SDWA 136

DRAFT

BAY DELTA CONSERVATION PLAN STATEWIDE ECONOMIC IMPACT REPORT

August 2013

ICF INTERNATIONAL

The Brattle Group

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Contents

Tables

Page

Figures

Acronyms and Abbreviations

AB	Assembly Bill
AQMD	air quality management district
Banks Pumping Plant	Harvey O. Banks Pumping Plant
Barker Slough Pumping Plant	North Bay Aqueduct Pumping Plant
BDCP	Bay Delta Conservation Plan
the Plan	Bay Delta Conservation Plan
BMPs	best management practices
CAISO	California Independent System Operator
CalEEMod	California Emissions Estimator Model
CAP	Climate Action Plan
CCWD	Contra Costa Water District
CDEC	California Data Exchange Center
CDFW	California Department of Fish and Wildlife
CEC	California Energy Commission
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CH_4	methane
CM	Conservation Measure
CO	carbon monoxide
CO_2	carbon dioxide
Contra Costa Pumping Plant	Contra Costa Water District Pumping Plant #1
CPI	Consumer Price Indices
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento–San Joaquin River Delta
DOT	U.S. Department of Transportation
DSM-II	Delta Simulation Model II
DWR	California Department of Water Resources
EIR	environmental impact report
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESO	Evaluated starting operations
ESP	Economic Sustainability Plan for the Sacramento-San Joaquin River Delta
FMMP	Farmland Mapping and Monitoring Program
FTE	full-time equivalent
GAC	granular activated carbon
GHG	greenhouse gas
GIS	geographic information system
GWh	gigawatt-hours

HFC	hydrofluorocarbons
HOS	High outflow scenario
I	Interstate
Jones Pumping Plant	C. W. "Bill" Jones Pumping Plnat
kWh	kilowatt-hour
LCFS	low carbon fuel standard
LOS	level of service
M&I	municipal and industrial
mg/L	milligram per liter
ML	multinomial logit
MPTO	Modified Pipeline/Tunnel Option
N_2O	nitrous oxide
NAICS	North American Industrial Classification System
NASS	National Agricultural Statistics Service
NEPA	National Environmental Policy Act
NO_2	Nitrogen dioxide
NO_X	nitrogen oxides
NRCS	National Resources Conservation Service
O&M	operation and maintenance
PFC	perfluorinated carbons
PFMC	Pacific Fishery Management Council
PM10	particulate matter less than 10 micrometers in diameter
PM2.5	particulate matter less than 2.5 micrometers in diameter
REPP	Renewable Energy Procurement Program
RESIN	Resilient and Sustainable Infrastructure Networks
ROG	Reactive organic gas
RPS	Renewables Portfolio Standard
SDBSIM	Supply-Demand Balance Simulation Model
SF_6	sulfur hexafluoride
SFBAAB	San Francisco Bay Area Air Basin
SFNA	Sacramento Federal Nonattainment Area
SIC	Standard Industrial Classification
SJVAB	San Joaquin Valley Air Basin
SO_2	Sulfur dioxide
SO_X	sulfur oxide
SWAP	Statewide Agricultural Production Model
SWP	State Water Project
SWPPP	stormwater pollution prevention plans
TAF	ton per acre foot
U.S. EPA	Environmental Protection Agency
VOC	volatile organic compounds
μg/l	micrograms per liter

Executive Summary

This report presents an analysis of the statewide economic impact of the implementation of the Bay Delta Conservation Plan (BDCP). The BDCP sets out a comprehensive conservation strategy for the Sacramento–San Joaquin River Delta (Delta) designed to restore and protect ecosystem health, water supply, and water quality within a stable regulatory framework. The BDCP reflects the outcome of a multiyear collaboration between public water agencies, state and federal fish and wildlife agencies, nongovernment organizations, agricultural interests, and the general public. The BDCP is both a habitat conservation plan under the federal Endangered Species Act and a natural community conservation plan under the state Natural Community Conservation Planning Act. The BDCP is expected to result in endangered species permits from the state and federal fish and wildlife agencies for 56 species for a term of 50 years.

Economic impacts were estimated by measuring the various incremental costs and benefits of the BDCP to state and federal water contractors, Delta-dependent economic activities, non-market environmental amenities, and statewide income and employment. The impacts of the BDCP in these areas are summarized below, followed by an estimation of their associated costs and benefits. Economic impacts that could not be quantified because of a lack of data or high level of uncertainty regarding effects are discussed qualitatively.

ES.1 Welfare Impacts on State and Federal Water Contractors

ES.1.1 Incremental Costs to State and Federal Contractors

The direct costs to the state and federal water contractors for the BDCP result from the construction and operation of the new water conveyance facility (*Conservation Measure [CM] 1 Water Facilities and Operation*) and mitigation for impacts on covered species associated with CM1 construction and operation identified in both the BDCP and its environmental impact report/environmental impact statement (EIR/EIS). The total estimated cost of CM1 (construction and operation) and mitigation to the water contractors is as follows.

- The state and federal water contractors have committed to funding 100% of the construction and operation of CM1. Total CM1 capital costs are estimated at $14.5 billion in undiscounted 2012 dollars. Incremental operational costs over the 40 years of expected operations of the new water conveyance facility (from year 10 to 50) have been estimated at $1.9 billion in undiscounted 2012 dollars. Together, the construction and operational incremental costs of the new water conveyance facility total $16.4 billion in undiscounted 2012 dollars.
- The mitigation costs associated with the BDCP have been estimated in BDCP Chapter 8, *Implementation Costs and Funding Sources*, as a portion of eight conservation measures (California Department of Water Resources 2013). The total incremental mitigation costs to the

state and federal water contractors are estimated at $834.5 million in undiscounted 2012 dollars.[1]

- The sum of these costs is $17.2 billion (undiscounted 2012 dollars). The $17.2 billion in real expenditures assigned to the contractors has a net present value of $13.3 billion discounted at a 3% real discount rate.

See Section 2.1, *Incremental Costs Borne by State and Federal Water Contractors*, for details on these assumptions, methods, and results.

ES.1.2 Benefits to State and Federal Water Contractors

Implementation of the BDCP would result in direct economic benefits to the state's urban and agricultural water agencies receiving water supplies from the State Water Project (SWP) and Central Valley Project (CVP), referred to as the state and federal water contractors. These benefits include increased water supply reliability, improved water quality, and reduced seismic risks to Delta water supplies. Benefits from increased water supply reliability are measured separately for the urban and agricultural sectors.

The urban sector benefits of the BDCP are evaluated using the Supply-Demand Balance Simulation Model (SDBSIM). Agricultural benefits are calculated using the Statewide Agriculture Production (SWAP) model. The benefits from improved water quality mainly result from reduced salinity levels and are calculated using the Lower Colorado River Basin Water Quality Model for the Metropolitan Water District service areas, and the South Bay Water Quality Model for the Alameda County Water District, Zone 7, and Santa Clara Water District service areas.

Current seismic risks to the SWP and CVP arise from the potential for levee failure from seismic activity, which could result in the reduction of project deliveries for some period of time. The BDCP conveyance infrastructure would safeguard against such failures and would attenuate shortages resulting from seismic activity. The seismic risk reduction benefit is based on estimates of water availability with and without an earthquake, as well as the marginal value of water, which is estimated using the SDBSIM and SWAP models.

The analysis of the direct economic benefits of the BDCP assumes a 10-year planning and construction period for the new water conveyance facility, followed by a 40-year operating period. All BDCP benefits and costs presented are incremental to the Existing Conveyance scenario, described in BDCP Chapter 9, which assumes constraints on water operations similar to those described for CM1 in BDCP Chapter 3, Section 3.4.1 but without the new north Delta facilities. Benefits to the state and federal contractors across all categories total $18.0 billion (Table ES-1). Section 2.2, *Net Economic Benefit to State and Federal Water Contractors*, describes these assumptions, methods, and results.

Comparing incremental costs and benefits, implementing the BDCP would increase the economic welfare of the state and federal contractors by $4.7 billion. Table ES-1 displays summary welfare changes experienced by the state and federal water contractors.

[1] Some costs associated with tidal natural communities restoration (CM4) and the installation and operation of nonphysical fish barriers (CM16) are expected to occur whether or not the BDCP is approved and implemented. Therefore, these costs are not included in the estimate of the incremental costs of the BDCP to the state and federal water contractors.

Table ES-1. Summary of Welfare Impacts on State and Federal Contractors

Category of Benefits	Present Value Benefits ($ millions)
Water supply reliability	$15,722
Water quality	$1,819
Reduced seismic risk	$470
Total contractor benefits	**$18,011**
Total costs assigned to contractors	**$13,328**
Net welfare impact on contractors	**$4,683**

ES.2 Impacts Related to Delta-Dependent Economic Activities

The BDCP would have impacts on Delta-dependent economic activities including Delta agriculture, outdoor recreation, and transportation. Descriptions and brief summaries of the estimated impacts are presented below. Impacts on urban water treatment and commercial fisheries are discussed but not monetized.

ES.2.1 Salinity of Agricultural Water Supplies

The salinity changes resulting from the construction and operation of the new water conveyance facility (CM1) would have indirect economic impacts on Delta agriculture. Anticipated changes in salinity under the BDCP have been modeled using the Delta Simulation Model II (DSM-II), a hydrological simulation model created and maintained by the California Department of Water Resources (DWR). The DSM-II was used to predict Delta salinity levels at various locations across the Delta under the BDCP as well as under the Existing Conveyance scenario, which provides a basis for comparison.

The modeling methodology is adopted from that applied in the *Economic Sustainability Plan for the Sacramento-San Joaquin River Delta* (Delta ESP) (Delta Protection Commission 2012). The model was implemented as outlined in the ESP, with the exception of the incorporation of estimated salinity data from the DSM-II.

This study predicts that salinity changes as a result of the BDCP will lead to an annual decrease in average agricultural revenues in the Delta of $1.86 million. Assuming CM1 operations begin in 2025, this represents a net present value of $33.9 million (under a 3% real discount rate) through 2075. Predicted annual losses are much lower than those included in the Delta ESP, and reflect significantly smaller expected changes in salinity levels as a result of CM1 operations. While the Delta ESP predicted revenue changes from a lower bound of a 25% uniform salinity increase, DSM-II modeling suggests actual salinity levels would rarely increase by more than a few percentage points. Additionally, in some areas of the Delta, salinity levels are expected to decrease, further limiting the impacts of rising salinity experienced elsewhere. Section 3.1, *Salinity of Agricultural Water Supplies*, provides detail on the assumptions, methods, and results.

ES.2.2 Outdoor Recreation

The land use changes associated with CM1 and the other conservation measures (CM2–CM11, CM13–CM22) would affect outdoor recreational activities in the region. In some cases, existing recreational opportunities would be disrupted or eliminated. In other cases, recreational opportunities would be expanded.

This analysis used the Benefit Transfer Toolkit, developed by Dr. John Loomis of Colorado State University, to estimate the monetary costs of changes to recreation (Loomis and Richardson 2007). The toolkit uses a method called benefit transfer to take results of previous studies that have ascribed a value to outdoor recreation and customize them to fit a new context. In this study, the visitor use models included in the toolkit were used to estimate the change in recreational visits for different activities, given the changes in land use that would result from the BDCP. The models include nonconsumptive visits (birding and other wildlife viewing, hiking, recreational boating, camping, picnicking, and water contact sports), migratory bird–hunting visits, and freshwater fishing visits (shoreline- and boat-based). Unit-day values for different recreational activities were used to ascribe a value to these changes in recreational uses. Unit-day values are monetary estimates of the value of a day spent participating in a recreational activity that are specific to that type of activity or a group of similar activities.

Impacts of the BDCP on outdoor recreation would result primarily from the conservation measures that protect, restore, and enhance natural communities (CM2 through CM11) and those that address other ecological stressors on covered aquatic species in the Delta (CM13 through CM21). Restrictions on migratory waterfowl hunting lands imposed by CM1, CM2, and CM4 are estimated to result in total discounted costs ranging from $1.5 million to $3.0 million over the 50-year permit term. CM3, CM4, CM5, CM8 and CM9 are expected to result in increases in nonconsumptive recreation (e.g., hiking, picnicking, birding, wildlife viewing) and freshwater angling ranging from $223.3 million to $373.0 million. The net benefits of the BDCP on outdoor recreation in the Delta are thus estimated to range from $221.8 million to $370.0 million. Section 3.2, *Outdoor Recreation,* provides detail on the assumptions, methods, and results.

ES.2.3 Transportation

Economic impacts of the BDCP related to transportation disruptions and delays would result from CM1 construction, which will increase traffic volumes in the immediate Plan Area[2] and surrounding areas. To determine the economic impact of transportation delays resulting from CM1 construction, monetary costs of additional travel time spent by travelers in the region were estimated over the 9-year construction period. Additional travel times were estimated by comparing projected travel times in the region with and without CM1 construction.

To estimate the costs associated with travel delays, a value was applied for the opportunity cost of a traveler's time, which is the value of the time that a traveler must forego from spending on other activities due to their increased time spent in transit. Opportunity cost varies based on how the foregone time would have been spent (i.e., whether it is work or leisure time). This analysis incorporates the opportunity cost of time for both business and leisure travelers, since CM1 construction will affect both types of travelers.

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[2] The Plan Area for the BDCP encompasses the statutory Sacramento–San Joaquin River Delta and Suisun Marsh.

Using the low and high monetized values for all-purpose transportation, a range for the total costs of travel time delays over the CM1 construction period was calculated. The model estimates approximately 4.4 million additional car-hours of traffic delays due to increased traffic from CM1 construction over 9-year construction period. These travel delays will result in a total discounted cost of between $73.8 million (low estimate) and $110.8 million (high estimate) over the analysis period of 2016 through 2024 with no mitigation measures. Measures to mitigate transportation impacts, identified in BDCP EIR/EIS Chapter 19 (California Department of Water Resources et al. 2013), are expected to reduce these total costs by $21.0 million to $31.5 million. Thus, the total cost associated with transportation disruptions and delays under the BDCP were estimated to range from $52.8 million to $79.3 million. Section 3.3, *Transportation*, provides detail on the assumptions, methods, and results.

ES.2.4 Other Delta-Dependent Economic Activities

The BDCP will affect area water quality primarily through operation of CM1 and from other conservation measures that would make changes to the physical landscape (CM2 through CM11). This analysis focused on the changes in concentrations of two key contaminants (bromide and nitrate), because the other contaminants considered in the BDCP EIR/EIS are not directly tied to adverse health impacts and do not have mandated thresholds for Delta waterways. Expected bromide and nitrate concentration levels at the four major pumping stations in the Delta were examined, because drinking water originating from the Delta comes from these pumping stations. Changes in bromide and nitrate concentrations were defined by subtracting the concentrations in area waters in the baseline scenario from the concentrations in the four operational BDCP scenarios (labeled H1 through H4 in the BDCP EIR/EIS). For both bromide and nitrate, the net effect of the BDCP is a decrease compared to the baseline scenario. The reductions from the BDCP in bromide and nitrate concentrations offer water security benefits for the region, reducing the potential negative economic cost of bromide or nitrate increases in the future. Given the uncertainty of unexpected increases in levels of these two key contaminants, the study does not monetize these water security benefits.

The primary impacts of the BDCP on Delta commercial fisheries result from effects related to Chinook salmon, which is the only major commercial fish species in the Delta. Other affected commercial species include threadfin shad, crayfish, and California bay shrimp, though the commercial markets for these species are much smaller than the Chinook salmon market. Overall effects of CM1 operations would benefit fall-run and late fall–run Chinook salmon through substantial reductions in entrainment, improved San Joaquin River and Delta flow conditions, and neutral or positive changes in upstream conditions. The effects of floodplain, tidal, channel margin, and riparian natural community restoration activities on Chinook salmon are expected to be beneficial, providing net increases in amounts and quality of available habitat, increasing habitat diversity, increasing overall productivity and reducing predation. Although adverse effects on Chinook salmon are expected near the end of the permit term due to climate change, the overall effect of BDCP restoration activities is expected to remain beneficial for fall-run Chinook salmon. The overall impacts of the BDCP on Delta commercial fisheries (including Chinook salmon and other smaller fisheries) are expected to be positive to both the population and commercial landings for these species. This study was not able to quantify and monetize the impacts of BDCP related to commercial fisheries due to the high level of uncertainty involved in forecasting populations of salmon and other species over time.

ES.3 Economic Impacts Related to Non-Market Environmental Amenities

The BDCP would have economic impacts related to a wide range of non-market environmental amenities including air quality, greenhouse gas emissions, flood risk, property values and viewscapes, and erosion and sedimentation. Descriptions and brief summaries of the estimated impacts are presented below. Impacts on flood risk, property value and viewscapes, erosion and sedimentation were evaluated qualitatively, because these impacts are difficult to quantify and monetize.

ES.3.1 Regional Air Quality

Economic impacts of the BDCP related to changes in regional air quality would result from the construction and operation of the new water conveyance facility (CM1) and construction of natural community protection, restoration, and enhancement measures (CM2 through CM11). Air quality impacts result from increases in emissions of contaminants that have been linked to adverse health outcomes. Air quality estimates were derived based on air quality models developed for the BDCP EIS/EIR. Section 4.1, *Regional Air Quality*, describes these models in detail.

The monetary costs of increased air emissions are based on costs incurred as a result of increases in morbidity (decreased health) and mortality (death) that can be linked to air contaminants. This analysis focuses on emissions of six criteria pollutants[3]—reactive organic gases, nitrogen oxides, carbon monoxide, particulate matter less than 10 micrometers in diameter, particulate matter less than 2.5 micrometers in diameter, and sulfur oxides—and links changes in emissions of these contaminants to changes in expected health costs for the region. The human health costs for each contaminant are estimated using widely accepted methods applied by the U.S. Environmental Protection Agency to evaluate the economic costs of national regulatory decisions on air quality standards.

Mitigation measures in the BDCP EIR/EIS are designed to reduce the projected health effects of BDCP contaminant emissions through the purchase of offsets. These offsets would be purchased when emissions of a particular contaminant exceed the air quality threshold established by an air quality management district over a year or in the course of a day. Offsets represent an alternative project or program that reduces the amount of a criteria contaminant. When an offset is purchased, the net emission is zero.[4] No health costs are realized when an offset is purchased, which reduces the total health costs of air emissions from construction activities. For the offsets, the avoided health costs were estimated and subtracted from the total health costs. The costs of purchasing the offsets were then added to the health costs. This study predicts that the total costs of changes in regional air quality will range from $10.8 million to $15.5 million. Section 4.1 provides details on the assumptions, methods, and results.

[3] Section 4.1, *Regional Air Quality*, summarizes the definition of the criteria contaminants and their potential health effects.

[4] Annual pollution offsets equal the total contaminant for that basin. Daily pollution offsets, however, equal the pollution amount exceeding California Environmental Quality Act levels.

ES.3.2 Greenhouse Gas Emissions

Economic burdens associated with increasing greenhouse gas (GHG) emissions are frequently monetized in terms of regulatory costs (e.g., cost to comply with Assembly Bill 32, the California Global Warming Solutions Act) or community costs (e.g., public health costs from deteriorating air quality).[5] This study focuses primarily on regulatory costs because GHG emissions generated by construction and operation of the BDCP will be offset to net zero through mitigation required by the EIR/EIS. Reduced community costs associated with climate change moderation are briefly discussed in relation to carbon sequestration benefits from land conversion and natural community restoration.

According to Assembly Bill 32, GHGs include the following gases: carbon dioxide, methane, nitrous oxide, perfluorinated carbons, sulfur hexafluoride, and hydrofluorocarbons. Construction of the new water conveyance facility (CM1) would generate GHG emissions during both construction and operation. Construction activities would result in short-term (temporary) emissions from mobile and stationary construction equipment exhaust, employee vehicle exhaust, electrical transmission, and concrete batching. Operation of the water conveyance facility would generate long-term (permanent) emissions from maintenance equipment exhaust and electrical generation. A portion of carbon dioxide emissions generated by calcination during cement manufacturing would also be reabsorbed (i.e., removed from the atmosphere) into concrete structures during the life of the BDCP.

GHG emissions associated with CM1 were quantified using data provided by DWR and accepted software tools, techniques, and emission factors. Information on the location and types of construction equipment required for the other conservation measures were unavailable. Consequently, GHG emissions resulting from implementation of these conservation measures were assessed qualitatively.

This study predicts costs of GHG emissions from CM1 ranging from $82.3 million to $236.7 million and economic benefits ranging from $35.3 million to $715.4 million. Net benefits would range from -$47.0 million to $478.7 million. The large range in potential benefits stems from a high degree of uncertainty in the carbon sequestration potential of tidal natural communities restoration (CM4). Section 4.2, *Greenhouse Gas Emissions*, provides details on the assumptions, methods, and results.

ES.3.3 Other Non-Market Environmental Amenities

The economic impacts of the BDCP on flood risk in the Delta would result from both the operation of the water conveyance facility (CM1) and the implementation of other conservation measures (CM2 through CM22), particularly tidal natural communities restoration (CM4) and seasonally inundated floodplain restoration (CM5). These components of the BDCP are expected to have both positive and negative influences on flood risk in the Delta. Changes to the volume and patterns of water flows can increase or decrease flood risk by adding more or less pressure on levees. Land use also plays a large role in the level of flood risk. Although the land use changes resulting from the BDCP will result in increases and decreases in flood risk, the overall change to flood risk in the Delta from the BDCP is expected to be minimal. Section 4.3, *Flood Risk*, discusses these impacts, how they have been valued in other studies, and the challenges of quantifying and monetizing these impacts in the Delta region.

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[5] Refer to Section 4.1, *Regional Air Quality*, for an analysis of public health costs associated with criteria pollutant emissions generated by the BDCP.

The BDCP may affect area property values due to both the construction and operation of the new water conveyance facility (CM1) and implementation of other conservation measures, particularly natural community protection, restoration, and enhancement measures (CM2 through CM11). Section 4.4, *Property Values and Viewscapes*, considers the potential impacts of the BDCP related to property values that are not evaluated elsewhere (e.g., transportation delays, air quality), and impacts from changes to viewscapes and noise. To evaluate the potential impacts of CM1 on property values, studies of the impact of various kinds of infrastructure projects on nearby property values were reviewed. A similar review was also conducted of previous studies on the impact on property values for properties located adjacent to or nearby natural areas such as wetlands. The impacts of CM1 on property values are expected to be negative for properties near the new facilities. Positive effects on property values are expected for properties located near restoration sites. This study was unable to quantify or monetize these changes in property values and viewscapes; however, the total impact on property values is expected to be small in comparison with other statewide economic impacts of the BDCP.

The BDCP would result in changes to area erosion and sedimentation rates as a result of the construction and operation of the new water conveyance facility (CM1) and the protection, restoration, and enhancement measures (CM2 through CM11). BDCP-related impacts on erosion and sedimentation include potential changes in turbidity due to the construction and operation of CM1. In addition, CM2 through CM11 could change rates of erosion and sedimentation in area waterways due to the ecosystem services provided by the restored natural areas such as wetlands and grasslands. Section 4.5, *Erosion and Sedimentation*, discusses qualitatively the conservation measures expected to have impacts on rates of erosion and sedimentation.

ES.4 Summary of Welfare Impacts

The BDCP would greatly enhance the welfare of urban and agricultural water consumers receiving all or part of their water supplies from the Delta. The state and federal contractors would enjoy an enhanced level of water supply reliability, and would avoid prolonged water shortages that may result in the future from increasing environmental restrictions in the Delta. The net welfare gain to the state and federal contractors as a result of implementing the BDCP is $4.7 billion in 2012 dollars.

The BDCP would also affect individuals participating in Delta-dependent activities such as recreation, farming, and use of the regional road network. Impacts in these areas are expected to result in net benefits between $135 million and $257 million. In addition, the BDCP would affect various non-market environmental amenities such as carbon fluxes in the Delta and regional air quality. Taken together, these two categories of impacts are expected to result in small changes in welfare, ranging from -$58 million to roughly $463 million in net benefits over the 50-year permit term. The largest source of welfare gain is the possible reduction in carbon emissions resulting from restoration of tidal natural communities (CM4) in the Delta.

Adding all monetized impacts together, the BDCP would improve the economic welfare of California residents by $4.8 billion to $5.4 billion.

Table ES-2. Summary of Welfare Changes Resulting from Implementation of the BDCP (million $)

Category	Present Value Costs	Present Value Benefits	Present Value Net Benefits	Present Value Costs	Present Value Benefits	Present Value Net Benefits
	Low Value			High Value		
	A	B	C = A + B	D	E	F = D + E
State and Federal Water Contractors						
State and federal water contractors	-$13,328	$18,011	$4,683	-$13,328	$18,011	$4,683
Impacts on Delta-Dependent Economic Activities						
Salinity of agricultural water suppliers	-$34	$0	-$34	-$34	$0	-$34
Outdoor recreation	-$2	$223	$222	-$3	$373	$370
Transportation delays	-$53	$0	-$53	-$79	$0	-$79
Subtotal	**-$88**	**$223**	**$135**	**-$116**	**$373**	**$257**
Impacts on Non-Market Environmental Amenities						
Air quality	-$11	$0	-$11	-$16	$0	-$16
Greenhouse gas emissions	-$82	$35	-$47	-$237	$715	$479
Subtotal	**-$93**	**$35**	**-$58**	**-$252**	**$715**	**$463**
Total Welfare Impact	**-$13,509**	**$18,270**	**$4,761**	**-$13,696**	**$19,099**	**$5,403**

Notes:
Employment impacts are not show in this table, because the value added is through full-time equivalents, not dollars.
Numbers in the table may not add due to rounding.

ES.5 Impacts on Statewide Income and Employment

In addition to measuring changes in economic welfare, this study evaluates the statewide economic impact of the BDCP in terms of business output and employment. These impacts will result from the construction and operation under CM1, implementation of the other conservation measures (CM2–CM11, CM13–CM21), and increased water supply reliability. These positive impacts on output and employment will be offset to some degree by higher water costs and higher state spending, and by the loss of some agricultural land in the Delta.

ES.5.1 Impacts on State Income

The BDCP is expected to result in a significant increase in the sales of California businesses over the 50-year permit term. Table ES-3 summarizes the economic activity impacts associated with each of the following categories.

- **CM1 Water Facilities and Operation**. Economic activity generated through the planning and construction of the new water conveyance facility is estimated at $21.2 billion in California during an expected 10-year planning and construction period.[6] Operations and maintenance, assumed to begin in year 11, are expected to generate an estimated $1.3 billion of economic activity over the remaining 40 years of the permit term.

[6] All impacts are based on cost estimates in 2012 dollars and are discounted to present value at a 3% real discount rate.

- **Other Relevant Conservation Measures (CM2–CM11, CM13–CM21).** The construction and planning; operations and maintenance; land acquisition; and administrative implementation, monitoring, and research share of conservation measures involving the protection, restoration and enhancement of natural communities will result in an increase in economic activity of an estimated $9.4 billion over the 50-year permit term. The retirement of agricultural lands will result in an estimated loss of $2.8 billion in economic activity during the same period, for a net gain of an estimated $6.6 billion over the 50-year permit term.
- **Water Supply Reliability.** Economic activity generated from increased water supply reliability begins when the new north Delta water conveyance facility begins operation, expected in 2026. Impacts on the commercial/industrial/institutional sector and the agricultural sector are estimated to be a net gain of $67.5 billion and $5.9 billion, respectively, totaling $73.4 billion over the 40 years of dual conveyance operations in the Delta.

Taking all these impacts together, and netting out the business activity lost as a result of higher water costs and taxes, the BDCP will increase California state business output by $83.5 billion over the 50-year permit term.

Table ES-3. Changes in Economic Activity ($ Millions)

Category	Years 1–10	Years 10–20	Years 20–30	Years 30–40	Years 40–50	Total over 50 Years
CM1 Water Facilities and Operation						
Construction and planning	$21,238	$0	$0	$0	$0	$21,238
Operations and maintenance	$0	$474	$353	$263	$195	$1,285
Subtotal	**$21,238**	**$474**	**$353**	**$263**	**$195**	**$22,523**
Other Relevant Conservation Measures (CM2–CM11, CM13–CM21)						
Construction and planning	$2,486	$1,318	$987	$690	$132	$5,612
Operations and maintenance	$497	$529	$364	$282	$217	$1,890
Land acquisition[b]	$319	$197	$137	$102	$0	$755
Other[c]	$342	$298	$204	$156	$103	$1,103
Agricultural land retirement[d]	($319)	($584)	($672)	($677)	($539)	($2,791)
Subtotal	**$3,325**	**$1,757**	**$1,020**	**$553**	**($87)**	**$6,569**
Water Supply Reliability						
Commercial/industrial/institutional	$0	$24,919	$18,542	$13,797	$10,266	$67,525
Agricultural	$0	$2,181	$1,623	$1,208	$899	$5,910
Subtotal	**$0**	**$27,100**	**$20,165**	**$15,005**	**$11,165**	**$73,435**
Increased Water Rates and Taxes						
Induced Output Impact	($16,327)	($925)	($777)	($580)	($411)	($19,019)
Subtotal	**($16,327)**	**($925)**	**($777)**	**($580)**	**($411)**	**($19,019)**
Total Economic Impacts Across All Categories	**$8,236**	**$28,407**	**$20,761**	**$15,241**	**$10,863**	**$83,508**

[a] All impacts are based on cost estimates in 2012 dollars and are discounted to present value at a 3% real discount rate.

[b] Represents the impacts from payments made to landowners to acquire reserve lands for protection, restoration, and enhancement either in fee title or as conservation easement.

[c] Impacts from administrative implementation, monitoring, and research costs.

[d] Represents agricultural revenue loss from decreased agricultural activity that would result from the conversion of agricultural lands to reserve lands. Impacts due to conversion of agricultural lands to water conveyance facilities were not modeled; however, these impacts are small in comparison, representing only 10% of agricultural retirement under the BDCP.

ES.5.2 Impacts on Employment

Significant job gains and increases in employee compensation will result from construction and operation of the new water conveyance facility (CM1), the implementation of other conservation measures (CM2–CM11, CM13–CM21), and improved water reliability. Job creation will be offset somewhat by job losses from the conversion of agricultural land to the water conveyance facilities and reserve lands. There will also be induced job losses associated with increased water rates and taxes.

Table ES-4 and Table ES-5 summarize the employment impacts and employee compensation impacts, respectively, associated with each of the three categories below. The analysis of employment compensation does not currently include employment compensation impacts from water reliability due to lack of data.

- **CM1 Water Facilities and Operation**. Employment impacts associated with planning and construction of the new water conveyance facility will create an estimated 110,596 full-time equivalent (FTE) jobs and increase employment compensation by an estimated $7.8 billion in California during an expected 10-year planning and construction period.[7] The operations and maintenance expenses are assumed to begin in year 11 and will create an additional estimated 11,331 FTE jobs and increase employment compensation by $510 million over the remaining 40 years of the permit term. This will result in an annual rate of just under 283 FTE operations and maintenance positions.
- **Other Relevant Conservation Measures (CM2–CM11, CM13–CM21).** The construction and planning; operations and maintenance; land acquisition; and administrative implementation, monitoring, and research share of the protection, restoration, and enhancement measures will result in an estimated 92,589 FTE jobs and $3.5 billion in employee compensation over the 50-year permit term. The retirement of agricultural lands will result in an estimated loss of 36,819 FTE jobs and $807 million in employee compensation during the same period, for a net gain of an estimated 55,770 FTE jobs and $2,732 million in compensation over the 50-year permit term.
- **Water Supply Reliability.** Employment impacts resulting from increased water supply reliability begin when the BDCP comes into operation. Impacts on the commercial/industrial/institutional sector and the agricultural sector are estimated to be 761,840 jobs and 257,824 jobs, respectively, totaling 1,019,664 jobs over the 50-year permit term.

Overall, the BDCP will create or preserve an estimated 1.1 million FTE jobs. Construction of new conveyance facilities and restoration areas will also result in $11.0 billion in additional employee compensation over the 50-year permit term.

[7] FTE or full-time equivalent is defined as the number of total hours worked divided by the maximum number of compensable hours in a work year as defined by law. For example, an FTE of 1.0 means that the position is equivalent to 1 full-time worker, while an FTE of 0.5 means the position is equivalent to a half-time worker.

Table ES-4. Statewide Employment Impact Summary (Full-Time Equivalent Jobs[a])

Category	Years 1–10	Years 10–20	Years 20–30	Years 30–40	Years 40–50	Total over 50 Years
CM1 Water Facilities and Operation						
Construction and planning	110,596	0	0	0	0	110,596
Operations and maintenance	0	2,833	2,833	2,833	2,833	11,331
Subtotal	**110,596**	**2,833**	**2,833**	**2,833**	**2,833**	**121,928**
Other Relevant Conservation Measures (CM2–CM11, CM13–CM21)						
Construction and planning	15,962	11,338	11,414	10,733	2,753	52,200
Operations and maintenance	3,494	4,909	4,539	4,727	4,879	22,548
Land acquisition[b]	2,016	1,676	1,580	1,572	0	6,844
Other[c]	2,070	2,400	2,219	2,280	2,028	10,998
Agricultural land retirement[d]	(2,092)	(5,076)	(7,824)	(10,569)	(11,258)	(36,819)
Subtotal	**21,450**	**15,247**	**11,928**	**8,743**	**(1,598)**	**55,770**
Water Supply Reliability						
Commercial/ industrial/ institutional	0	190,460	190,460	190,460	190,460	761,840
Agricultural	0	64,456	64,456	64,456	64,456	257,824
Subtotal	**0**	**254,916**	**254,916**	**254,916**	**254,916**	**1,019,664**
Increased Water Rates and Taxes						
Induced Employment Impact	(88,322)	(5,004)	(4,202)	(3,137)	(2,221)	(102,885)
Subtotal	**(88,322)**	**(5,004)**	**(4,202)**	**(3,137)**	**(2,221)**	**(102,885)**
Total Employment Impacts Across All Categories	**43,725**	**267,992**	**265,475**	**263,355**	**253,930**	**1,094,477**

[a] Jobs are defined as full-time equivalents (total hour worked divided by average annual hours worked in full-time jobs.)

[b] Represents the employment impact from payments made to landowners to acquire reserve lands for protection, restoration, and enhancement either in fee title or as conservation easement.

[c] Impacts from administrative implementation, monitoring, and research costs.

[d] Represents agricultural revenue loss from decreased agricultural activity that would result from the conversion of agricultural lands to reserve lands. Impacts due to conversion of agricultural lands to water conveyance facilities were not modeled; however, these impacts are small in comparison, representing only 10% of agricultural retirement under the BDCP.

Table ES-5. Statewide Employee Compensation Impact Summary (million $[a])

Category	Years 1–10	Years 10–20	Years 20–30	Years 30–40	Years 40–50	Total over 50 Years
CM1 Water Facilities and Operation						
Construction and planning	$7,791	$0	$0	$0	$0	$7,791
Operations and maintenance	$0	$188	$140	$104	$78	$510
Subtotal	**$7,791**	**$188**	**$140**	**$104**	**$78**	**$8,301**
Other Relevant Conservation Measures (CM2–CM11, CM13–CM21)						
Construction and planning	$923	$489	$366	$256	$49	$2,084
Operations and maintenance	$192	$204	$140	$109	$84	$728
Land acquisition[b]	$103	$64	$44	$33	$0	$245
Other[c]	$149	$130	$89	$68	$45	$482
Agricultural land retirement[d]	($92)	($169)	($194)	($196)	($156)	($807)
Subtotal	**$1,275**	**$718**	**$446**	**$270**	**$22**	**$2,732**
Total Employment Impacts Across All Categories (except water reliability)	**$9,066**	**$907**	**$586**	**$375**	**$99**	**$11,033**

[a] All impacts are based on cost estimates in 2012 dollars and are discounted to present value at a 3% real discount rate.

[b] Represents the employment impact from payments made to landowners to acquire reserve lands for protection, restoration, and enhancement either in fee title or as conservation easement.

[c] Impact from administrative implementation, monitoring, and research costs.

[d] Represents agricultural revenue loss from decreased agricultural activity that would result from the conversion of agricultural lands to reserve lands. Impacts due to conversion of agricultural lands to water conveyance facilities were not modeled; however, these impacts are small in comparison, representing only 10% of agricultural retirement under the BDCP.

ES.6 Findings of Statewide Economic Impacts of the BDCP

Implementing the BDCP would substantially increase economic welfare, business activity, and employment in California. The BDCP would prevent future reductions in SWP and CVP deliveries that may result from implementation of stricter environmental flow requirements in the Delta. By maintaining and stabilizing Delta exports at close to levels of the recent past, the BDCP would increase California business output by over $83.5 billion and create or preserve up to 1.1 million California jobs. Construction and operation of water conveyance facilities in the Delta and implementation of other conservation measures would result in $11.0 billion in additional compensation (i.e., salary and benefits) to California workers.

The BDCP would generate $4.7 billion in net benefits to the state and federal water contractors that receive SWP and CVP deliveries from the Delta. These benefits result from improved water supply reliability, reduced salinity, and reduced seismic risks to water supplies.

The BDCP would have an impact on individuals participating in Delta-dependent activities such as recreation, farming, and use of the regional road network. Across the activities that could be evaluated quantitatively, the BDCP is expected result in a small increase in economic welfare of $135 million to $257 million. In addition, the BDCP would affect various non-market environmental amenities such as carbon fluxes in the Delta and regional air quality. Taken together, these two categories of impacts are expected to result in small changes in welfare, ranging from -$58 million to roughly $463 million in net benefits over the 50-year permit term. The large range of potential economic benefits is largely due to the high uncertainty in carbon sequestration potential of the extensive tidal wetlands restored under the BDCP.

Adding all monetized impacts together, the BDCP would result in an improvement in the economic welfare of California residents of between $4.8 billion and $5.4 billion. These totals do not include additional expected statewide economic costs and benefits to the activities or values in the Delta that could not be quantified or monetized in this study: flood risk, property values and viewscapes, commercial fisheries, urban water treatment, and erosion and sedimentation. The BDCP is expected to have a net positive economic effect on commercial fisheries. In all other cases, the BDCP may have both positive and negative economic effects, but those effects are predicted to be small. It is unlikely that these unmonetized categories of impacts are large relative to the welfare gains from improved water supply reliability, or to the stimulus effect of the BDCP on California output and employment. Therefore, the BDCP is predicted to result in substantial economic benefits to California businesses and residents.

Chapter 1
Introduction

This report presents an analysis of the statewide economic impact of the implementation of the Bay Delta Conservation Plan (BDCP). The BDCP reflects the outcome of a multiyear collaboration between local water agencies, state and federal fish and wildlife agencies, nongovernment organizations, agricultural interests, and the general public. The BDCP is both a habitat conservation plan under the federal Endangered Species Act and a natural community conservation plan under the state Natural Community Conservation Planning Act. The BDCP is expected to result in endangered species permits from the state and federal fish and wildlife agencies for a term of 50 years.

In compliance with the California Environmental Quality Act and the National Environmental Policy Act, a comprehensive environmental impact report/environmental impact statement was prepared for the BDCP.

The BDCP planning documents present detailed information on the capital and operating costs of implementation. The BDCP also provides analysis of the economic benefits to the urban and agricultural water users that receive water from the State Water Project (SWP) and Central Valley Project (CVP). This report expands the information available on the economic impacts of the BDCP to include economic interests within the Delta and the public at large throughout the state. This assessment is appropriate given that the BDCP is expected to be partially funded by the people of California through two statewide water bonds and through continued appropriations by Congress. This statewide economic impact study is not required by the federal Endangered Species Act, Natural Community Conservation Planning Act, California Environmental Quality Act, National Environmental Policy Act, or any other state or federal law. However, because of the importance of the BDCP, its relatively large costs, and its large share of public funding (32%), this report has been prepared to help the public and decision makers evaluate the full economic impacts of BDCP.

This chapter provides a brief overview of the BDCP followed by an introduction to the economic impacts considered in the rest of the report. It then introduces the types of economic impacts estimated in this report and the methods used to estimate these impacts. Lastly, this chapter provides an overview of the full report.

1.1 Overview of the BDCP

Since the mid-twentieth century, the SWP and CVP have drawn water from the southern edge of the Sacramento–San Joaquin River Delta, near where the two major rivers converge in a tangle of sloughs and channels before flowing to San Francisco Bay and the Pacific Ocean. Today, water pumped through the Delta provides part of the water supply to 66% of the state's population, from the San Francisco Bay Area to San Diego. This through-Delta water system is outdated and at risk. The aging system was built before passage of many environmental laws, and some fish and wildlife species have suffered dramatic declines over the past 30 years. Pumps in the south Delta can cause reverse flows, harming sensitive fish and altering Delta habitats. The Delta levees, built throughout the nineteenth century to protect towns, infrastructure, and the state's central water supply system, are vulnerable to winter storms, seepage, slumping, and earthquakes. Climate change and rising sea levels will heighten the risk of levee failure with more intense storm runoff. Earthquakes could destroy Delta levees, result in catastrophic flooding, and cause long-term suspension of water deliveries from SWP/CVP facilities. These events could have severe consequences for the economy of the state.

The BDCP aims to help secure California's water supplies and restore some of the Delta's natural ecosystem. The BDCP would modernize the heart of California's aging water supply network, while balancing environmental and water supply considerations. Additionally, the BDCP is intended to reverse trends of species in decline with an accelerated and substantial habitat restoration program. The goals include protection and creation of approximately 145,000 acres of aquatic and terrestrial habitat. Reconnecting floodplains, developing new tidal marshes and returning riverbanks to a more natural state should boost food supplies and protection for fish that depend on the Delta. The BDCP aims to achieve these goals through its conservation strategy, summarized below.

Under *Conservation Measure (CM) 1 Water Facilities and Operation*, the BDCP would construct and operate new water conveyance facilities and modify operation of existing SWP/CVP facilities to protect fish populations and accommodate new Delta facilities and proposed habitat restoration. This new system is expected to reduce fish entrainment by pumping less from the south Delta and achieving flows throughout the Delta that would more closely reflect natural conditions. The system would also provide critical flexibility in operations in the event of a catastrophic earthquake and in the face of rising sea level as a result of climate change.

CM2 through CM11 provide for protection, restoration, and enhancement of habitats for native fish, wildlife, and plants in the Plan Area[1]. These measures will provide more than 80,000 acres of restoration and more than 60,000 acres of habitat protection. In addition, these measures will enhance operations in the Yolo Bypass to benefit fish species.

CM12 through CM21 include specific actions to address other ecological stressors on covered aquatic species in the Delta. Examples of these measures include the construction and operation of additional conservation hatcheries, control of nonnative predators at specific locations, and control of invasive aquatic vegetation throughout the Delta.

1.2 Overview of the Economic Impacts of the BDCP

The costs and benefits of the BDCP to urban and agricultural water users that receive water from the SWP and CVP have previously been quantified by BDCP Appendix 9.A, *Draft Benefits Analysis of Bay Delta Conservation Plan Project Alternatives* report, Appendix 9.A (California Department of Water Resources 2013). An understanding of this issue is essential to making a determination regarding the financial feasibility of the BDCP, because the state and federal contractors will be responsible for paying for an estimated 68% of BDCP costs, including all of the construction and operation costs of the new water conveyance facility (CM1). However, the potential economic costs and benefits of the BDCP to other water users and to the public at large have not yet been evaluated. This report addresses this knowledge gap to quantify, where possible, these additional economic costs and benefits of the BDCP.

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[1] The Plan Area covers the Sacramento–San Joaquin Delta, as defined by California Water Code Section 12220 (statutory Delta), as well as certain areas in which conservation measures will be implemented such as Suisun Marsh and the Yolo Bypass.

Some economic impacts are considered only on a qualitative basis due to either a lack of reliable data on these parameters, large uncertainties in their estimated costs or benefits, or both.

This analysis followed generally accepted principles for analyzing economic impacts by comparing incremental, or marginal, changes in costs and benefits to determine net economic impacts of a project. This analysis estimates the various impacts in present value terms by discounting future streams of costs and benefits using a discount rate that reflects a real rate of return.

This study considers the impacts of the BDCP on ecosystem services by first defining the range of affected ecosystem services and then quantifying and, where possible, monetizing the change in the quantity and quality of the affected ecosystem services over time. In addition, this study relied primarily on methods with links to actual market activity when estimating the value of ecosystem services.

The primary intent of this study is to provide additional information to the public on the economic impacts of the BDCP. Such information is particularly useful given that roughly one-third of the cost of the BDCP is being funded by the State of California and various federal agencies. This study was not conducted to fulfill any specific regulatory objectives.

1.3 Types of Economic Impacts

Estimation of the economic impacts of the BDCP requires an identification of the affected ecological goods and services. These ecological goods and services are a result of ecosystem functions—the physical, chemical, and biological processes occurring within ecosystems. Some ecological goods and services (e.g., timber, fuel, food, water) are bought and sold in markets. Thus, market prices can provide at least some measure of their societal value. Other ecological goods and services have a less clear, or no clear, connection to market activity, and must be estimated by other means as described further below.

Different types of values are associated with ecological goods and services. At the highest level, the values attributed to ecological goods and services can be described as use or non-use values (as discussed below). *Total economic value* is known as the sum of all the different possible components of value, or the sum of the use and non-use values of ecological goods and services.[2]

1.3.1 Use Values

The most straightforward manner in which ecological goods and services provide benefits, and are therefore valued by society, is through their direct use. Some direct uses of ecological goods and services involve human consumption, whereas other direct uses of ecological goods and services do not involve any actual consumption (i.e., they are nonconsumptive). Human beings also can use ecological goods and services indirectly. Indirect use occurs when the good or service is an input to something else people directly use (e.g., flood protection, waste assimilation, carbon sequestration and habitat provision services of ecosystems).

[2] One additional component of the value of ecological goods and services is called *option value*, which is the value that people ascribe to the knowledge that they can use a good or service in the future. Economists differ on whether option value should be considered a use or a non-use value.

1.3.2 Non-Use Values

Another way society values ecological goods and services is through non-use values, which do not involve any actual use of ecological goods and services (either direct or indirect). One type of non-use value is existence value, which is the value people place on the knowledge that a particular good exists, even if they have no plans to personally use it. Similarly, bequest value refers to the value individuals might place on knowing that a good or service would be available for use by future generations.

1.4 Methods Used to Estimate Economic Impacts

Economists have developed a variety of methods that can be used to value both the use and non-use values of ecological goods and services. These valuation methods differ primarily in how values for ecological goods and services are measured. *Revealed preference* methods and *cost*-based methods rely on actual market data, and *stated preference* methods rely on the responses of people to hypothetical scenarios. *Benefit transfer* methods take the values estimated by existing revealed preference and stated preference studies and adapt, or customize, them to fit a new context. Table 1-1 lists the various applications of these methods. A discussion of each method and its appropriateness for valuing impacts of the BDCP follows the table.

Table 1-1. Methods for Valuing Ecological Goods and Services

Revealed Preference	Cost-Based	Stated Preference	Benefit Transfer
Market price method Productivity method Hedonic pricing method Travel cost method	Damage cost method Replacement cost method Substitute cost method	Contingent valuation method Choice experiments (conjoint analysis)	Benefit value transfer Benefit function transfer

1.4.1 Revealed Preference Methods

Revealed preference methods all rely on market data to estimate individuals' willingness to pay, either by using market data for specific ecological goods and services, or by using market data for some other good or service that can be linked to the ecological good or service of interest. Revealed preference methods can be used to value aspects of ecological goods and services that can be linked either directly or indirectly to market activity, but they cannot be used to estimate the non-use values of ecological goods and services.

The market price method is the most straightforward method for valuing ecological goods and services. It uses the price of the market goods and services as a proxy for the value of the ecosystems that provide them. The main data needed for this method are the change in the quality and/or quantity of the potentially affected market goods and services, and the corresponding market prices of these affected goods and services. This study uses the market price method to estimate the impacts of the BDCP on Delta-dependent economic activities, such as impacts on Delta agriculture, transportation, and outdoor recreation.

Similar to the market price method, the productivity method can be used to value ecosystem services when they contribute to the production of goods and services sold in markets. The main data needed for the productivity method is information that relates changes in ecosystem services, such as changes to the size and quality of habitat, to the production of market goods. The productivity method also requires data on the costs of producing the market goods and services, and market price data. The productivity method faces the same limitation as the market price method for valuing ecological goods and services, in that it can only value aspects of ecological goods and services that can be linked back to market activity.

The hedonic pricing method uses property market data to estimate the value of ecological goods and services. More specifically, this method uses statistical techniques to infer the value of ecological goods and services by comparing values of properties that include or do not include them. The applicability of the hedonic pricing method to value ecological goods and services is limited, however, because the method can only estimate values of ecological goods and services that would be reflected in property markets. Section 4.4, *Property Values and Viewscapes*, discusses how the hedonic pricing method could be used to estimate the impact of the BDCP on property values, and provide additional detail on this method.

The travel cost method is used to value natural areas that are used for recreation. This method is based on the premise that the cost people incur to travel to and use a recreational area is equal to their willingness to pay for it, and therefore the value they receive from it. Estimating travel cost generally includes travel expenses (e.g., gas and airfare), travel time, and other expenditures related to the trip to a recreation site (e.g., entrance fees). The travel cost method has been used extensively by government agencies such as the U.S. Forest Service to value the recreational values of forest areas and to develop "unit-day" values for recreational activities, or the value to individuals of days spent engaged in these activities (Loomis 2005; Rosenberger and Loomis 2001). In Section 3.3, *Outdoor Recreation*, unit-day values are used to estimate BDCP impacts on outdoor recreation.

1.4.2 Cost-Based Methods

Cost-based methods such as the damage cost, replacement cost, and substitute cost methods all attempt to value ecological goods and services by estimating the costs that could be incurred as a result of the loss of their provision. The damage cost method uses the cost of the damages that could result if a particular ecological good or service were lost as a proxy for their value. The replacement cost method estimates value based on the cost to replace lost ecological goods and services, and, similarly, the substitute cost method involves estimating the cost of providing substitutes for lost ecological goods and services. Cost-based methods are useful for valuing certain kinds of ecological goods and services, such as reductions in flood risk and the ability of natural areas to filter pollutants out of the air and water. This study used cost-based methods to value several impacts of the BDCP, including impacts on air quality, water quality, and greenhouse gas emissions.

1.4.3 Stated Preference Methods

Stated preference methods construct hypothetical markets and use them to elicit information from survey respondents on their willingness to pay for ecological goods and services. The main advantage of stated preference methods is that they are the only methods available to measure the non-use component of the value of ecological goods and services, or the value that individuals may derive from ecological goods and services without actually using them. These methods have been used extensively by economists to estimate non-use values of ecological goods and services. Stated preference methods are particularly applicable when there is reason to believe that a potentially affected natural area would have significant non-use values. Areas that provide habitat for threatened or endangered species are one example where this may be the case, because people other than those who can immediately use the habitat area might value the continued protection of these species.

1.4.4 Benefit Transfer Methods

Benefit transfer is a method that allows for results on the economic values (obtained from revealed and/or stated preference methods) of a particular ecological good or service to be customized and adapted to match a new context. Benefit transfer is commonly used for valuing ecological goods and services, because the time and expense of implementing revealed and stated preference methods are often prohibitive. This is particularly true for stated preference methods, which, for the reasons discussed above, are especially time- and resource-intensive to implement. Benefit transfer either involves directly transferring a benefit value from one context to another, or transferring the function used to estimate benefits across contexts. The latter approach is preferred, because it affords a greater ability to customize the benefit value to match the new context to which it is being applied. A limitation of the benefit transfer method, however, is that benefit transfers can only be conducted when suitable source data are found. Suitability of source data is determined by a variety of factors, including the following.

- The similarity of the characteristics of the good or service being valued in the original study to the current context.
- The similarity of the population affected by the good or service (in terms of socioeconomic characteristics).
- The quality of the source study.

This study relied in part on benefit transfer methods to estimate many of the impacts of the BDCP, including impacts on air quality, water quality, and recreation.

1.5 Report Overview

This report first presents a summary of the welfare benefits of the BDCP to state and federal water contractors. These welfare changes result from improved water supply reliability, improved water quality, and reduced seismic risk. It then considers the economic impacts of the BDCP grouped into two main categories: Delta-dependent economic activities, and non-market environmental amenities. As discussed above, analyses were quantitative whenever possible. Data related to urban water treatment, commercial fisheries, flood risk, property values, and sedimentation and erosion (Table 1-2) were unavailable or too uncertain; in these cases, analyses were conducted qualitatively.

After detailing the changes in economic welfare resulting from the BDCP, the study then documents the changes in state income and employment resulting from the construction, operations, habitat restoration, and water supply reliability elements of the Plan. The report concludes that while the BDCP is expected to result in negative impacts on some selected groups (e.g., Delta residents experiencing air quality changes or increased traffic congestion during the construction period), these effects are small in relation to the substantial statewide economic benefits of the BDCP.

The analyses contained in this report were conducted by The Brattle Group and ICF International. Table 1-2 lists the chapters of this report along with the firm that prepared each chapter and conducted the associated analyses.

Table 1-2. Chapters/Sections, Analysis Type, and Preparers of this Report

Chapter/Section Title	Type of Analysis	Preparer
2. Summary of Welfare Impacts on State and Federal Water Contractors		
2.1. Incremental Costs Borne by State and Federal Water Contractors	Quantitative	ICF International/ The Brattle Group
2.2. Net Economic Benefits to State and Federal Water Contractors	Quantitative	The Brattle Group
3. Economic Impacts Related to Delta-Dependent Economic Activities		
3.1. Salinity of Agricultural Water Supplies	Quantitative	The Brattle Group
3.2. Outdoor Recreation	Quantitative	ICF International
3.3. Transportation	Quantitative	ICF International
3.4. Urban Water Treatment	Qualitative	ICF International
3.5. Commercial Fishing	Qualitative	ICF International
4. Economic Impacts Related to Non-Market Environmental Amenities		
4.1. Regional Air Quality	Quantitative	ICF International
4.2. Greenhouse Gas Emissions	Quantitative	ICF International
4.3. Flood Risk	Qualitative	ICF International
4.4. Property Values and Viewscapes	Qualitative	ICF International
4.5. Sedimentation and Erosion	Qualitative	ICF International
5. Statewide Income and Employment Impacts from Construction, Restoration, and Enhanced Water Supply Reliability		
5.1. Impacts on Income	Quantitative	The Brattle Group
5.2. Impacts on Employment	Quantitative	The Brattle Group
6. References		ICF International/ The Brattle Group
Appendix A. Greenhouse Gas and Air Quality Analysis Assumptions		ICF International
Appendix B: Land Conversion and GHG Flux Assumptions		ICF International

Chapter 2
Summary of Welfare Impacts on State and Federal Water Contractors

This chapter summarizes the costs and benefits that would be incurred by the state and federal water contractors—the urban and agricultural water agencies that receive water supplies from the SWP and CVP—as a result of implementation of the BDCP.

2.1 Incremental Costs Borne by State and Federal Water Contractors

The direct costs to the state and federal water contractors for the BDCP come from construction and operation of the new water conveyance facility (*CM1 Water Facilities and Operation*) and mitigation associated with construction and operation identified in both the BDCP (California Department of Water Resources 2013) and its environmental impact report/environmental impact statement (EIR/EIS) (California Department of Water Resources et al. 2013). This section summarizes those direct costs to the state and federal water contractors helping to fund BDCP. Costs are presented as incremental costs of BDCP, net of any costs expected to be incurred by state and federal contractors even without the BDCP. Costs are calculated under the assumption that the BDCP will operate for 50 years past the construction period, totaling 60 years of costs.[1]

The state and federal water contractors have committed to funding 100% of the construction and operation of CM1. Construction costs include the design, project management, and construction management of the water conveyance facilities; construction of the intake and conveyance facilities; the construction cost contingency; and land acquisition. These costs have been estimated in BDCP Chapter 8, *Implementation Costs and Funding Sources* (Section 8.4.1, *CM1 Water Facilities and Operation*), based on data from the *Modified Pipeline/Tunnel Option (MPTO) 2012 Conceptual Engineering Report* (Delta Habitat Conservation and Conveyance Program 2012) and associated cost estimates[2]. Total incremental CM1 capital costs are estimated at $14.5 billion in undiscounted 2012 dollars.

Water facilities operation costs consist of three components.

- Labor and equipment costs for operations and maintenance.
- Power costs for conveyance pumping.
- Capital replacement costs.

Incremental operational costs of the 50 years of expected operations of the new water conveyance facility (from year 10 to year 60) have been estimated at $1.9 billion in undiscounted 2012 dollars.

[1] BDCP Chapter 8 costs assume only 40 years of operation, totaling 50 years of costs. This analysis assumes and additional 10 years to stay consistent with the economic benefits in Section 2.2, which are calculated assuming 50 years of operation.

[2] Cost estimates for *CM1 Water Facilities and Operation* are based on the water facility alignment proposed in California Department of Water Resources 2013.

Together, the construction and operational incremental costs of the new water conveyance facility total $16.4 billion in undiscounted 2012 dollars.

The BDCP conservation strategy includes actions to mitigate the impacts on covered species of the improvements to and on-going operations of the SWP and CVP in the Delta. BDCP also includes actions to mitigate the impacts of habitat restoration, which have both beneficial and adverse effects to covered species. Finally, a large share of the conservation measures are devoted to providing for the conservation and management of the covered species, going beyond mitigation requirements to contribute to species recovery.

The share of these mitigation costs that are proposed to be the responsibility of the state and federal water contractors are related to the direct and indirect effects of the water facility construction and operation. These BDCP mitigation costs have been estimated as a portion of eight conservation measures (Table 2.1-1). The proportion of the conservation measure considered as mitigation for the construction and operation of the water facility varies by conservation measure according to the impact on that natural community or resource (Table 2.1-1). Mitigation costs are also assigned to the state and federal water contractors for program management, monitoring, and remedial actions in proportion to the impacts of CM1 relative to other conservation measures.

The BDCP EIR/EIS includes additional mitigation measures for topics such as air quality, cultural resources, greenhouse gas emissions, and impacts to non-covered special-status species. The costs of these additional mitigation measures will be shared by public funding sources and the state and federal contractors. Based on the proportion of impacts from water facility construction to these EIR/EIS resources, the share of EIR/EIS mitigation from the state and federal water contractors is estimated at $92.4 million (65% of these costs). Together with the mitigation share of BDCP conservation measures (i.e., all but CM1), the total incremental mitigation cost to state and federal water contractors is estimated at $834.5 million in undiscounted 2012 dollars (Table 2.1-1).

Two mitigation costs associated with the BDCP that will be paid by the contractors are expected to be incurred by the contractors even without the BDCP. As seen in Table 2.1-1, some costs associated with tidal natural communities restoration (CM4) and the installation and operation of nonphysical fish barriers (CM16) are expected to occur whether or not the BDCP is approved and implemented. These costs are removed from the $17.2 billion (undiscounted 2012 dollars) net estimate of the direct incremental costs to the state and federal water contractors. The $17.2 billion comes to a net present value of $13.3 billion discounted at a 3% real discount rate.

Table 2.1-1. Summary of Costs to Participating State and Federal Water Contractors (2012 million $, undiscounted)

Cost Item	Total BDCP Cost[a]	% Cost to Contractors[b]	Total BDCP Cost to Contractors	Costs Borne by Contractors with or without BDCP	Net BDCP Cost to Contractors (Incremental Costs)
CM1 Water Facilities and Operation[c]	$16,367	100.0%	$16,367	0.0	$16,367
CM3 Natural Communities Protection and Restoration	$422.2	18.3%	$77.3	0.0	$77.3
CM4 Tidal Natural Communities Restoration	$1,867.8	12.6%	$235.3	-$28.3	$207.1
CM6 Channel Margin Enhancement	$135.0	13.0%	$17.5	0.0	$17.5
CM7 Riparian Natural Community Restoration	$50.9	2.9%	$1.5	0.0	$1.5
CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration	$1.7	9.0%	$0.2	0.0	$0.2
CM10 Nontidal Marsh Restoration	$44.4	4.9%	$2.2	0.0	$2.2
CM11 Natural Communities Enhancement and Management	$391.2	18.3%	$71.6	0.0	$71.6
CM15 Localized Reduction of Predatory Fishes	$50.2	33.8%	$17.0	0.0	$17.0
CM16 Nonphysical Fish Barriers	$1,271.7	14.3%	$181.9	-$72.8	$109.0
CM22 Avoidance and Minimization Measures	$36.3	22.4%	$8.1	0.0	$8.1
Program administration	$336.9	8.8%	$29.8	0.0	$29.6
Monitoring and research	$912.8	7.8%	$71.2	0.0	$71.2
Property tax revenue replacement	$218.5	44.5%	$97.2	0.0	$97.2
Changed circumstances	$178.2	18.3%	$32.6	0.0	$32.6
EIR/EIS Mitigation[d]	$141.7	65.2%	$92.4	0.0	$92.4
Total			**$17,303.0**	$101.1	**$17,201.9**

Source: California Department of Water Resources 2013: Table 8-50.

[a] The *Total BDCP Cost* column only includes costs to categories that affect contractor costs. Actual total BDCP costs include more conservation measure costs.

[b] See BDCP Chapter 8, Table 8-50 for the rationale for these contractor cost shares.

[c] CM1 costs in this table do not reflect the costs represented in BDCP Chapter 8, *Implementation Costs and Funding Sources*, because this table captures 50 years of operations rather than the 40 years captured in Chapter 8. This is done to stay consistent with the economic benefits in Section 2.2, *Net Economic Benefits to State and Federal Water Contractors*, which are calculated assuming 50 years of operation.

[d] The costs of the majority of EIR/EIS mitigation are accounted for in other costs of implementing the BDCP. The EIR/EIS mitigation costs identified in this table are in addition to the costs of the conservation measures.

