4.5 Groundwater

Affected Environment

The Restoration Project area is located within four separate groundwater basins as delineated by DWR (DWR 2003). The four basins are the Modoc Plateau Pleistocene Volcanic Area Basin, the North Fork Battle Creek Basin, the Sacramento Valley Eastside Basin, and the Redding Basin. The Redding Basin is divided into two subbasins: the South Battle Creek Subbasin and the Millville Subbasin. The following sections describe the North Fork Battle Creek and Redding Basins in detail. DWR has not described the Modoc Plateau Pleistocene Volcanic Area Basin and the Sacramento Valley Eastside Basin in detail at the time of this report.

North Fork Battle Creek Basin

Water-bearing formations in the North Fork Battle Creek Basin include the Quaternary alluvium and underlying volcanic rocks. Alluvium is approximately 32 feet thick overlying a succession of volcanic rocks (DWR 2003). The volcanic rocks are composed of two 10- to 40-foot thick flows, which are separated by a 40- to 80-foot section of sand, gravel, ash, and cinders. DWR (2003) indicates that the interbedded sand-gravel-ash-cinder strata is the primary groundwater source in the area.

Redding Basin

South Battle Creek Subbasin

The South Battle Creek Subbasin is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include younger alluvium and the Pleistocene Modesto Formation. The Tertiary deposits include the Tuscan Formation and possibly the Tehama Formation along the Sacramento River. The Tuscan Formation is the primary water-bearing unit in the subbasin. The Tehama Formation may extend beyond the Sacramento River. The following descriptions are from DWR (2003). The Tehama Formation is described in the Millville Subbasin section.

Holocene Alluvium

The Holocene alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These deposits are found along the Sacramento River. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer.

Pleistocene Modesto Formation

The Modesto Formation consists of terrace deposits containing poorly consolidated gravel with some sand and silt. These deposits are found along Inks Creek, Battle Creek, and the Sacramento River. The thickness varies by up to 50 feet. The sediments are moderately to highly permeable and can yield limited domestic water supplies.

Pliocene Tuscan Formation

The Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers, and is the principal water-bearing formation in the subbasin. Generally, the formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Unit A is the oldest water-bearing unit of the formation and is characterized by the presence of metamorphic clasts within interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone.

Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. Coarse cobble-to-boulder conglomerate predominates in the eastern and northern parts of mapped unit. This portion of the formation is approximately 430 feet thick.

Unit C is the primary surficial deposit in the subbasin and consists of several massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. The thickness of Unit C exposed in the vicinity of Tuscan Springs and Tuscan Buttes ranges from 165 to 265 feet.

Unit D consists of fragmental deposits characterized by large monolithologic masses of andesite, pumice, and fragments of black obsidian in a mudstone matrix. The deposit varies in thickness from 30 to 160 feet. The total thickness of the Tuscan Formation ranges from approximately 750 feet in the northeastern extents of the subbasin to 2,400 feet at the Sacramento River (DWR 2003).

Millville Subbasin

The Millville Subbasin aquifer system is comprised of continental deposits of late Tertiary to Quaternary age. The Quaternary deposits include Holocene alluvium and the Pleistocene Modesto and Riverbank Formations. The Tertiary deposits include the Pliocene Tehama Formation along the Sacramento River and the Tuscan Formation; the latter is the primary water-bearing unit in the subbasin. The following descriptions of water-bearing formations are from DWR (2003).

Holocene Alluvium

The alluvium consists of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. These alluvial deposits are found along stream and river channels. The thickness ranges up to 30 feet. This unit represents the perched water table and the upper part of the unconfined zone of the aquifer. Although the alluvium is moderately permeable, it is not a significant contributor to groundwater usage due to its geomorphic distribution.

Pleistocene Modesto and Riverbank Formations

The Modesto and Riverbank formations consist of poorly consolidated gravel with some sand and silt deposited during the Pleistocene. The formations are usually found as terrace deposits near the surface along the Sacramento River and its tributaries. The thickness ranges up to 50 feet. They are moderately to highly permeable and can yield limited domestic water supplies.

Pliocene Tehama Formation

The Tehama Formation consists of locally cemented silts, sand, gravel, and clay of fluviatile origin derived from the Klamath Mountains and Coast Ranges. The permeability of the formation is moderate to high with yields of 100 to 1,000 gallons per minute (gpm).

Pliocene Tuscan Formation

The Tuscan Formation is composed of a series of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash layers, and is the principal water-bearing formation in the subbasin. The formation is described as four separate but lithologically similar units, Units A through D (with Unit A being the oldest), which in some areas are separated by layers of thin tuff or ash units.

