Chapter 9 Risk and Uncertainty

During the NODOS Investigation, reasonable assumptions based on engineering, economic, and scientific judgment were made to support the evaluation and comparison of alternatives. Analyses were developed with advanced modeling and estimating tools using historical data and trends. Although this analysis supported the evaluation of project outcomes, many risks and uncertainties could affect the future performance of the project. These risks and uncertainties are discussed below.

Climate Change and Sea Level Rise

Future climate change could result in hydrologic conditions and sea levels that differ from the existing conditions used to evaluate the alternatives. This uncertainty could result in benefits that differ from the benefits estimated for the alternatives. The potential for, and magnitude of, climate change is widely debated. DWR is conducting ongoing studies of how climate change could affect the way California receives and stores its water. According to the *California Water Plan Update 2013* (DWR 2013), California could experience changes in temperature, precipitation, and snow levels. The results to date indicate that climate change could affect the hydrology, water temperature, and future operations for both flood management and water supply deliveries. The *California Water Plan Update 2013* indicates that further study is necessary to develop climate data to reduce the risk and uncertainty in future California water management.

The *Sacramento and San Joaquin Basins Study* (Reclamation 2016b) has similar findings to this report. This study indicated that Delta salinity, reservoir surface area, pelagic species, and coldwater pool would all be negatively impacted by more than 10 percent compared to current conditions. End-of-September and end-of-May storage would decrease, but the change would be less than 10 percent. Improved climate change data would likely increase confidence in the accuracy of these percentages.

Sites Reservoir Project investigators requested a sensitivity analysis of the effects and benefits of the Sites Reservoir Project alternatives under scenarios associated with climate change. The resulting Sites Reservoir Project climate change and sea level rise sensitivity analysis has been prepared as a tool for planners, resources specialists, stakeholders, and the public to consider the influence of climate change and sea level rise on the Sites Reservoir Project and to verify that the findings in the Draft Feasibility Report are adequate.

For the climate change and sea level rise sensitivity analysis, the No Project Alternative and Sites Reservoir Project Alternatives A, B, C, and D were simulated for four additional climate and sea level scenarios. The climate and sea level scenarios used in this sensitivity analysis were previously developed for the *Bay Delta Conservation Plan (BDCP) Effects Analysis and ADEIR/S* (DWR 2012). The following four climate and sea level scenarios, in addition to the current climate and sea level scenario (Current) were selected for sensitivity analyses:

- The Early Long-Term (ELT) scenario, which assumes the median (Q5) of an ensemble of general circulation model (GCM) projections at a point in time 8 years into the future (approximately 2025) and a sea level rise of 15 centimeters (6 inches)
- The Late Long-Term (LLT) scenario, which assumes the median (Q5) of an ensemble of GCM projections at a point in time 40 years into the future (approximately 2060) and a sea level rise of 45 centimeters (18 inches)
- The Late Long-Term (LLT Q2) scenario, which assumes the "drier, more warming" lower bound (Q2) of an ensemble of GCM projections at a point in time 40 years into the future (approximately 2060) and a sea level rise of 45 centimeters (18 inches)
- The Late Long-Term (LLT Q4) scenario, which assumes the "wetter, less warming: upper bound (Q4) of an ensemble of GCM projections at a point in time 40 years in the future (approximately 2060) and a sea level rise of 45 centimeters (18 inches)

The ELT Q5, LLT Q5, LLT Q2, and LLT Q4 projections described above were based on 112 future climate projections under the World Climate Research Program's Coupled Model Intercomparison Project Phase 3 (CMIP3). Appendix 25A of the Sites Reservoir Draft EIR/EIS includes a detailed description of the climate change sensitivity analysis using the CMIP3-based projections. Appendix 25B of the Sites Reservoir Draft EIR/EIS summarizes a climate change sensitivity analysis using the CMIP5-based projections.

