating Plants					$1,589,100,000.00
	12	Construct Lower Dam Power System Surge Shafts					$19,646,200.00
	13	Construct embankment lower dam					$209,905,310.00
	14	Construct lower reservoir liner					$255,916,735.00
	15	Construct Lower Dam Power Tunnels					$68,578,500.00
	16	Construct Lower Dam emergency spillway chute and stilling basin					$1,946,080.00
	17	Construct Lower Dam Spillway Crest Bridge					$426,575.00
	18	Construct "J" and "D" Canal Cut and cover Intake/OW conduits					$61,155,500.00
	19	Construct Lower Dam Outlet Work Tower and Access Bridge					$5,321,130.00
	20	Electric Installations					$21,351,000.00
	21	Access Roads					$978,500.00
	22	Water Treatment facillity					$66,600,000.00
		Subtotal 1					**$2,441,989,302.00**
		Mobilization	5%	+/-			$120,000,000.00
		Subtotal 1 with Mobilization					**$2,561,989,302.00**
		Design Contingencies	25%	+/-			$640,497,326.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$3,202,486,628.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$3,202,486,628.00
		CONTRACT COST					**$3,200,000,000.00**
		Construction Contingencies	25%	+/-			$800,000,000.00
		FIELD COST					**$4,000,000,000.00**
		Non-Contract Costs	25%	+/-			$1,000,000,000.00
		CONSTRUCTION COST (does not include land costs)					**$5,000,000,000.00**

Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.

QUANTITIES		PRICES	
BY Stan Mattingly	**CHECKED**	**BY** Lonnie Zlomke	**CHECKED** KMB 12/20/10
DATE PREPARED 09/20/10	**PEER REVIEW / DATE** S.Mattingly 11/3/10	**DATE PREPARED** 12/21/10	**PEER REVIEW / DATE** HA 12/22/10

BUREAU OF RECLAMATION — ESTIMATE WORKSHEET — SHEET _1_ OF _18_

FEATURE: Bryant Mtn Dams, Reservoirs and Pump/Gen Plant - 610 cfs inflow capacity, 12,400 cfs pump/gen cap No Water Treatment	**PROJECT:** UPPER KLAMATH BASIN Offstream Storage Study
	WOID: AF329 — **ESTIMATE LEVEL:** Preliminary
	REGION: MP — **UNIT PRICE LEVEL:** Oct-10
	FILE: H:\D8170\EST\Spreadsheet\Zlomke\0-Work Files\MP\Klamath\UKBOS\28 Alts-Working\A-22 Bryant Mtn-Main Pumped Storage-New\Dec-10\[IA-22 Bryant_Mtn_wo_WT xlsx] FeatureSum-ltz

PLANT ACCOUNT	PAY ITEM	DESCRIPTION	CODE	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	1	Construct Wetlands outlet works					$476,250.00
	2	Construct embankment dam for wetlands					$387,110.00
	3	Construct embankment upper dam					$94,691,500.00
	4	Construct Upper Dam Intake Channel and Bypass Release Structures					$8,002,180.00
	5	Construct Upper Dam emergency spillway chute and stilling basin					$3,483,900.00
	6	Construct Upper Dam Spillway Crest Bridge					$422,500.00
	7	Construct Upper Dam Outlet works					$3,285,600.00
	8	Construct Upper Dam Outlet Work Tower and Access Bridge					$9,325,720.00
	9	Construct J-Canal fish screen and headwork structure					$16,350,416.00
	10	Construct D-Canal fish screen and headwork structure					$4,638,596.00
	11	Pumping/generating Plants					$1,589,100,000.00
	12	Construct Lower Dam Power System Surge Shafts					$19,646,200.00
	13	Construct embankment lower dam					$209,905,310.00
	14	Construct lower reservoir liner					$255,916,735.00
	15	Construct Lower Dam Power Tunnels					$68,578,500.00
	16	Construct Lower Dam emergency spillway chute and stilling basin					$1,946,080.00
	17	Construct Lower Dam Spillway Crest Bridge					$426,575.00
	18	Construct "J" and "D" Canal Cut and cover Intake/OW conduits					$61,155,500.00
	19	Construct Lower Dam Outlet Work Tower and Access Bridge					$5,321,130.00
	20	Electric Installations					$21,351,000.00
	21	Access Roads					$978,500.00
		Subtotal 1					$2,375,389,302.00
		Mobilization	5%	+/-			$120,000,000.00
		Subtotal 1 with Mobilization					$2,495,389,302.00
		Design Contingencies	25%	+/-			$623,847,326.00
		Subtotal 2 = Subtotal 1 + Design Contingencies					$3,119,236,628.00
		Allowance for Procurement Strategies (APS)					
		Type of solicitation assumed is: Full and open sealed bid competition					
		Subtotal 3 = Subtotal 2 + APS					$3,119,236,628.00
		CONTRACT COST					$3,100,000,000.00
		Construction Contingencies	25%	+/-			$800,000,000.00
		FIELD COST					$3,900,000,000.00
		Non-Contract Costs	25%	+/-			$1,000,000,000.00
		CONSTRUCTION COST (does not include land costs)					$4,900,000,000.00
		Ref.: For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03.					

QUANTITIES		PRICES	
BY Stan Mattingly	**CHECKED**	**BY** Lonnie Zlomke	**CHECKED** KMB 12/20/10
DATE PREPARED 09/20/10	**PEER REVIEW / DATE** S.Mattingly 11/3/10	**DATE PREPARED** 12/21/10	**PEER REVIEW / DATE** MA 12/22/10

IA-22. Bryant Mountain pumped storage option.
Preliminary-level capital construction cost estimate worksheet.

[redacted]

Summary of Life Cycle Costs

UKBOS Studies
IA-22 Bryant Mtn-Malin Pumped Storage with Water Treatment

90,800 TAF Capacity; 610 cfs inflow,12,400 cfs pump storage capacity
Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-22 Bryant Mtn-Malin Pumped Storage with Water Treatment	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$5,000,000,000	$5,000,000,000
Land purchase costs				
Private land for reservoir and facilities			$3,546,000	$3,546,000
Mitigation wetlands			$240,000	$240,000
Subtotal 1				**$5,003,786,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$628,123	$13,209,427
Maintenance Costs	PWA Factor	21.03	$35,389,212	$744,235,128
Energy Costs	PWA Factor	21.03	$26,216,743	$551,338,105
Replacement Costs	PWA Factor	21.03	$2,804,258	$58,973,546
Generation Revenue (neg. cost)	PWA Factor	21.03	-$51,840,000	-$1,090,195,200
WT Maint Costs	PWA Factor	21.03	$3,710,000	$78,021,300
Subtotal 2				**$355,582,306**
Total Present Worth Costs = Subtotal 1 + 2				**$5,359,368,306**
Total Present Worth Costs Rounded				**$5,400,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor =

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is partially manned.

Lower reservoir pump plants operating 8 weeks/year, upper pumping plant operates 16 weeks/year.

610 cfs with a total of 50,000 acre-feet/year for lower reservior; 12,400 cfs for 12 hours daily in summer season.

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

Pump Generators operates 12hrs/day for 6 months each.

Revenue: $40/MWhr * 12hrs/day * 30days/month * 6 months * 200MW/unit * 6 units = $103,680,000.00. However, pump/generation units cannot from pump to generation instantly. Per John Brooks, under the best conditions and power demand conditions, the efficiency is 65%, but can be as low as 35%. Use 50%.

BY:	L Zlomke	CHECKED:	CMB 1/13/11
DATE PREPARED:	12-Jan-11	PEER REVIEW:	1/13/11

File Name: IA-22 Bryant Mtn w WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

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Summary of Life Cycle Costs

UKBOS Studies

IA-22 Bryant Mtn-Malin Pumped Storage without Water Treatment

90,800 TAF Capacity; 610 cfs inflow,12,400 cfs pump storage capacity
No Water Treatment
Estimate Level: Preliminary
Price Level: Oct-10

			IA-22 Bryant Mtn-Malin Pumped Storage without Water Treatment	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$4,900,000,000	$4,900,000,000
Land purchase costs				
Private land for reservoir and facilities			$3,546,000	$3,546,000
Mitigation wetlands			$240,000	$240,000
Subtotal 1				**$4,903,786,000**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	21.03	$628,123	$13,209,427
Maintenance Costs	PWA Factor	21.03	$35,389,212	$744,235,128
Energy Costs	PWA Factor	21.03	$26,216,743	$551,338,105
Replacement Costs	PWA Factor	21.03	$2,804,258	$58,973,546
Generation Revenue (neg. cost)	PWA Factor	21.03	-$51,840,000	-$1,090,195,200
Subtotal 2				**$277,561,006**
Total Present Worth Costs = Subtotal 1 + 2				**$5,181,347,006**
Total Present Worth Costs Rounded				**$5,200,000,000**

Assumptions:

50 = n = year analysis period.

4.125% = i = FY2011 planning interest rate for the year 50 year period.

PWA Factor = P/A

P/A = (((1+i)^n) - 1)/(i*((1+i)^n)) = 21.03

These Life Cycle Annual Costs were developed using the pumping plant operations and maintenance program and addresses only those related items annualized costs. Water Treatment Annual Costs are from the UKBOS WT Prelim Report V4, dated 11/6/2010.

Rather than periodic replacement costs, the program provides an annualized replacement cost for the pumping plant which is used for these costs. At later levels where features are clearly defined, then periodic costs can be evaluated in lieu of the annual replacement costs.

Input to the Pumping Plant Operation and Maintenance Program:

2010RUS Base Schedule Hourly Wages plus DB OR20100054 10-22-10 Mechanic Fringes

Operator's Hourly Wage: 2010 GS9 - Level 5 @ $25.77/hr plus $11.50/hr DB fringes = $37.27/hr

Mechanic's Hourly Wage: 2010 GS7 - Level 5 @ $21.07/hr plus $11.50/hr DB fringes = $32.57/hr

Interest Rate 4.125% for water storage projects

Assume plant is fully manned.

Lower reservoir pump plants operating 8 weeks/year, upper pumping plant operates 16 weeks/year

610 cfs with a total of 50,000 acre-feet/year for lower reservior; 12,400 cfs for 12 hours daily in summer season

Energy Costs: $0.07/kwh using Pacific Power of Oregon's Rate Schedule 23.

Pump Generators operates 12hrs/day for 6 months each.

Revenue: $40/MWhr * 12hrs/day * 30days/month * 6 months * 200MW/unit * 6 units = $103,680,000.00. However, pump/generation units cannot from pump to generation instantly. Per John Brooks, under the best conditions and power demand conditions, the efficiency is 65%, but can be as low as 35%. Use 50%.

BY:	L Ziomke	CHECKED:	1/13/11
DATE PREPARED:	12-Jan-11	PEER REVIEW:	1/13/11

File Name: IA-22 Bryant Mtn wo WT.xlsx Tab: App A Life-Cycle Costs Analysis

Page 1 of 1

IA-22. Bryant Mountain pumped storage option.
Preliminary-level Life-cycle cost estimate worksheet table.

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Summary of Life Cycle Costs

UKBOS Studies
Agency Lake/Barnes Ranches - Current Scenario - Managed Storage
150 cfs No Water Treatment
Estimate Level: Preliminary
Price Level: Oct - 10
WOID: AF329

			Swan Lake A B Canal Feed	
			Estimated Costs	Present Worth
Initial Capital Costs				
Initial Construction and Other Costs				
Construction Costs			$0	$0
Subtotal 1				**$0**
Periodic Replacement Costs		P/F		
Year 15	PW Factor	0.545	**$1,300,000**	$708,890
Year 25	PW Factor	0.364	**$220,000**	$80,080
Year 30	PW Factor	0.297	**$1,950,000**	$579,930
Subtotal 2				**$1,368,900**
Annual Costs		P/A (n = 50)		
Operations Costs	PWA Factor	19.36679	$17,882	$346,317
Maintenance Costs	PWA Factor	19.36679	$94,061	$1,821,660
Energy Costs	PWA Factor	19.36679	$796,460	$15,424,874
Subtotal 3				**$17,592,851**
Total Present Worth Costs = Subtotal 1 + 2 +3				**$18,961,751**
Total Present Worth Costs Rounded				**$20,000,000**

Assumptions:
50-year analysis period.
FY2011 planning interest rate 4.125% per year for 50 years.
PW Factor = P/F = $(1+ i)^{-n}$ = Single Payment Present Worth (P/F, 4.125%, 50).
PWA Factor = P/A = ((1+i)n - 1)/(i*((1+i)n) = Uniform Series Present Worth Factor (P/A, 4.125%, 50).
These Life Cycle Costs were developed using the pumping plant operations and maintenance program and only address those related items with their costs.
Input to the Pumping Plant Operaiton and Maitnenance Program:
Operator's Hourly Wage: 2009 GS9 - Level 5 @ $22.32/hr plus $10.80/hr DB fringes = $33.12/hr
Mechanic's Hourly Wage: 2009 GS7 - Level 5 @ $18.24/hr plus $10.80/hr DB fringes = $29.04/hr
Interest Rate 4.625% for water storage projects
Assume plant is not manned.
Operating 21 weeks/year
150 cfs with a total of 6200 acre-feet/year
Energy Costs: $0.07/kwh and no demand factor

BY: Stan Mattingly	CHECKED:
DATE PREPARED: 12-Oct-10	PEER REVIEW:

File Name: UKBOS_ALR_Barnes_Current_Management_Scenario_LCC_20110218.xlsx Tab: App A Life-Cycle Costs Analysis
Page 1 of 1

Agency Lake/Barnes Ranches – Current Scenario – Managed Storage
Life-cycle cost estimates

Cost estimating and project planning guidelines reference

Reclamation Manual Directives and Standards (D&S) that apply for the construction and life-cycle cost estimates developed for this UKBOS IAIR are as follows:

FAC 09-01
FAC 09-02
FAC 09-03

The D&S information can be found at the website:
http://www.usbr.gov/recman/DandS.html

UKBOS Options Construction Cost Estimate Development Factors
For each of the alternatives, preliminary level construction cost estimates were prepared. These estimates are prepared for studies conducted at the very early stages of the planning process.

Preliminary Cost Estimates
Preliminary cost estimates are prepared for studies conducted at the very early stages of the planning process. They are developed and produced to document a very preliminary analysis performed to look at a given problem, need, or opportunity utilizing readily available data. The estimates do not meet the criteria used for preparation of either Appraisal or Feasibility cost estimates. While no minimum criteria or formal standards exist for the development of the prices and costs associated with this estimate level, sound estimating practices must be utilized in estimate preparation.

The unit prices are based on historical, bid, and industry reference costing data.

Preliminary cost estimates are not suitable for requesting authorization or construction fund appropriations from Congress due to the early stage of development.

Price Level
All costs shown in the preliminary level cost estimates are in October 2010 dollars.

Escalations
For projects which are to be developed over an extended period of time, or at some distant time in the future, it is prudent that some consideration of the time value of money be incorporated.

Escalation for two distinct periods of time must be considered. First, the time from when the estimate is prepared until notice to proceed, and second, the duration of the construction contract.

The estimates do not include escalation to notice to proceed; however, the unit prices include escalation to midpoint of construction.

Mobilization
Mobilization costs include contractor bonds and mobilizing contractor personnel and equipment to the project site during initial project start-up. The assumed 5% ± of the subtotal cost used in the preliminary price level cost estimates contained in this report is based on past experience of similar projects.

Design Contingency
Design contingencies are intended to account for three types of uncertainties inherent as a project advances from the planning stage through final design which directly affects the estimated cost of the project. There include: (i) unlisted items, (ii) design and scope changes, and (iii) cost estimating refinements. For this set of alternatives the design contingency percentage varies from 20% ± to 30% ±. For example, the Long Lake Valley alternatives had much more detailed quantities; therefore, design contingency was set at 20%. The majority of the alternatives assumed a design contingency of 25% ±. On a few alternatives that indicated the design contingency includes dewatering, un-watering, and cofferdam a design contingency of 30% ± was assumed.

Allowance for Procurement Strategies
A line item allowance for procurement strategies (considerations) may be included in preliminary cost estimates to account for additional costs when solicitations will be advertised and awarded under other than full and open competition. These include solicitations that will be set aside under socio-economic programs, along with solicitations that may limit competition or allow award to other than the lowest bid or proposal. Examples of these practices include: Hub-zone, 8(a) competitive and negotiated procurement, small business set aside, Public Law 93-638 Indian Self-Determination Act, or Request for Proposal where award may be based on technical considerations.

The APS was set at zero percent. These estimates assume full and open competition, receipt of sealed bids, with award to the lowest responsive and responsible bidder.

Construction Contingency
Preliminary estimates shall include a percentage allowance for construction contingencies as a separate item to cover minor differences in actual and estimated quantities, unforeseeable difficulties at the site, changed site conditions, possible minor changes in plans, and other uncertainties. Estimated quantities or unit prices are not to be increased as a means for including construction contingencies. The allowance used should be based on engineering judgment of the major pay items in the estimate, reliability of the data, adequacy of the projected quantities, and general knowledge of site conditions.

It was determined that based upon the completeness and reliability of the; engineering design data provided, geological information, projected quantities and the general knowledge of the conditions at the site, that 25% ± be added for construction contingencies to the preliminary level cost estimates.

Non-Contract Costs

Non-Contract costs were estimated to be 25% ± of the Total Field Costs based on typical non-contract cost percentage ranges from past large Reclamation projects (25% to 40% ± non-contract costs range). Land acquisition (corollary type cost) is not included in these estimates.

Non-contract costs include some or all of the following: (This list may not be all-inclusive.)

Distributive type costs

1. Services facilities: camps, construction roads, utility systems, temporary plants used for construction, etc.
2. Investigations: studies and surveys (collection, assembly, analysis of data and preparation and review of reports such as environmental impact studies, cultural resources studies, mitigation studies, etc.)
3. Design and specifications: preparation and review of final designs, construction drawings, specifications, and construction cost estimates, etc.
4. Construction engineering and supervision: construction management, surveying, inspection, laboratory work, program engineering, safety engineering, etc.
5. Other: general expenses after appropriation of funds for construction not identified in the above items such as; general office salaries, transportation, supplies and rent/utility services, security, environmental oversight, mitigation/cultural resources services, legal services, etc.

Corollary type costs:

1. Parallel costs such as transitional development costs, and relocation, or right-of-way costs that may be required for construction of the project features.

APPENDIX D

Aquifer Storage and Recovery (ASR) Studies

- **U.S. Geological Survey administrative project report on groundwater ASR investigations in the Klamath Basin**

Prepared in cooperation with the Bureau of Reclamation

Preliminary Hydrologic Assessment of Potential Sites for Managed Underground Storage and Recovery of Water in the Upper Klamath Basin, Oregon and California

By Marshall W. Gannett

Administrative Report

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia 2010

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Suggested citation:
Gannett, M.W., 2010, Preliminary hydrologic assessment of potential sites for managed underground storage and recovery of water in the Upper Klamath Basin, Oregon and California: U.S. Geological Survey Administrative Report, 30 p.

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Conversion Factors

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
gallon per minute (gal/min)	0.06309	liter per second (L/s)

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Elevation, as used in this report, refers to distance above the vertical datum.

Preliminary Hydrologic Assessment of Potential Sites for Managed Underground Storage and Recovery of Water in the Upper Klamath Basin, Oregon and California

By Marshall W. Gannett

Abstract

A preliminary assessment of the hydrogeologic feasibility of managed underground storage and recovery of water was conducted for 14 areas in the upper Klamath Basin of Oregon and California. The assessment was based on available geologic, stratigraphic, and hydrologic information from published maps, reports, and well logs. The assessment also relied on the recent characterization of the regional groundwater system by the U.S. Geological Survey. The preliminary assessment considered hydrogeologic factors only; water quality, water availability, and cost were not considered. Principal factors considered include the presence of large-capacity wells (wells with yields greater than 1,000 gallons per minute), characteristics of potential target aquifers, the likelihood of available storage, and proximity to discharge boundaries to which stored water could leak. Also evaluated were knowledge of subsurface geology, potential for the application of surface infiltration techniques, physical presence of source water, and probable filtration requirements.

Of the 14 areas considered, 7 were eliminated based on the lack of a water source, lack of subsurface storage space, or lack of suitable water conveyance infrastructure. The depth of knowledge about the 7 remaining areas is variable. There are some, such as the Tule Lake and Klamath Valley areas, where hydrogeologic conditions are reasonably well understood, and others, such as the Clear Lake and Gerber Reservoir areas, where there is little subsurface information. In the well understood areas, the next steps in evaluating the feasibility of underground storage and recovery of water would include determining water availability, determining treatment requirements and methods, and testing. In poorly understood areas, the next steps would likely involve test drilling. In areas where surface infiltration techniques are being considered, the next steps would likely involve detailed canal seepage tests coupled with targeted groundwater-level monitoring.

Introduction

Managing available water in the upper Klamath Basin to meet the needs of fish as well as irrigation is difficult because of limited storage capacity. Water managers would have more flexibility to meet the water needs of both irrigators and aquatic wildlife if they had the ability to store water during the winter and spring for use later in the season and to store water on an interannual basis for use during droughts. The Bureau of Reclamation (Reclamation) is interested in exploring the possibility of managed underground storage and recovery of water to fill the need for seasonal and interannual storage of water.

Managed underground storage and recovery of water involves introducing water into an aquifer through injection wells or by surface infiltration and removing the water for use at a later time. Managed underground storage and recovery of water is sometimes referred to as aquifer storage and recovery (ASR), particularly where water is introduced to the subsurface through injection wells. The term artificial recharge (AR) is used where surface infiltration methods are employed.

Managed underground storage of water, although simple in concept, requires certain conditions in order to be successful. Major considerations for hydrologic feasibility are the availability of source water, presence of a suitable aquifer, available storage in the target aquifer, as well as infrastructure and water quality considerations. Managed underground storage may be a technically feasible method for storing useful volumes of water seasonally or on an interannual basis in the upper Klamath Basin. Volcanic deposits that dominate the area are locally highly permeable and contain a substantial regional groundwater flow system. Such conditions are potentially favorable for managed underground storage of water.

The purpose of the work described in this report is to provide a preliminary assessment of the hydrogeologic feasibility of managed underground storage and recovery of water at 14 assessment areas provided by Reclamation's Klamath Basin Area Office (fig. 1). This assessment was limited to the hydrologic factors, including presence of a suitable aquifer, source of water, and available storage, and did not specifically address infrastructure considerations, water-quality and treatment considerations, regulatory considerations, or cost. Although no new data were collected for this assessment, the effort benefitted from extensive collection and analysis of groundwater data in the upper Klamath Basin in recent years by the U.S. Geological Survey, Oregon Water Science Center, much of which is reported in Gannett and others (2007).

For sites where this preliminary assessment suggests that managed underground storage and recovery of water might be feasible, suggestions are provided as to logical next steps in the assessment process. Next steps generally will include hydrologic and geologic data collection, water sampling and analysis, and possibly drilling and testing of wells.

Managed underground storage and recovery of water involves introducing water into an aquifer and storing it there for later extraction and use. Water is typically introduced either directly through injection wells or indirectly by infiltration through overlying unsaturated deposits. Infiltration techniques (sometimes referred to as surface spreading techniques) usually involve structures designed to pond water, such as canals, infiltration basins, or modifications to natural stream channels. Surface infiltration methods require a target aquifer that is unconfined. Where the target aquifer is overlain by low-permeability strata, injection wells must be used.

Aquifers must have certain characteristics to be suitable for managed underground storage and recovery of water. Aquifers must have sufficient transmissivity (a product of the permeability and thickness) to allow introduction and recovery of water at the required rates. Suitable aquifers must also have sufficient available storage capacity. Increasing the amount of water stored in an aquifer results in an increase in the hydraulic head. In unconfined aquifers, the hydraulic head equates to the water table elevation. In a confined aquifer, the hydraulic head equates to the water levels in wells open to the aquifer. The water levels in wells penetrating confined aquifers define an imaginary surface known as the potentiometric surface. Whether aquifers are unconfined or confined, there must be sufficient room for the hydraulic head to increase without causing water levels in wells to rise above land surface, causing them to become flowing artesian wells. Aquifers in which the head elevation is very close to land surface offer less potential storage than aquifers where the head elevation is far below land surface.

Aquifers must also have the appropriate boundary conditions to ensure stored water remains in the aquifer for the required time. For example, water stored in aquifers bounded by nearby streams or springs could leak back to the surface before it is recovered (figure 2, page 4). Aquifers bounded by low-permeability strata, in contrast, will retain stored water for longer periods (fig. 3, page 5).

