Figure 14. Central and southern California withdraw far more ground water than most of the rest of the areas in Segment 1.

EXPLANATION

Fresh ground-water withdrawal during 1965, in million gallons per day

- 0 to 5
- 5 to 10
- 10 to 20
- 20 to 50
- 50 to 200
- Greater than 200

Figure 11. The aquifers in Segment I have been grouped into three major systems: aquifer, aquitard, and aquiclude. Although the boundaries between these three systems are fixed, their boundaries may change in response to land use, geology, and climate.

SW Aquifer Systems
Figure 15. Water use in the Central Valley aquifer system of California is more than that of the other Segment 1 aquifers combined and far more than that of any other single aquifer system in the United States.
Figure 16. The Basin and Range aquifers extend through parts of seven States. In Segment 1 they underlie most of Nevada and a large part of southeastern California. This area is characterized by internally drained basins, except for small parts that drain to the Colorado and the Columbia Rivers.

Figure 9. The alternating valleys and low mountain ranges of Nevada contrast sharply with the high, rugged California mountain ranges that surround the low-lying Central Valley.
Figure 23. Four types of basins have been identified in the Basin and Range area and are classified on the basis of differences in ground-water flow.

EXPLANATION
- Basin-fill deposits
- Playa that receives ground-water discharge
- Playa
- Playa playa—Playa with lakes that are fed by water table
- Low-permeability bedrock
- Permeable bedrock
- Direction of ground-water movement
- Fault—Arrows show relative vertical movement

Figure 24. A diagrammatic hydrogeologic section of a basin shows the interlayering of fine and coarse sediments from the edge to the center. Although the coarsest materials are at the edge of the basin, extreme depth to groundwater may prevent efficient water-supply development.

EXPLANATION
- Gravel
- Sand
- Clay
- Clay, silt, and evaporites deposited in a lake or on a playa
- Low-permeability bedrock

Figure 69. Agriculture (primarily irrigation) is by far the greatest use of ground water withdrawn from the Basin and Range aquifers.

EXPLANATION

Use of fresh ground-water withdrawals during 1985, in percent

- Public supply: 17.7%
- Domestic and commercial: 1.4%
- Agricultural: 76.8%
- Industrial, mining, and thermoelectric power: 4.1%

Total withdrawals: 1.670 million gallons per day


Figure 70. Dissolved solids concentrations in water from the unconfined basin fill aquifers generally increase from the basin borders, where the aquifers are recharged by the influx of water from the mountains, to the center of the basins, where evaporation concentrates the minerals dissolved in the ground water.

EXPLANATION

Estimated solids concentration in water from the unconfined aquifers, in milligrams per liter

- < 500
- 500 - 1,000
- 1,000 - 5,000
- > 5,000

Basin fill aquifer absent
Figure 27. Most of the coarse-grained sediments that fill Antelope Valley were deposited during episodic periods of flash flooding that followed intense precipitation. A lacustrine clay confining unit separates the sediments into two aquifers.

Figure 28. A generalized diagram of the block-fault system of Antelope Valley, Calif., shows the mountain ranges that border the basin-fill sediments and the probable pattern of faulting. The view is to the northwest.
Figure 30. The predevelopment potentiometric surface for the principal aquifer in 1915 shows that the general pattern of ground-water movement was from the edges of the basin to the playa at Rosamond Lake. Water levels in the aquifer can be several hundred feet different on opposite sides of faults such as the Randsburg-Joyave Fault.

EXPLANATION

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20--- Potentiometric contour—Shows altitude at which water level would have stood in unsealed wells in 1915. Interpolate 20 and 100 feet. Datum at sea level.

--- Principal aquifer boundary—Location approximately.

--- Direction of ground-water movement.

Figure 31. The potentiometric surface for the principal aquifer in 1961 showed the effects of development. The pattern of ground-water movement changed from predevelopment conditions, and much of the ground water flowed toward two depressions in the potentiometric surface, which are centered around withdrawal sites south and west of Rosamond Lake.

