CALFED BAY-DELTA PROGRAM

ASSESSMENT METHODS

CALFED
BAY-DELTA
PROGRAM

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EXECUTIVE SUMMARY

This report summarizes the approach the CALFED Bay-Delta Program (CALFED) will use to determine the impacts of alternatives. The report is divided into sections, each of which describes the methods that will be used to assess changes in a particular resource area (e.g., aquatic resources, air quality, vegetation and wildlife, regional economics). Each section discusses, in general terms, the types of effects that CALFED alternatives (and the actions contained in the alternatives) are likely to have on the resource being discussed and lists the changes to that resource that will be used to measure impacts of the alternatives.

The report provides brief discussions of the methods CALFED proposes to use to conduct the programmatic impact analysis. For those issue areas where formal, quantitative methods are applicable and well accepted, the particular models or calculation methods being proposed are described. For those issue areas where less formal, qualitative methods are more appropriate, a more general description is provided.

The relationships between the analysis of the subject resource area and the analyses of other resource areas are described briefly at the end of each section. Analyses whose results feed into the subject analysis, and those that require the results of the subject analysis, are listed.

BACKGROUND

The CALFED Bay-Delta Program (CALFED) began in June 1995 as a collaborative effort to address a declining ecosystem, uncertain water supplies, imperiled water quality, and unstable levees in California's Bay-Delta region, where the San Francisco Bay meets the Sacramento/San Joaquin River Delta.

CALFED has divided its work into three phases. During Phase I, from June 1995 to September 1996, CALFED identified the problems, developed a mission statement and several guiding principles (the "solution principles"), and designed three solutions to Bay-Delta problems. In Phase II, from June 1996 to fall 1998, CALFED will conduct a broad-based environmental review of the three solutions and will identify the single preferred alternative. During Phase III, starting in late 1998 or early 1999 and lasting many years, the preferred alternative will be implemented in stages.

All of the three solutions, called the Phase II alternatives, are designed to address Bay-Delta problems comprehensively. They share a common program that includes a measure of water-use efficiency, ecosystem restoration, water quality protection, and levee improvements and they include a range of water storage options. Their approaches to moving water (conveyance) differ. Alternative 1 uses the existing system of Delta channels, alternative 2 uses the existing system with significant modifications, and alternative 3 uses both the existing system with significant changes and an isolated facility.

The environmental changes associated with each CALFED alternative will be analyzed in a Programmatic Environmental Impact Report/ Environmental Impact Statement (EIR/EIS) during Phase II. The primary purpose of the Programmatic EIR/EIS is to inform decision makers about the environmental consequences of the alternatives and to identify a preferred alternative. Changes in resources, such as air quality, recreation, and cultural resources, will be analyzed to distinguish relative detrimental and beneficial impacts of each alternative.

PROGRAMMATIC IMPACT ANALYSIS AND ASSESSMENT METHODS

Impact analyses are used to assess the potential beneficial and detrimental impacts of each alternative by evaluating important changes to resources. Assessment methods are the tools that will be used to evaluate these important changes. The results will be used in the programmatic impact analysis to determine the effects of CALFED actions, components, and alternatives.

Assessment methods may include:

- qualitative descriptions: general narratives or written hypotheses, assembled from existing information, that provide a reasonable scientific basis for predicting environmental impacts and benefits;
- quantitative indices: quantitative estimates, based on one or more simple relationships and/or weighting factors, that provide a relative measurement of impacts and benefits; and
- models: series of interacting or complex relationships, variables, and weighting factors that provide a quantitative measurement of impacts and benefits.

Most assessment methods will involve quantitative measures. Qualitative descriptions based on existing studies, historical data, and expert opinion will be used when no specific quantitative method exists or when the relationships between program actions and assessment variables are not easily quantifiable or well known.

In many cases, potential changes to resources are complex or difficult to measure. In these situations, impacts will be analyzed by measuring changes to related elements known as assessment variables. The results of the analyses of changes to individual assessment variables might be combined to determine the overall effect on the resource category. Table 1 lists the resource categories, variables to be evaluated, and related information to be measured for use in the Programmatic EIR/EIS.

CALFED staff has discussed potential assessment methods with resource experts from agency and stakeholder groups. Feedback from these experts and subsequent communication on a variety of resource categories have helped form the programmatic assessment process presented in this report. CALFED is communicating with agency and stakeholder experts to determine the most effective and appropriate assessment methods to use in the Programmatic EIR/EIS. These methods will determine the impacts of a wide range of potential CALFED actions.

The remainder of this document provides a summary of the proposed assessment methods that will be used for many of the resource categories.

FUTURE EFFORTS IN REFINING THE ASSESSMENT METHODS

The assessment methods for water management facilities and operations and Bay-Delta hydrodynamics are under development and therefore not included in this document. To assess water management facilities and operations, CALFED staff proposes using the California Department of Water Resources' (DWR's) water simulation model, DWRSIM. DWRSIM is being modified, refined, and tested for applicability to CALFED alternatives assessment. Experts from both State and federal agencies (i.e., DWR and U.S. Bureau of Reclamation) continue to work on the model to enable its use for assessing changes in water facilities and operations.

CALFED staff are developing assessment methods for water quality using input from stakeholders and State and federal experts. CALFED staff established three committees to address water quality assessment methods for ecosystem, agricultural, and urban uses. These committees are reviewing and revising the proposed assessment variables and assessment methods, suggesting targets for water quality effects of the CALFED alternatives, and defining the common water quality component for CALFED alternatives. CALFED is proposing to use the DWR Delta water quality model (DWRDSM) to evaluate effects of the CALFED alternatives. Additional methods will be reviewed and developed to address the assessment variables agreed on by the committees.

Assessment methods for fisheries and aquatic ecosystem resources are being developed by a working team of experts from State and federal agencies and stakeholder groups. This group identified a list of species on which to assess impacts and made recommendations on the important changes and assessment variables for each species. This report includes a summary of the group's results. Team meetings are being held to determine the most suitable assessment methods for fishery and aquatic resources and habitats.

TABLE 1. RESOURCE CATEGORIES AND ASSESSMENT-RELATED INFORMATION FOR THE PROGRAMMATIC EIR/EIS

I. PHYSICAL ENVIRONMENT

A. Surface-Water Hydrology

Variables to Be Evaluated	*Related Information to Be Measured*
Volume of flow	Rainfall Snowmelt Groundwater discharge Direct runoff Evapotranspiration
Timing of flow	Seasonal weather pattern variation

B. Groundwater Hydrology

Variables to Be Evaluated	*Related Information to Be Measured*
Effective groundwater capacity	Basin storage capacity Groundwater recharge Groundwater withdrawals Conjunctive use

C. Water Management Facilities and Operations

Variables to Be Evaluated	*Related Information to Be Measured*
Reservoir storage volumes, releases, and spills	Capacity Elevation Runoff Flood control Diversion targets Instream targets
Instream flow targets, deficits, and surpluses	Instream targets Runoff Storage Diversion targets Transport

Diversion/export targets, deficits, and surpluses	Runoff Diversion targets Diversion limits Reservoir storage Groundwater pumping
Agricultural drainage volumes	Rainfall Irrigation Soils Drainage facilities
Remaining opportunities for water management	Spills/surplus outflow Unused conveyance Carryover storage Urban stormwater drainage volumes

D. Bay-Delta Hydrodynamics

Variables to Be Evaluated	*Related Information to Be Measured*
Delta outflow	Delta inflows Channel depletions Exports
X2 location	Outflow Tidal mixing
Channel flows at key Delta locations	Delta inflows Channel depletions Exports River diversions Transport
Water entrainment in diversions/exports	Delta inflows Channel depletions Exports River diversions

E. Water Quality

Variables to Be Evaluated	*Related Information to Be Measured*
Ecosystem water quality	Metals Cadmium Copper Mercury Selenium Zinc Organics/Pesticides Carbofuran Chlordane Chlorpyrifos DDT Diazinon Polychlorinated bipheyls (PCBs) Toxaphene Ammonia Dissolved oxygen Salinity (total dissolved solids [TDS], electroconductivity [EC]) Temperature Turbidity/transparency
Urban water quality	Bromide Nutrients Pathogens Salinity Total organic carbon (TOC) Turbidity Viruses
Agricultural water quality	Boron Chloride Nutrients pH Salinity Sodium adsorption ratio (SAR) Turbidity Temperature

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F. Geomorphology, Soils, and Seismicity

Variables to Be Evaluated	*Related Information to Be Measured*
Surface soil erosion	Agricultural soil loss Wind Stormwater
Soil salinity	Soil geology Applied EC Agricultural drainage
Subsidence caused by peat oxidation	Peat content Soil moisture Ground disturbance and tilling practices
Subsidence caused by groundwater withdrawals	Groundwater levels Aquifer clay content
Seismicity (risk of levee failure during seismic event)	Levee structural integrity

G. Air Quality

Variables to Be Evaluated	*Related Information to Be Measured*
Ozone	Construction activities Agricultural operations Pump operations
Carbon monoxide	Construction activities Agricultural operations Pump operations
Particulate matter	Construction activities Agricultural operations Pump operations Wind and soil conditions

H. Noise

Variables to Be Evaluated

Noise from short-term construction activities

Noise from aquatic recreation (i.e., boating)

Noise from terrestrial recreation (i.e., hunting)

Noise from facilities operation

I. Traffic and Navigation

Variables to Be Evaluated

Regional roadway level of service

Roadway safety conditions

Regional waterway traffic

Waterway navigation conditions

Roadways

II. BIOLOGICAL ENVIRONMENT

A. Fisheries and Aquatic Resources

Variables to Be Evaluated	*Related Information to Be Measured*
Flow	Instream flow Net channel flow Tidal flow Estuarine Salinity
Reservoir elevation	
Temperature	
Substrate	
Diversions	
Barriers	
Physical habitat	
Water quality	Agricultural salinity Thermal pollution Dissolved oxygen Nutrient availability Toxicants Transparency
Fishing	

Artificial production	
Species interactions	Predation Competition Disease Non-native plants