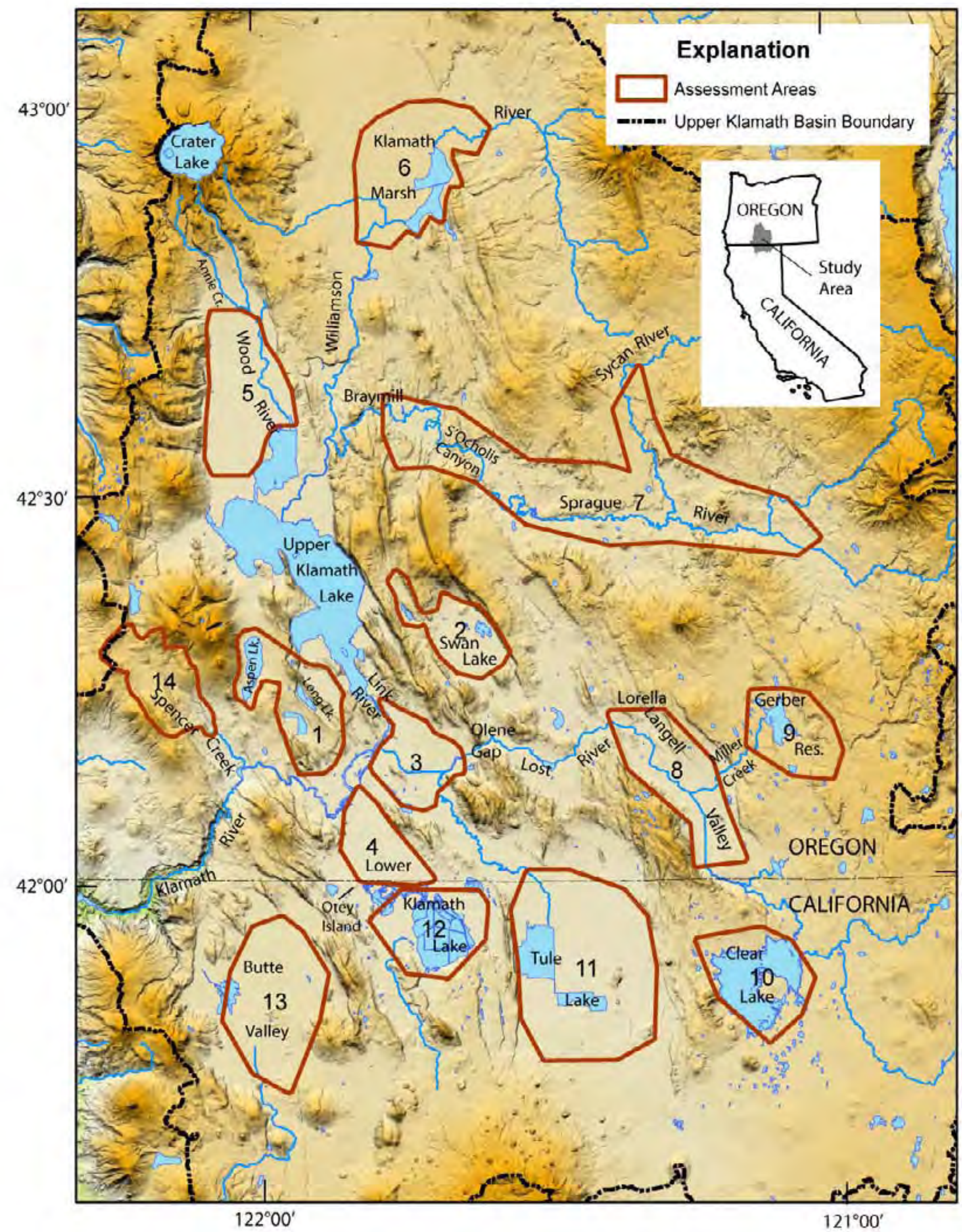

Figure 1. Upper Klamath Basin, showing assessment areas for managed underground storage and recovery of artificially recharged water.

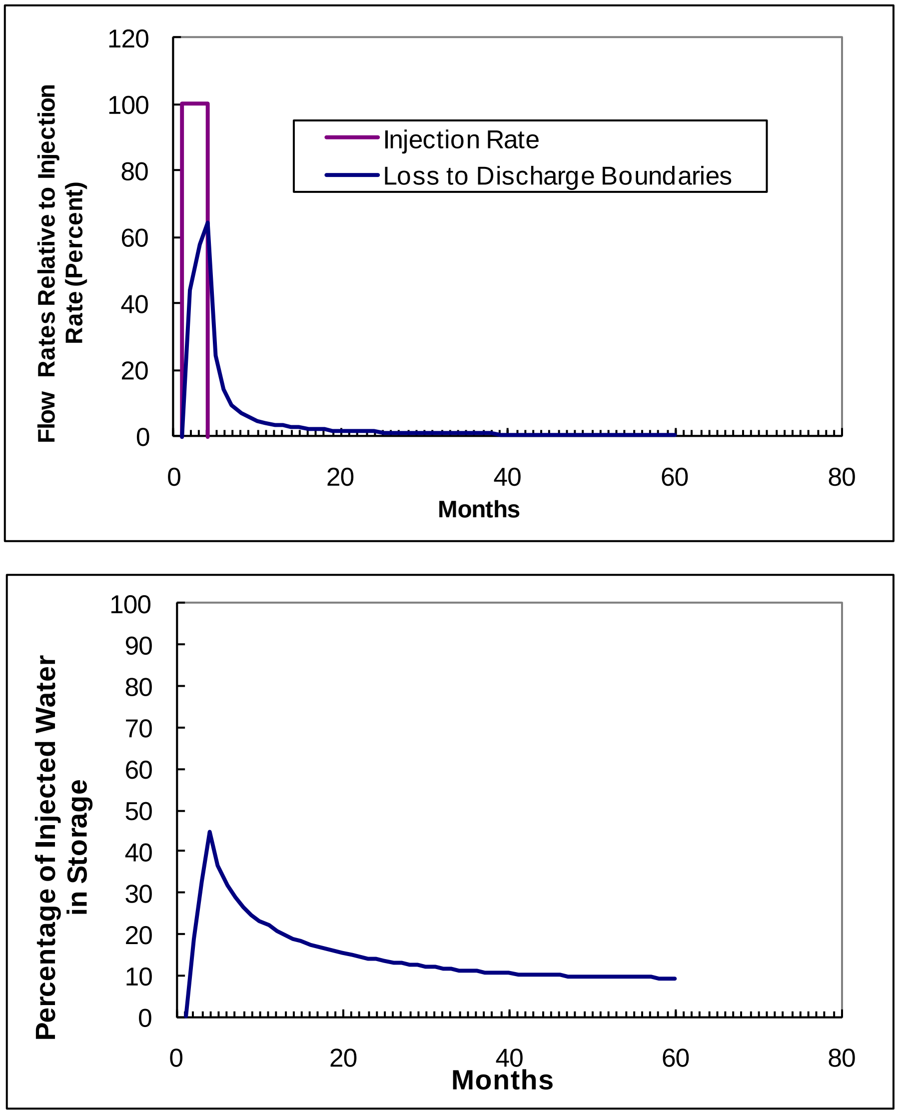

Figure 2. Graphs showing loss to boundaries relative to injection rates (upper) and percentage of injected water in storage (lower) for a theoretical case where water is injected for 3 months into a target aquifer in close proximity to discharge boundaries. Note large and rapid discharge to boundaries and small percentage of water remaining in storage.

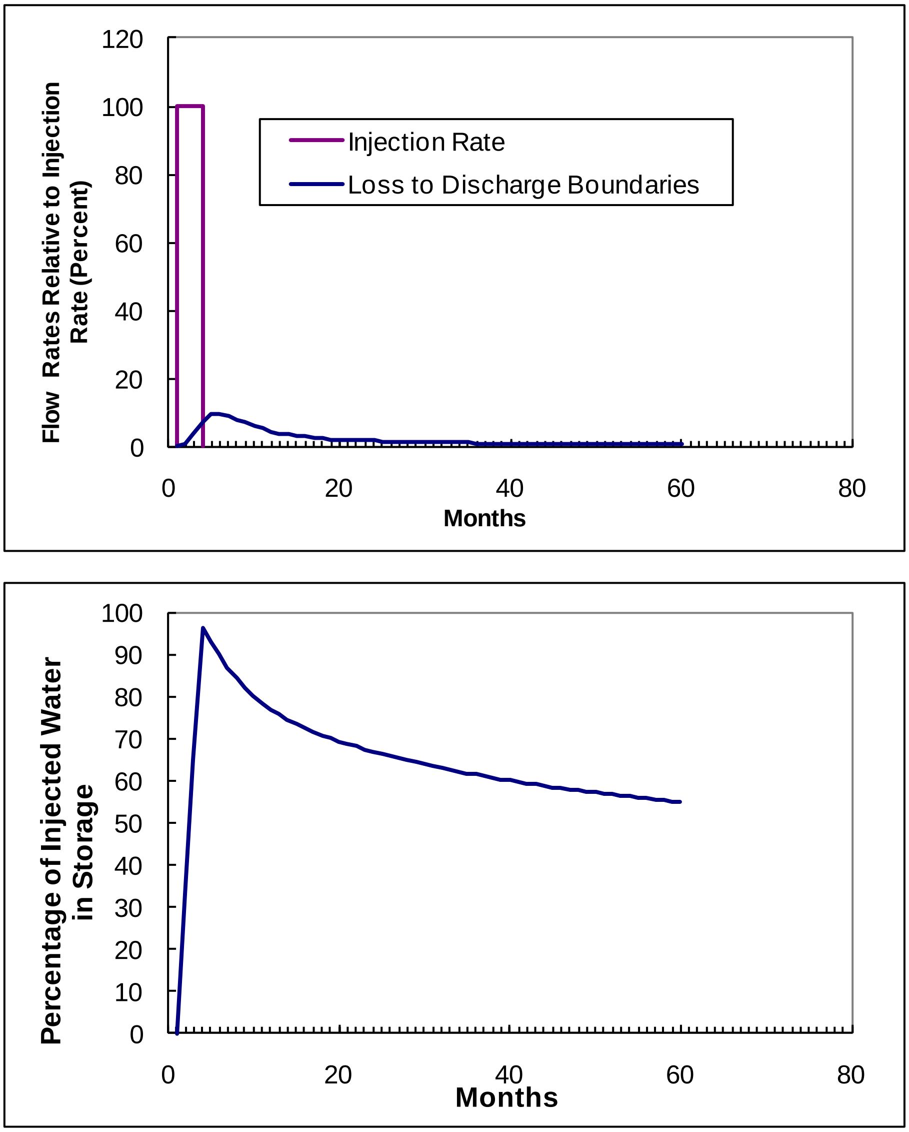

Figure 3. Graphs showing loss to boundaries relative to injection rates (upper) and percentage of injected water in storage (lower) for a theoretical case where water is injected for 3 months into a target aquifer distant from discharge boundaries. Note smaller and delayed discharge to boundaries and larger percentage of water remaining in storage relative to figure 2.

The feasibility of managed underground storage also depends on the physical and chemical characteristics of the source water. Considerations include the water-quality requirements of regulatory agencies (which, for example, do not allow degradation of water quality) as well as characteristics of the water that may result in undesirable chemical reactions, mineral precipitation, or biological activity in the receiving aquifer. Understanding the suitability of water for subsurface storage requires knowledge of the major ion chemistry, pH, dissolved oxygen, dissolved organic carbon, and turbidity, among other factors. The chemistry of the native water in the receiving aquifer, as well as the mineralogy of the aquifer material, must be understood as well. In general, the water quality requirements for surface infiltration methods are less stringent from both regulatory and practical perspectives.

Methods

Several sources were used to determine appropriate methods and criteria for this analysis including the National Research Council (2008), the Natural Resource Management Ministerial Council [of Australia] (2009), and the American Society of Civil Engineers (2001). This preliminary feasibility assessment focused primarily on the hydrologic considerations. Geologic and hydrologic background information was largely from Gannett and others (2007). This was augmented by evaluating information from several hundred large-capacity wells in Oregon and California. Infrastructure considerations were based largely on information from 1:24,000 scale topographic maps and maps of the Klamath Project. This analysis does not include evaluation of water quality. However, obvious water-quality considerations are pointed out for certain sites.

Each of the 14 assessment areas identified by Reclamation was evaluated on the basis of the following criteria:

1. **Source(s) of Available Surface Water.—**Possible sources of water are identified for each area. The assessment is limited to the physical presence of a source. Legal and regulatory factors were not considered. The identification of a source does not imply that water is actually available. No obvious sources of water could be identified for some areas.
2. **OWRD Water Availability Assessment.—**To aid in the evaluation of potential water sources in Oregon, the Oregon Water Resources Department (OWRD) Water Availability Reporting System (WARS) was queried. The basic determination from the WARS is included for each site with a potential source in Oregon. For ASR and AR purposes, water availability is calculated based on a 50-percent exceedence (meaning the historical record shows there is a 50-percent probability water would be available for particular months) (Doug Woodcock, OWRD, written commun., 2010). In Oregon, water for ASR generally is provided under an existing water right. Water for AR usually requires a specific authorization. A secondary groundwater permit is then needed to extract the water stored through AR.WARS is only one of many methods for determining water availability in Oregon. Reclamation should meet with OWRD to discuss details regarding water availability for specific areas. Assessment of water availability in California was based solely on the physical presence of a possible source.
3. **Probable Treatment Requirements**.—Evaluation of treatment requirements for this project are cursory and limited to differentiating waters that probably have low turbidity from waters that are likely to contain sufficient amounts of algae or suspended sediment to require filtration. Water quality and treatment requirements may differ markedly depending on whether water is injected through wells or recharged through surface infiltration.
4. **Presence of Large-Capacity Wells.—**The best indicator of an aquifer system with suitable permeability and storage characteristics for managed underground storage is the presence of large-capacity wells. This analysis included inventorying wells with yields of 1,000 gallons per minute (gal/min) or more in and around each of the 14 assessment areas. Some of the areas lack large-capacity wells and some lack wells entirely. In Oregon, this assessment was based on the OWRD well log database (which contains about 14,000 wells in Klamath County) and on field-inventoried wells (fig. 4). The OWRD well log database was used to identify square-mile sections that contain wells with reported yields of more than 1,000 gal/min. Field inventoried wells include those in the USGS National Water Information System (NWIS) and wells used in the pilot water bank. In California, the analysis was based on the field inventoried wells described

above (fig. 4) and a collection of several hundred well logs on file in the USGS Oregon Water Science Center. Well data and pumping test results from consultant's reports also were evaluated.

5. **Depth and Lithology of Receiving Aquifer**.—The nature and depth of aquifers that could be used for storage were evaluated based on the geologic logs from the large-capacity wells (fig. 4, on page 8) and, where no large-capacity wells are present, on other field inventoried wells (fig. 5, on page 9).
6. **Likelihood of Available Subsurface Storage**.—The receiving aquifer, whether it is deep or shallow, must have sufficient capacity to store the desired volume of water. Whether the receiving aquifer is a shallow unconfined aquifer or a deep confined aquifer, the water table or potentiometric surface must be sufficiently below land surface to accommodate some increase in head without causing existing wells to start flowing at the surface (become flowing artesian wells). The primary measure of available storage used for this assessment was the static water level depth in existing wells in the area. In most areas, the depth to water (and available storage) is a result of the natural geometry of the water table or potentiometric surface. The potential existence of artificially created storage space in areas where recent pumping has lowered the water table, such as the Tule Lake subbasin, also was considered. Static water levels used for this assessment were from the well logs used for the aquifer depth and lithology assessment.
7. **Knowledge of Subsurface Geology.—**Knowledge of subsurface geology in the assessment areas is highly variable, depending largely on the presence or absence of well data. Knowledge of the subsurface is more uncertain in areas where deep wells are sparse and geologic conditions are more heterogeneous. There are no subsurface data for some of the areas, and conditions must be inferred from surface geology. The surface geology used was the compilation from Gannett and others (2007).
8. **Potential for application of surface infiltration methods—**The potential for application of surface infiltration methods, whereby water is introduced into the subsurface by infiltration through constructed canals, ditches, or basins, was also evaluated. The principal considerations were presence of permeable surface deposits likely to be in direct hydraulic connection with the target aquifer, presence of discharge features such as drains, springs, or gaining streams, and depth to the water table.
9. **Proximity to discharge boundaries—**The proximity to potential discharge boundaries is a critical consideration in evaluating the potential for underground storage of water. If water is artificially introduced into an aquifer close to discharge features such as springs, gaining stream reaches, or agricultural drains, a significant portion of the stored water could be lost through discharge to the surface before it can be put to the intended use (fig. 2). Any water artificially recharged to an aquifer will eventually dissipate as the system equilibrates, and the proximity of discharge boundaries can cause this to happen more rapidly. Potential discharge boundaries were identified using topographic maps and maps of the Klamath Project.
10. **Infrastructure Considerations.—**Although not strictly a hydrologic consideration, the presence of suitable infrastructure, such as canals that could be used to convey water to or from sites and wells that could be used for injection, is noted in this assessment.

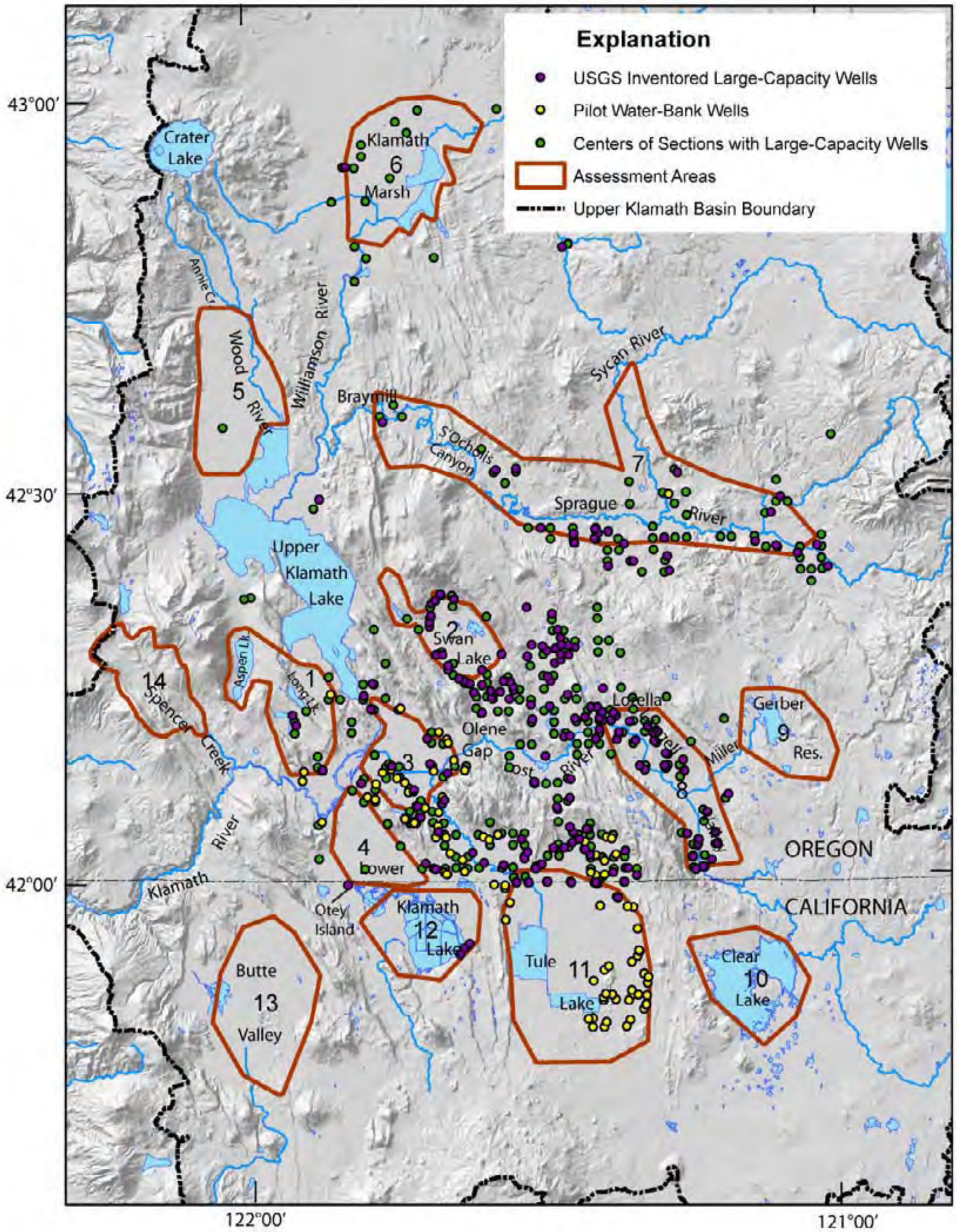

Figure 4. Locations of assessment areas and selected large-capacity wells in the upper Klamath Basin including wells used for the pilot water bank, wells field inventoried by the USGS with yields over 1,000 gallons per minute, and centers of sections in which the OWRD data base indicated presence of a well or wells with yields over 1,000 gallons per minute.

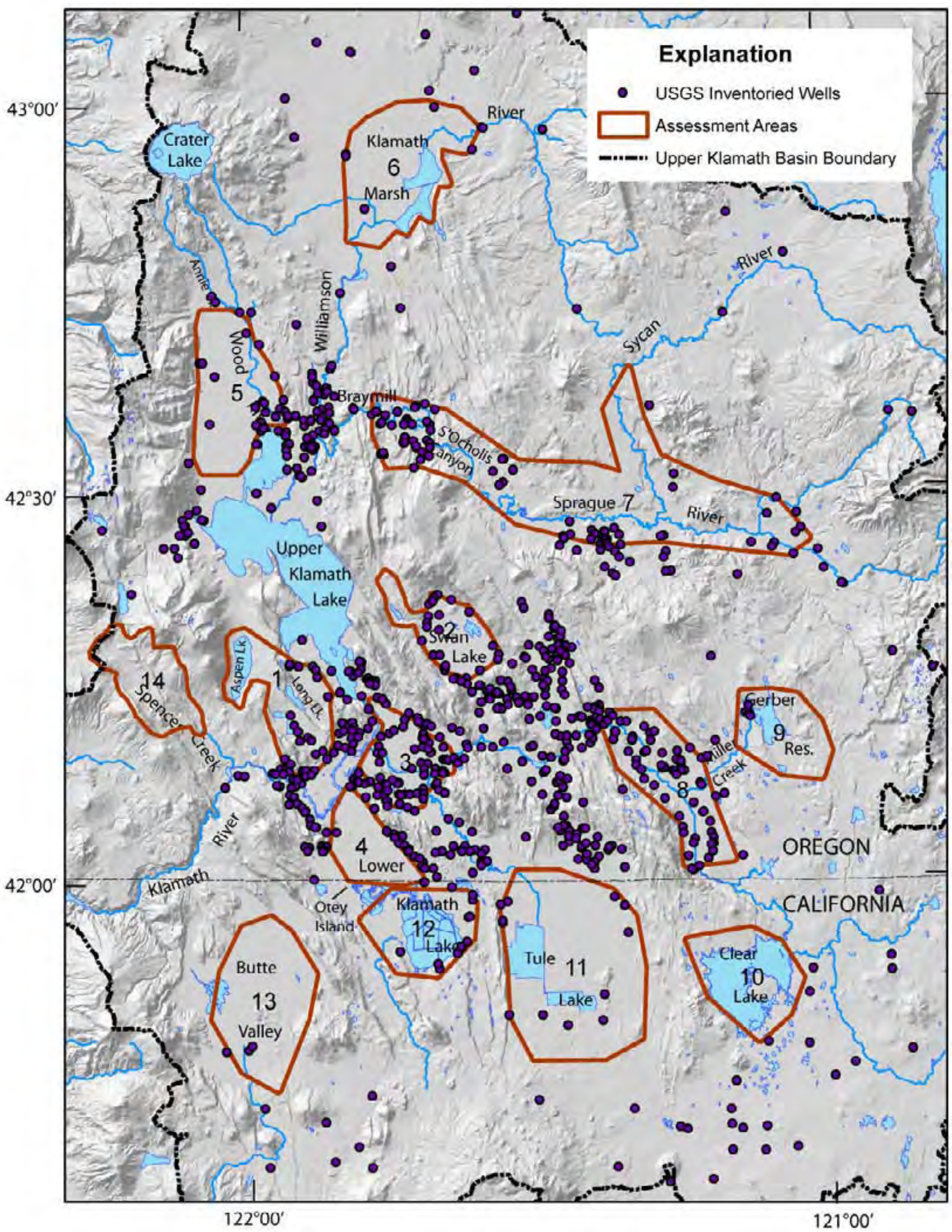

Figure 5. Locations of assessment areas and wells with subsurface geologic information field inventoried by the USGS. Additional wells (not shown) in California provide useful subsurface information but they have not been field inventoried by USGS and have uncertain locations.

Preliminary Hydrologic Assessments of Potential Sites

Fourteen assessment areas were identified by Reclamation. Locations of 13 assessment areas were given to the USGS in the form of a GIS polygon coverage, and Area 14 was described verbally. Sites were evaluated using the best information available given the time and resource limitation of this project. Detailed results are presented in the following paragraphs and summarized in table 1.

Area 1—Aspen Lake/Long Lake area

Source(s) of Available Surface Water: No obvious source. Minor springs and ephemeral streams enter Aspen, Round, and Long Lakes, but no streamflow measurements are available. Judging from topography and drainage areas, volumes are unlikely to be adequate for significant storage. Pumping from Upper Klamath Lake is possible but infrastructure costs would be large.

OWRD Water Availability Assessment: None available.