2.2 Net Economic Benefits to State and Federal Water Contractors

2.2.1 Introduction

This section summarizes the direct economic benefits of implementing the BDCP to the state and federal water contractors. The goal of the BDCP is to restore and protect ecosystem health, water supply, and water quality within a stable regulatory framework. Benefits stated in this section assume a 10-year permitting and construction period for the new water conveyance facility under *CM1 Water Facilities and Operation*, followed by a 40-year operating period.

2.2.2 Scenarios Evaluated

As is standard in welfare economics, this report compares economic outcomes under the BDCP to the conditions without the BDCP. For purposes of this analysis, the BDCP is evaluated in relation to a scenario that assumes that the existing water conveyance (i.e., south Delta facilities) will continue into the future. The operational components of the BDCP are based on existing information and future developments in science and understanding. The operational criteria assumed have the potential to be implemented even if the BDCP is not actualized. This applies to the existing south Delta facilities and Delta outflow (high fall and spring outflow) operations. For purposes of understanding future conditions without the BDCP, but with the potential future operational constraints, this analysis uses a comparison scenario that includes the fall and spring outflow (high outflow scenario discussed in BDCP Chapter 3, Section 3.1.4.4, *Decision Trees*) and south Delta operating restrictions of the BDCP (current biological opinions plus Scenario 6 operations discussed in BDCP Chapter 9) imposed on existing water conveyance facilities. This comparison scenario, *Existing Conveyance Scenario*, is discussed in BDCP Chapter 9, *Alternatives to Take*, and BDCP Appendix 9.A, *Economic Benefits of the BDCP and Take Alternatives*, to provide a reasonable comparison point for the cost practicability analysis of the BDCP (California Department of Water Resources 2013).

A discussion of the method of developing the BDCP scenario can be found in BDCP Chapter 9, Section 9.1, *Introduction*. A detailed description of the BDCP (called the Proposed Action in Chapter 9) can be found in Chapter 9, Section 9.2, *Descriptions of Take Alternatives*. For reference, Table 2.2-1 summarizes the BDCP and the Existing Conveyance Scenario.

Table 2.2-1. Summary of the BDCP and Existing Conveyance Scenarios

Scenario	Description
BDCP	Dual conveyance with Intakes 2, 3, and 5, and up to 9,000 cfs diversion capacity
Existing Conveyance Scenario	Existing conveyance with Fall X2, enhanced spring outflow, Scenario 6 Old and Middle River, without San Joaquin River inflow/export ratio

2.2.3 Categories of Benefits

Several distinct categories of benefits to water users may result from the BDCP. These benefits include increased water supply reliability, improved water quality, and reduced seismic risks to Delta water supplies. Each category of benefits is assessed under the BDCP relative to the Existing Conveyance Scenario. For a detailed description of the analysis methods, see BDCP Appendix 9.A.

2.2.3.1 Water Supply Reliability

Water supply reliability benefits were calculated separately for SWP urban and SWP/CVP agricultural water contractors. These benefits are evaluated using the Supply–Demand Simulation Model (SDBSIM) on a disaggregated level for 36 major urban water utilities receiving Delta water supplies. This model takes in a given a supply portfolio for 83 different hydrologic scenarios and forecasted water demand levels, and generates forecasted shortages for years 2012 to 2050 through dynamic balancing of supply, demand, and storage availability. Shortages are appropriated across sectors[1] of use and valued given a sophisticated estimation of the value of water individually tailored to each SWP urban water contractors for varying levels of shortage. The value estimation is conducted through a refined econometric approach relying on a large set of observed price and consumption data for over 15 years for almost 120 water retailers across the state. These data allow for an accurate estimation of the elasticity of demand for each of the SWP water contractors modeled.

Water supply benefits for the agricultural sector stem from reductions in groundwater pumping and cost, decreases in fallowing, and increases in net returns from crop production under the BDCP. These benefits are measured using the Statewide Agriculture Production model (SWAP) on a regional level for all of the SWP/CVP agricultural water contractors in the Central Valley receiving Delta supplies. The SWAP model evaluates these benefits by relying on observed data to deduce the marginal impacts of the implementation of the BDCP on cropping patterns, water use, and economic performance by SWAP region. As the availability or cost of these water supplies changes within a region, the model optimizes production by adjusting the crop mix, water sources and quantities used, and other inputs, or even by fallowing land if that is the most cost-effective response. SWAP's outcomes reflect the impacts of environmental constraints on land, water availability, labor, and any other technological constraints on farm production.

2.2.3.2 Water Quality Benefits

Implementation of the BDCP will result in water quality benefits through reduced salinity levels. Salinity-related benefits are calculated using the Lower Colorado River Basin Water Quality Model for the Metropolitan Water District service areas, and the South Bay Water Quality Model for the Contra Costa and Santa Clara Water District service areas. To measure urban water benefits, these models use data on regional demographic characteristics, water deliveries, total dissolved solids concentration, and costs for typical water uses by sector. They assess the average annual economic impacts of SWP and Colorado River salinity changes using mathematical relationships between total dissolved solids and important characteristics in each affected category of water use, such as the useful life of appliances, specific crop yields, and costs to industrial and commercial customers. To calculate near-term agricultural water quality impacts, the models determine the reduced amount of

[1] All sectors are composed of single-family residential, multifamily residential, commercial/industrial/institutional, and agriculture.

irrigation required to maintain root zone salt balance. For the purposes of this analysis, this saved water is valued at the avoided cost of additional water supply, which is assumed to come from groundwater pumping. For the portion of SWP/CVP water that replaces groundwater pumping, the benefit is calculated relative to the applied groundwater quality. For all other applied water under the BDCP, the benefit is calculated relative to the Existing Conveyance Scenario water quality. Estimating the long-term effects on salt load in shallow groundwater, drainage conditions, and drainage-related costs would require a more complex analysis of groundwater conditions over time.

2.2.3.3 Benefits of Reduced Seismic or Flooding Risk

Construction of the water conveyance facility, under *CM1 Water Facilities and Operation*, will reduce the risks to the state's water system from flood- or earthquake-induced supply disruptions. With the current water supply infrastructure, large earthquakes or floods in and around the Delta region may cause numerous levees to fail, with the result that some number of islands will flood. As a result, seawater will be pulled into the Delta, potentially reducing SWP/CVP water deliveries for some period of time. During this recovery period, urban and agricultural water consumers may experience incremental water shortages if agencies are unable to replace lost Delta supplies.

Benefits associated with reduced vulnerability of the water export system to seismic or flooding events in the Delta region are calculated by observing differences in water supplies under no-flood/earthquake and post-flood/earthquake conditions across the urban and agricultural sectors for the BDCP and the Existing Conveyance Scenario. The difference in supplies under each scenario between the two conditions is considered to be the flood- or earthquake-induced shortage. Some level of shortage is inevitable; however, the mitigation of these shortages is important. The marginal value of water is used to value the economic loss associated with these flood- or earthquake-induced shortages under each scenario. The marginal value of water is estimated using the SDBSIM for urban and the SWAP for agriculture. Benefits of reduced flood or seismic risk are derived from the abatement of this economic loss, and are therefore calculated as the difference in flood- or earthquake-induced economic losses under the BDCP and the corresponding Existing Conveyance Scenario.

2.2.4 Summary of Benefits

The economic benefits of the BDCP are calculated to the year 2075 and are expressed as present values. Table 2.2-2 summarizes the benefits and costs to the contractors receiving SWP deliveries under the BDCP relative to the Existing Conveyance Scenario, respectively. For a balanced comparison, costs in this table are also calculated out to year 2075 and expressed in 2012 dollars.

Table 2.2-2. Summary of Welfare Impacts on State and Federal Water Contractors[a]

	BDCP (million $)[b]
Water supply reliability	$15,722
Water quality	$1,819
Reduced seismic or flooding risk	$470
Total Benefits	**$18,011**
Cost	$13,328
Net Benefits	**$4,684**

Notes:
[a] Construction is assumed to begin in 2015, and BDCP operations are assumed to begin in 2025. Benefits and costs are calculated out to year 2075.
[b] All values are discounted to present value using 3% real discount rate.

The analysis presented in this report demonstrates that the BDCP will result in significant net water supply benefits to the participating state and federal water contractors. A large portion of benefits will arise from the value of increased water supply reliability. These benefits will result from higher levels of Delta water exports under the BDCP relative to the Existing Conveyance Scenario. The increased water supply reliability benefits under the BDCP relative to Existing Conveyance Scenario, for the state and federal projects combined, are expected to be $15.7 billion, evaluated across the historical hydrology.

The BDCP will also result in water quality benefits. By diverting water directly from the Sacramento River, the BDCP will reduce salinity levels, thereby improving the quality of Delta water exports. The improved water quality benefits to urban and agricultural users attributed to reduced salinity has a present value of roughly $1.8 billion under the BDCP relative to the Existing Conveyance Scenario.

The BDCP will also reduce the vulnerability of the Delta's water export infrastructure to floods or earthquakes. As discussed above, a large flood or earthquake could compromise water quality, and ultimately, SWP deliveries, resulting in a potential shortage to consumers. The expected welfare benefits of reduced flooding and seismic risks to urban and agricultural water contractors would be $0.5 billion under the BDCP relative to the Existing Conveyance Scenario.

Benefits across all the categories total to $18.0 billion. Total costs of the BDCP to the water contractors comes to $13.3 billion relative to the Existing Conveyance Scenario. Net benefits of the BDCP are estimated to be $4.7 billion.

Because the ultimate economic benefits of the BDCP depend on factors that cannot be known with certainty (e.g., demand growth, future hydrology, future regulations, climate change), an exact quantification of the direct benefits of the BDCP is elusive. Nonetheless, given the available evidence, two conclusions seem certain. First, the BDCP will result in substantial net benefits to the water contractors that rely on the Delta for at least a portion of their water supplies. Second, implementing the BDCP will reduce a range of risks that are of great consequence to the public. These risks include the vulnerability to floods or earthquakes in the Delta region that may disrupt water exports for an unknown period of time; gradual, long-term sea level rise that could progressively restrict Delta water exports unless mitigating action is taken; and an increasingly strict regulatory environment under the state and federal Endangered Species Acts that could further restrict exports from the Delta.

Chapter 3
Economic Impacts Related to Delta-Dependent Economic Activities

3.1 Salinity of Agricultural Water Supplies

3.1.1 Introduction and Summary of Findings

This section examines the projected indirect economic impacts on Delta agriculture associated with salinity changes resulting from implementation of the BDCP. These salinity changes would occur as a result of the construction and operation of new water conveyance facilities and restoration of tidal marsh. Anticipated changes in salinity due to the implementation of the BDCP have been modeled using the Delta Simulation Model II (DSM-II), a hydrological simulation model created and maintained by the California Department of Water Resources (DWR). DSM-II was used to predict Delta salinity levels at various locations across the Delta under the BDCP with a high outflow scenario as well as the Existing Conveyance High Outflow scenario, which is the basis for comparison. The high outflow scenario assumes that Fall X2 and high spring outflow are implemented as part of the operations of the new water conveyance facility[1].

The modeling methodology is consistent with that employed in the *Economic Sustainability Plan for the Sacramento-San Joaquin River Delta* (ESP) (Delta Protection Commission 2012). The model is implemented as outlined in the ESP, with the exception of the incorporation of estimated salinity data from the DSM-II.

This section predicts that salinity changes resulting from implementation of the BDCP would cause an annual decrease in average agricultural revenues in the Delta of $1.86 million dollars. Assuming BDCP operations begin in 2025, this represents a net present value of $33.9 million (under a 3% real discount rate) through 2075. Predicted annual losses are much lower than those included in the Delta ESP. This outcome reflects the fact that the DSM-II modeling reveals much smaller changes in salinity than assumed in the Delta ESP. While the Delta ESP predicted revenue changes from a lower bound of a 25% uniform salinity increase, DSM-II modeling suggests actual salinity levels would rarely increase by more than a few percentage points. Additionally, in some areas of the Delta, salinity levels are expected to decrease, further limiting the impacts of rising salinity experienced elsewhere. Although this presentation considers Delta-wide impacts, it is recognized that negative impacts on one set of growers are not offset by positive impacts on another set. The BDCP EIR/EIS will consider mitigation for negative impacts on local groups of growers (California Department of Water Resources et al. 2013).

This section presents an overview of the status of Delta agriculture, followed by a discussion of the modeling methodology and results and a summary of the data sources used in the underlying analysis.

[1] See BDCP Chapter 3, Section 3.4.1.4.4, *Decision Trees*, for a description of the High Outflow scenario. See BDCP Chapter 9, Section 9.3.4, *Practicability*, for a description of the Existing Condition High Outflow scenario.

3.1.2 Status of Delta Agriculture

This overview of Delta agriculture is based on available crop data.

3.1.2.1 Total Farmland Acreage

Agricultural production in the Delta is supported by high-quality farmland that covers most of the region. Adequate soil quality, moisture, and temperatures are just a few of the farmland characteristics necessary to support sustainable high yields for Delta crops. The Farmland Mapping and Monitoring Program (FMMP) of the California Department of Conservation has established a tiered system of farmland categories that provide an inclusive view of the agricultural suitability of Delta cropland. The analysis is confined to the Statutory Delta and thus excludes Suisun Marsh (which contains only 2.3% of agricultural lands in the Plan Area). Table 3.1-1 and Figure 3.1-1 provide snapshots of Delta farmland in 2008, the most recent year from which FMMP maps were available. FMMP data estimate the total size of Delta farmland at 500,383 acres, with close to 80% of all land in the top tier of "Prime Farmland."[2]

Table 3.1-1.Total Farmland Acreage in the Statutory Delta—2008

County	Farmland (acres)		Crop Class	Farmland (acres)
San Joaquin	267,741		Prime Farmland	396,554
Sacramento	71,722		Farmland of Statewide Importance	33,360
Yolo	54,644		Unique Farmland	29,525
Solano	53,509		Farmland of Local Importance	40,944
Contra Costa	49,685			
Alameda	3,082			
Total	**500,383**		**Total**	**500,383**

3.1.2.2 Agricultural Production

Detailed mapping of Delta agriculture is made possible by California state law, which requires the full reporting of agricultural pesticide use. Through the pesticide reporting process, counties collect annual information on all crop fields for which pesticide applications are expected. This information is then mapped using geographic information system (GIS) software, allowing for composition of a digital map of all crop fields in a given year. Roughly 90% of all Delta agricultural acreage is available at this extremely disaggregated level. The remaining crop cover is estimated using satellite remote sensing data from the National Agricultural Statistics Service (NASS).

For the purposes of analysis, it is necessary to classify the close to 100 reported crops in the Delta into a smaller number of discrete crop categories. Doing so enables the use of econometric techniques for forecasting future land use and makes possible the comprehensive overview of Delta agriculture presented in the tables and maps throughout this report. The six categories and some of the major Delta crops they include are listed in Table 3.1-2.

[2] The acreages in Table 3.2-1 differ slightly from those presented in the BDCP EIR/EIS, because they focus on the statutory Delta and thus exclude Suisun Marsh.

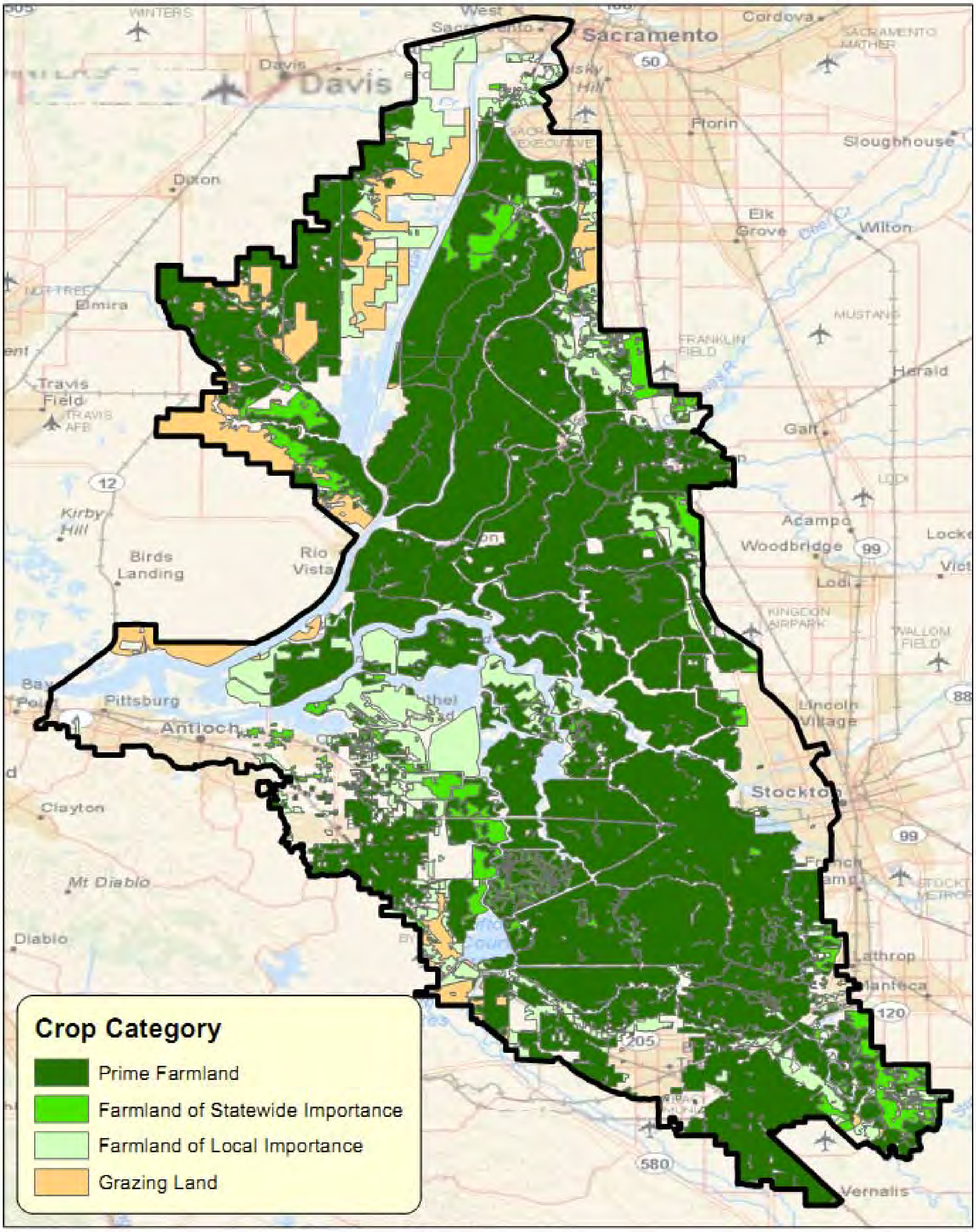


Figure 3.1-1. Delta Farmland Coverage by FMMP Category—2008

Table 3.1-2. Crop Categories Used and Crop Type Examples

Crop Category	Crop Type Examples
Deciduous	Almond, cherry, pear, walnut
Field	Alfalfa, corn, rice[a]
Grain	Barley, oat, wheat
Pasture	Pastureland, clover
Truck	Tomato, asparagus, potato, blueberry
Vineyard	Grapes

[a] Rice is shown as a separate category in Figure 3.1-2 but is combined with field crops for reporting amounts in acres.

Based on available data, an estimated 419,891 acres are under agricultural production in the Delta. This acreage includes all irrigated crops and pastureland, but excludes grazing land. Table 3.1-3 lists the total acreage of each crop category, including grazing land, by county and Delta-wide; Table 3.1-4 lists the total acreages and estimated values of the top 20 Delta crops. Figure 3.1-2 depicts the individual Delta crop fields from 2010 by crop category.

Table 3.1-3. Delta Agricultural Acreage—2010

	County						
Crop Category	**San Joaquin**	**Sacramento**	**Yolo[a]**	**Solano[a]**	**Contra Costa[b]**	**Alameda[b]**	**Total**
Deciduous	7,127	6,902	816	486	1,426	82	**16,839**
Field	127,912	33,178	13,082	16,097	22,591	789	**213,649**
Grain	21,222	7,589	9,141	14,295	14,196	2,262	**68,705**
Pasture	3,724	3,957	7,465	19,738	6,243	223	**41,350**
Truck	43,158	3,661	3,789	1,755	248	4	**52,615**
Vineyard	10,477	8,295	9,194	1,528	1,074	1	**30,569**
Grazing land[c]	433	2,846	11,499	18,600	2,284	1,991	**37,653**
Total	**214,053**	**66,428**	**54,986**	**72,499**	**48,062**	**5,352**	**461,380**

[a] Pasture acreage adjusting using National Agricultural Statistics Service estimates.
[b] National Agricultural Statistics Service data used due to lack of recorded field borders
[c] Grazing land acreage estimated from FMMP data.

Table 3.1-4. Top 20 Delta Crops by Acreage—2009

Crop		Acreage	Value
1	Corn	105,362	$92,975,715
2	Alfalfa	91,978	$66,027,076
3	Processing tomatoes	38,123	$117,242,615
4	Wheat	34,151	$17,549,215
5	Wine grapes	30,148	$104,990,142
6	Oats	15,847	$4,195,540
7	Safflower	8,874	$3,312,014
8	Asparagus	7,217	$50,050,037
9	Pear	5,912	$36,746,649
10	Bean, dried	5,493	$3,990,318
11	Rice	4,874	$6,822,488
12	Ryegrass	4,398	$1,061,436
13	Cucumber	3,737	$7,866,553
14	Turf	3,633	$31,643,344
15	Potato	3,353	$28,605,465
16	Almond	3,121	$8,776,101
17	Sudangrass	3,025	$1,398,634
18	Walnut	2,512	$9,453,874
19	Pumpkin	2,103	$7,926,038
20	Watermelon	1,717	$7,953,590
Note: Acreages for 2009 used, because accompanying value estimates were not available for 2010.			

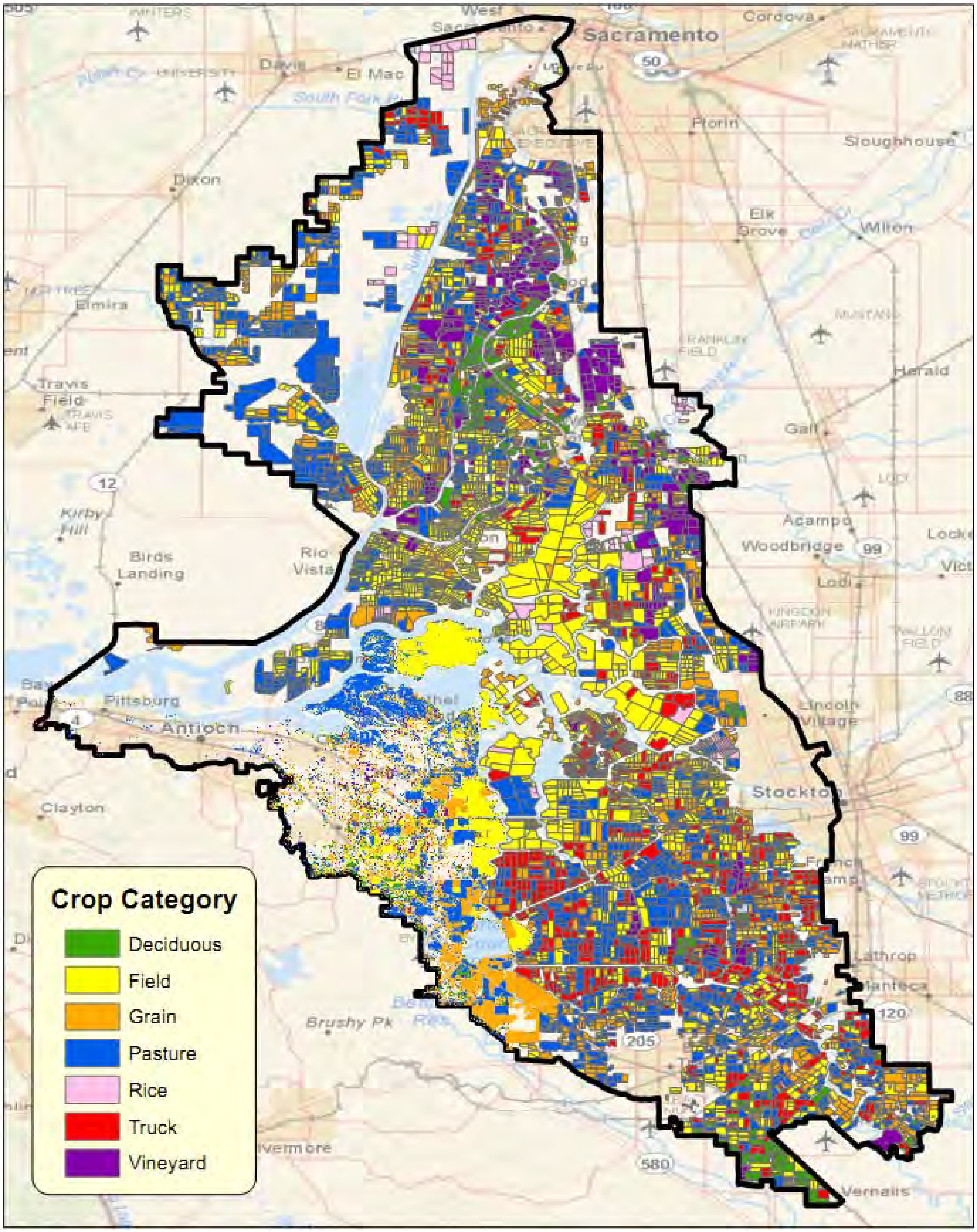


Figure 3.1-2. Agricultural Land Cover—2010

3.1.2.3 Agricultural Revenues

Using the crop acreages calculated above, total Delta agriculture revenues can be calculated by multiplying the acreage of each individual crop by its yield and unit price reported in county crop reports. This produces a total of $702 million dollars in revenues from Delta agriculture in 2009, the most recent year for which crop reports were available. Table 3.1-5 lists total revenue by crop category in each county; Table 3.1-6 lists the Delta crops with the highest total revenue.

Table 3.1-5. Delta Agricultural Revenues (thousand $)—2009

	County						
Crop Category	**San Joaquin**	**Sacramento**	**Yolo[a]**	**Solano[a]**	**Contra Costa[b]**	**Alameda[c]**	**Total**
Deciduous	25,118	41,738	3,345	1,347	8,667	355	**80,570**
Field	107,001	22,071	9,341	12,418	21,398	398	**172,627**
Grain	15,535	3,276	2,587	7,512	288	1,059	**30,257**
Pasture	741	438	411	1,717	1,013	270	**4,590**
Truck	248,982	20,847	15,987	8,949	13,871	17	**308,653**
Vineyard	32,099	28,474	32,718	5,042	6,657	3	**104,993**
Grazing land[d]	9	57	230	372	46	40	**754**
Total	**429,485**	**116,901**	**64,619**	**37,357**	**51,940**	**2,142**	**702,444**

[a] Crop value calculations use 2010 field borders acreage.
[b] Values for non-grazing land include all reported county crop report acreage due to lack of reported field borders.
[c] Values computed using 2010 National Agricultural Statistics Service acreage estimates and average crop category values.
[d] Grazing land acreage estimated from 2008 Farmland Mapping and Monitoring Program data and valued at $20 an acre.

Figure 3.1-3 depicts the revenue per acre of Delta crops at the field level. Higher average revenues in the southern Delta are primarily driven by the prevalence of truck crops, while vineyards in the northern and eastern Delta are mainly responsible for the higher revenue fields in those regions. These relationships are readily apparent when comparing Figure 3.1-2 and Figure 3.1-3.

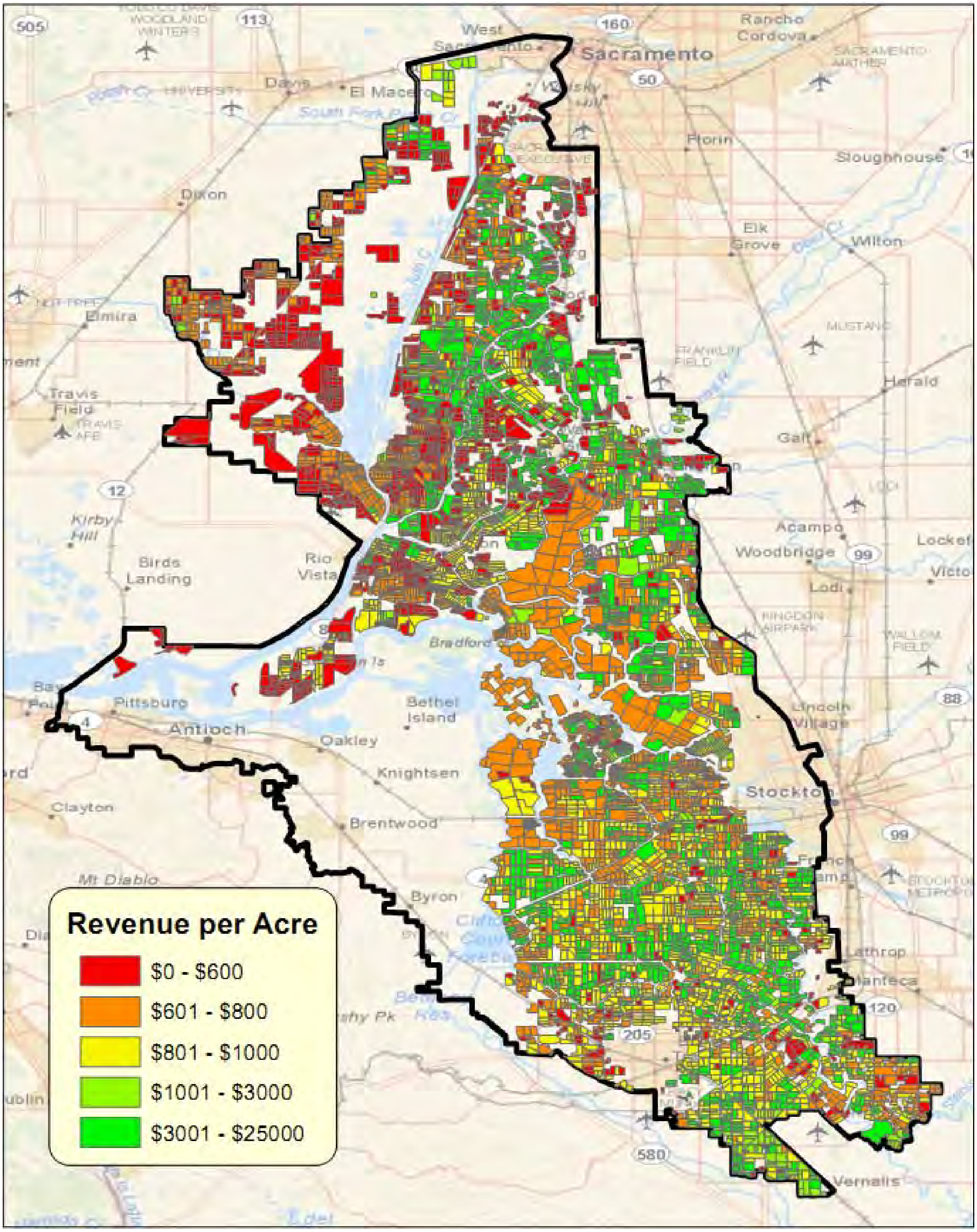


Figure 3.1-3. Average Revenues per Acre—2009

Table 3.1-6. Top 20 Delta Crops by Value—2009

	Crop	Value	Acreage
1	Processing tomatoes	$117,242,615	38,123
2	Wine grapes	$104,990,142	30,148
3	Corn	$92,975,715	105,362
4	Alfalfa	$66,027,076	91,978
5	Asparagus	$50,050,037	7,217
6	Pear	$36,746,649	5,912
7	Turf	$31,643,344	3,633
8	Potato	$28,605,465	3,353
9	Blueberry	$25,255,917	1,097
10	Wheat	$17,549,215	34,151
11	Cherry	$11,490,843	1,855
12	Almond	$8,776,101	3,121
13	Walnut	$9,453,874	2,512
14	Watermelon	$7,953,590	1,717
15	Pumpkin	$7,926,038	2,103
16	Cucumber	$7,866,553	3,737
17	Rice	$6,822,488	4,874
18	Pepper	$6,247,592	1,289
19	Apple	$4,455,826	846
20	Oats	$4,195,540	15,847

Note: Kern County crop report value used for turf value, because no Delta counties report turf separately from other nursery crops.

3.1.2.4 Urbanization

When forecasting future land use changes in the Delta, it is important to take into account the effects of urbanization around the borders of the agricultural regions. This forecast relies on the urbanization probability map developed in the Delta ESP. This map was primarily derived from data generated by the UC Berkeley Resilient and Sustainable Infrastructure Networks (RESIN) project, with additional adjustments based on input from local city officials and developers. Areas categorized as having a high or very high probability of urbanization were assumed to be removed from agricultural production in the future, and are thus excluded from the salinity impacts analysis that follows. Figure 3.1-4 shows the crop fields expected to be affected by urbanization.

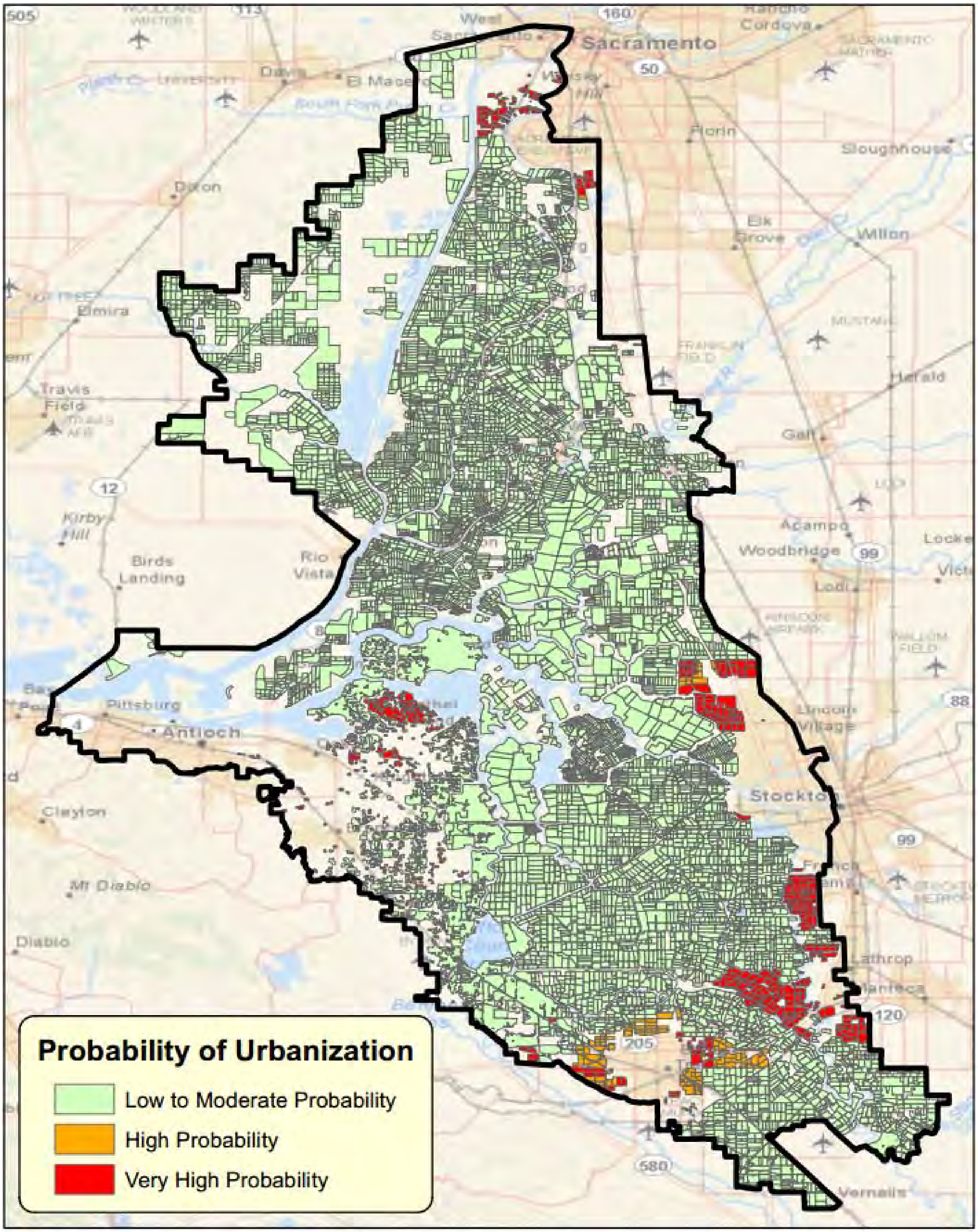


Figure 3.1-4. Predicted Delta Urbanization

3.1.3 Salinity Impacts on Delta Agriculture

Salinity in the Delta is expected to change in response to two factors: implementation of the BDCP and climate change. Under the BDCP, the operation of the new water conveyance facilities is expected to affect salinity in different ways depending on location in the Delta. In the west and interior Delta, salinity is expected to increase as a result of the decrease in Sacramento River water from operation of the new north Delta diversions and the increase in San Joaquin River water from reduced operations of the south Delta diversions. In the south Delta, salinity is expected to decrease as a result of reduced operations of the south Delta diversions (by 49%) and increased freshwater flows from the San Joaquin River. In the west Delta and Cache Slough, salinity is also expected to increase as a result of large-scale restoration of tidal inundation. Salinity in the west Delta would be further increased by sea level rise associated with climate change, which would occur gradually over the 50-year term of BDCP and beyond.

Agricultural production in the Delta would be affected by increasing salinity levels in irrigation water where these increases are expected to occur. To predict the impacts of BDCP implementation, the marginal effect of varying salinity levels on crop choice were modeled using the same methodology applied in the Delta ESP. After training the model on observed salinity levels over a 10-year period, predicted changes in land allocation were predicted for two scenarios: under the BDCP with a high outflow scenario and under the Existing Conveyance High Outflow scenario. Estimated salinity levels for each of these scenarios were derived from DSM-II modeling results provided by DWR. The difference between total agricultural revenue under each scenario's predicted land allocations was then calculated to arrive at a final result.

Currently there is considerable variation in salinity across regions in the Delta and from year to year. Observations of these differences in salinity level are used in estimating a statistical model of cropping patterns in the Delta, allowing prediction of the marginal effect of changes in the salinity of irrigation water on farmers' cropping decisions. These changes in Delta land allocation are modeled using a multinomial logit (ML) framework with a time-varying salinity variable and geographically fixed determinants, including location fixed effects. Under this specification, the ML model can be used to predict the likelihood of observing a particular crop in a given field conditional on the salinity of nearby water sources, as well as other covariates.

Data were collected on observed salinity levels for over 50 sites to construct the baseline model. The data span a 10-year period (2001–2010), and were used to calculate an annual average value for observed salinity from May through August, a time period during which crops are most sensitive to changes in the salinity of irrigation water. These salinity values were then mapped to each individual crop field, taking the average of the observed salinity values at all monitoring sites within a 3-mile radius of each field. For those fields without multiple monitoring stations in that radius, the observed salinity level of the nearest monitoring station was used.

The model is trained on a dataset of over 6,000 crop fields for which land use data were available from 2002 through 2010, excluding 2005 for which reliable data were not available. The modeled results thus represent predicted land allocation changes across a subset of Delta lands representing the vast majority of agricultural production in the Delta. Lands for which complete information was not available are mainly low-value pasture acreage for which field borders were not consistently maintained.

Summary statistics of the data used in estimating the baseline model are shown in Table 3.1-7. Table 3.1-8 depicts the ML model output, including the estimated coefficients and standard errors for each covariate.

Table 3.1-7. Summary Statistics

Variable	Description	Units	Mean	Standard Deviation
ec	May through August electroconductivity average (2001–2010)	microSiemens/centimeter (mS/cm)	353.24	159.81
acres	Field acreage	Acres	49.9	59.81
soil	Soil storie index	0–100 point scale	49.43	16.08
elev	Elevation	Feet	3.11	7.47
tmas	Average annual maximum temperature	Degrees Celsius	23.4	0.22
slope	Slope	Decimal degrees	0.14	0.59
year	Annual fixed effects			
conzone	Conservation zone fixed effects			

Table 3.1-8. Multinomial Logit Estimation Results

Dependent Variable: Crop Category	(1) Deciduous	(2) Field	(3) Grain	(4) Pasture	(5) Truck	(6) Vineyard
10-year average electroconductivity (mS/cm)	BASE OUTCOME	0.0021***	0.0034***	0.0031***	-0.0002	-0.0002
		(0.0003)	(0.0004)	(0.0005)	(0.0004)	(0.0005)
Acres		0.0159***	0.0125***	0.0170***	0.0131***	0.0166***
		(0.0010)	(0.0010)	(0.0011)	(0.0010)	(0.0010)
Soil		-0.0126***	-0.0111***	-0.0381***	-0.0047***	0.0158***
		(0.0016)	(0.0018)	(0.0025)	(0.0017)	(0.0019)
Elevation		-0.0926***	-0.0810***	-0.0606***	-0.1053***	-0.0317***
		(0.0029)	(0.0036)	(0.0050)	(0.0032)	(0.0044)
Maximum temperature		-1.7292***	-1.1753***	-1.9907***	-0.5044**	1.6564***
		(0.2102)	(0.2250)	(0.2820)	(0.2230)	(0.2922)
Slope		-0.0661*	0.0213	0.0985*	-0.0541	0.0285
		(0.0370)	(0.0410)	(0.0576)	(0.0395)	(0.0474)

Notes:
Deciduous is the base outcome.
Standard errors are reported in parentheses.
*, **, and *** indicate significance at the 90%, 95%, and 99% level, respectively.
mS/cm = microSiemens/centimeter

As shown in Table 3.1-8, the estimated coefficient on salinity is significant at the 99% level for field, grain, and pasture crops. It is important to note that due to the ML specification, the coefficients cannot be interpreted as the partial derivative effect of a one-unit change in the independent variable, as they would be in a standard linear model. Rather, marginal effects must be calculated separately.

The estimated coefficients of the ML model are used to predict the probability of observing each future land use category in all Delta crop fields. By substituting predicted salinity levels from the DSM-II modeling for the observed levels used in the baseline, the estimated model can be used to predict the impacts of the BDCP on agricultural land use. The predicted salinity levels under the BDCP with high outflow average 351 microSiemens/centimeter (mS/cm) across all crop fields modeled, reaching as high as 8,606 mS/cm and as low as 176 mS/cm for some crop fields. The predicted salinity levels under the Existing Condition High Outflow scenario average at 347 mS/cm across all fields modeled, reaching as high as 7,518 mS/cm and as low as 176 mS/cm for some crop fields. Table 3.1-9 depicts the modeling results for predicted salinity changes under the BDCP with high outflow and under the Existing Condition High Outflow scenario (i.e., without BDCP). Predicted changes in crop allocation are translated into changes in revenue using the average revenue per acre of each crop classification.

Overall, implementation of the BDCP is expected to decrease annual average revenues in the Delta by roughly $1.86 million dollars. This loss amounts to less than one half of one percent of farm revenues in the Delta. Assuming BDCP operations begin in 2025, the net present value of these agricultural revenue losses at a 3% real discount rate would total $33.9 million through 2075.

The predicted annual losses are much lower than those included in the Delta ESP. This outcome reflects the fact that the DSM-II modeling reveals much smaller changes in salinity than assumed in the Delta ESP. While the Delta ESP predicted revenue changes from a lower bound of a 25% uniform salinity increase, DSM-II modeling suggests actual salinity levels would rarely increase by more than a few percentage points. Additionally, in some areas of the Delta, salinity levels are expected to decrease, further limiting the impacts of rising salinity experienced elsewhere.

Table 3.1-9. Estimated Crop Revenue Impacts of the BDCP

Crop Category	Crop Category Average. Revenue per Acre[a]	Forecast Acreage		Total Revenue	
		Existing Conveyance High Outflow Scenario	BDCP High Outflow Scenario	Existing Conveyance High Outflow Scenario	BDCP High Outflow Scenario
	[a]	[b]	[c]	[a] * [b]	[a] * [c]
Deciduous	$4,612	12,936	12,896	$59,660,832	$59,476,352
Field	$780	184,438	184,719	$143,861,640	$144,080,820
Grain	$426	47,827	48,083	$20,374,302	$20,483,358
Pasture	$116	22,929	22,956	$2,659,764	$2,662,896
Truck	$3,903	43,310	42,889	$169,038,930	$167,395,767
Vineyard	$3,566	25,860	25,758	$92,216,760	$91,853,028
		Total Revenue		**$487,812,228**	**$485,952,221**
		Scenario Revenue Losses			**-$1,860,007**

[a] The average crop class revenue per acre is based on 2009 yield and price data from county crop reports.

3.1.4 Data Sources

3.1.4.1 Land Use Data

3.1.4.1.1 Field Borders

Field borders generated from data collected in the pesticide use permitting process were available in GIS shapefile format from Sacramento, San Joaquin, Solano, and Yolo Counties. These fields were used as the predominant disaggregated unit of analysis in the ML modeling effort. Approximately 90% of Delta acreage in this analysis was available at this level.

In order to develop a condensed dataset for statistical analysis, agricultural field border layers were converted from polygons to points, georeferenced at the centroid of the polygon. If the centroid was located outside the polygon border, it was moved to the point of closest distance inside the polygon, though these instances are rare. Based on the resulting set of points, the local attributes (e.g., crop, salinity, soil quality) were extracted to create a single file containing all the data used in the statistical analysis.

3.1.4.1.2 National Agricultural Statistics Service

Satellite remote sensing data from the NASS were used for the two counties, which do not digitally map their field borders. NASS data is used in a wide range of agricultural applications, and the accuracy of the methods used to determine crop type is quantified in detail. Though less accurate than direct field borders reporting, this data helped in surveying Delta land not covered by county field borders data.

3.1.4.1.3 Farmland Mapping and Monitoring Program

GIS data from the FMMP was used to assess total farmland acreage in the Delta, as well as estimate the extent of grazing lands. The FMMP’s grazing land classification further allowed for isolating acreage incorrectly captured in the NASS data as active pastureland.

3.1.4.1.4 National Agriculture Imagery Program

Satellite imagery provided by the National Agriculture Imagery Program was used to resolve any apparent inconsistencies that arose from the other land use data sources. While it was impossible to eliminate all smaller errors, for large acreage areas in which discrepancies were noted, the National Agriculture Imagery Program imagery helped ascertain into what land use category a parcel was best attributed.

3.1.4.1.5 UC Berkeley Resilient and Sustainable Infrastructure Networks

GIS data from the UC Berkeley RESIN project was used to map Delta regions expected to undergo urbanization in the future. Further small adjustments were made based on discussions with city officials and local developers with knowledge of future land development plans.

3.1.4.2 Agricultural Revenues Data

3.1.4.2.1 County Agricultural Commissioner's Reports

Estimated revenues from Delta crop production were compiled using yield and price figures published in each Delta county's annual crop report. Though crop report values are collected through a variety of sources and represent average yields for each county, they offer the most practical and direct means of determining total revenues from agriculture in the Delta.

3.1.4.3 Salinity Data

3.1.4.3.1 Interagency Ecological Program

The Interagency Ecological Program samples discrete water quality data at 19 sites throughout the Delta. The sites are chosen in an attempt to represent the major inflows and outflows of the Delta, and collect data on a monthly basis. Report values undergo a detailed quality assurance process prior to being made publicly available.

3.1.4.3.2 California Data Exchange Center

Data from the California Data Exchange Center were the second source used to collect baseline salinity levels for the ML model. The center's salinity data are collected from 45 Delta water monitoring stations maintained by a variety of organizations, including DWR, Bureau of Reclamation, and U.S. Geological Survey. Monthly averages calculated from reported daily values were used in this analysis.

3.1.4.3.3 Delta Simulation Model II

Salinity estimates under the Existing Conveyance High Outflow scenario and the BDCP with a high outflow scenario were calculated for 24 sites throughout the Delta using the DSM-II. These estimates were used as inputs for predicting salinity impacts from BDCP implementation.

3.1.4.4 Other Data Sources

3.1.4.4.1 Natural Resources Conservation Service

The Natural Resources Conservation Service's Soil Storie Index scales soil quality from 1 to 100, with 100 being the highest quality. The measure takes into account permeability, slope, pH, and other factors.

3.1.4.4.2 PRISM Climate Group

The PRISM Climate Group at Oregon State University provides a continuous digital grid estimate of annual precipitation and average maximum temperature generated from point measurements.

3.1.4.4.3 National Elevation Dataset Elevation and Slope

Elevation data was collected from the National Elevation Dataset provided by the U.S. Geological Survey.

3.2 Outdoor Recreation

3.2.1 Introduction

This section evaluates the economic impacts of changes in outdoor recreation that would result from implementation of the BDCP. The land use changes associated with *CM1 Water Facilities and Operation* and the other conservation measures (CM2 through CM22) would affect outdoor recreational activities in the region. In some cases, existing recreation opportunities would be disrupted or eliminated. In other cases, recreation opportunities would be expanded.

This analysis uses the Benefit Transfer Toolkit, developed by Dr. John Loomis of Colorado State University, to estimate the monetary costs of changes to recreation (Loomis and Richardson 2007). The toolkit uses a method called benefit transfer to take results of previous studies that have ascribed a value to outdoor recreation and customize them to fit a new context. Benefit transfer is commonly used for valuing environmental amenities due to the often prohibitive time and expense needed to implement primary studies, such as those using stated preference or revealed preference methods. Benefit transfer offers an efficient and reliable way to leverage the results of previous studies and extend their application to a new context. Benefit transfer either involves directly transferring a benefit value from one context to another, or transferring the function used to estimate benefits across contexts. The latter approach is preferred, because it affords a greater ability to customize the benefit value to match the new context to which it is being applied. The Benefit Transfer Toolkit uses benefit function transfer methods to estimate the change in visitor days for different recreational activities based on characteristics of recreational sites and the potential users of those sites.

In this study, the visitor use models included in the Benefit Transfer Toolkit are used to estimate the change in recreation visits for different activities, given the changes in land use that would result from the BDCP. The models include nonconsumptive visits (birding and other wildlife viewing, hiking, recreational boating, camping, picnicking, and water contact sports), migratory bird–hunting visits, and freshwater fishing visits (shoreline- and boat-based). Unit-day values for different recreation activities were used to ascribe a value to these changes in recreational uses. Unit-day values are monetary estimates of an outdoor recreation activity that are specific to that type of activity or a group of similar activities. Unit-day values aim to measure the value to a participant of a day spent engaging in a given recreation activity, over and above what they must pay for it.

The Delta region supports a range of recreation activities. The region is a maze of channels and islands at the confluence of the Sacramento and San Joaquin Rivers. It encompasses the largest estuary system on the West Coast. The Delta region is a 1,150-square-mile area that provides more than 500 miles of navigable waterways, equaling more than 57,000 navigable surface acres (California Department of Boating and Waterways 2003). This vast network of rivers, channels, sloughs, and islands provides a unique and important recreation resource in California.

Based on a statewide survey in which California boaters were asked which waterways they used most out of nearly 300 different waterways, the Delta was identified as one of the most popular boating destinations in the state, exceeded only by the Pacific Ocean, San Francisco Bay, and the Colorado River. In addition, among the 10 regions the state delineated for the survey, the three regions that include portions of the Delta (San Francisco Bay, Sacramento River Basin, and Central

Valley) accounted for nearly half of the registered boats in the state (California Department of Boating and Waterways 2002).

Recreational users in the Delta often participate in multiple activities; although boating and fishing are the most popular, participants in these activities also take part in wildlife viewing, sightseeing, walking, picnicking, and camping (California Department of Parks and Recreation 1997), contributing to overlaps in activity participation by visitors. Overlaps also occur, because activities such as hunting, fishing, wildlife viewing, and sightseeing can be both water- and land-based. This overlap creates an interconnected web of users and activities, and leads to an appreciation and enjoyment of the Delta for the variety of recreation opportunities available on each trip. BDCP EIR/EIS Chapter 15, *Recreation*, presents details on the types of recreation currently supported by the region (California Department of Water Resources et al. 2013).

The construction and operation of the new water conveyance facility under CM1 is expected to have a deterring effect on outdoor recreation. This effect, however, is difficult to quantify due to a lack of data and information on how the presence of the facility would affect recreation in adjacent sites. Furthermore, the BDCP EIR/EIS identifies mitigation measures that will either reduce the adverse effects on recreation or create recreational opportunity elsewhere to offset those adverse effects. It is difficult to quantify, however, the net impacts of these mitigation measures on outdoor recreation. Due to these uncertainties, the CM1 impacts on recreation are addressed in qualitative terms. Other conservation measures are expected to benefit outdoor recreation in the Plan Area, because they will create new recreation opportunities at restoration sites. Data on affected recreation sites and on the users of these sites, and the Benefit Transfer Toolkit, are used to quantify and monetize these benefits. Table 3.2-1 summarizes the expected recreation impact and whether or not this study quantifies the effect.

Table 3.2-1. Conservation Measures and Potential Recreation Impacts

Conservation Measure	Description	Potential Recreation Impact	Recreational Impacts Quantified (median value)
CM1 Water Facilities and Operation	CM1 focuses on promoting connectivity and water flows between native fish habitats and spawning areas, supporting the movement of juvenile and larval stages, and reducing mortality levels for adult fishes.	Temporary decrease in recreation at or near construction sites	Impacts discussed qualitatively
CM2 Yolo Bypass Fisheries Enhancement	CM2 will increase the frequency, duration, and magnitude of floodplain inundation in the Yolo Bypass, improving passage and habitat for many fish species and supporting the biological productivity of nutrition sources for aquatic species.	Increase in boating/fishing opportunity and quality after flooding; possible negative impact on waterfowl hunting and observation due to increase in inundation	Impacts combined with the waterfowl hunting loss for CM4
CM3 Natural Communities Protection and Restoration	CM3 will provide a mechanism for acquiring conservation lands in the Delta in a reserve system that will support the continued existence of natural communities and covered species habitat.	Increase in nonconsumptive recreation on protected lands	$171.8 million nonconsumptive recreation benefit
CM4 Tidal Natural Communities Restoration	CM4 will restore tidal wetlands and associated uplands, mostly within the BDCP restoration opportunity areas.	Increase in boating, fishing, hiking, and wildlife viewing opportunities; possible negative impact on waterfowl hunting and observation due to conversion of managed wetlands to tidal wetlands	$7.5 million nonconsumptive recreation benefit; $2.9 million angler benefit; $3.0 million waterfowl hunting loss
CM5 Seasonally Inundated Floodplain Restoration	CM5 will restore floodplains that historically existed but have been lost due to flood control and channelization.	Increase in fishing, hiking, and wildlife viewing opportunities	$101.5 million nonconsumptive benefit and $121,162 angler benefit
CM6 Channel Margin Enhancement	CM6 will restore channel margin habitat by improving channel geometry and restoring riparian, marsh, and mudflat habitats on the inboard side of levees.	Improvement in the quality of boating and fishing opportunities	Impacts discussed qualitatively
CM7 Riparian Natural Community Restoration	CM7 will restore riparian forest and scrub in association with land restoration measures in CM4, CM5, and CM6.	Improvement in the quality of nonconsumptive recreation (boating and nonboating) and fishing	Impacts quantified indirectly in the improvements estimated for CM4 and CM5

Conservation Measure	Description	Potential Recreation Impact	Recreational Impacts Quantified (median value)
CM8 Grassland Natural Community Restoration	CM8 will protect grassland natural community in Conservation Zones 1, 8, and/or 11.	Increase in nonconsumptive recreation on protected lands	$51.7 million nonconsumptive benefit
CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration	CM9 will prevent net loss of vernal pool acreage in Conservation Zones 1, 8, and/or 11 due to covered activities.	Although the net change is zero, restoration of vernal pools on public land would increase the opportunity for nonconsumptive recreation	$37.4 million nonconsumptive benefit
CM10 Nontidal Marsh Restoration	CM10 will restore nontidal freshwater marsh in Conservation Zones 2 and 4.	Potential expansion of opportunity for nonconsumptive recreation	Impacts discussed qualitatively
CM11 Natural Communities Enhancement and Management	CM11 outlines the steps that will be taken to contribute to the biological goals and objectives for each type of acquired conservation land held in the reserve system. Many possible steps entail active vegetation management to optimize conditions for important species.	Improvement in the quality of recreation and viewsheds and increase in the diversity of habitat and wildlife viewing opportunities	Impacts discussed qualitatively
CM12 Methylmercury Management	CM12 defines measures that will be taken to decrease the production of methylmercury in the Plan Area and reduce its introduction into sediments, the water column, or the foodweb.	None	None
CM13 Invasive Aquatic Vegetation Control	CM13 describes procedures that will be used to remove invasive aquatic vegetation that degrades habitat for covered fish species.	Potential improvement in fishing quality; improvement in boating opportunities; potential degradation of bass fishing quality due to reduction in invasive vegetation (in which bass thrive)	Impacts discussed qualitatively
CM14 Stockton Deep Water Ship Channel Disolved Oxygen Levels	CM14 defines steps that will be taken to increase dissolved oxygen levels in the Stockton Deep Water Ship Channel to promote better water quality conditions for covered fish species.	Potential improvement in fishing quality	Impacts discussed qualitatively

Conservation Measure	Description	Potential Recreation Impact	Recreational Impacts Quantified (median value)
CM15 Localized Reduction of Predatory Fishes	CM15 provides for management of the distribution and abundance of predators that affect levels of native covered fish species.	Potential improvement in fishing quality for native fish outside the Delta; reduction in density of nonnative sport fish (e.g., striped bass) at specific predator control locations	Impacts discussed qualitatively
CM16 Nonphysical Fish Barriers	CM16 outlines the siting and design of nonphysical barriers that will direct juvenile salmonids down channels and river reaches where they have higher survival rates.	Potential improvement in fishing quality	Impacts discussed qualitatively
CM17 Illegal Harvest Reduction	CM17 will reduce illegal harvest of salmon, steelhead, and sturgeon in the Delta by hiring additional game wardens and supervisory and administrative staff.	Potential improvement in fishing quality as a result of improved sport fish populations	Not applicable
CM18 Conservation Hatcheries	CM18 will establish new and expand existing conservation propagation programs for delta and longfin smelt.	None	Not applicable
CM19 Urban Stormwater Treatment	CM19 will improve Delta fish habitat by funding stormwater treatment measures that will result in decreased discharge of contaminants to the Delta.	Potential improvement in fishing quality	Impacts discussed qualitatively
CM20 Recreational Users Invasive Species Program	CM20 will fund a watercraft inspection program in the Delta to prevent the introduction of nonnative invasive species by visiting recreationists.	Potential improvement in fishing quality; potential cost applied to fishing because of increased launching times or need for additional facilities	Impacts discussed qualitatively
CM21 Nonproject Diversions	CM21 will decrease incidental take of all covered fish species by decreasing Delta diversions not directly related to State Water Project/Central Valley Project water supply needs. This will be achieved partially as a consequence of introducing lands to the reserve system.	Potential improvement in fishing quality	Impacts discussed qualitatively
CM22 Avoidance and Minimization Measures	CM22 provides a mechanism for conducting site-specific surveys to identify appropriate measures to avoid and minimize effects of covered activities on covered species and habitats; most measures focused on terrestrial species.	None	Not applicable

3.2.2 CM1 Water Facilities and Operation

This section evaluates the effects on recreation resources in the Delta resulting from the construction, operation, and maintenance of the water conveyance facility (CM1). CM1 will affect the following activities.

- Recreation activities (water-dependent, water-enhanced, and land-based) and opportunities that are near the water conveyance facility.
- Water-dependent (e.g., boating and swimming) and water-enhanced recreation opportunities at major north-of-Delta reservoirs and major SWP/CVP south-of-Delta reservoirs that may be affected by changed operations under CM1.

Effects on recreation could occur as a result of maintenance and operation of the water conveyance facilities. Maintenance activities could result in short-term loss of recreation opportunities by disrupting use of recreation areas or facilities. Operation of the pump stations could result in noise levels that affect recreation areas. Mitigation measures, discussed below, will help alleviate some of these disturbances to recreation sites.

Operation of the water conveyance facility could also result in changes in reservoir storage and river flows. The resulting change in reservoir storage could affect the frequency and duration that reservoir levels are within acceptable ranges, or above the minimum level necessary to conduct certain recreational activities (Table 3.2-2).

Table 3.2-2. Recreation Opportunity Thresholds for North-of-Delta and South-of-Delta Recreation Resources

Water Resource	Elevation when Full (feet above mean sea level)	Water Surface Elevation Recreation Thresholds[a] (feet above mean sea level)
Folsom Lake	466	405—marina closes
Shasta Lake	1,067	<967—limited surface area (boating constrained)
Trinity Lake	2,370	2,270—recreation opportunities limited
Lake Oroville	900	700—boating opportunities limited
San Luis Reservoir	543	360—boating impaired
New Melones Reservoir	1,090	900—boating impaired

This analysis focuses on a level (the recreation threshold) at which the recreation experience would be degraded for reservoirs that would experience changes as a result of CM1 operations: Trinity Lake, Shasta Lake, Lake Oroville, Folsom Lake, New Melones Lake, and San Luis Reservoir. These reservoirs could experience slight variations in the storage and elevation patterns due to CM1 operations. North-of-Delta reservoirs that are below these major reservoirs including Lewiston, Whiskeytown, Keswick, Thermalito Forebay and Afterbay, and Natoma are operated with a seasonal storage pattern (elevations) with very small variation from year to year.