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**Explanation**

- Potentiometric contour — Shows attitude at which water level would have stood in highly closed wells in 1915. Interval 20 and 100 feet. Datum is sea level.
- Principal aquifer boundary — Location approximate.
- Direction of ground-water movement


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Figure 32. Estimated withdrawals from 1915 to 1975 for the principal aquifer in Antelope Valley ranged from zero during 1915 to a maximum of over 400,000 acre-feet per year during 1950, compared to average annual runoff of 40,700 acre-feet that entered the valley. Withdrawals in excess of recharge resulted in water-level declines, which required a reduction in withdrawals after 1950.

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Fissures from subsidence of Rogers Lake Bed in Antelope Valley

How Much do we need?

WATER SUPPLY
AVERAGE WATER YEAR
Antelope Valley Integrated Regional Water Management Plan (May 2007)

2035 Demand = 400,000 AFY
2035 Supplies = 236,500 AFY
MISMATCH = 163,500 AFY
Water Supplies and Demands, SJV Portion of Kern

Figure 4.1. Withdrawals rates from the central valley aquifer system are greatest in the San Joaquin Valley during years of lower normal precipitation (A) and less than normal precipitation (B). Decreased recharge and reduced surface-water supplies in dry years result in increased ground-water withdrawals, as in 1977.

EXPLANATION
Estimated annual withdrawals, in acre-feet per acre:

A. 1975, more normal precipitation
B. 1977, less than normal precipitation

Figure 74. The Central Valley is a large structural trough that has been partially filled by marine sediments and continental deposits. The Sierra Nevada, which forms most of the eastern boundary of the valley, is the edge of a huge tilted granite block. The Coast Ranges, which form most of the western boundary, consist, for the most part, of folded and faulted marine rocks.

EXPLANATION
- Continental deposits
- Marine sediments
- Crystalline rock

Flows—arrows show relative direction of movement.


Figure 71. The Central Valley aquifer system is located in a large structural trough in central California. The aquifer system is divided into three subregions on the basis of surface-water basins.

EXPLANATION
- Central Valley
- Redding Basin—includes the Northern California basin-fill aquifers

Central Valley aquifer system subregions
- Sacramento Valley
- Sacramento—San Joaquin Delta
- San Joaquin Valley

Tuolumne Basin
- Central Valley drainage basin boundary

Figure 91. Ground-water withdrawals from the Central Valley aquifer system were about 37 percent of total freshwater withdrawals during 1965.

EXPLANATION

Percentage of freshwater withdrawn during 1965

- 36.7% Ground water
- 53.3% Surface water


Figure 92. Agricultural irrigation is by far the major ground-water use in the Central Valley (A). More ground water is withdrawn in the Tulare Basin than elsewhere (B), because the basin is the driest area of the valley.

EXPLANATION

Use of fresh ground-water withdrawals during 1965, in percent

- 53.6% Public supply
- 0.5% Domestic and commercial
- 46.4% Agricultural
- 0.5% Industrial, mining, and thermo-electric power

Data from U.S. Geological Survey.

Figure 93. The Central Valley is a large structural basin that has been partially filled by marine sediments and continental deposits. The Sierra Nevada, which forms most of the eastern boundary of the valley, is the edge of a large tilted granite block. The Coast Ranges, which form most of the western boundary, consist for the most part of folded and faulted marine rocks.

EXPLANATION

- Continental deposits
- Marine sediments
- Crystalline rock

Figure 76. Continental sediments form the Central Valley aquifer system. These sediments average 2,500 feet in thickness but are more than 9,000 feet thick in the Tulare Basin.

**EXPLANATION**

Thickness of continental deposits, in feet

- 1,000
- 3,000
- 5,000
- 7,000
- 9,000

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Line of equal thickness of continental deposits—Interval 1,000 feet


Figure 78. According to early concepts of the aquifer system (A), it was generally considered to be unconfined in the Sacramento Valley and confined where the Corcoran Clay Member of the Tulare Formation, or “E-clay,” is present in the San Joaquin Valley. However, recent studies suggest that the entire aquifer system is a single heterogeneous system (B) in which vertically and horizontally scattered lenses of fine-grained materials provide increasing confinement with depth.