Probable Treatment Requirements: Unknown. Upper Klamath Lake water would need filtration and possible treatment for injection but probably not for surface infiltration. Filtration may not be required if water were diverted from the lake through infiltration wells or galleries.

Presence of Large-Capacity Wells: Six wells in the defined area have yields of 1,000 gal/min or greater. The median yield of these wells is about 2,025 gal/min. The maximum reported yield is 3,000 gal/min.

Depth and Lithology of Receiving Aquifer: Large-capacity wells range from 220 to 650 ft deep, with a median depth of 388 ft. All large-capacity wells in the area produce from fractured lava.

Likelihood of Available Subsurface Storage: Good likelihood. Static water levels in large-capacity wells range from 42 to 150 ft, with a median depth of 94 ft. The median depth to water in all wells in the area is 136 ft.

Knowledge of Subsurface Geology: Limited; few deep wells have been drilled in this geologically complex area.

Potential for Surface Infiltration Methods: Not well known. Thin Quaternary sedimentary deposits and lavas flooring the basin may be sufficiently permeable. Engineering studies done for the proposed Long Lake Valley Reservoir might provide information on the potential for surface infiltration methods in that area.

Proximity to Discharge Boundaries: Discharge boundaries close to the area include Upper Klamath Lake and the Wocus Marsh drains. Leakage to these features is likely.

Infrastructure Considerations: The area has no infrastructure, and the fact that most land is in private ownership is a consideration.

Other Considerations: None noted.

Table 1. Summary of key criteria for assessment of potential for managed underground storage of water for 14 candidate areas in the upper Klamath Basin.

Area	Number of large-capacity wells in area	Median yield (GPM)	Median depth to water (ft)	Median depth of large-capacity wells (ft)	Assumed injection rate per well (GPM)*	Potential volume assuming 10 wells injecting for 90 days (AF)	Comments	Potential for application of surface infiltration	Status of consideration for injection/ASR	Major reason(s) for removal from consideration for injection/ASR
1. Aspen Lake/ Long Lake area	6	2,025	94	388	--	--		Possible	Area no longer under consideration	No obvious water source. Area close to discharge boundaries.
2. Swan Lake Valley	11	2,150	51	320	--	--		Low	Area no longer under consideration	No obvious water source. Area close to discharge boundaries.
4. Northern Lower Klamath Lake subbasin	0	**	--	No large capacity wells in area	--	--		Low	Area no longer under consideration	Available storage unlikely.
5. Wood River Valley	0	**	0	No large capacity wells in area	--	--		No	Area no longer under consideration	Available storage highly unlikely.
6. Klamath Marsh area	9	2,400	5	300	--	--		Low	Area no longer under consideration	Available storage unlikely. Area close to discharge features (springs, flowing artesian wells, and wetlands)

Table 1. Summary of key criteria for assessment of potential for managed underground storage of water for 14 candidate areas in the upper Klamath Basin—continued

Area	Number of large-capacity wells in area	Median yield (GPM)	Median depth to water (ft)	Median depth of large-capacity wells (ft)	Assumed injection rate per well (GPM)*	Potential volume assuming 10 wells injecting for 90 days (AF)	Comments	Potential for application of surface infiltration	Status of consideration for injection/ASR	Major reason(s) for removal from consideration for injection/ASR
7. Sprague River Valley	41	1,900	33	439	1,900	7,557		Low		
8. Langell Valley	25	1,600	26	423	1,600	6,364		Low		
9. Gerber Reservoir area	0	**	374	409****	2,000	7,955	Theoretical injection rate based on geology	Possible		
10. Clear Lake area	0	**	100	No large capacity wells, median depth of stock wells is 257 ft	2,000	7,955	Theoretical injection rate based on geology	Possible		
11. Tule Lake subbasin	38	2,300	35***	452	4,000	15,910	Theoretical Injection rate based on TID wells	Possible		
12. Southern Lower Klamath Lake subbasin	Several	**	28***	Median depth of 5 large-capacity wells is 800 ft	2,000	7,955	Theoretical injection rate based on pump tests	Low		

Table 1. Summary of key criteria for assessment of potential for managed underground storage of water for 14 candidate areas in the upper Klamath Basin—continued

Area	Number of large-capacity wells in area	Median yield (GPM)	Median depth to water (ft)	Median depth of large-capacity wells (ft)	Assumed injection rate per well (GPM)*	Potential volume assuming 10 wells injecting for 90 days (AF)	Comments	Potential for application of surface infiltration	Status of consideration for injection/ASR	Major reason(s) for removal from consideration for injection/ASR
13. Butte Valley	50 (Q > 3,000 GPM)	**	32	408	--	--		Possible	Area no longer under consideration	No obvious source of water, considerable conveyance costs.
14. Buck Lake/ upper Spencer Creek area	0	**	--	No wells in the area	--	--		Unknown	Area no longer under consideration	No obvious source of water, considerable conveyance costs.

* Injection rate based on median pumping rate for large-capacity wells unless otherwise noted
** Median pumping not calculated
*** Large-capacity wells only
**** Single 1,200 gpm well near area.

Area 2—Swan Lake Valley

Source(s) of Available Surface Water: No obvious sources. Limited surface water appears to be appropriated and many landowners presently rely on groundwater. Lost River water is a physically possible source.

OWRD Water Availability Assessment: No assessment available for streams in Swan Lake Valley. WARS indicates availability for October and November, and January through May from the Lost River at Olene Gap at the 50-percent exceedence level.

Probable Treatment Requirements: Unknown.

Presence of Large-Capacity Wells: Eleven wells in the area have yields of 1,000 gal/min or greater and several more wells are close by. The 11 wells have a median yield of 2,150 gal/min. The maximum reported yield is 4,200 gal/min. Most of these wells are on the periphery of the valley.

Depth and Lithology of Receiving Aquifer: Wells range from 200 to 1,620 ft deep with a median depth of 320 ft and produce from fractured lava and volcanic vent deposits (such as cinders).

Likelihood of Available Subsurface Storage: Probable. The median static water level depth of large-capacity wells is 73 ft. The median depth to water in all wells is 51 ft. Water levels out in the flat part of the basin are, however, much shallower.

Knowledge of Subsurface Geology: Limited. The small number of wells in the area are spatially clustered, and the geology is complex.

Potential for Surface Infiltration Methods: Unknown, but probably low given the shallow groundwater and marsh-like conditions in much of the area.

Proximity to Discharge Boundaries: No major springs are known close to this area. Swan Lake may be fed to some degree by shallow groundwater discharge and could be a discharge boundary for shallow aquifers.

Infrastructure Considerations: No suitable infrastructure.

Other Considerations: None noted.

Area 3—Northern Klamath Valley

Source(s) of Available Surface Water: Lost River, Klamath River (through the Lost River Diversion Canal), and Upper Klamath Lake (through the A Canal).

OWRD Water Availability Assessment: WARS indicates availability for October and November, and January through May from the Lost River at Olene Gap at the 50 percent exceedence level. WARS indicates availability from the Link River in January, and March through May at the 50-percent exceedence level.

Probable Treatment Requirements: Water from Upper Klamath Lake, the Klamath River, or the Lost River would require filtration and possibly other treatment prior to subsurface injection. Filtration may not be required if water were diverted through infiltration wells or galleries. Water introduced into the aquifer through surface infiltration methods would require little or no prefiltration, however, nondegradation requirements would still apply.

Presence of Large-Capacity Wells: Fifteen wells in this area have yields of 1,000 gal/min or greater. Yields from these wells range from 1,000 to 5,700 gal/min. The median yield is 2,400 gal/min.

Depth and Lithology of Receiving Aquifer: Large-capacity wells range from 164 to 1,600 ft deep, with a median depth of 480 ft. All wells produce from fractured lava and vent deposits (cinders) except one well that produces from sand and gravel deposits.

Likelihood of Available Subsurface Storage: Limited storage is possible. Static water levels in the large-capacity wells range from 12 to 90 ft with a median of 29 ft. The median depth to water in all wells in the area is 13 ft. Water-level declines caused by supplemental irrigation pumping may have created additional artificial storage capacity in parts of this area.

Knowledge of Subsurface Geology: Fairly good due the large number of wells in the area.

Potential for Surface Infiltration Methods: Probably limited on the valley bottom due to the large density of drains. There may be potential along the margin through canals that may recharge bedrock (like the G Canal).

Proximity to Discharge Boundaries: No major discharge features in the area.

Infrastructure Considerations: Considerable water conveyance infrastructure in the area. Public landownership is limited. All large-capacity wells are privately owned.

Other Considerations: None noted.

Area 4—Northern Lower Klamath Lake Subbasin

Source(s) of Available Surface Water: Klamath River through the North or Ady Canals, and Klamath Strait Drain.

OWRD Water Availability Assessment: WARS indicates availability from the Link River in January and March through May at the 50-percent exceedence level. Availability from the Klamath Strait Drain is unknown.

Probable Treatment Requirements: Klamath River water would require filtration and possible other treatment prior to injection through wells. Diversion through infiltration wells or galleries may reduce or eliminate the need for additional filtration. Water introduced into the aquifer through surface infiltration methods would require little or no treatment.

Presence of Large-Capacity Wells: The area outlined by Reclamation has no large-capacity wells. A few large-capacity wells have been completed east of the southern part of this area along the southern end of the Klamath Hills. These wells yield from 1,500 to 4,500 gal/min. The median yield is 2,700 gal/min. Some of these wells produce warm water. There may be regulatory issues regarding injecting cold surface water into thermal aquifers.

Depth and Lithology of Receiving Aquifer: Four wells with yields of 1,000 gal/min or more have been drilled just east of the area in the southern end of the Klamath Hills. These wells range from 165 to 770 ft deep and have a median depth of 324 ft. The wells produce from either fractured lava or sedimentary deposits.

Likelihood of Available Subsurface Storage: Not well known but unlikely. The sedimentary fill in the Lower Klamath Lake subbasin is predominantly very fine grained (hence no wells in the area). The geology of the Klamath Hills is variable and contains both low- and high-permeability materials. Water levels are very shallow in much of the Lower Klamath Lake subbasin.

Knowledge of Subsurface Geology: Extremely limited. No wells are in the area except on the periphery. Moreover, no wells penetrate through the fine-grained basin-fill sediments in the center of the subbasin, which geophysical studies suggest are thousands of feet thick (Northwest Geophysical Associates, 2002).

Potential for Surface Infiltration Methods: Low due to the shallow groundwater conditions in the subbasin. There may be potential along the periphery using the North Canal. Wells are known to respond to canal operation, but the volumes of water involved and the fate of that water are not known.

Proximity to Discharge Boundaries: No major natural discharge features are known in this area, but shallow groundwater could discharge through the many agricultural drains.

Infrastructure Considerations: The area has many canals and laterals.

Other Considerations: None noted.

Area 5—Wood River Valley

Source(s) of Available Surface Water: The Wood River and its major tributaries, as well as several streams emanating from the Cascade Range, including Annie Creek and Sevenmile Creek.

OWRD Water Availability Assessment: The WARS indicates that water is available from the Wood River System in January and March through May at the 50-percent exceedence level.

Probable Treatment Requirements: Depending on the source, only minimal treatment may be required. Water in the groundwater-dominated Wood River system generally has low turbidity. Some flowing artesian wells in the area reportedly have elevated phosphorous concentrations.

Presence of Large-Capacity Wells: No large-capacity wells have been drilled in or near the area outlined. This may be a result of abundant surface water and does not necessarily imply that productive aquifers are not present.

Depth and Lithology of Receiving Aquifer: Unknown. The depth of the sedimentary fill in the Wood River Valley is not known.

Likelihood of Available Subsurface Storage: Probably extremely limited to nonexistent. Many of the wells in the basin-filling sediments encounter artesian conditions with heads above land surface. Because many wells in area are under artesian pressure, the median static water level depth of all wells in the area is 0 (meaning groundwater levels are, on average, at land surface).

Knowledge of Subsurface Geology: Limited due to the lack of deep wells.

Potential for Surface Infiltration Methods: None, given shallow groundwater depths and artesian conditions.

Proximity to Discharge Boundaries: Major springs emanate from the base of the fault escarpment that defines the eastern margin of the Wood River Valley. Water injected into the subsurface would likely leak rapidly back to these springs. Springs along the western margin of the valley could pose similar problems.

Infrastructure Considerations: The Wood River Valley has many canals and drains, but it is unclear how they would be used.

Other Considerations: Because of the lack of subsurface storage and proximity to major discharge boundaries, the Wood River Valley is a poor candidate for managed underground storage of water and probably should be removed from further consideration.

Area 6—Klamath Marsh Area

Source(s) of Available Surface Water: Upper Williamson River or streams draining the east side of the Crater Lake highlands.

OWRD Water Availability Assessment: The OWRD water availability system shows that water is available from the Williamson River at Kirk in January and March through May at the 50-percent exceedence level.

Probable Treatment Requirements: Unknown.

Presence of Large-Capacity Wells: Nine wells in the areas have reported yields of 1,000 gal/min or greater. Yields of these wells range from 1,500 to 4,000 gal/min. The median yield is 2,400 gal/min.

Depth and Lithology of Receiving Aquifer: High-capacity wells range from 104 to 498 ft with a median depth of 300 ft. Most wells produce from basalt or basalt and vent deposits. A few wells produce from sand, gravel, and pumice.

Likelihood of Available Subsurface Storage: Storage probably is limited in the area outlined. The water table is shallow. Static water-level depths in the large-capacity wells range from 0 to 19 ft. The median depth to water in large-capacity wells is about 10 ft. Median static water level depth for all wells in the area is 5 ft.

Knowledge of Subsurface Geology: Limited. The area has few wells and the geology is complex.

Potential for Surface Infiltration Methods: The potential for applying surface infiltration methods in the area outlined probably is low due to the shallow water table elevation and proximity to discharge features.

Proximity to Discharge Boundaries: There are springs and flowing artesian wells along the western margin of Area 6. The marsh itself is also a potentially large discharge boundary.

Infrastructure Considerations: The Klamath Marsh area has little in the way of infrastructure.

Other Considerations: The principal route for moving water from the Klamath Marsh area would be the Williamson River, which goes dry from July through November most years. Transporting stored water to the project area would be problematic during this period without considerable infrastructure development.

Area 7—Sprague River Valley

Source(s) of Available Surface Water: The Sprague River and its tributaries.

OWRD Water Availability Assessment: The WARS indicates that water is available from the Sprague River system in January and March through May at the 50-percent exceedence level. Water is available from the Sycan River only during March through May at the 50-percent exceedence level.

Probable Treatment Requirements: Suspended sediment and algae may require filtration; other possible treatment needs are unknown.

Presence of Large-Capacity Wells: Forty-one wells in this area have yields of 1,000 gal/min or greater. Many more are known within a few miles of the boundary. Of the 41 wells, yields are as much as 4,000 gal/min, and the median yield is 1,900 gal/min.

Depth and Lithology of Receiving Aquifer: Depths of large-capacity wells range from 40 to 1,625 ft. The median depth is 439 ft. Most wells produce from fractured lava and fragmental volcanic materials interbedded with sediments. A small number of wells produce from sand and gravel deposits.

Likelihood of Available Subsurface Storage: Moderate in lowland areas, potentially greater in adjacent uplands. Water level depths in the large-capacity wells range from a few feet to greater than 100 ft. The median static water level depth is of the 41 wells is 33 ft. Median static water level depth for all wells in the area is also 33 ft.

Knowledge of Subsurface Geology: The subsurface geology of the Sprague River valley is complex owing to the interstratification of lava flows, hydrovolcanic deposits, silicic domes, and sedimentary deposits. Subsurface geology is poorly understood because few wells have been field inventoried in the area. The Oregon Department of Geology recently mapped the surface geology at 1:24,000 scale in much of this area.

Potential for Surface Infiltration Methods: The potential for application of surface infiltration methods is low due to the interbedded nature of the geology and the degree of confinement of productive aquifers. Water artificially recharged through surface infiltration on alluvial benches in the area may discharge back to streams rapidly.

Proximity to Discharge Boundaries: Several major spring complexes and gaining stream reaches drain groundwater from the Sprague River Valley. These could limit the effectiveness of ASR projects unless careful consideration is given to the placement of injection wells or other recharge structures.

Infrastructure Considerations: Water conveyance infrastructure in the Sprague River Valley generally is limited to canals that deliver water from the mainstem Sprague River or tributary drainages to irrigated areas on the valley bottom. Public land is limited to uplands around the area and U.S. Forest Service holdings around S'Ocholis Canyon and Braymill.

Other Considerations: Should underground storage be considered in the Sprague River basin, there may be opportunities for coordination with the Upper Basin Water Program of the Klamath Basin Restoration Agreement.

Area 8—Langell Valley

Source(s) of Available Surface Water: The Lost River (from Clear Lake) and Miller Creek (from Gerber Reservoir).

OWRD Water Availability Assessment: The WARS indicates availability for October and November, and January through May from the Lost River at Olene Gap at the 50-percent exceedence level.

Probable Treatment Requirements: Unknown.

Presence of Large-Capacity Wells: Twenty-five wells in the area outlined have yields of 1,000 gal/min or larger. The maximum reported yield is 4,200 gal/min and the median yield is 1,600 gal/min.

Depth and Lithology of Receiving Aquifer: Depths of large-capacity wells range from 165 to 2,056 ft. The median depth is 423 ft. All large-capacity wells produce from fractured lava or a mixture of lava, cinders, and other fragmental volcanic material.

Likelihood of Available Subsurface Storage: Because of the large size of the area, the potential varies spatially. Water level depths in the large-capacity wells range from 12 to 195 ft. The median water level depth of large-capacity wells is 30 ft. The median water level depth of all wells in the area is 26 ft. Existing time-series water level data could be used along with pumping estimates to calculate possible storage.

Knowledge of Subsurface Geology: Certain aspects of the subsurface geology in the area are well constrained because of the large number of wells inventoried by OWRD and their subsurface mapping efforts. In addition, the Oregon Department of Geology mapped the surface geology at 1:24,000 scale. Much of the OWRD work, however, is limited to lowland areas. The geology of the Langell Valley includes complexly interbedded volcanic deposits and sediments making detailed interpretation difficult.

Potential for Surface Infiltration Methods: Not well known. Interbedded sediments may locally preclude recharging deep aquifers through surface infiltration. Surface infiltration might be possible in the Lorella area using the North Canal.

Proximity to Discharge Boundaries: Groundwater discharges to the upper Lost River between Malone Dam and Bonanza. The area has many agricultural drains, and a major spring complex exists in the town of Bonanza. All of these boundaries would have to be considered when developing an ASR project.

Infrastructure Considerations: Many canals in the area could be used to deliver water to recharge projects. Some of the peripheral canals, such as the North Canal may be useful for surface infiltration.

Other Considerations: A large amount of hydrologic information is available for the Langell Valley area because of the substantial efforts of the OWRD. This information could be of considerable use for further investigating ASR potential in this area.

Area 9—Gerber Reservoir Area

Source(s) of Available Surface Water: Gerber Reservoir, tributaries, and Miller Creek.

OWRD Water Availability Assessment: No specific water availability assessment is available for Gerber Reservoir or Miller Creek. However, WARS indicates availability for October and November and January through May from the Lost River at Olene Gap at the 50-percent exceedence level.

Probable Treatment Requirements: Unknown.

Presence of Large-Capacity Wells: None in the area. One test well about 2 mi west of the outlined area reportedly yields 1,200 gal/min from fractured lava. There are 10 wells in the area with yields ranging from 3 to 90 gal/min and a median yield of 35 gal/min. The absence of large-capacity wells is due to the lack of large demand and does not necessarily mean that sufficiently permeable aquifers are not present.

Depth and Lithology of Receiving Aquifer: Depth to an appropriate aquifer is unknown as there are no large-capacity wells in the area. The wells in the vicinity range from 81 to 665 ft deep with a median depth of 409 ft. The wells penetrate a sequence of interbedded lava and sediment with occasional cinders. A receiving aquifer would likely be composed of fractured lava and volcanic vent deposits.

Likelihood of Available Subsurface Storage: Storage is likely; the depth to water in the 10 wells in the area ranges from 30 to 476 ft. The median depth to water is 374 ft.

Knowledge of Subsurface Geology: Subsurface knowledge is sparse due to the small number of wells and their limited depths and poor geographic distribution.

Potential for Surface Infiltration Methods: Surface infiltration might be possible in the permeable surficial volcanic deposits. The potential would have to be determined through field work and testing.

Proximity to Discharge Boundaries: The area has no major discharge features.

Infrastructure Considerations: Other than Gerber Reservoir and Dam, the area has no infrastructure. Public land is extensive around Gerber Reservoir.

Other Considerations: Test drilling and pumping would be required to determine the presence of sufficiently productive aquifers and to determine their hydraulic characteristics. Little or no data exist on shallow groundwater conditions immediately adjacent to Gerber Reservoir. Data from few wells west of Gerber suggest that the lake is perched above the regional groundwater system and that water-table elevations fall off rapidly toward the west. No data are available for the area east of Gerber. The reservoir probably loses some water to seepage, causing local mounding of groundwater, or at least a zone of vertical flow through the unsaturated zone. The available data do not suggest that the effects extend laterally very far from the reservoir. It is reasonable to assume that any ASR operations that included injection wells would have no influence on reservoir operations as long as the wells are not immediately adjacent to the reservoir and heads in the target aquifer were kept below the elevation of the reservoir. The same can probably be said for surface infiltration operations as long as infiltration structures were sited outside the area of major influence of the reservoir, which sparse data suggest is probably a mile or less. Field investigations, probably involving shallow drilling, will be necessary to develop an understanding of the shallow groundwater hydrology adjacent to Gerber Reservoir.

Area 10—Clear Lake Area

Source(s) of Available Surface Water: Clear Lake and its tributaries, and the Lost River

OWRD Water Availability Assessment: Not applicable, the area is in California.

Probable Treatment Requirements: Unknown.

Presence of Large-Capacity Wells: No large-capacity wells exist in the area. Several stock wells within about 10 mi of the site on the Modoc Plateau have yields ranging from 2 to 30 gal/min.

Depth and Lithology of Receiving Aquifer: Stock wells within 10 mi of the site range in depth from 168 to 375 ft, with a median depth of 257 ft. These wells penetrate lava and interbedded volcanic vent deposits. The presence or absence of aquifers sufficiently productive for managed underground storage of water is unknown.

Likelihood of Available Subsurface Storage: Wells in the general area have static water level depths ranging from 58 to 322 ft with a median depth to water of 100 ft, suggesting storage would be available if sufficiently productive aquifers can be found.

Knowledge of Subsurface Geology: Extremely limited due to the lack of wells in the outlined area.

Potential for Surface Infiltration Methods: Surface infiltration in permeable surface deposits might be possible, but it would have to be determined by field work and testing.

Proximity to Discharge Boundaries: The area has no discharge boundaries.

Infrastructure Considerations: The area has no infrastructure.

Other Considerations: Test drilling would be required to determine the presence of sufficiently productive aquifers. Little or no data on shallow groundwater conditions immediately adjacent to Clear Lake reservoir are available. Data from wells within a few miles east and south of Clear Lake suggest a westward gradient with the lake perched above the regional groundwater system (Gannett and others, 2007). Clear Lake probably loses some water to seepage resulting in local mounding of groundwater, or at least a zone of vertical flow through the unsaturated zone. The available data do not suggest that the effects extend laterally very far from the reservoir. ASR operations that included injection wells probably would have no influence on reservoir operations as long as the wells are not immediately adjacent to the reservoir and heads in the target aquifer were kept below the elevation of the reservoir. The same could be said for surface infiltration operations as long as infiltration structures were sited outside the area of influence of the reservoir, which sparse data suggest is probably 1 mi or less. Field investigations, probably involving shallow drilling, will be necessary to develop an understanding of the shallow groundwater hydrology adjacent to Clear Lake.

Area 11—Tule Lake Subbasin

Source(s) of Available Surface Water: Lost River, Klamath River (through the Lost River Diversion Canal), and Upper Klamath Lake (through the A Canal).

OWRD Water Availability Assessment: The WARS indicates availability for October and November, and January through May from the Lost River at Olene Gap and at the State line at the 50-percent exceedence level.

Probable Treatment Requirements: If water is injected into wells, filtration will be required to remove turbidity and algae, additional treatment may be required to meet regulatory requirements. Additional filtration may not be required if diversion is through infiltration wells or galleries. If surface infiltration is used, little or no treatment may be necessary.

Presence of Large-Capacity Wells: USGS has inventoried 38 large-capacity wells in the area that produce 500 to 10,500 gal/min. The median yield of inventoried wells is 2,300 gal/min. Many large-capacity wells are known in addition to those in the USGS inventory.

Depth and Lithology of Receiving Aquifer: Large-capacity wells range in depth from 126 to 2,600 ft, with a median of 452 ft. Almost all of the wells produce from fractured lava and fragmental volcanic deposits, sometimes with interbedded coarse sediments (sand and gravel). A few wells are reported to produce solely from coarse sediments.

Likelihood of Available Subsurface Storage: Static water level depths in large-capacity wells range from 7 to 173 ft. The median depth to water is 35 ft. Water-level declines resulting from supplemental irrigation pumping over the past several years represents artificially created storage. Active management of both natural and artificially created storage may be a useful management strategy.