Based on the comparison of the Sites Reservoir Project alternatives with the No Project Alternative evaluated across Current, ELT, and all LLT climate and sea level scenarios, the following expectations have been confirmed based on the results of CALSIM II simulations of these scenarios:

- The ability to divert water into Sites Reservoir Project storage is the same or slightly increased due to changes in the timing of snowmelt runoff and the continued opportunity to use the intakes under a wide range of climate scenarios.
- The Sites Reservoir Project alternatives can provide a similar array of potential benefits under a wide range of climate and sea level scenarios.
- The Sites Reservoir Project alternatives could be operated to potentially mitigate some of the effects of climate change and sea level rise.

The potential effects of climate change on the primary objectives are summarized as follows:

- **Water Supply:** Between the Current, ELT, and LLT climate and sea level scenarios, for all Sites Reservoir Project alternatives, long-term average annual total exports at Banks Pumping Plant and Jones Pumping Plant increase from the No Project Alternative consistently. Across all climate and sea level scenarios below median and Dry year (lower quartile) averages show strong exports throughout, due to the Sites Reservoir Project alternatives, with the absolute and relative magnitude of improvement increasing as the effect of climate change and sea level rise increases. The sensitivity analysis results indicate that the increment of water provided by the Sites Reservoir Project alternatives could increase even as overall system supply decreases. The relative economic value of

all three Sites Reservoir Project alternatives is likely to increase relative to the No Project Alternative condition, given that the performance of water supply reliability for agricultural, urban, and environmental uses under the No Project Alternative is decreasing as a result of climate change and sea level rise.

- **Improving the Survivability of Anadromous Fish:** For the primary objective of increasing survival of anadromous fish populations, the highest priority is to maintain improved storage conditions through the Dry years (lower quartile) and summer months (July through September season). The most substantial relative improvement in storage is at Shasta Reservoir. The increase in coldwater pool would improve the benefits in Dry years, which may occur more frequently as a result of climate change. Anadromous fish benefits would likely increase with climate change.
- **Water Quality:** The uncertainty surrounding water quality improvements is greater than it is for any of the other primary objectives. Between Current, ELT, and LLT climate and sea level scenarios, for all Sites Reservoir Project alternatives, X2 position and Old River at Rock Slough salinity conditions are improved during the April through December seasons. As sea level progresses from ELT to LLT, the magnitude of improvement in water quality (due to supplemental Delta outflow) decreases.

Reclamation evaluated a series of water management action portfolios in *Central Valley Project Integrated Resource Plan Final Report* (Reclamation 2014b) using three socioeconomic and six climate futures. Sites Reservoir was included in two of the portfolios, but not modeled as a standalone project. With both Sites Reservoir and Delta conveyance, this evaluation showed reductions in unmet demands averaging 795 TAF/year, decreases in Sacramento River water temperatures at Jelly's Ferry averaging 0.5^0F, and net economic benefits of $341M in 2085.

More recently, the Authority evaluated the potential effects of climate change for the WSIP application. A detailed description of the climate change and sea level rise assumptions for the WSIP evaluation is provided in Appendix A to the *WSIP Technical Reference* (CWC 2016). The climate change projections for 2030 and 2070 were derived from an ensemble of 20 global climate projections selected by DWR's Climate Change Technical Advisory Group. These climate assumptions were incorporated into the CALSIM II model. For Sites Reservoir, the evaluation of the 2030 and 2070 conditions with climate change showed a sharp decline in environmental water quality benefits, but a considerable increase in the benefits to anadromous fish, as is shown on Figure 9-1 (Authority 2017).

In summary, the climate change scenarios considered in the sensitivity analysis would likely increase water supply and anadromous fish benefits for all alternatives. Water quality benefits would likely decrease with climate change due to sea level rise.

