A WATER-QUALITY MONITORING NETWORK FOR VALLECITOS VALLEY, ALAMEDA COUNTY, CALIFORNIA

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations 80-59

Prepared in cooperation with the
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
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In Vallecitos Valley, the Livermore Gravel and the overlying alluvium constitute the ground-water reservoir. There is no subsurface inflow from adjacent ground-water basins. Ground-water flow in the Vallecitos subbasin is toward the southwest.

The proposed network consists of four surface-water sampling sites and six wells to sample the ground-water system. Samples collected monthly at each site and analyzed for tritium and for alpha, beta, and gamma radiation would provide adequate data for monitoring.

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October 1980

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

For readers who may prefer to use metric units rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Inch-pound units	Multiply by	Metric units
acres	0.004047	km^2 (square kilometers)
acre-ft (acre-feet)	0.001233	hm^2 (cubic hectometers)
ft (feet)	0.3048	m (meters)
ft/d (feet per day)	0.3048	m/d (meters per day)
$(ft^3/d)/ft^2$ (cubic feet per day per square foot)	0.305	$(m^3/d)/m^2$ (cubic meters per day per square meter)
ft/mi (feet per mile)	0.1894	m/km (meters per kilometer)
gal (gallons)	0.003785	m^3 (cubic meters)
gal/min (gallons per minute)	0.06309	L/s (liters per second)
(gal/min)/ft (gallons per minute per foot)	0.2070	(L/s)/m (liters per second per meter)
inches	25.4	mm (millimeters)
mi (miles)	1.609	km (kilometers)

National Geodetic Vertical Datum (NGVD) of 1929 is a geodetic datum derived from the average sea level over a period of many years at 26 tide stations along the Atlantic, Gulf of Mexico, and Pacific Coasts and as such does not necessarily represent local mean sea level at any particular place. To establish a more precise nomenclature, the term "NGVD of 1929" is used in place of "Sea Level Datum of 1929" or "mean sea level."

Other abbreviations used:

mg/L (milligrams per liter)
µmho/cm (micromhos per centimeter)
pCi/L (picocuries per liter)

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ABSTRACT

A water-quality monitoring network is proposed to detect the presence of and trace the movement of radioisotopes in the hydrologic system in the vicinity of the Vallecitos Nuclear Center. The source of the radioisotopes is treated industrial wastewater from the Vallecitos Nuclear Center that is discharged into an unnamed tributary of Vallecitos Creek. The effluent infiltrates the alluvium along the stream course, percolates downward to the water table, and mixes with the native ground water in the subsurface. The average daily discharge of effluent to the hydrologic system in 1978 was about 100,000 gallons.

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The proposed network consists of four surface-water sampling sites and six wells to sample the ground-water system. Samples collected monthly at each site and analyzed for tritium and for alpha, beta, and gamma radiation would provide adequate data for monitoring.

INTRODUCTION

The U.S. Geological Survey and the California Regional Water Quality Control Board, San Francisco Bay Region, have made a cooperative effort to describe the geology and hydrology of Vallecitos Valley and devise a water-quality monitoring network, based on knowledge of the hydrology, that will detect the movement of radioisotopes and other pollutants in the surface and ground water.

Treated industrial wastewater containing low concentrations of radioisotopes produced at the Vallecitos Nuclear Center is discharged into an unnamed tributary of Vallecitos Creek. The General Electric Co., operator of the plant, has conducted an environmental monitoring program since 1956 to determine to what extent, if any, discharges from the Center are detectable in the environment. Surface water, ground water, and stream-bottom sediments are monitored for pollutants that could have been dispersed by water. Vegetation sampling, soil sampling, environmental air sampling, and cloud-gamma monitoring are utilized to detect radioactivity (Mohr, 1978, p. 2). At the time that network of water-quality sampling sites was devised, however, comprehensive information on the local hydrology and geology was not available.

Purpose and Scope

The purpose of the study is to devise a water-quality monitoring network that will permit the tracing of nuclear contaminants through the hydrologic system in Vallecitos Valley. The network consists of surface- and ground-water monitoring sites.