**EXPLANATION**

Coarse-grained materials

Fine-grained materials

precipitation amounts are much greater on the western slopes

Figure 73. Nearly all the recharge received by the Central Valley aquifer system is provided by runoff from the mountains that surround the Central Valley.

EXPLANATION

Average annual runoff (1951-80), in inches

- Central Valley drainage
  basin boundary

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Figure 79. Under unstressed, pre-development conditions, groundwater in the upper part of the Central Valley aquifer system flowed from upland recharge areas at the valley margins to discharge areas, such as rivers, lakes, and marshes on the valley floor.

EXPLANATION

Water-table contour—Shows altitude of water table. Heights indicate depression. Contour interval, in feet, is variable. Datum is sea level.

Direction of ground-water movement

Figure 80. Before development, most of the recharge to the Central Valley aquifer system was from rain and snowmelt in the mountains at the valley margins, and discharge was to rivers and marshes near the valley axis.

EXPLANATION

Recharge area
Discharge area

Figure 81. A diagrammatic hydrogeologic section shows that before development, water that recharged the aquifer at the valley margins moved downward and laterally into the aquifer system and then moved upward to discharge at rivers and marshes at the valley axis.

![Diagram](image)

**EXPLANATION**

- Sandy unconsolidated deposits of continental origin
- Clay loess
- Clays oxidized to associated deposits of marine origin
- Bedrock of Sierra Nevada
- Dewatering of water-saturated, lower permeability material


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Figure 82. Ground-water withdrawals from 1860 to the 1960's caused water levels in the confined part of the aquifer system to decline over most of the Central Valley, in some areas more than 400 feet.

![Diagram](image)

**EXPLANATION**

Hydraulic-head change in the lower confined aquifer (1860-1961), in feet: + rise, - decline

- 10 to 0
- 0 to -40
- -40 to -80
- -80 to -120
- -120 to -200
- -200 to -300
- -300 to -400
- Greater than -400

Figure 83. Agricultural use of ground water from the late 1800s to the 1960s dramatically altered the ground-water flow pattern in the Central Valley aquifer system. Water in the deep confined parts of the aquifer system once flowed toward surface water bodies in the center of the valley, but now discharges in large part at pumping centers, notably those in the western and southern parts of the San Joaquin Valley.

Figure 86. As a result of increased surface-water importation during the 1960s and 1970s, ground-water withdrawals were reduced and water levels rose in the deep confined aquifer in many areas from 1961 to 1976. However, declines continued in the southern part of the San Joaquin Valley.
Figure 93. Land subsidence has affected large areas of the Central Valley. Most of the subsidence is the result of compaction of fine-grained sediments, which has been caused by large withdrawals of groundwater.

EXPLANATION

- Subsidence due to water-level decline is more than 1 foot
- Extent of subsidence due to compaction of peat
- Extent of subsidence due to hydrocompaction


Figure 94. Some of the most severe recorded land subsidence in history occurred in the western San Joaquin Valley near Mendota, where the land surface has subsided nearly 30 feet.
Figure 98. The thickness of the Central Valley aquifer system that is saturated with freshwater is greatest in the San Joaquin Valley, where freshwater extends to a depth of more than 4,000 feet below land surface.

Figure 99. Ground water in most of the confined aquifers is fresh; however, in some areas of the southwestern San Joaquin Valley, the water has large concentrations of dissolved solids.

EXPLANATION

Dissolved solids concentration, in milligrams per liter

- 200
- 500
- 1,500
- No data

Figure 100. Evapotranspiration of recirculated irrigation water increases the dissolved-solids concentration, and the water may become too saline for salt-intolerant crops. Salinity is a problem in many localities, and the potential for crop losses exists over most of the southern two-thirds of the Central Valley.

EXPLANATION

Area subject to saline irrigation return flow

Figure 101. Although the quality of the water in the Central Valley aquifer system is generally suitable for agricultural, industrial, and public-supply uses, some areas have potential or actual problems. Boron levels that are damaging to some crops in the Sacramnto and the San Joaquin valleys, nitrate levels that might be damaging to crops or that exceed drinking-water standards are in the Sacramento Valley, selenium levels that exceed drinking-water standards are in three wells in the Sacramento Valley, potentially toxic levels of heavy metals are in the western part of the San Joaquin Valley, and the pesticide dimethoate is present in several wells detected throughout the San Joaquin Valley.