Water Supply Reliability and Demands

Future water supplies and demands are uncertain. This uncertainty affects the projected water supply benefits. Many variables are considered in forecasting future water supply requirements for California. The *California Water Plan Update 2013* (DWR 2013) estimates demand for several growth scenarios, ranging from "lower than current trends," which assumes that

population growth would be slower than currently projected; to "higher than current trends," which assumes that population growth would be faster than currently projected, with nearly 70 million people living in California in 2050. The analysis in this report is consistent with current trends, but future growth could be higher or lower than forecasted. In summary, there is uncertainty in estimating the future benefits of water supply.

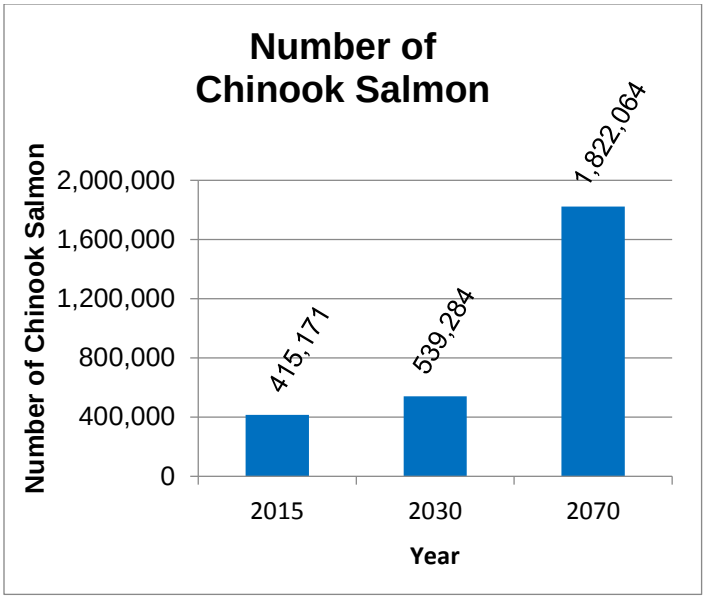

Figure 9-1. Increased Salmon Population with Sites Reservoir and Climate Change (Authority 2017)

Energy Costs Associated with Transporting Water to the South Coast

To generate the energy price forecast for the study, three sources were used:

- Forward energy "broker" quotations provided by Tullet Liberty (Tullet)[1]
- Natural gas futures and natural gas futures basis as reported by the New York Mercantile Exchange
- Forecasted spot electricity and natural gas prices as provided by Ventyx semiannual structural forecast (formerly Global Energy Decisions)[2]

Nevertheless, there is extraordinary volatility in wholesale energy markets, especially price risk and uncertainty in the underlying fuel markets. Changes in future energy costs may result in the following uncertainties:

[1] Tullet, among other things, is an energy brokerage company that matches buyers and sellers.
[2] Ventyx is forecasting the actual day-ahead cash price that will occur in the sport markets in the future, not the price at which futures or forward contracts should be priced.

- Operating costs (specifically, the energy costs required for pumping) could be higher or lower than estimated. The recent trend is a decrease in energy costs for pumping during the hours when solar energy and wind energy are readily available.
- The estimated hydropower benefits are dependent on the market for renewable energy and the ancillary benefits from integration with these resources. Widespread implementation of renewable energy has been the primary driver of volatility in the energy market over the last decade. These benefits are likely to stay the same or increase.

Anadromous Fish Populations

Anadromous fish are highly affected by changes in their surroundings, especially elevated temperatures and low flows. Trying to predict fish survival is difficult because of the many factors that influence it. As a result, there is uncertainty in how fish populations would respond to the temperature and flow changes that would be accomplished by the alternatives. There is also uncertainty in the estimated benefits.