Comparison of conditions under CM1 operations to baseline conditions shows changes in SWP/CVP reservoir elevations that are caused by three factors: sea level rise, climate change, and implementation of the BDCP. Because both conditions reflect sea level rise and climate change, this comparison allows for isolation of the effects on recreation attributable to CM1 operations. Table

3.2-3 summarizes the total years of impact and the relative change in mean sea level from the recreation elevation thresholds above for four operational BDCP scenarios (labeled H1 through H4 in the BDCP EIR/EIS). The four operational BDCP scenarios are as follows.

- **Scenario H1.** This low-outflow scenario excludes enhanced spring outflow and excludes Fall X2 operations.
- **Scenario H2.** This scenario includes enhanced spring outflow, but excludes Fall X2 operations. This scenario lies within the range of scenarios H1 and H4.
- **Scenario H3.** This evaluated starting operations scenario excludes enhanced spring outflow, but includes Fall X2 operations.
- **Scenario H4.** This high-outflow scenario includes enhanced spring outflow, and includes Fall X2 operations.

A positive value indicates that the water conveyance facility operation would limit recreational opportunities due to lowering of the mean water level below the thresholds. CM1 operation would have negative impacts on recreation in the San Luis Reservoir and Lake Oroville under Scenario H4. Section 3.2.4, presents the mitigation measures proposed to help alleviate these losses to recreation.

Table 3.2-3. Summary of Years with Reduced SWP and CVP Reservoir Recreation Opportunities due to the Operation of CM1 Relative to the Baseline Scenario (End-of-September Elevations below Recreation Thresholds, 2060)

	Trinity Lake		Shasta Lake		Lake Oroville		Folsom Lake		New Melones Lake		San Luis Reservoir	
	Years[a]	Change[b]	Years[a]	Change[b]	Years[a]	Change[b]	Years[a]	Change[b]	Years[a]	Change[b]	Years[a]	Change[b]
H1	40	-3	22	-7	23	-9	41	-9	13	0	20	11
H2	38	-5	25	-4	24	-8	37	-13	12	-1	47	38
H3	41	-2	28	-1	29	-3	44	-6	13	0	37	28
H4	40	-3	29	0	35	3	47	-3	12	-1	55	46

[a] The number of years out of the 82 simulated when the September end-of-month elevation is less than the recreation elevation threshold for the selected BDCP operational scenario. An elevation less than the recreation threshold indicates occurrences during which recreation opportunities may be diminished.
[b] The change values are the number of years the simulated conditions differs from the baseline condition. A positive change would indicate more years with reduced recreation opportunities.

CM1 construction effects also were evaluated qualitatively. Construction activities could result in a temporary loss of recreation opportunities (2 years or less) by disrupting use of recreation areas or facilities. A permanent impact (more than 2 years) could occur, if a recreation opportunity is substantially changed or eliminated due to the presence of construction-related activities and noise, or the opportunity is fully eliminated as a result of placement of a water conveyance structure(s) on or adjacent to a recreation area or facility. CM1 includes the construction of three north Delta intake facilities (Intakes 2, 3, and 5) between Clarksburg and Walnut Grove. An operable barrier will be placed at the head of Old River at the confluence with the San Joaquin River. Table 3.2-4 lists the recreation sites and areas that may be affected by CM1. No recreation sites fall within the construction footprint. Specific effects on recreation areas or sites are discussed below.

Table 3.2-4. Recreation Sites Potentially Affected by Construction[a] and Operation of CM1

Recreation Site or Area	Primary Feature	Potential Impact Source	Duration
Clarksburg Boat Launch (fishing access)	Intake 3 and transmission lines	Noise and visual disturbances	Ongoing; up to 5 years
Stone Lakes National Wildlife Refuge	Potential borrow area north of Intake 2; Intakes 2 and 3 associated work areas; intermediate forebay and related work areas	Noise and visual disturbances	Ongoing; up to 5 years
Georgiana Slough Fishing Access	Tunnel easement, safe haven work area, temporary transmission line, and temporary access road	Noise	Intermittent; up to 2 years
Cosumnes River Preserve (Private Lands)	Temporary transmission lines; safe haven work area; permanent and temporary access roads (on Tyler Island along tunnel alignment) reusable tunnel material area; barge unloading facility; concrete batch plant (on Tyler Island); Temporary access road, safe haven work area, temporary transmission line (within the preserve)	Noise	Not applicable; no recreation use in areas affected
Cosumnes River Preserve (California Department of Fish and Wildlife Ecological Reserve)	Permanent transmission lines (east-west transmission line option only) (along portion of northern boundary of reserve lands)	Noise	Not applicable; no recreation use in areas affected
Bullfrog Landing (Marina)	Transmission line, permanent access road	Noise, access	Less than 2 years
Whiskey Slough Harbor Marina	Permanent access road	Noise, access	Less than 2 years
Clifton Court Forebay	Byron Tract Forebay, control structures and associated work areas	Noise and visual disturbances	Up to 2 years
Clifton Court Forebay	Byron Tract Forebay pumping plant canal approach structures	Noise	Up to 1 year

Sources: Green Info Network 2011; U.S. Fish and Wildlife Service 2012; AECOM/ICF International 2012.
[a] Construction duration information is approximate and subject to further revision.

The proposed location of the three intake facilities (Intakes 2, 3, and 5), tunnels, and associated water conveyance facilities would not lie within the designated boundaries of an existing public-use recreation site. The post-construction location of the water conveyance facilities would not result in long-term disruption or reduction of any well-established recreation activity or site, including parks, marinas, or other designated areas.

Access to and availability for use of all the facilities in the construction impact area would be maintained. Nonetheless, construction of CM1 would result in temporary short-term (2 years or less) and long-term (more than 2 years) impacts on well-established recreation opportunities and experiences: access, noise, and visual setting disruptions that could result in loss of public use. These impacts would be temporary, but could occur year-round and would occur over the 9-year construction schedule. Mitigation measures, environmental commitments, and avoidance and minimization measures would reduce construction-related impacts on wildlife, visual setting, transportation, and noise conditions that could detract from the recreation experience by protecting or compensating for effects on wildlife habitat and species; minimizing the extent of changes to the visual setting, including nighttime light sources; managing construction-related traffic; and reducing noise and tracking noise complaints. However, the level of impact would not be reduced to a less than significant level, because the dispersed effects on the recreation experience across the Delta may not be readily mitigated. Therefore, these impacts are considered significant and unavoidable.

3.2.3 Other Conservation Measures

Many of the other conservation measures (CM2 through CM22) involve land use changes that are expected to have an impact on outdoor recreation in the Plan Area. Based on data contained in the BDCP EIR/EIS, the land use impacts of CM2 through CM22 were evaluated to determine which ones would affect outdoor recreation activities in the Plan Area. Table 3.2-5 presents a list of the conservation measures that would affect land use and are likely to benefit outdoor recreation in the Plan Area. Although other conservation measures could affect recreation, this analysis focuses on CM2, CM3, CM4, CM5, CM8, and CM9, because they would directly affect acres available for recreation.

Although other conservation measures could result in improvements to the quality of Plan Area recreation sites, the analysis assumes that increases in recreation would result from increases in the size of recreation areas, and that the public will have access to these new sites in order to use them for recreation. Examples of increased public access include the creation of user facilities or the expansion of regions already supporting levels of recreation. Conservation measures other than those listed in Table 3.2-5 will not increase the acreage of areas that directly support recreation. These other conservation measures, however, will likely enhance the recreation opportunities in adjacent recreation areas. An example of quality improvement is enhancing the biological diversity of the area, which may increase the number and diversity of fish and wildlife in the region. Many of the conservation measures will enhance the overall quality of the natural areas and therefore the quality of the recreational enjoyment. Changes in recreation resulting solely from changes in quality and not from increases in acreage of recreation sites or improvements in access could not be quantified. Table 3.2-6 summarizes the conservation measures that may have qualitative impacts on recreation.

Table 3.2-5. Conservation Measures with Quantitative Impacts on Outdoor Recreation

Conservation Measure	Description of Changes	Quantifiable Impacts on Recreation
CM1 Water Facilities and Operation	CM1 will promote connectivity and water flows between native fish habitats and spawning areas, supporting the movement of juvenile and larval stages and reducing mortality levels for adult fishes.	CM1 will cause a permanent decrease of 3 acres in migratory bird hunting due to the placement of the water conveyance facility.
CM2 Yolo Bypass Fisheries Enhancement	CM2 will increase the frequency, duration, and magnitude of floodplain inundation in the Yolo Bypass, improving passage and habitat for many fish species and supporting the biological productivity of nutrition sources for aquatic species.	CM2 will limit the recreational opportunities for migratory bird hunting due to increased winter flooding. The model does not include the increase in the quality for anglers or nonconsumptive recreation.
CM3 Natural Communities Protection and Restoration	CM3 will create a reserve system of protected lands through fee-title acquisition and conservation easements. Total acquisition will be at least 61,455 acres, with an estimated 36,324 acres in conservation easement and 25,131 acres in fee title.[a]	Fee-title acquisition will expand recreation opportunities where recreation is compatible with meeting biological goals and objectives. Benefits are based on land-based nonconsumptive activities (hiking, sightseeing, camping, picnicking).
CM4 Tidal Natural Communities Restoration	CM4 will restore at least 55,000 acres of tidal natural communities and 10,000 acres of adjacent upland transitional areas to accommodate sea level rise. The goal is to restore 16,300 acres by year 10 of the permit term, 25,975 acres by year 15, and 65,000 acres by year 40.	Because CM4 will increase tidal wetlands, water-based recreation opportunities will expand. This includes shore and boat-based fishing, nonconsumptive boating, and shore- based recreation. The benefits are quantified for water-based nonconsumptive activities and fishing (boat and shoreline). Where managed wetlands are converted into tidal natural communities, waterfowl hunting opportunity will likely decrease.
CM5 Seasonally Inundated Floodplain Restoration	CM5 will restore historical floodplains that were lost to flood control and channelization. The goal is to restore at least 10,000 acres through the use of setback levees, with 1,000 acres restored by year 15 and all 10,000 acres restored by year 40.	CM5 will increase the opportunity for water-based recreation (fishing and nonconsumptive recreation). In the event of increased water flow, the setback levees will allow public access to these waterways.
CM8 Grassland Natural Community Restoration	CM8 will protect grassland natural community in Conservation Zones 1, 8, and/or 11. The goal is to restore 1,400 acres of grassland under fee title.	CM 8, through fee title, will increase the opportunity for nonconsumptive recreation on restored grasslands (hiking, sightseeing, camping, picnicking).
CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration	CM9 will prevent net loss of vernal pool acreage in Conservation Zones 1, 8, and/or 11. The goal is to restore 750 acres.	Although CM9 will not generate a net gain in acres, the restored acres will be on public land and will increase the opportunity for guided botany and wildlife tours.

[a] Summing the land acquisition requirement by natural community yields 62,955 acres. Actual land acquisition will be slightly less, because it is assumed that the requirement to preserve 1,500 acres of rice will be met through restoration in CM4 or CM10.

Sources: California Department of Water Resources 2013: Table 6-2; Table 8-1.

Table 3.2-6. Conservation Measures with Qualitative Impacts on Outdoor Recreation

Conservation Measure	Description of Changes	Qualitative Impacts on Recreation
CM1 Water Facilities and Operation	CM1 will promote connectivity and water flows between native fish habitats and spawning areas, supporting the movement of juvenile and larval stages and reducing mortality levels for adult fishes.	CM1 will cause a temporary decrease in recreation at or near construction sites.
CM2 Yolo Bypass Fisheries Enhancement	CM2 will increase the frequency, duration, and magnitude of floodplain inundation in the Yolo Bypass, improving passage and habitat for many fish species, as well as supporting the biological productivity of nutrition sources for aquatic species.	CM2 will increase boating/fishing opportunity and quality after flooding. However, CM2 and increased flooding could have a negative impact on waterfowl hunting, bird watching, and angling.
CM3 Natural Communities Protection and Restoration	CM3 will create a reserve system of protected lands through fee-title acquisition and conservation easements. Total acquisition will be at least 61,455 acres, with an estimated 36,324 acres in conservation easement and 25,131 acres in fee title.[a]	CM3 will protect the opportunity to engage in migratory bird hunting on 5,000 acres.
CM6 Channel Margin Enhancement	CM6 will restore 20 linear miles of channel margin by improving channel geometry and restoring riparian, marsh, and mudflat habitats on the inboard side of levees.	CM6 will improve the quality of boating and fishing opportunities.
CM7 Riparian Natural Community Restoration	CM7 will restore 5,000 acres of riparian forest and scrub in association with land restoration measures in CM4, CM5, and CM6.	CM7 will improve the quality of nonconsumptive recreation (boating and nonboating) and fishing.
CM10 Nontidal Marsh Restoration	CM10 will restore 1,200 acres of nontidal freshwater marsh in Conservation Zones 2 and 4.	CM10 could expand opportunity for nonconsumptive recreation; however, the amount is uncertain.
CM11 Natural Communities Enhancement and Management	CM11 will contribute to the biological goals and objectives for each type of acquired conservation land held in the reserve system. Many possible steps entail active vegetation management to optimize conditions for important species.	CM11 will improve the quality of recreation, better viewsheds, more diverse habitat and wildlife viewing opportunities.
CM13 Invasive Aquatic Vegetation Control	CM13 will remove invasive aquatic vegetation that degrades habitat for covered fish.	CM13 could improve fishing quality.
CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels	CM14 will increase dissolved oxygen levels in the Stockton Deep Water Ship Channel to promote better water quality conditions for covered fish species.	CM14 could improve fishing quality.
CM15 Localized Reduction of Predatory Fishes	CM15 will manage the distribution and abundance of predators that affect levels of native covered fish species.	CM15 could improve fishing quality for salmonids but will reduce density of nonnative sport fish (e.g., striped bass) at specific predator control locations.
CM16 Nonphysical Fish Barriers	CM16 outlines the siting and design of nonphysical barriers that will direct juvenile salmonids down channels and river reaches where they have higher survival rates.	CM16 could improve fishing quality.

Conservation Measure	Description of Changes	Qualitative Impacts on Recreation
CM19 Urban Stormwater Treatment	CM19 will improve Delta fish habitat by funding stormwater treatment measures that will result in decreased discharge of contaminants to the Delta.	CM19 could improve fishing quality.
CM20 Recreational Users Invasive Species Program	CM20 will fund a watercraft inspection program in the Delta to prevent the introduction of nonnative invasive species by visiting recreationists.	CM20 could improve fishing quality but could also impose a cost on boaters

Source: California Department of Water Resources et al. 2013: Chapter 3, Table 6-2.

[a] Summing the land acquisition requirement by natural community yields 62,955 acres. Actual land acquisition will be slightly less, because it is assumed that the requirement to preserve 1,500 acres of rice will be met through restoration in CM4 or CM10.

3.2.4 Mitigation Measures

Mitigation measures address the construction and operation of CM1 as well as the impacts from the other conservation measures (CM2–22). Table 3.2-7 highlights the potential negative impacts of the BDCP on recreation and the proposed mitigation measures for each impact. BDCP EIR/EIS Chapter 15, *Recreation*, describes these impacts in detail (California Department of Water Resources et al. 2013).

Table 3.2-7. Negative Impacts on Recreation, Level of Significance of the Impact, and Associated Mitigation Measures

Negative Recreational Impacts	CEQA Level of Significance before Mitigation	Mitigation Measure	CEQA Level of Significance after Mitigation
REC-1: Permanent displacement of existing well-established public use or private commercial recreation facility available for public access as a result of the location of the proposed water conveyance facilities	Less than significant/ not adverse	None	Less than significant
REC-2: Long-term reduction of recreation opportunities and experiences as a result of constructing the proposed water conveyance facilities	Significant/ adverse	REC-2: Provide alternative bank fishing access sites BIO-72: Conduct preconstruction nesting bird surveys and avoid disturbance of nesting birds AES-1a: Locate new transmission lines and access routes to minimize the removal of trees and shrubs and pruning needed to accommodate new transmission lines AES-1b: Install visual barriers between construction work areas and sensitive receptors AES-1c: Develop and implement a spoil/borrow and tunnel muck area reclamation plan AES-1d: Restore barge unloading facility sites once decommissioned AES-1e: Apply aesthetic design treatments to all structures to the extent feasible AES-1f: Locate concrete batch plants and fuel stations away from sensitive visual resources and receptors and restore sites upon removal of facilities AES-1g: Implement best management practices to implement project landscaping plan AES-4a: Limit construction to daylight hours within 0.25 mile of residents AES-4b: Minimize fugitive light from portable sources used for construction AES-4c: Install visual barriers along access routes, where necessary, to prevent light spill from truck headlights toward residences TRANS-1a: Implement site-specific traffic management plan TRANS-1b: Limit hours or amount of construction activity on congested roadway segments TRANS-1c: Make good faith efforts to enter into mitigation agreements to enhance capacity of congested roadway segments Mitigation Measure NOI-1a: Employ noise-reducing construction practices during construction NOI-1b: Prior to construction, initiate a complaint/response tracking program	Significant and unavoidable

Negative Recreational Impacts	CEQA Level of Significance before Mitigation	Mitigation Measure	CEQA Level of Significance after Mitigation
REC-3: Long-term reduction of recreational navigation opportunities as a result of constructing the proposed water conveyance facilities	Significant/ adverse	TRANS-1a: Implement site-specific traffic management plan	Unknown at this time.
REC-4: Long-term reduction of recreational fishing opportunities as a result of constructing the proposed water conveyance facilities	Less than significant / not adverse	REC-2: Provide alternative bank fishing access sites AQUA-1a: Minimize the use of impact pile driving to address effects of pile driving and other construction-related underwater noise AQUA-1b: Use an attenuation device to reduce effects of pile driving and other construction-related underwater noise NOI-1a: Employ noise-reducing construction practices during construction NOI-1b: Prior to construction, initiate a complaint/response tracking program AES-1a: Locate new transmission lines and access routes to minimize the removal of trees and shrubs and pruning needed to accommodate new transmission lines AES-1b: Install visual barriers between construction work areas and sensitive receptors AES-1c: Develop and implement a spoil/borrow and tunnel muck area reclamation plan AES-1d: Restore barge unloading facility sites once decommissioned AES-1e: Apply aesthetic design treatments to all structures to the extent feasible AES-1f: Locate concrete batch plants and fuel stations away from sensitive visual resources and receptors and restore sites upon removal of facilities AES-1g: Implement best management practices to implement project landscaping plan	Less than significant
REC-5: Long-term reduction of recreational fishing opportunities as a result of the operation of the proposed water conveyance facilities	Less than significant / not adverse	None	Less than significant

Negative Recreational Impacts	**CEQA Level of Significance before Mitigation**	**Mitigation Measure**	**CEQA Level of Significance after Mitigation**
REC-6: Change in reservoir or lake elevations resulting in substantial reductions in water-based recreation opportunities and experiences at north- and south-of-Delta reservoirs	Significant (H2 and H4)/ adverse (H1, H2 and H4)	REC-6: Provide a temporary alternative boat launch to ensure access to San Luis Reservoir	Less than significant
REC-7: Long-term reduction in water-based recreation opportunities as a result of maintenance of the proposed water conveyance facilities	Less than significant/ not adverse	None	Less than significant
REC-8: Long-term reduction in land-based recreation opportunities as a result of maintenance of the proposed water conveyance facilities	Less than significant/ not adverse	None	Less than significant
REC-9: Long-term reduction in fishing opportunities as a result of implementing the proposed conservation components	Less than significant/ not adverse; (beneficial in long-term)	AES-1a: Locate new transmission lines and access routes to minimize the removal of trees and shrubs and pruning needed to accommodate new transmission lines AES-1b: Install visual barriers between construction work areas and sensitive receptors AES-1c: Develop and implement a spoil/borrow and tunnel muck area reclamation plan AES-1d: Restore barge unloading facility sites once decommissioned AES-1e: Apply aesthetic design treatments to all structures to the extent feasible AES-1f: Locate concrete batch plants and fuel stations away from sensitive visual resources and receptors and restore sites upon removal of facilities AES-1g: Implement best management practices to implement project landscaping plan AES-4b: Minimize fugitive light from portable sources used for construction AES-4c: Install visual barriers along access routes, where necessary, to prevent light spill from truck headlights toward residences TRANS-1a: Implement site-specific traffic management plan TRANS-1b: Limit hours or amount of construction activity on congested roadway segments	Less than significant; (beneficial in long-term)

Negative Recreational Impacts	CEQA Level of Significance before Mitigation	Mitigation Measure	CEQA Level of Significance after Mitigation
		TRANS-1c: Prohibit construction traffic on congested roadway segments NOI-1a: Employ noise-reducing construction practices during construction NOI-1b: Prior to construction, initiate a complaint/response tracking program	
REC-10: Long-term reduction in boating-related recreation opportunities as a result of implementing the proposed conservation measures	Less than significant (CM2 through CM17 and CM19 through CM22)/not adverse; significant (CM18)	AES-1a: Locate new transmission lines and access routes to minimize the removal of trees and shrubs and pruning needed to accommodate new transmission lines AES-1b: Install visual barriers between construction work areas and sensitive receptors AES-1c: Develop and implement a spoil/borrow and tunnel muck area reclamation plan AES-1d: Restore barge unloading facility sites once decommissioned AES-1e: Apply aesthetic design treatments to all structures to the extent feasible AES-1f: Locate concrete batch plants and fuel stations away from sensitive visual resources and receptors and restore sites upon removal of facilities AES-1g: Implement best management practices to implement project landscaping plan AES-4b: Minimize fugitive light from portable sources used for construction AES-4c: Install visual barriers along access routes, where necessary, to prevent light spill from truck headlights toward residences TRANS-1a: Implement site-specific traffic management plan TRANS-1b: Limit hours or amount of construction activity on congested roadway segments TRANS-1c: Prohibit construction traffic on congested roadway segments NOI-1a: Employ noise-reducing construction practices during construction NOI-1b: Prior to construction, initiate a complaint/response tracking program	Less than significant
REC-11: Long-term reduction in upland recreational opportunities as a result of implementing the proposed conservation components	Less than significant/ adverse	None	Less than significant
Source: California Department of Water Resources et al. 2013: Chapter 15. CEQA = California Environmental Quality Act.			

3.2.5 Data, Methods, and Assumptions

The first step for evaluating the impacts of the BDCP on recreation was to collect the data needed for inputs in the Benefit Transfer Toolkit's visitor use models that would predict the changes in visitor days. One key input was information on the land use changes that would occur under the various conservation measures. To evaluate these changes, land use changes under the conservation measures were estimated over a 50-year analysis period, using information on the restoration goals associated with each conservation measure. In the absence of information on the annual rate of land use changes, linear interpolation was used to estimate annual totals for the years where annual data were not available.

CM3 and CM8 will increase acres for nonconsumptive recreation, mainly hiking and wildlife viewing. Through fee title, CM3 and CM8 will increase grasslands by 8,000 acres and 1,400 acres, respectively. Using the estimates reported in the BDCP (California Department of Water Resources 2013: Table 6-2), the gain in acres was estimated based on the 5-year benchmarks established by the BDCP. The percentage of total acres at each benchmark was estimated and multiplied by the total acres acquired by fee title. Linear interpolation was used to estimate the total acres for years falling in between the 5-year benchmarks.

CM1, CM2, and CM4 will reduce the acres available for waterfowl hunting. To estimate the change in recreation for migratory bird hunting, the total loss in the area of managed wetlands used by private duck clubs was estimated. There are 12,813 acres of managed wetlands that overlap with duck club regions (CM1, 2, and 4). The figure assumes that 3 acres would be lost to construction (CM1) and 24 acres would be lost in the Fremont Weir/Yolo Bypass region (CM2) in year 1, and would be lost for the total 40-year analysis period.

CM4 will increase opportunities for boating-based activities and nonconsumptive recreation uses such as sightseeing, swimming, and other general boating activities. CM4 calls for 65,000 acres of restored tidal natural communities by year 40. This will include 55,000 acres of tidally influenced communities and 10,000 acres of adjacent upland transitional areas to accommodate sea level rise. Using the estimates reported in the BDCP (California Department of Water Resources 2013: Table 6-2), the gain in area was estimated based on the 5-year benchmarks established by the BDCP. Linear interpolation was used to estimate the total acres for years falling in between the 5-year benchmarks. Because not all of the 65,000 acres would directly increase boating accessibility, we assumed that only intertidal restoration acres (28,000 or 43% of the total acres) will increase the number of visitor days for freshwater angling or nonconsumptive recreational uses.

For CM5, the same interpolation assessments for the benchmarks set forth in BDCP Table 6-2 were used. Because CM5 relates to seasonally inundated floodplain restoration, the area is assumed to benefit only anglers and nonconsumptive recreation when in season, or 15% (roughly 2 months) of each year. Finally, the floodplain will not be accessible by boat without an increase in the water levels on these floodplains, which is assumed to happen, on average, once every 4 years. In alternate years, it is assumed that there would be no impact on outdoor recreation as a result of CM5. Seasonally inundated floodplain restoration could occur along channels in many locations in the north, east, and/or south Delta. CM5 will result in a further increase in onshore and boat-fishing opportunities due to improvements in riparian habitat for fish; however, existing points of access may be modified or disrupted.

CM9 will increase nonconsumptive recreation, mainly guided botany and wildlife viewing tours. CM9 would restore 750 acres of vernal pools. Based on Table 6-2 in the BDCP, we assumed that the 750 acres would be restored by year 25. To estimate the annual increase in acres, the model assumes a liner increase of 30 acres per year.

Other needed inputs for the visitor use models include information on the population thought to use recreation areas in the Plan Area and the average income of these populations. Assuming that the vast majority of recreational users live within 50 miles of the recreation site they visit, the population in each of the counties in the Plan Area and the counties immediately surrounding the Plan Area (California Department of Finance 2010) was assessed,[1] along with 2008 per-capita income (Bureau of Economic Analysis 2011). Although individuals may travel farther than 50 miles to visit the Delta, the study is constrained by the 50-mile assumption due to the specifications of the benefit transfer function. The 2008 per-capita income data were used, because the visitor use models in the Benefit Transfer Toolkit were calibrated in 2008, assuming prices in 2008. Using income in 2011 but prices in 2008 would overstate the resulting increases in outdoor recreation that will result from the BDCP. A constant per-capita income was assumed over the analysis period to reflect the inherent price assumptions of the model that do not grow over time. However, the analysis assumes that the population with access to the recreation sites in the region will grow over the analysis period. Table 3.2-8 presents data for the population in 2015 and per-capita income in 2008 for counties where users of recreation sites in the Plan Area are assumed to live.

Table 3.2-8. Population and Per-Capita Income for Affected Counties[a]

County	Population in 2015[b]	Per-capita Income in 2008[c]
Alameda	1,577,938	$50,302
Contra Costa	1,093,171	$58,547
Napa	140,855	$51,712
Placer	371,536	$49,436
Sacramento	1,477,479	$38,782
San Joaquin	725,884	$31,250
Solano	424,494	$39,178
Stanislaus	540,853	$31,093
Sutter	98,833	$33,117
Yolo	209,198	$37,488

[a] Affected counties include counties in the immediate Plan Area and counties directly adjacent to the Plan Area.
[b] California Department of Finance 2010
[c] Bureau of Economic Analysis 2008

3.2.5.1 Visitor Use Models

To estimate the change in recreational activities in the Plan Area that would result from the BDCP, the wildlife refuge visitor use models (Benefit Transfer Toolkit) were used to predict visitation to recreation sites and participation in various recreation activities. The visitor use models estimate

[1] The California Department of Finance estimates the county populations in 5-year increments to 2050. We estimated a yearly population using a linear interpolation for the 4 years between each point estimate.

participation levels in recreational activities based on the characteristics of the available sites (i.e., their natural features) and the population and income of residents in the surrounding area who might use these sites.[2] These models were developed using data from a sample of National Wildlife Refuges and visitor use data for different recreation activities obtained from the U.S. Fish and Wildlife Service (Caudill and Henderson 2004). The Benefit Transfer Toolkit developed separate models for a range of recreation activities. In this study, the models developed for nonconsumptive visits (birding and other wildlife viewing, hiking, picnicking, recreational boating), migratory bird–hunting visits, and freshwater fishing visits (shoreline and boat-based) were used. The models developed for these three categories of recreational activities are presented below, along with an explanation of the significant model results and the inputs for each model.

3.2.5.1.1 Nonconsumptive Recreation Visits

Table 3.2-9 presents the visitor use model for nonconsumptive recreation visits. The model inputs include the total acres, whether the activity is ocean-related, the per-capital income, and the surrounding county populations. The inputs have a positive effect on the number of nonconsumptive visits to a recreation site, implying that as any one of the inputs (acres, per-capita income, or population) increases, the number of visitor days also will increase. For example, a 1% increase in per-capita income results in a 1.46% increase in the number of nonconsumptive visits. The interpretation of other variables is shown in Table 3.2-9. This model was applied for the assumed annual population, the fixed per-capita income, and the land changes that will result from CM 3, CM4, CM5, CM8, and CM9.

Table 3.2-9. Visitor Use Model for Nonconsumptive Recreation Visits

Independent Variables	Change in Independent Variable	Estimated Change in Visitor Days
Total acres	1%	0.46%
Ocean	Ocean-based activity	0.36 Days
Per-capita income	1%	1.46%
County population	1%	0.25%

3.2.5.1.2 Migratory Bird–Hunting Visits

For the migratory bird–hunting model, the independent variables only include the acres of increased wetlands. The number of wetland acres has a positive effect on the number of migratory bird–hunting visits to a recreation site. For example, the model predicts that a 1% increase in wetland acres of a site will result in a 0.5% increase in the number of migratory bird–hunting visits.

To estimate the change in recreation for migratory bird hunting, the total loss in the area of managed wetlands used by private duck clubs was estimated. There are 12,789 acres of managed wetlands that will be converted to tidal wetlands and that overlap with duck club regions (CM4). The analysis assumes that 3 acres of managed wetlands would be lost to construction and 24 acres

[2] The results of the benefit transfer function method are heavily reliant on the functions in the source studies used to estimate benefits. If the BDCP offers amenities that differ greatly from the amenities offered in these source studies, the ability to transfer these benefit functions to match the context of recreation sites affected by the BDCP could be limited.

would be lost in the Fremont Weir/Yolo Bypass region due to flooding (CM2) in year 1, and would be lost for the total 40-year analysis period.

3.2.5.1.3 Freshwater Angling Visits

Table 3.2-10 presents the visitor use model for freshwater angling visits. The independent variables for the freshwater angling model include acres, per-capita income and populations. Total acres and populations in the counties surrounding the site had positive effects on the number of freshwater angling visits to a recreation site. For example, the model predicts that a 1% increase in population results in a 0.65% increase in the number of freshwater angling visits. Other variables can be interpreted in a similar manner. We applied the model above for the assumed annual population, the fixed per-capita income and the land use changes from CM4 and CM5.

Table 3.2-10. Visitor Use Model for Freshwater Angling Visits

Independent Variables	Change in Independent Variable	Estimated Change in Visitor Days
Total acres	1%	0.22%
Per-capita income	1%	1.51%
County population	1%	0.23%

3.2.5.2 Unit-Day Values for Outdoor Recreation Activities

After estimating the change in recreation visits that would result from CM3, CM4, and CM5, these changes were monetized by assigning values to the changes in the affected recreation activities. For this purpose, unit-day values were used for the affected recreation activities. Unit-day values have been developed by the U.S. Forest Service for a wide range of recreation activities, and represent the consumer surplus a recreational user receives from engaging in a recreational activity (Rosenberger and Loomis 2001). Consumer surplus is defined as the difference in what an individual is willing to pay to receive a good or service over and above what they have to pay for it. As an example, if an individual would pay up to $80 to spend a day freshwater fishing, but it only costs them $30 to spend the day fishing at their chosen site, their consumer surplus for the day spent fishing is $50 ($80 minus $30). Because consumer surplus is the value people receive in excess of what they must pay, it is a measure of the value that is created by an individual's use of a good or service.

Table 3.2-11 presents the unit-day values used to value days spent engaging in recreation activities (nonconsumptive recreation, migratory bird hunting, and freshwater angling). These values are based on a total of 31 studies that estimated the value of recreation in the Pacific region of the United States.

Table 3.2-11 presents the source articles used to derive the unit-day values. For each model, the table presents the value for the low, median, and high unit-day values. Because the unit-day values summarize different studies, the high and low values reflect a specific study and a specific activity. Most non-market valuation studies of recreation will estimate a range of benefits based on use of the low and high unit-day values, but will rely on estimates based on low or median unit-day values to a greater extent than those based on high unit-day values. To be conservative, this study defines the range of potential recreation benefits to be the range of values obtained by using the low and median unit-day values to estimate benefits.

Table 3.2-11. Unit-Day Values for Affected Recreation Activities (2012 Dollars)

Unit-Day Values for Nonconsumptive Recreation Visits in the Pacific Region (N = 16)	
Minimum	$29.63
Max	$154.95
Average	$67.12
Median	$50.59
Unit-Day Values for Migratory Bird–Hunting Visits (N = 12)	
Minimum	$27.75
Max	$151.92
Average	$73.90
Median	$54.70
Unit-Day Values for Freshwater Angling Visits (N = 13)	
Minimum	$2.92
Max	$221.63
Average	$61.67
Median	$51.65

Table 3.2-12. Studies Used in the Unit-Day Values

Author	Title	Location	Number of Estimates
Unit-Day Values for Nonconsumptive Recreation Visits in the Pacific Region (N = 16)			
Brown, G. M. and M. Plummer	Recreation Valuation: An Economic Analysis of Nontimber Uses of Forestland in the Pacific Northwest	WA	1
Connelly, N., and T. Brown	Estimates of Nonconsumptive Wildlife Use on Forest Service and BLM Lands	OR, WA	2
Hay, M. J.	Net Economic Values of Nonconsumptive Wildlife-Related Recreation	HI, OR, WA	3
McCollum, D. W., G. L. Peterson, J. R. Arnold, D. C. Markstrom, and D. M. Hellerstein	The Net Economic Value of Recreation on the National Forests: Twelve Types of Primary Activity Trips across Nine Forest Service Regions	OR, WA	1
Cooper, J. C., and J. B. Loomis	Economic Value of Wildlife Resources in the San Joaquin Valley: Hunting and Viewing Values	CA	1
Waddington, D. G., K. J. Boyle, and J. Cooper	1991 Net Economic Values for Bass and Trout Fishing, Deer Hunting, and Wildlife Watching	HI, OR, WA	3
Aiken, R., and G. P. la Rouche	Net Economic Values for Wildlife-Related Recreation in 2001: Addendum to the 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation	HI, OR, WA	5
Unit-Day Values for Migratory Bird–Hunting Visits (N = 12)			
Brown, G. M., and J. Hammack	A Preliminary Investigation of the Economics of Migratory Waterfowl	AZ, CA, ID, NV, OR, UT, WA	1
Brown, G., and M. J. Hay	Net Economic Recreation Values for Deer and Waterfowl Hunting and Trout Fishing, 1980	CA, OR, WA	3
Cooper, J. C., and J. B. Loomis	Economic Value of Wildlife Resources in the San Joaquin Valley: Hunting and Viewing Values	CA	1
Cooper, J. C., and J. B. Loomis	Testing Whether Waterfowl Hunting Benefits Increase with Greater Water Deliveries to Wetlands	CA	2
Charbonneau, J. J., and M. J. Hay	Estimating Marginal Values of Waterfowl for Hunting	Pacific Flyway	2
Hay, M. J.	Net Economic Value for Deer, Elk and Waterfowl Hunting and Bass Fishing, 1985	CA, OR, WA	3
Unit-Day Values for Freshwater Angling Visits (N = 13)			
Brown, G., and M. J. Hay	Net Economic Recreation Values for Deer and Waterfowl Hunting and Trout Fishing, 1980	CA, OR, WA	3
Waddington, D. G., K. J. Boyle, and J. Cooper	1991 Net Economic Values for Bass and Trout Fishing, Deer Hunting, and Wildlife Watching	CA, OR, WA	3
Boyle, K. J., B. Roach, and D. G. Waddington	1996 Net Economic Values for Bass, Trout and Walleye Fishing, Deer, Elk and Moose Hunting, and Wildlife Watching: Addendum to the 1996 National Survey of Fishing, Hunting and Wildlife-Associated Recreation	CA, ID, NC, OR, WA, AK	2
Aiken, R., and G. P. la Rouche	Net Economic Values for Wildlife-Related Recreation in 2001: Addendum to the 2001 National Survey of Fishing, Hunting and Wildlife-Associated Recreation	CA, OR, WA	5
Source: Loomis and Richardson 2007.			

3.2.6 Results

Using the models described in Section 3.2.5, *Data, Methods, and Assumptions*, an increase in visitor days was estimated for nonconsumptive recreation and freshwater angling visits. A decrease in migratory bird hunting would result from a reduction in acres used for hunting under the BDCP. Using the unit-day values, the total consumer surplus gained (or lost) for each activity over 50 years was estimated, undiscounted and discounted at 3%. The following sections present the results by activity.

3.2.6.1 Nonconsumptive Recreation Visits

For nonconsumptive recreation, average annual visitor days would increase by 88,303 as a result of CM3; by 151,942 as a result of CM4; by 7,729 as a result of CM5; by 43,329 as a result of CM8; and by 32,054 as a result of CM9. This represents a total increase of 12.0 million visitor days over the 50-year permit term. Low and high unit-day values were used to monetize days spent engaging in nonconsumptive outdoor recreation. The resulting increase in consumer surplus over 50 years was $233 million to $1.1 billion, discounted. Table 3.2-13 summarizes the visitor days and the values for nonconsumptive recreation.

Table 3.2-13. Nonconsumptive Recreation Visitor Days and Values

Conservation Measures	Average Change in Visitor Days per Year	Total Change in Visitor Days Over 50 Years	Discounted Total Value of Change in Recreation (Low Value, Million $)	Discounted Total Value of Change in Recreation (Median Value, Million $)	Discounted Total Value of Change in Recreation (High Value, Million $)
CM3 Natural Communities Protection and Restoration	88,303	3,27	$61.23	$171.82	$310.89
CM4 Tidal Natural Communities Restoration	151,942	5,571,808	$103.64	$7.51	$526.25
CM5 Seasonally Inundated Flood Plain	7,729	281,054	$4.53	$101.51	$23.02
CM8 Grassland Natural Community Restoration	43,329	1,656,074	$31.18	$51.70	$158.34
CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration	32,054	1,219,724	$22.56	$37.41	$114.57
Total	**323,357**	**12,005,715**	**$223.16**	**$369.95**	**$1,133.07**

3.2.6.2 Migratory Bird–Hunting Visits

For migratory bird hunting, the loss in visits due to lost acres of hunting lands from construction (CM1), increased flooding in the Yolo bypass (CM2), and establishment of tidal wetlands (CM4) was estimated as an average annual decrease of 2,145 visitor days, amounting to 107,238 visitor days over the 50-year permit term. This change in visitor days would result in a consumer surplus loss of $1.5 million to $8.4 million, discounted. The value range relates to use of the low or high unit-day value for migratory bird hunting. Using the median value, the change in visitor days would result in a consumer surplus loss of $3.0 million.

3.2.6.3 Freshwater Angling

For freshwater angling, average annual visitor days would increase by 2,307 as a result of CM4, and by 110 as a result of CM5. Because the model estimates the impacts of angler visits based on increases or decreases in acres, the model does not reflect potential changes to the quality of the angler trip. The BDCP would thus have negative effects for bass anglers due to the predator control measures (CM15) that are not captured in the model of impacts on freshwater angling. The model does not capture these negative impacts. This will result in 137,579 visitor days over the 50-year permit term. Low and high unit-day values were used to monetize days spent engaging in freshwater angling. Unit-day values for cold-water angling were used to reflect the fact that a large majority of anglers in the region fish for bass. The resulting increase in consumer surplus over 50 years was $170,685 to $13.0 million, discounted. Table 3.2-14 summarizes the visitor days and the associated values for angler recreation.

Table 3.2-14. Freshwater Angling Visitor Days and Values

Conservation Measures	Average Change in Visitor Days per Year	Total Change in Visitor Days Over 50 Years	Discounted Total Value of Change in Recreation (Low Value)	Discounted Total Value of Change in Recreation (Median Value)	Discounted Total Value of Change in Recreation (High Value)
CM4 Tidal Natural Communities Restoration	2,307	131,308	$163,847	$2,903,173	$12,457,426
CM5 Seasonally Inundated Flood Plain	110	6,271	$6,838	$121,162	$519,904
Total	**2,417**	**137,579**	**$170,685**	**$3,024,335**	**$12,977,330**

3.2.7 Summary of Recreation Values

Table 3.2-15 summarizes the economic impact of the BDCP on outdoor recreation in the Plan Area. Assuming the low unit-day values for recreation activities, the BDCP would provide a benefit to outdoor recreation of $221.8 million, discounted; assuming the high unit-day values, the BDCP would provide a benefit to outdoor recreation of $1.1 billion, discounted. For the purposes of this study, the median value is more reflective of an upper range of recreational values. The total recreation benefit for BDCP based on median visitor use values is $370.0 million. The majority of the benefits to outdoor recreation would arise from increases in nonconsumptive recreation use. The overall impact of the BDCP on migratory bird hunting would be negative, but the magnitude of this change is much smaller than the positive impacts on nonconsumptive recreation.

Table 3.2-15. Economic Impact on Recreation Opportunities

Recreation Opportunity	Discounted Total Value of Change in Recreation (Low Value, Million $)	Discounted Total Value of Change in Recreation (Median Value, Million $)	Discounted Total Value of Change in Recreation (High Value, Million $)
Nonconsumptive recreation	$223.2	$370.0	$1,133.1
Migratory bird hunting	-$1.5	-$3.0	-$8.4
Freshwater angling	$0.2	$3.0	$13.0
Net Recreation Value	**$221.8**	**$370.0**	**$1,137.7**

3.3 Transportation

3.3.1 Introduction

This section evaluates the economic impacts of transportation disruptions and delays resulting from construction of the water conveyance facility (*CM1 Water Facilities and Operation*) under the BDCP. CM1 construction will result in higher levels of traffic in the immediate Plan Area and surrounding areas. To determine the economic impact of transportation delays resulting from CM1 construction, monetary costs of additional travel time spent by travelers in the region were estimated over the 9-year construction period of the new water conveyance facility. Additional travel times were estimated by comparing travel times in the region with CM1 construction (*BDCP scenario*) to travel times without CM1 construction (*baseline scenario*).

To estimate the costs associated with travel delays, a value was applied for the opportunity cost of a traveler's time, which is the value of the time that a traveler must forego from spending on other activities due to their increased time spent in transit. Opportunity cost varies based on how the foregone time will have been spent (i.e., whether it is work or leisure time). This analysis incorporates the opportunity cost of time for both business and leisure travelers, since CM1 construction will affect both types of travelers.

3.3.2 CM1 Water Facilities and Operation

Construction of the water conveyance facility under CM1 will affect several roadways throughout the region. The 9-year construction period will add construction-based commuters traveling to and from the construction site, in addition to trucks transporting materials and other construction-related equipment. CM1 construction will include building intakes, pumping plants, pipelines, tunnels, and other general structures relating to the water conveyance facility. The estimates in this section are based on BDCP EIR/EIS Alternative 4 (California Department of Water Resources et al. 2013); however, no project has been selected, and the final right-of-way has not been determined. These results are based on assumptions that are subject to change once final selections and determinations are made. Other conservation measures (CM2 through CM 22) could affect traffic flows; however, these measures are expected have a negligible impact. The locations of many of the conservation measures are in less densely populated areas, and many also involve relatively small-scale projects. Traffic generated by these conservation measures will be minimal and heavily localized to the immediate area of the measure.

As the volume of vehicles on roadways increases, the level of service (LOS) decreases for a given segment. The increase in volume slows the flow of traffic and adds additional travel time for each vehicle on the road. Volume estimates used in this analysis were taken from data in BDCP EIR/EIS Chapter 19, *Transportation* (California Department of Water Resources et al. 2013). For this study, 114 road segments in the region were analyzed, estimating the baseline speed and the decreases in speed on these road segments that will result from the increase in CM1 construction-related traffic. These projected changes in average speed on each roadway segment were used to estimate the additional time spent on each segment under the BDCP scenario compared to the baseline scenario. The estimated opportunity cost of a traveler's time was then used to convert the travel time delay for each vehicle on area roadways into a travel cost.

Increased traffic might also lead to changes in consumer behavior. For example, if a corridor experiences a high level of traffic, drivers may alter their routes to avoid traffic and reduce overall trip time. Such route changes could affect area businesses, e.g., businesses located on the original travel route may experience a decrease in revenue from customers who have chosen to travel on other routes. Alternately, businesses located on substitute routes might experience increases in sales and revenues due to the increase in customer traffic. These kinds of changes in consumer behavior are difficult to predict and quantify. Although it is possible to estimate the route for any given trip between two points that will have the shortest travel time, it is not possible to predict the changes in sales and revenues for businesses located along the different travel routes.

3.3.3 Baseline Scenario

The transportation delay time model developed for this analysis estimated traffic in the region in the baseline scenario by adding the volume of vehicles in 2012 to the anticipated growth in traffic through 2024 due to predicted population growth in the region. For each roadway segment, the model estimated a baseline LOS based on the observed flow of vehicles. [1] Because the region is expected to grow over the analysis period, the baseline also accounts for the projected population growth and the increases in traffic that will result from this growth. The analysis, however, only estimates the costs of travel delays resulting from CM1 construction (BDCP scenario) and not those related to area population growth.

For the baseline scenario, transportation data from the BDCP EIR/EIS Chapter 19 were used to estimate the volume of cars in 2012 and 2024, accounting for the anticipated increase in traffic on each segment due to population growth. The year 2024 was selected as the comparison year for estimating traffic delays, because it captures both the construction delays and the total expected population growth in the region over the analysis period. To estimate the volume of traffic for 2012 to 2024 under the baseline scenario, a linear increase in the volume of vehicles was assumed each year for each roadway segment included in the analysis. A linear function was used to project the increase volume because growth is based on a constant increase in volume each year due to population growth.[2] By estimating traffic volumes at each segment, the model allowed for different roadway segments to have different expected growth rates, and thus to experience different levels of congestion and reduced travel speeds as a result of CM1 construction. The construction right–of-way is projected for BDCP EIR/EIS Alternative 4 and is subject to change.

3.3.4 Data, Methods, and Assumptions

To estimate the economic impact of travel delays resulting from the construction of CM1, the congested speed that vehicles travel on a congested roadway was defined as a function of the volume of cars, the roadway capacity, and the free-flow speed (Singh 1999):

Congested Speed = (Free-Flow Speed)/(1 + 0.20 [volume / capacity]^10)]

[1] Traffic volumes by roadway segment in the baseline scenario were estimated for years 2008, 2009, 2011, or 2012 depending on the segment and the original data source. Because the baseline scenario does not account for population growth, the volume of traffic in any given year is assumed to be equivalent to the volume in 2012.

[2] This linear increase reflects the increase in volume of vehicles as a function of the increase in population. Under this model, population is projected to grow at a faster rate than the volume of vehicles.

Free-flow speed was assumed to be the typical speed or speed limit for the type of roadway. LOS E (the most congested rating) was assumed for each roadway type to define capacity. Table 3.3-1 presents the assumptions for road capacity and free-flow speed for each roadway type.

Table 3.3-1. Capacity and Free-Flow Speed Assumptions by Roadway Type

Roadway Type	Capacity at LOS E (vehicles per hour)	Free-Flow Speed[a] (miles per hour)
2-lane minor highway	1,740	55
2-lane major highway	2,050	55
4-lane, multilane highway	7,300	55
2-lane arterial	1,870	35
4-lane arterial, undivided	2,890	35
4-lane arterial, divided	3,740	35
6-lane arterial, divided	5,600	35
8-lane arterial, divided	7,470	35
2-lane freeway	4,010	65
2-lane freeway + auxiliary lane	5,035	65
3-lane freeway	6,060	65
3-lane freeway + auxiliary lane	7,100	65
4-lane freeway	8,140	65
5-lane freeway	10,250	65
5-lane freeway + HOV	11,320	65

[a] All freeway segments assume a speed limit of 65 miles per hour (mph) except for I-5 and I-205, which assumed 75 mph based on information from the California Department of Transportation (2013).

LOS = level of service; HOV = high-occupancy vehicle.

The next step for estimating the congested speed was to determine traffic volumes. Data from the BDCP EIR/EIS Chapter 19 on traffic volumes of affected roadways (weekday volume between 6:00 a.m. and 7:00 p.m.) were used to define traffic volumes for three scenarios: the baseline scenario in 2012, the baseline plus growth scenario (which accounts for area population growth through 2024), and the BDCP scenario (which accounts for both population growth and CM1-related travel impacts through 2024). Table 3.3-2 presents data for five of the affected high-volume roadway segments at different roadway types at 7:00 a.m. under the three scenarios. The far-right column shows the resulting impact of CM1 construction on traffic volumes.

Table 3.3-2. LOS Hourly Traffic Volume Threshold and Estimated Traffic Volume at 7:00 A.M. for Example Roadway Segments

				Traffic Volume (number of vehicles)			
Segment	From	To	Roadway Type	Baseline Scenario (2012)	Baseline Plus Growth Scenario (2024) [a]	BDCP Scenario (2024) [b]	BDCP Impact [b] – [a]
SR 4 (Charter Way)	Tracy Boulevard	I-5	4-lane freeway	1,228	1,228	1,800	572
SR 160	Brannan Island Road	SR 12	2-lane minor highway	674	735	1,735	1,000
I-205 eastbound	Grant Line Road	Tracy Boulevard	3-lane freeway	2,075	2,573	2,665	92
Freeport Boulevard (Old SR 160)	Pocket Road	Sacramento City Limits	2-lane arterial	337	391	849	458
Byron Highway	SR 4	Contra Costa/ Alameda County Line	2-lane major highway	818	1,014	1,586	572

SR = State Route; I = Interstate.

The congested speed was estimated for each of the three scenarios for each of the affected roadway segments. The baseline scenario assumes the volume of vehicles in 2009, while the baseline plus growth and the BDCP scenarios assume the volume of vehicles in 2024. Using the estimated volume of traffic by hour (for weekdays between 6:00 a.m. and 7:00 p.m.) and the assumed capacity for each roadway segment, the congested speed was calculated using the formula stated previously. Table 3.3-3 presents the estimated speeds on congested roadways under each of the three scenarios at 7:00 a.m. for the same five roadway segments shown in Table 3.3-2. The far-right column shows the resulting impact of CM1 construction on congestion.

Table 3.3-3. Congested Speeds at 7:00 A.M. for Five Example Roadway Segments

Segment	From	To	Free-Flow Speed	Congested Speed (miles per hour)			
				Baseline Scenario (2012)	Baseline Plus Growth Scenario (2024) [a]	BDCP Scenario (2024) [b]	BDCP Impact [b] – [a]
SR 4 (Charter Way)	Tracy Boulevard	I-5	65	54.66	54.66	42.94	-11.72
SR 160	Brannan Island Road	SR 12	55	55.00	55.00	46.05	-8.95
I-205 eastbound	Grant Line Road	Tracy Boulevard	70	70.00	70.00	70.00	0.00
Freeport Boulevard (Old SR 160)	Pocket Road	Sacramento City Limits	35	35.00	35.00	35.00	0.00
Byron Highway	SR 4	Contra Costa/ Alameda County Line	55	55.00	54.99	54.17	-0.82
SR = State Route; I = Interstate.							

After estimating the congested speed, the time spent by travelers on congested roadways was estimated by dividing the roadway segment length by the congested speed (hours = distance / miles per hour). This step implicitly assumes that each vehicle will be on the roadway segment for the entire length of the segment. Although this assumption might result in an overestimation of time spent on congested roadways, data are not available on how long each vehicle remains on each roadway segment. Because most segments are freeways and highways, and the average segment is relatively short (3.3 miles), this assumption is reasonable. To estimate the construction impacts, the baseline plus population growth estimates for congested travel times on affected roadways were subtracted from the congested travel times for the same roadway segments for the BDCP scenario. The result of this calculation is an estimation of increased time spent traveling solely due to CM1 construction, without including additional congestion that will result from population growth in the area over time. This increased congestion was estimated on a per-weekday basis. Table 3.3-4 presents the time estimates for traveling on the same five affected roadway segments as shown above at 7:00 a.m. for the three scenarios and the resulting impact of CM1 construction.

Table 3.3-4. Congested Travel Times at 7:00 A.M. for Five Example Roadway Segments

Segment	From	To	Free-Flow Speed	Congested Travel Times (minutes per vehicle, per day)			
				Baseline Scenario (2012)	Baseline Plus Growth Scenario (2024) [a]	BDCP Scenario (2024) [b]	BDCP Impact [b] – [a]
SR 4 (Charter Way)	Tracy Boulevard	I-5	65	11.09	11.09	14.11	3.03
SR 160	Brannan Island Road	SR 12	55	3.27	3.27	3.91	0.64
I-205 eastbound	Grant Line Road	Tracy Boulevard	70	7.37	7.37	7.37	0.00
Freeport Boulevard(Old SR 160)	Pocket Road	Sacramento City Limits	35	3.43	3.43	3.43	0.00
Byron Highway	SR 4	Contra Costa/ Alameda County Line	55	4.36	4.36	4.43	0.07
SR = State Route; I = Interstate.							

Table 3.3-5 presents estimates of the additional time due to CM1 construction for the same five roadway segments shown above for the hours between 6:00 a.m. and 10:00 a.m. on weekdays.

To estimate delays due to congestion over the analysis period, we first estimated the total delay time in 2016 to reflect the anticipated start to construction (i.e., delay time per vehicle by the baseline volume of traffic). Next, the delay time in 2024 was estimated by multiplying the delay time volume of traffic in the baseline plus growth scenario, because this total represents the total population of vehicles that will be affected by CM1 construction (Table 3.3-5). Liner interpolation was then used to estimate the annual delay time for years between 2016 and 2024. The per-weekday time was also converted to an annual value by multiplying the per-weekday delay by 5 days per week and 50 work weeks per year. A construction rollout cycle was approximated to account for CM1 construction not occurring at the same rate every year.

Table 3.3-5. Increased Travel Times from 6:00 A.M. to 10:00 A.M. for Five Example Roadway Segments in 2024

Segment	From	To	Increased Travel Time due to CM1 Construction (hours across all vehicles per day)				
			6:00 A.M.	7:00 A.M.	8:00 A.M.	9:00 A.M.	10:00 A.M.
SR 4 (Charter Way)	Tracy Boulevard	I-5	61.92	17.32	8.09	7.04	17.32
SR 160	Brannan Island Road	SR 12	7.79	6.05	4.95	3.95	2.37
I-205 eastbound	Grant Line Road	Tracy Boulevard	0.01	0.00	0.00	0.02	0.03
Freeport Boulevard (Old SR 160)	Pocket Road	Sacramento City Limits	0.00	0.01	0.00	0.00	0.00
Byron Highway	SR 4	Contra Costa/ Alameda County Line	1.12	2.43	0.12	0.04	0.03
SR = State Route; I = Interstate.							

The volume estimates were based on the worst-case scenario for any segment, not the volume on each segment for a given year. Delay time for each year was decreased by the percentage of estimated construction days that year relative to the total number projected construction days. Table 3.3-6 presents the assumed scaling factor used to account for the rollout of CM1 construction for each year.[3]

Table 3.3-7 presents the annual delay times for the example roadway segments shown above from 2016 to 2024.

Table 3.3-6. Percentage of the Overall Construction Project Occurring Each Year

	2016	2017	2018	2019	2020	2021	2022	2023	2024
Percentage of construction completed	23.8%	19.7%	14.5%	12.7%	13.7%	7.6%	6.1%	1.6%	0.3%

[3] These percentages are different than the relative construction emissions shown in BDCP EIR/EIS Chapter 22, *Air Quality and Greenhouse Gas Emissions*. The GHG emissions as reported in the BDCP EIR/EIS include both off-road and on-road vehicles; whereas, this analysis only considers the on-road vehicles. Off-road equipment emissions overwhelm the emission by on-road vehicles, causing the annual impact of GHG emissions to differ considerably from the annual impact of traffic delays.

Table 3.3-7. Total Annual Hourly Delay Times for Example Roadway Segments (hours across all vehicles per year, 2016–2024)

Segment I	2016	2017	2018	2019	2020	2021	2022	2023	2024
SR 4 (Charter Way)	48,534	40,319	29,545	26,027	27,957	15,593	12,388	3,264	614
SR 160	7,112	5,960	4,405	3,914	4,240	2,384	1,910	0	0
I-205 eastbound	761	645	482	433	474	269	218	58	0
Freeport Boulevard (Old SR 160)	3	2	2	2	2	0	0	0	0
Byron Highway	469	397	296	266	290	165	133	36	7
SR = State Route; I = Interstate.									

The total delay time was multiplied by estimates of the opportunity cost of a traveler's time used by the U.S. Department of Transportation (DOT) to assign a monetary value to delay times in regulatory analyses (Belenky 2011). DOT develops and periodically updates the value of travel time to be used in analyses of proposed regulations. This value is widely used by transportation agencies to estimate the time burden of proposed regulations, including those promulgated by DOT, the Transportation Security Administration, and the U.S. Coast Guard. DOT's "all purpose" estimate of the value of time was used in the calculation, which is a weighted average of the value of time for both business and leisure trips based on historical rates of each type of trip. DOT estimates an intercity low value of $16.26 and a high value of $24.40 (2009 dollars inflated to 2012 dollars using the Consumer Price Index). From these two values, a low and high cost to transportation delays was approximated.

3.3.5 Mitigation Strategies

Under baseline conditions (with projected growth), a total of 23 roadway segments would exceed LOS for at least 1 hour during the 6:00 a.m. to 7:00 p.m. analysis period. Construction associated with the BDCP would cause LOS thresholds to be exceeded for at least 1 hour during the 6:00 a.m. to 7:00 p.m. analysis period on a total of 33 roadway segments under the BDCP conditions. The BDCP would therefore increase the number of roadway segments that operate at an unacceptable LOS by 10 (33 minus the 23 that would already be operating at an unacceptable LOS under the baseline plus growth conditions).

Mitigation Measures TRANS-1a through TRANS-1c (BDCP EIR/EIS Chapter 19) aim to reduce the transportation impacts associated with CM1 construction. These measures include requirements to avoid or reduce circulation effects, notify the public of construction activities, provide alternate access routes, require direct haulers to pull over in the event of an emergency, limit/prohibit the amount of construction activity on congested roadways, and enhance roadway conditions. Although TRANS-1a through TRANS-1c would reduce the severity of this effect, the BDCP proponents are not solely responsible for the timing, nature, or complete funding of required improvements. If an improvement that is identified in any mitigation agreement(s) contemplated by Mitigation Measure TRANS-1c is not fully funded and constructed before the project's contribution to the effect is made, an adverse effect in the form of unacceptable LOS would occur. If, however, all improvements required to avoid adverse effects prove to be feasible and any necessary agreements are completed before the project's contribution to the effect is made, effects would not be adverse.

The 33 roadway segments mentioned above represent over 99% of the delays associated with CM1 construction. Successful mitigation would greatly lower the economic cost of transportation delays. Even small reductions in traffic volumes achieved through the mitigation measures could lead to large cost savings in the form of avoided traffic delays. As an example, a study conducted for Sacramento and San Francisco on congestion pricing showed that a 1.7% decrease in trips resulted in a 19.5% reduction in traffic delay times in San Francisco, and a 0.5% reduction in trips resulted in a 6% reduction in traffic delay times in Sacramento (Deakin et al. 1996). Figure 3.3-1 shows the functional relationship between a percent reduction in the volume of vehicles and the resulting percent reduction in delay times on the 33 roadway segments most heavily affected by CM1 construction. As shown in the figure, initially small reductions in the volume of vehicles lead to large reductions in the overall delay time. Mitigation would not alleviate all the anticipated traffic delays on the segments, however, because some delays will still occur even after the mitigation measures are implemented.