B. Vegetation and Wildlife, Including Special-Status Species

Variables to Be Evaluated	*Related Information to Be Measured*
Area and condition of habitat	Open water and tidal wetlands Saline, brackish and freshwater wetlands Riparian and riverine habitats Upland habitats
Area of agricultural land use providing habitat value	
Connectivity and orientation of habitats	
Number of known populations of special-status species	
Area and condition of habitat occupied by special-status species	
Changes in non indigenous/introduced species populations	
Changes in ecological processes that sustain habitats	

III. ECONOMICS AND SOCIAL ENVIRONMENT

A. Land Use

Variables to Be Evaluated

Acres in agricultural use

Acres in open space and habitat use

Acres in developed use

Indian trust assets

B. Flood Control System

Variables to Be Evaluated	*Related Information to Be Measured*
Potential for levee failure	Overtopping failure (flood stage elevation) Mass failure (potential for erosion, stability, seepage, and seismic failure)
Flood damage and value of protected resources	Existing and planned property values Existing and planned utility and infrastructure values Distribution of values lost from levee failure Natural resource values (including protected species) Maintenance of Delta water quality Cost of repair and rehabilitation of facilities after levee failure
Cost of flood-damage protection	Levee improvements (project and nonproject levees) Levee design standards and guidelines

C. Agricultural Economics

Variables to Be Evaluated	*Related Information to Be Measured*
Value of agricultural production	Acres in production Crop prices Crop choices Crop yield
Cost of production	Cost of surface water used Groundwater costs Irrigation efficiency and costs Production costs Acres in agricultural production
Agricultural net income	Crop revenue Production costs Water transfers
Cost of water supply variability	Certainty in water supply and cost Indirect/third-party impacts

D. Municipal and Industrial Water Supply Economics

Variables to Be Evaluated	*Related Information to Be Measured*
Cost of water supply	Surface-water supply and distribution Groundwater pumping costs Alternative water supplies and cost Water transfer costs Infrastructure costs for water conveyance and distribution
Cost of water shortage	Water supplies Consumer willingness to pay and demand elasticity
Cost of treatment	Quality of water supply Constraints to treatment

E. Fish, Wildlife, and Recreation Economics

Variables to Be Evaluated	*Related Information to Be Measured*
Recreation-related spending	Recreation use and opportunity Distance traveled to recreation area
Recreation benefits	Value of recreation resource Recreation use and opportunity
Commercial fishing harvest values	Income Catch
Recreation employment and net income	

F. Regional Economics

Variables to Be Evaluated	*Related Information to Be Measured*
Income	Agricultural income Recreational expenditure Commercial fishing income Municipal and industrial water expenditure Indirect income (i.e., third-party effects)

Employment	Agricultural Recreation-related Commercial fishing Municipal and industrial water expenditure Indirect employment (i.e., third-party effects)
Fiscal conditions	Property tax revenues Sales tax revenues Public costs/costs of actions Indirect (i.e., third-party) fiscal effects

G. Power Production and Energy

Variables to Be Evaluated	
Power-generating capacity	
Energy production	
Central Valley Project restoration fund payments	

H. Recreation Resources

Variables to Be Evaluated	*Related Information to Be Measured*
Recreation opportunities	Resource conditions and availability
Recreation use	Regional population and demographics Demand for recreation resources

I. Visual Resources

Variables to Be Evaluated	
Visual quality	
Viewer sensitivity	

J. Cultural Resources

Variables to Be Evaluated	*Related Information to Be Measured*
Risk to prehistoric sites	Acreage of ground disturbance from construction Distribution of culturally sensitive landforms Locations of known sites

Risk to historic sites	Association of historic sites with land conditions Locations of known sites

K. Public Health and Environmental Hazards

Variables to Be Evaluated	*Related Information to Be Measured*
Area of mosquito breeding habitat	
Area of habitat that supports other disease vector populations	
Risk of contact between humans and vector populations	
Risk of hazardous material and waste upset	Known hazardous material sites

L. Utilities and Public Services

Variables to Be Evaluated

Electrical supply and use

Water conveyance

Transportation facilities (e.g., roads, railroads, and ferry)

Deepwater ship channels and shipping ports

Natural gas fields and storage reservoirs

Underground pipelines

Communications facilities

Police, fire, and emergency services

M. Social Well-Being

Variables to Be Evaluated	*Related Information to Be Measured*
Community stability	Demographics Regional economics
Environmental justice	Demographics Regional economics

SURFACE WATER HYDROLOGY

Changes in surface-water hydrology are measured as changes in the amount of water entering or leaving a component of the hydrologic system during a given time period. These inflows and outflows are governed by natural phenomena, such as runoff and evapotranspiration, but can be altered by human intervention through land and water management. The assessment of impacts on surface-water hydrology must be able to simulate the interrelationships between natural processes and management actions. CALFED actions could affect the hydrologic system by changing groundwater levels, water conveyance, facility operations and development, and land use and management practices. Although technology is not available to control weather patterns, it is possible to control, to a degree, the runoff that these weather patterns generate, using water management facilities and operations.

The proposed assessment approach uses existing models of physical processes in the hydrologic system to simulate the hydrologic effects of implementing CALFED actions. Simulation periods and hydrologic data were selected based on data availability, existing trends in hydrology and water use, and the range of conditions expected to occur in the future. For the programmatic impact assessment, simulation results are summarized to the scale of major drainages such as the Sacramento and San Joaquin Rivers and their principal tributaries.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on surface water hydrology:

- the volume of flow, and
- the timing of flow.

The volume of runoff from a watershed is calculated from rainfall, snowmelt, groundwater discharge, direct surface runoff, and evapotranspiration. These variables indicate how much water enters the surface water system, and although these are natural occurrences, they can be influenced by human activities.

Direct surface runoff occurs when precipitation or irrigation rates exceed the capacity of the soil to absorb the moisture. The water then either evaporates, flows overland to a surface waterway, or ponds and slowly percolates into the ground. Direct runoff contributes a significant volume of flow to waterways during the wet season.

Groundwater discharge refers to flows from groundwater sources to surface water, and includes flows from springs into streams and groundwater seepage into streams and rivers. Groundwater seepage occurs along reaches (gaining reaches) where the water table is higher than the stream surface. Groundwater discharge can decrease or cease if decreases in groundwater recharge (the flow of water into groundwater storage basins) or increases in withdrawals cause a substantial lowering of the water table.

Soil moisture is lost when the wind or sun (or both) evaporates water that is stored in the soil or in open-water areas such as reservoirs and natural lakes (evaporation) or water is used by vegetation (transpiration). The rate of evaporation in open-water areas will increase as the surface area of the lake increases (if wind and sun conditions remain the same). The rate of transpiration can be affected by the type of vegetation covering the soil, since different types of plants require different amounts of water.

The timing of flows that occur in surface water systems is controlled by both natural and artificial components. Seasonal weather pattern variations determine precipitation and evapotranspiration, which control groundwater discharge, snowmelt, and direct runoff. Ambient air temperature controls whether current precipitation will occur as rain or snow, the rate of snowmelt, and the volume of water lost through evapotranspiration. Rain will contribute to current flows, while snow will contribute to future flows. The operation of reservoirs, diversion pumps, canals and other water management facilities artificially affects the timing of flow through the system.

Surface-water hydrology is a component of many of the models proposed for use in evaluating the impacts of the CALFED alternatives. Some actions included in the CALFED alternatives will directly affect hydrology (e.g., through the construction of water conveyance or storage facilities). Other actions will indirectly affect hydrology (e.g., restoration of wetland habitats may change evapotranspiration rates in the system).

The Central Valley Groundwater Surface Water Model (CVGSM) is a regional surface-water and groundwater model that covers the Central Valley region from Red Bluff to the Tehachapi Mountains. CVGSM includes the most complete accounting of surface water, soil moisture, and groundwater. CVGSM simulates streamflow diversions, return flow, groundwater percolation, and groundwater pumping, and produces water budgets for groundwater, streamflow, and soil moisture as output. CVGSM does not, however, calculate reservoir operations and reservoir release flows. These riverflows will be calculated using DWRSIM, (as discussed in the "Introduction and Overview of the CALFED Bay-Delta Program Assessment Process"), and provided as input to CVGSM.

Results of the surface water hydrology assessment will be used to evaluate changes in the characteristics of river flow. River flow depends on physical conditions of the river channel and the volume of water moving through the channel. Modifications to either the channel, including levees and floodplains, or the volume of flows can alter the characteristics of river flow. Changes in river flows and the effect of those changes on water quality, aquatic habitats, and flooding will be described qualitatively based on existing studies and expert opinion.

Changes in surface-water hydrology may affect or be affected by groundwater hydrology, land use changes, regional economics, vegetation and wildlife including special-status species, fisheries and aquatic resources, agricultural economics, municipal and industrial water supply economics, recreation resources, and water management facilities and operations. For example, actions that affect the volume or timing of surface-water flows could affect groundwater pumping and water management; these changes could also affect evaporation from surface impoundments. Additionally, construction and use of new surface-water storage facilities could result in additional evaporation, and altering vegetation (e.g., from agricultural crops to wetland or marsh vegetation) would affect rates of evapotranspiration and runoff.

GROUNDWATER HYDROLOGY

Changes in groundwater hydrology are measured by changes in local and regional groundwater levels and water budgets. Although groundwater budgets include natural inflows (such as infiltration of rainfall and seepage to and from rivers), inflows and outflows can be affected by human intervention in water management. CALFED actions that could affect groundwater hydrology include increasing conjunctive use and groundwater banking and changing water and land management. The methods used to assess impacts on groundwater hydrology must simulate the interrelationships between natural processes and management actions, and evaluate impacts over a wide range of geographic locations and hydrologic settings.

Storage capacity in groundwater basins, unlike that in surface reservoirs, is not an absolute volume. The capacity in groundwater basins is limited to a volume considerably smaller than the total volume of the basin because of limitations imposed by pumping costs that increase with water-table depth, poor water quality, contamination, and the potential occurrence of undesirable side effects of pumping, such as subsidence and seawater intrusion.

CALFED has identified effective groundwater capacity (the portion of groundwater storage capacity that can be used) as an important measure of changes in groundwater hydrology. Effective groundwater capacity is a function of basin storage capacity, groundwater recharge, groundwater withdrawals, and conjunctive use. Each of these variables could potentially be affected by CALFED actions.