Occurrence and Movement of Groundwater

As mentioned previously, the Tuscan Formation is an important aquifer in the northeastern part of the Sacramento Valley and yields large quantities of fresh water. The aquifer is not a distinct, single geologic unit; rather, it contains water in fractured basalt flows, volcanic pipes, tuff beds, rubble zones, and interbedded sand layers. These water-bearing zones have little surface expression and typically must be located by exploratory drilling (Planert and Williams 1995). Perhaps of greater importance to the Restoration Project is a shallow, discontinuous, unconfined aquifer system comprised of volcanic and sedimentary (primarily alluvial) deposits that overlays the Tuscan Formation. As described above, these shallow deposits contain appreciable amounts of freshwater and are a major source of late spring to early fall baseflow for Battle Creek. Depth to groundwater is variable.

In the northern part of the Sacramento Valley, groundwater flows away from the Valley walls then generally southwestward. Recharge is from the Cascade Range geomorphic province, and groundwater is discharged to the Sacramento River or moves into the Butte Basin south of Chico. Most of the streams entering the Sacramento Valley are losing streams (i.e., they lose a portion of their flow to groundwater aquifer recharge), at least over part of their courses, and much of the groundwater recharge is from this source (Hull 1984). Battle Creek, because it cuts through volcanic and sedimentary deposits that contain fresh groundwater, is predominantly a gaining stream (i.e., it gains flow from groundwater discharge).

Groundwater Quality

The chemistry of groundwater in the Sacramento Valley is greatly influenced by the chemistry of the recharge areas along the Valley margins. The chemistry of groundwater in the Restoration Project reflects the low concentrations of dissolved solids carried by recharge from the Cascade Range, having low mean concentrations of magnesium, sodium, bicarbonate, sulfate, and chloride. Silica concentrations are high as a result of the solution of volcanic glass. The groundwater in the region has relatively high average nitrate-nitrogen concentrations (Hull 1984). Alkali feldspars and halloysite appear to be the most significant aluminosilicate minerals affecting water chemistry. Table 4.5-1 presents the mean, minimum, and maximum chemical concentrations for groundwater in Shasta and Tehama Counties. The distribution of chemical constituents in the groundwater is very similar to the distribution in surface streams draining into the valley (Hull 1984). The average groundwater temperature in the Sacramento Valley is 68^{o}F (Hull 1984).

Table 4.5-1. Groundwater Quality from Wells in Shasta and Tehama Counties

Constituent	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)
Dissolved solids	231	137	571
Calcium	26	14	75
Magnesium	19	9.1	60
Sodium	14	3.9	68
Potassium	1.3	0.3	5.9
Bicarbonate	170	98	400
Sulfate	8.1	0.0	71
Chloride	6.5	0.9	97
Fluoride	0.11	0.1	0.3
Nitrate-nitrogen	2.7	0.2	27
Phosphate	0.05	0.0	0.31
Silica	51	35	67
Iron	4.8	0	170
Manganese	3.4	0	10
Arsenic	1.2	0	4
Boron	0.066	0	1.50

Source: Hull 1984
mg/L = milligrams per liter

The EPA's Storage and Retrieval Water and Biological Monitoring Data database was accessed for information on wells in the area surrounding and including the Restoration Project; however, it did not contain any such information.

Regulatory Setting

The following laws, regulations, or policies relate to land use within the Restoration Project:

- SWRCB Resolution No. 68-16, Statement of Policy with Respect to Maintaining High Quality of Water in California, generally restricts dischargers from reducing the water quality of surface water and groundwater.
- SWRCB Resolution No. 88-63, Sources of Drinking Water Policy, specifies that all groundwaters in California are to be protected as existing or potential sources of municipal and domestic supply.
- The Porter-Cologne Water Quality Control Act (Water Code §13000 *et seq*.) establishes the SWRCB and each Regional Water Quality Control Board as the state agencies for having primary responsibility in coordinating and controlling water quality in California.
- The Water Quality Control Plan for the Sacramento and San Joaquin River Basins consists of a designation or establishment for the water within the Sacramento and San Joaquin River Basins of beneficial uses to be protected, water quality objectives to protect those uses, and a program of implementation needed for achieving the objectives.
- The Shasta County General Plan (Shasta County 1998) contains a policy objective to protect surface and groundwater resources so that all present and future Shasta County residents have a reasonable assurance that an adequate quantity and quality of water exists.
- The Tehama County General Plan (Tehama County Community Development Group 1983) contains policies to preserve groundwater recharge areas identified on Plan Land Use Maps and to prevent water pollution from point and non-point sources.
- The Groundwater Management Act, commonly referred to as AB 3030, was signed into law on September 26, 1992, and became effective on January 1, 1993. The legislation is designed to provide local public agencies with increased management authority over groundwater resources in addition to those existing groundwater management capabilities. AB 3030 was developed in response to EPA's Comprehensive State Groundwater Protection Programs.