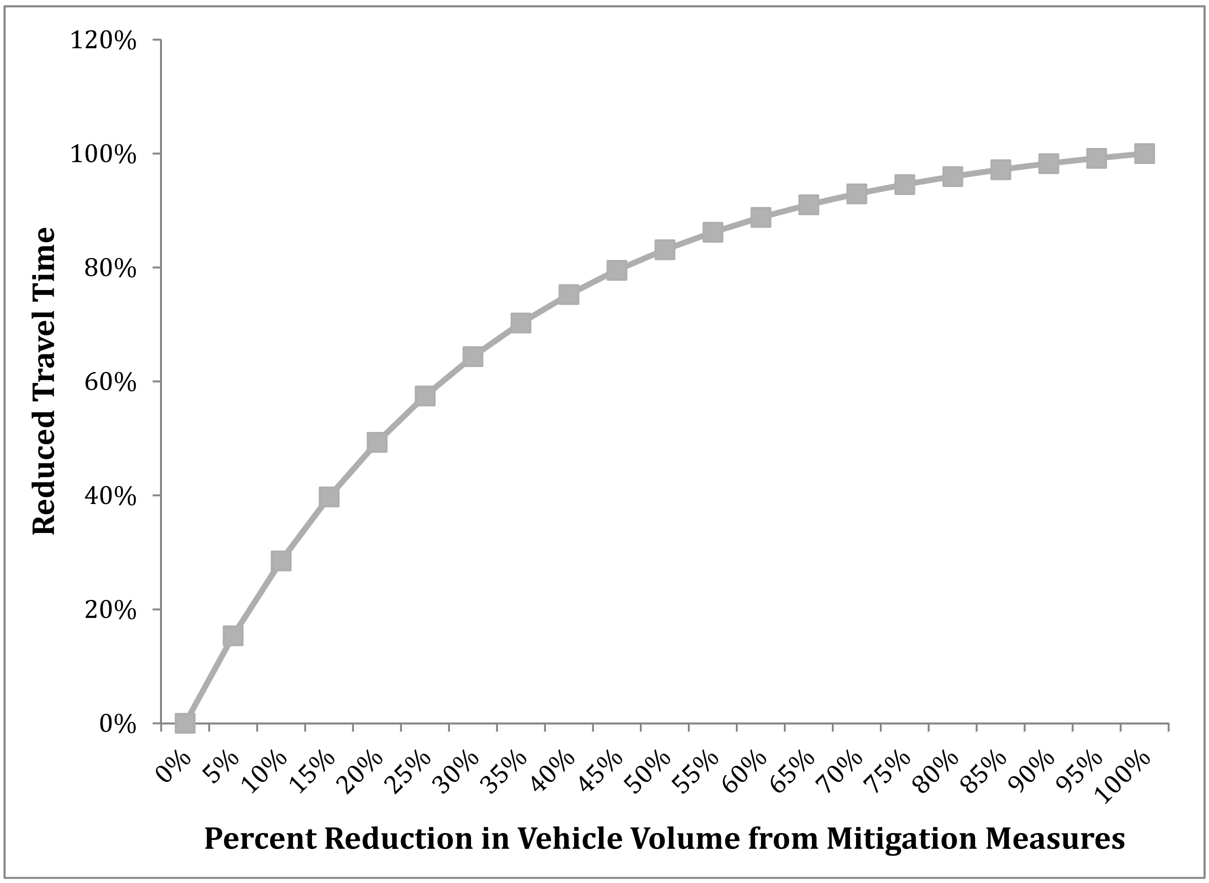


Figure 3.3-1. Potential Reduction of Travel Time Resulting from Mitigation Measures

For every 1% of delay time avoided by the mitigation measures, there is a $0.6 million to $1.0 million cost savings arising from reductions in traffic delays. To estimate the potential mitigation measures, the model assumes a 10% reduction in the volume of vehicles from mitigation with a corresponding 29% reduction in the delay time. Because the success of the mitigation measures is unknown, the 10% is an illustrative example of potential savings from the mitigation measures. In addition, the model assumes that this 10% of volume is removed from the road segments and not deferred to a different route or less busy time of day. Because it is unknown how the mitigation measures will function (e.g., shifting vehicles to alternative routes, time of day changes) the model cannot account for these shifts in traffic. These shifts in traffic will decrease the overall effect of the construction delays on the targeted segments; however, the shift in volume will increase the delay on an alternative segment. Because the alternative segment (or alternative time on the original segment) has a lower LOS, the marginal impact of the dislocated vehicle is smaller on the new roadway than on the original congested roadway. Figure 3.3-2 shows the resulting hours of avoided travel time for each percent reduction in the vehicle volume.

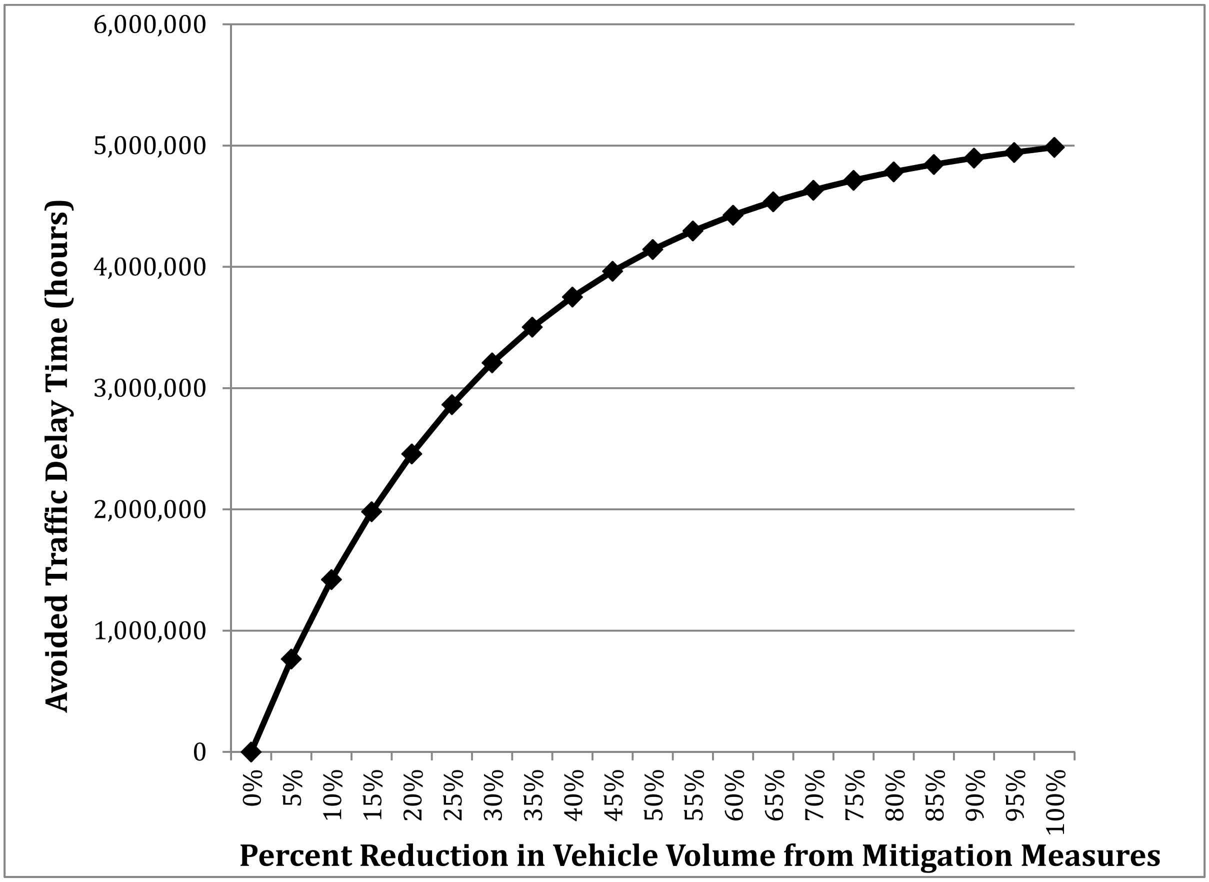


Figure 3.3-2. Potential Avoided Travel Time Resulting from Mitigation Measures

3.3.6 Results

Using the low and high values for the opportunity cost of a traveler's time, a range for the total costs of travel time delays over the period of CM1 construction was calculated. These costs are summarized in Table 3.3-8. The model estimates approximately 4.4 million additional car-hours of traffic delays due to increased traffic from construction of CM1 over its 9-year construction period. These travel delays will result in a total discounted cost to society of between $73.8 million (low estimate) and $110.8 million (high estimate) over the analysis period of 2016 through 2024 with no mitigation measures.[4] The greatest traffic delays, and therefore, the greatest economic cost of these delays, will occur in the first 2 years of construction (2016 and 2017).

Table 3.3-8. Cost of CM1 Construction-Related Travel Time Delays (No Mitigation, Millions $)

Year	Annual Delay per Day (Hours) in Plan Area	Cost ($) of Travel Time Low Estimate[a]	Cost ($) of Travel Time High Estimate[b]	Total Discounted Cost ($)[c] Low Estimate	Total Discounted Cost ($) High Estimate
2016	4,593	18.7	28.0	18.1	27.2
2017	3,903	15.9	23.8	15.0	22.4
2018	2,924	11.9	17.8	10.9	16.3
2019	2,632	10.7	16.1	9.5	14.3
2020	2,887	11.7	17.6	10.1	15.2
2021	1,639	6.7	10.0	5.6	8.4
2022	1,329	5.4	8.1	4.4	6.6
2023	72	0.3	0.4	0.2	0.3
2024	14	0.1	0.1	0.0	0.1
Total		81.3	121.9	73.8	110.8

[a] Assumes the low value of travel time of $16.26 per hour.
[b] Assumes the high value of travel time of $24.40 per hour.
[c] All values are discounted at a 3% rate relative to 2015.

As shown in Figure 3.3-3, delays and their economic costs decline steadily over the course of the analysis period. By 2020, delays will be approximately half those reflected for 2016, and will decrease again by 50% in 2021.

[4] All monetized amounts are discounted at a rate of 3%.

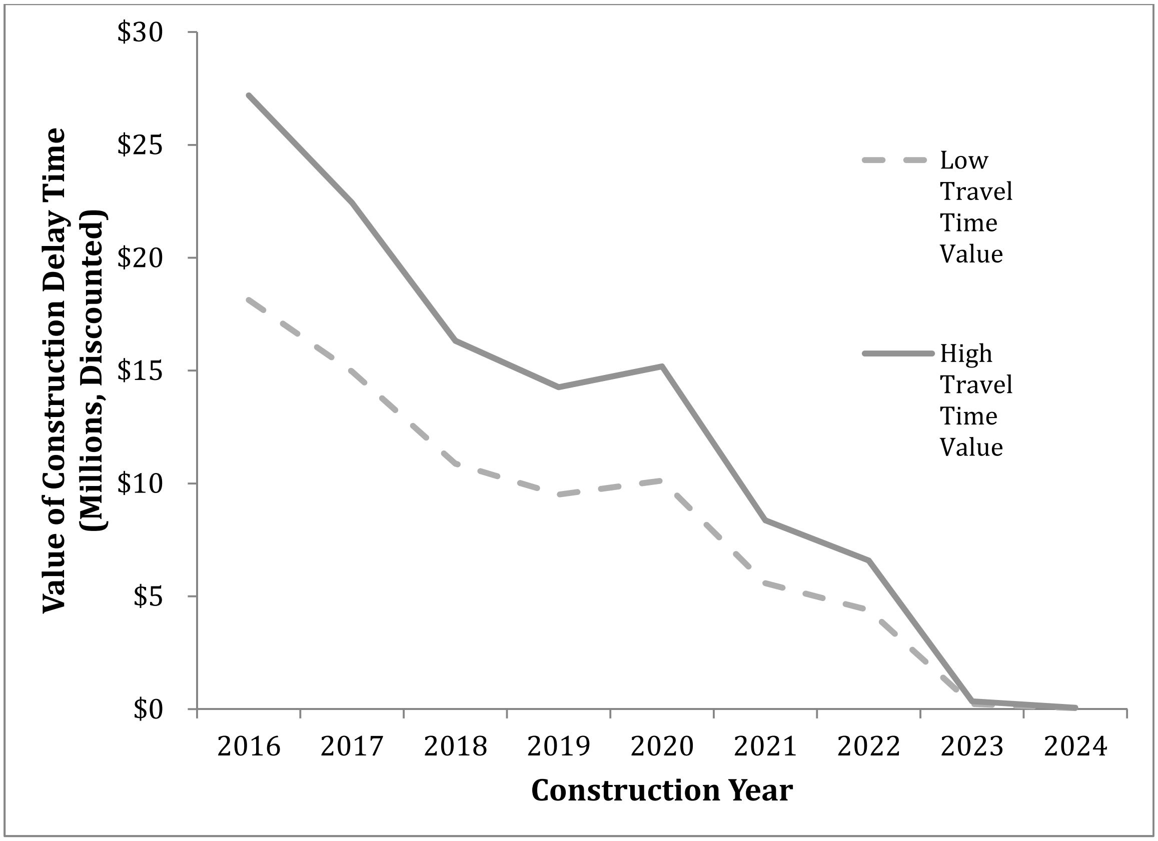


Figure 3.3-3. Cost of CM1 Construction-Related Travel Time Delays

Mitigation measures have the potential to ease the economic impacts of construction-related travel delays, especially in the first years of construction. To estimate the effectiveness of mitigation, the model isolates the segments where mitigation would occur, accounting for over 99% of construction-related delays. Although mitigation measures will not eliminate all transportation delays, they would lessen the overall impact. To estimate the net cost of construction, the model estimates the total delay on affected roadway segments and assumes that the mitigation measures will be able to achieve a 10% reduction in volume and a 29% reduction in overall delay time. Because specific mitigation measures will depend on each segment, and the needs for mitigation on specific segments are unknown at this time, the model does not account for the cost of mitigation. These costs would increase the economic impact of construction-related delays. Table 3.3-9 shows the total construction impacts, construction impacts on the 33 segments with a decrease in LOS, and the cost savings from the mitigation measures if they are able to achieve a 10% reduction in the volume of vehicles.

Table 3.3-9. Cost of Construction Delays, Delays on Mitigated Segments, and Mitigation Savings

	Annual Delay per Day (Hours) in Plan Area	Total Discounted Cost (million $)[a] Low Estimate[b]	Total Discounted Cost (million $) High Estimate[c]
Total construction impacts [a]	4,997,926	$73.8	$110.8
Construction impacts on segments with decreased LOS	4,985,091	$73.7	$110.5
Avoided traffic delays[d] [b]	1,421,677	$21.0	$31.5
Net construction impacts [a] – [b]	3,576,249	$52.8	$79.3

[a] All values are discounted at a 3% rate relative to 2015.
[b] Assumes the low value of travel time of $16.26 per hour.
[c] Assumes the high value of travel time of $24.40 per hour.
[d] Assumes a 10% reduction in the volume of vehicles on mitigated road segments.

3.4 Urban Water Treatment

3.4.1 Introduction

This section evaluates the economic impacts of changes in urban water treatment in the Delta resulting from implementation of the BDCP. Changes to area water quality will result from the operation of the new water conveyance facility (*CM1 Water Facilities and Operation*) and from other conservation measures that would make changes to the physical landscape (CM2 through CM11). While the habitat-focused conservation measures (CM2 through CM11) are expected to improve overall water quality in the Delta through the water filtration services provided by wetlands, tidal wetlands can increase the salinity of the water thereby degrading the overall water quality. The water quality impacts of these conservation measures are not included, because the degree to which water quality benefits or costs from these activities would actually be realized is uncertain.

Even without the BDCP, water quality in the Delta is expected to change as the sea level rises due to climate change and other factors. For this analysis, the BDCP-induced change in water quality was estimated as the difference between water quality conditions under the BDCP (with CM1) and future conditions without the BDCP (*baseline scenario*), both of which account for population growth, climate change, and sea level rise. This section focuses on the changes in concentrations of two key contaminants (bromide and nitrate) and the likelihood of incurring increased or decreased treatment costs.

This section begins with an analysis of the changes in concentrations of key water contaminants resulting from the BDCP. Next, the section describes the current status quo of treatment activities in the Delta and the effect of the change in contaminants on treatment activities.

3.4.2 CM1 Water Facilities and Operation

Data from the BDCP EIR/EIS (California Department of Water Resources et al. 2013) was used to determine the impact of the new water conveyance facility on area water quality. BDCP EIR/EIS Chapter 8, *Water Quality*, estimates the changes in concentrations for bromide, chloride, nitrate, and electrical conductivity that would result from CM1. Only the changes in bromide and nitrate concentrations were included in this analysis, because the other contaminants considered in the BDCP EIR/EIS are not directly tied to adverse health impacts and do not have mandated thresholds for Delta waterways. In addition, changes in salinity (chloride and electrical conductivity) are addressed in Section 3.1, *Salinity of Agriculture Water Supplies*.

Water salinity in the Delta region is commonly measured by the electrical conductivity of water. High levels of electrical conductivity typically correspond to high levels of chloride and bromide. High levels of chloride result in water that has a salty taste, but it is not linked to adverse human health impacts. The U.S. Environmental Protection Agency (2013a) classifies chloride contamination thresholds in its Secondary Drinking Water Regulations along with other undesirable contaminants that do not pose serious health risks.

Bromide and nitrate, however, are directly linked to adverse human health impacts. Bromate occurs when bromide in water reacts with ozone, and continued exposure to bromate has been linked to increased risks of cancer (U.S. Environmental Protection Agency 2012). The EPA includes nitrate in the National Primary Drinking Water Regulations because of its links to increased infant mortality (U.S. Environmental Protection Agency 2013b). To reduce human health risks from water contamination in Delta waters, the CALFED Record of Decision set a bromide target concentration of 50 micrograms per liter (µg/L) (CALFED 2000). The EPA sets a maximum contamination level of 1 milligram per liter (mg/L) of nitrogen for nitrate contamination. To evaluate the economic impacts of the BDCP related to water quality, this analysis focuses on the means by which CM1 will change the concentration levels of bromide and nitrate.

3.4.3 Baseline Scenario

The baseline scenario projects Delta water quality over time in the absence of the BDCP. These estimates account for the projected changes in the demand for water due to increasing populations, and water quality changes associated with climate change and sea level rise.

To characterize the existing water quality conditions in the Delta region, it is important to evaluate the water quality of the primary inflows to and outflows from the Delta. Consequently, the water quality data compiled and described in BDCP EIR/EIS Chapter 8 include monitoring data from the three major rivers in the north (Sacramento, Feather, and American Rivers), the tributaries from the east (Cosumnes, Mokelumne, and Calaveras Rivers), the San Joaquin River from the south (including its major tributaries), San Francisco Bay water from the west, and agricultural runoff in the Delta. Water quality is also characterized at points where water is pumped out of the Delta (e.g., Harvey O. Banks Pumping Plant [Banks Pumping Plant], C. W. "Bill" Jones Pumping Plant [Jones Pumping Plant], Contra Costa Water District Pumping Plant #1 [Contra Costa Pumping Plant], North Bay Aqueduct Pumping Plant [Barker Slough Pumping Plant], and in areas south of the Delta where exported water is conveyed and stored (e.g., the Delta-Mendota Canal, the California Aqueduct, and San Luis Reservoir).[1] Table 3.4-1 shows the concentrations for nitrate and bromide under the baseline scenario.

Table 3.4-1. Water Pollutant Concentrations at Delta Pumping Stations, Baseline Scenario (Late-Long Term Averages, 2025–2060)

Pumping Plant	Nitrate (mg/L-N)	Bromide (µg/L)
Barker Slough	0.27	50
Contra Costa	0.52	432
Banks	0.71	363
Jones	0.96	339
Notes: mg/L-N = milligrams per liter of nitrogen; µg/L = microgams per liter		

3.4.4 CM1 Water Facilities and Operation

Operation of the water conveyance facilities under CM1, including the new north Delta facility, will affect water quality in the Delta. The facility will convey up to 9,000 cubic feet per second (cfs) of water from the north Delta to the south Delta and will include an operable barrier at the head of Old

[1] The relocation of the North Bay Aqueduct intake to the Sacramento River is not included in the water modeling. While operations of this facility are a covered activity, the anticipated effects of this operation were not considered for the purposes of modeling water quality effects at Barker Slough Pumping Plant.

River. Diverted water will be conveyed through pipelines and tunnels from three screened intakes located on the east bank of the Sacramento River between Clarksburg and Walnut Grove. Additionally, CM1 will include a 750-acre intermediate forebay and pumping plant. A new 600-acre Byron Tract Forebay, adjacent to and south of Clifton Court Forebay, will be constructed to provide water to the south Delta pumping plants.

Expected bromide and nitrate concentration levels at the major pumping stations in the Delta were examined because drinking water originating from the Delta comes from these four pumping stations. The change in bromide and nitrate concentrations was defined by subtracting the concentrations in area waters in the baseline scenario from the concentrations in the four operational BDCP scenarios (labeled H1 through H4 in the BDCP EIR/EIS).

The four operational BDCP scenarios are as follows.

- **Scenario H1.** This low-outflow scenario excludes enhanced spring outflow and excludes Fall X2 operations.
- **Scenario H2.** This scenario includes enhanced spring outflow, but excludes Fall X2 operations. This scenario lies within the range of scenarios H1 and H4.
- **Scenario H3.** This evaluated starting operations scenario excludes enhanced spring outflow, but includes Fall X2 operations.
- **Scenario H4.** This high-outflow scenario includes enhanced spring outflow, and includes Fall X2 operations.

A positive change in concentration reflects an increased contamination level, while a negative change in concentration reflects a decreased contamination level. As show in Table 3.4-2, bromide levels increased under all four BDCP scenarios for the Barker Slough Pumping Plant and decreased under all scenarios at the Banks Pumping Plant and the Jones Pumping Plant. For the Contra Costa Pumping Plant, bromide levels increased under the H1 and H2 scenarios and decreased under the H3 and H4 scenarios. As shown in Table 3.4-3, nitrate levels decreased for all of the pumping plants except for the Contra Costa Pumping Plant.

Table 3.4-2. Changes in Bromide Concentration under the BDCP Scenarios Relative to the Baseline Scenario (micrograms per liter)

Pumping Plant	H1	H2	H3	H4
Barker Slough	19	22	12	13
Contra Costa	47	26	-22	-26
Banks	-102	-106	-129	-139
Jones	-94	-114	-115	-122

Table 3.4-3. Changes in Nitrate Concentration under the BDCP Scenarios Relative to the Baseline Scenario (milligrams per liter of nitrogen)

Pumping Plant	H1	H2	H3	H4
Barker Slough	-0.08	-0.08	-0.08	-0.08
Contra Costa	0.10	0.12	0.15	0.18
Banks	-0.22	-0.20	-0.21	-0.20
Jones	-0.25	-0.29	-0.28	-0.31

The changes in concentration would result in large economic costs, if the changes were great enough to alter the behavior of the treatment plants. Treatment plants must adhere to the state and federal standards for contamination levels. Table 3.4-4 shows the average bromide concentration under the BDCP scenarios.

Table 3.4-4. Average Bromide Concentration under the BDCP Scenarios (micrograms per liter)

Pumping Plant	H1	H2	H3	H4
Barker Slough	69	72	62	63
Contra Costa	479	458	410	406
Banks	261	257	234	224
Jones	245	225	224	217

For bromide, the relevant threshold is 50 µg/L. All pumping plants were at or exceeded the threshold under the baseline scenario. Therefore, all pumping plants would treat bromide under the BDCP and baseline scenarios. Because treatment plants are already treating bromide, it is important to consider their current treatment process and if the BDCP-related changes will generate a need for new technology.

Two plants (Baker Slough and Contra Costa) had potential increases in bromide. Currently, plants treat bromide through ozonation. Ozonation is a treatment process that destroys bacteria and microorganisms through the infusion of ozone into the water. The process of ozonation can lower the bromide levels up to 500 µg/L. Because both pumping plants are below the 50 µg/L threshold under the BDCP scenarios, under current practices the plants would not need to purchase new technology and thus would experience little to no cost to treat the increased bromide.

For plants where bromide would decrease, the treatment process will also likely remain unchanged. Ozonation is done to enhance water quality for several factors other than bromide treatment including inactivating viruses and bacteria, reducing of chlorinated disinfection byproducts, and improving taste and odor. At plants where bromide levels would decrease, savings could result from the use of less acid in the ozonation process; however, these cost savings would be minimal, because the process would continue at the lower levels of bromide. The benefit from the lower bromide levels stem from increased water security. Increases in water security result when actions reduce the consequence, threats, or vulnerabilities of the current water system. In terms of water quality, actions that increase water security reduce the expected long-term water treatment costs. Because the BDCP lowers the level of bromide overall, if other events unrelated to the BDCP increased the level of bromide (e.g., a western island levee failure), the BDCP would help mitigate the impact by lowering the status quo level of bromide. Given the uncertainty of unexpected increases in bromide, the study is unable to monetize the water security benefits resulting from the BDCP.

Table 3.4-5 shows average nitrate concentrations under the BDCP scenarios. Because the resulting increases and decreases in nitrate concentrations for each of the four pumping plants are below the 1 mg/L threshold for nitrates, water treatment plants are not expected to increase or decrease treatment compared to the baseline scenario. As with bromide, the BDCP scenario nitrate levels are lower overall. Lower nitrate levels will increase water security. If other events outside the BDCP increase the level of nitrates, the BDCP will have effectively lowered the baseline level of nitrate in the water.

Table 3.4-5. Average Nitrate Concentrations under the BDCP Scenarios (milligrams per liter of nitrogen)

Pumping Plant	H1	H2	H3	H4
Barker Slough	0.19	0.19	0.19	0.19
Contra Costa	0.62	0.64	0.67	0.70
Banks	0.49	0.51	0.50	0.51
Jones	0.71	0.67	0.68	0.65

The BDCP is expected to both increase and decrease levels of bromide and nitrate in the Delta region. For both contaminants, the net effect is a decrease under the BDCP compared to the baseline scenario. As discussed above, increases in the concentration levels of both bromide and nitrate will not change the current practices of treatment plants. The reductions from the BDCP in bromide and nitrate concentrations offer water security benefits for the region, reducing the potential negative economic cost of bromide or nitrate increases in the future. Given the uncertainty of unexpected increases in levels of key contaminants, the study does not monetize the water security benefits.

3.5 Commercial Fisheries

3.5.1 Introduction

This section evaluates the economic impacts of changes in commercial fisheries related to implementation of the BDCP. The BDCP is expected to affect fish populations as a result of construction and operation of the new water conveyance facility (*CM1 Water Facilities and Operation*) and measures that would benefit aquatic habitat (CM2 through CM22). After providing a brief introduction to commercial fisheries in the Delta, this section discusses the impacts of construction and operation of CM1 and the other conservation measures on Delta commercial fisheries. Finally, the section presents the potential impacts of the BDCP on affected commercially fished species by comparing projected populations under the BDCP to the baseline scenario. Although the Delta is home to many fish species, fall-run Chinook salmon is the only major commercial fish species[1]. Other prevalent fish found in the Delta, such as sturgeon and bass, do not have commercial fisheries, but are a main attraction for sports anglers. Chinook salmon migrate to the Pacific Ocean as juveniles, where they grow into adults. Some of these adults are then harvested by commercial fisheries. In recent years, oceanic conditions, among other factors, have negatively affected the Chinook salmon population. The issue was serious enough that the Pacific Fishery Management Council (PFMC) canceled the commercial seasons in 2008 and 2009, and only opened the season for 8 days in 2010 (Brickman 2011). Recently, the Chinook salmon fisheries have been reopened. In addition to Chinook salmon, the California Department of Fish and Wildlife (CDFW) reports commercial landings of threadfin shad and crayfish at Delta ports (California Department of Fish and Game 2012). A California bay shrimp fishery is also located in the Delta, although it is very small.[2] California bay shrimp is primarily used as baitfish, and no recent landings have been recorded by CDFW (California Department of Fish and Game 2012). Therefore, California bay shrimp is not included in this assessment.

Three affected commercial fish species (Chinook salmon, threadfin shad, and crayfish) were selected for analysis. Chinook salmon was selected because of its importance to the local fishing economy and the availability of data on its population in the surrounding area. Threadfin shad and crayfish were selected because of available data on commercial landings in Delta ports. This assessment describes the expected impacts on commercial fish species from the BDCP qualitatively. Although a preliminary quantitative analysis has been performed, its findings are not published in this section because of the amount of uncertainty in both the analysis inputs and results. This section limits its discussion of commercial fisheries to a quantitative description of historical trends and a qualitative assessment of the impacts from the BDCP.

[1] Based on data of commercial landings at Delta ports from the Pacific Fishery Management Council (2012) and the California Department of Fish and Wildlife (California Department of Fish and Game 2011).

[2] The historical fishery of California bay shrimp peaked in 1935 at 3.4 million pounds then declined substantially to near-collapse by 1964, when there were no landings. From 1985 to 1999, landings averaged 120,000 pounds (with a range of 75,000 to 150,000 pounds) (California Department of Fish and Game 2001).

3.5.2 CM1 Water Facilities and Operation—Construction

Construction of the new water conveyance facility under CM1 will affect environmental conditions in the Sacramento River where intakes will be constructed, and at several locations in the Delta where barge unloading facilities will be constructed Construction of CM1 could affect fish through temporary changes in water quality (e.g., turbidity and accidental spills); exposure to construction-related noise (e.g., pile driving); direct physical injury during construction; and temporary and permanent changes in rearing habitat area, migration habitat conditions, and predation.

The area of the Sacramento River that will be affected by construction of the intakes is primarily a migratory corridor for adult salmon returning to upriver spawning habitat and juvenile salmon outmigrating from upriver habitats to the ocean. Table 3.5-1 presents the adult and juvenile Chinook salmon migrations that pass the intake locations in the lower Sacramento River. The main in-water construction activities at the proposed north Delta intakes will be limited to one construction season from June through October (BDCP Appendix 5.H, *Aquatic Construction and Maintenance Effects* [California Department of Water Resources 2013]). Based on the timing of Chinook salmon migrations in the lower Sacramento River, as shown in Table 3.5-1, the BDCP in-water construction will avoid peak-period migrations of all Chinook salmon except for spring-run adults in June. In-water construction, however, will overlap with early (late fall–run) or late (spring-run) upriver migrants, or with late-emigrating juveniles. The seasonality of construction is intended to minimize these adverse effects. Any Chinook salmon present during in-water work may experience adverse effects from underwater sound (pile driving), entrapment within enclosed areas (e.g., cofferdams), exposure to temporary water quality deterioration (e.g., suspended sediment, suspension of toxic materials), and accidental spills. Temporary and permanent changes to habitat involve generally low-quality habitat along existing leveed banks (BDCP Appendix 5.H, Section 5.H.6.1.4). Maintenance dredging also may decrease water quality temporarily.

Despite this potential for disruption, the number of Chinook salmon potentially migrating past the intakes during the in-water construction window will be small when compared to the overall Chinook salmon population. As described in BDCP Appendix 5.H, the impact from construction of intakes on covered fish populations would be negligible, because construction will not overlap with sensitive migration periods, and in-water construction will be relatively brief (5 months).

Table 3.5-1. Periods of Adult and Juvenile Chinook Salmon Migrating Past Intake Locations in the Lower Sacramento River

Chinook Salmon		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter-run	Adult			Peak									
	Juveniles	Peak											Peak
Spring-run	Adult					Peak							
	Juveniles	Peak										Peak	
Fall-run	Adult											Peak	
	Juveniles			Peak									
Late Fall–run	Adult		Peak										
	Juveniles			Peak									

In general, CM1 construction is not expected to affect the quality or quantity of upstream habitat conditions for threadfin shad. The potential increase in turbidity from construction is considered less than significant because of the short duration of in-water construction activities (one season) and the implementation of stormwater best management practices and stormwater pollution prevention plans. Therefore, threadfin shad will not be affected by construction of the new water conveyance facility. Similarly, construction effects on crayfish are expected to be very small, because direct impacts would be highly localized (activities would affect only a very small part of the species' range), effects will be temporary, and crayfish have a relatively high tolerance to increases in suspended sediment (i.e., higher turbidity).

3.5.3 CM1 Water Facilities and Operation—Operation

This section only addresses Chinook salmon, because it experiences the most significant effects from CM1 operations. The BDCP EIR/EIS anticipates that CM1 operations will have a positive effect on threadfin shad through reduced entrainment. The BDCP EIR/EIS does not address impacts on crayfish; effects on this population are thus unknown.

3.5.3.1 Effects on Entrainment of Chinook Salmon

CM1 operations would result in reduced entrainment losses at the south Delta facilities (approximately 44% reduction, or 24,000 less fall-run Chinook salmon entrained per year, based on the salvage density calculation method). While entrainment would be reduced in all water-year types, the reduction is driven largely by substantial decreases in wetter years when more export pumping shifts to the north Delta intakes. The north Delta intakes would be screened and are not expected to result in entrainment of Chinook salmon, although impingement, predation, and other localized effects could occur. These losses are not expected to exceed 5% of the population, and several measures included in the BDCP are meant to minimize such effects. Overall, the BDCP would have a positive effect on Chinook salmon relative to entrainment. For more details, see BDCP Appendix 5.B, *Entrainment*.

3.5.3.2 Effects on Spawning Habitat for Chinook Salmon

Overall, the BDCP would have no major effects related to flow or water temperature on fall-run Chinook salmon spawning and egg incubation. In the Sacramento River, there would be a moderate increase in spawning habitat availability from increased flows during the spawning period, although there would be a small increase in the risk of redd scour from wider fluctuations in flow rates. The combination of these changes is not expected to affect fall-run Chinook salmon at a population level. This finding is further corroborated by similarities in juvenile production in the Sacramento River as predicted by the model SALMOD. In addition, National Marine Fisheries Service (NMFS) flow and water temperature threshold criteria for the Sacramento River (National Marine Fisheries Service 2009a, 2009b) would be met under the BDCP at the end of the permit term at similar frequencies to those under future conditions without the BDCP.

In the Feather River, fall-run Chinook salmon spawn and rear in both high- and low-flow channels of the river. The BDCP would generally have no effect on fall-run Chinook salmon spawning and egg incubation and adult migration and holding. In the American River, the BDCP would have no effects related to flow water temperature on fall-run Chinook salmon spawning and egg incubation or juvenile migration. Similarly, the BDCP would have no effects on fall-run Chinook salmon spawning and egg incubation in the Trinity River or Clear Creek related to flow or water temperature. For more details, see BDCP Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*.

3.5.3.3 Effects on Rearing Habitat for Chinook Salmon

Overall, upstream rearing habitat would not change substantially under the BDCP. However, in the Sacramento River, a reduction in juvenile rearing habitat area, as predicted by the model SacEFT, would have small negative effects on juvenile rearing habitat. Combined with the moderate benefits to rearing habitat in the Feather and American Rivers, as described below, the BDCP could have a small benefit for juvenile Chinook salmon.

In the Feather River, flows under the BDCP during the latter half of the fry and juvenile rearing period would be substantially higher (up to 79%) in the high-flow channel and similar the rest of the period. In addition, there would be small increases in flows in the high-flow channel during the juvenile migration period. There would be no differences in flows in the low-flow channel throughout the fry and juvenile rearing period. Collectively, these results indicate a moderate benefit to fall-run Chinook salmon juveniles rearing in the Feather River. There would be no differences in water temperatures during any fall-run Chinook salmon life stage. Further, NMFS flow and water temperature threshold criteria for the Feather River (National Marine Fisheries Service 2009a, 2009b, 2012) would be met under the BDCP at the end of the permit term at similar frequencies to those under future conditions without the BDCP.

In the American River, the BDCP would have small to moderate increases in flows during some months of the fry and juvenile rearing period, resulting in a small benefit to fall-run Chinook salmon. The BDCP would have no effects related to flow or water temperature on fall-run Chinook salmon fry and juvenile rearing in the Trinity River or Clear Creek. For more details, see BDCP Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*.

3.5.3.4 Effects on Migration Conditions for Chinook Salmon

In the Sacramento and Feather Rivers, the BDCP would have no effect on fall-run Chinook salmon juvenile and adult migration. In the American River, there would be moderate reductions in flows during the September through October adult migration period, although no relationships have been developed that quantify the attraction of adult fall-run Chinook salmon and flows in the lower American River. NMFS (2009a, 2009b) flow threshold criteria for the American River would be met at a 7 to 10% greater frequency in dry and critical water years under the BDCP at the end of the permit term than under future conditions without the BDCP, suggesting a small benefit of the BDCP on American River flows in these years. Further, NMFS (2009a, 2009b) water temperature threshold criteria for the American River would be met under the BDCP at the end of the permit term at similar frequencies to those under future conditions without the BDCP. The BDCP would have no effects on fall-run Chinook salmon juvenile and adult migration in the Trinity River, Stanislaus River, San Joaquin River, or Clear Creek. Collectively, these results indicate that there would be little or no change in migration conditions for Chinook salmon outside the Plan Area.

Within the Delta, CM1 operations would positively affect flow patterns that currently draw water from the north to the south by providing a more natural seaward flow from east (Sacramento and San Joaquin Rivers) to west (San Francisco Bay). The shift in flow pattern would improve the flows in Old and Middle Rivers by reducing the magnitude of reverse (towards south Delta) flows. These changes in flow patterns coincide with the seasonal period of migration of Chinook salmon through the Delta channels. These improved downstream flows provide substantial benefits to covered salmonids, especially San Joaquin River Chinook. Movement of Chinook salmon into the interior Delta would be reduced, resulting in substantial reductions in entrainment (as described above) and reductions in other adverse effects such as predation. However, reduced Sacramento River flows downstream of the new intakes would slightly decrease the olfactory cues for migrating salmon in the Sacramento River and slightly increase the olfactory cues of the San Joaquin River. For more details, see BDCP Appendix 5.C, *Flow, Passage, Salinity, and Turbidity*.

3.5.3.5 Overall Summary

Overall, the effects of CM1 operations would benefit fall-run Chinook salmon through substantial reductions in entrainment, improved San Joaquin River and Delta flow conditions, and neutral or positive changes in upstream conditions.

3.5.4 Other Conservation Measures

The other conservation measures (CM2 through CM22) include actions to protect, restore, and enhance natural communities such as floodplains, channel margins, and riparian woodlands in the Plan Area. These measures, as described in BDCP Chapter 3, Section 3.4, *Conservation Measures*, will benefit Chinook salmon by increasing amounts and quality of available habitat, habitat diversity, and overall productivity. These net benefits to Chinook salmon of all runs are described in BDCP Chapter 5, *Effects Analysis* (Sections 5.5.3, 5.5.4, and 5.5.5). Five conservation measures are responsible for most of the expected benefit to Chinook salmon throughout the Delta. These five conservation measures and their expected benefits are described below.

According to the BDCP EIR/EIS, construction associated with habitat restoration is not expected to have an adverse impact on threadfin shad (California Department of Water Resources 2013: Chapter 1, Part I, 11–379). Although habitat restoration may increase turbidity, the adverse impact will not be substantial to the point where additional mitigation measures are needed. Therefore, negative impacts on threadfin shad from the other conservation measures are not anticipated.

3.5.4.1 CM2 Yolo Bypass Fisheries Enhancement

CM2 Yolo Bypass Fisheries Enhancement is likely to substantially benefit Chinook salmon, both during their juvenile rearing period and their adult migration period.

CM2 modifications are designed to increase the frequency, duration, and magnitude of seasonal floodplain inundation in the Yolo Bypass. Increased frequency of inundation will enhance the existing connectivity between the Sacramento River and the Yolo Bypass floodplain habitat, result in the increased mobilization of organic material and the primary and secondary aquatic productivity, and provide additional shallow-water rearing habitat for juvenile Chinook salmon. Juvenile Chinook salmon that use this migratory route are expected to be larger than their counterparts that use the Sacramento River because of the increased availability of food, the additional time they spend on the floodplain, and the reduced threat of predators as compared to the Sacramento River. Juvenile Chinook salmon that use the Yolo Bypass also avoid the adverse effects of the north Delta intakes (impingement, predation, and other localized effects). As such, this conservation measure is being designed to maximize the number of Chinook salmon that enter the Yolo Bypass for rearing to provide as much benefit as possible. Additionally, adult Chinook salmon migrating through the Delta to spawn in upstream habitats would experience reduced migratory delays. For more details, see BDCP Appendix 5.E, *Habitat Restoration*, and Appendix 5.F, *Biological Stressors on Covered Fish*.

3.5.4.2 CM4 Tidal Natural Communities Restoration

CM4 Tidal Natural Communities Restoration will create an additional 55,000 acres of tidal natural communities in the Suisun Marsh, West Delta, South Delta, Cache Slough, and Cosumnes/Mokelmne restoration opportunity areas (ROAs). Habitat Suitability Analysis indicates that tidal wetland restoration under the BDCP will provide substantial increases in available habitat suitable for juvenile foraging and migrating Chinook salmon compared to existing conditions. The most relevant tidal habitat for assessing changes for fall-run and late fall–run Chinook salmon juveniles is found in the Cache Slough, North Delta, West Delta, Suisun Bay, and Suisun Marsh subregions. Habitat Suitability Index modeling (BDCP Appendix 5.E, *Habitat Restoration,* Section 5.E.4.2.4.4) indicates that tidal habitat in these subregions was estimated to change from just over 30,000 habitat units (HUs) under existing conditions to over 50,000 HUs under the BDCP by the end of the permit term (i.e., a 67% increase), with much of the change being driven by restoration in the Cache Slough and Suisun Marsh ROAs and to a lesser extent in the West Delta ROA. Tidal habitat in those subregions most relevant to fall-run/late fall–run Chinook salmon migrants was estimated at around 50,000 HUs under existing conditions and nearly 65,000 HUs under the BDCP by the end of the permit term, a relative increase of 30%. As such, Chinook salmon, especially foraging individuals, are likely to benefit from tidal wetland restoration, even when considering the many uncertainties related to predation, food availability, habitat structure, and invasive aquatic vegetation that may be associated with the restored areas. For more details, see BDCP Appendix 5.E, *Habitat Restoration.*

3.5.4.3 CM5 Seasonally Inundated Floodplain Restoration

Habitat conditions during juvenile rearing, including access to low-velocity, shallow-water habitat with few predators and abundant food supplies, are important for juvenile growth and survival. Floodplain restoration under the BDCP (*CM5 Seasonally Inundated Floodplain Restoration*) is intended to increase the suitable rearing habitat for juvenile salmonids within the south Delta subregion of the Plan Area by creating an additional 10,000 acres of seasonally inundated floodplains. These new floodplains would be created along key migration routes for salmon, which is intended to increase their through-Delta survival. Seasonally inundated floodplains are expected to provide suitable rearing conditions (i.e., suitable water depths, cover from predators, food), as well as improve migration corridors. For more details, see BDCP Appendix 5.E, *Habitat Restoration.*

3.5.4.4 CM6 Channel Margin Enhancement

CM6 Channel Margin Enhancement will enhance 20 miles of channel margin to provide rearing and outmigration habitat for juvenile salmonids. These channels include the Sacramento River between Freeport and Walnut Grove, and Steamboat and Sutter Sloughs. The affinity of Chinook salmon fry for channel margins is particularly high, and such enhancements will provide important refuge from high flows, and overhead and instream cover for protection from predators. Expanded nearshore habitat with improved inputs of terrestrial organic matter, insects, and woody material, as well as riparian shade and underwater cover, also will increase the quality of Chinook salmon rearing habitat in the Plan Area, channel margin habitat in the vicinity of the resting spots, and refuge for Chinook salmon moving through this area.

CM6 will increase habitat along important juvenile salmonid migration routes; consequently, it will improve connectivity between patches of higher-value habitats, a beneficial effect. This is particularly necessary for reaches that have very low existing habitat quality and are heavily used by salmonids, for example, the Sacramento River between Freeport and Georgiana Slough. The efficacy of the measure may depend on the lengths of enhanced channel margin habitat and the distance between enhanced areas; that is, there may be a tradeoff between enhancing multiple shorter reaches that have less distance between them and enhancing relatively few longer channel margin habitats with greater distances between them.

In addition to the multiple benefits identified above for enhancing channel margins, there is also the potential for negative effects. Any increase in the amount of time that Chinook salmon occupy these restored habitats may increase exposure to toxins sequestered in shallow-water sediments. However, the potential for effects is expected to be minimal because of the relatively short period Chinook salmon would spend in these areas. Channel margin enhancements also have the potential to provide habitat for nonnative predator species, which could increase the predation rates on Chinook salmon. Monitoring of bank protection projects and other future studies will inform site designs to limit the potential increase in such nonnative predator fish species. Overall, the effect of channel margin enhancement is expected to be beneficial for Chinook salmon. For more details, see BDCP Appendix 5.E, *Habitat Restoration.*

3.5.4.5 CM7 Riparian Natural Community Restoration

CM7 Riparian Natural Community Restoration will restore 5,000 acres of riparian natural community in the Plan Area. CM7 is intended to restore the riparian habitat within the context of flood control objectives and managed upstream hydrology to provide direct and indirect benefits to aquatic and terrestrial species along important migration corridors. Riparian restoration will increase instream cover through contributions of woody material derived from riparian forest. Downed wood provides structural complexity important for resting and refuge sites used by Chinook salmon, and will contribute to creation of shaded refugia. The overall benefit of these positive effects would depend on the extent to which restored riparian areas are allowed to undergo natural processes such as bank erosion, which would facilitate formation of undercut banks and introduction of complex structure into water bodies.

Chinook salmon would also benefit from contributions of the riparian community to the aquatic foodweb, in the form of terrestrial insects and leaf litter that enter the water, thereby increasing production of zooplankton and macroinvertebrates that provide food for Chinook salmon. Riparian vegetation also supports the formation of steep, undercut banks that provide cover for Chinook salmon. The increased habitat complexity provided by riparian restoration is expected to be beneficial to Chinook salmon. For more details, see BDCP Appendix 5.E, *Habitat Restoration.*

3.5.4.6 Overall Summary

The effects of floodplain, tidal, channel margin, and riparian habitat restoration activities on Chinook salmon are expected to be beneficial, providing net increases in amounts and quality of available habitat, increasing habitat diversity, increasing overall productivity, and reducing predation. In addition, besides providing increased habitat, Yolo Bypass enhancements would also reduce migratory delays and loss of adult salmon and improve overall passage conditions.

Even with these improvements in habitat and habitat functions in the Plan Area, habitat quality is expected to be tempered by the adverse effects of climate change expected near the end of the permit term. However, the overall effect of these conservation measures is expected to remain beneficial for fall-run Chinook salmon.

3.5.5 Baseline Scenario

The baseline conditions of the three affected commercial fisheries are described in this section.

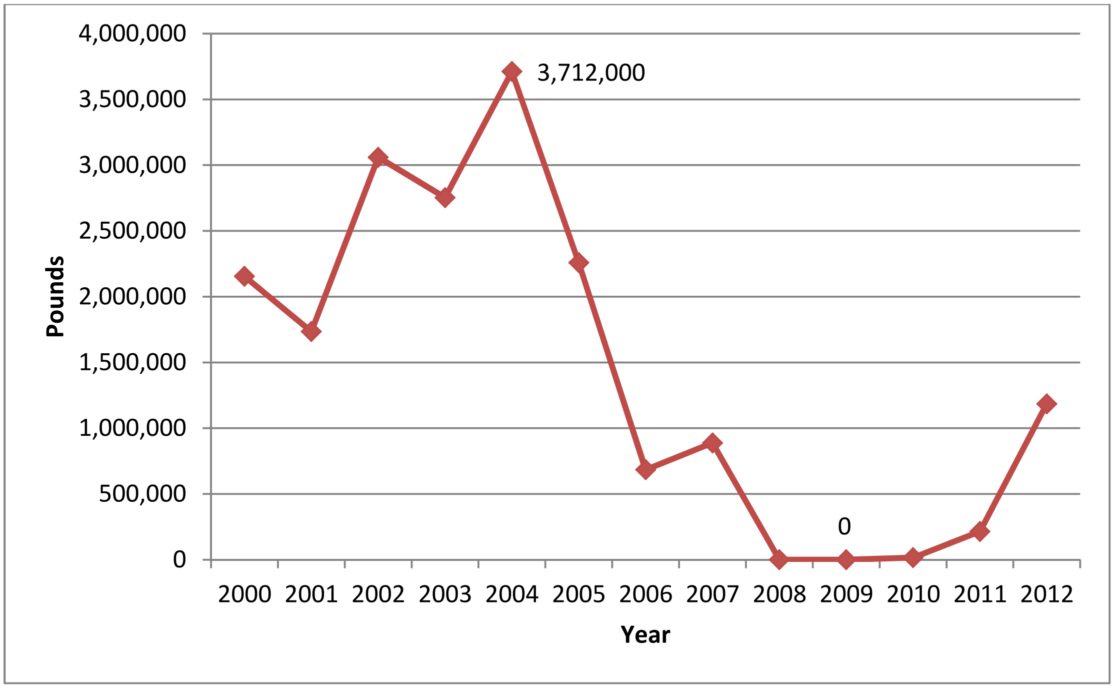
3.5.5.1 Chinook Salmon

The Chinook salmon fishery is an important commercial fishery along the Pacific Coast. However, the population of Chinook salmon has been declining in recent years. Decisions to cancel or curtail the fishing seasons, as described in Section 3.5.1, *Introduction,* were due in large part to record low numbers of Chinook salmon returning to California's Central Valley in 2008 as a result of poor ocean conditions (Lindley et al. 2007).

The Sacramento Chinook salmon run is usually one of the most productive on the coast (Gordon 2008). The closest major port to the Delta, San Francisco, has accounted for an average of 47% of California's Chinook salmon landings since 2000. Because the salmon is classified as a special-status species, fish management is a major factor to the industry, and the numbers of landings and harvest have been limited to avoid take of winter-run and spring-run Chinook salmon. According to PFMC (2012:92), the average price per pound for Chinook salmon in California was $5.17 in 2012.

Figure 3.5-1 charts the quantity of landings of Chinook salmon for the Port of San Francisco, as measured in dressed pounds.[3] Commercial Chinook salmon landings have declined since 2004, when commercial landings were 3.7 million pounds; no landings were recorded in 2008 and 2009. Based on this data, the compounded annual decline in landings from 2000 (2.2 million pounds) to 2012 (1.4 million pounds) was 4.86%. The compounded growth rate is for number of landings and takes into account exogenous factors such as harvest regulations and fuel prices.

[3] Total weight of catch after fish have been cleaned.

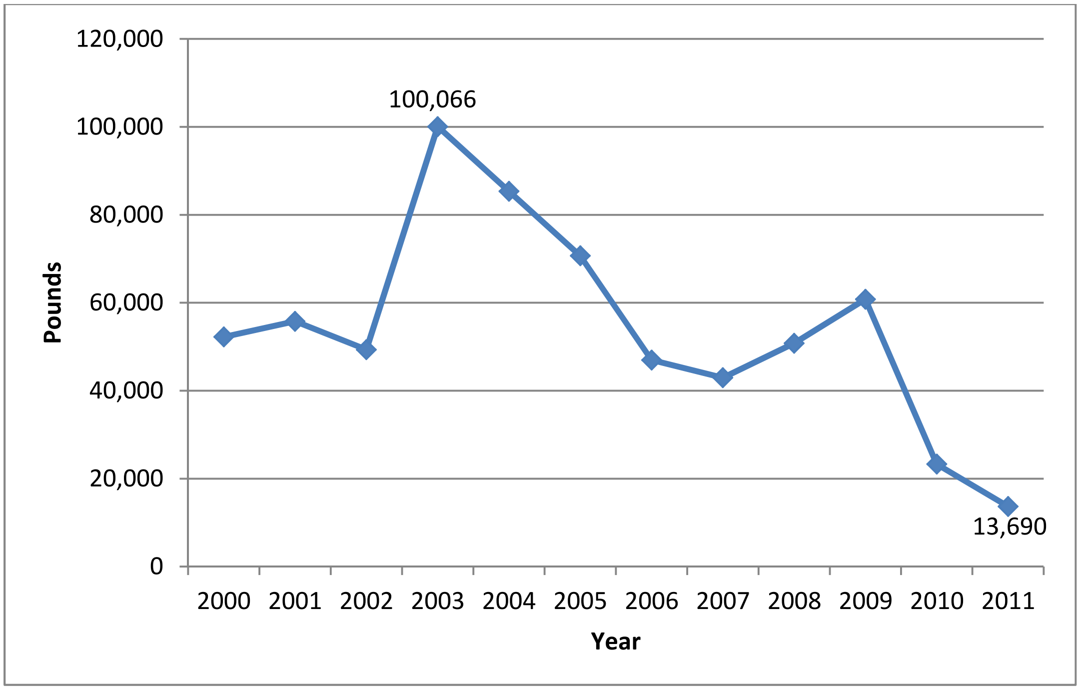


Source: Pacific Fishery Management Council 2012: Appendix A.

Figure 3.5-1. Historical Chinook Salmon Landings at Port of San Francisco

3.5.5.2 Threadfin Shad

Threadfin shad is a nonnative species and is used mostly as baitfish. It had an average landing of 54,336 pounds per year over the 11 years recorded at the Sacramento River ports. Like most pelagic fish in the Delta, threadfin shad has shown substantial variability in population, but there has been a steady decline since 2000. Figure 3.5-2 charts the quantity of landings of threadfin shad for all Delta ports, as measured in pounds. Commercial threadfin shad landings have declined since 2003, when commercial landings were 100,066 pounds; landings were 13,690 pounds in 2011. The compounded annual decline in landings from 2000 (52,241 pounds) to 2011 (13,690 pounds) is 11.46%. The compounded growth rate is for number of landings and takes into account exogenous factors such as harvest regulations and fuel prices.

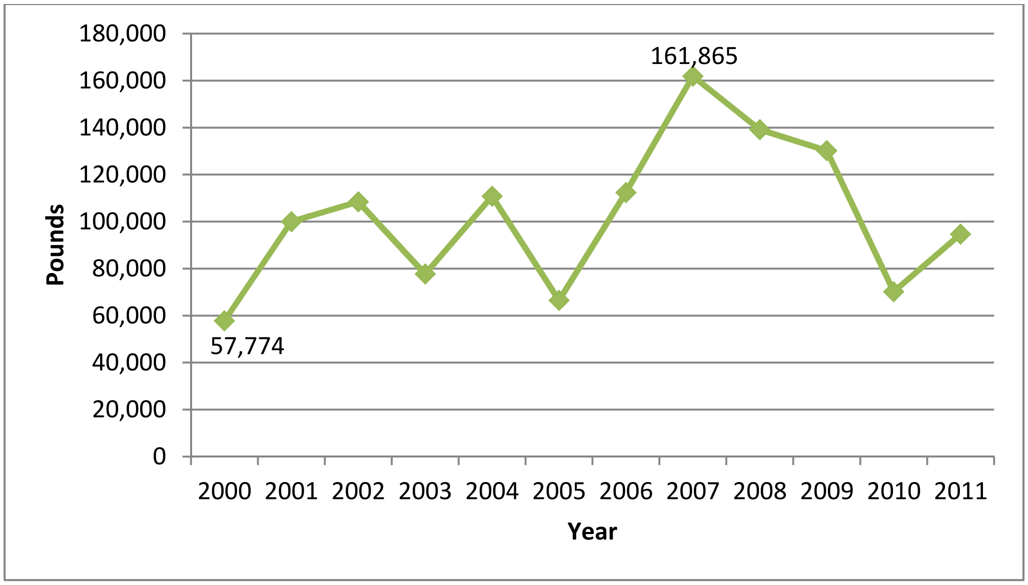


Source: California Department of Fish and Game 2011.

Figure 3.5-2. Historical Threadfin Shad Landings at Delta Ports

3.5.5.3 Crayfish

Crayfish, a nonnative fish species, is included in this analysis, because it yields the second largest amount of commercial landings. Figure 3.5-3 charts the quantity of landings of crayfish for all Delta ports. Crayfish has an average landing of 102,465 pounds per year over the 11 years recorded at the Sacramento River ports. Although commercial landings peaked significantly in 2007, no significant long-term trend is noted. In 2007, commercial landings were 161,865 pounds; landings were 57,774 pounds in 2000. The compounded annual growth rate of landings from 2000 (57,774 pounds) to 2011 (94,679 pounds) is 4.59%. The compounded growth rate is for number of landings and takes into account exogenous factors such as harvest regulations and fuel prices.



Source: California Department of Fish and Game 2011.

Figure 3.5-3. Historical Crayfish Landings for Bay Delta Ports

3.5.6 BDCP Scenario

The impacts of the BDCP on the three commercial fishery populations analyzed in this report are described in this section qualitatively.

3.5.6.1 Chinook Salmon

An important goal of the fish and wildlife purposes of the Central Valley Project Improvement Act is to restore natural populations of anadromous fish (such as Chinook salmon) in Central Valley rivers and streams in order to double their recent average abundance levels. The Anadromous Fish Restoration Program strives to achieve this goal by directing the Secretary of the Interior to develop and implement a program to ensure the sustainability of anadromous fish in the Central Valley rivers and streams. As part of this goal, the BDCP sets a biological objective for each run of Chinook salmon (BDCP Chapter 3, Section 3.3, *Biological Goals and Objectives*).

Table 3.5-2 lists the biological objectives in the BDCP that call for the increase in salmon survival through the Delta from a variety of conservation measures and avoidance and minimization measures. These changes in survival range from a 2 to 4% increase in absolute survival rates (for fall-run Chinook salmon on the Sacramento River) to an absolute increase of 33 to 38% for spring-run Chinook salmon on the San Joaquin River. The effects of these increases in survivorship on the population size of Chinook salmon in both the Sacramento River and San Joaquin River systems are expected to be positive. However, the magnitude of those positive impacts on population size are unknown because of the variety of other factors influencing Chinook salmon population size, both within and outside the Plan Area (e.g., availability and quality of spawning habitat upstream, predation, commercial harvest rates, habitat restoration, ocean conditions, and recreational harvest).

Table 3.5-2. BDCP Biological Objectives for Chinook Salmon Survival through the Delta, by Species Run, and Year

Salmon Run and Estimated Current Through-Delta Survival	Delta Interim Survival Objective by Year[a]	Notes
Fall-run (San Joaquin River) Current estimate = 5%	27% by year 19 29% by year 28 31% by year 40	Achieved by the BDCP and other actions in the Delta. The BDCP is responsible for the majority of these gains.
Fall-run (Sacramento River) Current estimate = 40%	42% by year 19 44% by year 28 46% by year 40	Same as above
Late fall–run (Sacramento River) Current estimate = 40%	49% by year 19 51% by year 28 53% by year 40	Same as above

[a] 5-year geometric mean interim through-Delta survival objectives, as measured on the Sacramento River between Knights Landing and Chipps Island and on the San Joaquin River between Mossdale and Chipps Island (California Department of Water Resources 2013: Section 3.3.4, *Species Biological Goals and Objectives*).

3.5.6.2 Threadfin Shad

According to the BDCP EIR/EIS (California Department of Water Resources et al. 2013), BDCP construction activities associated with CM1 and other conservation measures will not have a significant negative impact on the threadfin shad population. However, habitat restoration will have a positive effect on many of the game fish in the Delta. This is expected to result in an increase in commercial fishing activity and the increased use of threadfin shad as baitfish. However, because of the high uncertainties associated with the population of threadfin shad in the Delta, this benefit cannot be quantified and monetized.

3.5.6.3 Crayfish

The impacts of the BDCP on the Delta crayfish population are unknown due to a lack of data. Therefore, the economic impacts of BDCP on this fishery in the Delta cannot be quantified.

3.5.7 Conclusion

Although the Delta is home to many fish species, fall-run Chinook salmon is the major species harvested commercially. The BDCP will affect Chinook salmon through several conservation measures that include restoring and enhancing natural communities such as floodplains, channel margin, and riparian woodlands in the Delta. These measures are expected to increase the survival rates of fall-run Chinook salmon in both the Sacramento and San Joaquin Rivers over the next 40 years and, in turn, increase the number of salmon harvested off the Pacific coast. These conservation measures are also expected to affect smaller Delta commercial fisheries, such as threadfin shad, crayfish, and California bay shrimp. The overall impacts of the BDCP on Delta commercial fisheries are expected to be positive to both the population and commercial landings for these species. Due to exogenous oceanic conditions and other factors inside and outside the Delta, however, there is a high level of uncertainty involved in forecasting salmon populations over time. Thus, this study was not able to quantify and monetize the impacts of the BDCP related to commercial fisheries.

Chapter 4
Economic Impacts Related to Non-Market Environmental Amenities

This chapter addresses the economic impacts of changes in non-market environmental amenities—regional air quality, greenhouse gas emissions, flood risk, property values and viewscapes, and sedimentation and erosion—resulting from implementation of the BDCP.

4.1 Regional Air Quality

4.1.1 Introduction

This section evaluates the economic impacts of changes in regional air quality that would result from implementation of the BDCP. The construction and operation of the new water conveyance facility (*CM1 Water Facilities and Operation*) and other conservation measures that would make changes to the physical landscape (CM2 through CM11) would affect air quality by increasing emissions of pollutants that have been linked to adverse health outcomes.

The monetary costs are based on costs incurred as a result of increases in morbidity (decreased health) and mortality (death) that can be linked to air pollutants. This analysis focuses on emissions of six criteria pollutants:

- Reactive Organic Gasses (ROGs)
- Nitrogen oxides (NO_X)
- Carbon monoxide (CO)
- Particulate matter less than 10 micrometers in diameter (PM10)
- Particulate matter less than 2.5 micrometers in diameter (PM2.5)
- Sulfur oxide (SO_X)

The analysis links changes in emissions of these pollutants to changes in expected health costs for the region (the economic impact of greenhouse gas emissions are discussed in Section 4.2, *Greenhouse Gas Emissions*). Table 4.1-1 summarizes the definition of the criteria pollutants and the potential health effects. The human health costs for each pollutant are estimated using widely accepted methods applied by the U.S. Environmental Protection Agency (EPA) to evaluate the economic costs of national regulatory decisions on air quality standards. Details of the methods are described below.

Increased emissions of air pollutants from construction projects are expected to lead to increased health risks for the surrounding populations. To estimate the economic impacts of changes in air quality due to construction and operation of the BDCP, air quality modeling data for key pollutants from 2016 to 2024 were evaluated for the three air basins closest to the Plan Area: the San Francisco Bay Area Air Basin (SFBAAB), the Sacramento Federal Nonattainment Area (SFNA), and the San Joaquin Valley Air Basin (SJVAB).[1] Air quality is reported by air basin and not cumulatively across the entire Plan Area, because air basins cover a larger geographical area. Emissions from construction under the BDCP would affect those living both in the Plan Area and in basins outside the Plan Area. Because air quality is regulated by basin, the characteristics of each basin provided inputs used to model the changes in air quality.

This section presents a summary of air pollutant emissions that would be generated by construction and operation of the water conveyance facility (CM1) and implementation of the other conservation measures (CM2 to CM11). The analysis uses data provided by the DWR and accepted software tools, techniques, and emission factors to estimate emissions of ROGs, NO_X, CO, PM10, PM2.5 and SO_2 associated with the water conveyance facility. Pollutant emissions will result from off-road equipment, marine vessels, locomotives, construction schedule, and annual electricity demand for the construction project. Information on the location and types of construction equipment required for CM2 through CM11 was unavailable, so these air quality impacts were analyzed qualitatively.

[1] The SFNA includes the Yolo Solano Air Quality Management District and the Sacramento Metro Management District, but emissions generated under the BDCP will occur only in the Sacramento Metro Management District.