Groundwater recharge (the flow of water into groundwater storage basins) is provided mainly by the flow of rainfall and irrigation water through soils and from stream seepage. Changes in land use affect the percentage of rainfall that becomes groundwater recharge. The conversion of land to urban uses, the types of crops being irrigated, the extent of irrigation and the moisture content of the soils at the beginning of the rainy season can influence the flow of water through soils.

Groundwater withdrawals are a significant source of water in California. If pumping exceeds recharge, chronic declines in groundwater levels can result in increased pumping costs, dry wells, subsidence, and migration of contaminants or saline groundwater into formerly pristine areas.

Conjunctive use of surface water and groundwater is a method of managing groundwater recharge and withdrawals that can be used to increase water supply reliability. It promotes more efficient use of available water resources by using groundwater basins to store surface water. In the "in-lieu recharge" method, surface water is delivered in relatively wet years to users who would normally pump groundwater, thereby decreasing groundwater withdrawals and increasing recharge from irrigation return flow. Percolation ponds are a more active method used to store excess surface water.

Numerical groundwater flow models are the principal tools available for assessing impacts on groundwater hydrology. Many commonly used groundwater flow models, such as MODFLOW and FLOW3D, simulate the interaction of surface water and groundwater but do not simulate surface-water flow and operations in detail. The Central Valley Groundwater Surface Water Model (CVGSM) includes relatively complete simulation of surface-water flow, storage, allocation, and return flow. This complete modeling capability could also be accomplished by linking a groundwater flow model with a separate surface-water operations model such as DWRSIM or PROSIM.

Databases of groundwater well locations and groundwater levels are needed to provide for input for groundwater models and for model calibration. The eXterra database, maintained by DWR, contains substantial amounts of data for the Central Valley. Separate databases are maintained for DWR's northern and central districts.

Groundwater is closely related to a wide variety of resource categories including surface water hydrology; water management facilities and operations; geomorphology, soils, and seismicity; agricultural economics; municipal and industrial water supply economics; regional economics; power production and energy; and land use. For example, actions that affect the volume or timing of surface water flows could affect groundwater recharge by altering stream seepage, and groundwater pumping by affecting the availability of surface water. Changes in water management can alter conjunctive-use schemes by changing the availability and reliability of surface water, possibly decreasing dependence on groundwater.

GEOMORPHOLOGY, SOILS, AND SEISMICITY

Geomorphology and soil conditions depend on the characteristics of the soils (e.g., erodibility, organic content), management or use of the soil (e.g., agricultural and irrigation practices), and composition and condition of underlying materials and aquifers. CALFED actions could affect soil conditions, subsidence, and seismic hazards through actions that affect the quantity and quality of irrigation water supplies to soils, changes to the amount of land under irrigation, improvements to Delta levees, relocation of infrastructure in the Delta, and changes to agricultural practices and groundwater management.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on soil conditions:

- surface soil erosion,
- soil salinity,
- subsidence caused by peat oxidation,
- subsidence caused by groundwater withdrawals, and
- seismicity.

Surface soil erosion is a function of soil types and their relative erodibility, wind and water erosivity, slope and slope length, vegetation cover, and land use and management. Soil erosion is an area of concern in agricultural production.

Soil salinity is the result of salt accumulation over time in surface soils. Soil salinity is affected by the salinity of applied water, the amount of excess irrigation water applied to flush the salts, and the salinity and level of the groundwater. Soil salinity is of particular concern in the San Joaquin Valley and the southeastern areas of the Delta (near Stockton).

Oxidation of organic soils in the Delta has resulted in land subsidence. Factors affecting subsidence in the Delta include the organic content of the surface soil, soil moisture and water table management, seasonal flooding, and ground disturbance and tilling practices. Outside the Delta, land subsidence can be caused by increasing groundwater withdrawals. When an aquifer is dewatered, clay materials within the aquifer consolidate, causing the land surface above to subside. After an area has subsided, irreversible changes to the aquifer occur. Subsidence resulting from groundwater withdrawals is influenced by the groundwater levels in the aquifer, rates of recharge versus withdrawal for the aquifer, and the geology and mineralogy of the aquifer.

There is a risk that Delta island levees could fail during seismic events, and although there have been no catastrophic failures attributable to seismic events, significant damage has occurred in the form of cracks and sloughing of banks. The susceptibility of levees to failure from seismic activity (ground shaking and liquefaction) is affected by the levee material, foundation, and height.

Assessment methods will compare differences in the rates of soil erosion, soil salinity, and subsidence between CALFED alternatives. In addition, construction-related soil erosion under the CALFED alternatives will be compared based on the expected area of disturbance, regional location, duration, kind of construction disturbance, and average erodibility of soils in the region.

Changes in regionwide erosion rates will be derived from changes in land use and management. Estimates of changes in soil erosion will be qualitative or semiquantitative because of variability in soil type, soil erodibility, slope, and land management throughout the region. County soil surveys and discussions with district conservationists of the Natural Resources Conservation Service (NRCS) will be used as the basis for projections of soil conditions and land use practices.

Soil salinity problems will be assessed based on the projected area of salt-affected soils. In the Delta area, soil salinity is dependent on the quality of water drawn from the Delta channels. Delta water quality models will be used to assess where salinity in Delta channels will increase or decrease, and a comparison will be made of land areas affected by changes in the quality of intake water. For the San Joaquin Valley and other water export areas affected by soil salinity because of high groundwater, differences in soil salinity problem areas will be estimated based on differences in the electrical conductivity (EC) of export water, the resultant requirements for excess irrigation water to flush salts, and the expected effect on the level of groundwater. Plans for agricultural tailwater drains will be factored in. In addition, the effect of using groundwater and project water as alternative sources will be assessed. The soil salinity assessment, performed on a county-by-county basis, will incorporate the advice of NRCS district conservationists.

Differences in subsidence from peat oxidation in the Delta will be described in terms of the area of drained peat soils and the rate of subsidence of drained areas. For example, CALFED actions that could affect subsidence include using Delta islands for water storage or wetland habitat and improving the land on which levees are built through in-Delta conveyance using setback levees.

Assessing subsidence resulting from groundwater withdrawals will be based on projected rates of subsidence by groundwater basins or irrigation districts, changes in the amounts or reliability of delivered water, and resulting changes in the rate of groundwater pumping.

The likelihood of a seismic event would not change from existing conditions, but the relative susceptibility of Delta resources and infrastructure to seismic events could be influenced by plans for improvements to levees, projected changes in the rate of subsidence, and changes in island management and land use influenced by CALFED actions.

Other assessment areas will provide inputs to the soil assessment. Projections of land use from the impact assessments for land use and agricultural economics will provide input to the assessment of erosion and subsidence. The evaluation of salinity (EC) in Delta irrigation water and export water from water quality assessments will provide data for the assessment of soil salinity impacts. Output from the evaluation of soil erosion may provide information for the air quality analysis (dust and particulate matter evaluations), and information from the geology, soils, and seismicity assessment will be used in the flood control evaluation for the Delta.

AIR QUALITY

CALFED actions would affect air quality both directly (e.g., short-term emissions from construction vehicles at new facilities or long-term changes in water pump operations and resulting emissions at the CVP and SWP pumping plants) and indirectly (e.g., agricultural practices that change in response to CALFED water-efficiency policies or changes in water supply reliability that could affect regional agricultural emissions). The magnitude and measurability of these changes in air quality vary and the relative importance of each pollutant (e.g., particulate matter and carbon monoxide) varies from one geographic area to another because each region has different air quality problems.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on air quality:

- ozone (O_3),
- carbon monoxide (CO), and
- particulate matter.

Information that will be used to determine the magnitude of these changes are:

- duration using construction, agricultural, pumping, and recreational equipment and vehicles;

- acres of ground disturbance resulting from construction activities or agricultural operations;

- characteristics of soil disturbed by construction or agricultural operations (e.g., silt content, soil moisture, and vegetative or synthetic cover); and

- meteorological factors (e.g., wind speed, precipitation, and temperature).

The air quality assessment will focus on emission sources that would be affected either directly or indirectly by CALFED actions. Short-term construction-related activities and long-term operational activities will be assessed separately. The effects on air quality by construction and operational activities will be summarized by pollutant. Changes in pollutant types will be determined by evaluating expected changes in each emission-producing activity.

The assessment of CO can be determined by air-pollutant-dispersion simulation models and their results can estimate concentrations of CO where land uses sensitive to CO might be located (e.g., residences, schools, or hospitals). The assessment of reactive organic gases (ROG), oxides of nitrogen (NO_x), particulate matter (PM10), and oxides of sulfur (SO_x) involves estimating the emissions that would be generated during a period of time. Occasionally, generators of large amounts of NO_x, PM10, and SO_x emissions are also assessed using dispersion models.

Assessment methods might vary substantially for each component of the CALFED alternatives. Where appropriate to the programmatic assessment, CALFED staff will use assessment methods recommended by local air quality regulatory agencies (air quality management districts). Because many air quality management district guidelines address only conventional urban development activities (e.g., residential developments, office buildings, retail complexes), the U.S. Environmental Protection Agency (EPA) document, Compilation of Air Pollutant Emission Factors, will be used to define appropriate assessment methods for other CALFED actions.

The assessment of changes in air quality will incorporate information from changes in other resource topics and operations that could affect air quality and will reference the assessment of changes to agricultural practices, soils, power production or energy consumption, and recreation resources that produce emissions.

NOISE

Actions associated with CALFED alternatives could affect noise conditions by changing the intensity and location of construction activity, changing stationary sources of noise associated with hydropower generation and water conveyance systems, and changing the intensity and location of noise-generating recreational activities such as boating and hunting. CALFED actions could affect the various local noise environments both directly and indirectly. Direct effects would involve short-term noise from construction activities and long-term noise associated with the operation of mechanical equipment (e.g., pumps and generators). Indirect effects would involve noise from increased recreational activity, such as boating on new or expanded reservoirs and hunting in new or expanded marshland areas.

Changes in noise levels from the following sources will be evaluated to assesss the impacts of the CALFED alternatives on noise:

- short-term construction activities;
- facilities operation;
- aquatic recreation (e.g., boats); and
- terrestrial recreation (e.g., hunting).