To reduce the uncertainty associated with the evaluation of anadromous fish populations, the Draft Feasibility Report considered three independent lines of analysis:

- A qualitative evaluation of the effects of the increases in coldwater pool (with the greatest benefits at Shasta and Oroville Reservoirs) and flow augmentation (downstream from Keswick Dam) on fish populations
- Use of the SALMOD model to evaluate smolt growth, movement, and survival between Keswick Dam and Red Bluff (SALMOD is the best-available model for estimating survival and mortality for all four runs of Chinook salmon. SALMOD accounts for changes in both water temperature and flow and has been previously applied on the Sacramento River between Keswick Dam and Red Bluff [Bartholow 2003; Kent 1999; Reclamation 2008a].)
- Use of the Interactive Object-oriented Salmon Simulation (IOS) life-cycle model to evaluate the long-term response of Sacramento River winter-run Chinook salmon populations

Findings from each of these lines of analysis indicated overall beneficial trends from the implementation of the Sites Reservoir Project. Uncertainty regarding the survival of anadromous fish is also related to seasonal and long-term water conditions throughout the Sacramento River, in the Delta, and in the Pacific Ocean. Potential climate change also has the potential to influence anadromous fish survival.

In summary, there are uncertainties in estimating how the population of fish will change with implementation of the project. There are also uncertainties on how natural changes like climate change or other environmental factors will contribute to the decline in the abundance, distribution, or health of anadromous fish, regardless of project implementation.

Declining Populations of Aquatic Species in the Delta

A major concern in the Delta is the declining population of several species, including Delta smelt, threadfin shad, longfin smelt, and striped bass. In fall 2004, Delta fish surveys registered sharp declines in these four species. Subsequent surveys have confirmed the trend, raising concerns that Delta smelt risk extinction, and longfin smelt risk extirpation. Improvements in water quality provided by the Sites Reservoir Project alternatives would improve the conditions in the ecosystem, but it is uncertain how effectively they could arrest the decline of specific species.

Reducing Risk Through Adaptive Management

Adaptive management of Sites Reservoir operations reduces the risk and uncertainty of achieving the project objectives of increasing the survival of anadromous fish, and improving Delta environmental water quality. It is possible to shift operations of Sites Reservoir to selectively focus on either anadromous fish in the Sacramento River between Keswick Dam and Red Bluff, or to focus on species like Delta smelt much farther downstream. This possibility is illustrated by the differences in benefits from Alternatives C and D that are achieved with different operating strategies, in spite of having essentially the same facilities. As described in Chapter 6, Alternative Development, the alternatives incorporate modification of releases (e.g., shifting releases from the Delevan Intake/Release structure to the CBD to further enhance the potential benefits for smelt species). Flexible operations based on best-available science and new information as it becomes available can make use of adaptive management to focus on the highest-priority use within the purposes described in this report for water supplies from Sites Reservoir. Such operations would minimize the risk that the project would perform at a level that is below the forecasted level of benefits.

Water System Operations Analysis

Continuing uncertainty in the regulatory environment makes the long-term planning of CVP and SWP operations challenging. Uncertainty regarding future operations will need to be addressed in a framework for developing a cooperative operations agreement between Reclamation, the Authority, and DWR. In 2008, Reclamation and DWR published the CVP and SWP Long-Term Operations Criteria and Plan (OCAP) and Biological Assessment (BA) for impacts on species listed under the ESA (16 United States Code §1531 [1973]). In response to the BA, the USFWS issued a BiOp on the OCAP in December 2008 (USFWS 2008), addressing the impacts of the CVP/SWP operations on Delta smelt. In June 2009, NMFS issued a BiOp (NMFS 2009), *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project*. Both the USFWS and NMFS BiOps included a Reasonable and Prudent Alternative (RPA) that the agencies believed would enable the CVP/SWP operations to continue in compliance with the ESA. The USFWS and NMFS RPAs included non-operational and operational actions whose potential impact on CVP/SWP operations would vary notably from year to year, depending on biological, hydrologic, and meteorological variables that are difficult to predict.