Table 4.1-1. U.S. Environmental Protection Agency Definitions and Identified Health Impacts for Selected Air Pollutants

Pollutant	Definition	Health Impact
Reactive organic gases (ROGs)	ROGs, also referred to as volatile organic compounds (VOCs), are any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions, except those designated by the EPA as having negligible photochemical reactivity. VOCs are organic chemical compounds whose composition makes it possible for them to evaporate under normal indoor atmospheric conditions of temperature and pressure.[a]	Eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some organics can cause cancer in animals; some are suspected or known to cause cancer in humans. Key signs or symptoms associated with exposure to VOCs include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, nausea, emesis, epistaxis, fatigue, dizziness.[b]
Nitrogen oxides (NO_X)	Nitrogen dioxide (NO_2) is one of a group of highly reactive gases known as oxides of nitrogen or nitrogen oxides. Other nitrogen oxides include nitrous acid and nitric acid. EPA's National Ambient Air Quality Standard uses NO_2 as the indicator for the larger group of NO_X. NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment.[c]	Current scientific evidence links short-term NO_2 exposures, ranging from 30 minutes to 24 hours, with adverse respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people with asthma. Also, studies show a connection between breathing elevated short-term NO_2 concentrations, and increased visits to emergency departments and hospital admissions for respiratory issues, especially asthma.[d]
Carbon monoxide (CO)	CO is a colorless, odorless gas emitted from combustion processes. Nationally and, particularly in urban areas, the majority of CO emissions to ambient air come from mobile sources.[e]	CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. At extremely high levels, CO can cause death. Exposure to CO can reduce the oxygen-carrying capacity of the blood. People with several types of heart disease already have a reduced capacity for pumping oxygenated blood to the heart, which can cause them to experience myocardial ischemia (reduced oxygen to the heart), often accompanied by chest pain (angina), when exercising or under increased stress.[f]
PM10	Particle pollution is a mixture of microscopic solids and liquid droplets suspended in air. This pollution, also known as particulate matter, is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, soil or dust particles, and allergens (such as fragments of pollen or mold spores).[g] The PM10 standard includes particles with a diameter of 10 micrometers or less (0.0004 inches or one-seventh the width of a human hair).[h]	Major concerns for human health from exposure to PM10 include effects on breathing and respiratory systems, damage to lung tissue, cancer, and premature death. The elderly, children, and people with chronic lung disease, influenza, or asthma, are especially sensitive to the effects of particulate matter. Acidic PM10 can also damage human-made materials and is a major cause of reduced visibility in many parts of the United States. New scientific studies suggest that fine particles (smaller than 2.5 micrometers in diameter) may cause serious adverse health effects.[h]

Pollutant	Definition	Health Impact
PM2.5	Fine particle pollution or PM2.5 describes particulate matter that is 2.5 micrometers in diameter and smaller: one-thirtieth the diameter of a human hair.[g] PM2.5 is a subset of PM10.	Health studies have shown a significant association between exposure to fine particles and premature death from heart or lung disease. Fine particles can aggravate heart and lung diseases and have been linked to effects such as: cardiovascular symptoms; cardiac arrhythmias; heart attacks; respiratory symptoms; asthma attacks; and bronchitis. These effects can result in increased hospital admissions, emergency room visits, absences from school or work, and restricted activity days. Individuals that may be particularly sensitive to fine particle exposure include people with heart or lung disease, older adults, and children. [g]
Sulfur dioxide (SO_2)	SO_2 is one of a group of highly reactive gases known as oxides of sulfur. The largest sources of SO_2 emissions are from fossil fuel combustion at power plants (73%) and other industrial facilities (20%). Smaller sources of SO_2 emissions include industrial processes such as extracting metal from ore, and the burning of high sulfur containing fuels by locomotives, large ships, and non-road equipment. SO_2 is linked with a number of adverse effects on the respiratory system.[i]	Current scientific evidence links short-term exposures to SO_2, ranging from 5 minutes to 24 hours, with an array of adverse respiratory effects including bronchoconstriction and increased asthma symptoms. These effects are particularly important for asthmatics at elevated ventilation rates (e.g., while exercising or playing.) Studies also show a connection between short-term exposure and increased visits to emergency departments and hospital admissions for respiratory illnesses, particularly in at-risk populations including children, the elderly, and asthmatics.[j]

The information provided here was excerpted directly from the following EPA webpages.

[a] http://www.epa.gov/iaq/voc2.html
[b] http://www.epa.gov/iaq/voc.html
[c] http://www.epa.gov/airquality/nitrogenoxides/
[d] http://www.epa.gov/airquality/nitrogenoxides/health.html
[e] http://www.epa.gov/airquality/carbonmonoxide/
[f] http://www.epa.gov/airquality/carbonmonoxide/health.html
[g] http://www.epa.gov/pmdesignations/basicinfo.htm
[h] http://www.epa.gov/airtrends/aqtrnd95/pm10.html
[i] http://www.epa.gov/air/sulfurdioxide/
[j] http://www.epa.gov/air/sulfurdioxide/health.html

4.1.2 CM1 Water Facilities and Operation

Construction and operation of the water conveyance facility under CM1 will result in increased air pollutants. Construction activities will result in short-term (temporary) air pollutants from mobile and stationary construction equipment exhaust, employee vehicle exhaust, electrical generation, and concrete batching. Construction is assumed to occur for 9 years, from 2016 to 2024. Operation of the water conveyance facility will generate long-term (permanent) air pollutants from maintenance equipment exhaust and electrical generation. Operation is assumed to occur for 40 years, from 2024 to 2064. For this analysis, the BDCP-induced change in air quality was estimated by comparing a scenario with the BDCP and a scenario without the BDCP. Because both scenarios consider population growth and climate change impacts, the analysis only considers pollution emissions from the BDCP.

Construction of the water conveyance facility (CM1) will occur in multiple phases (e.g., mobilization, land clearing). A detailed construction schedule (DWR DHCCP Program Schedule, 20-Oct-11) was developed based on an economic analysis (5RMK, Inc. Bid-Item Detail, 4-Feb-2010) provided by DWR (California Department of Water Resources et al. 2013: Chapter 22). Construction activities for alternatives with the Pipeline/Tunnel Alignment, East Alignment, and Through Delta/Separate Corridors Alignment were assumed to proceed according to the schedules listed below. A construction schedule for alternatives with the West Alignment was developed based on data received for the East Alignment, due to similarities in project design.

- Pipeline/Tunnel Alignment: February 2016 to December 2024 (9 years).
- East/West Alignment: June 2014 to December 2022 (9 years).
- Through Delta/Separate Corridors Alignment: January 2014 to July 2020 (7 years).

Methods and assumptions used to develop the construction schedule are provided in an appendix to the EIR/EIS for the BDCP (California Department of Water Resources et al. 2013): Appendix 22A, *Air Quality Analysis Assumptions*. Detailed phasing assumptions are presented in Appendix 22B, *Air Quality Assumptions*.

Construction emissions from heavy-duty equipment operation and land disturbance were calculated based on the methods and default emission factors from the California Emissions Estimator Model (CalEEMod). CalEEMod analyzes the type of construction activity and the duration of the construction period to estimate criteria pollutants. The CalEEMod calculation spreadsheet workbooks were prepared as a separate technical report for the BDCP (ICF International 2012). Equipment and construction assumptions were provided by DWR (BDCP EIR/EIS Appendix 22B). The total area to be disturbed during construction was determined using GIS data provided by DWR (BDCP EIR/EIS Appendix 22A).

Criteria pollutant emissions occurring in each air district and air basin were identified based on the location and schedule of construction activities. Construction locations were identified using GIS data provided by DWR and are summarized in BDCP EIR/EIS Appendix 22A. Annual emissions estimates were developed by summing emissions that would occur in each year of construction. These emissions were apportioned to each air district based on the location of construction activity. For example, construction of the PTO tunnel in Reach 5 would occur in both SMAQMD and SJVAPCD. Construction would be completed in phases between 2017 and 2023. Emissions generated in each year of construction (e.g., 2017, 2018) were calculated using the methods described above. The annual emissions estimates were apportioned to SMAQMD and SJVAPCD based on the number of tunnel miles constructed within each location (BDCP EIR/EIS Appendix 22A).

Annual pollutants emissions of the various air pollutants of interest resulting from construction of the water conveyance facility (CM1) are presented in Table 4.1-2 through Table 4.1-4 for the three affected air basins. Operation emissions of the various air pollutants are presented in Table 4.1-5 for the three affected air basins. Operation related emissions are presented in aggregate due to the operational timeframe of the BDCP (2025 – 2060).

Table 4.1-2. Pollutant Emissions from Water Conveyance Facility Construction in San Francisco Bay Area Air Basin (Tons)

Year	ROG	NO_X	CO	PM10			PM2.5			SO_2
				Dust	Exhaust	Total	Dust	Exhaust	Total	
2016	0.0081	0.0495	0.0368	0.0000	0.0006	0.0006	0.0000	0.0006	0.0006	0.0001
2017	2.2906	17.5032	10.1757	0.0000	0.1848	0.1849	0.0000	0.1848	0.1848	0.1622
2018	2.2838	17.3747	11.2941	0.0245	0.2282	0.2527	0.0164	0.2282	0.2446	0.2302
2019	11.0634	72.8514	48.7731	0.0426	0.5606	0.6033	0.0217	0.5603	0.5820	0.3540
2020	7.9292	47.3192	34.8918	0.0056	0.3898	0.3954	0.0006	0.3897	0.3903	0.2831
2021	2.9457	15.0918	12.5695	0.0013	0.0893	0.0905	0.0001	0.0892	0.0893	0.0432
2022	0.4036	1.9647	2.1573	0.0880	0.0122	0.1002	0.0593	0.0122	0.0715	0.0061
2023	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2024	1.7730	8.1494	10.0888	0.2446	0.0466	0.2912	0.0517	0.0465	0.0983	0.0388

Table 4.1-3. Pollutant Emissions from Water Conveyance Facility Construction in Sacramento Federal Nonattainment Area (Tons)

Year	ROG	NO_X	CO	PM10			PM2.5			SO_2
				Dust	Exhaust	Total	Dust	Exhaust	Total	
2016	3.0615	23.4241	11.9811	0.0002	0.1751	0.1753	0.0000	0.1750	0.1751	0.1035
2017	7.2650	53.2501	31.1319	0.1359	0.4401	0.5760	0.0407	0.4399	0.4806	0.2917
2018	13.0769	95.5397	57.0355	2.5801	0.6777	3.2579	1.6605	0.6767	2.3372	0.3865
2019	13.2642	86.7101	58.1791	2.2858	0.5332	2.8189	1.4520	0.5316	1.9836	0.2187
2020	9.6354	59.8320	47.2780	1.0981	0.3766	1.4747	0.6975	0.3742	1.0717	0.1385
2021	4.6338	24.1998	23.7340	0.6224	0.1603	0.7827	0.4038	0.1600	0.5638	0.0677
2022	5.4622	28.6189	27.2434	0.1813	0.1700	0.3513	0.0988	0.1697	0.2685	0.0894
2023	0.7203	3.5030	4.0119	0.1870	0.0213	0.2084	0.1238	0.0212	0.1451	0.0119
2024	0.0103	0.0556	0.0536	0.0000	0.0003	0.0003	0.0000	0.0003	0.0003	0.0002

Table 4.1-4. Pollutant Emissions from Water Conveyance Facility Construction in San Joaquin Valley Air Basin (Tons)

Year	ROG	NO_X	CO	PM10			PM2.5			SO_2
				Dust	Exhaust	Total	Dust	Exhaust	Total	
2016	0.8340	6.2379	3.0358	0.0000	0.0349	0.0349	0.0000	0.0349	0.0349	0.0102
2017	1.4720	10.5697	5.6670	0.0024	0.0603	0.0627	0.0003	0.0603	0.0605	0.0190
2018	2.7612	20.9623	13.7632	0.2062	0.2299	0.4361	0.1348	0.2298	0.3646	0.2049
2019	5.1903	31.3292	24.6037	0.1268	0.3285	0.4553	0.0648	0.3283	0.3931	0.2641
2020	8.3324	45.8395	40.7864	0.0698	0.4269	0.4966	0.0075	0.4265	0.4341	0.3051
2021	6.9865	36.9043	35.8662	0.0674	0.3624	0.4298	0.0073	0.3622	0.3694	0.2924
2022	4.7660	25.9703	26.4756	0.5442	0.2713	0.8155	0.3587	0.2711	0.6299	0.2507
2023	3.3152	17.9619	17.0893	0.2055	0.1062	0.3117	0.1385	0.1061	0.2447	0.0514
2024	0.6623	3.5634	3.4327	0.0000	0.0207	0.0207	0.0000	0.0207	0.0207	0.0107

Table 4.1-5. Total Pollutant Emissions from Water Conveyance Facility Operation, 2025 – 2060 (Tons)

	ROG	NO_X	CO	PM10 (Exhaust)	PM2.5 (Exhaust)	SO_2
SFBAAB	0.015	0.139	0.100	0.005	0.004	0.001
SFNA	0.483	4.341	4.851	0.153	0.141	0.046
SJVAB	0.138	1.286	0.910	0.046	0.042	0.012
Total	0.637	5.766	5.861	0.203	0.187	0.059

SFBAAB = San Francisco Bay Area Air Basin
SFNA = Sacramento Federal Nonattainment Area
SJVAB = San Joaquin Valley Air Basin

4.1.3 Other Conservation Measures

Restoration techniques that require physical changes to the environment or that require use of construction equipment will generate temporary air pollutants through use of mobile and stationary construction equipment. Pollutants generated by these sources are highly dependent on the total amount of distributed area; the type, location, and duration of construction; and the intensity of construction activity. Thus, construction-related air pollutants would vary depending on the implementation actions. Nevertheless, construction-related air pollutants resulting from implementation of the other conservation measures (CM2 through CM11) are expected to be minor compared to construction-related air pollutants associated with CM1 (Table 4.1-6 through Table 4.1-7). However, without additional information on the location and types of construction equipment, a quantitative analysis of construction-related air pollutants of the other conservation measures is not possible.

CM2 through CM11 are expected to generate air quality benefits. Increasing the areas of wetlands, grasslands, and riparian vegetation lowers the overall air pollutant levels because vegetation provides air filtration services. The amount of pollutants that natural areas remove from the air depends on a variety of factors, including pollutant levels, density of vegetation, and wind patterns.

Due to these factors and the inherent uncertainty in estimating the air filtration benefits provided by natural areas, the air quality benefits of the CM2 through CM11 are not quantified or monetized in this analysis.

4.1.4 Data, Methods, and Assumptions

To monetize the air quality impacts of the water conveyance facility construction and operation, per-ton values for ROG, NO_X, PM2.5 and SO_X were derived from estimates used by the EPA in analyses of regulations involving air quality impacts from petroleum refineries (U.S. Environmental Protection Agency 2008). The per-unit value for PM10 comes from an EPA regulatory impact analysis for combustion engines (U.S. Environmental Protection Agency 2002). An analogous per-ton estimate for the heath cost of CO could not be found. All estimates were inflated to constant 2012 dollars using the Bureau of Labor Statistics (2013) inflation calculator.

EPA estimates the per-ton health cost of different pollutants by estimating the increased risks and associated costs of mortality and morbidity associated with each pollutant. First, EPA defines a concentration response function from epidemiological research for each pollutant. This function measures the human heath impact at different doses of the pollutant. The concentration response function estimates the frequency of mortality and morbidity events such as adult premature mortality, infant mortality, nonfatal heart attacks, hospital emissions (cardiovascular, chronic obstructive pulmonary, and pneumonia), emergency room visits for asthma, acute bronchitis, lower respiratory systems, upper respiratory systems, asthma exacerbation, lost work days and minor restricted activity days (U.S. Environmental Protection Agency 2013). See Table 4.1-1, above, for the specific heath impacts of each of the criteria pollutants.

Each adverse health impact results in a cost to society. Differences in estimates across pollutants are driven by the assumed frequency of the health events as estimated by the concentration response functions. For mortality, EPA uses the Value of a Statistical Life (VSL), which measures an individual's willingness to pay for reductions in mortality risk. The VSL is commonly used by federal agencies to estimate the cost of small changes in mortality risk across populations. For morbidity, the EPA estimates are based on the willingness to pay of individuals to reduce their risks of morbidity incidents. When willingness-to-pay studies are not available, EPA relies on actual health costs. For example, to value a hospital admission, EPA uses medical costs incurred by a patient (e.g., doctor fees, testing costs, nurse fees) to estimate a cost of illness for different morbidity outcomes. These estimates tend to underestimate the true cost of health impacts because the cost-of-illness estimate only considers direct expenditures and not the pain and suffering associated with health impacts (U.S. Environmental Protection Agency 2013).

For PM2.5 and the PM10, the value was only applied to PM levels of exhaust because the source of the PM values did not consider impacts from dust pollutants, which have different health effects than PM from exhaust. EPA estimated each of these values assuming a 3% discount rate for health costs occurring in the future. EPA discounted these values at a 3% rate to account for pollution in a given year imposing heath costs that could occur in future years. The discounted heath cost estimate is the present value cost of an emission in a given year, accounting for health costs occurring in later years. For example, if a ton of PM2.5 generated hospital visits after 2 years, the estimate would value the hospital visit in year 2 and then discount that value to the present day. Following the approach used by EPA, the per-ton health costs increase over time for all pollutants except PM10. The increase in health costs over time does not reflect inflation, but reflects the fact that individual willingness to pay to avoid adverse health outcomes is positively correlated with increases in real wealth (U.S.

Environmental Protection Agency 2013). To estimate the operation-related health costs, we used the 2024 cost for all years from 2026 to 2060.[2] Lastly, due to the inherent uncertainty in the air quality modeling data, and also uncertainty in the per-ton values ascribed to the various pollutants, ranges estimated by the EPA were used to obtain low and high costs for each pollutant. Table 4.1-6 and Table 4.1-7 present the low and high per-ton health cost for each pollutant included in the analysis.

Table 4.1-6. Annual Per-Ton Health Costs from Construction for Air Pollutants by Year (Low Value)

			Exhaust		
Year	**ROG**	**NO_X**	**PM10**	**PM2.5**	**SO_2**
2016	$247	$1,527	$2,328	$79,884	$9,398
2017	$249	$1,543	$2,328	$80,736	$9,498
2018	$252	$1,559	$2,328	$81,565	$9,596
2019	$254	$1,574	$2,328	$82,330	$9,686
2020	$257	$1,591	$2,328	$83,213	$9,790
2021	$260	$1,610	$2,328	$84,191	$9,905
2022	$263	$1,630	$2,328	$85,271	$10,032
2023	$267	$1,650	$2,328	$86,316	$10,155
2024	$270	$1,670	$2,328	$87,354	$10,277

Table 4.1-7. Annual Per-Ton Health Costs from Construction for Air Pollutants by Year (High Value)

			Exhaust		
Year	**ROG**	**NO_X**	**PM10**	**PM2.5**	**SO_2**
2016	$1,997	$12,922	$9,465	$669,618	$79,884
2017	$2,018	$13,060	$9,465	$676,760	$80,736
2018	$2,039	$13,194	$9,465	$683,709	$81,565
2019	$2,058	$13,318	$9,465	$690,116	$82,330
2020	$2,080	$13,461	$9,465	$697,519	$83,213
2021	$2,105	$13,619	$9,465	$705,720	$84,191
2022	$2,132	$13,794	$9,465	$714,775	$85,271
2023	$2,158	$13,963	$9,465	$723,534	$86,316
2024	$2,184	$14,131	$9,465	$732,229	$87,354

4.1.5 Cost-Benefit Analysis for Direct Air Quality Effects and Mitigation

Mitigation measures in the BDCP EIR/EIS are designed to reduce the projected health effects of BDCP pollutant emissions through the purchase of pollution offsets. Pollution offsets would be purchased when a particular pollutant exceeds the air quality threshold established by an air quality

[2] This assumption was due to data availability. Because the operating pollution effects are so small in comparison to the construction emissions, this assumption does not heavily influence the totals.

management district (AQMD) over a year or in the course of a day. Pollution offsets represent an alternative project or program that reduces the amount of a criteria pollutant. The goal is to achieve localized mitigation as much as possible, projects or programs will be selected to mitigate pollutions on a local level. When an offset is purchased, the net emission is zero (construction pollutants are equivalent to avoided offset pollutants).[3] No health costs are realized when an offset is purchased, which reduces the total health costs of pollution from the construction activities. In other words, a pollution offset reduces the total health cost for a pollutant but increases the total economic impact of the project because the offsets must be purchased. For the pollution offsets, the avoided health costs were estimated and subtracted from the total health costs. The costs of purchasing the pollution offsets were then added to the health costs to estimate the total air quality costs related to the BDCP.

On an annual basis, offsets occur for NO_X for Sacramento Metropolitan and San Joaquin Valley AQMDs and it is assumed that the purchase of offsets brings the pollutant level to a net value of zero.[4] For daily thresholds, the Bay Area AQMD exceeds pollutant emissions thresholds for ROG and NO_X, while the Sacramento Metropolitan AQMD exceeds emission for NO_X.[5] Daily pollutant emissions in excess of the federal *de minimis* threshold, but above the AQMD California Environmental Quality Act (CEQA) thresholds are assumed to be offset to below the applicable air district CEQA threshold. The model assumes that if, for a given year, the region exceeds the annual threshold and purchases offsets, those offsets also cover the daily offset requirement. To be conservative, it is assumed that, if an area exceeds a daily threshold, that area exceeds the threshold 125 days out of the year, or half of all construction days. The assumption of construction days exceeding the threshold was used to produce a high-level estimate of potential mitigation costs. The assumption likely overestimates mitigation costs, which could have the corresponding effect of underestimating public health costs.

To estimate the air quality mitigation costs, the annual per-ton offset costs were estimated by region and by pollutant. These offset costs ranged from $9,350 per ton (for the San Joaquin Valley AQMD for NO_X or ROG) to $17,460 per ton (for the Bay Area AQMD for NO_X or ROG and for the Sacramento Metropolitan AQMD for NO_X).[6] These values were provided by the air districts' current estimation of the mitigation costs, but are subject to market conditions and project-specific factors (e.g., timing of the pollutant emissions, other projects in the area). These values will likely change over time based on the market forces and the actual timing of BDCP construction. To estimate the total mitigation cost, the annual per-ton pollutant emissions needed to be offset were multiplied by the annual per-ton cost to purchase offsets. Finally, a 5% administration cost was assumed for the purchase of pollutant emissions offsets, and was added to the base mitigation cost estimates.

Next, to estimate the total economic impact of changes in air quality, the total costs attributable to increases in emissions of the various pollutants from construction were first estimated. Next, the avoided health cost resulting from the pollution permits that would be purchased were subtracted from those total costs. Lastly, the cost to purchase the pollution permits was added to the total costs.

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[3] Annual pollution offsets equal the total pollution for that basin. Daily pollution offsets, however, equal the pollution amount exceeding California Environmental Quality Act (CEQA) levels.

[4] The Sacramento Metropolitan AQMD exceeds the NO_X threshold from 2017 to 2020 and in 2022. The San Joaquin Valley AQMD exceeds the NO_X threshold from 2017 to 2023.

[5] The Bay Area AQMD exceeds the daily threshold for ROG in 2019, 2020 and 2024 and the NO_X daily threshold in 2017 to 2022 and 2024. The Sacramento Metropolitan AQMD exceeds the NO_X daily threshold from 2016 to 2023.

[6] The offset costs were provided by the air districts and applied to the air basins in which these offsets would occur because the air emissions from BDCP construction will be regionalized to the air districts.

4.1.6 Results

To estimate the total economic impact of pollutant emissions of BDCP construction, the total health-related costs of emissions of the criteria air pollutants were estimated. Next, the avoided costs were calculated by estimating the health costs resulting from the pollutant emissions that would be mitigated. Next, the net cost of emissions of criteria pollutants were estimated by subtracting the mitigated costs from the total pollutant emissions costs. Lastly, the total economic impact of the air quality changes were estimated by summing the net cost of pollutant emissions and the cost of purchasing offsets for the pollutant emissions that would be mitigated.

4.1.6.1 Total Health Costs

To obtain the total annual costs of air quality impacts, the pollutant emissions from the construction of the water conveyance facility in each year were multiplied by the per-ton value derived for that pollutant. The results of these calculations are annual health costs per pollutant for the three affected air basins. Table 4.1-8 through Table 4.1-13 present the construction-induced air quality costs for each pollutant when the low and high per-ton values are used. As shown in the tables, air quality costs (discounted at a rate of 3% relative to 2015) in all three basins are dominated by impacts from NO_X and PM2.5.

Table 4.1-8. Annual Air Quality Health Costs from Construction for San Francisco Bay Area Air Basin (Low Value, Discounted)

			Exhaust		
Year	ROG	NO_X	PM10	PM2.5	SO_2
2016	$2	$73	$1	$48	$1
2017	$538	$25,465	$406	$14,065	$1,452
2018	$526	$24,794	$486	$17,031	$2,021
2019	$2,499	$101,878	$1,160	$40,987	$3,046
2020	$1,758	$64,935	$783	$27,972	$2,391
2021	$641	$20,343	$174	$6,290	$359
2022	$86	$2,604	$23	$845	$50
2023	$0	$0	$0	$0	$0
2024	$367	$10,431	$83	$3,116	$305
Total	**$6,418**	**$250,523**	**$3,116**	**$110,355**	**$9,625**

Table 4.1-9. Annual Air Quality Health Costs from Construction for Sacramento Federal Nonattainment Area (Low Value, Discounted)

Year	ROG	NO_X	Exhaust		SO_2
			PM10	PM2.5	
2016	$733	$34,731	$396	$13,575	$944
2017	$1,707	$77,473	$966	$33,476	$2,612
2018	$3,014	$136,337	$1,444	$50,509	$3,394
2019	$2,996	$121,258	$1,103	$38,887	$1,882
2020	$2,136	$82,105	$756	$26,861	$1,170
2021	$1,009	$32,620	$313	$11,280	$561
2022	$1,170	$37,934	$322	$11,768	$729
2023	$152	$4,563	$39	$1,447	$96
2024	$2	$71	$1	$22	$1
Total	**$12,920**	**$527,093**	**$5,338**	**$187,827**	**$11,390**

Table 4.1-10. Annual Air Health Quality Costs from Construction for San Joaquin Valley Air Basin (Low Value, Discounted)

Year	ROG	NO_X	Exhaust		SO_2
			PM10	PM2.5	
2016	$200	$9,249	$79	$2,704	$93
2017	$346	$15,378	$132	$4,586	$170
2018	$637	$29,914	$490	$17,150	$1,799
2019	$1,172	$43,812	$679	$24,015	$2,273
2020	$1,847	$62,904	$857	$30,617	$2,577
2021	$1,521	$49,746	$707	$25,535	$2,425
2022	$1,020	$34,423	$514	$18,799	$2,045
2023	$698	$23,398	$195	$7,232	$412
2024	$137	$4,561	$37	$1,388	$85
Total	**$7,578**	**$273,384**	**$3,690**	**$132,026**	**$11,878**

Table 4.1-11. Annual Air Quality Health Costs from Construction for San Francisco Bay Area Air Basin (High Value, Discounted)

Year	ROG	NO_X	Exhaust		SO_2
			PM10	PM2.5	
2016	$16	$621	$6	$403	$4
2017	$4,358	$215,474	$1,649	$117,897	$12,342
2018	$4,262	$209,795	$1,977	$142,764	$17,182
2019	$20,232	$862,043	$4,715	$343,568	$25,894
2020	$14,229	$549,446	$3,183	$234,471	$20,322
2021	$5,192	$172,134	$708	$52,726	$3,049
2022	$700	$22,036	$94	$7,087	$425
2023	$0	$0	$0	$0	$0
2024	$2,968	$88,259	$338	$26,116	$2,594
Total	**$51,956**	**$2,119,808**	**$12,669**	**$925,031**	**$81,813**

Table 4.1-12. Annual Air Quality Health Costs from Construction for Sacramento Federal Nonattainment Area (High Value, Discounted)

Year	ROG	NO_X	Exhaust		SO_2
			PM10	PM2.5	
2016	$5,936	$293,880	$1,609	$113,794	$8,026
2017	$13,822	$655,539	$3,926	$280,610	$22,201
2018	$24,403	$1,153,617	$5,871	$423,384	$28,853
2019	$24,256	$1,026,031	$4,484	$325,969	$15,997
2020	$17,291	$694,738	$3,075	$225,162	$9,943
2021	$8,168	$276,018	$1,271	$94,553	$4,773
2022	$9,468	$320,981	$1,308	$98,646	$6,195
2023	$1,227	$38,611	$159	$12,130	$814
2024	$17	$603	$2	$182	$11
Total	**$104,588**	**$4,460,018**	**$21,705**	**$1,574,429**	**$96,814**

Table 4.1-13. Annual Air Quality Health Costs from Construction for San Joaquin Valley Air Basin (High Value, Discounted)

Year	ROG	NO_X	Exhaust		SO_2
			PM10	PM2.5	
2016	$1,617	$78,261	$320	$22,663	$791
2017	$2,801	$130,119	$538	$38,438	$1,444
2018	$5,153	$253,115	$1,991	$143,758	$15,295
2019	$9,492	$370,715	$2,763	$201,303	$19,320
2020	$14,952	$532,264	$3,485	$256,642	$21,901
2021	$12,315	$420,924	$2,873	$214,042	$20,613
2022	$8,261	$291,275	$2,088	$157,580	$17,379
2023	$5,647	$197,984	$793	$60,624	$3,500
2024	$1,108	$38,591	$150	$11,636	$719
Total	**$61,347**	**$2,313,247**	**$15,002**	**$1,106,687**	**$100,963**

Table 4.1-14 through Table 4.1-17 present the low and high estimates of total costs (discounted) from pollutant emissions for the three air basins over the analysis period. The total discounted costs across all three affected air basins range from $1.6 million (using the low per-ton pollutant values) to $13.4 million (using the high per-ton pollutant values).

Table 4.1-14. Total Air Quality Health Costs from Construction (Low Value, Discounted)

Air Basin	ROG	NO_X	Exhaust		SO_2	Total by Region
			PM10	PM2.5		
SFBAAB	$6,418	$250,523	$3,116	$110,355	$9,625	$380,036
SFNA	$12,920	$527,093	$5,338	$187,827	$11,390	$744,568
SJVAB	$7,578	$273,384	$3,690	$132,026	$11,878	$428,555
Total	**$26,916**	**$1,050,999**	**$12,144**	**$430,207**	**$32,893**	**$1,553,160**

Table 4.1-15. Total Air Quality Health Costs from Construction (High Value, Discounted)

Air Basin	ROG	NO_X	Exhaust		SO_2	Total by Region
			PM10	PM2.5		
SFBAA	$51,956	$2,119,808	$12,669	$925,031	$81,813	$3,191,276
SFNA	$104,588	$4,460,018	$21,705	$1,574,429	$96,814	$6,257,554
SJVAB	$61,347	$2,313,247	$15,002	$1,106,687	$100,963	$3,597,245
Total	**$217,891**	**$8,893,073**	**$49,375**	**$3,606,147**	**$279,589**	**$13,046,075**

Table 4.1-16. Total Air Quality Health Costs from Operation (Low Value, Discounted)

Air Basin	ROG	NO_X	Exhaust PM10	Exhaust PM2.5	SO_2	Total by Region
SFBAA	$2	$108	$5	$183	$6	**$304**
SFNA	$61	$3,376	$165	$5,714	$220	**$9,535**
SJVAB	$17	$1,000	$49	$1,711	$55	**$2,833**
Total	**$80**	**$4,484**	**$220**	**$7,607**	**$281**	**$12,672**

SFBAAB = San Francisco Bay Area Air Basin; SFNA = Sacramento Federal Nonattainment Area;
SJVAB = San Joaquin Valley Air Basin.

Table 4.1-17. Total Air Quality Health Costs from Operation (High Value, Discounted)

Air Basin	ROG	NO_X	Exhaust PM10	Exhaust PM2.5	SO_2	Total by Region
SFBAA	$15	$126	$5	$213	$7	**$366**
SFNA	$492	$3,943	$160	$6,651	$257	**$11,504**
SJVAB	$141	$8,464	$201	$14,339	$467	**$23,613**
Total	**$648**	**$12,533**	**$367**	**$21,203**	**$731**	**$35,482**

SFBAAB = San Francisco Bay Area Air Basin; SFNA = Sacramento Federal Nonattainment Area;
SJVAB = San Joaquin Valley Air Basin.

4.1.6.2 Total Avoided Costs

Table 4.1-18 shows the health-related cost for the pollution offsets. No pollution offsets were purchased for the operation-related emissions. These are health costs that are avoided by the purchase of offsets in regions that exceed the thresholds described above.

Table 4.1-18. Construction-related Health Cost Avoided due to Mitigation Measures (Discounted)

Air Basin	Low ROG	Low NO_X	High ROG	High NO_X
SFBAAB	$1,393	$140,107	$11,277	$1,185,520
SFNA	$0	$504,875	$0	$4,272,015
SJVAB	$0	$259,574	$0	$2,196,395
Total	**$1,393**	**$904,555**	**$11,277**	**$7,653,930**

4.1.6.3 Net Costs

Table 4.1-19 and Table 4.1-20 present the discounted net air quality health costs from construction for each affected air basin. These are the costs from pollutant emissions minus the avoided costs that result from the pollution offsets.

Table 4.1-19. Net Annual Air Quality Costs from Construction (Low Value, Discounted)

			Exhaust			
Air Basin	**ROG**	**NO_X**	**PM10**	**PM2.5**	**SO_2**	**Total by Region**
SFBAAB	$5,025	$110,416	$3,116	$110,355	$9,625	$238,536
SFNA	$12,920	$22,219	$5,338	$187,827	$11,390	$239,693
SJVAB	$7,578	$13,810	$3,690	$132,026	$11,878	$168,982
Total	**$25,523**	**$146,444**	**$12,144**	**$430,207**	**$32,893**	**$647,211**
SFBAAB = San Francisco Bay Area Air Basin; SFNA = Sacramento Federal Nonattainment Area; SJVAB = San Joaquin Valley Air Basin.						

Table 4.1-20. Net Annual Air Quality Costs from Construction (High Value, Discounted)

			Exhaust			
Air Basin	**ROG**	**NO_X**	**PM10**	**PM2.5**	**SO_2**	**Total by Region**
SFBAAB	$40,679	$934,288	$12,669	$925,031	$81,813	$1,994,479
SFNA	$104,588	$188,003	$21,705	$1,574,429	$96,814	$1,985,539
SJVAB	$61,347	$116,852	$15,002	$1,106,687	$100,963	$1,400,850
Total	**$206,614**	**$1,239,142**	**$49,375**	**$3,606,147**	**$279,589**	**$5,380,868**
SFBAAB = San Francisco Bay Area Air Basin; SFNA = Sacramento Federal Nonattainment Area; SJVAB = San Joaquin Valley Air Basin.						

4.1.6.4 Total Economic Impact of BDCP on Air Quality

Table 4.1-21 summarizes the components of the estimation strategy and presents the total estimated economic impact of construction of the BDCP related to air quality. These components are the costs of pollutant emissions, the costs avoided by mitigation and pollution offsets, and the costs to purchase the pollution offsets. The total economic impact of the construction of BDCP related to air quality is calculated as the total pollutant emissions costs minus the avoided pollutant emissions costs due to mitigation plus the cost to purchase the pollution mitigation offsets. As shown in the table, the total economic impact of air quality related to BDCP ranges from $10.8 million to $15.6 million.

Table 4.1-21. Total Economic Impact of the BDCP Related to Air Quality (3% discount rate, Million $)

Cost Component		**Low**	**High**
Total costs of pollutant emissions from construction	[a]	$1.55	$13.05
Total avoided heath costs due to mitigation	[b]	$0.91	$7.91
Total pollution mitigation offset costs	[c]	$10.14	$10.14
Total costs of pollutant emissions from operations	[d]	$0.01	$0.04
Total Economic Impact	**[a] –[b] + [c] + [d]**	**$10.80**	**$15.56**

4.2 Greenhouse Gas Emissions

4.2.1 Introduction

This section evaluates potential monetary costs associated with greenhouse gas (GHG) emissions generated as a result of implementation the BDCP. Economic burdens associated with increasing GHG emissions are frequently monetized in terms of regulatory costs (e.g., cost to comply with Assembly Bill [AB] 32, the California Global Warming Solutions Act) or community costs (e.g., public health costs from deteriorating air quality).[1] This section focuses primarily on regulatory costs, as GHG emissions generated by construction and operation and maintenance (O&M) of the BDCP will be offset to net zero through required mitigation. Reduced community costs associated with climate change moderation are briefly discussed in relation to carbon sequestration benefits from land conversion and natural community restoration.[2]

The section beings with a brief overview of climate change science. Estimated GHG emissions that will be generated by the BDCP are presented next, followed by an analysis of potential direct costs and community benefits associated with required BDCP mitigation. Direct costs are evaluated quantitatively, and include costs to mitigate or reduce GHGs emitted by construction and O&M of the BDCP. Benefits that may be gained through GHG emissions reduction are discussed qualitatively. The section concludes with an analysis of indirect costs and benefits from GHG emissions generated by the BDCP. Indirect costs are estimated qualitatively and are a consequence of GHG emissions induced by the BDCP that are beyond the jurisdiction of BDCP proponents (e.g., GHGs generated at statewide power plants that serve the BDCP electrical load).

4.2.2 Climate Change Science and Greenhouse Gas Emissions

The phenomenon known as the greenhouse effect keeps the atmosphere near the Earth's surface warm enough for the successful habitation of humans and other life forms. The greenhouse effect is created by sunlight that passes through the atmosphere (Figure 4.2-1). Some of the sunlight striking the earth is absorbed and converted to heat, which warms the surface. The surface emits a portion of this heat as infrared radiation, some of which is reemitted toward the surface by GHGs. Human activities that generate GHGs increase the amount of infrared radiation absorbed by the atmosphere, thus enhancing the greenhouse effect and amplifying the warming of the earth (Center for Climate and Energy Solutions 2011).

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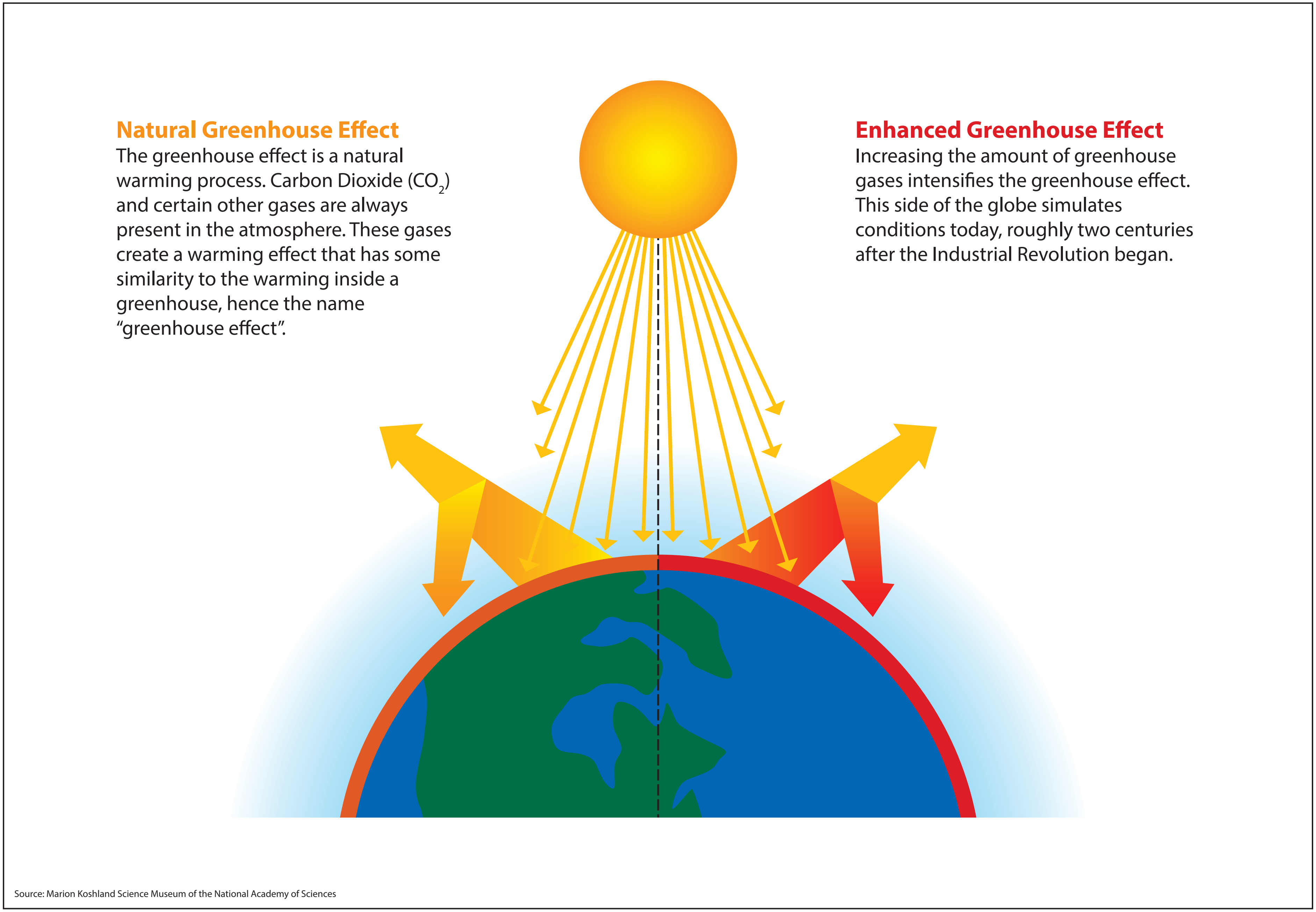
1 Please refer to Section 4.1, *Regional Air Quality*, for an analysis of public health costs associated with criteria pollutant emissions generated by construction of the BDCP.

2 BDCP EIR/EIS Chapter 29, *Climate Change*, analyzes how the BDCP will affect the resiliency and adaptability of the Plan Area to the effects of climate change. BDCP components that could affect the resilience and adaptability of the Plan Area consist of water diversion and conveyance facilities combined with differing operational scenarios, measures focused on the protection, restoration, and enhancement of natural communities, and measures related to reducing other stressors. Economic impacts associated with these potential effects are not evaluated in this section. Please refer to BDCP EIR/EIS Chapter 29, *Climate Change*, for additional information on this topic.



Graphics... BDCP EIR-EIS (7/29/13) AB

Figure 4.2-1
The Greenhouse Gas Effect

Increases in fossil fuel combustion and deforestation have exponentially increased concentrations of GHGs in the atmosphere since the Industrial Revolution. Rising atmospheric concentrations of GHGs in excess of natural levels result in increasing global surface temperatures, a phenomenon commonly referred to as global warming. Higher global surface temperatures, in turn, result in changes to the earth's climate system, including increased ocean temperature and acidity, reduced sea ice, increased variability in precipitation, and increased frequency and intensity of extreme weather events (Intergovernmental Panel on Climate Change 2007a, 2007b). Large-scale changes to the Earth's system are collectively referred to as climate change.

The EPA has issued an Endangerment Finding for GHGs, concluding that current and projected concentrations threaten the public health and welfare of current and future generations. California has likewise adopted AB 32, which establishes a cap on statewide GHG emissions and sets forth the regulatory framework to achieve the corresponding emissions reductions. According to AB 32, GHGs include the following gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorinated carbons (PFCs), sulfur hexafluoride (SF_6), and hydrofluorocarbons (HFCs).

4.2.3 Greenhouse Gas Emissions Analysis

This section presents a summary of GHG emissions that will be generated as a result of the BDCP, specifically, construction and O&M of *CM1 Water Facilities and Operation* and implementation of the other conservation measures (CM2 through CM11).GHG emissions associated with CM1 were quantified using data provided by DWR and accepted software tools, techniques, and emission factors. Information on the location and types of construction equipment required for each additional conservation measure were unavailable. Consequently, GHG emissions resulting from implementation of the conservation measures were assessed qualitatively. Please refer to Appendix A, *Greenhouse Gas and Air Quality Analysis Assumptions,* for specific assumptions and methods related to the GHG analysis.

4.2.3.1 CM1 Water Facilities and Operation

The water conveyance facility constructed under CM1 will generate GHG emissions during both construction and O&M. Construction activities will result in short-term (temporary) emissions from mobile and stationary construction equipment exhaust, employee vehicle exhaust, electrical transmission, and concrete batching. O&M of the water conveyance facility will generate long-term (permanent) emissions from maintenance equipment exhaust and electrical generation. A portion of CO_2 emissions generated by calcination[3] during cement manufacturing will also be reabsorbed (i.e., removed from the atmosphere) into concrete structures during the life of the BDCP.

Annual and total GHG emissions resulting from construction of CM1 (equivalent to Alternative 4 in the BDCP EIR/EIS [California Department of Water Resources et al. 2013]) are presented in Table 4.2-1. Data are presented annually for the 9-year construction period. Emissions assume implementation of environmental commitments and state mandates to reduce GHG emissions. State mandates include the Renewables Portfolio Standard, low carbon fuel standard, and AB 1493

[3] Calcination involves heating raw materials to over 2,500°F, which liberates CO_2 and other trace materials (Portland Cement Association 2011). According to Haselbach (2009), up to 57% of the CO_2 emitted during the cement manufacturing calcination is reabsorbed by concrete over the 100-year life cycle. Roughly 50% of these emissions will be absorbed once the structure is demolished and returned to fine particles (typically through recycling).

(Pavley Rules for vehicle efficiency).[4] Emissions are presented in terms of carbon dioxide equivalent (CO_2e), which accounts for the relative warming capacity (i.e., global warming potential) of individual GHGs.

Table 4.2-1. Annual Greenhouse Gas Emissions from Construction of CM1 (metric tons CO_2e)[a]

Year	Equipment and Vehicles	Electricity	Concrete Batching[b]	Total
1	4,720	7,032	20,187	31,939
2	14,087	10,746	20,187	45,021
3	24,984	22,407	20,187	67,579
4	39,800	99,789	20,187	159,777
5	36,008	145,284	20,187	201,479
6	21,563	169,498	20,187	211,249
7	16,496	106,873	20,187	143,556
8	5,794	36,321	20,187	62,302
9	4,227	36,321	20,187	60,735
Total	**167,680**	**634,272**	**181,686**	**983,638**

[a] Emissions estimates do not account for GHG flux from land disturbance. Surface and subsurface (e.g., tunneling) activities may oxidize peat soils, releasing GHG emissions. However, recent geotechnical surveys indicated that peat is negligible below 80 feet of depth. The tunnel will be placed well below this range (approximately 150 feet) and the design adjusted if peat soils are discovered. Peat material encountered during surface excavation for nontunnel work will be covered with top soil to reduce oxidation.
[b] A portion of concrete batching emissions will be reabsorbed throughout the project lifetime through calcination (Table 4.2-2).
CO_2e = carbon dioxide equivalent.

Table 4.2-2 summarizes long-term GHG emissions associated with operations, maintenance, and increased SWP[5] pumping for the proposed water conveyance facility. Emissions were quantified for both 2025 and 2060 conditions, although activities will take place annually until project decommissioning. Total CO_2e emissions assume implementation of state mandates to reduce GHG emissions and are compared to both the no-action alternative (NEPA point of comparison) and existing conditions (CEQA baseline).[6]

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[4] State mandates do not require action on the part of DWR, but will contribute to GHG emissions reductions. For example, the Pavley Rules will improve the fuel efficiency of vehicles. Equipment used to construct the water conveyance facility will, therefore, be cleaner and less GHG intensive than if the state mandate had not been established.

[5] The water conveyance facility will be owned and operated as a component of the SWP, although a portion of the water pumped will serve Central Valley Project (CVP) customers. Hydropower is the primary energy source for CVP activities. Increased CVP pumping associated with BDCP will, therefore, not directly result in increased GHG emissions (hydro is considered neutral with respect to emissions). However, as noted later in this section, the preference power customers who currently use CVP hydro power will be forced to go to other sources, and some of these will be fossil fuels.

[6] The no-action alternative is the future condition (i.e., 2060) that will occur if none of the BDCP action alternatives were implemented. Existing conditions are current conditions (i.e., 2010) within the Plan Area.

The four potential operational outcomes are as follows.

- **Scenario H1.** Low outflow scenario excludes enhanced spring outflow and excludes Fall X2 operations.
- **Scenario H2.** Includes enhanced spring outflow, but excludes Fall X2 operations. This scenario lies within the range of the other scenarios.
- **Scenario H3.** Evaluated starting operations excludes enhanced spring outflow, but includes Fall X2 operations.
- **Scenario H4.** High outflow scenario includes enhanced spring outflow, and includes Fall X2 operations.

Note that Table 4.2-2 only presents emissions associated with Scenario H1, because it will require the largest potential increase in SWP electricity demand (of the four scenarios).[7]

Table 4.2-2. Greenhouse Gas Emissions from Operation, Maintenance, and Increased State Water Project Pumping, (Scenario H1) (metric tons CO_2e/year)

Emissions Source	2025 Conditions	2060 Conditions
CEQA Baseline[a]		
Maintenance equipment and vehicles	137	136
Concrete absorption[a]	0	-3,815
Increased State Water Project electricity[b]	196,002	75,991
Total Emissions	**196,139**	**72,311**
NEPA Point of Comparison[a]		
Maintenance equipment and vehicles	-	136
Concrete absorption[a]	-	-3,815
Increased State Water Project electricity[b]	-	126,034
Total Emissions	**-**	**316,503**

[a] Assumes that concrete will absorb 7% of carbon dioxide (CO_2) emissions generated by calcination during the lifetime of the structure (i.e., value does not account for CO_2 reabsorbed during project demolition; end-of-life treatment is outside the analysis scope). Given that 2025 conditions only occurs 3 to 5 years after concrete manufacturing, CO_2 absorption benefits were assigned to 2060 conditions.
[b] The NEPA point of comparison compares total CO_2e emissions after implementation of the BDCP to the no-action alternative; whereas the CEQA baseline compares total CO_2-equivalent emissions to existing conditions. Differences in electricity-related emissions under the no-action alternative and baseline conditions differ produce corresponding differences in the net emissions impact associated with increased State Water Project electricity.
CO_2e = carbon dioxide equivalent; CO_2 = carbon dioxide; CEQA = California Environmental Quality Act; NEPA = National Environmental Policy Act.

[7] Delta outflow requirements will be determined by the outcome of a decision tree for the BDCP. The decision tree is divided into four outflow scenarios for the spring and fall. Scenario H1 results in outflows per D-1641 during both the spring and fall. Scenarios H2 through H4 create different requirements, with Scenario H4 resulting in a decrease in SWP electricity demand (and thus, no impact or a positive impact on SWP operational GHG emissions).

4.2.3.2 Other Conservation Measures

Restoration techniques that require physical changes to the environment or use of construction equipment will generate temporary construction emissions through the use of mobile and stationary construction equipment. Pollutants generated by these sources are highly dependent on the total amount of distributed area; the type, location, and duration of construction; and the intensity of construction activity. Thus, construction emissions will vary depending on the habitat restoration and enhancement conservation actions implemented under the BDCP. Nevertheless, construction-related GHG emissions resulting from implementation of the conservation measures are expected to be minor compared to construction emissions associated with CM1 (Table 4.2-1). However, without additional information on the location and types of construction equipment, a quantitative analysis of GHG emissions is speculative.

Operational GHG emissions from the implementation of the conservation measures will primarily result from vehicle trips for site inspections, monitoring, and routine maintenance. Implementing the conservation measures will also affect long-term sequestration rates and wetland CH_4 emissions through land use changes, such as conversion of agricultural land to wetlands, inundation of peat soils, and removal or planting of carbon-sequestering plants. An initial analysis of land cover/use changes associated with the conservation measures indicates that these program elements could have a beneficial impact on GHG emissions in the Delta (Section 4.2.5.3, *Land Use Conversion*). However, as discussed further below, GHG flux from land use change is dynamic and extremely variable. Without additional information on site-specific characteristics associated with each of the restoration components, a definitive and complete assessment of GHG flux is currently not possible.

4.2.4 Cost-Benefit Analysis of Direct Greenhouse Gas Effects and Mitigation

Mitigation measures to reduce GHG emissions generated during construction and O&M of CM1, as well as potential emissions associated with implementation of the conservation measures, are identified in the BDCP EIR/EIS. This section estimates upfront costs (e.g., the purchase and/or installation of a technology) for three required actions that will reduce direct GHG effects.

- Mitigation Measure AQ-15
- Mitigation Measure AQ-19
- Expansion of DWR's Renewable Energy Procurement Program (REPP)

Community benefits gained through implementation of these actions are discussed at the conclusion of this section.

4.2.4.1 Upfront Costs of Mitigation

4.2.4.1.1 Mitigation Measure AQ-15

Mitigation Measure AQ-15 requires developing and implementing a GHG mitigation program to completely offset (i.e., to net zero) construction-related GHG emissions through implementing emissions-reduction projects. The mitigation measure outlines 13 GHG-reduction strategies that will be used in formulating the GHG mitigation program (refer to the BDCP EIR/EIS Chapter 22, *Air Quality and Greenhouse Gas Emissions*, for additional information on each strategy).

- Strategy-1: Renewable Energy Purchase Agreement
- Strategy-2: Engine Electrification
- Strategy-3: Low Carbon Concrete
- Strategy-4: Renewable Diesel and/or Biodiesel
- Strategy-5: Residential Energy Efficiency Improvements
- Strategy-6: Commercial Energy Efficiency Improvements
- Strategy-7: Residential Rooftop Solar
- Strategy-8: Commercial Rooftop Solar
- Strategy-9: Purchase Carbon Offsets[8]
- Strategy-10: Development of Biomass Waste Digestion and Conversion Facilities
- Strategy-11: Agriculture Waste Conversion Development
- Strategy-12: Temporarily Increase Renewable Energy Purchases for Operations
- Strategy-13: Tidal Wetland Inundation

The quantification of initial costs for energy efficiency and renewable energy measures (Strategy-5 through Strategy-8) rely on assumptions and methodologies developed as part of the *Sacramento Municipal Utility District's GHG Forecast and Reduction Measure Analysis* (ICF International 2012). Costs associated with the renewable energy purchase agreement (Strategy-1) are based on current premiums for statewide green pricing programs (U.S. Department of Energy 2012). The price of carbon offsets (Strategy-9) is based on professional experience and carbon market pricing expectations. Initial costs required for renewable diesel (Strategy-4) and increases in renewable energy purchases (Strategy-11) are based on information provided by the State Energy Resources Conservation and Development Commission and DWR, respectively (Raitt pers. comm.; Schwarz pers. comm. (A)). Cost data for Strategies 2, 3, 10, 11, and 13 are either not readily available or beyond the scope of the initial strategy framework (i.e., quantification would require further strategy development).

Table 4.2-3 presents the estimated cost-per-unit (e.g., a kilowatt-hour [kWh] or a gallon of biodiesel) and cost-per-metric ton CO_2e values for the evaluated GHG reduction strategies.[9] Costs associated with unqualified measures (Strategies 2, 3, 10, 11, and 13) are listed as *not evaluated*. As previously noted, upfront costs summarized in Table 4.2-3 will be borne by the BDCP proponents. Implementation of some measures will result in operational costs and/or savings, which will be borne by the beneficiary (e.g., homeowner that received a rooftop solar installation). Please refer to the benefits analysis for additional information on potential operational savings.

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[8] A carbon offset is a reduction in CO_2e that can be used to compensate for emissions generated elsewhere. Carbon offsets are generated by projects that are funded by entities seeking to compensate for their GHG emissions. Offsets created by these projects are claimed by the funding entity and can be used to achieve compliance with emissions limits established by regulations (e.g., California Cap and Trade).

[9] Cost values developed for Mitigation Measure AQ-15 are based on local factors and conditions specific to the Plan Area. The cost-per-metric tons values are therefore relative to the strategies outlined in Mitigation Measure AQ-15 and should not be used for comparative purposes outside the scope of this analysis.

Table 4.2-3. Individual Cost-per-Unit and Cost-per-$MTCO_2e$ for Greenhouse Gas Reduction Strategies

Strategy	Cost/$MTCO_2e$[a,b]	Cost/Unit[a,c]	Unit	Lifetime[d]
Strategy-1: Renewable Energy Purchase Agreement	$43–$214	$0.01–$0.05	kWh purchased	9
Strategy-2: Engine Electrification	NE	NE	NE	NE
Strategy-3: Low Carbon Concrete	NE	NE	NE	NE
Strategy-4: Renewable Diesel and/or Bio-diesel	$19–$50	$0.19–$0.51	Gallon biodiesel	9
Strategy-5: Residential Energy Efficiency Improvements[e]	$140	$3,749	Retrofit package	18
Strategy-6: Commercial Energy Efficiency Improvements[e]	$79	$0.61	Square feet Retrofitted	18
Strategy-7: Residential Rooftop Solar[e]	$214	$4,771	3.4 kW System	25
Strategy-8: Commercial Rooftop Solar[e]	$171	$251,868	224 kW System	25
Strategy-9: Purchase Carbon Offsets	$5–$50[f]	$5–$50	$MTCO_2e$	9
Strategy-10: Biomass Waste Digestion/Conversion[e]	NE	NE	NE	NE
Strategy-11: Agriculture Waste Conversion Development[e]	NE	NE	NE	NE
Strategy-12: Increase Renewable Energy Purchases	$97	$1,500,000	36 GWh	9
Strategy-13: Tidal Wetland Inundation	NE	NE	NE	NE

[a] For simplicity, all costs were assumed to occur during year 1 of construction and were quantified using current prices.

[b] Initial cost divided by lifetime GHG reductions.

[c] Initial cost divided by the purchase unit.

[d] Represents the time over which the measure generates emissions reductions. Offsets and onsite strategies (e.g., 1, 4, 9, and 12) are only required during the construction period. As such, the lifetime for these measures was assumed to be nine years. Lifetimes for measures that fund long-term improvements, such as efficiency retrofits or renewable energy systems, were based on the actual lifetime of the installed facility (ICF International 2012).

[e] Strategy may result in operational cost savings for the beneficiary. Please refer to the benefits analysis for additional information.

[f] Carbon offset price is sensitive time, offset type, (e.g., livestock project) market type (e.g., California, national, international), and market conditions. Range based on professional experience and information provided by the Legislative Analyst's Office (Taylor 2012).

NE = not evaluated; $MTCO_2e$ = metric ton carbon dioxide equivalent; GWh = gigawatt-hour; kWh = kilowatt hour.

It is theoretically possible for many of the strategies identified in Table 4.2-3 to independently achieve a net-zero GHG footprint. Various combinations of measure strategies can also be pursued to optimize total costs or community benefits. Total mitigation costs are, therefore, highly variable and depend on the mix of mitigation strategies employed. Accordingly, low-, medium-, and high-cost estimates (discounted at a rate of 3% relative to 2015) were developed and are presented in Table 4.2-4.

Table 4.2-4. Low-, Medium-, and High-Cost Estimates (discounted) for Mitigation Measure AQ-15[a]

Estimate	Strategy	Cost/$MTCO_2e$	Total Initial Cost[b]
Low-cost	Strategy-9: Purchase Carbon Offsets	$5–$50	$4,640,000–$46,380,000
Medium-cost	Combination Approach[c]	$55–$125	$50,990,000–$115,900,000
High-cost	Strategy-8: Commercial Rooftop Solar	$171	$159,300,000

[a] Calculations do not include costs associated with staff time to develop and implement the mitigation.
[b] Represents total initial costs required to offset construction-related emissions CM1 (Table 4.2-1) to net zero.
[c] Combination of strategies to achieve a balance between costs and local benefits. Final determination of strategies will be decided at a later time and with more complete information. Current analysis includes the following measures and penetration assumptions:
  Strategy-1: Offset 50% of required construction electricity
  Strategy-4: Utilize renewable diesel and/or biodiesel in all diesel-powered equipment
  Strategy-5: Retrofit 2,500 homes in the Plan Area
  Strategy-6: Retrofit 1,000 commercial buildings in the Plan Area
  Strategy-7: Install rooftop solar on 2,500 homes in the Plan Area
  Strategy-9: Offset the remaining emissions (323,846)
$MTCO_2e$ = metric ton of carbon dioxide equivalent

4.2.4.1.2 Mitigation Measure AQ-19

Mitigation Measure AQ-19 requires preparing a land use sequestration analysis to evaluate GHG flux associated with implementation of CM2 through CM11. Capital costs required for the sequestration assessment represent the expected consultant time to prepare a robust analysis consistent with the requirements of Mitigation Measure AQ-19. Based on the expected level of effort and professional experience, preparation of the sequestration assessment will cost between $141,000 and $189,000 (discounted at a rate of 3% relative to 2015). Additional costs may be incurred if the land use analysis demonstrates a net positive GHG flux and project design changes or strategies to reduce GHG emissions are required. Primary costs associated with these activities will include staff time to develop and implement reduction strategies, as well as upfront costs required to purchase and/or install technologies.

4.2.4.1.3 Expansion of DWR's Renewable Energy Procurement Program

In May 2012, DWR adopted the *Climate Action Plan-Phase I: Greenhouse Gas Emissions Reduction Plan* (CAP), which details DWR's efforts to reduce GHG emissions consistent with AB 32. O&M GHG emissions generated by CM1 (Table 4.2-2) may affect DWR's ability to achieve emission-reduction targets outlined in the CAP. Accordingly, DWR will modify its REPP to compensate for GHGs associated with O&M of CM1.[10] Additional renewable energy obtained through the REPP will contribute to annual GHG emissions reductions through the generation of carbon-neutral electricity.

[10] The DWR REPP (GHG emissions reduction measure OP-1 in the CAP) describes the amount of additional renewable energy that DWR expects to purchase each year to meet its GHG emissions reduction goals. The REPP lays out a long-term strategy for renewable energy purchases, though actual purchases of renewable energy may not exactly follow the schedule in the REPP and will ultimately be governed by actual operations, measured emissions, and contracting.