The approach used to assess the potential noise effects of CALFED alternatives involves evaluating the noise effects of various component activities. The program activities will be divided into direct short-term (construction-related) activities, direct long-term (operational) activities, and indirect activities. As an example, the direct short-term effects of constructing a conveyance facility would include noise from construction equipment (i.e., grading and assembly). Direct long-term effects could involve noise from diesel-powered pumps if such pumps are used in new conveyance or storage facilities. An example of an indirect activity would be increased powerboat use resulting from increased available water surface area. Direct short-term activities, direct long-term activities, and indirect activities would be assessed separately.

Noise levels generated by the various types of project-related activities will be discussed and summarized at a general level of detail. The locations of potential sources of noise will be taken into consideration in evaluating potential effects. Appropriate assessment methods may vary for each of the components of the CALFED alternatives depending on the type and nature of potential sources of noise. In addition, the geographic location of the CALFED components may affect the type of assessment methods used. For example, noise produced in a previously quiet area near sensitive noise receptors (e.g., homes, parks, recreation areas) would be of greater concern and would require more detailed assessment than noise produced in an already noisy area. Noise is typically a local issue that is regulated at the city and county level. Local guidelines and regulations relating to noise will guide regional or programmatic evaluation of noise conditions.

The assessment of noise will incorporate information from other resource topics that describe changes in operations that could affect noise conditions in the area. The noise assessment will refer to the land use section for areas of potential construction and sensitive noise areas, the power production or energy consumption assessment for changes in power production and pump activities, the recreation resources assessment for changes in recreational activities that generate noise (e.g., boating and hunting), and the traffic and navigation assessment for changes in transportation-related activities that create noise.

TRAFFIC AND NAVIGATION

CALFED actions could affect existing roadway and waterway systems by changing the existing roadway infrastructure to accommodate new facilities, altering existing waterways to support water conveyance and levee improvements, increasing or decreasing roadway and waterway traffic by changing existing land uses, and creating short-term increases in road and waterway traffic and altering circulation patterns (e.g., detours and access roads) during construction.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on traffic and navigation:

- regional roadway level of service,
- roadway safety conditions,
- regional waterway traffic, and
- waterway navigation conditions.

The methods used to assess potential effects of CALFED program alternatives on traffic and navigation will qualitatively evaluate changes in road and waterway infrastructure and use. CALFED activities will be divided into direct short-term (construction-related) activities, direct long-term (operational) activities, and indirect activities. As an example, the direct short-term effects of constructing a conveyance facility would include roadway traffic (e.g., trucks) and waterway traffic (e.g., barges) and potential detours or closures of roads and waterways. Direct long-term effects could involve traffic generated by new water storage facilities (e.g., reservoirs) that draw recreationists to the area. Indirect activity would include increased power boat use resulting from increased available water surface area. Direct short-term, direct long-term, and indirect activities would be assessed separately.

Appropriate assessment methods may vary for each component of the CALFED alternatives depending on the type and nature of potential sources of traffic and safety problems. In addition, the geographic location of the CALFED components may affect the type of assessment methods used. For example, waterway detours in an area of heavy recreation boating would be of greater concern and require more detailed assessment than detours in an area of low recreation use. Local and State guidelines and regulations relating to waterway and roadway traffic and safety will guide regional or programmatic evaluation of traffic and navigational conditions. Most likely, assessment of roadway and waterway traffic will focus on regional transportation corridors.

Long-term impacts on roadway traffic resulting from CALFED actions will be evaluated using information from the recreation analysis and details of the water storage and conveyance facilities. An increase in recreation will most likely result in an increase in roadway traffic. Water storage and conveyance-related CALFED actions also have the potential to alter waterways (e.g., enlarging existing water channels) and land and could substantially change boating conditions in the Delta area. Altering the size of a waterway or changes in water conveyance systems could change

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the types of water vehicles and water vehicle capacity and alter the amount of water flowing through the Delta region. Reduced flows could impair ships moving through the Stockton and Sacramento Deep Water Ship Channels in the Delta.

The traffic and navigation assessment variables are related to other resource assessments and methods, including those for recreation and water management facilities and operations. Additionally, results of the traffic and navigation assessment will support analysis of impacts on air quality and noise.

FISHERIES AND AQUATIC ECOSYSTEM RESOURCES

The programmatic impact assessment will identify potential beneficial and detrimental changes in the aquatic ecosystem under each. As described earlier, fisheries and aquatic ecosystem resources assessment methods are being developed by a working team of State and federal agencies and stakeholder fish experts. This group has identified a list of species to be used in impact analysis and has made recommendations on the important factors to assess for each species. Meetings of the team are being held to determine the most suitable assessment methods for fisheries and aquatic ecosystem resources.

To conduct an assessment of changes in the aquatic ecosystem, the working team has identified aquatic communities, representative species, and ecosystem functions. CALFED and the technical working group are developing a process for selecting methods to evaluate the important changes to fish and aquatic ecosystem resources. The following text summarizes information on the fisheries and aquatic ecosystem analysis.

The aquatic ecosystem is divided into five communities based on occurrence of fish and invertebrate species and on habitat conditions that could be affected by CALFED actions. They are:

- reservoir,
- coldwater riverine,
- warmwater riverine,
- estuarine, and
- marine.

A representative group of species that occur in these communities was selected based on the importance of the species and their sensitivity to changes resulting from CALFED actions. Twenty-five species were selected for inclusion in the impact analysis, 18 species of fish and seven species or groups of invertebrates (Table 2).

Ecosystem functions are any of the natural, specialized actions of an ecosystem including complex patterns of transfer, transformation, utilization, and accumulation of inorganic and organic materials (i.e., the flow of energy, nutrients, and species). For the purpose of impact assessment for the aquatic ecosystem, ecosystem functions are divided into the broad categories of biomass production and biomass loss. Biomass production represents the capacity of the ecosystem to produce biomass through growth; reproduction; and external augmentation (e.g., migration and artificial production). Biomass loss relates to mortality and removal (e.g., death or permanent dislocation) of individuals.

The impact analysis will evaluate changes to those resources that affect ecosystem functions and species populations within the aquatic ecosystem. These resources represent structural components, including physical, chemical, and biological features. Ecosystem structure is reflected in the arrangement, interrelation, and manner of organization of the specific resources.

Table 2. Species Selected for Inclusion in the Fish Impact Assessment

Species (Common/Scientific Name)		Aquatic Community: Reservoir	Cold Water	Warm Water	Estuarine	Marine
Fish						
Rainbow trout	*Oncorhynchus mykiss*	X				
Largemouth bass	*Micropterus salmoides*	X			X	
White sturgeon	*Acipenser transmontanus*		X	X	X	X
Chinook salmon	*Oncorhynchus tshawytscha*		X	X	X	X
Steelhead trout	*Oncorhynchus mykiss*		X	X	X	
Sacramento squawfish	*Ptychocheilus grandis*		X	X		
American shad	*Alosa sapidissima*			X	X	
Sacramento blackfish	*Orthodon microlepidotus*			X	X	
Sacramento splittail	*Pogonichthys macrolepidotus*			X	X	
Striped bass	*Morone saxatilis*			X	X	X
Smallmouth bass	*Micropterus dolomieui*			X		
Tule perch	*Hysterocarpus traskii*			X	X	
Delta smelt	*Hypomesus transpacificus*				X	
Longfin smelt	*Spirinchus thaleichthys*				X	X
White catfish	*Ictalurus catus*				X	
Inland silverside	*Menidia audens*				X	
Pacific herring	*Clupea harengeus pallasii*					X
Starry flounder	*Platichthys stellatus*					X
Invertebrate						
Terrestrial invertebrates			X	X	X	
Other aquatic invertebrates			X	X		
Rotifers	Rotifera				X	
Native mysid shrimp	*Neomysis mercedis*				X	
Crayfish	*Pacifastacus leniusculus*			X	X	
Asian clam	*Potamocorbula amurensis*				X	X
Bay shrimp	*Crangon franciscorum*					X

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on fisheries and aquatic ecosystem resources:

- flow,
- reservoir elevation,
- temperature,
- substrate,
- diversions,
- barriers,
- physical habitat,
- water quality,
- fishing,
- artificial production, and
- species interactions.

The fish and aquatic ecosystem working group is developing a process to select the most appropriate assessment methods for the programmatic impact analysis. Currently, the process for selecting those methods includes six major tasks:

- identify the resources and variables likely to change under CALFED,

- distinguish important changes that may affect associated ecosystem functions,

- identify potential assessment methods,

- eliminate methods that do not meet the criteria for inclusion in the programmatic assessment,

- determine additional assessment needs and potential methods, and

- develop a preliminary strategy for application and interpretation of assessment results.

Information on aquatic communities, ecosystem functions, assessment variables, and representative species provides the foundation for the selection process. CALFED staff will continue selecting methods and will complete their selection after CALFED alternatives are clearly described.

VEGETATION AND WILDLIFE, INCLUDING SPECIAL-STATUS SPECIES

CALFED actions would most likely result in changes to vegetation and wildlife resources through implementation of the CALFED ecosystem restoration program, construction of facilities, and changes in facility operation (e.g., storage and conveyance). Measures to restore wetland, riparian, and other sensitive native habitats adopted in the ecosystem restoration program plan would directly benefit those communities and their associated wildlife. Additionally, some CALFED actions proposed for the restoration component are specifically designed to reduce populations of introduced plant and animal species that compete with native species. Construction of new water storage and conveyance facilities would most likely result in a loss primarily of native habitat.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on vegetation and wildlife, including special-status species:

- area and condition of habitat,
- area of agricultural land use providing habitat value,
- connectivity and orientation of habitats,
- number of known populations of special-status species,
- area and condition of habitat occupied by special-status species,
- changes in nonindigenous/introduced species populations, and
- changes in ecological processes that sustain habitats.

Changes to vegetation and wildlife resources will be defined and analyzed spatially. The change in acreage of each habitat type is used as the quantitative measure of impacts on wetland and terrestrial habitats. Special-status plant species and some wildlife species that have small ranges are typically assessed in terms of point locations of known populations. Impacts on vegetation and wildlife species or species groups are also assessed by identifying changes in the area of habitat used by that species or group.