This report describes (1) the geology and hydrology of Vallecitos Valley and the surrounding uplands which together compose the Vallecitos subbasin of the Sunol Valley ground-water basin (California Department of Water Resources, 1974), and (2) a network of water-quality sampling sites and a sampling program designed to detect and monitor the movement within the hydrologic system of radioisotopes discharged in wastewater from the Vallecitos Nuclear Center. Not considered in this report is the potential for direct or indirect contamination of the hydrologic system from airborne radioisotopes that might be emitted from the Vallecitos Nuclear Center.

Location and General Features

Vallecitos Valley occupies approximately 900 acres of relatively flat valley floor having an average altitude of about 440 ft. The valley floor is part of the Vallecitos subbasin of the Sunol Valley ground-water basin in the central part of Alameda County, Calif. (fig. 1). The Vallecitos subbasin lies within the central Coast Ranges of California about 35 mi east-southeast of San Francisco. The subbasin, as defined by the California Department of Water Resources (1974), was delineated on the north, south, and east by drainage divides and on the west by the Maguire Peaks fault. Recent geologic studies indicate that the Maguire Peaks fault is not present in this area; therefore, the fault is not shown in figure 2.

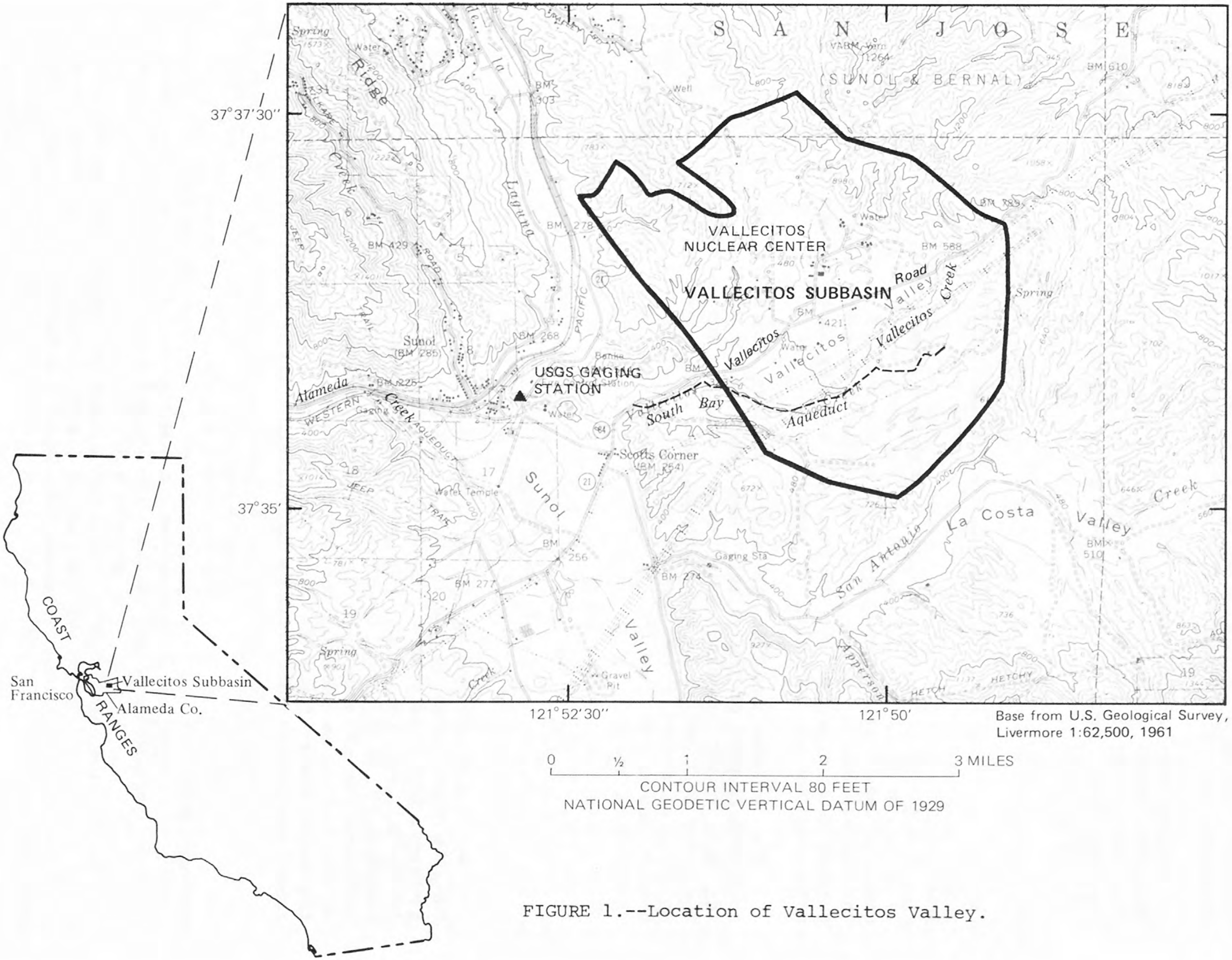


FIGURE 1.--Location of Vallecitos Valley.

The climate of the valley is mild, with hot, dry summers and cool, moist winters. The area receives about 20 inches of precipitation annually, about 80 percent of which falls during the period from November through March.

Vallecitos Valley slopes gently from east to west and is drained by Vallecitos Creek, which flows westward through a narrow gap in the uplands to join Arroyo de la Laguna, a tributary of Alameda Creek. The South Bay Aqueduct runs through the valley in a lined canal, then empties into Vallecitos Creek west of the valley.

Cultural Features and Water Use

The valley is rural, with no incorporated communities. There are about 20 homes in the area, each with one or more wells to provide water for domestic use. Stock ponds provide water for most of the livestock raised on the few ranches in the area, but some water from wells is used to supplement surface-water supplies. Agriculture in the valley is minor, and the amount of water used for irrigation is not significant.