Expansion of DWR's REPP to accommodate GHG emissions generated by O&M of CM1 will result in a net renewable energy increase of 4,125 gigawatt-hours (GWh) over the life of the BDCP (Schwarz pers. comm.). The price differential between renewable and traditional electricity represents the cost to DWR associated with expanding the REPP. Based on estimated renewable energy purchases required for the BDCP and renewable energy price forecasts developed by DWR (Hicks pers. comm.), expansion of the REPP will cost approximately $77.6 million (discounted at a rate of 3% relative to 2015) over the BDCP permit term.

4.2.4.2 Benefits of Mitigation

Many of the strategies outlined in Mitigation Measure AQ-15, as well as expansion of DWR's REPP, will result in financial, environmental, and public benefits for the community that supplement the expected GHG emission reductions. For example, energy efficiency upgrades (Strategy-5 in Mitigation Measure AQ-15) will reduce annual energy costs for the homeowner that receives the retrofit. Based on literature reviews and professional judgment, a qualitative analysis of anticipated benefits is provided for required BDCP mitigation and other emissions reduction activities. Table 4.2-5 summarizes the benefits considered in the analysis.

Table 4.2-5. Summary of Community Benefits of Greenhouse Gas Mitigation

Code	Benefit	Example
-	Community cost savings	Residential rooftop solar PV installations offset a portion of electricity that would have otherwise been purchased from the local utility.
-	Local job creation	Energy efficiency retrofits in Sacramento County create local jobs in home weatherization.
-	State job creation	Procurement of low carbon concrete creates jobs in material manufacturing in Butte County.
-	Toxic/criteria pollutant reductions	Engine electrification reduces equipment fossil-fuel combustion and associated criteria air pollutants (e.g., carbon monoxide) and toxic air contaminates (e.g., benzene).
1	Reduced energy use	Energy efficiency retrofits improve the efficiency of residential buildings. As such, the amount of energy (e.g., electricity, natural gas) consumed per unit of activity will be lowered.
2	Reduced energy volatility	Energy diversification through renewable energy installation buffers facilities from the volatile global energy market.
3	Public health improvements	Reduced regional and local air pollution from engine electrification contribute to improvements in public health.
4	Increased quality of life	Energy efficiency upgrades improve general comfort by equalizing room temperatures and reducing indoor humidity.
5	Increased property value	Energy efficiency upgrades increase property and resale value.
6	Energy diversification/ security	Renewable energy installations buffer facilities from potential energy insecurities.
7	Resource conservation	Biomass waste digesters displace a portion of electricity that would have otherwise been supplied by nonrenewable resources.
8	Reduced landfilled waste	Biomass waste digesters reduce waste generation by converting biomass to energy.
9	Economic opportunities	Wetland creation stimulates rice cultivation, providing revenue for local farmers.

Community cost savings, job creation potential, and toxic/criteria pollutant reductions were ranked (relatively) as low, moderate, or high. Note that the jobs created through implementation of GHG-reduction activities can be grouped into three major categories: direct, indirect, and induced.[11] Depending on their characteristics, GHG-reduction strategies may also generate jobs in different economic sectors (e.g., renewable energy measures might generate more industrial jobs than digester measures). For comparison purposes, the benefits analysis considers direct, indirect, and induced jobs, although effects on each specific job category are not explicitly identified.

Table 4.2-6 summarizes anticipated benefits that will be gained through implementation of required BDCP mitigation and other emissions-reduction activities. Benefits associated with individual strategies outlined under Mitigation Measure AQ-15 are evaluated separately. As noted above, community cost savings, job creation potential, and criteria pollutant reductions are ranked as low, moderate, or high. Other benefits, such as improved quality of life, are identified based on the codes summarized in Table 4.2-5. These benefits were not categorized as low, moderate, or high because many are subjective or tied to external variables, which are currently unknown.

Table 4.2-6. Anticipated Community Benefits Gained through Implementing Required Mitigation for Greenhouse Gas Emissions

Action	Community Cost Savings	Local Job Creation Potential	State Job Creation Potential	Toxic/Criteria Pollutant Reductions	Other Community Benefits
Mitigation Measure AQ-15					
Strategy-1	None	High	High	Low	2, 3, 6, 7
Strategy-2	None	Low	Low	Moderate	3, 7
Strategy-3	None	Low	Low	Low	1, 7
Strategy-4	None	Low	Low	Moderate	3, 6, 7
Strategy-5	High	High	Moderate	Low	1, 3, 4, 5, 7
Strategy-6	High	High	Moderate	Low	1, 3, 4, 5, 7
Strategy-7	High	High	Moderate	Low	2, 3, 5, 6, 7
Strategy-8	High	High	Moderate	Low	2, 3, 5, 6, 7
Strategy-9	None	NE[a]	NE[a]	NE[a]	NE[a]
Strategy-10	Low	Low[b]	Low[b]	Low	2, 6, 7, 8
Strategy-11	Low	Low[b]	Low[b]	Low	2, 6, 7, 8
Strategy-12	None	Moderate	Moderate	Low	2, 3, 6, 7
Strategy-13	None	Low	Low	Low	9
Mitigation Measure AQ-19	None	Low	Low	Low	None
Expansion of DWR's REPP	None	High	High	High	2, 3, 6, 7

[a] Benefits depend on the offset type. For example, international costs will not create local or state jobs, whereas, offsets created through the AB 32 Livestock Protocol may stimulate economic growth in the California Central Valley.

[b] Assumes agricultural facilities will not hire additional staff other than for initial project construction.

NE = not evaluated; DWR = California Department of Water Resources; REPP = Renewable Energy Procurement Program.

[11] Direct jobs = jobs directly created in the industry being analyzed. Indirect jobs = jobs indirectly created in supporting industries. Induced jobs = jobs induced by increased spending throughout the economy.

4.2.5 Cost-Benefit Analysis for Indirect Greenhouse Gas Effects

This section presents an analysis of the potential costs and benefits associated with indirect GHG emissions generated by the BDCP. Potential costs are discussed for three primary indirect effects: increased electricity demand, life-cycle emissions from construction materials, and land conversion. The first to indirect effects above will result in overall costs (e.g., regulatory compliance), whereas the third effect has the potential to result in an economic benefit or cost savings (e.g., climate change moderation). Indirect GHG emissions and associated costs and benefits are influenced by several factors that are currently unknown (such as future carbon costs and regulatory environments). Estimating indirect emissions and economic effects associated with the BDCP would, therefore, be highly speculative. Accordingly, the discussions below are primarily qualitative and focus on the *potential* economic consequences of indirect GHG emissions, including increased regulatory compliance and climate change moderation.

4.2.5.1 Increased Electricity Demand

Implementation of the BDCP will increase SWP electrical load by over 1,000 GWh per year. As discussed previously, DWR's REPP will be modified to purchase additional renewable energy to account for GHG emissions associated with this increased electricity demand. Several renewable energy technologies, such as solar and wind, are considered intermittent resources because they depend on external factors (e.g., sunlight, wind) that cannot be directly controlled. The unreliability of renewable resources creates the need for flexible or dispatchable resources that can quickly accommodate unexpected fluctuations in renewable energy generation.

Renewable resources developed under DWR's REPP may stress grid operation and require additional fast ramping flexible supply. Operational output from flexible resources can be directly controlled and quickly ramped up or down depending on the need. Flexible resources are, therefore, ideal for balancing the variable power output from several renewable resources. Costs associated with procuring new flexible resources will likely be borne by the California Independent System Operator (CAISO), DWR, or other electric service providers. Depending on the fuel type and GHG emissions generated by new flexible resources, these entities may also experience higher costs to comply with the California Cap and Trade regulation.[12] Added capital and operational expenses associated with expanding the REPP will likely be passed to market participants through increased electricity rates or tariffs.

In addition to indirect costs associated with increased SWP electricity demand, implementation of the BDCP may create additional expenses through increased CVP energy use. The CVP generates GHG emissions–free hydroelectric energy. This electricity is sold into the California electricity market or directly to energy users. Implementation of the BDCP will result in a 159-GWh increase in demand for CVP-generated electricity, which will result in a 159-GWh reduction in electricity available for sale from the CVP to electricity users. This reduction in the supply of carbon-neutral electricity to California electricity users could result in a potential indirect effect of the BDCP, as these electricity users will have to acquire substitute electricity supplies that may result in GHG

[12] The California Cap and Trade program is a market-based emissions trading scheme that covers sources responsible for 85% of statewide GHG emissions. Compliance obligations for electric generation and large stationary sources began on January 1, 2013.

emissions. Increased GHG emissions could create additional regulatory costs for entities subject to the California Cap and Trade program.

4.2.5.2 Life-Cycle Emissions from Construction Materials

Unlike direct GHG emissions, which are generated by onsite equipment and vehicle fuel combustion, life-cycle emissions are emitted during upstream and downstream activities required to support construction. Life-cycle emissions from construction are generally associated with mining of raw materials, manufacturing of processed materials, and transporting material and supplies to the work site. The intensity of these activities determines the magnitude of life-cycle emissions; the more energy it requires to mine, manufacture, and transport construction materials, the higher the life-cycle GHG emissions.

Materials used to construct the BDCP, including steel, aggregate, and plastic, require energy to manufacture and transport. Asphalt and concrete are some of the most energy- and GHG-intensive materials to manufacture and are often used as key indicators of life-cycle GHG emissions from construction.

Costs associated with life cycle GHG emissions from construction are diverse, but the most significant are related to regulatory compliance. GHG emissions occurring within California may need to be mitigated and this mitigation can be costly. The California Cap and Trade program covers large stationary sources, including cement plants. The quantity of cement needed for the construction of CM1 will increase cement manufacturing emissions and, may lead to additional regulatory compliance costs for manufacturers. These costs may be reflected in the future price of cement, increasing the total cost of construction for the BDCP. If aggregate produced outside of California is used to support the project,[13] increased California Cap and Trade regulatory compliance costs may be avoided. However, local regulations will affect overall costs of the sourced material.[14]

Estimating potential indirect costs associated with life cycle emissions requires a detailed and comprehensive materials inventory. Key variables for each of the materials, including geographical origin, extraction and transport methods, physical composition, and end of life treatment are required to estimate life cycle GHG emissions. Information on local, regional, and national carbon market conditions are also required to monetize the estimated GHG emissions. While data on required aggregate and materials for the BDCP have been developed, sufficient specificity to quantify indirect life cycle emissions and associated economic costs is current not available.

4.2.5.3 Land Use Conversion

Vegetation, through the process of photosynthesis or primary production, sequesters carbon from the atmosphere into the soil. Conversely, plant respiration and decomposition can release carbon back into the atmosphere. The interplay between GHG emissions released and stored by the land is called GHG flux. Different types of vegetation have varying rates of carbon sequestration and

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13 According to BDCP EIR/EIS Chapter 26, *Mineral Resources*, the regional supply of aggregate (including concrete) is great enough to meet the demands of the BDCP. California imports large volumes of aggregate from Canada and Mexico, and it may be necessary or financially advantageous to purchase some of this imported aggregate if specific aggregate supplies are insufficient at the local or regional level.

14 For example, aggregate sourced from outside California may be subject to future costs if regulatory mechanisms are adopted by other state or federal governments. Local regulations may also affect transport costs and other construction materials sourced from outside California.

respiration depending on several factors, including the vegetation type, climate, soil content, and rainfall. Converting land from one type to another can also change the rate of sequestration and decomposition. Figure 4.2-2 provides a high-level representation of GHG flux in wetlands. Wetlands both sequester carbon sources and release CH_4 and N_2O into the atmosphere, as discussed further in this section.

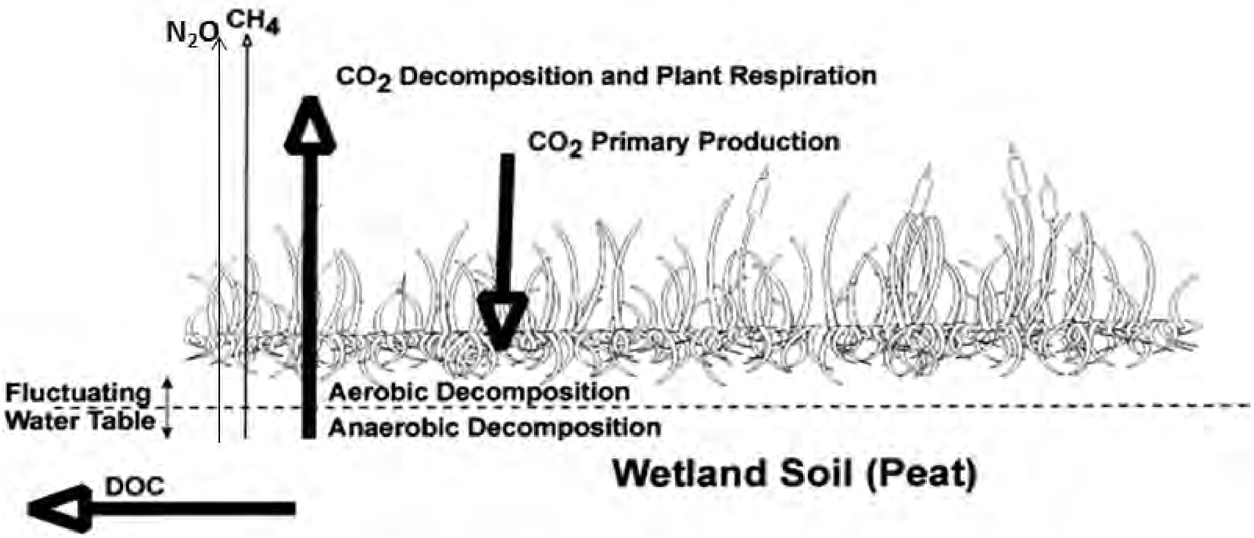

Figure 4.2-2. Greenhouse Gas Flux in a Wetland

Implementation of the conservation measures will convert land types to increase available habitat for BDCP covered species (e.g., cultivated land converted to tidal natural communities). Land use conversion can initially result in a loss of carbon storage during construction, but over time the newly restored land has the potential to increase the carbon sequestration capacity of the Plan Area. Likewise, restored habitat has the potential act as a carbon sink by sequestering CO_2 from the atmosphere. However, some land types like wetlands also release carbon and CH_4 (Figure 4.2-2), so the net change in the total greenhouse gas flux must be calculated carefully.

Table 4.2-7 presents a summary of converted land type acreages associated with implementation of all BDCP conservation measures. This table shows existing acres of land (before the BDCP), acres of land at year 40 (when BDCP restoration will be completed), and the amount of converted land as a result of the BDCP.

Quantifying the GHG flux from land conversion is difficult because of the numerous local factors that affect carbon uptake by land. For example, soil mineral content, plant density, organic content of the soil, and moisture all play a role in sequestration. Many land types (especially wetlands) also emit CH_4, which can partially or completely offset carbon sequestration. In addition, the restoration of agricultural land may result in leakage, which means that if agricultural land is lost in the Plan Area, it may be gained in another area. Leakage is generally driven by economic forces: if the demand for agricultural land remains constant, this land may be recreated elsewhere, offsetting the carbon sequestration gains achieved in the Plan Area.

Analysis of GHG fluxes from wetlands has received a considerable amount of study in the last two decades. Wetlands sequester CO_2, but at a much slower rate than saline marshes (Trulio 2007). While wetlands can remove CO_2 from the atmosphere, they can also emit large quantities of CH_4

through anaerobic decomposition of biomass, as well as CO_2 through peat soil oxidation. Since CH_4 is a far more potent GHG, when compared to CO_2, CH_4 production may overwhelm the benefits obtained from carbon sequestration (U.S. Climate Change Science Program 2007).

Table 4.2-7. Acres of Land Cover Types Converted by the BDCP

Land Cover Type	Total Lost (converted from)	Land Cover Types Added (converted to)[a]					
		Developed	Grassland	Open Bay	Alkali Wetland	Freshwater Wetland	Riparian Forest and Scrub
Tidal perennial aquatic	-51	51	0	0	0	0	0
Tidal mudflat	0	0	0	0	0	0	0
Tidal brackish emergent wetland	0	0	0	0	0	0	0
Tidal freshwater emergent wetland	-16	13	0	0	0	3	0
Valley/foothill riparian	-873	321	0	0	0	552	0
Nontidal perennial aquatic and nontidal freshwater perennial emergent wetland	-362	75	0	287	0	0	0
Alkali seasonal wetland complex	-72	45	0	27	0	0	0
Vernal pool complex	0	0	0	0	0	0	0
Managed wetland	-12,813	27	0	8,532	3,000	1,254	0
Other natural seasonal wetland	0	0	0	0	0	0	0
Grassland	-2,557	654	0	0	3	1,490	410
Cultivated lands	-55,800	6,574	2,000	20,052	2	22,619	4,553
Developed	-598	136	0	462	0	0	0
N/A[b]	-37	0	0	0	0	0	37
Total	**-73,179**	**7,896**	**2,000**	**29,630**	**3,005**	**25,918**	**5,000**

[a] The land type categories listed here are broader than the ones used by the BDCP EIR/EIS, because this is a simplified analysis that uses carbon sequestration values for general land types.

[b] Thirty-seven acres of riparian forest will be added under *CM6 Channel Margin Enhancement*. The terrestrial impact assessment assumes no loss of habitat for this restoration.

Dynamic wetland conditions make estimating potential changes in GHG emissions from restoration extremely variable and uncertain. In particular, key variables, including carbon cycling, CH_4 production, and nitrogen cycling vary by land use type, season, and site-specific chemical and biological characteristics. Depending on these conditions, wetland restoration associated with the BDCP may result in a net increase or decrease in GHG emissions. Given the number of local variables and lack of definitive scientific evidence supporting specific carbon uptake and CH_4 emission rates, estimating the GHG flux for converted wetlands from implementation of the conservation measures is highly uncertain.

Calculating the net difference in emissions between the removal and addition of GHGs into the atmosphere (i.e., GHG flux) requires site-specific land characteristics (e.g., salinity, pH, age of trees, type of grass, carbon content of soils) and fuel consumption data. Future analysis of wetland effects pursuant to Mitigation Measure AQ-19, as well as further development and verification of carbon uptake and CH_4 rates, may demonstrate a net GHG benefit associated with CM2 through CM22.

For the purposes of this analysis, a range of potential GHG flux values based on typical CO_2e flux densities for the restored land types was derived from a literature review. The primary source for wetland and cultivated land flux, which constitute the bulk of the converted land types and associated change in total GHG flux, is Merrell et al. (2011). This study addresses GHG flux within the Delta and uses measurements taken at Twitchell Island to represent conditions within the Delta as a whole. The flux values cited in Merrell et al. (2011) may not necessarily represent actual GHG flux values for land types located in the Plan area, but are intended to represent a reasonable range of GHG flux that could be expected from the Plan Area. Actual rates of subsidence on cultivated lands, carbon sequestration, and CH_4 emissions in wetlands vary substantially based on local agriculture practices, soil composition, dynamic wetland conditions, and many other factors.

Table 4.2-8 quantifies changes in GHG flux as a result of the conservation measures. As noted above, a range is presented to account the variability in actual GHG fluxes and illustrate the uncertainty inherent in analyzing the change in GHG emissions from land conversion. It is also important to note that the values used in this analysis are only an estimate based on general GHG flux values and do not reflect actual conditions at the project site. As such, the results of this analysis are estimates and should not be used as an absolute and perfect assessment of GHG fluxes due to land conversion. Please refer to Appendix A, *Greenhouse Gas and Air Quality Analysis Assumptions*, for the flux densities assumed in the emissions calculations and associated assumptions.

Table 4.2-8. Net Greenhouse Gas Flux as a Result of Land Conversion and Restoration

Land Cover Type	Net Change (acres)	Range of Greenhouse Gas Flux ($MT\ CO_2e$ per year)[a]	
		Low	High
Tidal perennial aquatic	-51	-172	-74
Tidal mudflat	0	0	0
Tidal brackish emergent wetland	0	0	0
Tidal freshwater emergent wetland	25,902	-85	151
Valley/foothill riparian	4,127	4,257	-5,931
Nontidal perennial aquatic and nontidal freshwater perennial emergent wetland	-362	-1,359	4,636
Alkali seasonal wetland complex	2,933	-395	869
Vernal pool complex	0	0	0
Managed wetland	-12,813	-28,339	111,227
Other natural seasonal wetland	0	0	0
Grassland	-557	-9,251	-18,171
Inland dune scrub	0	0	0
Cultivated lands	-55,800	-667,998	-1,126,355
Developed	7,298	1,855	795
Open Bay	29,323	-15	-15
Total	0	-683,000	-1,032,868

CO_2 Flux is the difference in CO_2 flux before and after implementation of the conservation measures. Negative (-) values are a sink, positive (+) values are an emission. These values are not the multiplication of the net change in acres by the flux density; the calculation depends on both the type of land lost and the type of land restored. See Table 4.2-7 for these values.

As shown in Table 4.2-8, land conversion may result in a net reduction of approximately 683,000 to 1,033,000 metric tons of CO_2e per year (low to high range). This benefit is primarily gained through the conversion of cultivated lands, which are relatively GHG-intensive (Appendix A, *Greenhouse Gas and Air Quality Analysis Assumptions*), to land use types with lower annual GHG emissions (primarily wetlands). Please note that these results are an estimate of CO_2e flux from the conservation measures and are based on general land types as reported in various studies. The GHG flux values are not necessarily specific to the local conditions in the Plan Area and only serve as an estimate of potential carbon benefits of land conversion.[15]

4.2.5.3.1 Carbon Offset Creation and Climate Change Mitigation

As discussed, implementation of the conservation measures has the potential to reduce GHG emissions in the Plan Area. Changes in GHG flux may have the potential to support carbon offsets, which can be sold in established carbon markets. However, the majority of funding for the conservation measures comes from public funding sources at the state and federal level. Therefore, it is assumed that carbon offsets would not be pursued, and the economic benefits from climate change moderation gained by long-term GHG reductions would accrue to the public at large.

Many studies have attempted to quantify the social cost of carbon. ESA (2013) recently completed a cost benefit analysis for tidal marsh restoration in the San Francisco Bay Area. The analysis values carbon sequestration services at $5 to $67 per ton of CO_2, which is based on a 2010 study by the Interagency Working Group on Social Cost of Carbon (Interagency Working Group on Social Cost of Carbon 2010; ESA 2013). The range reflects the potential reduced community costs associated with climate change moderation achieved by CO_2 emissions reduction.

Table 4.2-9 summarizes the range in potential communitywide economic benefits associated with long-term GHG reductions from land use conversion. The table presents annual savings as well as cumulative savings over the 50-year restoration lifetime of the conservation measures (discounted at a rate of 3% relative to 2015). The cumulative value was calculated using the restoration timeline presented in BDCP EIR/EIS Table 6-2 along with the GHG flux values provided in Appendix B, *Land Conversion and GHG Flux Assumptions*. According to Table 6-2, approximately 11% to 14% of the total acreage of restoration occurs in each 5-year time period. In order to conservatively estimate the value of potential carbon offsets, it was assumed that the acres of land would be fully restored in 5-year period following the period of restoration (e.g., if 5,000 acres are restored during years 1 through 5, then these acres would start sequestering additional carbon during year 6).

[15] To illustrate the uncertainty of this analysis, an additional range of GHG flux was calculated using flux densities for wetlands and agricultural areas from a variety of sources in addition to Merrell et al. (2011). Using this larger range in GHG flux, land conversion may result in a net *increase* of approximately 122,392 metric tons of CO_2e per year to a net reduction of approximately 2,190,123 metric tons of CO_2e per year (low to high range).

Table 4.2-9. Estimated Economic Benefits Associated with Land Conversion (million $, discounted)

Condition	Low Range[a]	High Range[a]
Annual	$3–$46	$5–$69
Cumulative[b]	$35–$473	$53–$715

[a] Low and high values based on the range in estimated GHG emissions from land use flux (Table 4.2-8). Internal cost range based on the estimated social cost of carbon between $5 and $67 per ton.

[b] Cumulative savings based on the 50-year restoration lifetime for the conservation measures. Cumulative costs have been discounted at a rate of 3% relative to 2015.

As shown in Table 4.2-9, GHG emissions reduced by the project could result in a communitywide economic benefit of $3 million to $46 million per year for the low range of GHG flux and $5 million to $69 million per year for the high range of GHG flux. Over the 50-year restoration lifetime of the conservation measures, GHG emissions reduced by the project could result in a communitywide economic benefit of $44 million to $590 million for the low range of GHG flux and $53 million to $715 million for the high range of GHG flux.

4.3 Flood Risk

4.3.1 Introduction

This section discusses in qualitative terms the economic impacts of flood risk in the Delta associated with implementation of the BDCP. The BDCP would affect flood risk in the Delta region by altering flows of water throughout the Plan Area. Effects on area flood risk would occur as a result of the operations under *CM1 Water Facilities and Operation* and the implementation of other conservation measures that would cause changes in the landscape (CM2 through CM11), particularly *CM4 Tidal Natural Communities Restoration* and *CM5 Seasonally Inundated Floodplain Restoration*. These components of the BDCP are expected to have both positive and negative influences on flood risk in the Delta region. Changes to the volume and patterns of water flows can increase or decrease flood risk by adding more or less pressure on levees. Upstream reservoirs and flood bypasses also play a large role in hydrology and flood management in the Delta. Nineteen major multipurpose dams, the Sacramento River Flood Control Project, and San Joaquin River flood management facilities reduce flood potential in the Sacramento and San Joaquin Rivers and their tributaries, and the Delta. Although the land use changes resulting from the BDCP will result in increases and decreases in flood risk, the overall change to flood risk in the Delta from the BDCP is expected to be minimal.

This section first provides a brief overview of flood risk in the Delta region, and then provides a brief qualitative overview of how different components of the BDCP may affect flood risk. Finally, this section describes methods that have been used to estimate economic impacts related to flood risk, and discusses the challenges for estimating these impacts for the BDCP.

4.3.2 Flood Risk in the Delta

The Delta region contains many levees that constrain the flow of water in the region and protect against flooding of cultivated lands and developed areas. When levees fail, the effects can be damaging to both the immediate area and the Delta region. Because of the delicate balance of fresh and saltwater in the Delta region, the levee system is particularly important. When Delta levees fail, the Delta water system can be compromised by an influx of saltwater from the ocean (CALFED 2007). An influx of saltwater in the Delta increases the salinity of the water, degrading the quality of water that is used for drinking or agriculture. A failure of multiple levees within the Delta would result in extensive saltwater intrusion and would significantly degrade water quality in the Delta region, potentially reducing SWP/CVP deliveries for some period of time. This would have significant negative economic impacts on the entire state of California and the economic impacts would potentially extend to other states. Two out of three Californians (66% of the state's population from San Jose to San Diego) and three million acres of farmland receive some of their water supply from the Delta. In addition, levee failure can harm the plants and animals that rely on the current concentrations of salinity in Delta waters. Beyond compromising water quality, extreme flood events can destroy houses, farms, and infrastructure in the region.

The majority of leveed lands in the Delta and Suisun Marsh are highly subsided, which means that island elevations are below mean sea level. Subsided, leveed lands are vulnerable to catastrophic failure because once a levee fails in one spot, the entire island, or a large portion of the island, is likely to flood. Catastrophic flooding can occur spontaneously due to levee failure ("sunny day" events) or during high-water events caused by extreme river flooding, or tidal surge. The increase in water surface elevation associated with high-water events is likely to overcome any localized decrease in average tidal elevation realized from tidal restoration.

One project being pursued in the Plan Area to address flooding concerns is the Lower San Joaquin River Bypass. This project would create a flood bypass on the lower San Joaquin River in the south Delta similar in function to the existing Yolo Bypass in the north Delta. The project is a collaborative effort between local reclamation districts, the South Delta Water Agency, local developers, and environmental organizations. A new Lower San Joaquin River Flood Bypass would substantially reduce flood risk for key areas in San Joaquin County and the cities of Manteca, Lathrop and Stockton. The new bypass would also enable habitat restoration actions that are difficult given the current conveyance constraints of the flood system. Future flood management actions such as levee setbacks in the new bypass would provide new opportunities for habitat restoration. The expanded bypass is specified as an important regional improvement in the *2012 Central Valley Flood Protection Plan (CVFPP)* and the *CVFPP Regional Project Summaries* (California Department of Water Resources 2012: Volume II, Attachment 7A).

4.3.3 CM1 Water Facilities and Operation

CM1 would construct new water diversion points in the north Delta and provide a means to transport water supplies under the Delta rather than through sensitive natural channels. This would address the reverse flow conditions for Old and Middle Rivers that are associated with 100% reliance on south Delta intakes, except during May and April, restoring more natural flow patterns to the Delta. However, the change in water flows brought on by the construction and operation of CM1 is not expected to significantly decrease flood risk. The surface water analysis addresses changes to surface waters affected by changes in SWP/CVP operations under the BDCP (primarily CM1 and CM4) in the Delta Region, upstream of the Delta Region, and in Export Service Areas. Factors that affect surface waters include operations requirements related to water supplies provided by SWP/CVP facilities (including water supplies to downstream water rights holders), SWP/CVP reservoir storage (multipurpose dams such as Oroville, Shasta, and Friant are operated in the winter and spring to reduce flood potential and replenish storage), and Delta outflow. As described in the BDCP EIR/EIS Chapter 5, *Water Supply*, the ability to release water from storage to SWP/CVP water users is dependent on the capability of the reservoir to store adequate water to meet instream releases, especially with cold water to protect aquatic resources, and to meet requirements to maintain freshwater conditions in the western Delta (as described in the EIR/EIS Chapter 8, *Water Quality*). To examine the changes in flood risk from CM1, the changes in channel volume of various waterways in the Plan Area were analyzed. The analysis focused on the percentage increase or decrease in channel capacity associated with flood events with a 10% or lower probability of occurring (i.e., a 10-year flood event). These flood events include the possible impacts resulting from climate change and sea level rise.

Table 4.3-1 summarizes the findings. Based on this analysis, the change in water flows brought on by the operation of CM1 is not expected to significantly increase flood risk in the Delta.

Table 4.3-1. Flood Flow Assessments

Location	BDCP Impacts (compared to baseline scenario)
Sacramento River at Freeport	Decrease by 1% of the channel volume (110,000 cfs)
San Joaquin River at Vernalis	Remain a similar channel volume (or show less than 1% change with respect to the channel volume: 52,000 cfs)
Sacramento River at Locations Upstream of Walnut Grove (downstream of north Delta intakes)	Decrease channel volume by 8% (in scenarios H1 and H2) to 9% (in scenarios H3 and H4) of the channel capacity (110,000 cfs)[a]
Trinity River Downstream of Lewiston Dam	Retain channel volume similar to (or show no more than 1% increase) current channel capacity (6,000 cfs)
American River Downstream of Nimbus Dam	Retain channel volume similar to (or show less than 1% change with current channel volume: 152,000 cfs)
Feather River Downstream of Thermalito Dam	Increase by no more than 1% of the channel volume (210,000 cfs)
Yolo Bypass at Fremont Weir	Increase by no more than 1% of the channel volume (increase would only occur at times of relatively low flow in the bypass)

Source: California Department of Water Resources et al. 2013: BDCP EIR/EIS Chapter 6, *Surface Water*, Table 6-2, *Surface Water Summary Table*

[a] Scenario H1: Low outflow scenario excludes enhanced spring outflow and excludes Fall X2 operations.
Scenario H2: Includes enhanced spring outflow, but excludes Fall X2 operations. This scenario lies within the range of the other scenarios.
Scenario H3: Evaluated starting operations excludes enhanced spring outflow, but includes Fall X2 operations.
Scenario H4: High outflow scenario includes enhanced spring outflow, and includes Fall X2 operations.

cfs = cubic feet per second

4.3.4 Other Relevant Conservation Measures

Several of the other conservation measures are expected to have a beneficial impact on flood risk in the Delta. *CM4 Tidal Natural Communities Restoration* calls for the restoration of at least 55,000 acres of tidal wetlands, and 10,000 acres of associated upland transitional areas to accommodate sea level rise. Full implementation of this conservation measure by year 40 of the BDCP permit term is expected to reduce flood risk within and adjacent to the five restoration opportunity areas (Suisun Marsh, Cache Slough, West Delta, Cosumnes-Mokelumne, and South Delta), where the majority of this tidal restoration would occur. This reduction in flood risk would result from flood control provided by wetlands[1], including the easing of water flow, capacity for water absorption, and slow release of water after a flooding event. The magnitude of this flood risk reduction is unknown but is assumed to be small, and while it could reduce the overall potential for any given levee to fail, it is not expected to significantly decrease the risk of catastrophic flooding to any given parcel. The increase in water surface elevation associated with high-water events is likely to overcome any localized decrease in average tidal elevation realized from the tidal restoration.

[1] Hydrodynamic modeling conducted as part of the BDCP EIR/EIS Chapter 5, *Water Supply*, indicates that tidal restoration under CM4 would likely cause localized tidal damping (California Department of Water Resources et al. 2013). This phenomenon occurs when there is a reduction in tidal amplitude (i.e., high tide is, on average, lower in elevation, and low tide is, on average, higher in elevation).

Under *CM5 Seasonally Inundated Floodplain Restoration*, the BDCP would restore at least 10,000 acres of floodplains that historically existed in the south Delta but have been lost due to flood control, channelization, and levees around Delta islands. Floodplain restoration would involve installing new levees inland from existing levees and breaching existing levees along the San Joaquin River and its tributaries. Once implemented, CM5 would help to mitigate the effects of high-water events that are expected to increase in frequency with the onset of climate change (BDCP EIR/EIS Chapter 6, *Surface Water*). Using modeling, other technical analyses, and a series of formal evaluation processes, BDCP identified areas in the south Delta with the greatest potential to implement conservation measures and simultaneously achieve benefits in flood risk reduction (BDCP Appendix 5.E, Attachment 5E.A, *BDCP South Delta Habitat and Flood Corridor Planning*).

Other conservation measures would restore nontidal natural communities and habitat for terrestrial covered species. Target natural communities include riparian woodland (CM7), grassland (CM8), vernal pool landscapes and alkali seasonal wetland (CM9), and freshwater nontidal wetlands and managed marsh (CM10). The vegetation on these restored lands is expected to help to reduce flood risks by improving soil permeability and groundwater recharge, absorbing surface water, and creating a natural buffer for water flows (U.S. Environmental Protection Agency 2006). Although natural areas cannot prevent a flood incident, they mitigate the intensity of flooding incidents compared to those that occur in areas with developed land and impervious surfaces (McShane 2012). The ability for natural lands to mitigate flood risk depends on several interconnected factors. For example, flood risk corresponds to the location of the land in relation to water flows in the region, the size of continuous parcels of restored or natural land, the annual precipitation rate in a region, the volume of water in an extreme flooding event, the frequency and magnitude of flooding events, and other factors.

4.3.5 Methods for Estimating Impacts

Economists have developed a variety of methods for ascribing a monetary value to ecosystem services such as the reduction of flood risk. This particular ecosystem service is most commonly valued by cost-based methods such as the damage cost, replacement cost, and substitute cost methods. These methods all attempt to value an ecosystem service by estimating the costs that could be incurred due to loss of an ecosystem service. The damage cost method estimates the cost of damages that could result if ecosystem services were lost, such as the cost to replace a destroyed home after a flood; the replacement cost method estimates the cost to replace the lost ecological service; and the substitution cost method estimates the cost to provide a substitute for the lost ecosystem service (U.S. Environmental Protection Agency 2010).

Changes in flood risk have been most commonly estimated by the damage cost method. One approach is to use data from previous flood events as a proxy for the damages that could occur from a flood event in a given area. To the degree that ecosystem services mitigate flood events expected to be of a similar magnitude as past events, the value of flood risk mitigation is equal to the percent risk reduction multiplied by the economic cost of a flood event (as measured by the cost of past events). A challenge with this method, though, is finding data on past flood events that are a close match to the current situation being studied, as the cost of flood events can vary widely. Some of this variation relates to the amount of property damage that occurs from a flood and the value of that property.

4.3.6 Challenges for Estimating Impacts

Because of the uncertainties that surround the impacts of the BDCP on flood risk in the Delta, this study was unable to quantify or monetize the economic impacts of changes in flood risk. For example, although the BDCP will likely result in localized tidal damping, the relationship between tidal damping and the ability of a particular levee to withstand a catastrophic water event is not known. Several confounding factors contribute to the ability of a levee to withstand a catastrophic event: materials, age of the levee, sustained pressure from tides, and severity of the catastrophic event. Additionally, levees that are not properly maintained could affect neighboring levees and increase the risk of occurrence of other levee failures. Because of the uncertainty in estimating the risk of levee failure and predicting the frequency and/or severity of events that would generate levee failure, this study was unable to quantify the precise change in flood risk resulting from the BDCP.

One other option for estimating the economic impact of the BDCP on flood risk would be to use the replacement cost method to estimate the cost savings from reductions in the amount of levees needed as a result of restoration under the BDCP. Making this calculation, however, would require precise quantitative information on how the conservation measures reduce flood risk. The rate of flood risk reduction provided by natural areas, however, is difficult to quantify. For example, the capacity of a wetland varies widely based on the type, the time of year, the proximity to other wetlands, the overall health of the wetland, and other factors. Because of the uncertainty around the actual reduction in flood risk provided by natural areas, it is not possible to use the replacement cost method to estimate the economic impact of the BDCP on flood risk.

For these reasons, the economic impacts of changes in flood risk as a result of the BDCP are described only qualitatively.

4.4 Property Values and Viewscapes

4.4.1 Introduction

This section discusses in qualitative terms the economic impacts—both positive and negative—of changes in the values of properties in the Delta region associated with the BDCP activities (i.e., impacts on property values for properties located near proposed facilities or conservation measures). The BDCP may affect area property values due to both the construction and operation of the water conveyance facility (*CM1 Water Facilities and Operation*, or CM1), and implementation of other conservation measures, particularly natural community protection, restoration, and enhancement measures (CM2 through CM11). This section briefly discusses these impacts, how they have been valued in other studies, and the challenges surrounding quantifying and monetizing these impacts in the Delta region that led to evaluate these impacts on a qualitative basis.

The impacts of the BDCP on property values could result from both the construction and operation of the water conveyance facility (CM1) and the implementation of other conservation measures. The BDCP could affect property values through changes to air quality, water quality, noise, traffic, and land use (including proximity to undesirable land uses such as landfills, power plants, or incinerators and proximity to open spaces such as parks and natural areas). This study uses various methods and approaches to quantify and monetize these impacts. Because these impacts have been estimated by other means, including the impacts of these attributes on property values would result in double-counting of these impacts. For example, Section 4.1 estimates the economic impacts of the BDCP related to air quality. If this study also included potential decreases in property values in the Delta due to air quality impacts, the economic impacts of the BDCP related to air quality would be counted twice. Thus, this section focuses on changes under the BDCP that could affect property values that have not been estimated by other means (e.g., impacts from changes to viewscapes and noise).

4.4.2 CM1 Water Facilities and Operation

BDCP EIR/EIS Chapter 17, *Aesthetics*, provides a detailed assessment of the changes in viewscapes that will result from implementation of the BDCP (California Department of Water Resources et al. 2013). As noted in the EIR/EIS, construction of the water conveyance facility will substantially alter the existing visual quality and character of certain locations in the Plan Area. The long-term nature of construction of the intakes, operable barrier, pipeline/tunnel, work areas, spoil/borrow and tunnel material disposal and reutilization areas, shaft sites, and barge unloading facilities; presence and visibility of heavy construction equipment; proximity to sensitive receptors; relocation of residences and agricultural buildings; removal of riparian vegetation and other mature vegetation or landscape plantings; earthmoving and grading that result in changes to topography in areas that are predominantly flat; addition of large-scale industrial structures (intakes and related facilities); remaining presence of large-scale borrow/spoil and reusable tunnel material area landscape effects; and introduction of tall, steel transmission lines will all contribute to this impact.

Construction of the water conveyance facility will last up to 9 years and will change the existing visual character in specific locations from those of agricultural, rural residential, or riparian and riverine settings to areas involving heavy construction equipment, temporary construction structures, work crews, other support vehicles and other activities that will modify and disrupt short- and long-range views. The construction rollout would be staggered, and thus specific sites would only be affected for a portion of the 9-year construction period. Properties affected by these changes in visual character include the following sites; although impacts on these sites, as well as the actual sites, may change depending on the final route of the tunnel, if one is constructed.

- Sites near the Sacramento River where intake and intake pumping plant facilities are proposed for construction, between River Mile 41 and River Mile 37. Specifically, residences and businesses in and near the towns of Clarksburg and Hood will have direct views of construction activities associated with these facilities, including tunnel shaft sites, borrow and spoil areas, and tunnel material disposal and re-use areas.
- Sites near barge unloading facilities on the following waterways: Sacramento River, North Fork Mokelumne River, San Joaquin River, Middle River, and Woodward Canal. Businesses and residential properties with views and vistas that include the sites will be affected by activities associated with these facilities.
- Sites near the head of Old River, west of Lathrop, where an operable barrier is proposed for construction.
- Sites throughout the conveyance facility alignment, where power lines would be constructed, and where construction traffic would move between individual work sites.

These construction activities will be disruptive to some viewers. Once construction is complete at the three intake locations, the BDCP will result in the placement of large, multistory industrial concrete and steel structures, pumping stations, fencing, and other similar anthropogenic features where none presently exist. Other large permanent structures in the Plan Area that could disrupt views include the new transmission line, the intermediate forebay, and the Byron Tract forebay adjacent to Clifton Court Forebay. At all other sites along the tunnel alignment, new permanent structures will be isolated and typically small (e.g., vent shafts, transmission line substation) and will therefore have minimal impacts on views in the region.

BDCP EIR/EIS Chapter 23, *Noise,* evaluates the noise impacts on nearby properties from construction of the water conveyance facility. The EIR/EIS notes that, while equipment could operate at any work area identified for construction under the BDCP, the highest noise levels are expected to occur at those sites where the duration and intensity of construction activities will be the greatest. The work areas for construction of Intakes 2, 3, and 5 will extend through several residential areas and communities located near the Sacramento River. Noise from intake construction activities is predicted to exceed daytime and nighttime noise thresholds at a small number of residential properties in the affected counties, as presented in BDCP EIR/EIS Tables 23-61 and 23-62.

4.4.3 Other Conservation Measures

Impacts on property values could also result from the natural community protection, restoration, and enhancement actions under other conservation measures, as described below. BDCP EIR/EIS Chapter 17, *Aesthetics,* notes that there may be site-specific, localized adverse visual effects from implementation of these measures. The impacts on property values could occur during construction and operation, and are expected to be both positive and negative. The following list presents each of the conservation measures expected to have an impact on property values, and provides some detail on its expected impact on property values.

- ***CM2 Yolo Bypass Fisheries Enhancement.*** Increased duration and frequency of flooding in the Yolo Bypass is expected to reduce the value of a limited number of private properties, because the additional flooding will reduce the duration of agricultural production at some sites and reduce the number of suitable crops. Howitt et al. (2013) estimated the economic impact on Yolo County due to increased flooding by analyzing 12 scenarios representing differing impacts on agriculture and the Yolo County economy. The scenario in this study representing CM2 resulted in annual losses to the Yolo County economy of $0.63 million (assuming flooding up to 3,000 cfs) to $1.5 million (assuming flooding up to 6,000 cfs). The study used an economic input/output model to estimate these economic impacts, which are based on disruptions to the agricultural economy and not on changes to property values.[1]
- ***CM3 Natural Communities Protection and Restoration.*** The BDCP will acquire in fee title and conservation easement an estimated 62,955 acres to permanently protect intact natural communities and preserve habitat for covered species. This conservation measure is expected to increase the values of private property adjacent to and near this new open space. Studies in other geographic locations have found positive impacts on property values for properties adjacent to similar kinds of open space, such as protected wetland areas. An example is a study by Doss and Taff (1996), as well as other studies discussed below in Section 4.4.4.2, *Other Conservation Measures*.
- ***CM4 Tidal Natural Communities Restoration.*** The restoration of at least 65,000 acres of tidally influenced natural communities will create substantial new areas of protected open space and will increase recreational values in the region. This conservation measure may increase the values of a small number of properties on the margins of the restoration opportunity areas due to increased wildlife viewing and the reduction in dust and noise from agricultural operations replaced by the restoration site.
- **CM7, CM8, CM9, and CM10: Other Natural Community Restoration.** Natural community restoration of riparian woodland (CM7), grassland (CM8), vernal pool complex and alkali seasonal wetland (CM9), and nontidal marsh and managed wetland (CM10) are expected to increase the values of properties immediately adjacent and in the vicinity of restoration sites, as discussed below. At least 8,569 acres of these natural communities will be restored, which, in many cases, will also require acquisition of private land and conversion to permanent open space. Riparian woodland and grassland restoration will also have aesthetic values to nearby private property that could increase their property value. These positive effects on property value could occur throughout the Plan Area near specific restoration sites.
- ***CM13 Invasive Aquatic Vegetation Control.*** The BDCP will substantially expand the existing program of the California Department of Boating and Waterways to control invasive aquatic vegetation throughout the Delta. Serious invasive species such as Brazilian waterweed (*Egeria densa*) and water hyacinth (*Eichhornia crassipes*) are expected to be largely eliminated in the Delta. Where infestations are severe, invasive aquatic vegetation can substantially limit or degrade boating opportunities, because the vegetation fouls motors. This conservation measure has the potential to increase the values of waterfront properties, especially those with boat docks that are recreation-dependent, and that occur near current infestations of invasive aquatic vegetation that will be controlled by the BDCP.

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[1] Some properties affected by CM2, such as those in the Frazio Refuge are publicly owned. Impacts on the values of these properties thus do not affect private parties.

4.4.4 Methods for Estimating Impacts

Economists use a method called hedonic pricing to measure the impacts of environmental attributes on property values. The hedonic pricing method uses the value of related market goods to estimate the value of non-market goods. More specifically, the hedonic pricing method uses statistical techniques to infer the value of environmental attributes (such as viewscapes and noise levels) by comparing values of properties that have a given environmental attribute and those that do not. Hedonic pricing is based on the assumption that individuals view goods such as houses as a bundle of attributes. In the case of houses, these attributes may include structural characteristics (e.g., size, number of bedrooms), neighborhood characteristics (e.g., crime rate, school quality, recreation opportunities, noise levels), and environmental attributes (e.g., trees, proximity to open space, viewscapes). Individuals choose houses based on a combination of these attributes. Differences in the market price of houses can be used to derive an implicit value of each attribute. The implicit value of an attribute reflects what individuals, on average, are willing to pay for that attribute. The result of the hedonic pricing method is a function that relates the value of a property to a set of housing attributes, including the environmental attribute being valued. For this study, the environmental attribute of concern include the viewscape of the property and the noise level at the property.

This section discusses previous hedonic pricing studies and insights they shed on the possible impacts of the BDCP on property values relating to viewscapes and noise levels.

4.4.4.1 CM1 Water Facilities and Operation

The new water conveyance facility (CM1) could affect property values by altering the viewscape of properties located close to the intake facilities. In addition, properties close to the intake facilities could be negatively affected by noise made by the facilities during operation. Research on the potential impacts of infrastructure on nearby property values defines three possible categories of impacts (Hoen et al. 2009).

- **Area stigma** refers to a concern that the general area surrounding the infrastructure will appear more developed. This impact could affect properties that do not have a direct view of the infrastructure project.
- **Scenic vista stigma** refers to a concern that a home could decline in value, because the infrastructure could affect the view or scenic vista from the home.
- **Nuisance stigma** refers to a concern that homes in close proximity to the infrastructure could be affected by noise or other factors that occur during the operation of the infrastructure.

No previous hedonic pricing studies were available that addressed the impact on property values of intake facilities similar to those that will be constructed as part of CM1. However, the Freeport Diversion project provides an example of one community's concerns related to a neighboring water diversion facility and the commitments made by the project proponent to address those concerns. In this example, the Freeport Regional Water Authority made the following commitments as part of its project.

- Moving the location of the intake almost 200 feet downstream to increase its distance from residences.
- Adding a landscape buffer between intake and residences and including neighbors in its design.

- Providing a noise ombudsman to address construction noise issues during construction.
- Establishing focus group (Architectural Review Committee) made up of neighbors, elected officials, and project representatives to select the architect and landscape design firms that would ultimately the design intake and landscape buffer.
- Committing to standard working hours and providing weekly notification of construction activities.
- Storing/using agents no stronger than household bleach onsite during operations.
- Providing house/window/car washing to neighbors due to dust generation during construction.
- Offering relocation to hotels during intense periods of pile driving.
- Conducting pre-/post-assessments of neighboring houses for damage (e.g., cracking, settling).
- Designing the intake facility in a manner that would keep noise at or below ambient conditions during operations.

Some hedonic pricing studies have been conducted that evaluate the impact of other industrial sites on property values. Due to the differences in the impacts of industrial sites compared to those of the water conveyance facility on properties, these studies are limited in their ability to provide useful information on the possible impacts of the BDCP. Several hedonic pricing studies, however, have examined the impact of transmission line proximity on property values, which is one component of the BDCP. Jackson and Pitts (2010) conducted a review of recent literature on the effect of transmission lines on property values. The authors noted that in most cases hedonic pricing studies found the impacts of being located close to transmission lines on property values to be small, ranging from 2 to 9% of average property values. When negative impacts on property values were observed, studies found that these impacts diminished quickly with distance (i.e., within a few hundred feet) and also weakened over time. Despite the conclusions of the literature review conducted by Jackson and Pitts (2010), individual studies have found significant impacts of transmission lines on property values.

Additionally, hedonic pricing studies have been conducted to estimate the impacts on property values of being located near wind power facilities. These studies present a somewhat analogous situation to possible impacts on properties from the BDCP intake facilities, as wind power facilities are large infrastructure facilities that generate noise during operation. In a study conducted for the Office of Energy Efficiency and Renewable Energy, Hoen et al. (2009) evaluated property value data on roughly 7,500 homes located within 10 miles of 24 wind facilities in nine U.S. states. The authors used these data to conduct eight hedonic pricing studies. Their results did not find any strong or persistent negative impacts on property values from being located close to wind energy facilities. The authors note that, despite their overall finding, the values of small numbers of properties could be negatively affected by being located close to wind power facilities. What their results did find is that, if these impacts do occur, they are not large enough or consistent enough to result in a significant impact in statistical models of property values. Table 4.4-1 presents a summary of the results of hedonic pricing studies of the impact of proximity of various infrastructure on property values.

Table 4.4-1. Impacts on Property Values Related to Proximity to Infrastructure

Study	Type of Impact	Property Value Impact (2012 $)	Property Value Impact (% of mean home price)	Distance Factor
Des Rosiers (2002)	Proximity to high-voltage transmission lines	-$21,470 to -$26,430	-9.8% to -12.0%	< 50 meters
		-$11,660	-5.3%	51 to 100 meters
		-$8,910	-4.1%	101 to 150 meters
Wolverton and Bottemiller (2003)	Proximity to high-voltage transmission lines	No statistically significant impact	No statistically significant impact	
Chalmers and Voorvaart (2009)	Proximity to high-voltage transmission lines	No statistically significant impact	No statistically significant impact	
Chalmers (2012)	Proximity to high-voltage transmission lines	Some impact seen in some of the case studies, but impact was not monetized	Not applicable	Within 500 feet of the centerline of a high voltage transmission line
Hoen et al. (2009)	Proximity to wind farm facilities	No statistically significant impact	Not applicable	Within 10 miles of a wind farm

4.4.4.2 Other Conservation Measures

Other hedonic pricing studies have evaluated the impacts on property values of being located adjacent or close to natural areas similar to those protected, enhanced, and restored by the BDCP. The majority of previous research on this topic comes from studies measuring the impact on property values of being located close to wetland areas. A study conducted by Bin and Polasky (2005) used wetland inventory data coupled with extensive property sales records from Carteret County, North Carolina, to estimate how proximity to wetlands affects nearby residential property values. The authors found that moving from an initial distance of 600 feet from the nearest coastal wetland to 52 feet raised the property value by $17,360 (in 2012 U.S. dollars) on average. A study by Bin (2005) evaluated the impact on property values of being located in proximity to different types of wetlands. For open-water wetlands, Bin found that moving from 2,500 feet (the minimum distance in the dataset) to 5,500 feet (the average distance) lowers the estimated property value by $27,900 (in 2012 dollars). Beyond 5,500 feet there was no effect. For emergent vegetation wetlands, Bin found property value to increase by $7.75 (in 2012 dollars) for every foot the property is away from a wetland between the minimum (5,000 feet) and maximum (9,000 feet) distance.

In addition to the studies on wetlands, other studies have been conducted that estimate the value of other kinds of natural areas on property values, including forests, grasslands, and urban parks. A hedonic pricing study in Minnesota examined property prices of 7,768 residential homes between 2002 and 2006 and found that being located within 200 feet of open space raised property prices by $19,075 (in 2012 dollars) on average (Moscovitch 2007). Crompton (2004) summarized the results of 20 studies of the impact of open space on property values, and found consistent evidence for the notion that being located close to open space raises property values. Crompton found that roughly 75% of the increase in property price values occurs for properties located within 500 to 600 feet of the open space, but that impacts may be realized for properties located 1,500 feet or even slightly farther from the open space. Table 4.4-2 presents a summary of the results of these hedonic pricing studies.

Table 4.4-2. Impacts of Proximity to Wetlands and Other Natural Areas on Property Values

Study	Type of Impact	Property Value Impact (2012$)	Property Value Impact (% of mean home price)	Distance Factor
Bin (2005)	Open-water wetlands	-$27,900	-13.2%	Move from 2,500 feet to 5,500 feet from wetland
	Emergent vegetation wetland	$7.75 increase per foot	NA	Move from 5,000 feet to 9,000 feet from wetland
Bin and Polasky (2005)	Coastal wetland	$17,360		Move from 600 feet to 52 feet from the nearest coastal wetland
Moscovitch (2007)	Open space	$19,075		Within 200 feet of open space

4.4.5 Mitigation Measures

The BDCP EIR/EIS includes several mitigation measures designed to reduce the impacts on properties from noise and changes to viewscapes. Table 4.4-3 presents the mitigation measures related to *CM1 Water Facilities and Operation* and the other conservation measures considered here (CM2 – CM11).

Table 4.4-3. BDCP EIR/EIS Mitigation Measures to Address Noise and Viewscape Impacts Related to BDCP

Impact	CEQA Level of Significance	Mitigation Measure	CEQA Level of Significance after Mitigation
NOI-1: Exposure of noise-sensitive land uses to noise from construction of water conveyance facilities	Significant/ adverse	NOI-1a: Employ noise-reducing construction practices during construction NOI-1b: Prior to construction, initiate a complaint/response tracking program	Significant and unavoidable
NOI-2: Exposure of sensitive receptors to vibration or groundborne noise from construction of water conveyance facilities	Significant/ adverse	NOI-2: Employ vibration-reducing construction practices during construction of water conveyance facilities	Significant and unavoidable
NOI-3: Exposure of noise-sensitive land uses to noise from operation of water conveyance facilities	Significant/ adverse	NOI-3: Design and construct intake facilities and other pump facilities such that operational noise does not exceed 50 dBA (one-hour L_{eq}) during daytime hours (7:00 a.m. to 10:00 p.m.) or 45 dBA (one-hour Leq) during nighttime hours (10:00 p.m. to 7:00 a.m.) or the applicable local noise standard (whichever is less) at nearby noise sensitive land uses	Less than significant
NOI-4: Exposure of noise-sensitive land uses to noise from implementation of proposed Conservation Measures 2-10	Significant/ adverse	NOI-1a: Employ noise-reducing construction practices during construction NOI-1b: Prior to construction, initiate a complaint/response tracking program	Significant and unavoidable
AES-1: Substantial alteration in existing visual quality or character during construction of conveyance facilities	Significant/ adverse	AES-1a: Locate new transmission lines and access routes to minimize the removal of trees and shrubs and pruning needed to accommodate new transmission lines where feasible AES-1b: Install visual barriers between construction work areas and sensitive receptors AES-1c: Develop and implement a spoil/borrow and tunnel muck area management plan AES-1d: Restore barge unloading facility sites once decommissioned AES-1e: Apply aesthetic design treatments to all structures to the extent feasible AES-1f: Locate concrete batch plants and fuel stations away from sensitive visual resources and receptors and restore sites upon removal of facilities AES-1g: Implement best management practices to implement project landscaping plan	Significant and unavoidable
AES-2: Permanent effects on a scenic vista from presence of conveyance facilities	Significant/ adverse	AES-1a: Locate new transmission lines and access routes to minimize the removal of trees and shrubs and pruning needed to accommodate new transmission lines AES-1c: Develop and implement a spoil/borrow and tunnel muck area reclamation plan AES-1e: Apply aesthetic design treatments to all structures to the extent feasible	Significant and unavoidable

Impact	CEQA Level of Significance	Mitigation Measure	CEQA Level of Significance after Mitigation
AES-3: Permanent damage to scenic resources along a state scenic highway from construction of conveyance facilities	Significant/ adverse	AES-1e: Apply aesthetic design treatments to all structures to the extent feasible	Significant and unavoidable
AES-4: Creation of a new source of light or glare that would adversely affect views in the area as a result of construction and operation of conveyance facilities	Significant/ adverse	AES-4a: Limit construction to daylight hours within 0.25 mile of residents AES-4b: Minimize fugitive light from portable sources used for construction AES-4c: Install visual barriers along access routes, where necessary, to prevent light spill from truck headlights toward residences	Significant and unavoidable
AES-5: Substantial alteration in existing visual quality or character during operation	Less than significant/ not adverse	Not applicable	Less than significant
AES-6: Substantial alteration in existing visual quality or character during construction of CM2–CM22	Significant/ adverse	AES-1a: Locate new transmission lines and access routes to minimize the removal of trees and shrubs and pruning needed to accommodate new transmission lines AES-1b: Install visual barriers between construction work areas and sensitive receptors AES-1c: Develop and implement a spoil/borrow and tunnel muck area management plan AES-1d: Restore barge unloading facility sites once decommissioned AES-1e: Apply aesthetic design treatments to all structures to the extent feasible AES-1f: Locate concrete batch plants and fuel stations away from sensitive visual resources and receptors and restore sites upon removal of facilities AES-1g: Implement best management practices to implement project landscaping plan AES-4a: Limit construction to daylight hours within 0.25 mile of residents AES-4b: Minimize fugitive light from portable sources used for construction AES-4c: Install visual barriers along access routes, where necessary, to prevent light spill from truck headlights toward residences AES-6a: Underground new or relocated utility lines where feasible AES-6b: Develop and implement an afterhours low-intensity and lights off policy AES-6c: Implement a comprehensive visual resources management plan for the Delta and study area	Significant and unavoidable

4.4.6 Challenges for Estimating Impacts

The BDCP has the potential to affect property values in both negative and positive ways. As discussed above, the construction and operation of the water conveyance facility are expected to have a negative effect on property values, because the intakes and other infrastructure will affect viewscapes and noise levels near the facilities. Moreover, previous studies have differed on the impact on property values of similar kinds of infrastructure with some showing statistically significant declines in property values for properties located close to the infrastructure, and some not finding significant impacts. A common finding across studies, however, was that impacts on property values dissipated quickly with distance from the infrastructure and also dissipated with time. Previous studies evaluating the impact of wetlands and other kinds of open space on property values have generally found positive effects. Similar to the impacts of infrastructure, the positive impacts on property values of being located near open space also dissipate quickly with distance but seem to remain permanently.

This study evaluates the impacts of the BDCP on property values only on a qualitative basis, for the following reasons.

- Both negative impacts on property values from infrastructure such as the water conveyance facility and positive impacts from the conservation measures dissipate rapidly with distance. Significant impacts will therefore affect only the relatively small number of properties located in proximity to the permanent structures of the water conveyance facility or the restoration sites.
- Because per-property impacts are relatively small (most commonly less than 10% of the property value), the total net impacts of the BDCP will be small in magnitude as compared to other impacts.
- For properties that would experience the greatest negative impact on value, the mitigation measures described above would alleviate some of the impact.

4.5 Erosion and Sedimentation

4.5.1 Introduction

This section evaluates the economic impacts of changes in erosion and sedimentation associated with implementation of the BDCP. Changes to area erosion and sedimentation rates under the BDCP would result from construction and operation of the new water conveyance facility (*CM1 Water Facilities and Operation*) and from implementation of other conservation measures that would alter the physical landscape (CM2 through CM11). Construction and operation of CM1 would affect erosion and sedimentation through potential changes in turbidity levels. CM2 through CM11, could change rates of erosion and sedimentation in area waterways as a result of ecosystem functions provided by restoration of natural areas such as wetlands and grasslands. This section discusses these impacts, along with how such impacts have been valued in other studies and the challenges surrounding quantifying and monetizing these impacts in the Plan Area.

4.5.2 CM1 Water Facilities and Operation

Once CM1 is operational, water would be conveyed from the north Delta to the south Delta through pipelines/tunnels. Water will be diverted from the Sacramento River through three fish-screened intakes on the east bank of the Sacramento River between Clarksburg and Walnut Grove. Water will travel through the levees in pipelines from the intakes to a sedimentation basin and solids lagoon before reaching the intake pumping plants.[1] In addition, intake pumping plants will have concrete sedimentation basins, associated solids-handling facilities, and conveyance piping to a point of discharge into the proposed conveyance structure (i.e., pipelines/tunnels or canals). These structures and facilities will be located on the landside of the levee. To protect the structures from flood waters, the sedimentation basins, solids lagoons, and pumping plant will be constructed on engineered fill above the design flood elevation. All construction and modifications will comply with applicable state and federal flood management, engineering, and permitting requirements.