The assessment of impacts on wetland and terrestrial habitat will consider their geographic extent, distribution, quality, and spatial configuration. A project that affects the continuity of linear riparian habitat or drainage patterns in wetlands may have greater impact than a project that avoids the spatial habitat characteristics. Similarly, the severity of impacts is determined by the quality or condition of habitat areas.

A variety of habitat types will be addressed in the assessment including open-water and tidal wetlands; saline, brackish and freshwater wetlands; riparian and riverine habitats; and upland habitats. An increase or decrease in the area of a particular habitat type usually implies that populations of wildlife or plant species closely associated with the affected habitat type will be beneficially or adversely affected.

To conduct the analysis of change to extent of habitats, CALFED staff will compare broadly defined areas potentially affected with regional distributions of habitat types and populations of special-status species. Geographic comparisons will be done using electronic databases and hard-copy maps of habitat-type distributions. Results of this analysis will provide information on the likelihood of affecting a given habitat type or special-status species. A final decision has not been made on the approach that will be used to conduct impact assessments on areas for which database or hard-copy maps of habitat-type distributions are not available.

The effects of CALFED actions on habitat condition will be assessed and described qualitatively based on the current understanding of existing land use and how ecosystems function. A quantitative analysis of change in habitat condition for some species or species groups associated with agricultural lands can be conducted only when project features are described in detail (Phase III). The ability of CALFED actions to control populations of non-native species will be assessed qualitatively by resource experts based on the expected effect on each species' population.

Available information on the extent, connectivity, and orientation of wetland and terrestrial habitats and the locations of special-status plant and wildlife populations will most likely be sufficient for the level of analysis of the Programmatic EIR/EIS.

The assessment of impacts from changes to biological resources for vegetation and wildlife, including special-status species, are directly related to the assessment of impacts from changes to fisheries and aquatic resources, public health and environmental hazards, flood control systems, riverine hydraulics, land use, and visual resources. Additionally, results of the assessment of impacts on species of high recreational or economic importance (e.g., wintering waterfowl) would be used to assess impacts on recreation resources and fish, wildlife, and recreation economics

LAND USE

CALFED actions have the potential to change existing land uses in the Delta, San Joaquin and Sacramento Valleys, upper reaches of rivers tributary to the Delta, and the CVP and SWP delivery areas. CALFED actions could directly affect land use by converting agricultural or open-space/habitat land into developed infrastructure or open-water habitat (by constructing water-related facilities) and could indirectly affect land uses by creating opportunities for M&I development or changes in agricultural uses (by improving water quality and water supply reliability). Constructing water facilities (e.g., reservoirs) could also indirectly affect land use if adjacent lands are developed to support new water-related recreation facilities. Additionally, economic growth stimulated by CALFED actions could result in indirect changes in land uses to support growing communities.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on land use:

- acres in agricultural use,
- acres in open-space and habitat use,
- acres in developed uses, and
- Indian Trust assets.

Supporting variables that influence the acreages of land in agricultural, open space/habitat, and developed uses are discussed in the assessment methods descriptions for agricultural economics, vegetation and wildlife including special-status species, and M&I water supply economics, respectively.

Land use assessment includes an analysis of land use changes that result from construction of new facilities or conversion of lands and analysis of indirect effects of changes in policies, resources, or economics. Urban development, agriculture, and open space/habitat are categories that will be evaluated. Although a programmatic assessment will not provide site-specific details for areas directly affected, potential changes in the number of acres of selected land uses will be estimated for each region. The land use assessment will describe overall changes in land use resulting from the aggregate behavior of water users and other landowners and managers. These changes can be estimated using quantitative assessment methods or qualitative assumptions based on past observations and expert judgments.

Direct impacts of the CALFED alternatives on land uses will be estimated by comparing areas potentially converted to specific uses (e.g., facilities and habitat restoration) to general maps of area land uses and calculating the amount of existing land being converted to other uses.

Indirect land use impacts will be assessed based on related analyses of other issue areas. Results from the Central Valley Production Model (CVPM) used in the agricultural economics impact assessment will provide estimates of changes in agricultural acreage resulting from various

CALFED features. Changes in open space/habitat acreage and conditions will be addressed in the wetlands and terrestrial habitat analysis. Where applicable, information from the regional economics and demographics assessment will be used to describe relative differences in land uses that result from population and economic growth in those areas affected by changes in water deliveries.

Indian Trust Assets are defined by the U.S. Bureau of Reclamation in its 1994 Draft Bureau of Reclamation Indian Trust Asset Policy and National Environmental Policy Act (NEPA) Implementation Procedures as: "'legal interests' in 'assets' held in 'trust' by the Federal Government for Indian tribes or individual Indians. Indian Trust Assets are located throughout the study area. A qualitative discussion about land use effects on Indian Trust Assets will be provided based on available data.

Assessing changes in land use is closely related to assessing changes in other resources including agricultural economics, vegetation and wildlife including special status species, M&I economics, and recreation. Additionally, results of the assessment of land use will support analysis of impacts on biological resources, visual conditions, cultural resources, flood control, surface water conditions, soils, and air quality.

FLOOD CONTROL SYSTEM

CALFED actions could affect the integrity of the levee systems protecting lands within the Bay-Delta region from flooding. Actions taken to alter water conveyance and hydrodynamics of the Delta region would directly and indirectly affect the extensive levee systems, as may some actions to restore ecosystem functions of the Bay-Delta region. The CALFED alternatives incorporating through-Delta conveyance and dual-Delta conveyance would directly affect some portions of the existing channel/levee systems by requiring their reconfiguration. Indirect effects on other levees may result from changed hydraulic conditions and wave energies associated with these structural changes or from planned changes in streamflow regimes.

In addition to conveyance alternatives and the ecosystem restoration program, CALFED actions include a levee-system integrity program, which includes elements for improved levee-maintenance funding and emergency response procedures, special projects to simultaneously improve flood control and habitat values, beneficial reuse of dredged materials, and subsidence control.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on flood control:

- potential for levee failure,
- flood damage and value of protected resources, and
- cost of flood-damage protection.

Levee systems fail from both overtopping failure and mass failure. Overtopping failure occurs when watershed-wide runoff exceeds the capacity of the leveed channels. The potential for overtopping failure has increased in the Delta because of gradual settlement of levees and sediment deposition in channels. Mass failure is structural collapse of a weakened levee. Levees are weakened when water from river channels seeps through permeable levee material. Streambank erosion, a rapid reduction in water elevation, or seismic activity are other factors that weaken levee structure and contribute to mass failure.

Flood damage is measured by the value of resources protected by the levee system. The Delta levee system protects areas that are primarily farmlands, many of which are considered prime agricultural areas. At obvious risk are farm and rural residences, inhabitants, recreationists, and personal property; farming structures and ; crops; small towns or communities; riverine recreational development; and regional transportation facilities (e.g., railroads and State highways) and utility infrastructure (e.g., electrical transmission lines, aqueducts, and gas fields) that affect regions well-beyond the Delta area. Also at risk, although less obvious, are terrestrial habitats and Delta water quality. Levee failure and inundation of Delta islands, especially the westernmost islands, can result in saltwater intrusion into the Delta's freshwater and brackish water habitats and into interregional water supplies conveyed through the Delta. Island flooding generally replaces terrestrial habitats, primarily agricultural but some riparian and wetland habitats, with open-water habitats.

Except for human life, the value of flood-damage protection can be estimated in terms of costs resulting from flooding (e.g., repair costs, utility rerouting costs, lost revenues during flooding). Changes in Delta water quality affect costs for water conveyance and water treatment. Costs resulting from changes in Delta habitat are more difficult to establish. In addition, their are costs for providing emergency services and repairing levee damage. These costs include those for emergency flood fight, rescue services, disaster relief, repairing damaged levee sections, and draining (i.e., dewatering) islands.

The cost of establishing and maintaining flood-damage protection under the CALFED levee-system integrity program includes the cost of improvements to and reconfiguration of levees and changes in emergency response resources.

Methods used by the U.S. Army Corps of Engineers for assessing flood-damage reduction benefits are appropriate tools for estimating physical damages, emergency costs, and populations at risk from levee failure in the Delta. These methods and information on existing values need to be supplemented with estimated increases in the cost of water treatment associated with the levee failures. DWR's hydrodynamic model of the Delta (DWRDSM) could potentially be used to estimate the degrees of salinity intrusion, and resulting costs of necessary countermeasures may be available from in-Delta and export water users. Values of habitats by type that could be damaged or lost by island inundation could be developed from habitat replacement costs (i.e., approximate costs per acre recently experienced in habitat restoration projects in the region).

DWRDSM could be used to determine the potential for levee overtopping by evaluating the interaction of various streamflow events and tides with stream channel geometry and showing the effect on water-surface elevations. A series of flood events spanning a range of probabilities could be evaluated, and historical flood frequency data could be applied to the results to estimate the locations and frequencies of overtopping or freeboard-encroaching events for various reconfigurations of Delta channels. Subsidence rates can be used to define the system at a future point in time for similar assessment.

General information and inventories on structural deficiencies in levees, such as problem areas or areas of relative instability, can be used to represent likelihoods of mass failure. and to reveal the relative potential afforded each island. Soil-survey and geologic data, including estimates of strength and susceptibility to liquefaction, could also be factored into this inventory and relative rating.

A risk-based analysis, using overtopping potential, mass failure potential, and the value of flood-damage protection as variables, may also be conducted to characterized the relative difference in flood-damage protection between the alternatives. Levee-failure rates or indices can measure relative failure potential by island, and a value index can reflect the relative value of preventing loss or damage to resources as a result of flooding. Spreadsheets to track this information could be designed for the programmatic analysis, or new (1996) software (Hydraulic Engineering Center's Flood Damage Assessment [HEC-FDA]) for risk-based analysis may be adapted to assist the planned analysis.

The assessment of impacts on levee-system integrity is closely related to impacts of CALFED actions on surface-water hydrology, water management operations, Bay-Delta hydrodynamics, and geomorphology, soils, and seismicity. Changes in flood-damage protection are closely related to impacts of CALFED actions on land use, agricultural economics, water supply M&I economics, and vegetation and wildlife.