The General Electric Vallecitos Nuclear Center is located in the northeastern part of the valley. Water for the Nuclear Center is supplied by the City of San Francisco Water Department from the Hetch Hetchy Aqueduct. The water provided is of excellent quality, averaging about 30 mg/L dissolved solids. Three wells are located on the General Electric property; two are unused, and one is used only to provide water for trees, lawns, and shrubbery around the grounds.

Well-Numbering System

Wells are numbered according to their location in the rectangular system for the subdivision of public land. Where the land has not actually been surveyed, appropriate subdivisions are projected. A well number, for example 4S/1E-10H1, has two parts. The part that precedes the hyphen indicates the township (T. 4 S.) and range (R. 1 E.). The number following the hyphen indicates the section (sec. 10); the letter indicates the 40-acre subdivision of the section as shown in the accompanying diagram; the final number, 1, is the serial number for wells in the 40-acre tract. All wells mentioned in this report are referenced to Mount Diablo baseline and meridian.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Previous Investigations and Acknowledgments

The geology of Vallecitos Valley has been described in studies by Hall (1958), California Department of Water Resources (1966 and 1974), and Herd (1977). Discussion of the general hydrology of Vallecitos Valley is included in studies by California Department of Water Resources (1963, 1964, and 1974). Soils in the study area have been described by Welch and others (1966).

The cooperation of the well owners who provided information and allowed data collection on their property is appreciated. The personnel at the General Electric Vallecitos Nuclear Center were helpful in providing information about the plant operations and water wells; in this respect, Howard Mohr is given special thanks. Many individuals in the Alameda County agencies and the California Department of Water Resources also provided information.

GEOLOGY

Vallecitos Valley lies within the Diablo Range, an uplifted block of Jurassic and Cretaceous rocks mantled in part with a thick sequence of marine and continental Tertiary rocks and continental Quaternary deposits. Folding and faulting has resulted in structures typical of the central Coast Ranges Geologic Province.