The Existing Condition and No Project Alternative CALSIM II models used by the Sites Reservoir Project modeling team to establish the modeling of the alternatives assume the full implementation of the operational actions of the USFWS and NMFS BiOps. However, under full implementation of the BiOps, not all conditions of the BiOps can be met, due to conflicting hydrologic, operational, and regulatory requirements that are not yet reconciled. The result is the occurrence in the simulations of storage at dead-pool levels. Dead-pool level is considered to be reservoir storage at or below the elevation of the lowest outlet. The CALSIM II model may reach a numerical solution, but the results of the simulation may not reflect a reasonably expected outcome (i.e., an outcome that would require negotiation) or how Reclamation and DWR would operate under real-time conditions.

The future regulatory requirements to meet environmental needs are uncertain. This uncertainty is especially true of the requirements for Delta smelt and Chinook salmon. Analyses and model runs performed for evaluating the Sites Reservoir Project alternatives simulated regulatory conditions from the BiOps from USFWS and NMFS (released in 2008 and 2009, respectively). Legal challenges to these BiOps make it difficult to describe future operations with any degree of certainty. The regulatory requirements governing water operations are likely to change on the completion of the reinitiation of consultation for "Coordinated long-term operation of the CVP and SWP" (i.e., USFWS and NMFS BiOps).

Water Rights Decision 1641 Revised (SWRCB 2000) defines water quality objectives for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary. These objectives include regulatory requirements applicable to Sites Reservoir operations (including diversions and outflow requirements). Future changes to the flow requirements established in D-1641 may reduce the allowable diversions into Sites Reservoir.

In summary, the modeled results will likely vary from future project performance. Factors including meteorological conditions and changing regulations could result in improved or diminished project performance.

California WaterFix

California WaterFix is being collaboratively studied by Federal, State, and local agencies, environmental organizations, and other interested parties. This effort includes evaluating new conveyance facilities with capacities of up to 9,000 cfs that would improve the capacity for exporting water released from Sites Reservoir. The following discussion describes how the implementation of new conveyance might affect the performance of a Sites Reservoir Project.

- **Water Supply and Water Supply Reliability:** Construction of new conveyance would reduce the uncertainty associated with Delta diversions to export water from the Delta. Diversions for export with new conveyance are expected to be more sustainable from a regulatory standpoint because the conveyance would not interfere with the recovery of aquatic species in the Delta. This type of diversion would tend to increase the benefits associated with the project, although diversions could be reduced in some years.
- **Anadromous Fish Survival:** California WaterFix and Eco Restore are expected to improve habitat conditions throughout the Delta. These alternatives should improve survival throughout the entire life cycle of anadromous fish (including migration through the Delta). This result would improve the survival of juvenile fish through the Delta that

would be produced upstream as a result of coldwater pool and flow augmentation benefits.

- **Water Quality:** Implementation of California WaterFix would not appreciably alter the ability of Sites Reservoir to improve Delta water quality and shift the position of X2 westward.

Other New Storage Projects

Water operations modeling was based on existing system facilities and operational considerations. Other potential storage projects outside of the NODOS Study Area, if implemented, would likely be integrated into the CVP and SWP systems; however, these projects were not accounted for in the model. Other storage projects being considered north-of-the Delta are unlikely to compete with Sites Reservoir diversions. Implementation of these projects is not expected to eliminate the benefits of Sites Reservoir, but may alter the operational priorities used for the evaluation in this study.

Cost Estimates

The cost estimates developed for the comprehensive plans included in this Draft Feasibility Report are based on 2015 price levels. Varying uncertainties are associated with the material and unit costs used to develop the estimates. Unknowns include the variability of the price of construction materials, the proximity of materials to the project site, and labor costs. Trends from the past few years were used to try to estimate the cost of materials, but outside factors could further influence price changes.

Monetizing Project Benefits

Uncertainties are associated with the methodologies that are used to estimate the benefits associated with each of the project objectives. Sensitivity analysis was performed to help define the likely range of NED benefits. As a result of increasing demands on the constrained CVP and SWP water systems, water is likely to become increasingly valuable due to the increased frequency and duration of water shortages.