**EXPLANATION**

Area affected by excessive concentrations of:

- **Boron**
- **Nitrate**
- **Selenium**
- **Selenium, mercury, chromium, and boron**
- **Dichloromethane (DCE)**


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Figure 102. The California Coastal Basin aquifers occupy a number of basins in coastal areas of California. These basins are in structural depressions filled with marine and alluvial sediments. Nearly all of the large population centers in California are located in the coastal basins and the available ground water is used primarily for municipal supplies.
Figure 103. The valleys that contain the Coastal Basins aquifers are formed by structural troughs that are typically filled with thousands of feet of marine and continental sediments. In the majority of the valleys, the natural groundwater flow follows the axis of the trough. Recharge to the aquifers is mostly by precipitation that runs off from the surrounding mountains and infiltrates as leakage through streambeds; some recharge is from rain that falls directly on the valley floor.

Figure 116. The Salinas Valley is the largest of California’s coastal basins.

EXPLANATION
- Unconsolidated continental deposits of permeable sand and gravel
- Impermeable clay
- Impermeable igneous and metamorphic rocks
- Faults - Arrows show relative vertical movement
- Direction of groundwater movement

Figure 118. Deposits in the basin are semiconsolidated and unconsolidated. The aquifer system is contained almost entirely in the unconsolidated deposits and is bounded by consolidated rocks.

EXPLANATION
- Salinas Valley aquifer— Unconsolidated continental deposits
- Surface-water drainage boundary
- Fault—Decayed where approximately located


Figure 121. Groundwater flow in the Salinas Valley is generally in the same direction as surface-water flow. Under natural conditions, freshwater would flow to Monterey Bay, but large withdrawals in the lower basin have changed the freshwater gradient from seaward to landward, which has resulted in seawater intrusion near the coast.

EXPLANATION
- Area where water table is below sea level
- Water table location—Shows relative height of water table in selected aquifer (drilled wells approximately located. Contour interval, 0.5 ft, or multiples. Broken area indicates direction of groundwater movement
- Fault

Figure 122. Ground-water quality in the Salinas Valley is suitable for most purposes except locally. East of the Salinas River in the northern part of the valley, industrial contamination limits ground-water use, and large-scale withdrawals have resulted in seawater intrusion. Contamination by sulfate in the San Lorenzo Creek and Salinas River area and by boron and arsenic in the Bitterwater area is natural.


Figure 123. The Los Angeles–Orange County coastal plain aquifer system is located in southern California, and occupies most of coastal Los Angeles and Orange Counties.

EXPLANATION

Los Angeles–Orange County coastal plain aquifer system


Figure 126. A diagrammatic hydrogeologic section shows that the aquifer system consists of alternating beds of permeable sediments, which are primarily sand and gravel, and beds of less permeable sediments, such as clay and silt. Structural features, such as anticlines, are common in the basin and affect ground-water movement.

EXPLANATION

- **Principal aquifer**—Unconsolidated sand and gravel
- **Consolidated rocks**
- **Confining unit**—Clay and silt
- **Unconsolidated to semiconsolidated deposits**
- **Saltwater**


Figure 127. Ground water moved toward and discharged into the Pacific Ocean before development of the aquifer system.

EXPLANATION

- **Direction of ground-water movement**
- **Fault**—Dashed where inferred, dotted where concealed

Figure 128. Withdrawals of ground water in excess of natural recharge have resulted in declining water levels. By the 1950's, water levels had declined below sea level throughout most of the basin. The reversal of the freshwater gradient from seaward to landward allowed seawater intrusion along most of the coast.


Figure 130. Four methods of limiting seawater intrusion are used conjunctively in the basin. Controlled withdrawals (A) and artificial recharge (C) serve to increase the amount of water in the aquifer system, while pumping troughs (C) and injection wells (D) create a barrier to seawater intrusion near the coast. The arrows indicate the direction of ground-water movement.