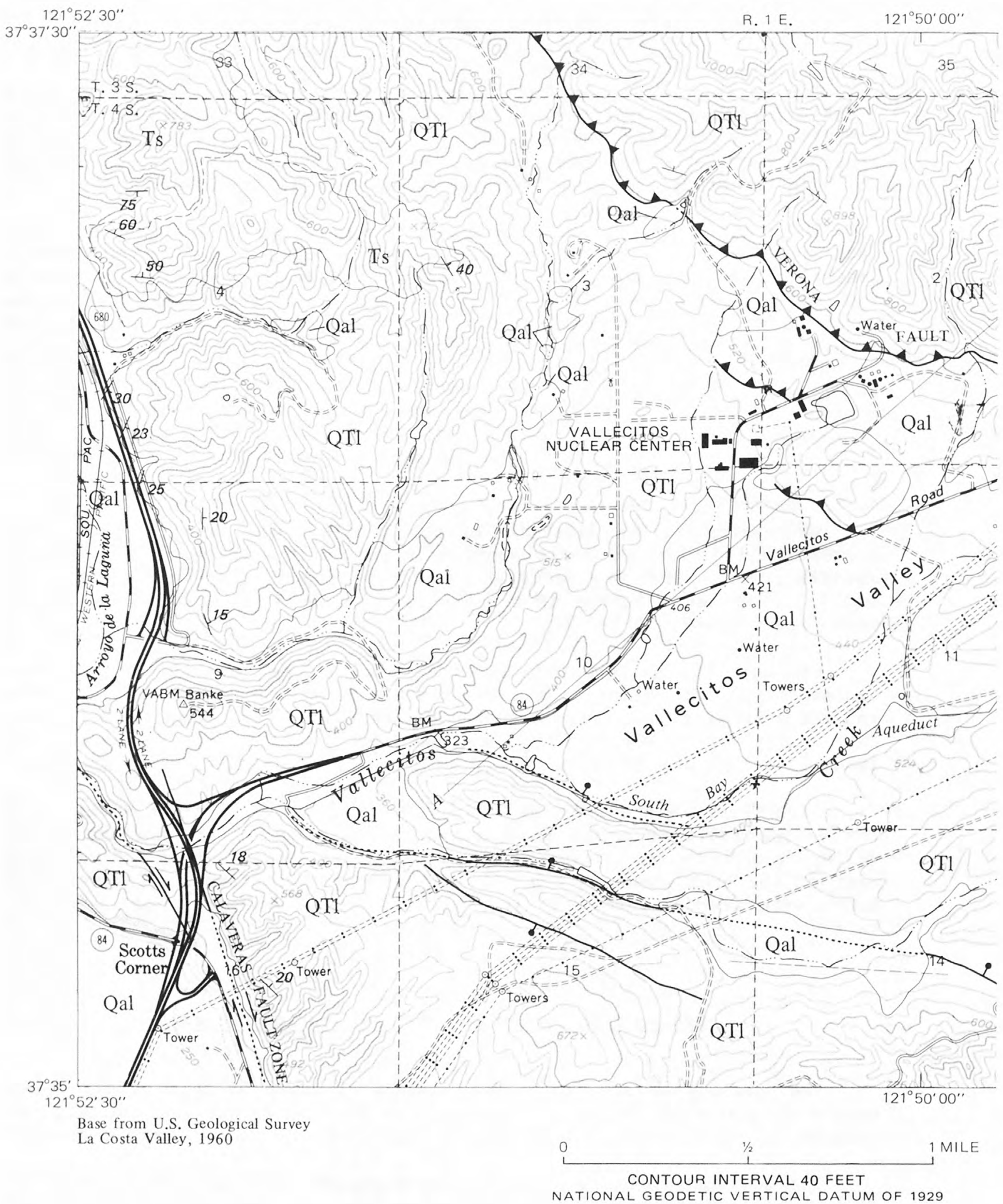
Geologic units exposed in the study area include upper Miocene sedimentary rocks, Pliocene and Pleistocene Livermore Gravel of Clark (1930), and the overlying Quaternary alluvial deposits (fig. 2). The low hills around the valley are marked with numerous small, active or recently active, landslides that are composed mostly of unconsolidated Quaternary material.