AGRICULTURAL ECONOMICS

Agricultural producers make many simultaneous and interacting decisions in response to changing water supply conditions, costs, and crop prices. CALFED's assessment method will simulate, as realistically as possible, the aggregate behavior of water users and others involved in the agricultural economy of the Bay-Delta region, the Sacramento and San Joaquin Valleys, and other areas of agricultural production. The assessment method will use information observed from past conditions and decisions to help estimate future responses to CALFED alternatives. Because future conditions may not imitate those of the observed past, the analysis will also evaluate how the agricultural sector might respond to such new conditions.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on agricultural economics:

- value of agricultural production (gross revenue),
- cost of production,
- agricultural net income, and
- cost of water supply variability.

The value of agricultural production depends on acres in production, crop choices, yield, and price. It is a measure of overall activity in the agricultural sector and can be used as a basis for estimating regional economic impacts.

Cost of production includes all production costs but will focus on costs that may change in response to CALFED actions. These include cost of surface water used, groundwater cost, irrigation efficiency and costs, production costs, acres in agricultural production, and other on-farm and regional water management costs.

Agricultural income is the difference between crop revenues and production costs. Water transfers may also be a potential source of income to the agricultural sector. (The terms net income, net revenue, and net returns are often used interchangeably.)

The costs of production can be estimated for a given year or water-year type. Increases or decreases in the certainty of water supply (or cost) over time also impose costs. This variability can also include indirect/third-party impacts. Farmers must make investment, marketing, and planting decisions based on uncertain conditions. Changes in the availability and reliability of water supply can change the cost associated with these decisions.

To estimate how growers are likely to react to changes in the conditions under which they operate, CALFED proposes to use an analytical approach that is based on the Central Valley Production Model (CVPM), an analytical tool developed at DWR and extensively revised for recent planning studies and impact analysis. CVPM is an agricultural production model covering the region from Redding to the Tehachapi Mountains. It was designed to serve as a tool for planning and assessing regional impacts on irrigated agriculture resulting from changes in market or resource conditions. This approach uses crop or farm budgets to estimate the least costly response to a potential change. CVPM currently incorporates only the Central Valley; however, CALFED actions may affect agricultural water supplies in other regions such as southern California. Other regions could be added to the CVPM model, or impacts could be estimated using simpler spreadsheet models.

The cost of water supply variability can be estimated in many different ways. Two approaches are proposed. The first would be to use CVPM to estimate production costs and revenues for different levels of water supply and weight the results to simulate changes in the probabilities of receiving different amounts of water. (Changes are defined by comparing results with CALFED action versus results without CALFED action.) The second approach would be to estimate the change in surface supply for the driest water years and the additional investment (or savings) required in groundwater pumping capacity to make up for this change.

The agricultural economics evaluation is related to the assessments of water supply and water quality, land use, surface-water hydrology, regional economics, social well-being, groundwater hydrology, air quality, and geomorphology, soils, and seismicity.

MUNICIPAL AND INDUSTRIAL WATER SUPPLY ECONOMICS

CALFED actions could affect municipal and industrial (M&I) water costs and economics in the Bay-Delta region and in other regions that use water exported from the Delta for M&I purposes. These water users must plan water production and rate structures in response to changing water supplies and costs. In the long run, supply should meet demand and revenues should cover costs. During a drought, water providers may impose mandatory conservation and/or acquire temporary supplies. These interrelated issues can be considered using an economic model that accounts for water quantities, costs and revenues, and the response of water customers to changing water prices.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on M&I water supply:

- costs of water supply,
- costs of water shortage, and
- costs of treatment.

Water supply costs include surface-water supply and distribution, groundwater pumping costs, alternative water supplies and cost, water transfer costs, and the cost of providing infrastructure for water conveyance and distribution. These costs are related to the source of water. The assessment will be based on the assumption that providers must match increased costs with increased revenues. The Central Valley Production and Water Transfer Model (CVPWTM) will be used to calculate the cost and quantity of water transfers.

The assessment will identify the costs of providing alternative water supplies to replace supplies lost to water shortages. New supplies typically cost more than the supplies they replace; however, if the provider increases water prices to pay for more expensive new supplies, the increased prices will cause a proportional reduction in water demand by consumers. M&I economics could be affected by losses resulting from these higher water prices. During a drought, alternative supplies are purchased when conservation efforts are insufficient to accommodate the water shortage. The analysis must assume that water conservation will be practiced during a temporary water shortage caused by drought. The costs of conservation during drought include costs to implement the conservation measures, lost revenues from lowered water sales, and costs to consumers resulting from a lack of water at the existing price.

Water treatment costs can be influenced by the quality of the water supply . Poor-quality water can increase the cost of treatment and influence the price of water to consumers.

The M & I economics assessment method uses information on water demand, supplies, sales, water prices, costs of supply alternatives, conveyance, treatment and distribution costs, conservation, and characteristics of demand to estimate responses to changing water supply availability and costs. CALFED proposes to use the CVPWTM to estimate important changes in the cost of water supply

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ant treatment under different water delivery and water quality conditions. A representative water price for the baseline and existing-conditions analyses will be estimated for different regions. Demand data for each regional water provider will be based on DWR Bulletin 160-93, and supply data will be based on Bulletin 160-93 and results of hydrology models.

Table 3 provides a summary of methods that will be used in the analysis.

Table 3. Summary of Assessment Methods for Municipal and Industrial Water Supply Economics

Important Change	Assessment Methods	Model Type	Model Status	Previous Use	Input Required
Costs of water supply	Conveyance, treatment, and distribution costs	Change in costs calculated on the basis of supply source	Available	Impact analyses	Quantity of water supplies and their source
Cost of treatment	Treatment costs	Based on information from providers	Not a model -- input data	Impact analysis	Costs of treatment as a function of water quality
Cost of Shortage: Makeup Water	Fixed cost or increasing costs, depending on provider. Transfer costs from the CVPWTM	Cost functions estimated with regression, from 160-93 data, or from inference. Transfer cost functions based on agricultural economics.	Available	Impact analyses	Varies. Quantity desired, retail price, shortage levels
Cost of Shortage: Economic Costs to Water Customers	Consumer surplus loss	Economic demand functions	Available	Impact analyses	Initial demand and price, amount of shortage or price increase

The M&I economics assessment focuses on the cost of water supply and treatment under different water delivery and water quality conditions; therefore, information provided by the water quality and water supply analyses is essential. Results of the M&I analysis support evaluation of regional economics, social well-being, and land use changes as a result of growth.

FISH, WILDLIFE, AND RECREATION ECONOMICS

The assessment of fish, wildlife, and recreation economics effects will address the effects of changes in various activities associated with recreational resources including boating, fishing, wildlife viewing, and sport fishing. The assessment process will rely on tools that are specific to the particular types of recreation and geographic areas affected by CALFED, but will be flexible enough so that these tools can be applied to combined recreation-use changes within a geographic area.

Because CALFED actions could also affect fish populations, a commercial-fishing economics analysis will address the economic effects of changes in the ocean salmon populations on different areas along the California and Oregon coasts. Changes to commercial and recreational harvest regulations could also affect these economies.

Changes to the following variables will be evaluated to assess the impacts of CALFED alternatives on fish, wildlife, and recreation economics:

- recreation-related spending,
- recreation benefits,
- recreation employment and net income, and
- commercial-fishing harvest values.

Total recreation-related spending is sensitive to changes in recreation-use and opportunity levels and to changes in spending associated with each category of recreation. Recreationists spend money to travel, use recreation sites, and purchase recreation equipment and supplies. The level of spending depends on the level of use, the type of recreation in which users are engaged, and the location of recreation areas.

Recreation benefits are measured in terms of the monetary amount that recreationists would be willing to spend over and above actual expenditures to participate in recreation activities at affected facilities. Total levels of recreation benefits depend on recreation-use levels and opportunities, and the values recreationists place on different types of recreation activities and facilities.

Recreation-related spending generates employment and net income in the economic sectors directly affected by recreation-travel expenditures (e.g., grocery stores, hotels, and recreation service providers). (For the purposes of this assessment, net income is defined as proprietary income, or profit, for business owners.) Levels of employment and income generated by recreation-related spending depend on recreation-use levels and associated trip spending levels.

Commercial fishing harvest value, or harvest revenue, is the measure of gross income received by commercial fishers. Levels of harvest revenues depend on the size of the commercial harvest and the price paid for the harvest. CALFED actions could affect the commercial salmon harvest; therefore, this measure would focus on changes in the value of the commercial salmon harvest in coastal regions. The assessment will also evaluate commercial fishing employment and income, which depends on harvest levels and market prices for fish.

CALFED proposes to evaluate the relative differences in recreation-related spending, recreation employment and income, recreation benefits, and commercial fishing economics of each alternative. Recreation-related spending will be determined by estimating changes in total recreation use, expressed in visitor days, and determining the average dollars spent. It is assumed that CALFED actions would change recreation use but visitor spending would be similar to existing average spending. Direct employment and net income generated by recreation spending will be estimated using information from the micro-IMPLAN input-output model on the number of jobs and amount of income generated by recreation. The model will also be used to estimate indirect employment and income changes by region. Recreation benefits or value will be estimated based on information describing the demand for existing recreation use at affected areas, previous studies of benefits at affected areas, or values inferred from studies of similar areas. Changes in benefits will be estimated as a function of predicted changes in visitor days for each region multiplied by an average value per visitor day.

Commercial fishing economics is a result of the interaction between harvest levels, values (market prices), and costs of production. Commercial salmon harvest levels will be estimated for each region based on information concerning existing harvest levels, changes in ocean salmon population levels, and expected changes in operational costs resulting from changes in regulations. If estimates of changes in fish population levels are not available, CALFED staff will communicate with agency experts to make assumptions concerning salmon harvest levels under alternative actions. Harvest values (i.e., market prices) will be developed based on historical prices and applied to harvest levels to estimate total harvest value for commercial salmon harvests.

Direct changes in employment and net income generated within the commercial fishing industry will be estimated for each region using IMPLAN. The model will also be used to estimate changes in indirect employment and income within other industries/sections.

Information from the impact assessments for both recreation and fisheries resources will be needed for the assessment of effects on fish, wildlife, and recreation economics. The recreation impact assessment will provide estimates of recreation use by activity and region that will be used to estimate spending related to recreation travel. The fisheries impact assessment will provide information on how CALFED actions would affect ocean salmon population levels. Additionally, information from the fish, wildlife, and recreation economics assessment will be needed for the impact assessment on regional economics.