Knowledge of Subsurface Geology: The subsurface geology is reasonably well known beneath the Tule Lake subbasin due to the relatively large number of deep wells in the area. Knowledge of the subsurface geology in the uplands surrounding the basin is more limited because there are fewer deep wells, and the geology is more complex.

Potential for Surface Infiltration Methods: Surface infiltration may be possible using the canal system. Water levels in wells of various depths declined during the drought in 2001 when Project canals were largely dry. In 2002, some of the Tulelake Irrigation District (TID) wells (TID 6 in particular) showed an increase in the recovery rate when canals were started up in the spring. This indicates there is a hydraulic connection between canals and the deep aquifer system, and that canal leakage has the potential to recharge deep aquifers. The spatial distribution of canal leakage and the details of the connection between the canal system and deep aquifers are largely unknown. Fieldwork and testing would be required to ensure that surface infiltration would target deeper aquifers in favor of shallow aquifers because shallow aquifers are more likely to discharge to agricultural drains.

Proximity to Discharge Boundaries: No major natural discharge features (such as springs or streams) exist in this area, although interbasin flow of groundwater out of the basin toward the south may occur. Discharge to the Tule Lake sumps from the shallow parts of the groundwater system also is possible. Agricultural drains in the area represent a substantial discharge boundary for shallow groundwater.

Infrastructure Considerations: Infrastructure is considerable in the Tule Lake basin, including an extensive canal network and10 large-capacity wells managed by the Tule Lake Irrigation District.

Other Considerations: This area is probably the best candidate for managed underground storage and recovery of water in the upper Klamath Basin, using either deep well injection or surface infiltration methods, because of the extensive infrastructure and extensive hydrologic dataset. Extensive field investigations would be required before an ASR or AR strategy could be developed.

Area 12—Southern Lower Klamath Lake Subbasin

Source(s) of Available Water: Klamath River through the Ady or North Canals, Tule Lake through the D Pumping Plant and the P canal, and the Klamath Strait drain.

OWRD Water Availability Assessment: Water could be used from California making the OWRD assessment not applicable. If water were to be used from the Klamath River, the Link River analysis might by relevant (see discussion for Area 4).

Probable Treatment Requirements: Unknown.

Presence of Large-Capacity Wells: Several wells have been drilled in or near the outlined area, although few have associated State well logs. Much of what is known is contained in reports prepared by consultants for the U.S. Fish and Wildlife Service (FWS), including those by WESCORP (2001, 2003). Contractors for FWS drilled five large-capacity wells on the periphery of Lower Klamath Lake between 2001 and 2002. Yields ranged from 2,500 to 6,200 gal/min.

Additional large-capacity wells are known west of the area. Two large-capacity wells near Otey Island reportedly produce 1,500 and 5,000 gal/min from fractured lava at relatively shallow depths (95 and 120 ft). Pumping tests on these wells indicate that "the aquifer….appears to be impacted by low permeability boundaries and appears to receive limited recharge" (WESCORP, 2003). This suggests that the aquifer may have limited storage potential. Two other wells west of the area produce 3,100 and 4,200 gal/min. Construction information on these wells is unavailable, although one is reported to be 250 ft deep. The lithology of the producing aquifer is not known. Pumping tests on these wells resulted in diminished discharge from nearby springs, indicating a direct hydraulic connection with surface features.

Depth and Lithology of Receiving Aquifer: The depths of the wells drilled for FWS range from 600 to 1,478 ft. Two of the wells drilled for FWS produce from fractured basalt and two others produce from "tuffaceous sandstone" (according to the driller's log). A fifth produces from an apparent mixture of volcanic and sedimentary strata.

Likelihood of Available Subsurface Storage: Unknown. Static water levels are generally shallow in the Lower Klamath Lake subbasin. Static water levels in wells in the southeastern part of the area, where most of the FWS wells were drilled, range from 28 to 75 ft. The median depth to water in the FWS wells is 28 ft. This suggests there may be limited storage available in the southeastern part of the area. Pump testing of wells west of the outlined area suggests connections to springs and streams and little potential for storage.

Knowledge of Subsurface Geology: Drilling in the area has helped delineate the distribution and thickness of sedimentary deposits on the periphery of the Lower Klamath Lake subbasin. Drilling also has delineated substantial lava flows in the northeastern part of the area. Gravity data indicate that the thickness of fine-grained basin filling sediments may exceed 6,000 ft in places (Northwest Geophysical Associates, 2002). Because of the small number and clustered distribution of wells in the area, understanding of the subsurface geology is limited, and large areas have no data.

Potential for Surface Infiltration Methods: Probably low because of very shallow groundwater in most of the area.

Proximity to Discharge Boundaries: Springs along the western margin of the area are known to respond to pumping of nearby wells.

Infrastructure Considerations: The area has many canals, which are used to supply water to the refuge. The area also contains wells owned by the Federal Government.

Other Considerations: Some of the wells drilled for FWS produced water with mercury concentrations toxic to wildlife (WESCORP, 2003). One of the wells along the southeastern margin of the area produced hot (180ºF) water. Water of undesirable quality may be displaced by injected water, but water quality would have to be monitored carefully during the recovery phase.

Area 13—Butte Valley

Source(s) of Available Surface Water: Unknown. Butte Creek infiltrates into lava flows before entering the valley. Most water from streams on the periphery of the valley appear to be channeled to canals and small reservoirs for irrigation use.

OWRD Water Availability Assessment: Not applicable; the area is in California.

Probable Treatment Requirements: Unknown.

Presence of Large-Capacity Wells: Butte Valley has many large-capacity wells. Well logs for the area on file with the USGS in Portland include 50 wells with yields of 3,000 gal/min or greater, ranging up to 6,000 gal/min.

Depth and Lithology of Receiving Aquifer: Depths of large-capacity wells range from 80 to 1,532 ft. The median depth is 408 ft. Of the 50 wells with yields greater than 3,000 gal/min, most produce from fractured lava, 15 produce from lava and interbedded sedimentary deposits (mostly sand and gravel), and 7 product solely from sedimentary deposits.

Likelihood of Available Subsurface Storage: Static water level depths of large-capacity wells range from 3 to 208 ft. The median water level is 32 ft.

Knowledge of Subsurface Geology: Knowledge of subsurface geology is good due to the large number of deep wells in the area.

Potential for Surface Infiltration Methods: Unknown, but the fact that surface streams, such as Butte Creek, infiltrate into the Quaternary lava in the southern part of the subbasin suggest there is potential for surface infiltration in at least part of the area.

Proximity to Discharge Boundaries: The area outlined has no discharge boundaries, except possibly agricultural drains in some areas and Meiss Lake. Hydraulic head gradients suggest, however, that several springs to the northeast of the outlined area in the Lower Klamath Lake subbasin may be connected to the deep groundwater system in the Butte Valley (Wood, 1960; Gannett and others, 2007).

Infrastructure Considerations: Infrastructure to support managed underground storage and recovery of water in Butte Valley or to convey water to the Klamath Project is limited.

Other Considerations: The extensive use of groundwater for irrigation in Butte Valley is due to the limited availability of surface water. Much of the central part of Butte Valley is a Wildlife Management Area managed by the California Department of Fish and Game. Obtaining water for subsurface storage in Butte Valley would likely be problematic.

Area 14—Buck Lake/Upper Spencer Creek Area

Source(s) of Available Surface Water: Spencer Creek and tributary springs.

OWRD Water Availability Assessment: WARS indicates that water is available from Spencer Creek in January, and March through May at the 50-percent exceedence level.

Probable Treatment Requirements: Unknown.

Presence of Large-Capacity Wells: There are no wells in or near the area.

Depth and Lithology of Receiving Aquifer: Uncertain due to lack of subsurface data. Surficial mapping indicates that any aquifers in the area would likely be in fractured basaltic and andesitic lava, and vent deposits.

Likelihood of Available Subsurface Storage: Unknown.

Knowledge of Subsurface Geology: Extremely limited due to the lack of wells.

Potential for Surface Infiltration Methods: Unknown.

Proximity to Discharge Boundaries: Multiple springs emanate at the margins of the Buck Lake valley (near the center of Area 14). It is not known, however, whether these springs are connected to any aquifer suitable for storage.

Infrastructure Considerations: The area has no infrastructure. Water stored in the area would probably have to be used for augmenting flow of the Klamath River.

Other Considerations: The Spencer Creek drainage has little water. Streamflow data from OWRD for water years 2003 through 2009 show an annual mean discharge volume of 23,400 acre-ft. Most of this is due to base flow from groundwater discharge in the basin. Seasonal runoff peaks make up a small proportion of the total discharge from this basin. Unless another source of water is identified, this area is probably not a good candidate for managed underground storage of water.

Summary/Next Steps

The assessment of existing information indicates that some of the areas outlined have low potential for managed underground storage of water and probably should be removed from further consideration for the time being. These include Areas 1, 2, 4, 5, 6, 13, and 14.

The remaining areas might have potential for managed underground storage of water. Prioritizing these areas for additional study will require identification of a specific water source and determination of both the physical and legal availability of water. Both the volume and timing of water availability need to be determined. Before plans can proceed in any of the areas, engineering considerations regarding filtration and treatment of water necessary for well injection need to be determined. Plans also need to be developed for use of the stored water.

Area 3, the northern Klamath Valley, and Area 11, the Tule Lake subbasin, appear to have the most potential given the available information. The areas have large-capacity wells, good water infrastructure, close proximity to areas of use, and available storage. Based on the response to canal operation observed in wells in the areas, both may have potential for application of surface infiltration methods (using existing canals) that could be implemented with relatively little cost.

The logical next step for determining hydrologic feasibility in Areas 3 and 11 is testing of candidate wells for feasible injection and recovery rates, impacts to adjacent wells, and recovery efficiencies. If there is interest in surface infiltration techniques, studies should be conducted to determine the rates and spatial distribution of canal losses and the connection between canals and shallow and deep aquifers.

Although Areas 7 and 8 (Sprague River and upper Lost River areas) may have potential for ASR, there is no clear path forward because (1) all of the wells in the area are privately owned, (2) public land is limited in lowland areas, and (3) infrastructure is not well developed. The details of any hydrologic investigations to further evaluate feasibility would depend on specific ASR project development strategies. Canal leakage studies in the Lorella area may be of value if surface infiltration techniques are being considered.

Areas 9 and 10 (Gerber and Clear Lake Reservoirs) lack deep well data, so exploration drilling is needed to determine whether suitable aquifers are present and to determine available storage. Shallow drilling may be required to understand the shallow groundwater hydrology immediately adjacent to the reservoirs in order to eliminate interference with reservoir operations.

In Area 12 (southern Lower Klamath Lake subbasin), permeability and storage capacity need be to determined. Some preliminary determinations might be possible using the test wells drilled by FWS. The details of prospective hydrologic studies would depend on the specific ASR strategy proposed. The location of the area at the southern (and hydrologic) end of the Klamath Project limits the potential use of stored water. Careful evaluation of all data collected by contractors during the drilling and testing of the wells would be a logical first step.

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APPENDIX E

Agency Lake Ranches Site Planning Studies

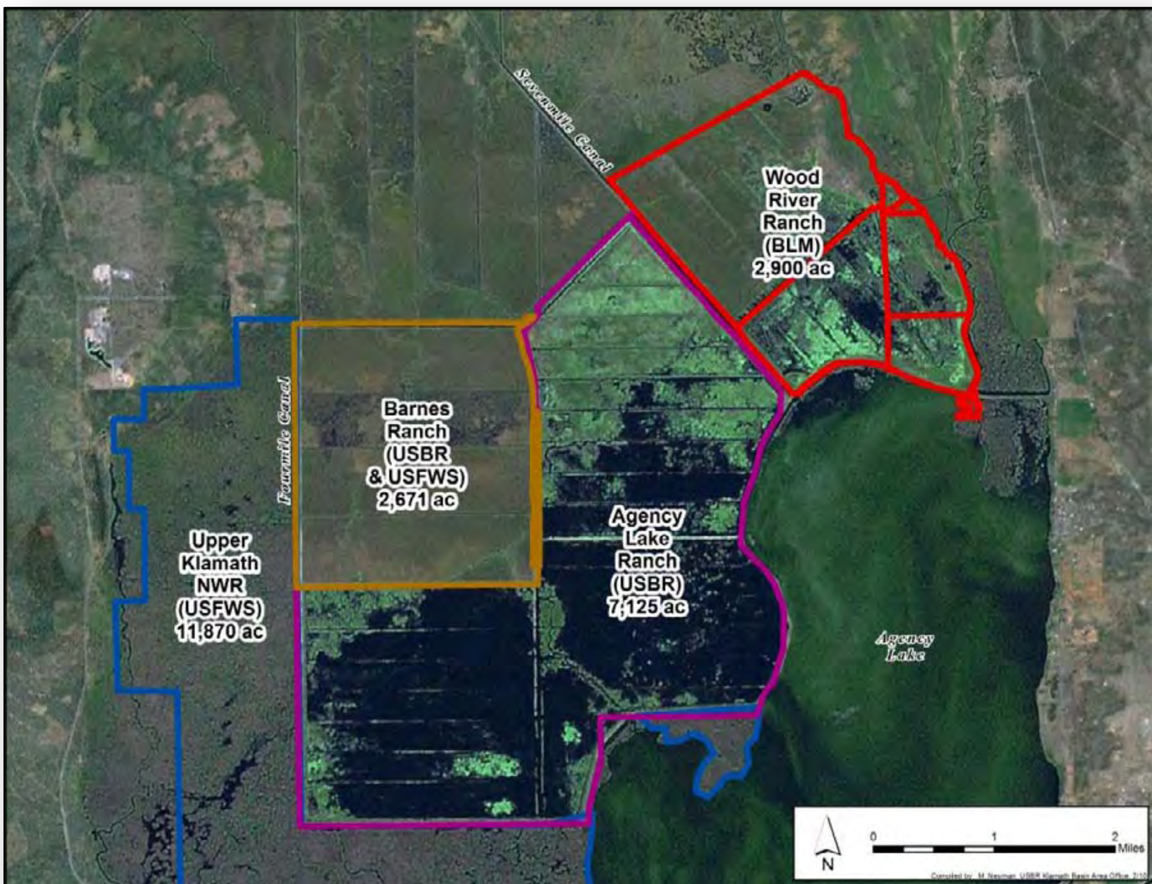
- **Reference notes report summarizing planning materials compiled for property transfer to the U.S. Fish and Wildlife Service, 2010**

RECLAMATION
Managing Water in the West

Reference Notes and Index

Barnes Ranch and Agency Lake Ranch – Information Compiled for Property Transfer

Upper Klamath Lake, Oregon



U.S. Department of the Interior
Bureau of Reclamation

May 2010

Mission Statements

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

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Reference Notes and Index

Barnes Ranch and Agency Lake Ranch – Information Compiled for Property Transfer

Upper Klamath Lake, Oregon

Prepared by:

U.S. Department of the Interior
Bureau of Reclamation

Technical Service Center
Denver, Colorado

Klamath Basin Area Office
Klamath Falls, Oregon

May 2010

Acknowledgement –

These materials were compiled by the U.S. Bureau of Reclamation, Technical Service Center (TSC), and Klamath Basin Area Office (KBAO). Project participants included project leader Jennie Land, with assistance by Kristen Hiatt, Stan Mattingly, and Michael Neuman of the KBAO, and Kathy Fenton and Eric Stiles of the TSC.

Cover Photographs –

Aerial photograph with Barnes Ranch, Agency Lake Ranch, Wood River Ranch, and the Upper Klamath National Wildlife Refuge near Agency Lake, Oregon. KBAO, March 2010.

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BARNES RANCH AND AGENCY LAKE RANCH – UPPER KLAMATH LAKE, OREGON

REFERENCE INFORMATION COMPILED FOR PROPERTY TRANSFER

Introduction

The Barnes Ranch (BR) and Agency Lake Ranch (ALR) sites are located along the northwest shoreline of Agency Lake—contiguous with Upper Klamath Lake (UKL) in southern Oregon. The ALR property was acquired by the U.S. Bureau of Reclamation (Reclamation) in late 1998 under the Congressional authorization condition that the property "will be operated to make water available to all users in the Klamath Basin" (House Appropriations Committee, 1998). Reclamation and the U.S. Fish and Wildlife Service (FWS) jointly purchased the BR property in 2006 under the direction it would be transferred to the FWS and incorporated into the Upper Klamath National Wildlife Refuge (UKNWR) managed by FWS.

The ultimate goal is to re-establish the historic open hydrological connection with Agency Lake. The property transfer and restoration plans are supported under the original 2007 Memorandum of Understanding between Reclamation, FWS, and The Nature Conservancy, and in Section 18.2.2 of the Klamath Basin Restoration Agreement for the Sustainability of Public and Trust Resources and Affected Communities (KBRA; February 18, 2010). Restoring open-to-lake conditions could involve various methods to establish or enhance site characteristics. The future planning for site restoration is the responsibility of the FWS. These notes give a synopsis of preliminary site planning efforts undertaken by Reclamation during the interim time between Reclamation acquisition and transfer to the FWS and an index to reports and information assembled for FWS use.

Site Planning Documents

Reclamation has completed a number of preliminary investigations on the BR and ALR properties to assess existing site characteristics, potential site management options contributing to wetlands restoration or water storage values, and possible relationships with the Klamath Basin resource conditions. Reference information assembled that may be helpful for future site management and planning efforts are grouped into the following categories:

1. Preliminary site planning
2. Wetlands delineation reports
3. Initial site field investigations
4. Property reference materials

Printed copies and electronic files for all reference reports, information, and data are included in the property transfer package. An index list and brief description of reference materials in each category are summarized in the attached table.

Background synopsis

Land elevations within most of the BR/ALR site have subsided and currently lie below the adjacent Agency Lake water surface even at relatively low water levels in the lake. Reclamation has managed the BR/ALR site water levels using the existing irrigation and pump systems to produce seasonal water storage, and will likely continue these operations until site restoration. More detailed information concerning the existing site conditions, historical background, preliminary site planning, water storage operations, and management activities in recent years is provided in the reference reports and materials compiled for property transfer.

Preliminary site planning

Reclamation preliminary or initial reconnaissance level planning studies are undertaken to compile information on existing conditions, formulate potential resource options, data or information needs, and to identify viable options and important issues for more detailed investigations. Reclamation projects that involve new or additional federal funding appropriations then, as a result of recommendations by early level planning studies, may lead to defined appraisal, feasibility, and final design engineering investigations and compliance with provisions of the National Environmental Policy Act (NEPA).

In the early planning stages, site options were identified for initial information gathering and screening evaluations. For example, the BR/ALR site restoration and integration within the UKNWR ultimately involves breaching the existing containment dikes to restore open-to-lake hydrologic conditions. Consequently, the preliminary site planning defined a basic option as: open-to-lake conditions using the minimum site work required (Option 1). Implications of this option include issues such as methods for breaching containment dikes along the lake, reinforcing the north dike to prevent flooding of nearby land owners, as well as site work that could be used to reduce fish entrapment.

The other site options evaluated involved methods to restore subsided lands using water control operations (Option 3), or additional site work and water control to enhance wetlands development and restore internal site stream pathways with delayed dike breaching (Option 4). In addition, staged restoration options that involved different scenarios of dike breaching, site restoration, or water storage operations were evaluated from a resource perspective including factors such as the overall effectiveness, cost-benefits, or major limitations.

The preliminary site planning also included initial layout for major site features and details for major components such as internal site earthwork, pump stations, dike breaching, or dike reinforcement. The latter planning studies focused on the north dike design criteria because this dike is the main component to allow for open-to-lake conditions without flooding lands north of the BR/ALR site.

Preliminary cost estimates

Initial reconnaissance planning level cost estimates are included in some of the preliminary site planning materials. However, any construction and life cycle cost estimates provided in these early planning reference materials are intended for relative comparative purposes only and should be reviewed only within the context and limitations in which they were derived. Reclamation planning guidelines describe how initial rough cost estimates are refined through each subsequent stage of planning and design (Reclamation, 2009b).

Preliminary and appraisal level cost estimates are intended primarily to provide an initial basis to evaluate and compare planning alternatives. The estimates include substantial contingency allowances to account for various uncertainty factors and are therefore not well-suited or appropriate for use in budget projections or direct funding purposes. More detailed feasibility level planning and final design stages are necessary to progressively refine project cost estimates.

Notes on reference documents assembled

The purpose and major findings for each of the reference materials assembled is provided in the following briefing notes sections. More detailed information on the site historic background, existing site conditions, and planning considerations is available in the first document listed—the BR/ALR Preliminary Site Planning Report, Part 1 (Reclamation, 2009a).

1.0 Preliminary site planning studies

Three planning studies cited as BR/ALR preliminary site planning (Part 1, Part 2, and Part 3) focus on site characterization, formulation of site restoration options, and subsequent evaluations of the site option attributes.

1.1 BR/ALR Preliminary Site Planning; Part 1 – The full title of this report is: "Restoration and Potential for Enhancing Wetland Values at the Barnes Ranch and Agency Lake Ranch Sites" (Reclamation, 2009a). This report provides useful background information on the BR/ALR site conditions, planning considerations, evaluation methods, and the first stage of preliminary site planning investigation results.

Four options with a total of sixteen variations were evaluated. These site option variations range from the containment dike breaching to produce open-to-lake conditions with minimal site work, to options that apply a temporary period of water control operations to restore the subsided site lands and additional site work to enhance wetland restoration rates and habitat values for fish or wildlife. These options offer the potential to contribute to wetlands restoration goals in the UKL basin and also considered the potential for enhancing wetland values for reserve mitigation credit and integrated resource planning.

Investigations included site hydrology, water level inundation, water volumes and drawdown pumping rates, preliminary layout of site features for each option, and quantity estimates for defined option strategies and physical features. All options considered the ultimate condition of breaching existing containment dikes along Agency Lake on the east side of the site area and some internal site earthwork to create small fish pathways to avoid fish entrapment in low-lying areas. Existing pump facilities would be removed and other existing water structures would either be demolished or buried on-site.

The difference between the options formulated in the report concern the amount of initial site work done to enhance restoration and immediate dike breaching versus applying water control for an initial period to help restore subsided lands.

A complete array of sixteen variants for the four options applied to each of four site sub-unit areas was evaluated to screen options for future studies. All options were evaluated on an equitable basis, and quantity estimates are provided for each of the four priority options identified. Cost data are not presented and as a result, this report provides a general purpose view of conditions and concepts that can be used in subsequent, more detailed site planning investigations.

1.2 BR/ALR Additional Site Planning; Part 2 – Preliminary site planning was extended to assess certain issues in more detail. These findings are summarized in: “Resource Management Considerations and Options for the Barnes Ranch and Agency Lake Ranch Sites" (Reclamation, 2009b), an internal report prepared for planning purposes that was not produced for open distribution.

These additional site planning studies addressed several issues. First, an option involving long term active water storage operations was formulated to provide a reference or boundary condition for evaluating all options. Secondly, preliminary level cost estimates were prepared for the current five options (four identified in Part 1 preliminary site planning and the new dedicated water storage option). In addition, the option review and in particular, the storage option resulted in more detailed assessment of the north dike as a major feature and cost component for all options. North dike planning considerations are also addressed in the separate site geology survey and north dike planning studies described in the initial field investigation reports described below. Finally, these Part 2 site planning efforts included an initial review of the basis for assessing economic benefits for either on-site water storage or environmental restoration.

The purpose of this effort was to address questions raised during the initial Part 1 site planning and to obtain additional information on aspects that could be used later in subsequent planning stages. If site planning were to proceed to the next stage, all of the initial information, findings and supplemental studies could be reviewed at that time. As a result, the materials in this report reflect a compilation of data and information and are not a defined planning stage report.

Several attachments to this report provide supplemental materials useful for site planning. In particular, the attached Reclamation directives and standards section on cost estimating describes how cost elements and allowances for contingencies are applied. This document also summarizes the project design planning process and how initial cost estimates are refined through each subsequent planning and design stage from preliminary, appraisal, feasibility, percent design stages, and ultimately to funding and independent cost estimates (Reclamation, 2009b).

1.3 BR/ALR Appraisal Review Option1; Part 3 – Information collected during the third BR/ALR site planning effort is summarized in the smaller paper entitled: "Summary Findings 1/4/10; Barnes Ranch/Agency Lake Ranch Site Planning—Option 1: Open-to-lake; Minimum Site Work" (Reclamation, 2009c).

This effort centered on refining site plans for Option 1 as the minimal approach to breach site perimeter dikes and re-establish the historic open-to-lake hydrologic conditions. Criteria applied in the previous site planning studies were reviewed and quantities and cost estimates for the north dike reconstruction work (or other means to address the potential for flooding to the north) were itemized so that the costs associated with the north dike could be considered independently from the essential BR/ALR dike breaching and internal site restoration work.

The summary findings paper describes the site planning review, including the site geology survey and separate north dike design investigations that are presented in respective supplemental reports. Option 1 cost estimates and separated estimates for the north dike construction and the internal site restoration and dike breaching work are also attached to this summary findings paper.