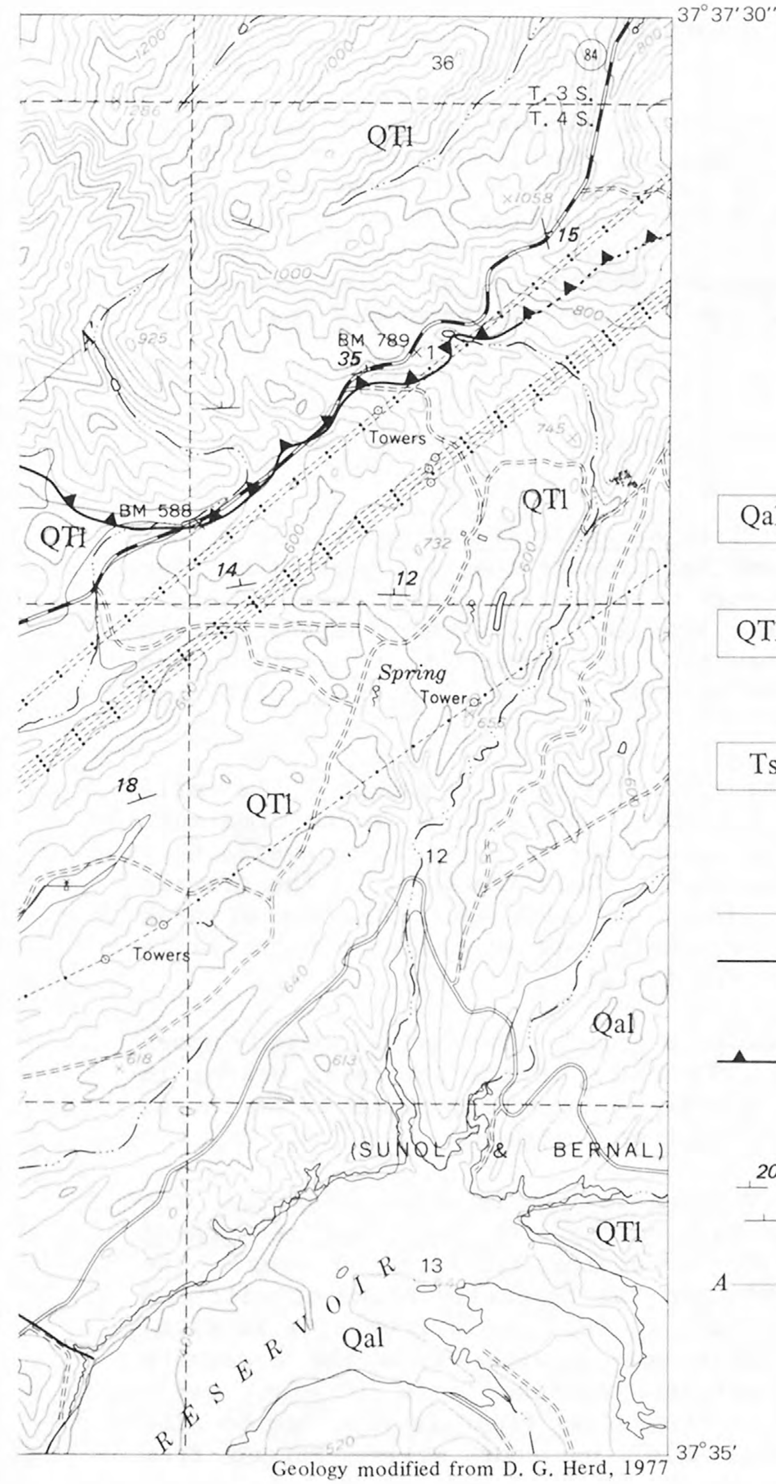
Structures in the area immediately surrounding Vallecitos Valley include the Verona fault, a major northwest-trending thrust fault northeast of the valley; the northeast-trending Las Positas fault zone, east of the valley (and east of the area shown in fig. 2); and the northwest-trending Calaveras fault zone, with predominant right lateral strike-slip movement, just west of the valley.

Geologic Units and Their Water-Bearing Properties

The geology as mapped by Herd (1977) is used in this study; however, Herd's six units of Quaternary alluvium are treated as one unit in this report because of their great similarity in lithology and water-bearing character.