Removing sediment from the sedimentation basins and solids lagoons is expected to be an ongoing process during operation of CM1. During operation of the water conveyance facilities, water will enter the three intakes along the east bank of the Sacramento River in the north Delta and then will enter sedimentation basins. Settled sediment will then be pumped to solids lagoons where it will be dewatered and removed for disposal or reuse offsite; water drained from the sediment will be pumped back into the sedimentation basins. Modeling results suggested that, under CM1, around 8% less sediment would be available to the Delta (Plan Area) on an average annual basis (BDCP EIR/EIS Attachment 5C.D, *Water Clarity—Suspended Sediment Concentration and Turbidity* [California Department of Water Resources et al. 2013]).

The dewatered solids, like the sediment dredged from the sedimentation basins will likely contain pesticides from agricultural and urban areas, metals or organic compounds from urban stormwater

[1] Additionally, a combination of diaphragm walls and slurry cutoff walls would also be constructed around the site and along the levee to provide enhanced public protection from levee underseepage in accordance with U.S. Army Corps of Engineers' requirements. The pumping plant would be built on a raised pad, which would sit at roughly the same elevation as the levee. The pad would itself be considered a widening of the levee prism and the slurry cutoff wall would extend around the perimeter of the public plant pad.

runoff, and mercury from historical mining upstream of the Delta. Dewatered sediment will, thus, require chemical characterization (i.e., various testing activities that would be undertaken to confirm that the material meets regulatory standards) prior to any reuse. To reduce the long-term effects on land use and potentially support implementation of other BDCP elements, the BDCP proponents will develop site-specific plans for the beneficial reuse of sediment, to the greatest extent feasible. Reuse options may include BDCP conveyance facility construction activities, habitat restoration and protection activities, and potential beneficial uses associated with flood protection and management of groundwater levels in the Plan Area.

Under Mitigation Measure HAZ-6, as cited in BDCP EIR/EIS Chapter 24 (California Department of Water Resources et al. 2013), dredged sediment and solids from the solids lagoons not used for beneficial reuse purposes, such as restoration, will be sampled and characterized to evaluate disposal options, and disposed of accordingly at an appropriate, licensed facility.

4.5.3 Other Relevant Conservation Measures

Through the establishment of new conservation lands and the enhancement of existing natural and riparian areas, CM2 through CM11 will reduce the rate of soil erosion that might have been accelerated due to human land use and management, and thus reduce sediment loads into waterways. As discussed further below, this reduction in sediment loads has both positive and negative impacts on the Delta ecosystem. Table 4.5-1 provides a listing and description of the conservation measures expected to have the greatest impact on erosion and sedimentation.

4.5.4 Methods for Estimating Impacts

Economists have developed a variety of methods for ascribing a monetary value to ecosystem services such as the reduction of the rate of erosion and sedimentation. This particular ecosystem service is most commonly valued by cost-based methods such as the damage cost, replacement cost, and substitute cost methods. These methods all attempt to value an ecosystem service by estimating the costs that could be incurred due to loss of an ecosystem service. The damage cost method uses the cost of the damages that could result if particular ecosystem services were lost as a proxy for their value. The replacement cost method estimates value based on the cost to replace lost ecosystem service, and, similarly, the substitute cost method involves estimating the cost of providing substitutes for a lost ecosystem service.[2]

The substitute cost method has been used to value reduced sediment in waterways through estimating the cost of removing sediment in water through other means. For example, some studies have used the cost of water treatment by other means to estimate the cost of the water filtration and sediment removal that natural areas such as wetlands, grasslands, forests, and riparian areas provide (U.S. Environmental Protection Agency 2009; Gschaid et al. 2010). Other studies have estimated the erosion control and sediment-retention benefits of natural areas by estimating the costs that businesses incur to remove sediment from water by other means (Belcher et al. 2001).

[2] One variation of the replacement cost method is called the *averting behavior method*. This method uses the expenditures people will make if a particular ecosystem service was lost as an estimate of their value. For example, one possible measure of improved water quality is an estimate of the money people will spend on filtering water or buying bottled water without the water quality improvements.

Table 4.5-1. Conservation Measures Expected to have the Greatest Impact on Erosion and Sedimentation

Conservation Measure	Description	Beneficial Effect	Detrimental Effect
CM3 Natural Communities Protection and Restoration	Provides a mechanism for acquiring and protecting lands within a reserve system, which will support the continued existence of natural communities and habitat for covered species.	Enhancement of vegetation cover in the reserve system will help reduce the rate of erosion and sediment entering waterways.	Reduction of sediment entering waterways reduces the ability of tidal marshes to respond to sea level rise.
CM4 Tidal Natural Communities Restoration	Restores at least 65,000 acres of tidal wetlands and adjoining uplands within the BDCP restoration opportunity areas. The goal is to restore 16,300 acres by year 10 of plan implementation, 25,975 acres by year 15, and 65,000 acres by year 40.	The restoration lands include 55,000 of tidally influenced communities and 10,000 acres of adjacent upland transitional areas. Enhancement of vegetation cover in the upland areas and reduction of tidal flow will reduce erosion rates.	Reduction of sediment entering waterways reduces the ability of tidal marshes to respond to sea level rise.
CM5 Seasonally Inundated Floodplain Restoration	Attempts to restore floodplains that historically existed but have been lost due to flood control and channelization. The goal is to restore 10,000 acres through the use of setback levees, with 1,000 acres restored by year 15 and all 10,000 acres restored by year 40.	Setback levees will add vegetation between the original levee and setback. This vegetation will help reduce the rate of erosion and sediment entering waterways.	Reduction of sediment entering waterways reduces the ability of tidal marshes to respond to sea level rise.
CM6 Channel Margin Enhancement	Restores 20 linear miles of channel margin habitat by improving channel geometry and restoring riparian, marsh, and mudflat habitats on the inboard side of levees. The goal is to have 5 miles completed by year 10, and phase in 5 more miles every 5 years until year 30.	The enhanced riparian areas will reduce the rate of erosion and sediment entering waterways.	Reduction of sediment entering waterways reduces the ability of tidal marshes to respond to sea level rise.
CM7 Riparian Natural Community Restoration	Establishes a goal of restoring 5,000 acres of riparian forest and scrub in association with land restoration measures in CM4, CM5, and CM6. Restoration will be phased in, with 2,300 acres restored by year 15, and the full 5,000 acres restored by year 40.	The enhanced riparian areas will reduce the rate of erosion and sediment entering waterways.	Reduction of sediment entering waterways reduces the ability of tidal marshes to respond to sea level rise.
CM8 Grassland Natural Community Restoration	Provides protection of 2,000 acres of grassland natural community in Conservation Zones 1, 8, and/or 11. The goal is to have 1,000 acres restored by year 10, and the full 2,000 acres restored by year 25.	The restored grassland areas will reduce the rate of erosion and, thus, sediment entering waterways.	Reduction of sediment entering waterways reduces the ability of tidal marshes to respond to sea level rise.
CM10 Nontidal Marsh Restoration	Restores 400 acres of nontidal freshwater marsh in Conservation Zones 2 and 4. It sets a goal of restoring 200 acres by year 2 and all 400 acres by year 8 of plan implementation.	The restored marsh areas will help reduce erosion and sediment entering the waterways.	Reduction of sediment entering waterways reduces the ability of tidal marshes to respond to sea level rise.
Source: California Department of Water Resources et al. 2013: Table 6-2.			

4.5.5 Challenges of Estimating Impacts

Because of the challenges surrounding estimating the costs associated with the BDCP impacts on erosion and sedimentation, these impacts are only assessed qualitatively. These challenges relate primarily to the unique characteristics of the Delta environment that result in sedimentation having both positive and negative effects on the environment. As is common in many ecosystems, improvements in water turbidity or clarity that will result from decreased sediment loading will likely be valued by some residents for aesthetic reasons. Delta ecosystems also will likely benefit from decreases in erosion resulting from the conservation measures. Unlike many other ecosystems, however, sedimentation plays a key role in the Delta ecosystem and provides many benefits. Sedimentation in the Delta region is critical to the build up and stabilization of wetland and marsh areas, which becomes increasingly important when considering the impact of sea level rise (Okamoto 2013). As an example, tidal marshes with an inadequate sediment supply rate as compared to the rate of sea level rise are at risk of drowning unless episodic floods deposit increased quantities of sediment to the marsh (Schoellhamer et al. 2013). These marshlands provide important ecological services such as shoreline erosion reduction, floodwater detention, and nutrient retention and degradation. Reductions in the provision of these services will have economic impacts on the Delta, which have not been quantified or monetized in this study.

A steady source of sediment is also important to maintain many native aquatic species in the Delta. Water turbidity has been shown to directly correlate with the survival of juvenile salmonids and delta smelt, two BDCP covered species. In more turbid waters, it is hypothesized that these species are better able to avoid abundant predators (Gregory and Levings 1998). The presence and distribution of delta smelt are correlated with turbidity levels (Nobriga et al. 2005; Feyrer et al. 2007). It has been demonstrated that turbidity can increase feeding success of larval delta smelt (Baskerville-Bridges et al. 2004).

For the reasons described above, costs related to BDCP impacts on erosion and sedimentation were discussed qualitatively.

Chapter 5
Statewide Income and Employment Impacts from Construction, Restoration, and Enhanced Water Supply Reliability

This chapter examines the economic impact of BDCP on statewide income and employment from the construction of the new water conveyance facility, construction associated with other conservation measures such as restoration, and improvements in water supply reliability. The first section of the chapter examines the impact of BDCP on statewide economic activities. The second section of the chapter evaluates direct and indirect impacts of BDCP on statewide employment.

5.1 Impacts on State Income

5.1.1 Introduction

This section evaluates the economic impacts of the BDCP on economic activity (i.e., output) in the state of California. These impacts would result from construction and operation of the new water conveyance system, under *CM1 Water Facilities and Operation*, implementation of other conservation measures, and water reliability generated from the BDCP. An important element of this economic impact is the increase of economic activity from the BDCP. This increase will be offset somewhat by economic activity loss from conversion of agricultural land to the water conveyance facility and restored natural communities. There will also be induced economic activity losses associated with increased water rates and taxes. This analysis uses conservative assumptions, and does not include economic activity impacts by other initiatives considered under the BDCP. Table 5.1-1 summarizes the economic activity impacts associated with each of the following three categories.

- **CM1 Water Facilities and Operation**. Economic activity generated through the construction and planning of the new water conveyance facility is estimated at $21.2 billion in California during an expected 9-year construction period.[1] Operations and maintenance, assumed to begin in year 11, are expected to generate an estimated $1.3 billion of economic activity over the remaining 40 years of the permit term.
- **Other Relevant Conservation Measures (CM2–CM11, CM13–CM21).** The construction and planning; operations and maintenance; land acquisition; and administrative implementation, monitoring, and research share of the other relevant conservation measures (i.e., those related to the protection, restoration and enhancement of natural communities) will result in an increase in economic activity of an estimated $9.4 billion over the 50-year permit term. The retirement of agricultural lands will result in an estimated loss of $2.8 billion in economic activity during the same period, for a net gain of an estimated $6.6 billion over the 50-year permit term.

1 All impacts are based on cost estimates in 2012 dollars and are discounted to present value at a 3% real discount rate.

- **Water Supply Reliability.** Economic activity generated from increased water supply reliability begins when the new north Delta water facilities begin operations, expected in 2026. Impacts on the commercial/industrial/institutional sector and the agricultural sector are estimated to be a net gain of $67.5 billion and $5.9 billion, respectively, totaling $73.4 billion over the 40 years of dual conveyance operations in the Delta.

There will be economic activity loss in California as a result of implementation costs of the BDCP. The cost of the BDCP to the state is estimated at a present value of $15.2 billion[2], which implies a reduction in household income from accompanying increases in water rates and taxes. Given the induced effect of a decrease in household income associated with BDCP expenditures, the resulting economic loss on California gross domestic product will be $19.0 billion.[3]

As shown in Table 5.1-1, the BDCP will generate a net increase in economic activity over the 50-year permit term. Importantly, increased economic activity associated with restoration planning, construction, and payments to land owners will more than offset agricultural economic activity losses attributed to the associated agricultural land retirements. Taking all impacts together, and netting out the economic activity lost as a result of higher water costs and taxes, the BDCP will increase California state business output by $83.5 billion over the 50-year permit term.

This section describes the specific methods, data, and results for each of the three categories presented above.

[2] BDCP cost to the state is calculated over the 50-year permit term, discounted at 3.0% real discount rate. These costs are calculated over a different time span than cost calculations in Section 2.1, *Incremental Costs Borne by State and Federal Water Contractors*, to stay consistent with the timeframe evaluated in this chapter. This cost is incremental relative to costs incurred even without implementation of the BDCP.

[3] Economic activity from changes in household income are calculated using IMPLAN. IMPLAN is described in detail in Section 5.1.2.1, *Methods*).

Table 5.1-1. Statewide Economic Activity Impact Summary (million $[a])

Category	Per 10-Year Period					Total over 50 Years
	1–10	10–20	20–30	30–40	40–50	
CM1 Water Facilities and Operation						
Construction and planning	$21,238	$0	$0	$0	$0	$21,238
Operations and maintenance	$0	$474	$353	$263	$195	$1,285
Total	**$21,238**	**$474**	**$353**	**$263**	**$195**	**$22,523**
Other Relevant Conservation Measures (CM2–CM11, CM13–CM21)						
Construction and planning	$2,486	$1,318	$987	$690	$132	$5,612
Operations and maintenance	$497	$529	$364	$282	$217	$1,890
Land acquisition[b]	$319	$197	$137	$102	$0	$755
Other[c]	$342	$298	$204	$156	$103	$1,103
Agricultural land retirement[d]	($319)	($584)	($672)	($677)	($539)	($2,791)
Total	**$3,325**	**$1,757**	**$1,020**	**$553**	**($87)**	**$6,569**
Water Supply Reliability						
Commercial/ industrial/ institutional	$0	$24,919	$18,542	$13,797	$10,266	$67,525
Agricultural	$0	$2,181	$1,623	$1,208	$899	$5,910
Total	**$0**	**$27,100**	**$20,165**	**$15,005**	**$11,165**	**$73,435**
Increased Water Rates and Taxes						
Induced Output Impact	($16,327)	($925)	($777)	($580)	($411)	($19,019)
Total	**($16,327)**	**($925)**	**($777)**	**($580)**	**($411)**	**($19,019)**
Total Economic Impacts Across All Categories						
Total	**$8,236**	**$28,407**	**$20,761**	**$15,241**	**$10,863**	**$83,508**

[a] All impacts are based on cost estimates in 2012 dollars and are discounted to present value at a 3% real discount rate.
[b] Represents the impacts from payments made to landowners to acquire reserve lands for protection, restoration, and enhancement either in fee title or as conservation easement.
[c] Impacts from administrative implementation, monitoring, and research costs.
[d] Represents agricultural revenue loss from decreased agricultural activity that would result from the conversion of agricultural lands to reserve lands. Impacts due to conversion of agricultural lands to water conveyance facilities were not modeled; however, these impacts are small in comparison, representing only 10% of agricultural retirement under the BDCP.

5.1.2 CM1 Water Facilities and Operation

The 9 years of construction and 40 years of operation and maintenance of the water conveyance facility (CM1) will have significant impacts on economic activity in California. Under the BDCP, water will be transported approximately 39 miles from intakes near Hood in Sacramento County to Byron Tract Forebay in Contra Costa County. This route will cross portions of three counties: Contra Costa, Sacramento, and San Joaquin (Figure 5.1-1). Impacts on economic activity are evaluated with the use of IMPLAN[4] for both construction and for operation and maintenance activities. (California Department of Water Resources 2013: Chapter 8, 8-13).

5.1.2.1 Methods

The economic activity impact estimates are based on economic output multipliers generated by the IMPLAN model. This input-output model was first specified in 1941 by Wassily Leontief, for which he won the Nobel Prize in economics (Leontief 1941).[5] The core of this model is a matrix of average input (purchase) coefficients that describe the mix of goods, services, and labor that are required to produce a unit of output. These coefficients represent what economists refer to as production functions. The dimensions of the matrix are determined by how many industry sectors are accounted for and whether government and household sectors are included. The basic model can be expressed in a straightforward equation:

$$X= (I-A)^{-1} *dY$$

where (I-A) is the inverse of the Leontief matrix, dY is a change in final demand, and X is output.

Employment, output, and income multipliers can be derived from this equation. These multipliers describe the change in employment, output, or income for a given change in final demand. Models are referred to as Type I and Type II, depending on whether they include a household sector. Type II models, which incorporate the household sector, provide multipliers that capture direct, indirect, and induced impacts. Direct impacts refer to the direct purchases of goods, services, energy, and labor to meet a final demand (i.e., the purchase of a crane used as part of construction of the tunnel). Indirect impacts refer to the purchases of goods, services, energy, and labor required to produce the directly demanded factors (i.e., the purchase of tires by the crane manufacturer). Induced impacts refer to the purchases of goods, services, energy, and labor to meet the demands of households that see increased income as a consequence of additional employment (i.e., the purchase of food by the newly employed crane producer). IMPLAN can be run as a Type II model providing direct, indirect, and induced output estimates.

The IMPLAN model also accounts for the trade of goods and services between jurisdictions (e.g., counties and states) using what are referred to as regional purchase coefficients. These coefficients are calculated based on observed trading of goods and services between these jurisdictions. For example, the demand for a particular good in one California county may be met in part by firms located in another California county or an out-of-state county. Consequently, both local (a county or group of counties) and state-level income, employment, and output impacts can be estimated.

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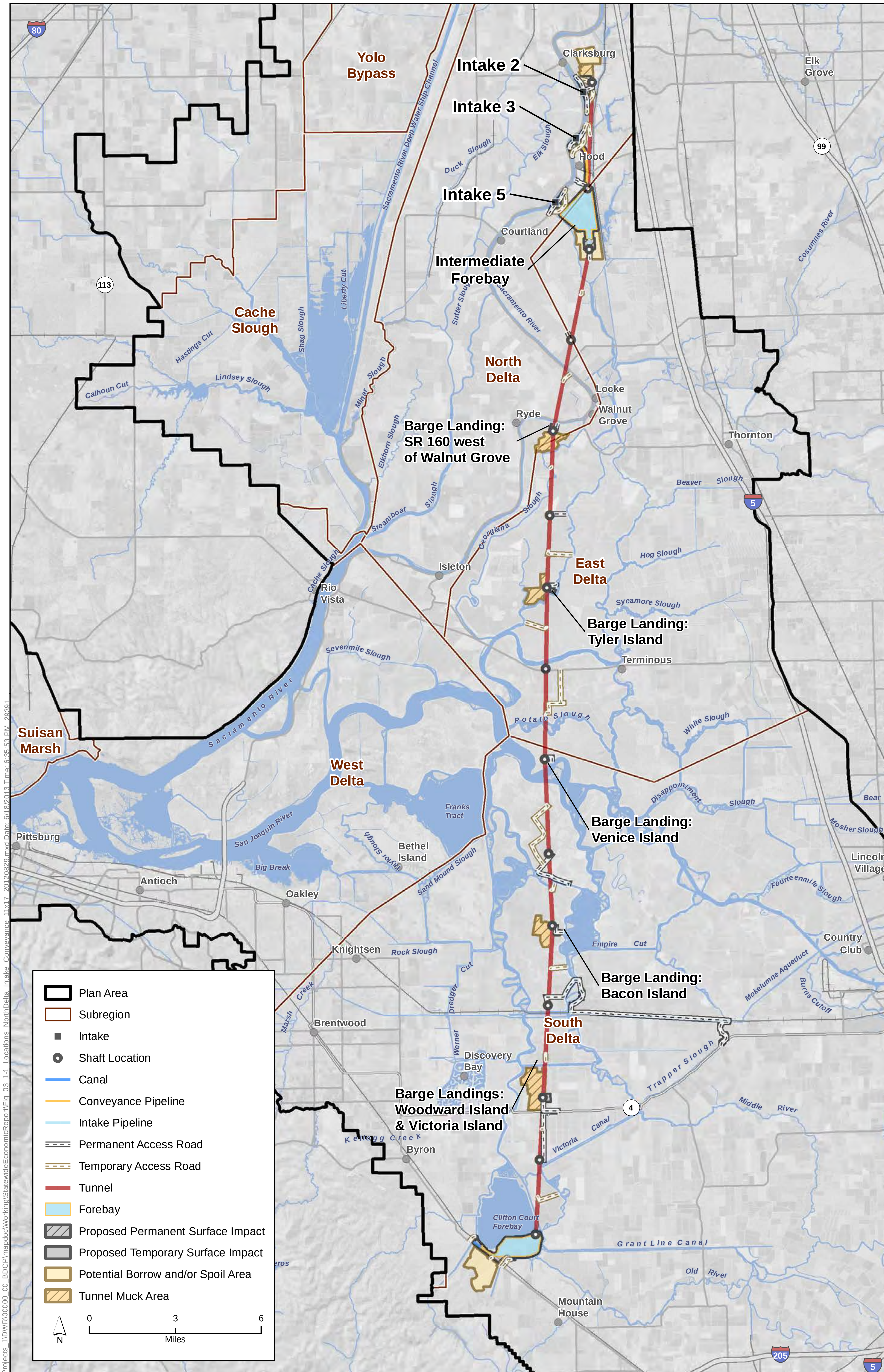
4 IMPLAN is the most widely used model for this purpose and has been used by many California government agencies. IMPLAN's client list includes the California Department of Finance, the California Department of Transportation, the California Department of Water Resources, and the California State Water Resources Control Board. At the federal level, IMPLAN has been used by the U.S. Army Corps of Engineers, the Bureau of Economic Analysis, the Bureau of Land Management and the Bureau of Reclamation. IMPLAN website: http://implan.com/V4/Index.php.

5 In 1941, Leontief published his first book on input-output economics under the title *The Structure of the American Economy, 1919-1929*.



K:\Projects_1\DWR\00000_00_BDCP\mapdoc\Working\StatewideEconomicReport\Fig_03_1-1_Locations_NorthDelta_Intake_Conveyance_11x17_20120829.mxd Date: 6/18/2013 Time: 6:35:53 PM 29391

GIS Data Source: Constructability (Rev 10b), DWR 2012; Plan Area, ICF 2012; Hydro Subregions, ICF 2012.

Figure 5.1-1
Locations of the Proposed North Delta Intake and Conveyance Facilities

In this analysis, economic activity impacts were estimated at the state level and at the county level for the three counties that would be directly affected by BDCP construction (Contra Costa, Sacramento, and San Joaquin Counties). As described in Section 5.1.2.2, *Data,* very disaggregate construction cost data were provided that identified equipment, materials, and labor expenses as well as expected sales tax payments. Each of the cost categories provided were assigned to specific North American Industrial Classification System (NAICS) codes, which were then mapped to the IMPLAN sectoring scheme. Consideration was also given to where expenditures would be made. For example, some materials, notably tunnel-drilling equipment and large pumps, are likely to be manufactured outside of California. Other cost items, in particular, construction labor and equipment and materials such as concrete and steel, are more likely to be purchased locally. For the purposes of estimation, initial local spending is assumed to occur within the county where specific system components are anticipated. Actual spending patterns, of course, could be different. As noted above, IMPLAN will account for intercounty spending patterns.

5.1.2.2 Data

This analysis is based on preliminary cost estimates prepared by Delta Habitat Conservation and Conveyance Program consultants (Delta Habitat Conservation and Conveyance Program 2012) and costs found in BDCP Chapter 8. According to these estimates, most costs will be incurred by construction, concrete product manufacturing, and architectural/engineering sectors. The water conveyance facility (CM1) is estimated to cost $14.2 billion.[6] The cost allocations of the facility (for in-state spending only) are shown in Table 5.1-2.

[6] This cost estimate includes imported materials. The water conveyance facility (CM1) will include approximately $1.7 billion in tunnel-boring machines, tunnel liners, and large valves and pumps that are likely to come from foreign sources.

Table 5.1-2. Construction Cost by IMPLAN Sector for Water Conveyance Facility (CM1)

IMPLAN Description	Total Cost[a, b] (U.S. Only) ($ millions)	Percentage of Total
Construction of other new nonresidential structures	$5,646	49.84%
Other concrete product manufacturing	$2,463	21.74%
Architectural, engineering, and related services	$1,903	16.79%
Plate work and fabricated structural product manufacturing	$925	8.17%
Ready-mix concrete manufacturing	$123	1.08%
Valve and fittings other than plumbing manufacturing	$62	0.55%
Wholesale trade business	$49	0.44%
Iron and steel mills and ferroalloy manufacturing	$36	0.31%
Mining and quarry stone	$30	0.26%
Fluid power process machinery manufacturing	$26	0.23%
Pump and pumping equipment manufacturing	$15	0.13%
Veneer and plywood manufacturing	$12	0.11%
Material handling equipment manufacturing	$10	0.09%
Ornamental and architectural metal products manufacturing	$9	0.08%
Fabricated pipe and pipe fitting manufacturing	$8	0.07%
Totalizing fluid meters and counting devices manufacturing	$3	0.03%
Cement manufacturing	$10	0.09%
Total without Imports	**$11,330**	**100.00%**

Sources: Cost estimates are from September 2012 5RKM cost estimates; contingency and design percentages are from December 2012 Working Draft of the BDCP.

[a] All cost numbers are in 2012 dollars (millions).

[b] This table shows the allocation of the $11 billion that will be spent in the United States only. It excludes imported materials such as tunnel-boring machines, tunnel liners, and large pumps, as well as out-of-state administrative costs.

Table 5.1-3 presents the construction cost by cost category. Materials account for most costs.

Table 5.1-3. Construction Cost for Water Conveyance Facility (CM1) by Category

Item[a]	Cost Including Imports and Out-of-State Services[b, c] ($ millions)	Cost Excluding Imports and Out-of-State Services[b] ($ millions)
Labor	$2,459	$2,459
Materials	$4,806	$3,782
Equipment	$2,522	$1,840
Subcontractor	$1,146	$1,146
Engineering/project management/ construction management/design[d]	$1,903	$1,903
Indirect charge[e]	$200	$200
Markup[f]	$1,182	-
Total Construction Cost	**$14,219**	**$11,330**

Sources: Cost estimates are from September 2012 5RKM cost estimates; contingency and design percentages are from December 2012 Working Draft of the BDCP.

[a] All items include contingencies assumed to be 36.5% for tunnel-related items and 34.3% for all other items. These percentages are in concordance with those assumed in the December 2012 Administrative Draft of BDCP.

[b] All cost numbers are in 2012 dollars (millions) and are subject to rounding error. All cost items include item-specific indirect costs.

[c] Imports consist of tunnel-boring machines (equipment), as well as tunnel liners and large valves and pumps (materials).

[d] Eng/PM/CM/Design is assumed to be 15.5% of all other costs including contingencies. This percentage is in concordance with the December 2012 Working Draft or BDCP Chapter 8.

[e] Indirect charge includes extra tunneling indirect cost not already included in the other items.

[f] Markup includes management and administrative service costs. These services are provided out-of-state and are therefore not included in the economic impact analysis.

The annual operating cost of the water conveyance facility (CM1) is expected to reach $36.4 million (Table 5.1-4) over the 50-year permit term.

Table 5.1-4. Operations Cost for Water Conveyance Facility (CM1)

Item	Cost per Year[a,b] ($ millions)
Energy	$6
Operations and maintenance	$19
Replacement and refurbishment	$11
Total Annual Operating Cost	**$36**

Source: California Department of Water Resources 2013: Chapter 8.

[a] All numbers are in 2012 dollars (millions).

[b] Costs have been annualized over a 40-year operating period.

5.1.2.3 Results

Table 5.1-5 and Table 5.1-6 present the estimated economic activity impacts from the construction and the operation and maintenance of the water conveyance facility (CM1), respectively, in terms of present-value impacts discounted at a 3% real rate. The construction of the facility is estimated to increase economic activity by $21.2 billion throughout the duration of the construction period. Thereafter, the operation and maintenance of the facility will increase economic activity at about $75 million per year (undiscounted) for 40 years of operation.

Table 5.1-5. Economic Activity Impact of Water Conveyance Facility (CM1)—Construction (million $)

Impact	California (State)	Contra Costa County	Sacramento County	San Joaquin County
Direct	$5,442	$480	$1,752	$1,540
Indirect	$9,807	$416	$1,635	$4,705
Induced	$5,990	$223	$1,097	$1,660
Total	**$21,238**	**$1,119**	**$4,484**	**$7,906**

[a] All impacts are based on cost estimates in 2012 dollars and are discounted to present value at a 3% real discount rate.
[b] Spending on engineering and design is assumed to occur outside of the three-county region.

Table 5.1-6. Economic Activity Impact (Annualized, Undiscounted) of Water Conveyance Facility (CM1)—Operation and Maintenance (million $)[a]

Impact	California (State)	Contra Costa County	Sacramento County	San Joaquin County
Direct	$36	$5	$17	$15
Indirect	$16	$1	$4	$3
Induced	$23	$2	$8	$6
Total	**$75**	**$7**	**$29**	**$24**

[a] All impacts are based on annualized cost estimates in 2012 dollars and are presented in undiscounted 2012 dollars.

5.1.3 Other Relevant Conservation Measures

The BDCP includes 21 additional conservation measures (CM2 through CM22). This section focuses on 19 of the 21 measures that include protection, restoration, or enhancement of natural communities and specific actions to address other ecological stressors on covered aquatic species in the Delta.[7,8] These conservation measures are listed below.

- *CM2 Yolo Bypass Fisheries Enhancement*
- *CM3 Natural Communities Protection and Restoration*

7 CM12 will incur a small cost of $1.7 million and relates to methylmercury management in tidal marsh restoration. This conservation measure is excluded from the analysis as it will have minimal effects on economic activity.

8 CM22 is not included in the analysis, because it addresses avoidance and minimization measures, not natural community restoration. Most of the funding for CM22 is for consultant surveys. It will generate economic activity, but spread over all years of restoration, the impact is very small. The total cost of CM22 is $36.3 million.

- *CM4 Tidal Natural Communities Restoration*
- *CM5 Seasonally Inundated Floodplain Restoration*
- *CM6 Channel Margin Enhancement*
- *CM7 Riparian Natural Community Restoration*
- *CM8 Grassland Natural Community Restoration*
- *CM9 Vernal Pool and Alkali Seasonal Wetland Complex Restoration*
- *CM10 Nontidal Marsh Restoration*
- *CM11 Natural Communities Enhancement and Management*
- *CM13 Invasive Aquatic Vegetation Control*
- *CM14 Stockton Deep Water Ship Channel Dissolved Oxygen Levels*
- *CM15 Localized Reduction of Predatory Fishes*
- *CM16 Nonphysical Fish Barriers*
- *CM17 Illegal Harvest Reduction*
- *CM18 Conservation Hatcheries*
- *CM19 Urban Stormwater Treatment*
- *CM20 Recreational Users Invasive Species Program*
- *CM21 Nonproject Diversions*

These conservation measures cover over 100,000 acres, including wetlands, grassland, vernal pool complexes, and agricultural lands. The total cost of implementing these conservation measures is expected to be $8.1 billion in undiscounted 2012 dollars to be spent over the 50-year permit term.[9]

- $4.4 billion of for planning and construction.
- $1.8 billion for operations and maintenance.
- $1.0 billion is for land acquisition.
- $1.0 billion is for administrative implementation, monitoring, and research costs.

Some of these conservation measures call for land acquisition, which is expected to account for as much as 12% of the total implementation cost. In addition, the BDCP will result in the retirement (i.e., conversion) of an estimated 64,158 acres of land currently under cultivation. This loss of agricultural land will result in economic activity losses described below.

5.1.3.1 Methods

The economic activity impact estimates presented here are based on multipliers generated by the IMPLAN model described in Section 5.1.3.1, *Methods*. In this analysis, economic activity impacts from natural community restoration were estimated at the state level. Only aggregate construction cost data are currently available, because the BDCP is currently under development. Consequently,

[9] Costs are from BDCP Chapter 8, *Implementation Costs and Funding Sources*. The cost components sum up to more than the total due to rounding.

all construction costs are assigned to the IMPLAN sector for new nonresidential construction as defined by North American NAICS. All operations and maintenance costs are assigned to the IMPLAN sector for maintenance and repair construction of nonresidential maintenance and repair. The administrative implementation costs are assigned to the IMPLAN sector for managerial tasks, and the research and monitoring costs are assigned to the IMPLAN sector for scientific research and development services.

The land acquisition required by the other relevant conservation measures must be addressed as a special case. First, the landowners who will sell their properties in fee title or conservation easement will receive payments at fair market value of the land. For the purposes of estimation, public data regarding land ownership in the affected counties are used. These data indicate that 60 to 72% of the properties that are likely to be acquired for restoration purposes in each county of the six-county region are owner-occupied.[10] In addition, it is assumed that 100% of landowners receiving payments for properties located in this six-county region reside in California. The economic activity impacts of these payments are modeled in IMPLAN as household income change rather than expenditures in a particular sector.

Second, because land acquisition for restoration will take some farmland out of production, this will result in lower agricultural output, which must be accounted for. This is accomplished by changing output to reflect the crop revenue loss. These losses will be highly dependent on which lands are taken out of production. As a result, estimates of required agricultural land retirement have been prepared, which take into account assumptions about the specific regions and crops affected. A more detailed description of the crop production loss and economic activity impacts is presented in the next section.

5.1.3.2 Data

5.1.3.2.1 Planning, Construction and Land Acquisition

This analysis is based on project cost estimates prepared for BDCP Chapter 8. According to these estimates, costs for the other relevant conservation measures can be allocated into four categories: planning and construction; operations and maintenance; land acquisition; and other costs that include administrative implementation, monitoring, and research costs. Table 5.1-7 summarizes the total cost by these categories in 5-year increments over the 50-year permit term. As shown, construction and planning account for most of the expenditure.

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[10] Assumptions regarding the proportion of owner-occupied versus absentee properties in each county are based on information from Metroscan (2013). Information is based on public records and was not verified or confirmed.

Table 5.1-7. Cost of the Other Relevant Conservation Measures ($ millions)[a]

Cost Category	Per 5-Year Period										Total over 50 Years
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Construction and planning	$641	$689	$474	$471	$476	$476	$447	$447	$115	$115	$4,352
Operations and maintenance	$106	$175	$195	$199	$181	$184	$188	$192	$196	$196	$1,813
Land acquisition[b]	$159	$126	$126	$111	$112	$112	$111	$111	0	0	$968
Other[c]	$82	$99	$111	$99	$96	$99	$98	$102	$91	$87	$964
Total	**$988**	**$1,089**	**$906**	**$880**	**$865**	**$871**	**$844**	**$852**	**$402**	**$398**	**$8,097**

Source: California Department of Water Resources 2013: Chapter 8.

[a] All numbers are in 2012 dollars (millions).

[b] Land acquisition costs assume that 100% of landowners live in state.

[c] *Other* category includes administrative implementation costs, monitoring, and potential research costs. Existing IEP and related program costs are excluded from this category as these costs will occur with or without BDCP.

5.1.3.2.1 Agricultural Land Retirement

The other relevant conservation measures also require that an estimated 64,158 acres of cultivated land be converted to an alternative land use. Calculating the impacts of the other conservation measures on Delta agriculture requires detailed knowledge of the agricultural lands that may be retired. To calculate region-specific losses, this analysis uses data at the level of the individual crop field, collected from the agriculture departments of the six Delta counties. As mandated by California pesticide use regulations, each Delta county collects information from its farmers on all crop fields in which pesticides are applied. Through the use of GIS software, those data are digitally mapped and aggregated to form a mosaic of agricultural fields within the Delta.

The use of annual crop reports produced by county agriculture departments allows for linking current crop revenues to individual fields based on the yield and price figures reported in each county. The result is a map of all reported Delta crop fields to which pesticide was applied in 2010, with corresponding revenue figures specific to the commodity produced in each field. Areas targeted by conservation measures are mapped into conservation zones, which overlap county and other administrative boundaries. GIS software allows for the extraction of all crops grown within each conservation zone, and thus provides a means to directly analyze the subset of fields potentially affected by each conservation measure.

Agricultural commodities are aggregated into a limited number of discrete classes to format data for input into IMPLAN. The major crop classes used in the analysis are deciduous, field, grain, pasture, truck, and vineyard. By assigning different revenue or job impacts based on the proportion of crop classes grown within each conservation zone, more precise calculations can be made. The commodities aggregated in each class tend to have similar labor requirements as well as similar revenues.

Current BDCP documents contain insufficient detail to make a precise estimate of total impacts, and this analysis thus makes conservative assumptions in establishing a reasonable estimate of potential revenue and economic activity impacts. Assumptions specific to the individual conservation measures affecting agricultural land use are outlined below.

CM2 Yolo Bypass Fisheries Enhancement. A document produced by the BDCP working group involved in CM2, which evaluates impacts from operation of the Fremont Weir Gated Channel, estimates 7,000 to 10,000 acres of agricultural land could be inundated after March 1 in all years, based on BDCP Chapter 3, Section 3.4, *Conservation Measures*. While late-season flooding is not expected to occur in every year, for the purposes of assessing economic effects, it is assumed to occur in every year. This is the period at which flooding would begin to interfere with agricultural planting. This analysis uses the midpoint of the aforementioned range and assumes that 8,500 acres are affected, with impacts affecting a representative mix of Yolo Bypass crops. In addition to the periodic impacts, 664 acres of permanent agricultural production is predicted to be lost due to infrastructure improvements associated with CM2.

CM4 Tidal Natural Communities Restoration. The restoration of tidal natural communities has the largest potential impacts for agriculture, and will lead to the retirement of an estimated 41,683 acres of cultivated agricultural land (California Department of Water Resources 2013). The estimate used in this analysis assumes that the restoration opportunity areas are fully utilized to meet half of the 65,000-acre target (32,500 acres), with acreage allocated proportionately based on each area's minimum acreage target. The analysis assumes a representative crop mix from each restoration opportunity area affected.

CM5 Seasonally Inundated Floodplain Restoration. The restoration of 10,000 acres of seasonally inundated floodplain will occur in the south Delta (Conservation Zone 7) through the use of setback levees. Cultivated lands permanently lost as a result of levee construction associated with CM5 are estimated at 2,144 acres. The 4,830 acres of floodplain secured through fee-title would be revegetated, creating periodic flooding and taking these acres out of production. Land restored under CM5 is expected to remain in private ownership, with flood easements purchased to allow for periodic flooding and use by fish from the San Joaquin River and its tributaries.

CM7 Riparian Natural Community Restoration. Riparian restoration from CM7 is expected to permanently remove 3,062 acres from agricultural production in Conservation Zone 7.

CM8 Grassland Natural Community Restoration. CM8 is expected to remove 2,000 acres from agricultural production. Implementation of CM8 will affect Conservation Zones 1, 2, 4, 5, 7, 8, and 11. The analysis assumes a representative crop mix from each conservation zone affected.

CM10 Nontidal Marsh Restoration. The restoration of nontidal marsh is expected to remove 1,950 acres from agricultural production in Conservation Zones 2, 4, and 5. The analysis assumes a representative crop mix from each conservation zone affected.

5.1.3.2.2 Agricultural Revenue Loss

The total estimated revenue impacts of each conservation measure are shown in Table 5.1-8. These totals are allocated to the county level based on the proportion of each affected region's land area located in each county.

Table 5.1-8. Revenue Impacts of Restoration Conservation Measures

CM	Affected Regions	Average Per-Acre Revenue [a]	Acreage Affected [a]	Revenue Loss [a] * [b]
CM2	Yolo Bypass	$1,211	9,164	$11,097,604
CM4	Cache Slough ROA	$491	9,601	$4,710,558
	Cosumnes/Mokelumne ROA	$2,175	7,134	$15,512,841
	West Delta ROA	$2,151	4,181	$8,994,511
	South Delta ROA	$1,279	20,768	$26,568,531
CM5	Conservation Zone 7	$1,822	6,974	$12,706,530
CM7	Conservation Zone 7	$1,822	3,062	$5,578,739
CM8	Conservation Zone 1	$463	467	$216,237
	Conservation Zone 2	$802	150	$120,304
	Conservation Zone 4	$2,075	150	$311,267
	Conservation Zone 5	$1,838	150	$275,742
	Conservation Zone 7	$1,822	150	$273,316
	Conservation Zone 8	$1,897	467	$885,186
	Conservation Zone 11	$367	467	$171,464
CM10	Conservation Zone 2	$802	600	$481,247
	Conservation Zone 4	$2,075	675	$1,400,722
	Conservation Zone 5	$1,838	675	$1,240,920
Total			**64,158**	**$89,304,798**

Sources: County Agricultural Commissioners 2010; County Fields Borders Data 2010; California Department of Water Resources 2013.
ROA = restoration opportunity area

5.1.3.3 Results

Table 5.1-9 through Table 5.1-13 present the estimated economic activity impacts of the BDCP in terms of the present value change in economic activity based on the estimated expenditures discussed in the previous section. The tables provide direct, indirect, and induced economic activity impacts by time period for each expenditure category.

- Planning and construction
- Operations and maintenance
- Land acquisition
- Other (administrative implementation, monitoring, and research)
- Agricultural land retirement

Most of the change occurs in the first two decades of BDCP implementation. In the first 10 years of plan implementation, restoration actions will increase economic activity by a total of $3.3 billion, measured in 2012 dollars. In the second 10 years, restoration actions will increase economic activity by a total of $1.8 billion, again measured in 2012 dollars. Impacts after the first two decades account for approximately 20% of the total change in discounted economic activity. The analysis demonstrates that the net economic activity benefits of restoration actions in the Delta are positive and large. Restoration actions under the BDCP will create over $6.6 billion dollars in economic activity in California, even after accounting for the effects of agricultural land retirement.

Table 5.1-9 presents economic activity impacts in terms of the output increase from estimated planning and construction expenditures. Table 5.1-10 does the same for operations and maintenance expenditures. Table 5.1-11 covers the economic activity impacts associated with land acquisition, which is a result of increased spending by landowners who sell their lands to the state. No direct or indirect economic activity impacts due to land acquisition are considered. Table 5.1-12 covers the economic activity impacts from administrative implementation, monitoring, and research costs. Table 5.1-13 presents the impacts on economic activity due to agricultural revenue losses from land retirement; these losses are attributable to reduced agricultural production and grow over time as the amount of land retired accumulates.

Table 5.1-9. Economic Activity Impact of Other Conservation Measures—Construction and Planning (million $)

Impacts	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	$612	$568	$337	$289	$251	$217	$176	$152	$34	$29	$2,664
Indirect	$303	$281	$167	$143	$124	$107	$87	$75	$17	$14	$1,318
Induced	$375	$348	$206	$177	$154	$133	$108	$93	$21	$18	$1,631
Total	**$1,290**	**$1,196**	**$709**	**$608**	**$530**	**$457**	**$371**	**$320**	**$71**	**$61**	**$5,612**
Note: All impacts are discounted at 3 percent real discount rate.											

Table 5.1-10. Economic Activity Impacts of Other Conservation Measures–Operations and Maintenance (million $)

Impacts	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	$101	$144	$139	$122	$96	$84	$74	$65	$57	$50	$932
Indirect	$42	$60	$58	$51	$40	$35	$31	$27	$24	$21	$388
Induced	$62	$88	$85	$75	$59	$51	$45	$40	$35	$30	$570
Total	**$204**	**$293**	**$281**	**$248**	**$194**	**$170**	**$150**	**$132**	**$116**	**$100**	**$1,890**
Note: All impacts are discounted at 3% real discount rate.											

Table 5.1-11. Economic Activity Impacts of Other Conservation Measures—Land Acquisition (million $)

Impacts (Payments to Landowners)	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Indirect	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Induced	$190	$129	$112	$85	$74	$64	$55	$47	$0	$0	$755
Total	**$190**	**$129**	**$112**	**$85**	**$74**	**$64**	**$55**	**$47**	**$0**	**$0**	**$755**
Note: All impacts are discounted at 3% real discount rate.											

Table 5.1-12. Economic Activity Impacts of Other Conservation Measures—Administrative, Implementation, Monitoring, Research (million $)

Impacts	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	$75	$78	$76	$58	$48	$43	$37	$33	$25	$21	$496
Indirect	$36	$37	$36	$28	$23	$21	$18	$16	$12	$10	$236
Induced	$56	$59	$57	$44	$36	$32	$28	$25	$19	$16	$371
Total	**$167**	**$174**	**$169**	**$129**	**$108**	**$96**	**$82**	**$74**	**$57**	**$47**	**$1,103**
Note: All impacts are discounted at 3% real discount rate.											

Table 5.1-13. Economic Activity Impacts of Other Conservation Measures—Agricultural Land Retirement (million $)

Impact (Agricultural Revenue Loss)	Expenditure Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	($51)	($87)	($119)	($134)	($143)	($148)	($148)	($145)	($125)	($108)	($1,208)
Indirect	($40)	($70)	($95)	($107)	($114)	($118)	($118)	($116)	($100)	($86)	($963)
Induced	($26)	($45)	($61)	($69)	($74)	($76)	($76)	($75)	($64)	($55)	($620)
Total	**($117)**	**($202)**	**($274)**	**($310)**	**($331)**	**($341)**	**($341)**	**($336)**	**($289)**	**($250)**	**($2,791)**
Note: All impacts are discounted at 3% real discount rate.											

5.1.4 Water Reliability

The water reliability associated with the new water conveyance facility (CM1) will have statewide economic impacts on both the commercial/industrial/institutional sector and the agricultural sector. Two separate approaches are employed in calculating impacts for each of these sectors. The following sections outline the approaches and present the analysis results.

5.1.4.1 Commercial/Industrial/Institutional Impacts

5.1.4.1.1 Methods and Data

The SDBSIM, described in BDCP Appendix 9.A, is used to evaluate the commercial/industrial/institutional avoided shortages under the BDCP relative to the baseline scenario. Impacts are calculated on a disaggregated retailer level given the distribution of commercial/industrial/institutional shortages estimated with the SDBSIM. The SDBSIM evaluates water shortages in each sector[11] given demand levels over time and water supply availability for each of the SWP contractors. The model runs 83 different trials for each agency by rotating through a historical hydrologic sequence and then allocates the shortages across the different sector within a region.

Given the commercial/industrial/institutional shortages calculated with the SDBSIM, retailer-specific output multipliers are used to translate a percent change in water availability into a percent change in direct output (MHB Consultants 1994:13–14). A separate multiplier is calculated for shortages below 15% of commercial/industrial/institutional demand and shortages above 15% of demand for output. The reason for using two separate multipliers for different levels of shortages is that economic impacts are much more dire at high levels of shortage when industries have to start making more drastic changes in operations to account for water limitations. Because these multipliers are specific to the industries classified by the NAICS, one weighted average multiplier for below 15% shortage and one for above 15% shortage are created for all output, regardless of NAICS code, within a retailer. GIS software is used to map NAICS establishments at the zip code level (U.S. Census Bureau 2007) into the number of NAICS-specific establishments within a water district. The share of the water district that belongs to each zip code and the share of NAICS establishments within a zip code are then used to translate county-level sales revenue data (U.S. Census Bureau 2007) into water district NAICS-specific sales revenue. The output multipliers by NAICS code are then weighted according to the share of the corresponding sales revenue within the district.

Direct economic activity impacts are calculated given the percent shortages from SDBSIM and the weighted output multipliers. IMPLAN is then used to calculate the indirect and induced economic activity impacts.

5.1.4.1.2 Results

The resulting impacts are aggregated across all retailers and discounted back to present value at a 3% real discount rate. Table 5.1-14 demonstrates the expected impacts of water reliability on economic activity in the commercial/industrial/institutional sector in an average year under the BDCP relative to the baseline scenario. The expected impacts of the BDCP are an average annual increase of $3,926 million (undiscounted) in output as compared to the baseline scenario.

[11] All sectors are composed of single-family residential, multifamily residential, commercial/industrial/institutional, and agriculture.

Table 5.1-14. Average Annual Commercial/Industrial/Institutional Employment and Output Impacts (Undiscounted)

Change under the BDCP Relative to Baseline Scenario	Output (million $)
	$3,926
[a] Output impacts are in annual undiscounted 2012 dollars.	

5.1.4.2 Agriculture Impacts

The impacts on economic activity associated with changes in water supply reliability in the agricultural sector under the BDCP are calculated using the SWAP model.

5.1.4.2.1 Methods and Data

The SWAP model is used to calculate crop production change under the BDCP relative to the baseline scenario within the regions served by the water contractors. The SWAP is an optimization model of California's agricultural economy, developed for use as a policy analysis and planning tool. The model is calibrated using the technique of Positive Mathematical Programming, which relies on observed data to deduce the marginal impacts of future policy changes on cropping patterns, water use, and economic performance (Howitt 1995). As a multi-input, multi-output model, SWAP determines the optimal crop mix, water supplies, and other farm inputs necessary to maximize profit subject to heterogeneous agricultural yields, prices, and costs. SWAP's outcomes reflect the impacts of environmental constraints on land and water availability, and can be adapted to reflect any number of additional policy or technological constraints on farm production.

The Positive Mathematical Programming approach taken by SWAP allows for calibration of parameters that exactly match base-year conditions, using observed data on land use, farmer behavior, and other exogenous information. Under the fundamental assumption of profit-maximizing behavior by farmers, the model uses a nonlinear objective function to derive parameters that satisfy first-order conditions for optimization under the base year's observed input and output data. While aggregate data on variables such as crop yield and acreage are often available, it is much more difficult to estimate a crop's marginal production costs. In lieu of relying on these often inaccurate estimates, the Positive Mathematical Programming technique uses the more reliable aggregate data to infer the marginal costs of production for each crop in a given region.

Aggregate data used in SWAP come from a variety of sources. Crops are aggregated into 20 categories defined in collaboration with the DWR, with a proxy crop identified to represent production costs and returns for each category. Input costs and yields for the proxy crops are derived from the regional cost and return studies from the University of California Cooperative Extension (2011) crop budgets. Base applied water requirements are derived from DWR (2010) estimates. Commodity prices from the model's base year are obtained from the California County Agricultural Commissioner's reports. County-level data are aggregated to a total of 37 agricultural subregions, based on DWR detailed analysis units. The SWAP regions aggregate one or more detailed analysis units, which are chosen based on similar microclimate, water availability, and production conditions.

The SWAP model specifically accounts for both surface and groundwater supplies. In total, the SWAP model considers a number of types of surface water: SWP delivery, CVP delivery, and local deliveries or direct diversions. Where applicable, water costs include both the SWP and CVP charge as well as a district's charge. For groundwater, the model includes both the fixed costs of pumping and the variable costs based off operations and maintenance and energy costs.

The SWAP model used to forecast crop production changes is the same model used to calculate benefits of agricultural water supply reliability. For a detailed description of the SWAP model, see BDCP Appendix 9.A.

5.1.4.2.2 Results

The SWAP model assumes an increase of roughly 0.7 million acre-feet per year of SWP/CVP deliveries to the agricultural sector. According to SWAP, there is an average annual increase of 202,176 acres of crop land in production and $134 million per year (undiscounted) of increased direct output associated with an additional 0.7 million acre-feet in water deliveries (Table 5.1-15). An increase in $134 million in direct economic activity implies a total increase of $344 million per year (undiscounted) in economic activity when accounting for direct, indirect, and induced impacts (University of California 2009: page 5-17). These results are summarized in Table 5.1-15.

Table 5.1-15. Average Annual Agricultural Impacts

	Crop Land	Output[a]
	(Acres)	(million $)
Change under the BDCP Relative to Baseline Scenario	202,176	$344
[a] Output impacts are in annual undiscounted 2012 dollars.		

5.2 Impacts on Employment

5.2.1 Introduction

This section evaluates the economic impacts of the BDCP on employment in California. These impacts will result from construction and operation of the new water conveyance facility under *CM1 Water Facilities and Operation*, implementation of other conservation measures (CM2–CM11 and CM13–CM21), and increased water reliability generated under the BDCP. An important element of these economic impacts is the creation of new temporary and permanent jobs. Job creation will be offset somewhat by job losses from the conversion of agricultural land to the water conveyance facility and reserve lands. There will also be induced job losses associated with increased water rates and taxes. This analysis uses conservative assumptions and does not include jobs created by other initiatives considered under the BDCP.

Table 5.2-1 and Table 5.2-2 summarize the employment and employment compensation[1] impacts, respectively, associated with each of the following three categories.

- **CM1 Water Facilities and Operation.** Increased employment associated with the planning and construction of the water conveyance facility is estimated at 110,596 new full-time equivalent[2] (FTE) jobs, and increased employment compensation is estimated at $7.8 billion in California during an expected 10-year planning and construction period. Operations and maintenance expenses are assumed to begin in year 11 and will create an estimated 11,331 FTE jobs and increase employment compensation by $510 million over the remaining 40 years of the permit term. This represents an annual rate of just under 283 FTE operations and maintenance positions.
- **Other Relevant Conservation Measures (CM2–CM11, CM13–CM21).** The construction and planning; operations and maintenance; land acquisition; and administrative implementation, monitoring, and research share of the other conservation measures will result in an estimated 92,589 FTE jobs and $3.5 billion in employee compensation over the 50-year permit term. The retirement of agricultural lands will result in an estimated loss of 36,819 FTE jobs and $807 million in employee compensation during the same period, for a net gain of an estimated 55,770 FTE jobs and $2.7 billion in compensation over the 50-year permit term.
- **Water Supply Reliability.** Employment impacts resulting from increased water supply reliability begin when the BDCP comes into operation. Impacts on the commercial/industrial/ institutional sector and the agricultural sector are estimated to be 761,840 and 257,824 FTE jobs, respectively, totaling 1,019,664 FTE jobs over the 50-year permit term.

As shown in Table 5.2-1 and Table 5.2-2, taking all impacts together, and netting out the induced employment loss as a result of higher water costs and taxes, the BDCP will create an estimated net 1,094,477 FTE jobs and $11.0 billion in employee compensation over the 50-year permit term.

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[1] The analysis of employment compensation does not currently include impacts from water reliability due to lack of data.

[2] Full-time equivalent or FTE is defined as the number of total hours worked divided by the maximum number of compensable hours in a work year as defined by law. For example, an FTE of 1.0 means that the position is equivalent to 1 full-time worker, while an FTE of 0.5 means the position is equivalent to a half-time worker.

Importantly, new jobs associated with restoration planning, construction, and payments to land owners will more than offset agricultural job losses attributed to the associated agricultural land retirements.

This section describes the specific methods, data, and results associated with the three categories of employment impacts.

Table 5.2-1. Statewide Employment Impact Summary (Full-Time Equivalent Jobs[a])

Category	Per 10-Year Period					Total over 50 Years
	1–10	10–20	20–30	30–40	40–50	
CM1 Water Facilities and Operation						
Construction and planning	110,596	0	0	0	0	110,596
Operations and maintenance	0	2,833	2,833	2,833	2,833	11,331
Subtotal	**110,596**	**2,833**	**2,833**	**2,833**	**2,833**	**121,928**
Other Relevant Conservation Measures (CM2–CM11, CM13–CM21)						
Construction and planning	15,962	11,338	11,414	10,733	2,753	52,200
Operations and maintenance	3,494	4,909	4,539	4,727	4,879	22,548
Land acquisition[b]	2,016	1,676	1,580	1,572	0	6,844
Other[c]	2,070	2,400	2,219	2,280	2,028	10,998
Agricultural land retirement[d]	(2,092)	(5,076)	(7,824)	(10,569)	(11,258)	(36,819)
Subtotal	**21,450**	**15,247**	**11,928**	**8,743**	**(1,598)**	**55,770**
Water Supply Reliability						
Commercial/industrial/ institutional	0	190,460	190,460	190,460	190,460	761,840
Agricultural	0	64,456	64,456	64,456	64,456	257,824
Subtotal	**0**	**254,916**	**254,916**	**254,916**	**254,916**	**1,019,664**
Increased Water Rates and Taxes						
Induced Employment Impact	(88,322)	(5,004)	(4,202)	(3,137)	(2,221)	(102,885)
Subtotal	**(88,322)**	**(5,004)**	**(4,202)**	**(3,137)**	**(2,221)**	**(102,885)**
Total Employment Impacts Across All Categories	**43,725**	**267,992**	**265,475**	**263,355**	**253,930**	**1,094,477**

[a] Jobs are defined as full-time equivalents (total hour worked divided by average annual hours worked in full-time jobs.)

[b] Represents the impacts from payments made to landowners to acquire reserve lands for protection, restoration, and enhancement either in fee title or as conservation easement.

[c] Impacts from administrative implementation, monitoring, and research costs.

[d] Represents agricultural revenue loss from decreased agricultural activity that would result from the conversion of agricultural lands to reserve lands. Impacts due to conversion of agricultural lands to water conveyance facilities were not modeled; however, these impacts are small in comparison, representing only 10% of agricultural retirement under the BDCP.

Table 5.2-2. Statewide Employment Compensation Impact Summary (million $)

Category	Per 10-Year Period					Total over 50 Years
	1–10	10–20	20–30	30–40	40–50	
CM1 Water Facilities and Operation						
Construction and planning	$7,791	$0	$0	$0	$0	$7,791
Operations and maintenance	$0	$188	$140	$104	$78	$510
Subtotal	**$7,791**	**$188**	**$140**	**$104**	**$78**	**$8,301**
Other Relevant Conservation Measures (CM2–CM11, CM13–CM21)						
Construction and planning	$923	$489	$366	$256	$49	$2,084
Operations and maintenance	$192	$204	$140	$109	$84	$728
Land acquisition[b]	$103	$64	$44	$33	$0	$245
Other[c]	$149	$130	$89	$68	$45	$482
Agricultural land retirement[d]	($92)	($169)	($194)	($196)	($156)	($807)
Subtotal	**$1,275**	**$718**	**$446**	**$270**	**$22**	**$2,732**
Total Employment Impacts Across All Categories (except water reliability)	**$9,066**	**$907**	**$586**	**$375**	**$99**	**$11,033**

[a] All impacts are based on cost estimates in 2012 dollars and are discounted to present value at a 3% real discount rate.

[b] Represents the impacts from payments made to landowners to acquire reserve lands for protection, restoration, and enhancement either in fee title or as conservation easement.

[c] Impacts from administrative implementation, monitoring, and research costs.

[d] Represents agricultural revenue loss from decreased agricultural activity that would result from the conversion of agricultural lands to reserve lands. Impacts due to conversion of agricultural lands to water conveyance facilities were not modeled; however, these impacts are small in comparison, representing only 10% of agricultural retirement under the BDCP.

5.2.2 CM1 Water Facilities and Operation

The 10 years of planning and construction and 40 years of operation and maintenance of the water conveyance facility (CM1) will have significant employment impacts on the state of California. These impacts are evaluated with the same method and data as the economic activity impacts described in Section 5.1, *Impacts on State Income* (with the use of IMPLAN[3] for the construction and the operation and maintenance).

[3] IMPLAN is the most widely used model for this purpose and has been used by many California government agencies. IMPLAN's client list includes the California Department of Finance, California Department of Transportation, California Department of Water Resources, and California State Water Resources Control Board. At the federal level, IMPLAN has been used by the U.S. Army Corps of Engineers, the Bureau of Economic Analysis, the Bureau of Land Management, and the Bureau of Reclamation. IMPLAN website: http://implan.com/V4/Index.php.

5.2.2.1 Methods

Refer to Section 5.1, *Impacts on State Income* (Section 5.1.2.1, *Methods*).

5.2.2.2 Data

Refer to Section 5.1, *Impacts on State Income* (Section 5.1.2.2, *Data*).

5.2.2.3 Results

5.2.2.3.1 Construction

The construction of the water conveyance facility (CM1) will create 110,596 FTE jobs and increase employee compensation by $7.8 billion in California during an expected 10-year planning and construction period. Summaries of FTE job impacts and employee compensation by county and statewide are presented in Table 5.2-3 and Table 5.2-4, respectively.

Table 5.2-3. Employment Impact of CM1 Construction (Full-Time Equivalent Jobs)[a,b,c]

Type of Impact	California (State)	Contra Costa County	Sacramento County	San Joaquin County
Direct	20,580	1,088	3,972	3,491
Indirect	51,715	2,187	10,623	25,310
Induced	38,302	1,435	7,977	13,457
Total	**110,596**	**4,710**	**22,572**	**42,258**

[a] All impacts are based on cost estimates in 2012 dollars.
[b] Spending on engineering and design is assumed to occur outside of the three-county region.
[c] Totals may not add correctly due to rounding.

Table 5.2-4. Employee Compensation Impact of CM1 Construction (million $)[a, b]

Type of Impact	California (State)	Contra Costa County	Sacramento County	San Joaquin County
Direct	$2,593	$216	$768	$651
Indirect	$3,212	$149	$640	$1,504
Induced	$1,986	$74	$385	$573
Total	**$7,791**	**$439**	**$1,793**	**$2,728**

[a] All impacts are based on cost estimates in 2012 dollars and are discounted to present value at a 3% real discount rate.
[b] Spending on engineering and design is assumed to occur outside of the three-county region.

Table 5.2-5 shows employment impacts for the top 10 IMPLAN sectors in terms of job creation for CM1 construction. These sectors account for over 60% of the estimated jobs. Most of the employment impacts are the result of indirect and induced spending, with substantial job creation occurring in the construction, design, and materials manufacturing sectors, as well as sectors supported by households spending their income on food, healthcare, and housing.

Table 5.2-5. Employment Creation by Top Ten IMPLAN Sectors for CM1 Construction

IMPLAN #	IMPLAN Sector	Full-Time Equivalent Jobs[a]
36	Construction of other new nonresidential structures	16,785
369	Architectural, engineering, and related services	15,765
163	Other concrete product manufacturing	10,692
413	Food services and drinking places	4,507
319	Wholesale trade businesses	3,625
186	Plate work and fabricated structural product manufacturing	3,275
360	Real estate establishments	3,053
283	Employment services	2,549
394	Offices of physicians, dentists, and other health practitioners	2,016
388	Services to buildings and dwellings	1,585

[a] Includes direct, indirect, and induced employment.