2.0 Wetlands delineation reports

Results from jurisdictional wetlands delineation surveys conducted on the BR and ALR sites are summarized in the following two reports. In 2009, the two reports were submitted to the Oregon Department of State Lands (DSL) and also to the U.S. Army Corps of Engineers (COE) for review. Reclamation has received letters from the COE and from DSL that indicate concurrence with the delineation findings (property reference materials 4.4). These wetlands delineation reports and determinations are a primary reference for future site planning efforts.

2.1. Wetlands delineation report; BR Site area – A wetlands delineation and functional assessment for the BR site were completed by a certified delineation contractor. The delineation results are summarized in the report: "Barnes Ranch Parcel Wetlands Delineation" (North State Resources, 2007).

The results found that within the 2,631 acre Barnes Ranch study area, 2,540 acres were mapped as freshwater emergent wetlands (Cowardin, 1979), with 49 acres as "waters" in the form of ditches and drainage canals, and the remaining 42 acres are upland habitat associated with perimeter dikes. Some habitat differences within the freshwater emergent wetland type were observed due to variations in dominant vegetation composition, percent cover, and topography conditions that can influence localized hydrology.

This report is considered a primary reference for characterizing existing wetlands and related conditions at the BR site.

2.2. Wetlands delineation report; ALR Site area – A wetlands delineation and functional assessment for the ALR site were conducted by Reclamation Technical Service Center (TSC). Results of this investigation are summarized in the report: "Agency Lake Ranch Wetlands Delineation" (Reclamation, 2009d). This report has separate files for the main text and five appendices that provide the supporting maps and figures, individual test point field data sheets, site photographs, plant species list, and the functional assessment.

Results of the wetlands delineation indicate that within the 7,087 acre total ALR site area, 6,635 acres (94%) consist of palustrine emergent seasonally flooded or palustrine aquatic bed semipermentantly flooded wetlands areas. Approximately 356 acres are non-wetland open water canals and ditches (man-made excavated riverine). The remaining 96 acres are upland areas associated with containment dikes and roads.

The hydrogeomorphic functional assessment found predominantly a depressional (low lying catchment) wetlands classification. It should be noted that most of the site lands lie below the normal water surface of the adjacent Agency Lake (contiguous with UKL) and the site hydrology is presently regulated by seasonal pumped drawdown. Restoration strategies are expected to directly influence the site wetlands habitat and functional attributes in response to the established hydrologic conditions.

This report is considered a primary reference for characterizing existing wetlands and related conditions at the ALR site.

3.0 Initial site field investigations

Reclamation also conducted field surveys and initial engineering investigations to obtain information useful in site management and planning. Supplemental reports were produced to document the findings of these studies and identify additional information needs for future site planning efforts.

3.1. BR/ALR site geology survey report – This initial geology survey was conducted by the Reclamation Mid-Pacific (MP) Regional Office primarily to assess conditions that could affect dike breaching or new dike construction work as part of the restoration planning. Findings are summarized in the report titled: "Geological Inspection and Evaluation of Agency Lake and Barnes Ranch Dikes; June 2 and 3, 2009" (Reclamation, 2009e).

The BR/ALR field geology survey was limited to surface inspections to generate baseline information. Additional data collection could be necessary as part of future site planning stages. Additional studies could include, subsurface data from drilling bore logs, soils sampling tests, pressure tests, and lab or in-situ seepage analysis. This report provides a summary of the geological conditions and important planning factors. The figures, maps, and photos provided in this report also give additional insight into the existing site conditions.

This report was reviewed as part of the preliminary site planning (Part 3) and the findings were considered consistent with the preliminary site plan concepts and resulting quantities used in preliminary level cost estimates.

3.2. BR/ALR north dike design planning – This report describes existing site conditions and the engineering design parameters associated with reconstructing the containment dike along the north side of the Barnes Ranch and Agency Lake Ranch properties. Initial engineering planning for the BR/ALR site north dike was conducted by the Reclamation MP Regional Office to protect adjacent private lands from inundation if the BR/ALR properties were restored to the historic open-to-lake hydrologic conditions. Findings of this initial design planning effort are summarized in the report titled: "Agency Lake Farmland Unit Project" (Reclamation, 2009f).

Separate cost estimates were prepared for the new north dike so that this work could be considered independently in future studies. For example, the north dike work could be pursued separately from internal site restoration or dike breaching work or these estimates might be useful to assess other approaches such as purchasing lands to the north, securing a flood easement, or obtaining insurance to address the potential damage from flooding at high lake levels. Separating the north dike also helps to directly compare cost estimates for the site options considered.

3.3. Wood River Ranch dike survey report – Reclamation conducted this initial inspection survey in conjunction with the Bureau of Land Management (BLM) to evaluate the integrity of the existing containment dike surrounding the Wood River Ranch property. This initial study was undertaken when Reclamation and BLM were considering the potential for cooperative efforts to restore or manage the adjacent Wood River Ranch and BR/ALR sites. This initial evaluation was completed by the Reclamation MP Regional Office and the study findings are summarized in: "Geologic Inspection and Evaluation of the Wood River Ranch Dikes" (Reclamation, 2009g). The Wood River Ranch property is located on the east side of Seven-mile Canal, adjacent to and northwest of the ALR site.

3.4. Existing site debris survey report – Reclamation conducted this survey to prepare for site cleanup and restoration. The survey mapping and inventory list of debris found at the BR/ALR site are printed in the paper: "Barnes Ranch and Agency Lake Ranch – Site Debris Survey (Reclamation, 2009h).

4.0 Property reference materials

Additional reference materials for the BR/ALR properties include administrative, interagency, and regulatory documents pertaining to the property acquisition, site planning, property transfer, and management activities by Reclamation. These reference materials include a number of documents scanned from originals and compiled into the reference document entitled: "Barnes Ranch and Agency Lake Ranch – Property Reference Information" (Reclamation, 2009i).

4.1 BR/ALR site activities update and fact sheets – Includes an outline summary table A1 that shows site management activities and studies completed for the BR and ALR sites. Separate 1-page fact sheets for the BR and ALR sites with a general site overview and water storage attributes are also included.

4.2 Interagency property transfer agreements – Includes the 2006 and 2007 agreements between Reclamation, FWS, and The Nature Conservancy regarding property acquisition and transfer to the FWS. These provisions are also indicated in the final Klamath Basin Restoration Agreement, Section 18.2.2. Also includes a recent letter indicating the FWS assumes responsibility for any cultural and archeological resource issues after property transfer.

4.3 Environmental compliance documents – Includes the Categorical Exclusion Checklist completed for the transfer of the BR/ALR properties for compliance with NEPA and other related environmental compliance documents.

4.4 Wetlands delineation agency review correspondence – Includes written correspondence for the submittals and resulting concurrence letters from the COE and DSL regarding the wetlands delineation report findings.

4.5 Reclamation original property acquisition documents – Includes some of the original property acquisition documents, authorization documentation, fund appropriations, and administrative reference materials.

2010 BRALR Property Reference Package – Electronic File Index	May, 2010
Disc 1 BRALR Reference Reports	
1. Preliminary Site Planning	
1 BRALR P1 PrelimSitePlan.pdf	Planning Report: *"Restoration and Potential for Enhancing Wetlands Values at the Barnes Ranch and Agency Lake Ranch Sites"*
2 BRALR P2 AddedSitePlan.pdf	Planning Notes: *"Resource Management Considerations and Options for the Barnes Ranch and Agency Lake Ranch Sites"*
3 BRALR P3 ApprPlanOpt1.pdf	Planning Notes: *"Barnes Ranch/Agency Lake Ranch Site Planning—Option 1: Open-to-lake; Minimum Site Work"*
2. Wetlands Delineation Reports	
1 BR Wetland Delin Report.pdf	Technical Report: *"Barnes Ranch Parcel Wetlands Delineation"*
2 ALR Wetland Delin Report.pdf	Technical Report: *"Agency Lake Ranch Wetlands Delineation"*
2a ALR AppA MapsFigs.pdf 2b ALR AppB FieldForms.pdf 2c ALR AppC SitePhotos.pdf 2d ALR AppD PlantSpecies.pdf 2e ALR AppE FuncAssess.pdf	Appendices in separate files (includes large scale insert map)
3. Initial Site Field Investigations	
1 BRALR Geology MP Study.pdf	Technical Report: *"Geological Inspection and Evaluation of Agency Lake and Barnes Ranch Dikes; June 2 and 3, 2009"*
2 BRALR NorthDike MP Study.pdf	Technical Report: *"Agency Lake Farmland Unit Project"*
3 WRR DikeSurvey MP Study.pdf	Technical Report: *"Geologic Inspection and Evaluation of the Wood River Ranch Dikes; December 8, 2009"*
4 BRALR Site Debris Survey.pdf	Site Survey Notes: "*Barnes Ranch and Agency Lake Ranch – Site Survey of Existing Debris"*
4. Property Reference Materials	
1 Property Reference Compilation.pdf Contents:	Compiled Reference Materials: *"Barnes Ranch and Agency Lake Ranch – Property Reference Information"*
A. ALR & BR Site Status and Fact Sheets 20091207 ALR BR Activities 20090826 ALR Fact Sheet 20090827 BR Fact Sheet	A. Briefing notes on site conditions and management during recent years of seasonal water storage operations
B. Interagency Agreements and Status 2006 Cooperative Agreement 2007 ALR BR Interagency MOU 2010 KBRA Section 18_2_2 2010 FWS S106 Lead Agency	B. Interagency agreements, correspondence, and excerpts pertaining to property acquisition, transfer, and long term resource management
C. NEPA CEC and Supporting Documents 2010 CEC-010 Signed 01_12	C. National Environmental Policy Act – Categorical Exclusion Checklist and supporting materials
D. Wetlands Delineation Correspondence 20091029 COE Submittal ALR 20091029 COE Submittal BR 20091203 COE ALR Concur 20091203 COE BR Concur 20091029 DSL Submittal ALR BR 20100304 DSL ALR Concur 20100304 DSL BR Concur	D. Wetlands delineation submittals and letters received from COE and DSL that signify concurrence with delineation survey findings
E. ALR & BR Property Acquisition Materials 1998 ALR Congressional Authorization 20030905 ALC Call for Fed Funding BR 20040325 ALC Willing Seller Price BR 20041109 BR Appraisal Request 2006 Barnes Acquisition Package	E. Miscellaneous correspondence and excerpted documents pertaining to BR and ALR property purchase

Disc 2 BRALR Data Appendices

1. Aerial Photo Base Mapping	
1 BRALR Aerial Photo Series	BRALR Aerial Photo History shows site condition at: 1940, prior to agricultural use; 1997, during livestock operations; and 2006 during current seasonal water storage operations Also includes aerial photographs taken from low flight level showing the flooded site areas next to the Upper Klamath NWR
2 ALRBR1940SidImage 3 NAIP20062mAerials	Geo-referenced aerial photography data files – file names indicate the year of the reference aerial photography: 1940 – Prior to extensive conversion to agricultural uses 2006 – Seasonal water storage; after drawdown; 2meter
2. LiDAR Topography Survey	
1 BRALR Full Elevation Grid	LiDAR Topographic survey base mapping for regional area around the BR, ALR and Wood River Ranch
2 BRALR 4units Clipped Topo	Topographic mapping clipped into the four identified unit areas for the Barnes Ranch and three Agency Lake Ranch units
3 WR LiDAR Survey Report.pdf	Original reference report for the LiDAR aerial survey mapping of the Wood River area; coverage included BR and ALR properties
4 Metadata alrbrnsborft.htm	Metadata reference information for the mapping and datum
3. GIS Hydrology WSEL Zones	
1 Selected WSEL Zones	Geographical Information System (GIS) layer files that illustrate the Water Surface Elevation (WSEL) relative depth zone maps that are shown in the Preliminary Site Planning (P1 report) Includes layers that show defined wetlands zones for WSEL 4135, 4135.5, 4136, 4136.5, 4137, 4137.5, and 4142.5 in reference to the annual low WSEL for select hydrological water years
4. GIS Wetlands Delineation Data	
1 ALR Coverage	GIS layer files that support the ALR Wetlands Delineation Report
2 ALR Boundary Points 3 ALR Sample Points	File names indicate the GIS coverage in each series including the overall coverage site area, the boundary points, and the sample points defined during the field survey work
5. GIS Site Debris Survey Data	
1 BRALR Site Debris Survey	GIS geodatabse that provides location information for the debris described in the site debris survey report
6. GIS Combined Geodatabase	
1 BRALR Geodatabase	GIS combined geodatabase that includes the site Lidar topographic base mapping and related GIS data files above (aerial photo base mapping and example WSEL layer files are separate)

APPENDIX F

Long Lake Valley Reservoir Appraisal Studies

- **Memorandum indicating final status of the Long Lake Valley reservoir appraisal studies completed in 2010**

KO-300
PRJ-1.10

MEMORANDUM

To: Regional Director, Mid-Pacific Region, Sacramento, SA
Attn: Donald Glaser

From: Susan M. Fry
Area Manager

Subject: Special Report, Long Lake Valley Appraisal Studies Conclusion

The draft Upper Klamath Basin Offstream Storage (UKBOS) Initial Alternatives Information Report (IAIR), as authorized under the Enhancement Act of 2000, recommended that appraisal level studies be conducted on the Long Lake Valley (LLV) surface-water-storage reservoir option. Studies and investigations for the LLV option have been completed and are included in the Final Long Lake Valley Offstream Storage Appraisal Report.

Some pre-feasibility level studies have also been completed, including a LLV facilities configuration optimization study. Those studies addressed optimal water conveyance features (canal, tunnel), water quality and pump-generation facility configurations. Paper copies of the final appraisal and optimization study reports were provided to Mid-Pacific Regional staff on November 2, 2010, during a Regional Director's Office presentation on the LLV Appraisal study findings.

Appraisal study findings include that depending on the alternative, construction cost estimates range from $548M to $2.3B in 2009 dollars. As such, repayment capability would likely require development of a multiple-purpose project. Power generation was considered as part of the project and was presented to various potential private-market and government (eg, BPA) partners. Unfortunately none expressed interest because of the limited head created by the facility. The Klamath Basin Hydro-Economics Model (KB_HEM) was used to determine the long-term benefits over a 50-year period. The results were a direct annual irrigation benefit equal to $1.2 million. Qualitative analysis was conducted and showed a very small benefit for the annual fisheries improvements in the Klamath River from LLV deliveries. At this time, data was insufficient to perform quantitative analyses on fishery benefits. Overall economic analyses results show the benefit/cost ratio (B/C) for the entire range of LLV alternatives studied is 0.01 to 0.04.

Local irrigation representatives including Klamath Water Users Association and Klamath Water and Power Agency representatives, Klamath County Commissioners, and Klamath Basin Tribes were invited to participate in a LLV briefing in late November 2010. Irrigation representatives, Klamath County Commissioners, and Karuk Tribe representatives participated in the presentation. Paper copies of the final appraisal and optimization study reports were given those in attendance. They were informed that due to the low B/C ratio, further Federal planning studies for LLV are not warranted.

Stakeholders were further informed that a second draft IAIR with recommendations will be available in 2011. If B/C ratios are favorable, Reclamation will continue investigations of the top several UKBOS options for appraisal level studies. If appraisal studies are conducted for the UKBOS top options, the B/C ratio would be used to determine Federal interest. Appraisal studies could be finished in 2012-13.

If you have any questions, please contact Stan Mattingly or Jon Hicks at 541-883-6935.

Cc: Al Switzer
Craig Tucker
Larry Dunsmoor
Kyle Gorman, OWRD
Barry Norris, OWRD
Greg Addington, KWUA
Hollie Cannon, KWAPA
Earl Danosky, TID
Mark Stuntebeck, KID

APPENDIX G

Deming Creek Initial Reconnaissance Studies

- **Status report on the initial reconnaissance site evaluation studies completed for the Deming Creek storage concept**

Deming Creek Alternative (s)

Three potential reservoir sites were investigated on Deming Creek, a tributary to the South Fork of the Sprague River in eastern Klamath County, Oregon. A report prepared by Wildlands Inc, Sept 2009 discusses issues related to the Deming Creek Ranch Management and Restoration Plan. The Deming Creek Ranch is a private operation which has shown interest in restoration of native fish species and riparian habitats. Potential damsites for the reservoirs are shown on the Figure 2. Representatives of the Deming Creek Ranch contacted Reclamation staff in late 2009 to inquire about the interest in investigating potential reservoir sites on Deming Creek Ranch owned and managed lands. Reclamation staff toured the potential reservoir sites in early December, 2009.

Figure 1 - Photo of Reservoir site # 2 and of the general rolling terrain nature of the Deming Creek Ranch lands.

Investigation Results

Hydrology issues

There are no stream gaging stations in the Deming Creek watershed so it is not currently known what the average annual hydrologic yield would be. If feasibility planning studies of the Deming Creek Ranch reservoir sites were to be pursued further, hydrologic yield analyses would need to be performed. The Management and Restoration Plan discusses the potential for improvements to the nearby Campbell Reservoir so it is assumed by Reclamation staff that adequate water supplies exist to fill it on an average annual basis.

Reservoir Wetland Impact Issues

Reservoir site #2 could potentially impact 140 acres whereas reservoir site # 3 could potentially impact 12 acres of wetlands. Any potential impacts may require the acquisition of land and water to be dedicated to construction and operation of mitigation wetlands. Cost for land acquisition and wetland construction are not included in this scoping.

Dam and reservoir design details

The 2 largest potential reservoirs on Deming Creek Ranch, Reservoir Site # 2 (middle reservoir) and Reservoir Site # 3 (highest in elevation and farthest east) on Figure 2 would hold volumes of up to 2600 and 2800 af respectively. A preliminary cost analysis for a dam at the potential reservoir sites used a cost estimate for the Torrent Springs dam and reservoir UKBOS alternative for a comparative basis (TSC Reclamation, 8/2009). The preliminary design for both reservoir sites would situate the dam(s) on Deming Creek, utilize embankment fill for the impoundment structure(s), would need an outlet works and an emergency spillway to pass normal irrigation releases and high flows safely, and would need a fish passage structure such as a fish ladder.

As in the design for Torrent Springs UKBOS dam alternative, the spillways for either site would consist of a uncontrolled ogee crest with a concrete chute and stilling basin type structure. The outlet works would be a concrete conduit with a gate structure located at the upstream end necessitating a bridge to safely allow access for O&M staff. For either damsite, the spillway would be approximately half the size of the Torrent Springs dam, where the outlet works is judged to be nearly the same size as for Torrent Springs and the fish ladder is judged to be half the size of the Torrent Springs dam design.

Damsite 2 design impoundment structure (dam) characteristics:

Hydraulic height: 52 ft

Structural Height: 65 ft

Dam length at Normal Reservoir WS: 2140 ft

Structural crest length: 2550 ft

Constructed volume:

Elevation (ft)	Area (ft2)	Ave area (ft2)	Volume (cy)
4545	51000		
		480500	445000
4520	910000		
		835000	618500
4500	760000		
		542500	401851
4480	325000		
			1.5 M CY

Damsite 3 design impoundment structure (dam) characteristics:

Hydraulic height: 128 ft

Structural Height: 150 ft

Dam length at Normal Reservoir WS: 740 ft

Structural crest length: 1000 ft

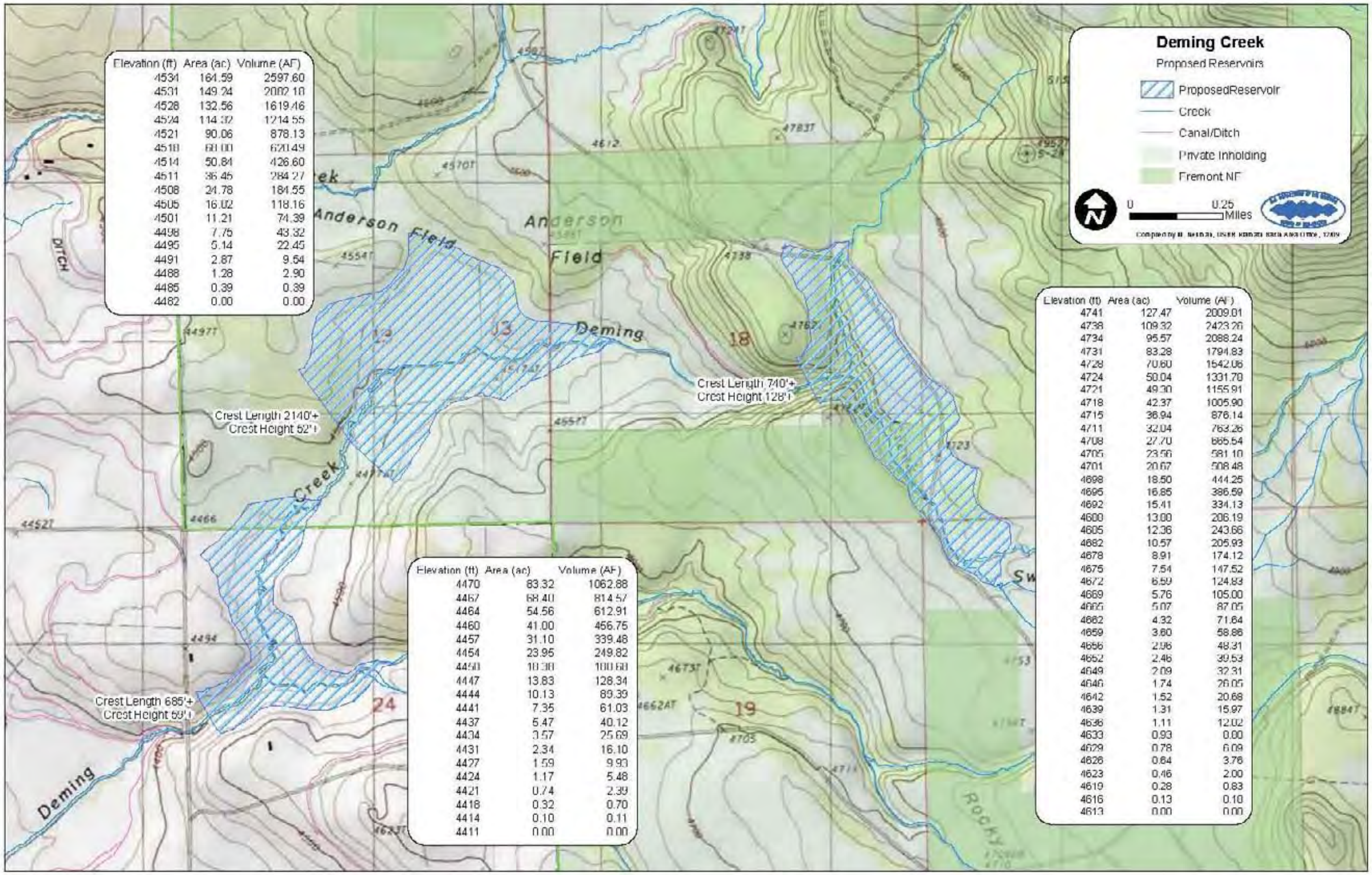
Constructed volume:

Elevation (ft)	Area (ft2)	Ave area (ft2)	Volume (cy)
4745	20000		
		79895	133160
4700	139790		
		135980	201450
4660	132174		
		80090	177980
4600	28015		
			512590 CY

The cost analysis for both individual damsites is shown in the following table:

Torrent Springs UKBOS alternative	Deming Creek #2 damsite (2600 af)	Deming Creek #3 damsite (2800 af)
Dam volume 620K CY – cost = $33M	Dam volume 1.5 M CY – cost = $40M	Dam volume 513K CY – cost = $30M
Spillway – cost = $18M	$10M	$10M
Outlet works tunnel, gate tower, gate structure and gate, and gate bridge – cost = $11M	$10M	$10M
Electrical and access roads - $5M	$5M	$5M
Fish ladder – cost = $20M	$10M	$10M
	Total cost - $75M	Total cost - $65M
	Total w/mobilization (@5%) = $78.3M	Total w/mobilization (@5%) = $68.3M
	Total w/ design contingencies (@25%) = $95.3M	Total w/ design contingencies (@25%) = $85.3M
	Total w/ construction contingencies (@25%) = $117M	Total w/ construction contingencies (@25%) = $107M
	Total w/ non-contract costs (@40%) = $160M	Total w/ non-contract costs (@40%) = $150M
	Construction cost = $160M	Construction cost = $150M
	Cost/af stored = $61,538/af stored	Cost/af stored = $53,571/af stored

The cost/af stored figures for the two largest potential Deming Creek Ranch reservoir sites as tabulated above do not compare favorably with any of the other UKBOS alternatives. In addition the construction costs do not include mitigation wetlands which are very likely to be needed for construction of the potential reservoirs. Were these costs added into the above costs, the total reservoir project construction costs would be higher and, subsequently, the cost/af stored would be higher. Therefore, no further feasibility planning studies or investigations into Deming Creek Ranch reservoir sites is recommended at this time.