C-000687

REGIONAL ECONOMICS

Changes in regional economic conditions stem from changes in agricultural, recreation, and M&I economics. The assessment of regional economics will measure the effects of changes in various types of economic activities throughout several geographic regions. An economic model that considers these interrelationships will be used to assess the effects of CALFED alternatives on regional economics.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on regional economics:

- income,
- employment, and
- fiscal conditions.

For the purposes of this assessment, regional income is defined as proprietary income, or profit, for business owners. Total regional income includes agricultural income, recreation expenditure income, commercial fishing income, M&I water expenditures, and indirect income. Levels of regional income generated by these items depend on a variety of factors including water costs and deliveries and recreation-use levels.

Total regional employment for an area is provided by a variety of business sectors. Agricultural employment, recreation-related employment, commercial fishing employment, and indirect employment contribute to total regional employment and have the potential to be affected by CALFED actions.

Fiscal impacts of CALFED actions on local governments could include changes in revenues, expenditures, and public services. Property tax revenues, sales tax revenues, and public costs contribute to a local government's fiscal condition and have the potential to be affected by CALFED actions. Fiscal conditions also depend on various indirect effects including agricultural, municipal, and industrial water availability and cost.

The proposed method of assessing impacts on regional economics uses the IMPLAN input-output modeling software, which was developed for the U.S. Forest Service by the Minnesota IMPLAN Group. A series of geographic models will be developed to provide specific regional economic analyses under baseline and project conditions. The flexibility of the IMPLAN model make it an appropriate tool for analyzing both the direct and indirect regional economic impacts associated with CALFED actions.

Input from other CALFED analyses will be required for the assessment of regional economic effects. The assessment of impacts on agricultural economics; M&I water costs and economics; and fish, wildlife, and recreation economics will be used to estimate total regional economic changes within each region. Output from the regional economics assessment will be required for the assessment of impacts on social well-being.

Power Production and Energy

CALFED actions could affect power production and the availability of energy in the Bay-Delta region and northern and central California. Western Area Power Administration (Western) and Pacific Gas and Electric Company (PG&E) are the primary providers of energy to northern and central California power customers.

Changes in power production and energy are indicated by changes in project pumping requirements (project use) and reductions in the firm load-carrying capacity of the project (project capacity). As system water operations change, the timing and levels of electric production also vary, affecting providers' ability to meet their obligation to their customers.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on power production and energy:

- power-generating capacity,
- energy production, and
- Central Valley Project (CVP) restoration fund payments.

The level of capacity for meeting customer loads over a given period is a function of the level of energy available during that period. For capacity to be "firm", it must be available when needed, including during critical water conditions. Therefore, capacity levels will be modeled assuming a critical water year.

The output from the water facilities management and operations assessment model (DWRSIM or PROSIM) will be used to provide data for the PROSYM production-cost model. The PROSYM model is an hourly production-cost model that can be used to simulate the hour-to-hour operation of the CVP hydroelectric system. Both critical and average water conditions will be modeled for each alternative. For study purposes, the critical year will be defined as the year having the lowest July through December energy production for the CVP system over the 70-year hydrologic record. An average year will be simulated by determining monthly averages over the 70-year hydrologic record.

The detailed hourly hydro unit generation output of PROSYM provides information on the firm load-carrying capacity for each month (the monthly level of capacity that is supported by project energy and usable to meet daily load requirements). Results of the analysis will be used to estimate the gain or loss in capacity for each CALFED alternative. This process will be repeated for each month of the critical year to determine monthly changes in capacity.

An average-year scenario will be used to analyze the effects of CALFED alternatives on energy production. The CVP hydro system will be modeled in PROSYM using average-year capacity to determine changes in the ability to meet customer load. Because the price of energy changes hourly and depends on onpeak and offpeak demands, energy requirements to meet customer load will be divided into these two demand periods, and varying onpeak, offpeak, and seasonal energy prices will be used to determine consumption and sales.

The Central Valley Project Improvement Act (CVPIA) created the CVP Restoration Fund, which authorizes payment of up to $50 million annually for enhancement of CVP. Payment into the fund is allocated among power and water customers. To the extent that contributions to the restoration fund from water users are reduced as a result of reduced water deliveries, CVPIA stipulates that power customers increase their contributions to make up the difference. Any changes in water deliveries under CALFED would therefore affect power-provider fund payments. The agricultural, municipal, and industrial water deliveries and the rates stipulated in CVPIA for CVP Restoration Fund payments will be used to calculate changes in power-provider fund payments.

To estimate the net costs to power providers and customers, the cost of annual purchases and increased restoration will be subtracted from revenues from surplus capacity sales and monthly energy savings. These figures can be used to compare relative changes in power production economics between CALFED alternatives.

Power production and energy is directly related to other assessment topics, including surface-water hydrology, water facilities management and operations, recreation resources, and M&I economics. Output from the power production and energy economics assessment will be required to assess impacts on regional economics and air quality.

RECREATION RESOURCES

CALFED actions could affect recreation by changing waterway access, creating new recreation sources (e.g., by developing storage facilities), and changing the abundance of fish and wildlife important to recreation.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on recreation resources:

- recreation opportunities, and
- recreation use.

Recreation opportunities depend on the availability and condition of resources that may vary over time. These include access to waterways; reservoir surface area; riverflows; access to support facilities (boat ramps, marinas, campgrounds, etc.); and abundance of fish and wildlife. CALFED actions could affect boating opportunities in the Bay-Delta region by changing access to Delta sloughs, changing access to facilities such as marinas or boat launches, or affecting fishing and hunting activity by changing the abundance of sport fish and waterfowl. Factors contributing to recreation use include regional population and demographics, the demand for recreation resources, and recreation opportunities.

Both qualitative and quantitative methods can be used to assess changes in recreation opportunities. Where recreation opportunity thresholds (e.g., the reservoir level at which boat ramps become unusable) and necessary input data exist, they will be used to assess the effects of CALFED actions on recreation opportunities. In other areas, and for other activities, qualitative methods based on historical use data; availability and accessibility of recreation sites; and the abundance of fish, waterfowl, and support facilities (e.g., boat launches and marinas) will be used.

Methods for assessing changes in recreation opportunities include the following:

- Recreation opportunities within the Bay-Delta can be assessed qualitatively based on the availability and accessibility of recreation sites (e.g., Delta channels), the availability of support facilities (e.g., boat launches and marinas), and the abundance of fish or waterfowl.

- Recreation opportunities at rivers and existing reservoirs for which hydrologic modeling output would be available can be assessed quantitatively using "recreation opportunity thresholds", indicated by reservoir surface elevations or river flows that can be determined for individual recreation sites. Recreation opportunity thresholds (e.g, usable reservoir surface area, boat ramp availability) determine the frequency with which activities could be affected at each recreation area.

- Recreation opportunities at new facilities will be assessed through use of information on existing facilities with similar characteristics to predict opportunities at new facilities.

- Recreation opportunities at wildlife refuges, private hunting clubs, and coastal waters can be assessed qualitatively based on the abundance of fish or the abundance of waterfowl habitat.

The recreation-use assessment will focus on determining how annual recreation use at important recreational facilities could change under the CALFED alternatives. Recreation-use equations estimate recreation activity as a function of the environmental attributes of a recreation site (e.g., distance to population centers, fish and wildlife abundance, lake levels, water flows). Typically, these equations are based on historical recreation-use levels and environmental conditions. Existing recreation-use equations appropriate for assessment of effects of CALFED actions will be used to estimate the changes in annual recreation use under the CALFED alternatives.

Results from the assessment of effects on fisheries and aquatic resources and surface water hydrology will be required to assess effects on recreation . The fisheries analysis will provide information on how CALFED actions would affect sport-fish populations and will be used to estimate changes in sport-fishing levels at various recreation sites. The hydrology analysis will provide information on how CALFED actions would affect the availability of water for recreation resources in the study area.

Output from the recreation impact assessment will be required to assess impacts on fish, wildlife, and recreation economics. The recreation impact assessment will provide estimates of recreation use by activity and region and will be used to estimate recreation-related spending.

VISUAL RESOURCES

CALFED actions that could affect existing visual/aesthetic resources in the program region include alteration or modification of levees, construction of water storage and/or conveyance facilities, and habitat restoration activities. Changes in water storage and flow conditions may also affect visual conditions in recreation areas where water levels are a prominent visual characteristic (e.g., Shasta Lake). The process to assess visual/aesthetic resources in the CALFED region involves identifying important viewing locations, determining the quality of views, establishing the importance of views to people who visit the area, and determining the potential changes that could occur to viewed landscapes as a result of CALFED actions.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on visual resources:

- visual resource conditions (visual quality), and
- viewer response to those changes (viewer sensitivity).

Assessments of visual quality will be made relative to overall regional visual character. Viewer sensitivity will vary depending on the characteristics and preferences of the viewer group.

The visual quality of an area or view is formed by the combination of distinct landscape components, including topography, vegetation, wildlife, surface waters, and the artificial elements of the environment. Assessments of visual quality must be made with a regional frame of reference. The same landform or visual resource appearing in different geographic areas could have a different effect on the overall visual quality of the viewed landscape.

Viewer exposure refers to the location of viewer groups, the number of viewers, and the frequency and duration of views. Viewer sensitivity will vary depending on the characteristics and preferences of the viewer group. An assessment of viewer sensitivity can be made based on the extent of the public's concern for a particular landscape or for scenic quality in general.

The description and evaluation of visual/aesthetic resources in the CALFED study area involves the following steps:

- Identify the visual features or resources that compose and define the visual character of the landscapes.

- Assess the quality of the identified visual resources relative to overall regional visual character.

- Identify major viewer groups and describe viewer exposure.

- Identify the importance to people, or the viewer sensitivity, of views in the landscape.

These steps establish the existing or baseline conditions of visual resources within the area. This information will be used to identify areas of high, medium, and low visual quality and sensitivity in the program region. The benefits and adverse impacts of proposed CALFED alternatives on visual resources will be based on representative changes in visual quality of similar actions and regional visual quality information. Indirect effects of CALFED actions on visual resources may be more difficult to determine (e.g., changes in land uses that result from changes in water supply reliability). Indirect effects on visual resources would be described only briefly.