5.2.2.3.2 Operations

The operations and maintenance of the water conveyance facility (CM1) will create an additional 283 FTE jobs annually and will increase employee compensation at about $30 million per year (undiscounted) over the analyzed 40-year operating period. The annual employment impacts are summarized in Table 5.2-6 and Table 5.2-7.

Table 5.2-6. Employment Impact of CM1 Operations (annualized full-time equivalent jobs)[a]

Type of Impact	California (State)	Contra Costa County	Sacramento County	San Joaquin County
Direct	80	10	37	33
Indirect	75	6	28	21
Induced	128	9	48	43
Total	**283**	**25**	**113**	**97**

[a] All impacts are annualized over a 40-year operating period.

Table 5.2-7. Employee Compensation Impact of CM1 Operations (annualized, undiscounted million $)[a]

Type of Impact	California (State)	Contra Costa County	Sacramento County	San Joaquin County
Direct	$17	$2	$8	$7
Indirect	$5	$0	$2	$1
Induced	$8	$1	$3	$2
Total	**$30**	**$3**	**$12**	**$10**

[a] All impacts are based on annualized cost estimates in 2012 dollars and are displayed in annualized undiscounted 2012 dollars.

5.2.3 Other Relevant Conservation Measures

There are significant employment impacts from the other conservation measures (CM2–CM11 and CM13–CM21). Section 5.1, *Impacts on State Income,* outlines the additional conservation measures considered in this employment impact analysis (Section 5.1.3, *Other Conservation Measures*). These conservation measures cover over 100,000 acres, with a total estimated cost of $8.1 billion in undiscounted 2012 dollars to be spent over the 50-year permit term.[4] Some of these conservation measures call for land acquisition, which is expected to account for as much as 12% of the total implementation cost. In addition, the BDCP will result in the retirement (i.e., conversion) of an estimated 64,158 acres of land currently under cultivation. This loss of cultivated land will result in employment losses.

5.2.3.1 Methods and Data

The employment estimates presented in this section are calculated using the same method and data described in Section 5.1, *Impacts on State Income* (Section 5.1.3.1, *Methods* and Section 5.1.3.2, *Data*).

5.2.3.2 Results

Table 5.2-8 and Table 5.2-9 present the estimated job impacts and employment compensation impacts from the BDCP. Job impacts are presented in terms of the number of jobs gained or lost based on the estimated expenditures discussed in the previous section. The corresponding employment compensation impacts are in terms of 2012 dollars discounted at a 3% real discount rate. The tables provide direct, indirect, and induced employment impacts by time period for each expenditure category.

- Planning and construction
- Operations and maintenance
- Land acquisition
- Other (administrative implementation, monitoring, and research)
- Agricultural land retirement

Most of the change occurs in the first two decades of the permit term. In the first 10 years, habitat restoration will increase employee compensation by a total present value of $1.3 billion, measured in 2012 dollars. In the second years, restoration will increase compensation by a total present value of $0.7 billion, again measured in 2012 dollars. Impacts after the first two decades account for around 30% of the total change in discounted compensation. The analysis demonstrates that the net employment compensation benefits of habitat restoration in the Delta are positive and large. The BDCP will create a present value of over $2.7 billion dollars in employee compensation in California, even after accounting for the effects of agricultural land retirement.

Table 5.2-8 and Table 5.2-9 present employment impacts based on estimated planning and construction expenditures. Table 5.2-10 and Table 5.2-11 do the same for operations and maintenance expenditures. Table 5.2-12 and Table 5.2-13 cover the employment impacts associated

[4] Costs are from BDCP Chapter 8, *Implementation Costs and Funding Sources* (California Department of Water Resources 2013).

with land acquisition, which is a result of increased spending by landowners who sell their lands to the state. No direct or indirect employment impacts due to land acquisition are considered.

Table 5.2-14 and Table 5.2-15 cover the employment impacts from the administrative implementation, monitoring, and research costs. Table 5.2-16 and Table 5.2-17 present the impacts on employment due to agricultural revenue losses from land retirement. These losses are attributable to reduced agricultural production and increase over time as the amount of land retired accumulates.

Table 5.2-8. Employment Impact of Other Conservation Measures—Construction and Planning (full-time equivalent jobs)

Construction and Planning	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	3,918	4,211	2,896	2,878	2,907	2,907	2,733	2,733	701	701	26,586
Indirect	1,516	1,629	1,120	1,113	1,124	1,124	1,057	1,057	271	271	10,284
Induced	2,259	2,428	1,670	1,660	1,676	1,676	1,576	1,576	404	404	15,330
Total	**7,693**	**8,269**	**5,687**	**5,651**	**5,707**	**5,707**	**5,366**	**5,366**	**1,377**	**1,377**	**52,200**

Table 5.2-9. Employment Compensation Impact of Other Conservation Measures—Construction and Planning (million $)

Construction and Planning	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	$256	$237	$141	$121	$105	$91	$73	$63	$14	$12	$1,112
Indirect	$101	$94	$56	$48	$42	$36	$29	$25	$6	$5	$441
Induced	$122	$113	$67	$58	$50	$43	$35	$30	$7	$6	$531
Total	**$479**	**$444**	**$263**	**$226**	**$197**	**$170**	**$138**	**$119**	**$26**	**$23**	**$2,084**
Note: All impacts are discounted at 3% real discount rate.											

Table 5.2-10. Employment Impacts of Other Conservation Measures—Operations and Maintenance (full-time equivalent jobs)

Operations and Maintenance	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	724	1,201	1,338	1,366	1,240	1,260	1,288	1,316,	1,344	1,344	12,420
Indirect	219	363	404	413	375	381	389	398	406	406	3,753
Induced	371	617	687	701	636	647	661	675	690	690	6,374
Total	**1,313**	**2,181**	**2,429**	**2,480**	**2,251**	**2,287**	**2,338**	**2,389**	**2,439**	**2,439**	**22,548**

Table 5.2-11. Employment Compensation Impacts of Other Conservation Measures—Operations and Maintenance (million $)

Operations and Maintenance	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	$45	$64	$62	$54	$42	$37	$33	$29	$25	$22	$413
Indirect	$14	$20	$19	$17	$13	$12	$10	$9	$8	$7	$129
Induced	$20	$29	$28	$24	$19	$17	$15	$13	$11	$10	$186
Total	**$79**	**$113**	**$108**	**$95**	**$75**	**$66**	**$58**	**$51**	**$45**	**$39**	**$728**
Note: All impacts are discounted at 3% real discount rate.											

Table 5.2-12. Employment Impacts of Other Conservation Measures—Land Acquisition

Land Acquisition (Payments to Landowners)	Expenditure Per 5-Year Period (full-time equivalent jobs)										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	0	0	0	0	0	0	0	0	0	0	0
Indirect	0	0	0	0	0	0	0	0	0	0	0
Induced	1,128	888	894	782	790	790	786	786	0	0	6,844
Total	**1,128**	**888**	**894**	**782**	**790**	**790**	**786**	**786**	**0**	**0**	**6,844**
Note: Payments to landowners are modeled as a household income change and only create induced employment effects.											

Table 5.2-13. Employment Compensation Impacts of Other Conservation Measures—Land Acquisition (million $)

Land Acquisition (Payments to Landowners)	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Indirect	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Induced	$62	$42	$36	$27	$24	$21	$18	$15	$0	$0	$245
Total	**$62**	**$42**	**$36**	**$27**	**$24**	**$21**	**$18**	**$15**	**$0**	**$0**	**$245**
Note: All impacts are discounted at 3% real discount rate.											

Table 5.2-14. Employment Impacts of Other Conservation Measures—Administrative, Implementation, Monitoring, Research (full-time equivalent jobs)

Administrative Implementation, Monitoring, Research (Other)	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	379	457	513	456	441	456	451	470	418	401	4,443
Indirect	214	258	290	258	249	257	255	266	236	227	2,510
Induced	345	416	467	415	401	415	410	428	380	365	4,044
Total	**938**	**1,132**	**1,270**	**1,130**	**1,091**	**1,128**	**1,116**	**1,164**	**1,034**	**994**	**10,998**

Table 5.2-15. Employment Compensation Impacts of Other Conservation Measures—Administrative, Implementation, Monitoring, Research (million $)

Administrative Implementation, Monitoring, Research (Other)	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	$41	$43	$42	$32	$27	$24	$20	$18	$14	$12	$272
Indirect	$13	$14	$13	$10	$9	$8	$7	$6	$4	$4	$88
Induced	$19	$19	$19	$14	$12	$11	$9	$8	$6	$5	$123
Total	**$73**	**$76**	**$74**	**$57**	**$47**	**$42**	**$36**	**$32**	**$25**	**$21**	**$482**
Note: All impacts are discounted at 3% real discount rate.											

Table 5.2-16. Employment Impacts of Other Conservation Measures—Agricultural Land Retirement (full-time equivalent jobs)

Agricultural Land Retirement (Revenue Loss to Agriculture)	Expenditure Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	(242)	(485)	(764)	(1,001)	(1,240)	(1,479)	(1,717)	(1,957)	(1,957)	(1,957)	(12,799)
Indirect	(295)	(591)	(930)	(1,219)	(1,511)	(1,802)	(2,091)	(2,383)	(2,383)	(2,383)	(15,588)
Induced	(160)	(319)	(503)	(659)	(817)	(975)	(1,131)	(1,289)	(1,289)	(1,289)	(8,432)
Total	**(697)**	**(1,395)**	**(2,198)**	**(2,878)**	**(3,568)**	**(4,256)**	**(4,940)**	**(5,629)**	**(5,629)**	**(5,629)**	**(36,819)**

Table 5.2-17. Employment Compensation Impacts of Other Conservation Measures—Agricultural Land Retirement (million $)

Agricultural Land Retirement (Revenue Loss to Agriculture)	Per 5-Year Period										Total
	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	
Direct	($12)	($20)	($28)	($31)	($33)	($34)	($34)	($34)	($29)	($25)	($280)
Indirect	($13)	($23)	($32)	($36)	($38)	($39)	($39)	($39)	($33)	($29)	($321)
Induced	($9)	($15)	($20)	($23)	($24)	($25)	($25)	($25)	($21)	($18)	($206)
Total	**($34)**	**($58)**	**($79)**	**($90)**	**($96)**	**($99)**	**($99)**	**($97)**	**($84)**	**($72)**	**($807)**
Note: All impacts are discounted at 3% real discount rate.											

Table 5.2-18 shows construction and planning and operations and maintenance employment impacts for the top 10 IMPLAN sectors in terms of job creation over the 50-year permit term. These sectors account for almost 70% of the estimated jobs. Most of the employment impacts are the result of direct and induced spending, with substantial job creation occurring in the construction, design, and materials manufacturing sectors, as well as sectors supported by households spending their income on food, healthcare, and housing.

Table 5.2-18. Construction, Planning, and Operations and Maintenance Employment Impacts by Top 10 IMPLAN Sector for Other Conservation Measures

IMPLAN	IMPLAN Description	Full-Time Equivalent Jobs[a]
36	Construction of other new nonresidential structures	26,586
39	Maintenance and repair construction of nonresidential structures	12,597
369	Architectural, engineering, and related services	2,876
413	Food services and drinking places	2,282
319	Wholesale trade businesses	1,753
360	Real estate establishments	1,543
394	Offices of physicians, dentists, and other health practitioners	1,140
382	Employment services	990
397	Private hospitals	869
329	Retail stores – general merchandise	812
[a] Includes direct, indirect, and induced employment.		

5.2.4 Employment Impacts of Water Reliability

The water reliability associated with CM1 operations will have statewide employment impacts on both the commercial/industrial/institutional sector and the agricultural sector. Two separate approaches are utilized in calculating impacts for each of these sectors. The following sections outline the two approaches and present the analysis results.

5.2.4.1 Commercial/Industrial/Institutional Impacts

The employment estimates presented in this section are calculated using the same method and data as described in Section 5.1.4, *Water Reliability*. Employment specific multipliers are used instead of the output multipliers to translate a percent shortage into direct employment impacts. Also, zip code–level payroll data (U.S. Census Bureau 2007) is used instead of sales revenue data in order to calculate employment impacts.

5.2.4.1.1 Results

The resulting impacts are aggregated across all retailers. Table 5.2-19 demonstrates the expected impacts of water reliability on the number of commercial/industrial/institutional jobs in an average year under the BDCP relative to the baseline scenario. The expected impacts of the BDCP are an average increase of 19,046 FTE jobs compared to the baseline Existing Conveyance scenario.

Table 5.2-19. Average Annual Commercial/Industrial/Institutional Employment and Output Impacts

BDCP Relative to Baseline Scenario	Employment (full-time equivalent jobs)
	19,046

5.2.4.2 Agriculture Impacts

The impacts of water supply reliability from the BDCP on employment in the agricultural sector are calculated using econometric regression modeling techniques (as developed by The Brattle Group).

5.2.4.2.1 Forecasting Employment Change

The econometric regression analysis used to forecast employment change relies on historical data of Delta water deliveries and agricultural employment. The data are composed of an annual panel data set covering the years 1980 to 2009 for Fresno, Kern, Kings, Merced, San Joaquin, Stanislaus and Tulare Counties. As a control group, six California counties that do not receive Delta water deliveries are used to capture the effects of general changes in the agricultural economy: Madera, Imperial, Monterey, Sutter, Yolo and Yuba Counties. The data period covered by the analysis evidences significant variation both in employment and water deliveries. It also includes two of the largest droughts in the recent past (1987 to 1992 and 2007 to 2009).

The employment data used for this analysis are publicly available county-level employment figures from the Bureau of Economic Analysis (2011a). A distinction is made between direct farm employment and total agricultural employment. Direct farm employment includes anyone who works in the direct production of agricultural commodities, including crops and livestock (Standard Industrial Classification [SIC] codes 01–02; NAICS code 111 - 112) (Bureau of Economic Analysis (2011b). Total agricultural employment is the sum of direct farm employment and employment in the agricultural services sector (SIC code 07; NAICS code 113 - 115). The agricultural services sector includes farm labor contractors. This analysis evaluates total agricultural employment.

The data from 1980 to 2000 are categorized in the SIC system. In the 1990s, a new classification system (NAICS) was introduced, in part to facilitate accounting under the North American Free Trade Agreement. The SIC data series was discontinued in 2000. In that year, the Bureau of Economic Analysis shifted to reporting sectoral employment based on the SIC industry classification to reports based on the NAICS classification. The Bureau of Economic Analysis provides a concordance to match industry descriptions between the two coding systems (Bureau of Economic Analysis 2011b). The regression specification used in this analysis controls for year fixed effects; thus, the method controls for any year-to-year differences in employment that are due to the new classification. Employment figures are in FTE employment measures.

Government water delivery data include both state deliveries from the SWP and federal deliveries from the CVP. The state water delivery data comes from DWR Bulletin 132 (2009 and 2011) and the Kern County Water Agency (2009 and 2011). The federal water deliveries data are from the Bureau of Reclamation (2009). A GIS is used to allocate water deliveries to counties. First, the intersection of the boundaries of each of the water districts and counties are used to calculate the acreage of the district-county intersection. This intersection acreage is then divided by the acreage of each of the districts to get the share of the district that belongs to the county. This ratio is multiplied by the water deliveries in each water district to get a measure of how much water delivery from each water district is attributed to a particular county. All the shares of the water deliveries in the district-county intersection are then summed over each county. Thus, water deliveries are allocated to the county level according to the share of acres of each water district that falls within each county (Cal-Atlas Geospatial Clearinghouse 2009). Annual deliveries are reported in acre-feet.

The regression model assesses the correlation between total agricultural employment and Delta water deliveries. The specifications include county fixed-effects and year fixed-effects, as well as county controls. The model is based on 385 observations and includes seven counties that receive SWP and CVP water as well as an additional six control counties that do not receive Delta water. The estimated coefficient on Delta water deliveries comes to 0.0045 at a 1% significance level.

5.2.4.2.2 Results

The BDCP scenario is estimated to increase mean Delta deliveries relative to the baseline scenario by approximately 1.3 million acre-feet per year in total over both urban and agricultural use. As assumed in the SWAP model, described in Section 5.1.4.2.1, *Methods and Data*, this averages to an increase of roughly 0.7 million acre-feet per year of SWP/CVP deliveries to the agricultural sector. The regression modeling results imply that an increase of 0.7 million acre-feet in deliveries annually will lead to an increase of approximately 3,357 direct jobs created on average per year. This increase in direct employment implies a total increase of 6,446 FTE jobs a year when accounting for direct, indirect, and induced impacts (University of California 2009) (Table 5.2-20).

Table 5.2-20. Average Annual Agricultural Employment and Crop Impacts

	Employment (full-time equivalent jobs)
BDCP Relative to Baseline Scenario	6,446

Chapter 6
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Appendix A

Greenhouse Gas and Air Quality Analysis Assumptions

Appendix A
Greenhouse Gas and Air Quality Analysis Assumptions

This appendix discusses the approach used to assess construction and operations criteria pollutants and greenhouse gas (GHG) emissions associated construction and operation of the water conveyance facilities (*CM1 Water Facilities and Operation* or CM1) of the Bay Delta Conservation Plan (BDCP). Information presented in this appendix has been modified from Appendix 22A, *Air Quality Assumptions,* of the environmental impact report/statement (EIR/EIS) for the BDCP (California Department of Water Resources *et al.* 2013) to focus exclusively on emissions generated by CM1 and other conservation measures (CM2 through CM22), collectively referred to here as the BDCP scenario. Criteria pollutants analyzed include reactive organic gases (ROG), nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter 10 micrometers or less in size (PM10), particulate matter 2.5 micrometers or less in size (PM2.5), and sulfur dioxide (SO_2). GHG emissions analyzed include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and sulfur hexafluoride (SF_6).

A.1 Construction

Construction of CM1 would generate emissions of ROG, NO_X, CO, PM10, PM2.5, SO_2 and GHGs (CO_2, CH_4, N_2O, and SF_6) that would result in short-term impacts on ambient air quality in the Plan Area. Emissions would originate from mobile and stationary construction equipment exhaust, employee vehicle exhaust, dust from earthmoving and clearing the land, electricity use, and concrete batching. Construction-related emissions vary substantially depending on the level of activity, length of the construction period, specific construction operations, types of equipment, number of personnel, wind and precipitation conditions, and soil moisture content.

The California Department of Water Resources (DWR) provided detailed construction schedule or activity assumptions for off-road equipment, marine vessels, locomotives, helicopters, and on-road vehicles for Alternative 1A (15,000 cubic feet per second option). Information on these activities specific to the BDCP scenario was not available at the time of this analysis. Accordingly, emissions generated by off-road equipment, marine vessels, locomotives, helicopters, and on-road vehicles were calculated for the BDCP scenario by scaling emissions estimates for Alternative 1A. For example, Alternative 1A will construct five intakes during intake construction, whereas the BDCP scenario will construct only three. For each construction component, the ratio of identified project features between Alternative 1A and the other alternatives was calculated (e.g., three intakes to five intakes).

Table A-1 summarizes the scaling factors for the BDCP scenario by major construction component. These scaling factors were applied to the emissions calculations for Alterative 1A, as described further in Sections A1.1.1 through A1.1.5.

Table A-1. Scaling Factors for Alternative 4

Feature	Scaling Method	Value	Ratio (to Alt 1A)
Intakes			
Intake 1 (number)	Scale by whether the feature is built	0	0
Intake 2 (number)	Scale by whether the feature is built	1	1
Intake 3 (number)	Scale by whether the feature is built	1	1
Intake 4 (number)	Scale by whether the feature is built	0	0
Intake 5 (number)	Scale by whether the feature is built	1	1
Pumping Plant			
Pumping Plant 1 (number)	Scale by whether the feature is built	0	0
Pumping Plant 2 (number)	Scale by whether the feature is built	1	1
Pumping Plant 3 (number)	Scale by whether the feature is built	1	1
Pumping Plant 4 (number)	Scale by whether the feature is built	1	1
Pumping Plant 5 (number)	Scale by whether the feature is built	0	0
Intermediate Pumping Plant	Scale by whether the feature is built	1[a]	0.07
Pipelines (miles)	Scale by length of pipeline built	6.29	0.79
Tunnels			
Reach 1 (miles)	Scale by length of reach built	0.26	1
Reach 2 (miles)	Scale by length of reach built	5.53	1
Reach 3 (miles)	Scale by length of reach built	5.37	1
Reach 4 (miles)	Scale by length of reach built	5.47	1
Reach 5 (miles)	Scale by length of reach built	5.99	1
Reach 6 (miles)	Scale by length of reach built	5.81	1
Reach 7 (miles)	Scale by length of reach built	5.99	1
Reach 8 (miles)	Scale by length of reach built	4.78	1
Forebays			
Intermediate Forebay (acres)	Scale by acres of forebay built	1,892	1
Byron Tract Forebay (acres)	Scale by acres of forebay built	1,489	1
Control Structures			
Structure 1 (number)	Scale by whether the feature is built	1	1
Structure 2 (number)	Scale by whether the feature is built	1	1
Structure 3 (number)	Scale by whether the feature is built	1	1
Structure 4 (number)	Scale by whether the feature is built	1	1

[a] The Intermediate Pumping Plant would be replaced by an outlet control structure under Alternative 4. This assumption is reflected in the scaling factors.

The BDCP scenario will cross three air basins—San Francisco Bay Area Air Basin (SFBAAB), Sacramento Valley Air Basin (SVAB), and San Joaquin Valley Air Basin (SJVAB)—and falls under the jurisdiction of three air districts—Sacramento Metropolitan Air Quality Management District (SMAQMD), Bay Area Air Quality Management District (BAAQMD), and San Joaquin Valley Air Pollution Control District (SJVAPCD). Global information system (GIS) technology was used to identify the location of all construction activities associated with CM1. Table A-2 summarizes the air districts and air basins crossed by each major construction component. Several features cross multiple air districts or air basins. The proportion of activity in each air district and basin was based on the number of miles or acres constructed within each air district and basin. For example, 5.99 miles of tunnel in the tunnel conveyance alignment will be constructed in Reach 5, of which 0.30 (5%) will be located in the SMAQMD and 5.69 (95%) will be located in the SJVAPCD.

Table A-2. Location of Major Construction Activity by Air District and Air Basin

Component	Air District(s)	Air Basin(s)
Intakes	SMAQMD	SVAB
Pumping Plants	SMAQMD	SVAB
Intermediate Pumping Plant	SMAQMD	SVAB
Intermediate Forebay	SMAQMD	SVAB
Byron Tract Forebay	BAAQMD	SFBAAB
Control Structures	BAAQMD	SFBAAB
Pipeline	SMAQMD	SVAB
Head of Old River Barrier	SJVAPCD	SJVAB
Tunnel		
Reaches 1–4	SMAQMD	SVAB
Reach 5	SMAQMD (5%) SJVAPCD (95%)	SVAB (5%) SJVAB (95%)
Reaches 6–7	SJVAPCD	SJVAB
Reach 8	SJVAPCD (55%) BAAQMD (45%)	SJVAB (55%) SFBAAB (45%)
Transmission Lines		
Temporary (12 kV)[a]	SMAQMD (39%) SJVAPCD (52%) BAAQMD (9%)	SVAB (39%) SJVAB (52%) SFBAAB (9%)
Temporary (69 kV)	SMAQMD (51%) SJVAPCD (33%) BAAQMD (16%)	SVAB (51%) SJVAB (33%) SFBAAB (16%)
Permanent (69 kV)	SMAQMD	SVAB
Permanent (230 kV)	SMAQMD (23%) SJVAPCD (44%) BAAQMD (33%)	SVAB (23%) SJVAB (44%) SFBAAB (33%)

[a] Temporary lines will only be used during construction.
kV = kilovolts.

A.2 Calculation Methods (Alternative 1A)[1]

A.2.1 Heavy-Duty Off-Road Equipment

The California Emissions Estimator Model (CalEEMod) emissions model[2] was used to calculate exhaust emissions from heavy-duty construction equipment without project commitments. DWR provided equipment assumptions for each construction phase as part of detailed cost estimates. Equipment descriptions were frequently model specific (e.g., CAT 963), and were not grouped into generic operating types (e.g., bulldozer). To estimate emissions using CalEEMod emission factors, which are given for generic equipment, individual equipment provided by DWR was assigned a generic type based on the model description, industry resources, and professional experience.

Key assumptions included:

- Equipment load factors were based on latest Carl Moyer Program Guidelines[3] (California Air Resources Board 2011:236-237).
- Equipment summarized in Appendix 22B, *Air Quality Assumptions,* of the BDCP EIR/EIS was assumed to be diesel powered.
- Equipment summarized in Appendix 22B, *Air Quality Assumptions,* would operate 8 hours per day.
- Accessory equipment (e.g., trailers, clamshell bucket) with no engines or emissions-generating components were excluded from the analysis.
- Tunnel-boring machines, tunnel fans, tunnel lights, certain air compressors, and pumps were assumed to be electric and were included in the electricity analysis.

Criteria pollutant, CO_2, and CH_4 emissions for each construction phase were calculated using the information summarized in Tables 22B-4 through 22B-6 of Appendix 22B, *Air Quality Assumptions,* of the BDCP EIR/EIS and Equation A-1.

Equation A -1 $$E_{phase} = \Sigma(Activity_i \times EF_i \times LF_i \times HP_i) \times Conv$$

Where:

E_{phase} = Total exhaust emissions for the phase, pounds per day

Activity = Equipment activity, hours per day

EF = Engine emissions factor, grams/horsepower-hour (CalEEMod)

LF = Engine load factor, unitless (Carl Moyer Program)

HP = Engine horsepower, unitless (Tables 22B-4 through 22B-6)

Conv = Conversion from grams to pounds, 0.002205

i = Equipment type (Tables 22B-4 through 22B-6)

1 As noted, emissions quantified for Alternative 1A were scaled to the BDCP scenario using the scaling factors summarized in Table A-1.

2 CalEEMod analyzes the type of construction activity and the duration of the construction period to estimate criteria pollutants and GHG emissions.

3 The Carl Moyer Program provides funding to encourage the voluntary purchase of cleaner-than-required engines. Load factors provided in the guidelines account for the most recent engine technologies and regulations.

CalEEMod does not include emission factors for N_2O for off-road equipment. Emissions of N_2O were determined by scaling the CO_2 emissions quantified by Equation A-1 by the ratio of N_2O/CO_2 (0.000026) emissions expected per gallon of diesel fuel according to the California Climate Action Registry (CCAR) (California Climate Action Registry 2009).

A.2.1.1 Marine Vessels

Exhaust emissions from marine vessels without project commitments were quantified using emission factors developed by ICF International (2009:3-8) and activity data provided by DWR. Similar to the heavy-duty equipment, generic vessel types were not provided. To estimate emissions using emission factors developed by ICF International (2009:3-8), individual vessels provided by DWR were assigned a generic type based on the model description, industry resources, and professional experience.

Key assumptions included:

- Vessels summarized in Appendix 22B, *Air Quality Assumptions,* of the BDCP EIR/EIS were assumed to be Tier 0 Category 1 workboats.
- Vessel horsepower and load factors are based on information provided by ICF International (2009:3-8).
- Vessels summarized in Appendix 22B, *Air Quality Assumptions,* of the BDCP EIR/EIS were assumed to operate 8 hours per day.
- Barges are assumed to be either pushed or pulled by tug-boats; no emissions are generated by the barge.

Criteria pollutant, CO_2, and CH_4 emissions for each phase were calculated using the information summarized in Tables 22B-4 through 22B-6 Appendix 22B, *Air Quality Assumptions* of the BDCP EIR/EIS and Equation A-2. N_2O emissions were calculated by scaling the CO_2 emissions quantified by the N_2O/CO_2 identified in Section A1.1.1.

Equation A -2 $$E_{phase} = \Sigma(Activity_i \ X \ EF_i \ X \ LF_i \ X \ [HP_i \ X \ Conv_1]) \ X \ Conv_2$$

Where:

E_{phase}	= Total exhaust emissions for the phase, pounds per day
Activity	= Vessel activity, hours per day
EF	= Engine emissions factor, grams/kWh (ICF International 2009:3-8)
LF	= Engine load factor, unitless (ICF International 2009)
HP	= Engine kW, unitless (Tables 22B-4 through 22B-6)
$Conv_1$	= Conversion from horsepower to kilowatts, 0.75
$Conv_2$	= Conversion from grams to pounds, 0. 002205

A.2.1.2 Locomotives

Small, mining-type locomotives would be used to convey excavated material and personnel in rail cars through the tunnel alignments. Emissions from these diesel-powered locomotives without project commitments were quantified using. U.S. Environmental Protection Agency (EPA) Tier 0 off-road diesel emission standards (ICF International 2009:4-13 to 4-17). Locomotive engine rating, based on engineering specifications (25-ton), were assumed to be 150 horsepower.

Criteria pollutant CO_2 and CH_4 emissions for each phase requiring locomotives were calculated using Equation A-3. N_2O emissions were calculated by scaling the CO_2 emissions quantified by the N_2O/CO_2 identified in Section A1.1.1.

Equation A -3 $$E_{phase} = \Sigma(\text{Activity} \times \text{EF} \times \text{HP}) \times \text{Conv}$$

Where:

E_{phase} = Total exhaust emissions for the phase, pounds per day

Activity = Engine activity, hours per day

EF = Engine emissions factor, grams/horsepower-hour (ICF International 2009)

HP = Engine horsepower, 150

Conv = Conversion from grams to pounds, 0. 002205

A.2.1.3 On-Road Vehicles

On-road vehicles include vehicles used for materials hauling and general crew movement, as well as vehicles used for employee commuting to the project site. Emissions from materials hauling and general crew movement without project commitments were estimated using the EMFAC2011[4] emissions model and activity data provided by DWR. Similar to heavy-duty equipment and marine vessels, generic vehicle types were not provided. To estimate emissions using EMFAC emission factors, individual vehicles provided by DWR were assigned a generic type based on the model description, industry resources, and professional experience. Emissions from employee commuting were estimated using EMFAC2011 and the total number of personnel required to complete construction of each phase, which was provided by DWR.

Key assumptions included:

- Vehicles used for materials hauling and general crew movement would make a maximum of 8 trips per day. This value represents a conservative estimate of vehicle activity and is based on consultation with Fehr & Peers, the project traffic engineer.
- Vehicle trips used for materials hauling and general crew movement would be 9.5 miles in all air districts, based on Plan area CalEEMod default trips lengths for “commercial work” trips.
- Employees would make 2 trips to the project site per day.
- Passenger vehicles were assumed to be used for employee commute trips. Based on CalEEMod defaults for the Plan area, 82% of passenger vehicles were assumed to be light-duty automobiles and 18% were assumed to be light-duty trucks.
- Employee vehicle trips would be 10.8 miles in the SMAQMD and SJVAPCD, based on Plan area CalEEMod default trips lengths for “home-based work” trips.
- Employee vehicle trips would be 12.4 miles in the BAAQMD, based on Plan area CalEEMod default trips lengths for “home based work” trips.

[4] EMFAC2011 provides criteria pollutant and GHG emission factors in grams per mile for vehicle types (e.g., trucks) within specific geographies (e.g., Sacramento County).

- Vehicle emission factors were based on EMFAC2011 for the air district in which activity would occur, as determined by GIS (Section A.1.2).

Criteria pollutant and CO_2 emissions for each phase were calculated using the information summarized in Tables 22B-4 through 22B-6 of Appendix 22B, *Air Quality Assumptions* of the BDCP EIR/EIS and Equation A-4.

Equation A -4 $$E_{phase} = \Sigma(EF \times Trips \times Trip\ Distance) \times Conv$$

Where:

E_{phase} = Total exhaust emissions for the phase, pounds per day

EF = Engine emissions factor, grams/mile (EMFAC2011)

Trips = Vehicle trips per day

Trip Distance = Default trip length, miles (CalEEMod)

Conv = Conversion from grams to pounds, 0.0002205

EMFAC2011 does not include emission factors for CH_4 or N_2O. Emissions of CH_4 and N_2O from diesel-powered vehicles were determined by scaling the CO_2 emissions quantified by Equation A-4 by the ratio of CH_4/CO_2 and N_2O/CO_2 (0.000026) emissions expected per gallon of diesel fuel according to the CCAR (2009). Emissions of CH_4 and N_2O emissions from gasoline-powered vehicles were determined by dividing the CO_2 emissions quantified by Equation A-4 by 0.95. This statistic is based on EPA's recommendation that CH_4, N_2O, and other GHG emissions account for approximately 5% of on-road emissions (U.S. Environmental Protection Agency 2011).

A.2.1.4 Helicopters

Helicopters would be used during line stringing activities for the 230 kV transmission lines. Based on guidance provided by DWR, two light-duty helicopters were assumed to operate four hours a day to install new poles and lines. Helicopter emissions were estimated using expected fuel consumption for a MD 500 D/E (U.S. Department of Interior National Business Center 2006) and emission factors derived from the California Public Utilities Commission (2006 and 2007) and the U.S. Department of Energy (2008). Table A-3 summaries the fuel consumption data and emission factors used in the analysis.

Table A-3. Helicopter Fuel Consumption (gallon/hour) and Emission Factors (pounds/hour)

Helicopter	Fuel Use	ROG	NO_X	CO	PM10[a]	SO_2	CO_2[b]
MD 500 D/E	28	0.66	1.75	2.07	0.10	0.14	18.36

[a] Emission factors for PM2.5 are currently unavailable. Consequently, PM2.5 emissions were assumed to equal PM10 emissions. Because PM2.5 represents a fraction of PM10, this approach represents a conservative assessment of PM2.5 emissions from electricity consumption.

[b] Emission factor in pounds per gallon of fuel consumed. Emissions of CH_4 and N_2O were determined by scaling the CO_2 emissions by the California Climate Action Registry ratios discussed in Section A.1.1

A.2.2 BDCP Scenario Calculations

Activity assumptions specific to the BDCP scenario related to electricity usage, concrete batching, and land disturbance were provided by DWR. Consequently, unlike emissions generated by heavy-duty offroad equipment, marine vessels, locomotives, on-road vehicles, and helicopters (which were scaled based on calculations for Alternative 1A); GHG emissions from these activities were calculated based on actual data for the BDCP scenario. Sections A1.2.1 through A1.2.3 describe the methods used to estimate GHG emissions from land disturbance, electricity usage, and concrete batching.

A.2.2.1 Fugitive Dust from Land Disturbance

Fugitive dust emissions (without project commitments) from land disturbance were quantified using CalEEMod. Estimates of the acres disturbed as a result of construction of the major water conveyance features (e.g., Intakes, pumping plants) were obtained using GIS. As shown in the construction schedules for the proposed action (see Appendix 22B, *Air Quality Assumptions,* of the BDCP EIR/EIS), construction of CM1 would require multiple phases with the potential to disturb land. The duration of phases with land disturbance activity for each water conveyance feature were summed to obtain the total number of days in which fugitive dust could be generated. PM10 and PM2.5 emissions estimated for the water conveyance features were divided by the total number of activity days to determine average PM10 and PM2.5 emissions per day. For example, land disturbance associated with Intake 1 would generate 203 pounds of PM10 and occur over a period of 381 days. Average daily PM10 emissions would equate to 0.53 pounds per day (203/381).

Table 22B-7 through Table 22B-9 in Appendix 22B, *Air Quality Assumptions* of the BDCP EIR/EIS summarize the construction phases assumed in the emissions calculations. Total acres disturbed for each major water conveyance feature are also provided.

A.2.2.2 Electricity Usage

Construction of CM1 will require the use of electricity for lighting, tunnel ventilation, boring, and certain types of equipment. Annual electric demand for the BDCP scenario was provided by DWR and is summarized in Table A-4. Generation of this electricity will result in criteria pollutant and GHG emissions at regional power plants.

Table A-4. Annual Electric Demand for Construction (megawatt-hours [MWh])

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8[a]	Year 9[a]
BDCP Scenario	27,256	42,744	91,520	418,828	627,088	731,602	461,296	156,772	156,772

[a] Based on guidance provided by DWR, electrical demand assumed to be one-quarter the demand for year 5.

EPA (2012)[5] and University of California, Davis (Delucchi 1996:110) have developed emission factors for the current generation of electricity within California. Table A-5 summarizes the criteria pollutant and GHG emission factors used in the unmitigated analysis. Emissions associated with the generation of electricity were estimated by multiplying the expected annual electricity usage (Table A-4) by the emission factors.

[5] Power will be supplied to BDCP by multiple utilities. The quantity of power supplied by each utility is currently unknown. Consequently, average statewide emission factors, as opposed to utility-specific factors, were used to quantify emissions associated with electricity consumption.

Table A-5. Criteria Pollutant and GHG Emission Factors (2009) for Electricity Generation

Pollutant	Value	Unit	Source
CO_2	298.772	MT/GWh	EPA 2012
CH_4	0.013	MT/GWh	EPA 2012
N_2O	0.003	MT/GWh	EPA 2012
SF_6	0.0001	MT/GWh	ARB 2010; CEC 2012[a]
NMHC[b]	0.0014	g/kWh	Delucchi 1996
CO	0.0134	g/kWh	Delucchi 1996
NOx	0.2321	g/kWh	Delucchi 1996
PM10[c]	0.0155	g/kWh	Delucchi 1996
SO_2	0.4267	g/kWh	Delucchi 1996

MT/GWh = metric tons gigawatt-hour; g/kWh = grams per kilowatt-hour; NMHC = non-methane hydrocarbons; ARB = California Air Resources Board; CEC = California Energy Commission.

[a] Neither EPA nor the University of California, Davis have a published emission factor for SF_6. Statewide SF_6 emissions in 2008 were, therefore, used to identify an emission factor per megawatt-hour by dividing total SF_6 emissions by the total electricity generation in California (California Air Resources Board 2010; California Energy Commission 2012).

[b] Emission factor used to quantify ROG (because ROG only represents a fraction of NMHC, this assumption is conservative).

[c] Emission factor used to quantify PM2.5 (because PM2.5 only represents a fraction of PM10, this assumption is conservative).

Adopted and proposed statewide legislation will increase future energy efficiency and the proportion of renewable energy supplied to the electrical grid. Actual emissions from construction of CM1 will therefore likely be less than those estimated using emission factors presented in Table A-4. This analysis thus provides a worst-case scenario of criteria pollutants and GHG emissions associated with electricity use.

A.2.2.3 Concrete Batching

Particulate Matter

Concrete required to construct CM1 will be manufactured at batch plants that store, convey, and discharge water, cement, fine aggregate, and coarse aggregate. PM10 and PM2.5 may be emitted through the transfer of aggregate, truck loading, mixer loading, vehicle traffic, and wind erosion. The amount of PM10 and PM2.5 generated during concrete batching depends primarily on the surface moisture content of surface materials, and the extent of fugitive emission controls.

PM10 emissions from concrete batching were estimated using emission factors provided the EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) (U.S. Environmental Protection Agency 2006:11.12-11) and concrete data provided by DWR. The total volume of concrete required to construct the major CM1 features (e.g., Intake, pumping plants) is summarized in Table 22A-8. PM10 emissions from concrete batching were calculated by multiplying the anticipated volume of concrete required to construct the project features by the AP-42 dust emission factors. Note that AP-42 does not provide emission factors for PM2.5. Consequently, PM2.5 emissions were calculated assuming that PM2.5 represents 0.674% of PM10 (South Coast Air Quality Management District 2006:A-1).

As shown in the construction schedules for the proposed action (Appendix 22B, *Air Quality Assumptions* of the BDCP EIR/EIS), construction of each water conveyance feature would require multiple phases that utilize concrete. Average daily PM10 and PM2.5 emissions generated by concrete batching were estimated using the methodology described above for fugitive dust from land disturbance (Section A.1.2.1). Table 22B-10 through Table 22B-12 in Appendix 22B, *Air Quality Assumptions* of the BDCP EIR/EIS summarize the construction phases assumed in the emissions calculations.

Carbon Dioxide

Cement manufacturing produces CO_2 through fuel combustion and calcination. Emissions generated by on-site fuel combustion account for approximately 40% of total emissions generated by a batching facility, whereas calcination accounts for the reaming 60%. Calcination involves heating raw materials to over 2,500 degrees Fahrenheit (°F), which liberates CO_2 and other trace materials (Portland Cement Association 2011).

Emissions generated by concrete batching were calculated using information provided by the Portland Cement Association and data presented in Table A-6. It was assumed that the batching of 1 cubic yard of concrete generates 400 pounds of CO_2 through both combustion and calcination. CO_2 emissions generated by concrete manufacturing were therefore calculated by multiplying the volume of required concrete by 400 pounds (Portland Cement Association 2011).

Table A-6. Concrete Required for Construction of CM1

Type	Cubic Yards
Intakes	88,500[a]
Pumping Plants	265,221[a]
Pipelines	161,608
Canals	0
Siphons	0
Control Structures/Forebay	139,991
Tunnels	343,194[b]
Bridges	0
Intermediate Pumping Plant	2,857[c]
Total	**1,001,371**

[a] Assumes the construction of three intakes/pumping plants.
[b] Tunnels 2 and 3 reduced by 24% relative to Alternatives 1A (based on DWR electricity modeling).
[c] Inlet control structure.

Studies have calculated the CO_2 absorption rates of hardened concrete. These studies assume a 70 year service life and a 30-year demolition and recycling period for concrete materials. Given these assumptions up to 57% of the CO_2 emitted during the cement manufacturing calcination is re-absorbed by concrete over the 100 year life cycle. All CO_2 released by calcination will be re-absorbed by carbonation in a geologic time frame (Haselbach 2009).

A.2.3 Project Commitments

The lead agency has identified several project commitments to reduce construction-related criteria pollutants and GHG emissions. Pursuant to the project commitments discussed in Appendix 3B, *Environmental Commitments,* of the BDCP EIR/EIS the following assumptions were made to quantify emissions reductions achieved by project commitments.

- Electrification of 5% of equipment in the following general categories:
  - Air compressors
  - Cranes
  - Excavators
  - Pumps
  - Loaders
  - Dozers
  - Other construction equipment
- Electrification of all materials-handling equipment and welders.
- Electrification of 75% of general industrial equipment.
- Electrification of 10% of light duty on-road vehicles.
- Use of diesel particulate filters on 100% of all non-electrified off-road, marine, and locomotive equipment.
- Use of compressed natural gas in approximately 10% of heavy-duty trucks and 50% of forklifts.
- Use of Tier 4 engines in diesel locomotives.
- Implementation of fugitive dust control measures to achieve a 75% reduction in dust from land disturbance.

Based on guidance provided by DWR, annual electric demand identified in Table A-3 would be sufficient to support new electrification commitments. Emissions associated with the electrification of project equipment were therefore assumed to be accounted for in the electricity analysis (see Section A1.3.6).

Diesel particulate filters were assumed to result in an 85% reduction in PM10 and PM2.5 exhaust (California Air Resources Board 2012). Emissions generated by use of Tier 4 locomotive engines were calculated using EPA Tier 4 off-road diesel emission standards in place of Tier 0 emissions standards. Compressed natural gas emissions were calculated by multiplying emissions generated by diesel equipment by the percent reduction achieved by switching from diesel to compressed natural gas (Table A-7). Note that for some pollutants, compressed natural gas results in an emissions increase, relative to diesel fuel.

Table A-7. Percentage of Change in Emissions Resulting from Diesel Fuel Switch to Compressed Natural Gas

Equipment	ROG	NO_X	CO	PM	SO_2	CO_2e
Forklift	-16%	+17%	+696%	-45%	0%	+21%
Heavy Truck	-8%	+3%	+485%	-44%	0%	+19%
Source: California Air Pollution Control Officers Association 2010.						

A.2.4 State Mandates to Reduce GHG Emissions

Actions undertaken by the state will contribute to project-level GHG reductions. For example, the state requires electric utility companies to increase their procurement of renewable resources by 2020. Renewable resources, such as wind and solar power, produce the same amount of energy as coal and other traditional sources, but do not emit any GHGs. By generating a greater amount of energy through renewable resources, electricity provided to the project will be cleaner and less GHG intensive than if the state had not required the renewable standard.

The analysis assumes implementation of Pavley, low-carbon fuel standard, and renewables portfolio standard. Pavley will improve the efficiency of automobiles and light duty trucks, whereas low-carbon fuel standard will reduce the carbon intensity of diesel and gasoline transportation fuels. To account for GHG reductions achieved by Pavley and low-carbon fuel standard, emissions generated by construction equipment and vehicles were calculated using adjusted emission factors from EMFAC2011.

The renewables portfolio standard will increase the proportion of renewable energy supplied to the electrical grid. The emission factors summarized in Table A-4 are based on the statewide renewable energy mix in 2009 (12%). Implementation of the renewables portfolio standard will increase the proportion of renewable energy within the state to 33% by 2020. To account for emissions reductions achieved by increases in renewable energy, annual electricity emission factors were calculated assuming a linear increase in statewide renewables between 2007 and 2020 (Table A-7). Because renewables portfolio standard requirements end in 2020, the percentage of renewable energy after 2020 was assumed to remain constant at 33%.

Electricity emissions with implementation of the renewables portfolio standard were estimated by multiplying the expected annual electricity usage (Table A-4) by the emission factors show in Table A-7. Note that implementation of the renewables portfolio standard will affect criteria pollutants, in addition to GHG emissions.

Table A-7. Annual Criteria Pollutant and GHG Emission Factors with Renewables Portfolio Standard [a]

Year	% Renewable	CO_2	CH_4	N_2O	NMHC[b]	CO	NO_X	PM10[c]	SO_X
		MT/MWh	MT/MWh	MT/MWh	g/kWh	g/kWh	g/kWh	g/kWh	g/kWh
2014	0.21	0.266790	0.000012	0.000002	0.0012	0.0118	0.2042	0.0136	0.3755
2015	0.23	0.260237	0.000011	0.000002	0.0012	0.0115	0.1992	0.0133	0.3663
2016	0.25	0.253685	0.000011	0.000002	0.0012	0.0112	0.1942	0.0130	0.3570
2017	0.27	0.247132	0.000011	0.000002	0.0011	0.0109	0.1892	0.0126	0.3478
2018	0.29	0.240580	0.000011	0.000002	0.0011	0.0106	0.1842	0.0123	0.3386
2019	0.31	0.234027	0.000010	0.000002	0.0011	0.0103	0.1792	0.0120	0.3294
2020+	0.33	0.227474	0.000010	0.000002	0.0011	0.0101	0.1741	0.0116	0.3201

MT/MWh = metric tons megawatt-hour; g/kWh = grams per kilowatt-hour.

[a] No change in SF_6 emission factor.

[b] Emission factor used to quantify ROG (because ROG only represents a fraction of NMHC, this assumption is conservative).

[c] Emission factor used to quantify PM2.5 (because PM2.5 only represents a fraction of PM10, this assumption is conservative).

A.3 Operations

A.3.1 Maintenance Activities

Operations and maintenance include both routine activities and major inspections. Routine activities would occur on a daily basis throughout the year, whereas major inspections would occur annually.

Routine Maintenance

Operational emissions associated with vehicle traffic and maintenance equipment were estimated using the EMFAC2011 and CalEEMod models, respectively. Emissions were quantified for both 2025 and 2060 conditions. Key assumptions include:

- Routine operations and maintenance activities for the BDCP scenario were scaled based on the number of intakes relative to Alternative 1A.
- Employees would make two trips to the project site per day, 250 days per year.
- Employee vehicle trips would be 10.8 miles in the SMAQMD and SJVAPCD, based on Plan Area CalEEMod default trips lengths for “home based work” trips.
- Employee vehicle trips would be 12.4 miles in the BAAQMD, based on Plan area CalEEMod default trips lengths for “home based work” trips.
- Crew, foreman, and dump trucks would make a maximum of eight trips per day. This value represents a conservative estimate of vehicle activity and is based on consultation with Fehr & Peers, the project traffic engineers.
- Crew and foreman trucks trips would be 9.5 miles in all air district, based on Plan Area CalEEMod default trips lengths for “commercial work” trips. Dump truck trips would be 20 miles in all air districts.

- Vehicle emission factors were based on EMFAC2011 for the air district in which activity would occur, as determined by GIS (Section A.1.2).
- The backhoe would operate a maximum of 8 hours per day, 250 days per year.

Yearly Maintenance

Yearly maintenance will include both annual inspections and half-decadal tunnel dewatering. Annual inspections will be limited to work on the gate control structure and inspection by a remotely operated vehicle (ROV). Tunnel dewatering will include a physical inspection and sediment removal. Table A-8 summarizes the number of employees, vehicles, and equipment required for annual inspections and tunnel dewatering.

Table A-8. Yearly Maintenance Assumptions for the BDCP Scenario

Operations and Maintenance Type	Number of Employees	Number of Vehicles	Equipment (number)
Annual inspections	6	1 crew truck[a]	Crane (1)[b]
Tunnel dewatering	18 (sediment crew) 11 (inspection crew)	1 crew truck	Crane (2)

[a] Four electric vehicles will also be required. Emissions associated with these vehicles are included in the electricity analysis (Section A.2.2).
[b] ROV assumed to be electric.

Operational emissions associated with vehicle traffic and maintenance equipment were estimated using the EMFAC2011 and CalEEMod models, respectively. Emissions were quantified for both 2025 and 2060 conditions. Key assumptions include:

- Annual inspections would occur over a 1 month for the tunnel conveyance option, 2 weeks for the west canal option, and 1 week for the east canal option. Work would occur 5 days per week.
- Sediment removal would occur over 1 to 2 months.[6]
- Tunnel dewatering inspections would cover 1 mile of tunnel per day.
- Employees would make two trips to the project site per day according to the inspection and dewatering schedules identified above.
- Employee vehicle trips would be 10.8 miles in the SMAQMD and SJVAPCD, based on Plan Area CalEEMod default trips lengths for "home based work" trips.
- Employee vehicle trips would be 12.4 miles in the BAAQMD, based on Plan Area CalEEMod default trips lengths for "home based work" trips.
- Crew trucks would make a maximum of eight trips per day. This value represents a conservative estimate of vehicle activity and is based on consultation with Fehr & Peers, the project traffic engineers.
- Crew trucks trips would be 9.5 miles in all air district, based on Plan Area CalEEMod default trips lengths for "commercial work" trips.

[6] Two months for alternatives with two tunnels; one month for alternatives with one tunnel

- The cranes would operate a maximum of 8 hours per day according to the inspection and dewatering schedules identified above.

A.3.2 Electricity Usage

Construction of CM1 would modify BDCP operations and cause the BDCP alternatives to have slightly different energy requirements for 2025 and 2060 conditions. Increases in annual electricity consumption for all alternatives relative to the No Action Alternative and existing conditions were calculated in Chapter 21, *Energy*, of the BDCP EIR/EIS and is summarized in Table A-9. Generation of this additional electricity would result in criteria pollutant and GHG emissions at regional power plants.

Table A-9. Additional Annual Electricity Consumption for the BDCP Scenario (GWh)

Alternative	State Water Project		Central Valley Project	
	2025	2060	2025	2060
BDCP scenario	332	-108	89	83
Baseline scenario	6,867	0	780	733

Criteria pollutant and GHG emissions generated by increased electricity consumption were calculated using adjusted emission factors for state renewable energy mandates (Table A-7).

A.4 References

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Appendix B
Land Conversion and GHG Flux Assumptions

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Land Conversion and GHG Flux Assumptions

This appendix presents the land use and GHG flux assumptions used to estimate the net change in GHG emissions from implementation of the BDCP conservation measures. Emissions were quantified using a range of typical CO_2e flux densities for the restored land types. The CO_2e flux densities were derived from a variety of sources and published literature.

A range in GHG flux densities was used for this analysis due to the uncertainty associated with estimating GHG flux from different land types. This range represents a "reasonable" range of potential fluxes based on reviewed literature. The low and high values do not necessarily correlate with the actual value of the flux for each land type; rather, the range represents the overall net magnitude of total GHG flux from the total conversion of land types associated with the project. In other words, the "low" flux values produce the lowest reduction in GHG emissions overall for all land types and the "high" flux values produce the highest reduction in GHG emissions overall for all land types.

From this perspective, the difference in GHG flux between an existing land type and the converted land type drives the analysis, not the individual flux value for each land type. For example, using values in Table B-1, the "low" value for open bay is 3.5 MT CO_2e/acre/year, while the "high" value is 1.5. The value 3.5 is classified as the "low" value because a large number of acres of cultivated land (16.10 MT CO_2e/acre/year) are converted to open bay. The difference in flux between cultivated land and open bay is 12.6 for the low open bay value and is 15.6 for the high open bay value. Consequently, converting cultivated land to open bay will result in a smaller change in overall GHG flux using the larger flux value of 3.5 for open bay. The net difference between converted land types is what actually drives the low and high ends of the range.

Table B-1 summarizes the GHG flux values and associated citations assumed in the emissions modeling.

Table B-1. GHG Flux Values

Land Type	GHG Flux (MT CO_2e/acre/year)[1]		Notes	Sources
	Low	High		
Tidal perennial aquatic	3.50	1.50	2	Merrill et al. 2011
Tidal mudflat	3.50	1.50	2	Merrill et al. 2011
Tidal brackish emergent wetland	6.80	-11.50	3	Merrill et al. 2011
Tidal freshwater emergent wetland	6.80	-11.50	3	Merrill et al. 2011
Valley/foothill riparian	-0.40	-0.40	-	California Energy Commission 2004; National Council for Air and Stream Improvement 2008
Nontidal perennial aquatic and nontidal freshwater perennial emergent wetland	6.80	-11.50	3	Merrill et al. 2011
Alkali seasonal wetland complex	6.80	-11.50	3	Merrill et al. 2011
Vernal pool complex	3.50	1.50	2	Merrill et al. 2011
Managed wetland	6.80	-11.50	3	Merrill et al. 2011
Other natural seasonal wetland	6.80	-11.50	3	Merrill et al. 2011
Grassland	0.36	0.36	4	Zhang et al. 2011
Inland dune scrub	-0.40	-0.40	-	Zhang et al. 2011
Cultivated lands	16.10	16.10	5	Merrill et al. 2011
Developed	0.00	0.00	6	Merrill et al. 2011
Fisheries	0.00	0.00		Merrill et al. 2011
Tidal Communities				
Grassland	0.36	0.36	4	Zhang et al. 2011
Open Bay	3.50	1.50	2	Merrill et al. 2011
Alkali Wetland	6.80	-11.50	3	Merrill et al. 2011
Freshwater Wetland	6.80	-11.50	3	Merrill et al. 2011
Seasonally Inundated Floodplain	3.50	1.50	2	Merrill et al. 2011
Riparian	-0.40	-0.40	-	California Energy Commission 2004; National Council for Air and Stream Improvement 2008
Nontidal Marsh	6.80	-11.50	3	Merrill et al. 2011
Hatcheries	0.00	0.00	6	Merrill et al. 2011
Channel Margin Enhancement	-0.40	-0.40	-	California Energy Commission 2004; National Council for Air and Stream Improvement 2008

Table B-1 Notes

Notes

[1] The range represents the overall net magnitude of the change in GHG flux after all land conversion occurs under BDCP conditions, and does not refer to the individual flux values for each land type. Consequently, the flux values which result in the smallest change in total GHG flux for the conversion of all land types are the "low" values, and the flux values which result in the largest change in total GHG flux for the conversion of all land types are the "high" values.

[2] Aquatic and wetland land cover types both sequester carbon and produce methane. The low flux value is representative of the flux for the water surface of shallow wetlands measured at Twitchell Island in the Sacramento-San Joaquin Delta: 3 $MTCO_2e$/acre-year of CO_2 and 0.5 $MTCO_2e$/acre-year of methane for a combined flux of 3.5 (Merrill et al. 2011). The high flux value is representative of the flux for the water surface of deep wetlands with submerged vegetation: 1 $MTCO_2e$/acre-year of CO_2 and 0.5 $MTCO_2e$/acre-year of methane for a combined flux of 1.5 (Merrill et al. 2011).

[3] The low flux value is representative of the flux for the plant mediated surface of deep wetlands with submerged vegetation measured at Twitchell Island in the Sacramento-San Joaquin Delta: -7.5 $MTCO_2e$/acre-year of CO_2 and 14.3 $MTCO_2e$/acre-year of methane for a total of 6.8 $MTCO_2e$/acre-year of emissions (Merrill et al. 2011). This value is the most conservative flux value reported by Merrill et al. (2011), and represents the low end of the range of wetland CO_2 sequestration (and positive net emissions). The high flux value is representative of the flux for the plant mediated surface of deep wetlands with submerged vegetation: -25.3 $MTCO_2e$/acre-year of CO_2 and 13.8 $MTCO_2e$/acre-year of methane for a total of -11.5 $MTCO_2e$/acre-year of emissions (Merrill et al. 2011). This value represents the high end of the range of wetland CO_2 sequestration (and negative net emissions). Values for individual wetland types (such as brackish, freshwater, etc.) were not available so the same flux values were used for all wetland types.

[4] The regional average for the Great Plains grasslands is 24 grams carbon per cubic meter per year (Zhang et al. 2011). Using the molecular weight of carbon (12) and carbon dioxide (44), a conversion factor of 3.667 was used to convert carbon to carbon dioxide (24 / 1,000,000 grams/metric ton * 4,046.86 cubic meters/acre * 3.667 = 0.36)

[5] This flux value is composed of CO_2, CH_4, and N_2O emissions fluxes. CO_2 emissions include current measured carbon loss rates from Twitchell Island due to Subsidence = 12 $MTCO_2e$/acre-year. Methane emissions include Twitchell island methane emission measurements for agricultural soils = 0.3 $MTCO_2e$/ acre-year. N2O emissions include author-derived average for Delta agriculture land = 3.8 $MTCO_2e$/acre-year (Merrill et al. 2011). According to Merrill et al. (2011), converting agricultural lands to wetlands could save 25 $MTCO_2e$ per year, with a range in savings of 10 to 35 $MTCO_2e$ per year. For the purposes of this analysis, the range in GHG flux for converting cultivated land to wetlands is 9.3 to 27.6 (low range: 6.8 minus 16.1; high range: -11.5 minus 16.1), which falls within the range reported by Merrill et al. (2011).

[6] Assumed to be zero (no vegetation).

Implementation of the BDCP conservation measures will convert land types to increase available habitat for BDCP covered species (e.g., cultivated land converted to tidal natural communities). Existing land use types currently represent a source of GHG emissions, which will be effectively eliminated and replaced with GHG emissions associated with the BDCP. The difference in GHG emissions between the BDCP and the existing conditions represents the net impact of the project analyzed in land conversion analysis.

The GHG flux values summarized in Table B-1 were multiplied by the number of land use acres in the Plan Area under both existing and BDCP conditions. Tables B-2 and B-3 present the GHG flux results by land use type for existing and BDCP conditions, respectively. The net change in GHG flux as a result of the BDCP was estimated using the information provided in Tables B-2 and B-3 and Equation B-1.

Equation B -1 $E_{land\ type} = \Sigma(BDCP - Existing)$

Where:

$E_{land\ type}$ = GHG emissions for each land use type, MT CO_2e per year

BDCP = GHG flux under BDCP conditions (Table B-3)

Existing = GHG flux under existing conditions (Table B-2)

Table B-2. Land Use Assumptions and GHG Emissions under Existing Conditions

Land Use Type	Existing Acres[1]	Existing GHG Flux (MT CO_2e per year)[2]	
		Low	High
Tidal perennial aquatic	51	179	77
Tidal mudflat	0	0	0
Tidal brackish emergent wetland	0	0	0
Tidal freshwater emergent wetland	16	109	-184
Valley/foothill riparian	873	-353	-353
Nontidal perennial aquatic and nontidal freshwater perennial emergent wetland	362	2,462	-4,163
Alkali seasonal wetland complex	72	490	-828
Vernal pool complex	0	0	0
Managed wetland	12,813	87,128	-147,350
Other natural seasonal wetland	0	0	0
Grassland	2,557	911	911
Inland dune scrub	0	0	0
Cultivated lands	55,800	898,380	898,380
Developed	598	0	0
N/A	37	0	0
Total	**73,179**	**989,305**	**746,490**

Notes

Existing acres will be converted to one or more of the proposed land use types (see Table B-3).

The low/high flux range refers to the lowest/highest total change in GHG flux under BDCP conditions compared to existing conditions, not the lowest/highest amount of GHG emissions under existing conditions. To obtain the low/high change in total GHG flux, subtract the total values above from the values in Table B-3 (low: 306,305 - 989,305 = -683,000; high: -286,378 – 746,490 = -1,032,686).

Table B-3. Land Use Assumptions and GHG Emissions under BDCP Conditions

Land Use Type	Proposed Acres	BDCP GHG Flux (MT CO_2e per year) [1]	
		Low	High
Grassland	2,000	712	712
Developed	4,272	0	0
Fisheries	1,253	0	0
Tidal Communities			
Grassland	0	0	0
Open Bay	29,360	102,760	44,040
Alkali Wetland	3,005	20,434	-34,558
Freshwater Wetland	23,968	162,982	-275,632
Seasonally Inundated Floodplain	2,336	8,176	3,504
Riparian	4,963	-2,005	-2,005
Nontidal Marsh	1,950	13,260	-22,425
Hatcheries	35	0	0
Channel Margin Enhancement	37	-15	-15
Total	**73,179**	**306,305**	**-286,378**

Notes

The low/high flux refers to the lowest/highest total change in GHG flux under BDCP conditions compared to existing conditions, not the lowest/highest amount of GHG emissions under existing conditions. To obtain the low/high change in total GHG flux, subtract the total values above from the values in Table B-3 (low: 306,305 - 989,305 = -683,000; high: -286,378 – 746,490 = -1,032,686).

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