Elevation (ft)	Area (ac)	Volume (AF)
4534	164.59	2597.60
4531	149.24	2002.10
4528	132.56	1619.46
4524	114.32	1214.55
4521	90.06	878.13
4518	68.00	620.49
4514	50.84	426.60
4511	36.45	284.27
4508	24.78	184.55
4505	16.02	118.16
4501	11.21	74.39
4498	7.75	43.32
4495	5.14	22.45
4491	2.87	9.54
4488	1.28	2.90
4485	0.39	0.39
4482	0.00	0.00

Elevation (ft)	Area (ac)	Volume (AF)
4470	83.32	1062.88
4467	68.40	814.57
4464	54.56	612.91
4460	41.00	456.75
4457	31.10	339.48
4454	23.95	249.82
4450	18.38	180.68
4447	13.83	128.34
4444	10.13	89.39
4441	7.35	61.03
4437	5.47	40.12
4434	3.57	25.69
4431	2.34	16.10
4427	1.59	9.93
4424	1.17	5.48
4421	0.74	2.39
4418	0.32	0.70
4414	0.10	0.11
4411	0.00	0.00

Elevation (ft)	Area (ac)	Volume (AF)
4741	127.47	2009.01
4738	109.32	2423.26
4734	95.57	2088.24
4731	83.28	1794.83
4728	70.60	1542.06
4724	50.04	1331.70
4721	49.30	1155.91
4718	42.37	1005.90
4715	36.94	876.14
4711	32.04	763.26
4708	27.70	665.54
4705	23.56	581.10
4701	20.67	508.48
4698	18.50	444.25
4695	16.85	386.59
4692	15.41	334.13
4600	13.00	206.19
4605	12.36	243.66
4682	10.57	205.93
4678	8.91	174.12
4675	7.54	147.52
4672	6.59	124.83
4669	5.76	105.00
4665	5.07	87.05
4662	4.32	71.64
4659	3.60	58.86
4656	2.96	48.31
4652	2.46	39.53
4649	2.09	32.31
4646	1.74	26.05
4642	1.52	20.68
4639	1.31	15.97
4636	1.11	12.02
4633	0.93	0.00
4629	0.78	6.09
4626	0.64	3.76
4623	0.46	2.00
4619	0.28	0.83
4616	0.13	0.10
4613	0.00	0.00

APPENDIX H

Sycan River–Torrent Spring Dam Site–Preliminary Geologic Investigation, August 2007

RECLAMATION

Managing Water in the West

Sycan River
Torrent Spring Dam Site
Preliminary Geologic Investigation

KLAMATH FALLS PROJECT – OREGON

August 2007

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Geology Branch, MP-230

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Torrent Spring Dam Site
Preliminary Geologic Investigation

Mike McCulla, MP-230

August, 2007

INTRODUCTION

Reclamation's MP-230 Geology Branch was requested to conduct a site inspection of the Torrent Spring area on Sycan River. This area has previously been discussed as the potential location of an on-river water storage project.

LOCATION

Sycan River, a tributary of the Sprague River, is located in the Fremont and Winemma National Forests about 45 miles (~80 road-miles) northeast of Klamath Falls Oregon. Torrent Spring is in Section 22, T33N, R12E (Figure 1). The water flows from natural springs at the Torrent Spring site into Sycan River from the north side of the canyon.

ACCESS

Access to the north side of Sycan River and Torrent Spring is from Klamath Falls, OR via paved roads 60- to 70-miles, either northwest on Hwy. 97 through the town of Chiloquin, or northeast on Hwy. 140 through the town of Beatty. Where pavement ends, access is via a well maintained two lane Forest Service gravel road (#46) to within 2-miles of the area, and then on unimproved one lane dirt roads (#4660 & #4670) to the canyon rim above Torrent Spring. The springs are about 150 feet below the canyon rim, 20 feet above the river. Access to Sycan River and Torrent Spring requires hiking down a steep slope with several 10- to 30-ft. high cliff faces. Safe descent from the canyon rim is best made along game trails, avoiding vertical cliff faces.

Access to Torrent Spring from the south side of Sycan River is from Klamath Falls, OR via paved roads 60- to 70-miles northeast through the town of Beatty, then via a series of improved gravel two lane and unimproved one lane roads to the canyon rim From the canyon rim it is an easy hike down gentle slopes to Sycan River.

PURPOSE

The purpose of the current work was a preliminary geologic site characterization to:

- Identify major geologic units.
- Determine the physical properties of rock on both abutments.
- Record major joint/shear orientations and spacing.
- Identify access routes for future possible subsurface investigations, such as drilling and permeability testing.

INVESTIGATIONS

PREVIOUS INVESTIGATIONS

During the summer of 2000, water resources along the Sycan River, from Sycan Marsh, located about 6 miles upstream of Torrent Spring, to its confluence with the Sprague River were identified and tabulated by J.L. La Marche for the Klamath Alternative Dispute Resolution Participants [Ref. 1].

Basic geology of the region is shown on the 1: 500,000 scale geologic map of Oregon State, compiled by Walker and MacLeod, 1991 [Ref. 2]. The 1-degree area surrounding and encompassing Sycan River was geologically mapped by D.R. Sherrod (1984-1985); [Ref. 3].

There are no known detailed geologic investigations of the Torrent Spring area.

CURRENT INVESTIGATIONS

Current investigations were carried out over a two day period (June 7 and 8, 2007), with one day each on the north and south sides of Sycan River.

<u>Scope of Work</u>

A brief literature search was made of geologic records in the Mid-Pacific Region Geology Branch (MP-230) files to determine if previous work had been carried out by Reclamation. No information on the Torrent Spring area was located. The regional scale a (1:500,000) geologic map [Ref. 2] was reviewed for basic geologic data.

A site visit was made to Torrent Spring to determine the extent of surface exposures in the area, and to collect preliminary geologic data. While there, it was determined that cliff faces on the north side of Sycan River provide excellent exposures of the local volcanic flows, and the opportunity was taken to construct a "measured section" of the local volcanic stratigraphy.

REGIONAL GEOLOGY

Topographically the Sycan River flows from the northeast to the southwest through a high plateau. The plateau covers an area about 25-miles by 25-miles, and is mostly composed of Tertiary age basalt flows. The plateau itself is relatively high, about el 5,000 feet, and Sycan River has cut a steep canyon 150- to 200-ft. into the volcanic rocks.

The volcanic plateau straddles a major structural zone that hosts numerous north-northwest striking faults and shears. Few faults have been mapped along Sycan River [Ref. 2]. This is potentially due more to the lack of good access and limited geologic mapping than it is to the absence of faulting.

Sycan River has cut a moderately deep canyon into the plateau, exposing a series of lava flows. These flows are mapped as 4- to 7-m.y. (million-year old) olivine basalt, basaltic andesite, and platy olivine andesite [Ref. 2]. The current work found most of the flows along Sycan River canyon to be composed of platy olivine andesite.

Regional Groundwater

The current site investigation did not include identification of the local groundwater flow regime or a literature review. However, a few basic observations were noted.

- In the canyon around Torrent Spring, Sycan River is at an elevation of about 4,900 feet.
  The regional groundwater system including Sycan River is being fed by higher groundwater surfaces within the 6,421-ft. high Hamelton Butte to the north, 6,331-ft. high Fuego Mtn. to the east, 6,421-ft. high Black Hills to the south, and by 6,175-ft. high Riverbed Butte to the southeast.

- These mountains and buttes are all greater than 1,000 to 1,500 feet higher than Sycan River, and individually are likely to host correspondingly high groundwater mounds.

- A dam on Sycan River with a crest to an elevation of about 5,040 feet is not likely to affect the regional groundwater gradient. Regional groundwater mounds associated with the various buttes and mountains surrounding Sycan River may be advantageous to a water storage project near Torrent Spring.

SITE GEOLOGY

The canyon walls around Torrent Spring expose a series of Tertiary-age lava flows. These flows are mostly andesitic in composition. Volcanic flows on both sides of the canyon, as well as the gentler talus slopes and interflow benches are covered to varying degrees with pumice and ash deposits explosively ejected from Mount Mazama 6,845 years ago [Ref. 2]. The ash is rhyodacite in composition and is mostly fresh to locally moderately weathered. Most of the ash and pumice has a visual classification of Silty Sand.

Numerous cliff faces form the canyon walls along the north side of Sycan River while the south side of the river hosts gentle, covered slopes. This difference in morphology is not due to a change in geology, but most likely weathering conditions, groundwater flow, and a variety of other physiographic variables. Because of this, exposures on the north side of the river are a good source of geologic information.

Measured Volcanic Section

An area on the north side of Sycan River was selected to map the local volcanic stratigraphy. Mapping took place about ½-mile downstream from Torrent Spring where lava flows form particularly good exposures from the canyon rim to the river about 160 feet below (Figure 1).

Mapping located good exposures of five individual volcanic flows, and a sixth less well exposed flow is also suspected to be present (Figure 2). All flows are composed of fine grained, platy olivine andesite (Toa). The designation Toa for Tertiary-age olivine andesite is used in the current investigation as a unit subdivision of the larger group designation Tob (Tertiary-age olivine basalt) of Walker and MacLeod, 1991 [Ref. 2].

The platy nature of the olivine andesite (Toa), shown in Photos 1 and 2, is a natural parting of the rock at, or near, the ground surface. At depth the platy parting will be much less distinct, less open, and importantly less of a path for groundwater flow.

Flow #1

This flow crops out along the rim of the canyon at an elevation of about 5,040 feet. It consists of platy olivine andesite (Toa) that forms a cliff face about 30 feet high (Photos 3, 4, and 5; Figure 2). The andesite is mostly fine grained to aphanitic with fewer than about 5% vesicles, maximum size about 5mm, that are locally filled with a white mineral (calcite?). The andesite flow is roughly sub-horizontal to dipping slightly northerly and is mostly fresh to slightly weathered and gray colored.

Andesite is cut by variably striking, widely spaced, vertical joint sets into rough 4 to 5 sided columns or blocks, many of which crop out over the entire height of the cliff face (Photos 4 and 5).

Table 1. Major joint directions in andesite flow #1, (observable on cliff faces).

Joint Direction (±10-degrees)	Spacing (feet)	Continuity (feet)	Photo Number	Remarks
East-West, V	3 to 15	30 to 50 or longer	2	Prominent joint direction forming cliff faces along the river. Joints tend to curve.
N50E, V	6 to 15	?	5	
N30W, V	6 to 15	?	5	
North-South, V	3 to 15	20 to 30	5	
Sub-Horizontal	3-inches to 3-feet		2 and 4	Platy parting at the surface.

The base of Flow #1 is not exposed. At the base of the cliff face there is a talus covered bench about 35-ft. wide, dropping 5-ft. before reaching the top of Flow #2.

Flow #2

The top of Flow #2 starts at an elevation of about 5,005 feet. It has a cliff face 21 feet high exposing platy olivine andesite (Photos 6, 7, and 8). This flow is similar in composition, joint direction, and joint spacing to Flow #1. The only significant difference is that near the base of Flow #2 (~el 4,986 to 4,992-ft.) there are up to 20% vesicles, many of which have been flattened or elongated in a sub-horizontal direction. Maximum vesicle length is about 20mm.

Flow #3

The top of Flow #3 starts at an elevation of about 4,979 feet. It has a cliff face 22 feet high exposing platy olivine andesite (Photo 9). This flow is similar in composition, joint direction, and joint spacing to Flows #1 & #2. The primary difference is that there are about 10% vesicles throughout, and up to 20% near the base of the flow (~el 4,957 to 4,963-ft.), where they are mostly flattened and up to 25mm long.

At the base of this flow there are a few small caves and an abundance of vegetation. This is suggestive of a groundwater exit; however, no water was observed at the time of mapping.

Flow #4
The top of Flow #4 starts at an elevation of about 4,952 feet. It has a cliff face 20 feet high exposing platy olivine andesite (Photo 10). This flow is similar in composition as Flow #1, but the joint spacing and regularity are not as distinct as in Flows #1, #2, and #3. In Flow #4, joint-bound blocks vary from 8-ft. to 2- to 3-ft. in size.

Flow #5
It is unclear if there is a distinctly separate Flow #5. What is known is that, between the base of Flow #4 and the top of Flow #6, there is a sloping bench about 60-ft. wide that drops about 20-ft. in height.

Since most of the flows mapped in this area are about 20-ft. thick, this 20-ft. high and 60-ft. wide bench is probably an individual flow. Due to the lack of outcrop little else can be said.

Flow #6
The top of Flow #6 starts at an elevation of about 4,912 feet. The flow has a cliff face 15-ft. high with one small bench about 4-ft. down from the top.

Flow #6 is of similar composition as the overlying flows and has a similar joint orientation, spacing, and continuity as present in Flow #1. However, instead of having east-west trending vertical joints the joint orientation is closer to about N75E,V.

Flood Plain and Sycan River
From the base of the cliff face of Flow #6 (~el 5,897-ft.) a 38-ft.-wide talus slope drops about 10 feet to a distinct flattening in gradient. This gradient change is most likely Sycan River's flood plain. From this gradient change it is an additional 50-ft. horizontally and a drop of 5-ft. to the active river channel.

SUMMARY

The measured section was located about ½-mile downstream from Torrent Spring. Volcanic flows that crop out at this location are sub-horizontal to dipping gently to the north. This is the same volcanic stratigraphy present at Torrent Spring.

The measured section was over a vertical distance of about 195 feet and a horizontal distance of about 245 feet (from the top of Flow #1 to Sycan River). Over this distance, 5 individual volcanic flows crop out with very good exposures of rock type, weathering, joint orientation, spacing, and continuity. One additional flow is suspected to be present, but is covered by talus.

The composition of all volcanic flows cropping out is olivine andesite. This type of volcanic lava has more silica in it than basalt, and thus forms thicker more massive flows

with wide to very widely spaced cooling joints. Several of the flows mapped show columns of massive rock 20 to 30 feet high with diameters 8- to 15 feet across.

Platy sub-horizontal parting of the volcanic rock is mostly controlled by flow banding in the lava. The platy (open) properties of the rock are best developed at, or near, the ground surface and openness is likely to decrease rapidly with depth and into the hill. Joint orientations in exposures along the cliff face form regular patterns (Table 1).

CONCLUSIONS

The following conclusions are based on surface exposures examined during a one-day-each visit to the north and south sides of Sycan River, near Torrent Spring. Some of these conclusions could change significantly if subsurface investigations are carried out.

- Geologically there are no readily observable fatal flaws at the proposed dam site on Sycan River, near Torrent Spring.
- In the areas examined, canyon walls along both sides of Sycan River are composed of hard, relatively fresh andesite that is structurally sound and should provide reasonably good abutments for a dam.
- Volcanic rock on the south side of Sycan River is not as well exposed as on the north side of the river, but limited south-side outcrops indicate that volcanic flows on both sides of the river are the same. It is also likely that volcanic flows on the south side of the river host joint orientations, spacing, and continuity similar to those found in flows on the north side of the river.
- The water retention characteristics of this rock are unknown, but based on surface exposures, permeability is largely fracture controlled and should be significantly lower than that of average basalt flows, such as those forming the abutments of Clear Lake and Gerber Dams and underlying their reservoirs.
- High buttes and mountains, and their associated groundwater mounds, around the Sycan River area may have a positive affect on groundwater flow out of the Sycan River canyon.
- If on-river water storage is desirable at this general location, and hydrologic studies indicate an adequate water supply, then additional surface and subsurface geologic investigations are warranted.

RECOMMENDATIONS

- Complete work necessary to identify the availability of water, and determine if that water supply is adequate to be considered as a viable option for future development as part of the Klamath Project.
- Determine the available area for storage, and develop area/capacity curves.
- Decide whether there is multi-agency support for a water storage project in this general location.

- If results of the above recommendations are positive, then conduct detailed geologic mapping and appraisal-level subsurface geologic investigations.

REFERENCES

[1] La Marche, J.L., October 2, 2000; Sycan River Synoptic Measurements from Sycan Marsh to the Sprague River; Prepared for Klamath Alternative Dispute Resolution Participants; KADR Hydrologist; Oregon Department of Water Resources; Oregon State.

[2] Walker, G.W., and MacLeod, N.S., 1991; 1:500,000 Scale Geologic Map of Oregon; United States Geological Survey.

[3] Sherrod, D.R., 1984-1985; Unpublished Mapping in the 42^o – 43^o Longitude and 121^o – 122^o Latitude area; United States Geological Survey.

Photographs

North Side of Sycan River

Photo 1. View of platy olivine andesite (Toa) at the top of Flow #1 (~el 5,040-ft.). Note the platy, 3- to 6-inch spaced sub-horizontal parting of the andesite. The openness of this rock should decrease substantially with depth. Photo by M. McCulla, June 7, 2007.

Photo 2. View of platy olivine andesite (Toa) near the top of Flow #1 (~el 5,035-ft.). Note the platy, sub-horizontal parting of the andesite and the widely spaced east-west trending joints paralleling the canyon. Photo by M. McCulla, June 7, 2007.

A

B

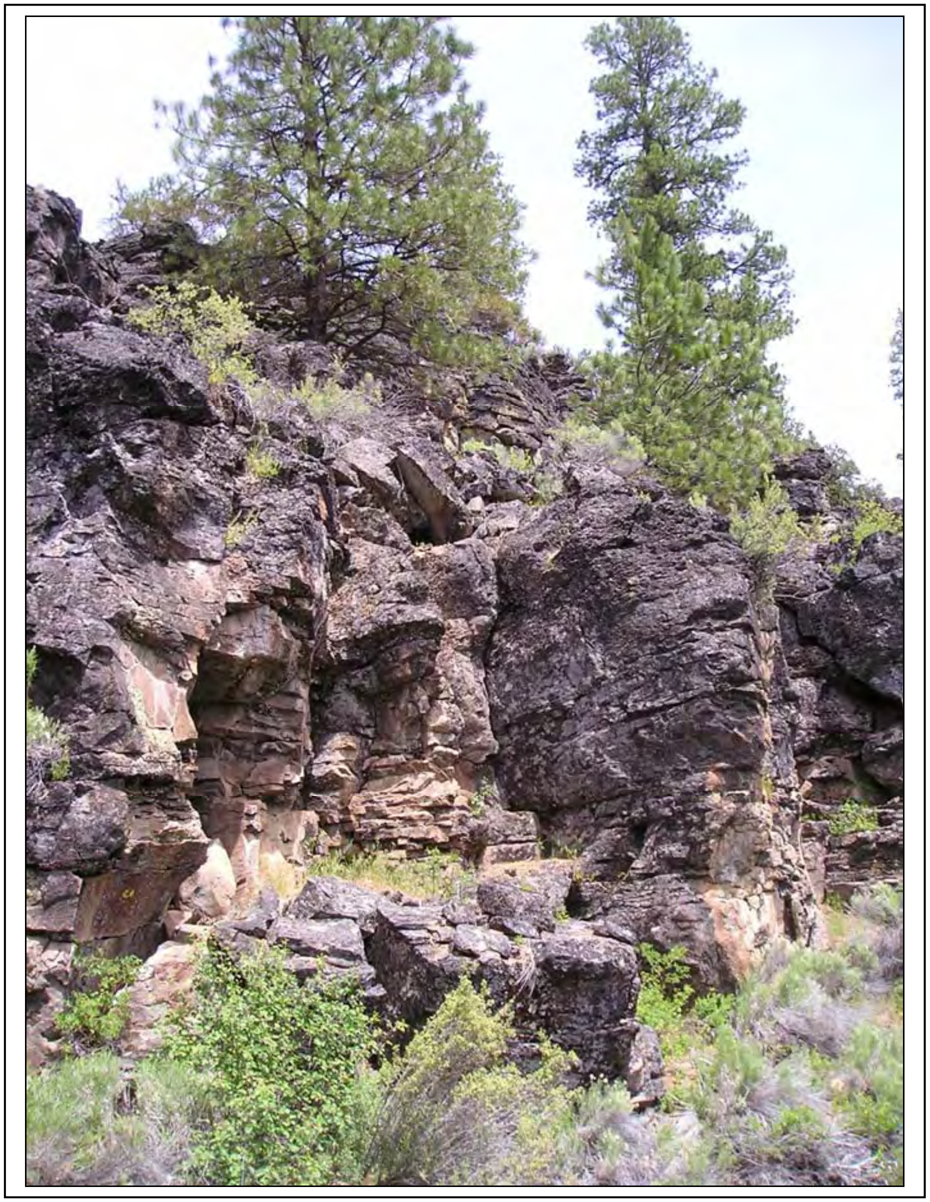

Photo 3. View of platy olivine andesite (Toa) cliff face of Flow #1. **A** – From the top of the flow looking upstream. **B** – From the base of the flow looking upstream. Note the platy, sub-horizontal parting of the andesite and the widely to very widely spaced joints. Photo by M. McCulla, June 7, 2007.

Photo 4. View of platy olivine andesite (Toa) taken from the base of Flow #1 (~el 5,010-ft.). Note the platy, sub-horizontal parting of the andesite and the widely spaced joints. Photo by M. McCulla, June 7, 2007.

Photo 5. View of platy olivine andesite (Toa) taken from the base of Flow #1 (~el 5,010-ft.). Note the platy, sub-horizontal parting of the andesite and the widely spaced joints. Photo by M. McCulla, June 7, 2007.

Photo 6. View of platy olivine andesite (Toa) exposed in a 21-ft. high cliff face of Flow #2. The base of the cliff is at about el 4,984 feet. Note the platy, sub-horizontal parting of the andesite and the widely spaced joints. Photo by M. McCulla, June 7, 2007.

Photo 7. View of platy olivine andesite (Toa) near the base of Flow #2. Here the platy, sub-horizontal parting of the andesite is tight with few open spaces. The paucity of open spaces between plates is likely typical of the andesite with increasing depth. Photo by M. McCulla, June 7, 2007.

Photo 8. View of platy olivine andesite (Toa) exposed in a 21-ft. high cliff face of Flow #2, with Flow #1 shown above the yellow dashed line. Joints in both flows are widely to very widely spaced. Photo by M. McCulla, June 7, 2007.

Photo 9. View of platy olivine andesite (Toa) exposed in a 22-ft. high cliff face of Flow #3. Note that the widely spaced joints form tall columns, many of which remain relatively intact when they fall off the cliff face. The platy nature of the andesite does not necessarily form through-going fractures. Photo by M. McCulla, June 7, 2007.

Photo 10. View of platy olivine andesite (Toa) exposed in a 12-ft. high cliff face of Flow #4. The full flow is at least 20-ft. thick, as seen about 20-ft. downstream of this photo. Photo by M. McCulla, June 7, 2007.

Photographs

South Side of Sycan River

Photo 11. View of platy olivine andesite (Toa) exposed in a 10-ft. high cliff face at about el 4,980-ft. across from Torrent Spring on the south side of Sycan River. Photo by M. McCulla, June 8, 2007.

Photo 12. View from the south side of Sycan River towards Torrent Spring on the north side of the river. Springs are identified by the abundance of green grass and shrubs at the base of an andesite flow (blue circles). Photo by M. McCulla, June 8, 2007.

Photo 13. View at Torrent Spring looking upstream along Sycan River. An outcrop of platy andesite is exposed in a 20-ft. high cliff face along the north side of the river. Photo by M. McCulla, June 8, 2007.

Photo 14. View at Torrent Spring looking downstream along Sycan River. Photo by M. McCulla, June 8, 2007.

Figures

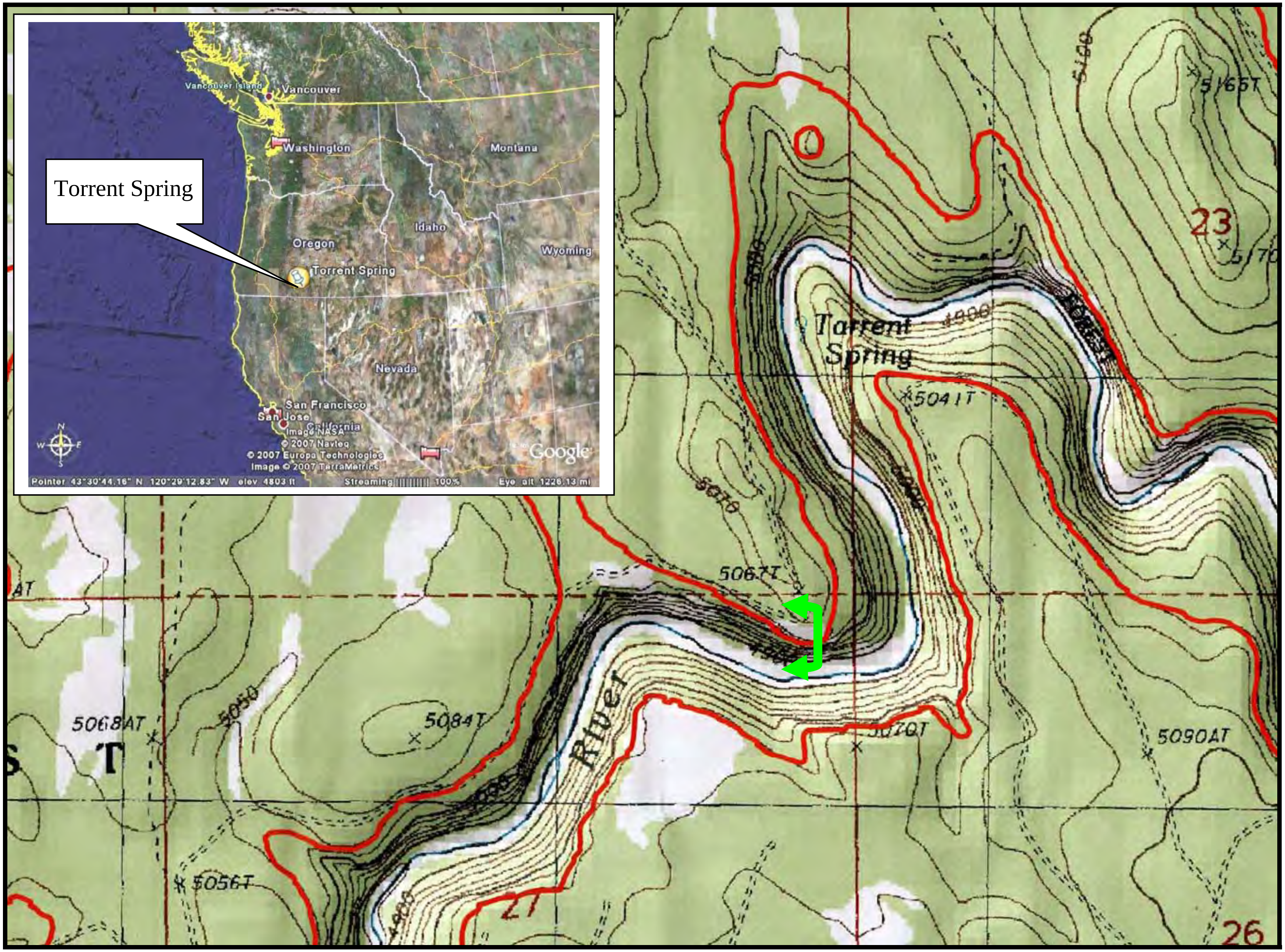

Figure 1. Location map showing Torrent Spring in Section 22, T33N, R12E on Sycan River. Location of the measured volcanic section (Figure 2) is shown by the green arrow.