The visual resources assessment requires input from the assessment of changes in land uses, vegetation and wildlife including special-status species, and increases or decreases in recreation use at visually sensitive areas.

C-000695

CULTURAL RESOURCES

The effects of CALFED alternatives on cultural resources will be analyzed at a regional level. The cultural resources analysis will describe the potential for prehistoric and historic resources to occur in each geographic regions based on the presence of specific landforms such as channel deposits and floodplains. Cultural resources could be affected by CALFED actions such as construction of new facilities and habitat and levee improvements. The indirect effects of CALFED actions on cultural resources (e.g., development of facilities that result from changes in water supply reliability) may be more difficult to determine and will be described qualitatively. Once the precise location and size of alternatives have been defined at the end of Phase II, additional efforts will be required in Phase III to identify and evaluate both prehistoric and historic resources for compliance with the National Historic Preservation Act.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on cultural resources:

- risk to prehistoric sites, and
- risk to historic sites.

Related information to be measured includes the following:

- acreage of ground disturbance from construction activities anticipated in a given region,
- distribution of culturally sensitive landforms,
- locations of known historic or prehistoric sites, and
- association of historic and prehistoric sites with land conditions.

The cultural resources assessment, based on methods developed by the U.S. Bureau of Reclamation, will determine the risk to historic and prehistoric sites using the following steps:

- identify the probability of finding a site in a given area or region (based on known site information and estimated likelihood for various landforms or other geographic conditions),

- determine the general location and estimated extent of ground disturbance that would be associated with CALFED actions, and

- calculate the relative risk to known and unknown sites.

The proposed assessment methods are presented below for prehistoric sites in the Delta, historic sites in the Delta, and prehistoric and historic sites outside the Delta.

The general locations of CALFED actions in the Delta will be compared with information about landforms in those areas to determine the potential locations of and potential effects on prehistoric sites. The presence of prehistoric sites in the Delta region can be determined using selected landforms where prehistoric sites are typically located such as channel deposits, organic soils, and basins and basin rims. Information from the land use impact assessment will also be used to determine land use changes that could affect cultural resources.

For historic sites, there is not a strong relationship between landforms and historic site location in the Delta. Additional variables need to be examined to determine whether using a geographic-based system for analysis of historic site location is appropriate. The U.S. Bureau of Reclamation anticipates conducting records searches for historic sites in the Delta to determine whether geographic conditions can be used to estimate the likelihood of sites. Development of these assessment methods is continuing.

For areas outside the Delta, the location of known prehistoric and historic sites and the potential for locating new sites will be identified based on information gathered by the U.S. Bureau of Reclamation for Central Valley Project Improvement Act Programmatic Environmental Impact Statement.

C-000697

PUBLIC HEALTH AND ENVIRONMENTAL HAZARDS

The programmatic assessment for public health and environmental hazards is based on the predicted responses of disease vector and host populations and hazardous materials to CALFED actions. Mosquitos can transmit malaria and several types of encephalitis and can cause a substantial nuisance. Therefore, they are a public health concern. Other public health concerns include the transmission of Lyme disease by ticks, bubonic plague by fleas, rabies by wildlife and other animals, and the safety hazards and nuisance caused by midges. CALFED actions could affect public health by creating conditions favorable to an increase in vector populations and therefore an increase in the possibility of disease transmission by mosquito, tick, and wildlife.

Hazardous materials include both raw materials and products (e.g., fuels and oils) commonly used in commercial activities and during construction, and hazardous wastes from known and unknown sources. The assessment of hazardous materials is based on the potential for changes in exposure of people and the environment to these materials as a result of CALFED actions.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on public health and environmental hazards:

- area of mosquito breeding habitat,
- area of habitat that supports other disease vector populations,
- risk of contact between humans and vector populations, and
- risk of hazardous material and waste upset (construction and operation).

CALFED habitat restoration actions involve restoring acres of land to various habitat types. Changes in the acreage of habitats that serve as mosquito breeding habitat would require changes in the level of mosquito abatement needed for each CALFED alternative. Evaluation of mosquito breeding habitat, and habitat that supports other disease vector populations, would be conducted primarily using electronic databases of habitat-type distributions (see "Vegetation and Wildlife Including Special-Status Species").

The change in the risk of transmission of diseases by mosquitoes and other vectors (e.g., fleas) to humans under the CALFED alternatives will be assessed qualitatively based on predicted responses of vector and host populations to CALFED actions.

The assessment of the effects of CALFED actions on the relative risk of exposure of people and the environment to hazardous materials will be based on existing State, federal, and local regulations; emergency response plans; and other programs. The general geographic areas where hazardous materials or known hazardous waste sites are most likely to be encountered under a given alternative or action will be identified. The CALFED actions that could disturb areas and alter exposure to hazardous materials will be evaluated and the relative magnitude of the most important actions (i.e., construction and flooding) in areas where hazardous materials could be present will be compared to estimate the change in potential for exposure.

Public health assessment variables and methods are directly related to the assessment of impacts on habitats that support disease-vector populations and are used for recreation. These are discussed in the section on vegetation and wildlife and special-status species.

The assessment of impacts from hazardous materials is directly related to the assessment of impacts on water quality, aquatic wildlife, and aquatic habitats because of the relationship between the exposure to these materials and water quality and the subsequent effects on wildlife and habitat as a result of exposure. Information from the land use assessment will be used to determine areas of potential disturbance.

UTILITIES AND PUBLIC SERVICES

CALFED actions have the potential to affect utilities and public services in the Delta, San Joaquin and Sacramento Valleys, upstream areas of rivers tributary to the Delta areas, and the CVP and SWP delivery areas. CALFED actions could directly affect utility infrastructure by constructing water-related facilities that could require new or modified electrical services and lines and changing water operations that could affect flows in deepwater ship channels, and could indirectly affect public services by creating opportunities for M&I development or changes recreational uses that require emergency services. Economic growth stimulated by CALFED actions could also result in indirect demands for utilities and public services resulting from land use changes to support growing communities. The utilities and public services analysis will describe overall changes that result from implementing CALFED actions.

Changes to the following variables will be evaluated to assess the impacts of CALFED alternatives on utilities and public services:

- electrical facilities and supply;
- water conveyance facilities;
- natural gas fields and storage reservoirs;
- underground pipelines;
- transportation infrastructure (roads, railroads, bridges, ferries);
- deepwater ship channels and shipping ports;
- communication facilities; and
- police, fire, and emergency services.

Impacts of CALFED alternatives on utility infrastructure will be estimated by comparing the spacial distribution of existing infrastructure to areas of potential construction or land use changes that would result in displacement or modification of the existing infrastructure. The assessment of changes in utilities and services may depend on related resource analyses. For example, results from the water management and operations assessment using DWRSIM could provide estimates of changes in flows that affect viability of deepwater ship channels, and changes in recreation use levels will influence police and emergency service demands. Methods used to address changes in hydroelectric power supply are addressed in the section entitled "Power Production Economics" and the value of in-Delta utility infrastructure (e.g., natural gas fields, transportation infrastructure, etc.) will be used in the evaluation of flood damage as described in the "Flood Control" section.

Where applicable, information from the regional economics and demographics assessment will be used to determine the effects of regional growth on utilities and public infrastructure. Regional changes in utilities and services demands will be assessed qualitatively based on land use changes that result from population and economic growth in those areas affected by changes in water deliveries.

The analysis of utilities and public services are closely related to other resource assessments and methods including those for land use, power production economics, water facilities and operations, recreation resources, regional economics, and flood control. Results of the utilities and public services assessment will also support analysis of impacts on flood control, visual conditions, and traffic and navigation.

C-000701

SOCIAL WELL-BEING

The assessment of social well-being will address the ability of people to cope with changes in economic and demographic conditions that may arise as a result of a CALFED action. Applicable assessment methods would incorporate economic and demographic data from other CALFED impact assessments and information collected from interviews with experts.

Changes to the following variables will be evaluated to assesss the impacts of the CALFED alternatives on social well-being:

- community stability, and
- environmental justice.

Community economic and demographic profiles will be developed for representative communities or social groups that could be affected by CALFED actions, and to evaluate community stability. Demographic data are varied and provide a range of community information including income profiles, employment rates, population growth rates, and ethnicity composition. This data will be used to determine how CALFED actions and their direct or indirect results would affect various social groups or populations within a community. Economic and demographic information will be obtained from government agencies, including the U. S. Census Bureau and the California Department of Finance, and additional input would be obtained from interviews with appropriate social groups, public agencies, and other institutions.

CALFED actions could affect the stability of a community by altering its demographics, such as ethnic composition. Significant population or economic changes could bring about either more or less ethnic diversity in a community. Economic or demographic changes could also affect a community's ability to provide appropriate levels of public services (e.g., education and housing) to its members. The magnitude of this impact is also a function of the existing capacity of the community to provide these services.

Economic impacts may not be distributed equally among the various communities within the proposed study area. Social impacts could vary significantly, depending on whether the impacts are concentrated and whether the community is almost entirely dependent on one particular industry (i.e., agriculture). Similarly, economic impacts may not be distributed equally among social groups (e.g., minority, low-income) within particular communities. An environmental justice analysis will be used to identify the potential for project alternatives to have disproportionately high and adverse impacts on specific communities or on specific social or cultural groups.

The proposed assessment method for the social well-being analysis will draw on information developed as part of the regional economics analysis. Demographic information (i.e., ethnicity, age structure, poverty rates, etc.) will be collected for representative communities with the potential to be affected by CALFED actions. The information, together with regional economic information (employment, income, fiscal conditions), will serve as the foundation for the development of economic and demographic community profiles. Interviews will also be conducted within various representative communities to help assess CALFED-related effects on various social groups, agencies that provide public services, and other institutions within each community. Compilation and use of this information would provide the tools necessary to evaluate social impacts associated with CALFED actions.

As discussed above, information from the regional economics and demographics analyses will be required to assess effects on social well-being. This information will include, but is not limited to, estimates of employment, income, and fiscal revenues; unemployment rates; population growth rates; ethnic composition; and poverty rates. This information will be necessary to develop the community economic and demographic profiles that could be affected by CALFED actions.