Environmental Consequences

Summary

No significant groundwater impacts are associated with the No Action Alternative. The potential for inadvertent hazardous materials spills during construction of the Action Alternatives (Five Dam Removal, No Dam Removal, Six Dam Removal, and Three Dam Removal) could result in significant localized groundwater effects. Groundwater in the Restoration Project area would not be affected by operation of the Restoration Project.

Impact Significance Criteria

For this analysis, impacts would be considered significant if implementation of the Restoration Project would:

- Violate any water quality standards or waste discharge requirements as discussed in the Regulatory Setting.
- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted).

Impact Assessment

As applicable, the General Environmental Protection Measures listed in the introduction to this chapter shall be utilized for this resource.

No Action Alternative

The No Action Alternative would not affect groundwater. Under this alternative, groundwater conditions in the Restoration Project would continue as they have historically, and there would be no impact to groundwater resources.

Five Dam Removal Alternative (Proposed Action)

Impact 4.5-1 Significant—Potential spills of hazardous materials could occur and contaminate the shallow groundwater system.
Any dewatering necessary for construction activities for the Five Dam Removal Alternative may result in inadvertent spills of hazardous materials that, if not

attended to, could contaminate the shallow groundwater system. Project construction could result in inadvertent spills of hazardous materials used in standard construction practices. Construction would require the transport and use of potentially hazardous materials, such as gasoline, diesel fuel, concrete, cement, industrial chemicals, and other hazardous chemicals. Implementing the following mitigation measure would reduce this significant impact to a less-than-significant level.

Mitigation Measure for Impact 4.5-1. To avoid or minimize potential impacts to the shallow groundwater system related to potentially hazardous spills, Reclamation will implement the following measures:

- Reclamation will develop a spill prevention control and countermeasures plan in coordination with the CVRWQCB through the Section 401, Clean Water Act, permitting process in obtaining approval for the Restoration Project.
- Soils contaminated with fuels or chemicals will be disposed of in a suitable location to prevent discharge to surface waters.
- Temporary cofferdams with culverts will be used to divert flowing waters around construction areas.
- On-site fuels and toxic materials will be placed or contained in an area protected from direct runoff.
- If hazardous materials are released, the Coleman National Fish Hatchery will be immediately notified.
- Cement and concrete delivery and transfer equipment will be washed in contained areas protected from direct runoff until the material sets.

Implementation of the spill prevention control and countermeasures plan would reduce impacts resulting from potential spills of hazardous materials to a less-than-significant level.

No Dam Removal Alternative

Impact 4.5-2 Significant—Potential spills of hazardous materials could occur and contaminate the shallow groundwater system.

Any dewatering necessary for construction activities for the No Dam Removal Alternative may result in inadvertent spills of hazardous materials that, if not attended to, could contaminate the shallow groundwater system. Project construction could result in inadvertent spills of hazardous materials used in standard construction practices. Construction would require the transport and use of potentially hazardous materials, such as gasoline, diesel fuel, concrete, cement, industrial chemicals, and other hazardous chemicals. This impact is similar to Impact 4.5-1 described under the Five Dam Removal Alternative. Implementing the mitigation measures for Impact 4.5-1 would reduce this significant impact to a less-than-significant level.

Six Dam Removal Alternative

Impact 4.5-3 Significant—Potential spills of hazardous materials could occur and contaminate the shallow groundwater system.
Any dewatering necessary for construction activities for the Six Dam Removal Alternative may result in inadvertent spills of hazardous materials that, if not attended to, could contaminate the shallow groundwater system. Project construction could result in inadvertent spills of hazardous materials used in standard construction practices. Construction would require the transport and use of potentially hazardous materials, such as gasoline, diesel fuel, concrete, cement, industrial chemicals, and other hazardous chemicals. This impact is similar to Impact 4.5-1 described under the Five Dam Removal Alternative. Implementing the mitigation measures for Impact 4.5-1 would reduce this significant impact to a less-than-significant level.

Three Dam Removal Alternative

Impact 4.5-4 Significant—Potential spills of hazardous materials could occur and contaminate the shallow groundwater system.
Any dewatering necessary for construction activities for the Three Dam Removal Alternative may result in inadvertent spills of hazardous materials that, if not attended to, could contaminate the shallow groundwater system. Project construction could result in inadvertent spills of hazardous materials used in standard construction practices. Construction would require the transport and use of potentially hazardous materials, such as gasoline, diesel fuel, concrete, cement, industrial chemicals, and other hazardous chemicals. This impact is similar to Impact 4.5-1 described under the Five Dam Removal Alternative. Implementing the mitigation measures for Impact 4.5-1 would reduce this significant impact to a less-than-significant level.

Cumulative Impacts

Cumulative groundwater impacts associated with the Proposed Action and past, present, or probable future projects would not occur in the Battle Creek watershed because no other projects that could affect groundwater availability are proposed within the Battle Creek watershed (including those projects mentioned in Chapter 6, “Related Projects”).