APPENDIX I

Williamson River Canyon–Proposed Water Storage Site–Preliminary Geologic Investigation, August 2007

RECLAMATION

Managing Water in the West

Williamson River Canyon
Proposed Water Storage Site
Preliminary Geologic Investigation

KLAMATH PROJECT – OREGON

August 2007

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Geology Branch, MP-230

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Williamson River Canyon
Proposed Water Storage Site
Preliminary Geologic Investigation

Mike McCulla, MP-230

August, 2007

INTRODUCTION

Reclamation's MP-230 Geology Branch was requested by the Klamath Basin Area Office to conduct a site inspection of the Williamson River Canyon area. This area is being considered as the potential location of an on-river water storage project.

LOCATION

The Williamson River Canyon is located in the Upper Klamath Basin, within the Winema National Forest, about 22 miles north of Klamath Falls, OR (7 miles north of Chiloquin, OR). The proposed water storage project site starts in Section 25, T33S, R7E and extends upstream for about 3-½ miles (Figure 1).

ACCESS

Access to the west side of the Williamson River Canyon is from Klamath Falls, OR via State Hwy. 97. About one mile north of Collier the highway climbs to the top of a 400 foot high plateau. At the top of the hill, the first dirt road to the right is Forest Service road #9734. Access to the west side of the Williamson River Canyon is east along road #9734 for about 1 mile from Hwy. 97. Road #9734 turns north and generally follows the canyon rim for another ¾-mile, where a dry creek at Hilltop Reservoir marks the proposed location of the Williamson River Canyon water storage site.

Forest Service road #9734 is a one lane dirt road, not surfaced or maintained, and is on deep deposits of loose ash and pumice from Mt. Mazama. The road is mostly suitable to 4x4 vehicles or other high-clearance vehicles. Brush and tree limbs along the road will likely scratch most vehicle traveling the road.

To access the east side of the Williamson River Canyon, continue north on Hwy 97 about 4¼-miles from the Forest Service road #9734 to Forest Service road #43. Forest Service road #43 is an improved and well maintained two lane road with red cinder and ash road base. Road #43 crosses the Williamson River on a wooded bridge and continues to the railroad siding of Kirk. At Kirk an improved and maintained Forest Service road #4502 goes south to a cinder cone borrow area at Burnt Butte. The road parallels the east side Williamson River Canyon for about 3 miles to Forest Service road #9731. To continue paralleling the eastern side of the Williamson River Canyon it is necessary to take road

#9731 towards the railroad crossing at Calimus. About 1½-miles south of Calimus the road intersects Forest Service road #9730, and within one mile along that road there is another bridge crossing the Williamson River.

Forest Service roads #9730 and #9731 are one lane, unimproved, poorly maintained roads in deep, soft, pumice and ash deposits. Travel along these roads is not advised without a high clearance 4x4 vehicle. Travel is easiest from the north to south (uphill to downhill), and a vehicle is less likely to bog down in the soft pumice deposits.

PURPOSE

The purpose of the current work was a preliminary geologic site characterization to:

- Identify major geologic units.
- Determine the physical properties of rock units on both abutments.
- Record major joint/shear orientations and spacing.
- Identify access routes for future possible subsurface investigations, such as drilling and permeability testing.

PROPOSED WATER STORAGE SITE

The proposed water storage site is a steep canyon with walls 300 to 400 feet high (Photos 1-9). The narrowness of the canyon dictates that for a significant water storage capacity to be created, a dam would have to be high and the impoundment area would have to extend up-canyon a considerable distance (Table 1).

Table 1. Dam Height vs Capacity estimates for the proposed water storage site.

Capacity Estimate*		
Dam Height	Upstream Extent of Pool	Capacity (very rough estimate)
150 feet	5,700 feet (1+ mile)	5,700 acre-feet
200 feet	9,300 feet (1¾ mile)	12,800 acre-feet
300 feet	21,120 feet (4-miles)	58,200 acre-feet

* Estimate very rough using a hand calculator and a 1"=2,000' scale topographic map.

With canyon walls about 300 feet high, a dam height of 150 feet is both geologically and geotechnically reasonable for this location (Photo 9), although the storage capacity is very small. A dam with a height of 200 feet may be possible to construct at this location, but with the additional height comes additional risk and visual impact. A dam with a height of 300 feet is not likely to be geotechnically economic to construct at this location.

INVESTIGATIONS

PREVIOUS INVESTIGATIONS

There are no known previous geologic or groundwater investigations near the proposed water storage site. The only geologic mapping available is ½-million scale geologic mapping by Walker and MacLeod [Ref. 1].

CURRENT INVESTIGATIONS

Current investigations were carried out over a two day period (August 22 and 23, 2007), with one day each spent on the west and east sides of the Williamson River Canyon.

Scope of Work

A brief literature search was made of geologic records in the Mid-Pacific Region Geology Branch (MP-230) files to determine if previous work had been carried out by Reclamation. No information on the Williamson River Canyon area was located. The regional scale a (1:500,000) geologic map [Ref. 1] was reviewed for basic geologic data.

Regional Groundwater

The current site investigation did not include identification of the local groundwater flow regime or a literature review. However, a few basic observations were noted.

- During the summer and fall months of the year, Spring Creek provides the majority of flow to the Williamson River. An estimated several hundred cubic-feet-per-second (CFS) of crystal clear, cold, spring-fed water discharges into Spring Creek, less than three miles from the proposed water storage site in Williamson River Canyon. For all practical purposes, throughout much of the year, Spring Creek is the source of the Williamson River.

  Understanding the regional groundwater setting and the origin of the springs at Spring Creek, is critical to understanding the water holding capabilities of a water storage project in the Williamson River Canyon.

- There are two principal rock units within the Williamson River Canyon: andesite lava flows (Qa) and pyroclastic deposits of tuff breccia (Qtb). During the time of the current investigation, the Williamson River was dry to flowing slightly in the upper reaches of the canyon where andesite (Qa) is present. Where tuff breccia (Qtb) is present, water flow picks up substantially. This increased flow in the river is likely due to an influx of water along the Qa/Qtb contact. Major faults/shears may also play a significant, but as of yet undetermined, role in groundwater flow in the area.

- Tuff breccia (Qtb) is a relatively impermeable unit throughout the area. Lava flows (Qa) that cap the tuff breccia have a much higher relative permeability. Springs are commonly present at the contact between these two units.

- Groundwater flow appears to be mostly through the relatively permeable, jointed andesite (Qa), and along the upper surface of the underlying low permeability tuff breccia (Qtb). Groundwater flow through tuff breccia (Qtb) appears to be low.

REGIONAL GEOLOGY

Large scale regional geologic mapping shows the Williamson River Canyon cutting through a plateau of rhyodacitic to andesitic ash-flow deposits (Qma), capped by andesitic flows (Qa) on the west side and covered by basaltic flows (QTb) on the east side [Ref. 1]. Most of the rocks throughout the area are covered in pumice and ash deposits from the explosive eruption of Mount Mazama, about 6,845 years ago [Ref. 1].

Numerous regional-scale north-northwest trending faults and shears traverse the area, cutting all but the youngest of volcanic units.

The 1:500,000 scale geologic map of the area [Ref 1] does not adequately portray the local geologic units and cannot be used as a basis for site geology of the proposed water storage project. Field mapping at a scale of about 1"=50' at the proposed damsite, and 1"=2,000' for the reservoir area will be required during the next phase of the project.

SITE GEOLOGY

The canyon is deeply dissected with both abutments and the canyon floor cut into tuff breccia (Photos 6-9). The tuff breccia (Qtb) is well-bedded to massive, moderately hart to moderately soft rock with angular gravel to cobble size clasts of andesite in a well-indurated tuff matrix (Photos 10 and 13). The upper 40 to 60 feet of the canyon has andesitic lava flows (Qa) overlying the tuff breccia (Photos 1, 10, and 11).

Both units have been folded or tilted, and on the western side of the canyon the Qa/Qtb contact dips at about 20^{o} upstream (Photos 14 and 15). Because of the dipping contact, the andesitic flows compose more of the canyon wall with distance upstream. About 3,500 feet upstream from the proposed damsite the entire canyon walls and floor of the canyon are composed of andesitic lava flows.

<u>Andesite</u> (Qa)

Lava flows of andesitic composition overlie tuff breccia at the proposed damsite. Here the lava flows host cooling joints that generally fracture the rock into blocks 1 to 3 feet across (Photos 1 and 3). Upstream from the proposed damsite andesitic lava flows become thicker, and fractures in the massive cooling center of the flows become spaced farther apart.

In Photo 11 the massive cooling center of a lava flow exhibits widely to very widely joint spacing, mostly 3 to 10 feet, while the 3 to 4 foot flow bottom is highly porous and permeable rubble. Most of the andesite is fresh to slightly weathered and hard to moderately hard.

The relative permeability of andesite (Qa) is estimated to be low to moderate. Permeability is fracture controlled, with the greatest permeability at the base of flows, and along the contact with underlying tuff breccia (Photo 11).

<u>Tuff Breccia</u> (Qtb)

Tuff breccia crops out along both sides of the Williamson River Canyon in Sections 25, 35, and 36. Tuff breccia formed from lahar (mudflow) and volcaniclastic deposits resulting from a large-scale explosive volcanic eruption. The current description of tuff breccia at the proposed water storage site comes from outcrops along the western canyon wall.

The tuff breccia forms both abutments of the dam site, from the river to within 40 to 60 feet of the canyon rim. Lava flows composed of andesite overlie tuff breccia and form the remainder of the canyon wall (Photos 1-9).

The tuff breccia is well-bedded to massive and is composed of about 20 to 40% gravel to cobble size angular clasts of hard andesite in a tuff matrix (Photos 10 and 12-15). The rock is well indurated and moderately hard to moderately soft.

The permeability of massive tuff breccia is estimated to be low to very low. The greatest permeability will be along highly continuous, widely spaced to very widely spaced, nearly vertical discontinuities (Photos 7 and 8).

Table 2. Orientation of bedding in tuff breccia (Qtb).

Tuff Breccia Bedding Orientations (Outcrops in the Western Canyon Wall)	
Location	Strike and Dip
Downstream of Hilltop Reservoir Creek	N10W, 28^{o}SW
Upstream of Hilltop Reservoir Creek	N70E, 20^{o}SE
1,000 feet upstream of Hilltop Reservoir Creek	East-West, 20^{o}North
Upstream Dipping Contact with andesite (Qa/Qtb)	East-West, 20^{o}North

Table 3. Major discontinuity orientations in tuff breccia (Qtb).

Tuff Breccia Discontinuity Orientations (Outcrops in the Western Canyon Wall)			
Location	Strike and Dip	Continuity (feet)	Spacing (feet)
Downstream of Hilltop Reservoir Creek	N10W, 85^{o}NE N75E, V	100's 3 to 40	10 to 50 3 to 20
1,000 feet upstream of Hilltop Reservoir Creek	North-South, V	100's	10 to 50

CONCLUSIONS

The following conclusions are based on surface exposures examined during a one-day-each visit to the east and west sides of Williamson River Canyon, near Hilltop Reservoir. Some of these conclusions could change significantly if subsurface investigations are carried out.

- The Williamson River Canyon is deep and narrow. A very high dam would have to be constructed at the proposed site to obtain a significant amount of storage potential (Table 1).

- Geologically there are no readily observable fatal flaws that would prevent construction of a dam at the proposed site. Tuff breccia cropping out on both the floor and sides of the canyon is generally an excellent rock type for the foundation of a dam.
- The water retention characteristics of this rock are unknown, but based on surface exposures, permeability is largely fracture controlled and should be significantly lower than that of average basalt flows, such as those forming the abutments of Clear Lake and Gerber Dams and underlying their reservoirs.
- At the proposed damsite the bottom of the canyon, and the lower 240 feet of both canyon walls are composed of tuff breccia (Qtb). Tuff breccia is a relatively impermeable, very stable, non-erosive material that has the potential for making an excellent foundation for a dam.
- The upper 40 to 60 feet of the western canyon wall is composed of an andesitic lava flow. This unit dips gently upstream, and about 3,500 feet upstream of the damsite the floor of the canyon and its walls are composed entirely of andesitic lava flows. Due to the presence of a larger number of fractures, the lava flows are relatively more permeable than the more massive tuff breccia they cap.
- Even though the lava flows are expected to have a higher relative permeability than the tuff breccia, that does not necessarily make them unsuitable geologic units for water storage.
- Because of the very high artesian spring flows in Spring Creek, within a few miles of the proposed damsite, understanding the geology that controls regional groundwater flow is critical to understanding whether Williamson River Canyon is suitable for water storage.
- If on-river water storage is desirable at this general location, and hydrologic studies indicate an adequate water supply, then additional surface and subsurface geologic investigations are warranted.

RECOMMENDATIONS

- Complete work necessary to identify the availability of water, and determine if that water supply is adequate to be considered as a viable option for future development as part of the Klamath Project.
- Determine the available area for storage, and develop area/capacity curves for storage in the Williamson River Canyon.
- Decide whether there is multi-agency support for a water storage project in this general location.
- If results of the above recommendations are positive, then conduct detailed geologic mapping and appraisal-level subsurface geologic investigations. A clear understanding of the principal geologic features that control regional groundwater flow are needed before a determination of the water holding capability of rocks that form Williamson River Canyon can be made.

REFERENCES

[1] Walker, G.W., and MacLeod, N.S., 1991; 1:500,000 Scale Geologic Map of Oregon; United States Geological Survey.

Figures

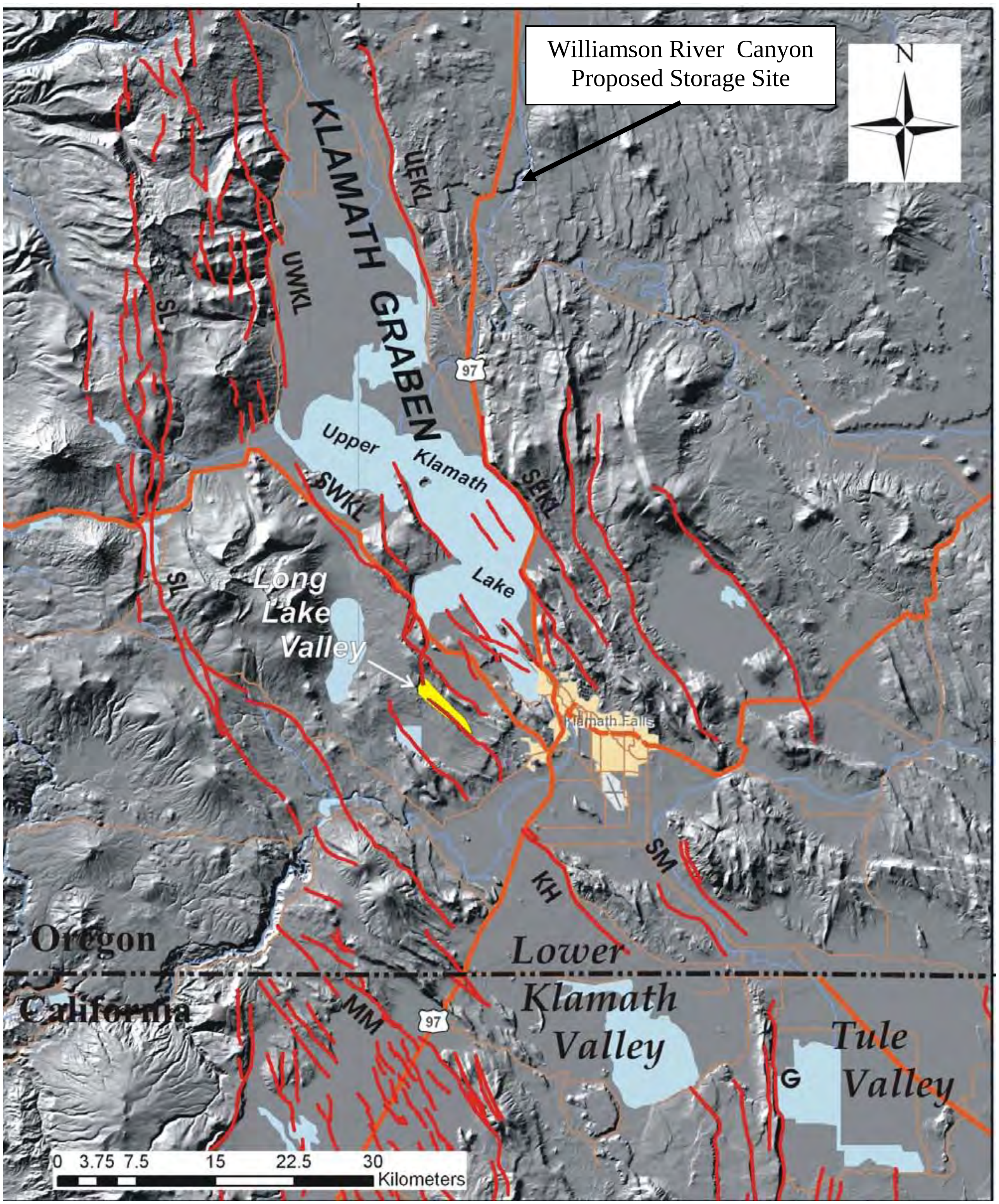

Figure 1. Location Map of the Klamath Falls region showing the location of the proposed Williamson River Canyon Water Storage Site. Map prepared by M. Neuman.

Photographs

Photo 1. Southerly (downstream) view of the Williamson River from near the center of Section 35, T33S, R7E. The view is downstream from a proposed water storage site. Andesitic volcanic flows about 40 to 60 feet thick cap an escarpment about 400 feet above the river. Photo by M. McCulla, 8/22/07.

Photo 2. Close up view of Williamson River from the same location as Photo 1. The view is downstream from a proposed water storage site. Note the presence of a significant amount of water in the river at this location. Photo by M. McCulla, 8/22/07.

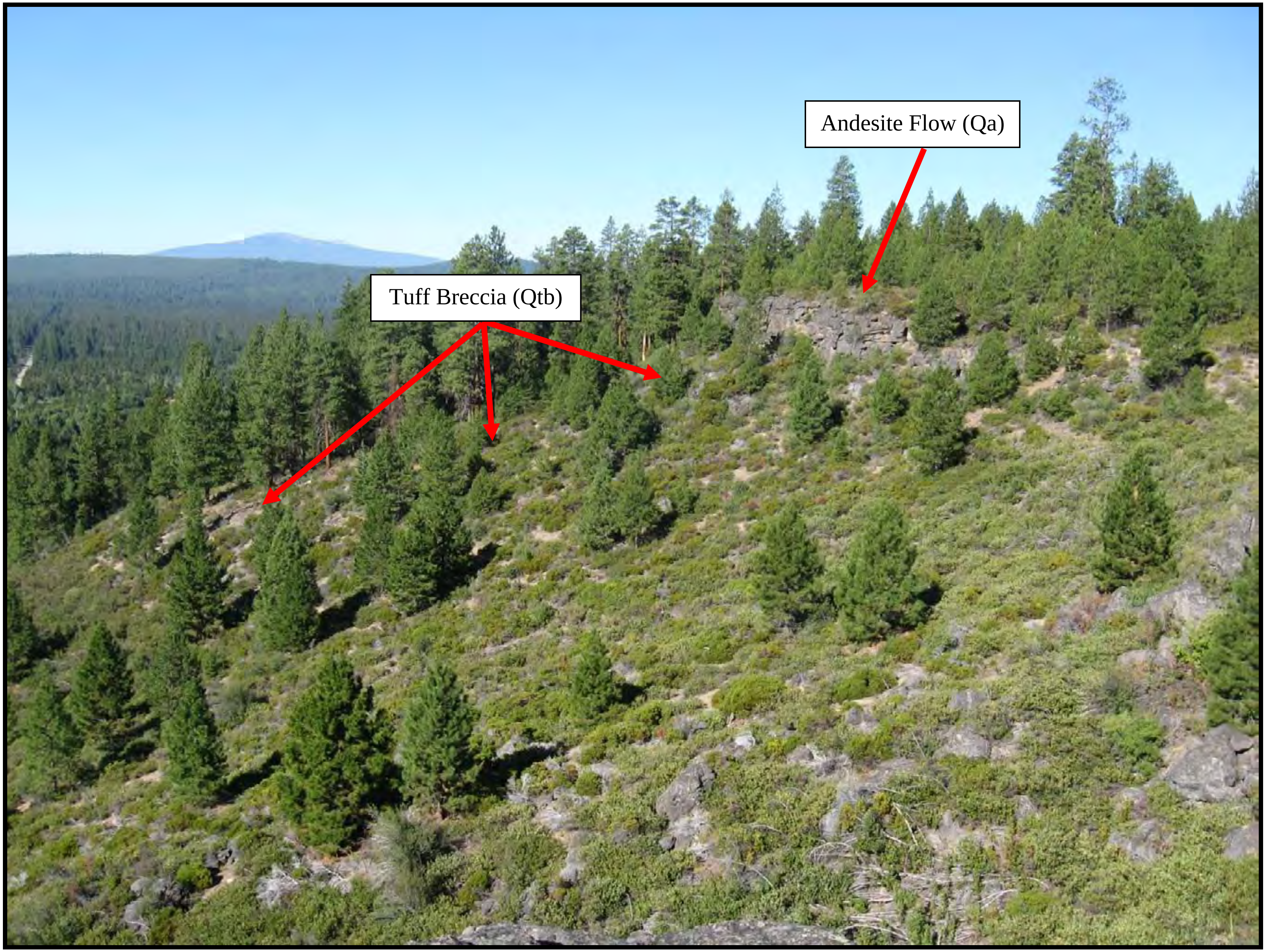

Photo 3. Southerly view from the same location as Photos 1 & 2, showing a 40 to 60 foot thick section of andesite overlying tuff breccia and other volcaniclastic rocks (Qtb). Photo by M. McCulla 8/22/07.

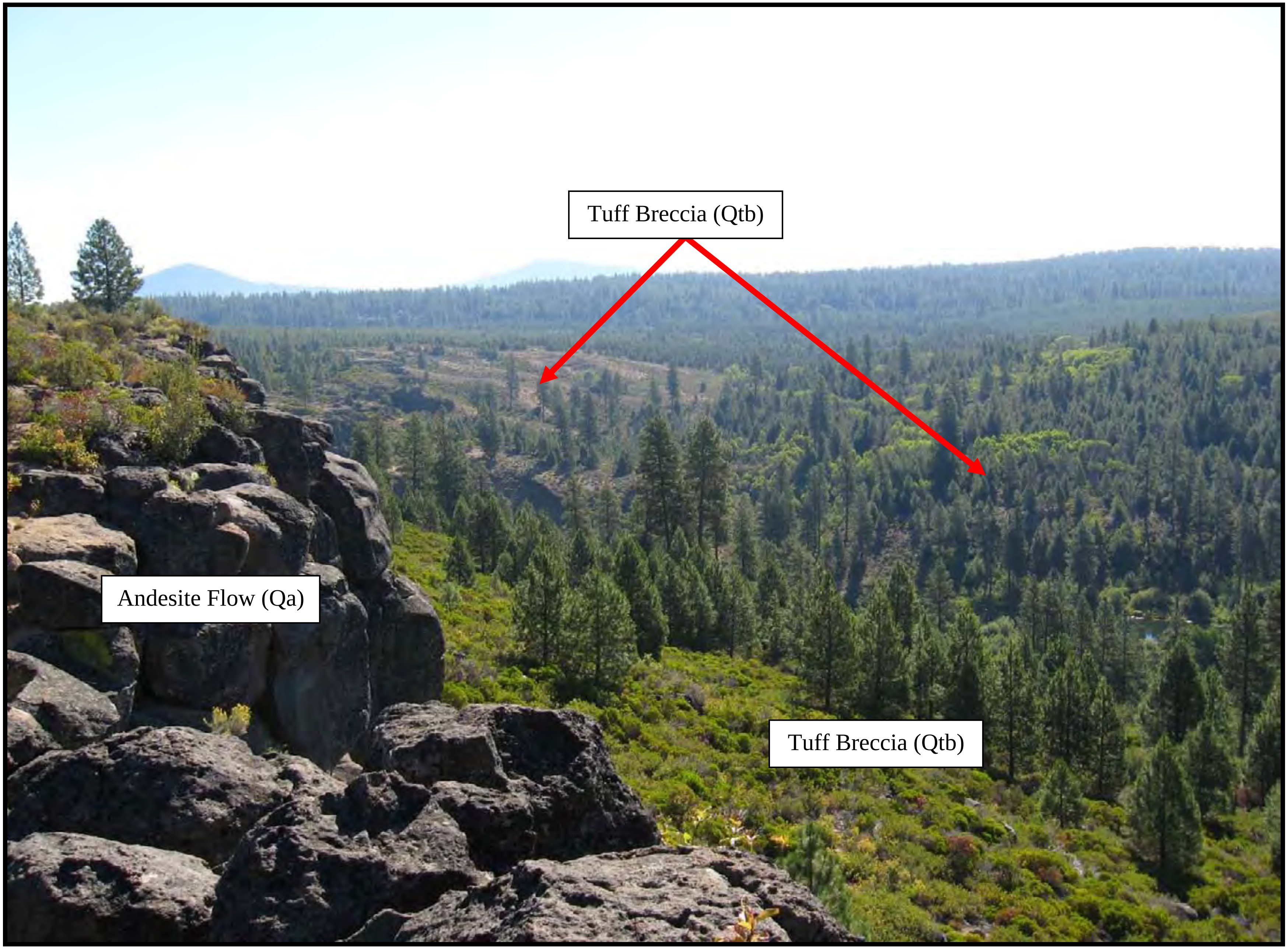

Photo 4. View to the east, across the Williamson River from the same area as Photos 1-3. In the foreground (left-center to bottom-left) is a 40 to 60 foot thick andesite flow. Below this flow, on both sides of the Williamson River tuff breccia and other volcaniclastic rock crop out. Photo by M. McCulla 8/22/07.

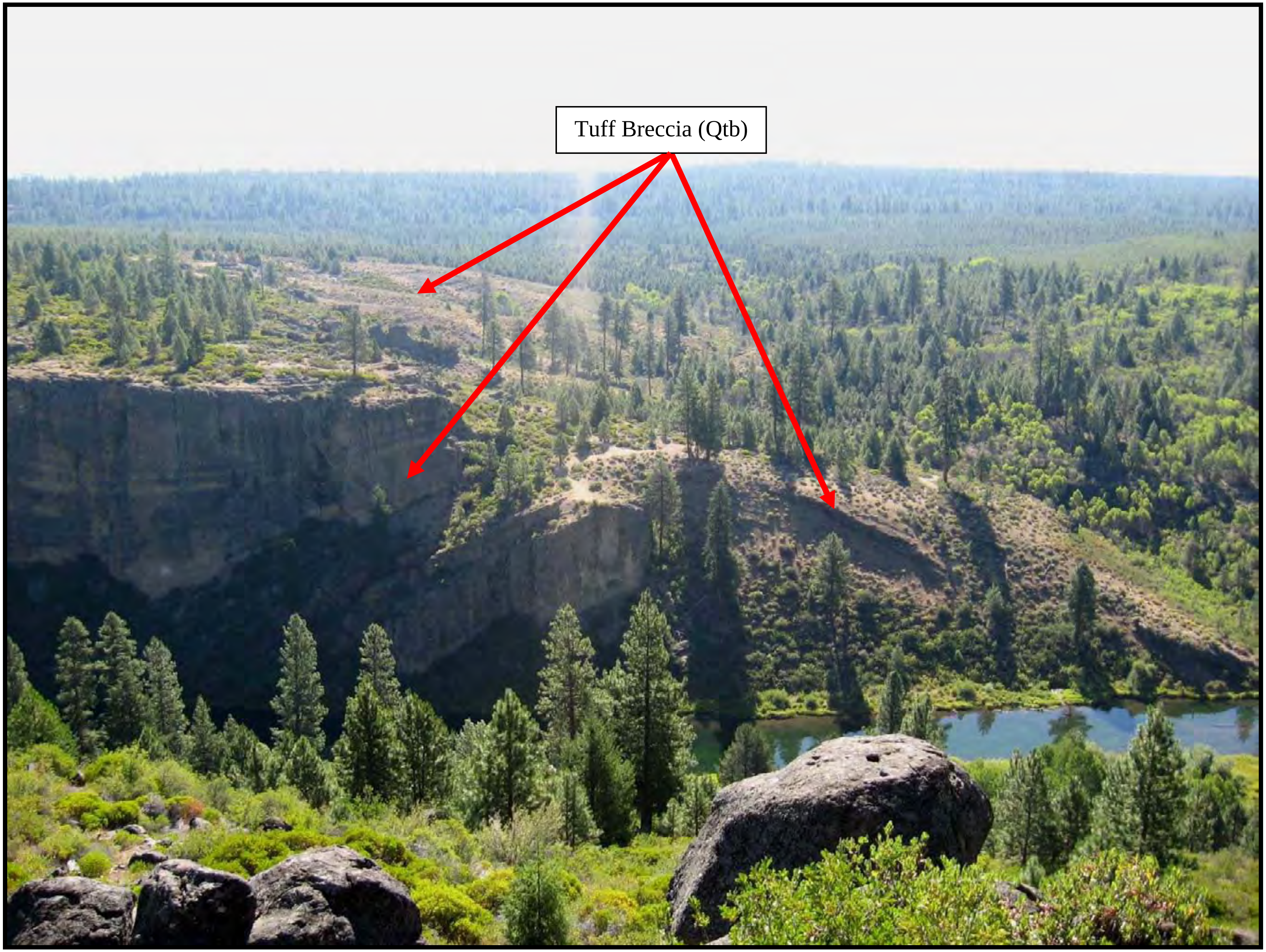

Photo 5. View to the east of the mouth of the Williamson River Canyon (downstream to the right). Tuff breccia and other volcaniclastic rock crop out on the far side of the river. Photo by M. McCulla 8/22/07.

Photo 6. View upstream along the Williamson River Canyon from the same location as Photo 5. Rock cropping out on the far side of the canyon is mostly tuff breccia (Qtb) and other volcaniclastic rock. Locally they are capped by thin flows of basalt or andesite. The proposed water storage site is to the left of this view. Photo by M. McCulla 8/22/07.

Photo 7. View of the eastern side of the Williamson River Canyon at the proposed water storage site. The cliff faces are composed of tuff breccia (Qtb) and other volcaniclastic rock with regular orientations of very-widely-spaced joints and shears. Photo by M. McCulla 8/22/07.

Photo 8. Close up view of the cliff faces shown in Photo 7 on the eastern side of the Williamson River Canyon. Photo by M. McCulla 8/22/07.

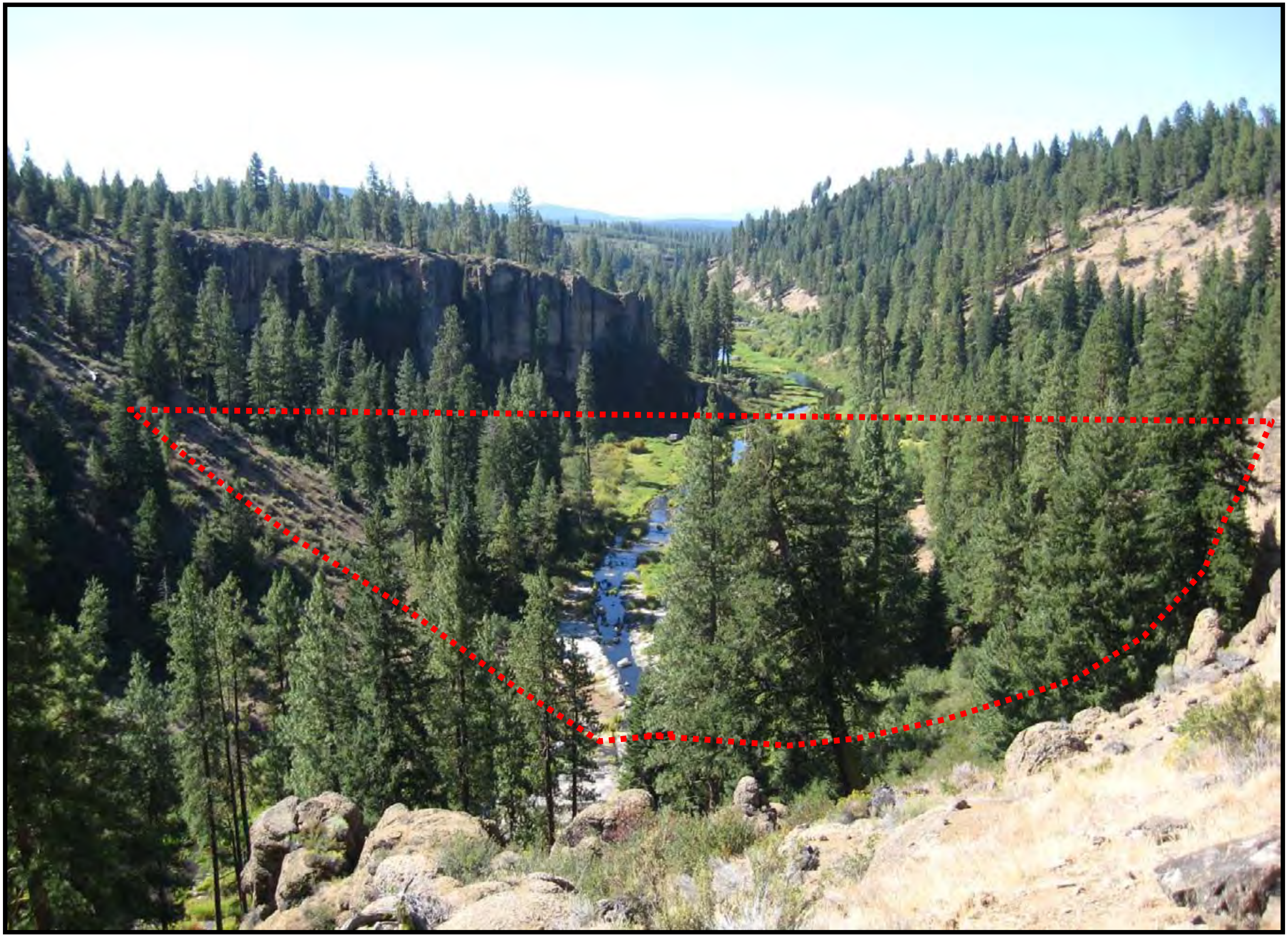

Photo 9. Downstream view of the Williamson River Canyon. The dotted line represents the proposed location of an embankment (approximately 150 feet high) for a water storage project in the SE¼, NW¼, Sec 25, T33S, R7E. Both abutments of the site are composed of moderately to well indurated tuff breccia (Qtb) and other volcaniclastic rock. Photo by M. McCulla, 8/22/07.

Photo 10. View of 40-ft. high andesite flow (Qa) capping tuff breccia (Qtb) on the western side of Williamson River Canyon, just upstream of the proposed water storage site. Note the massive nature of the tuff breccia. Photo by M. McCulla, 8/22/07.

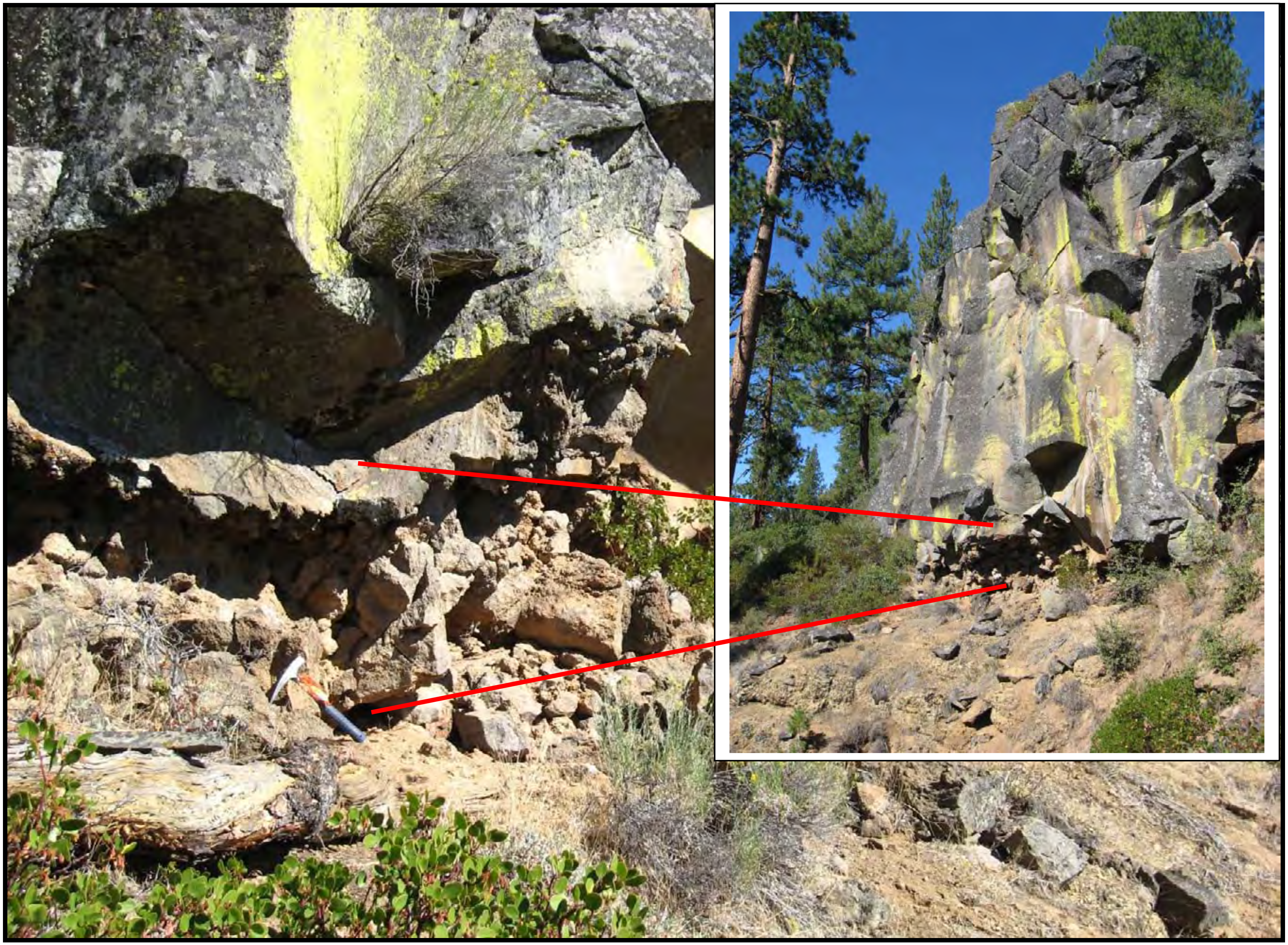

Photo 11. View of a contact between the andesite (Qa) and underlying tuff breccia (Qtb) on the western side of Williamson River Canyon. A typical contact has a 1 to 4-ft. thick rubble zone at the base of the andesite flow. This highly permeable rubble zone above impermeable tuff breccia is the location of numerous seasonal springs. Photo by M. McCulla, 8/22/07.

Photo 12. View of a contact between the andesite (Qa) and underlying tuff breccia (Qtb) on the western side of Williamson River Canyon. This contact hosts flow banded vesicular andesite above impermeable tuff breccia. An active spring is present along the contact, about 200 feet beyond this location. Photo by M. McCulla, 8/22/07.

Photo 13. Downstream view of tuff breccia (Qtb) cliff faces on the western side of Williamson River Canyon, just downstream of the proposed water storage site. Note the massive nature of the tuff breccia. Photo by M. McCulla, 8/22/07.

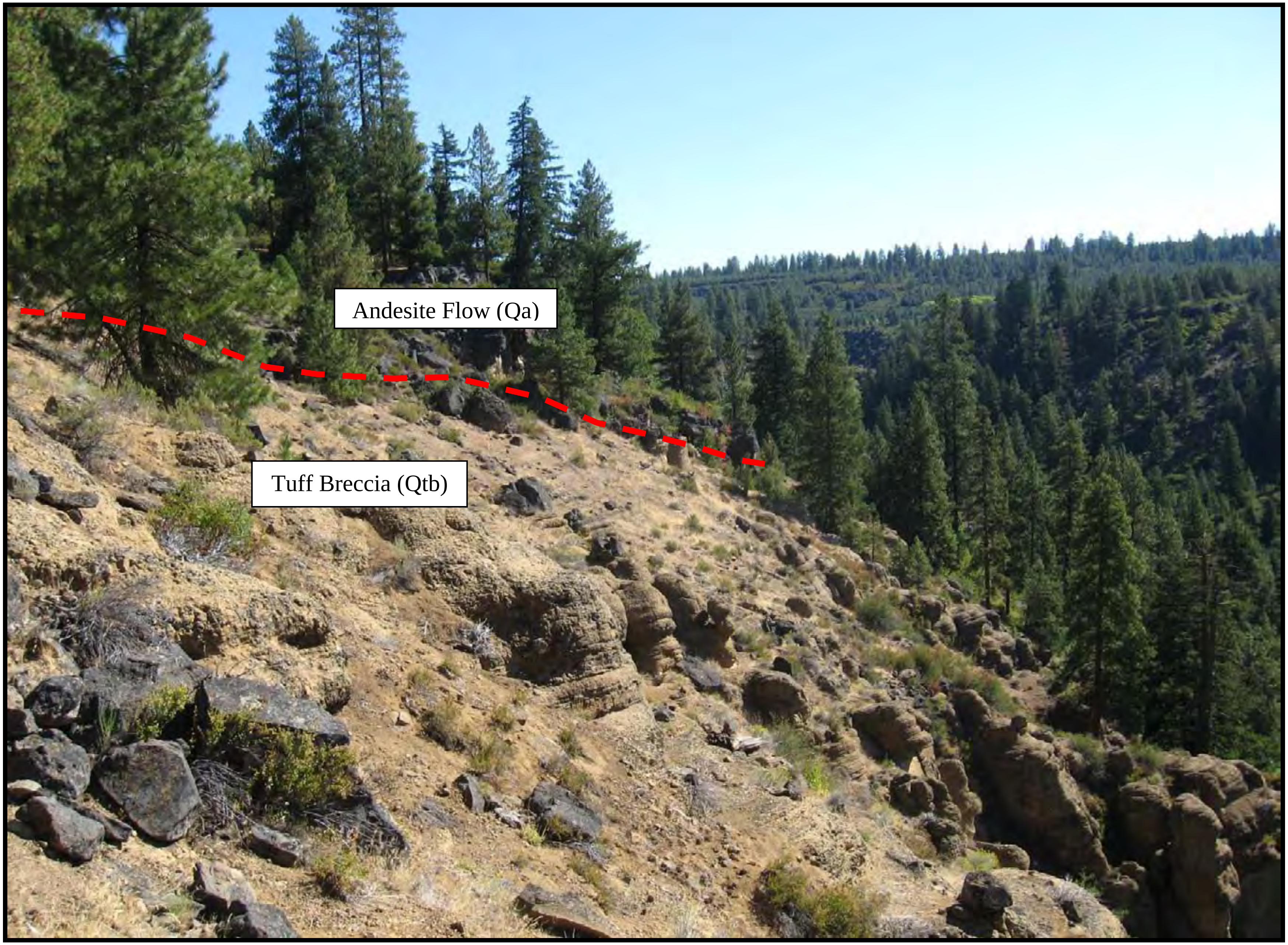

Photo 14. Upstream view of the contact between tuff breccia (Qtb) and overlying andesite (Qa). The contact dips at about 20^o upstream, intersecting the Williamson River about 3,000-ft. upstream of the proposed water storage site. Photo by M. McCulla, 8/22/07.

Photo 15. Close up view of upstream-dipping contact between the tuff breccia (Qt) and overlying andesite (Qa). Photo by M. McCulla, 8/22/07.

Photo 16. View of cutslope along Hwy 97 about 6 miles north of Chiloquin, Oregon. Exposed are deposits of airfall tuff and alluvial volcaniclastic tuffaceous sediment that form an escarpment about 400 feet above the Williamson River flood-plain. The current mapping did not determine if deposits such as shown here can be traced into the project area. Photo by M. McCulla, 8/22/07.

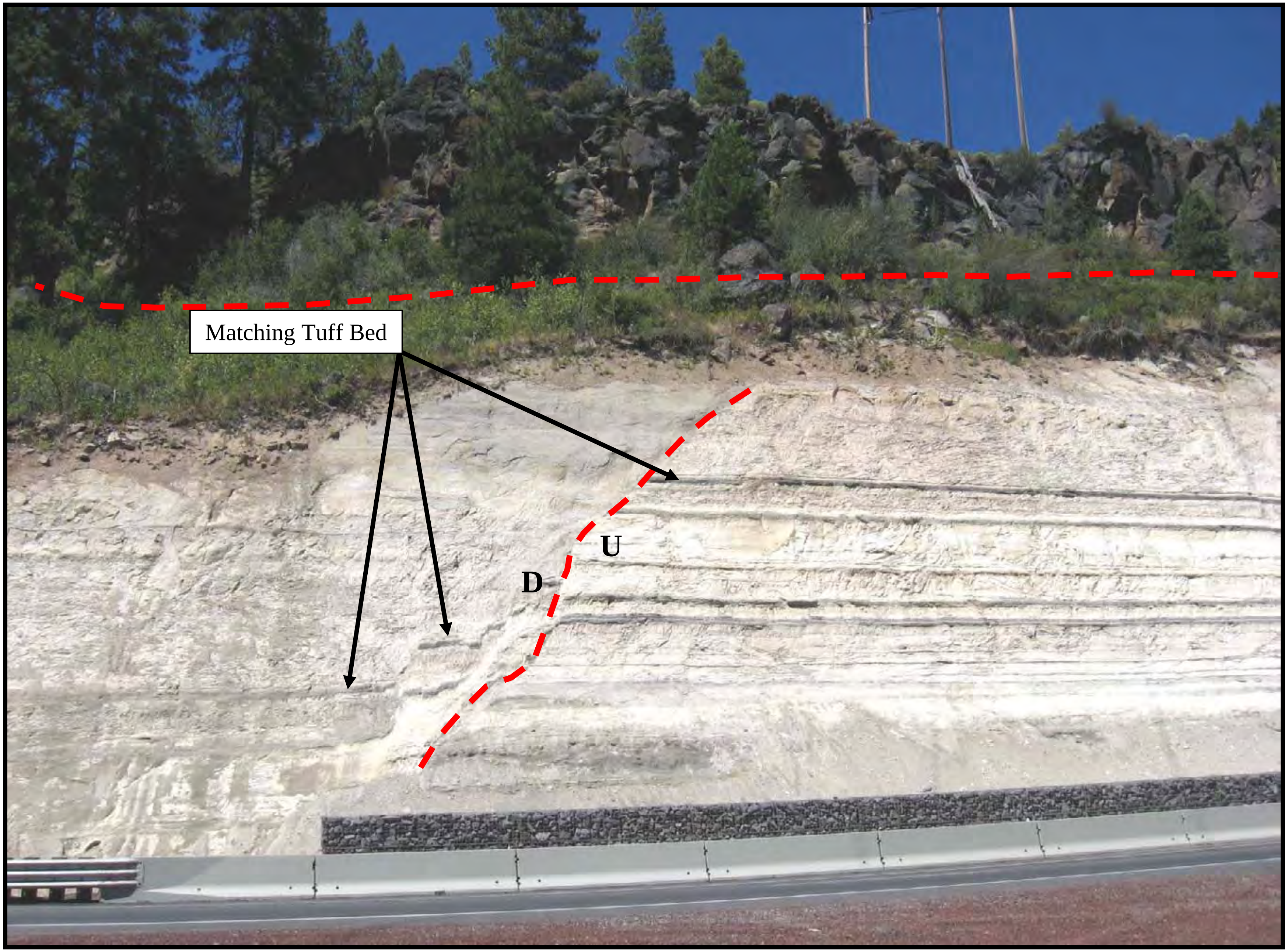

Photo 17. View of cutslope along Hwy 97 taken a few hundred feet uphill from Photo 16. Deposits of faulted airfall tuff and alluvial volcaniclastic sediment capped by an andesite flow (Qa). It is not known whether this fault cuts the andesite flow. Photo by M. McCulla, 8/22/07.