The geologic formations may be characterized as either consolidated rocks or unconsolidated deposits. In the study area the consolidated rocks include the upper Miocene sedimentary rocks; the unconsolidated deposits include the Pliocene and Pleistocene Livermore Gravel of Clark (1930) and the Quaternary alluvium.





CORRELATION OF MAP UNITS

Qal	Holocene and Pleistocene	QUATERNARY
QTl	Pleistocene and Pliocene	QUATERNARY AND TERTIARY
Ts	Upper Miocene	TERTIARY

DESCRIPTION OF MAP UNITS

Qal — ALLUVIUM (Holocene and Pleistocene)—Gravel, sand, silt, and clay; permeable, yields water to wells

QTl — LIVERMORE GRAVEL OF CLARK (1930) (Pleistocene and Pliocene)—Weakly cemented gravel, sand, silt, and clay; moderately permeable, yields water to wells

Ts — CONSOLIDATED SEDIMENTARY ROCK (Upper Miocene)—Sandstone, siltstone, shale, and conglomerate; yields only minor quantities of water to wells

CONTACT

FAULT—Dotted where concealed. Arrows show direction of relative movement. Bar and ball on downthrown side

THRUST FAULT—Dotted where concealed. Sawteeth on upper plate

STRIKE AND DIP OF BEDS

20 Inclined

Approximate

A——A' LINE OF GEOLOGIC SECTION (fig. 3)

FIGURE 2.--Geologic map of Vallecitos Valley.

Consolidated Sedimentary Rocks

Upper Miocene sedimentary rocks, including sandstone, siltstone, shale, conglomerate, tuff, and some coal seams (California Department of Water Resources, 1966, p. 13), crop out in the northwestern part of the area. They dip generally to the northeast and underlie Vallecitos Valley at depths to more than 2,000 ft (fig. 3). This sequence of consolidated sedimentary rocks is considered non-water-bearing (California Department of Water Resources, 1966, p. 11) and acts as a lower hydrologic boundary in the study area.

Unconsolidated Deposits

Livermore Gravel of Clark (1930) (Pliocene and Pleistocene).--The Livermore Gravel in Vallecitos Valley is composed of more than 2,000 ft of massive beds of Pliocene and Pleistocene nonmarine, lenticular, weakly cemented gravel, sand, silt, and clay. Coarse-grained beds in the Livermore Gravel contain boulders 1 ft or more in diameter; however, the formation is poorly sorted throughout and even coarse-grained beds contain considerable clay, silt, and sand.

The Livermore Gravel underlies the entire study area except for a small area in the northwest where the upper Miocene consolidated rocks crop out. The gravels are exposed in the low hills around the valley and are overlain by a thin cover of alluvium on the valley floor. Good exposures of the gravels occur along some drainages and in a few road cuts, but, because of weak cementation, the formation generally is poorly exposed throughout the hills and is mostly concealed under a thin cover of soil.

The Livermore Gravel unconformably overlies the consolidated upper Miocene sedimentary rocks. Structural attitudes of the Livermore Gravel in outcrops show some variation, but the strike is generally north to northwest and the dip ranges from 10 to 30 degrees east or northeast.

Throughout the study area the Livermore Gravel is water bearing. The yield in any particular area depends in part on the lithology; sand and gravel beds yield greater quantities of water than the fine-grained beds. The discontinuous nature of the gravel beds and the generally abundant silt and clay in them create considerable variations in well yield from site to site. In the study area approximately 20 wells obtain water from the Livermore Gravel. Well yields reported from short-term pumping tests of eight wells ranged from 4 to 40 gal/min. One well on the valley floor is reported to flow at 7 gal/min. Specific capacity, available for four wells, ranged from 0.05 to 0.5 (gal/min)/ft of drawdown.

Alluvium (Quaternary).--Alluvium in Vallecitos Valley consists of mixtures of gravel, sand, silt, and clay deposited by streams during late Pleistocene to Holocene time. The alluvium consists of stream-channel, floodplain, and fan deposits that form a relatively thin cover over the underlying Livermore Gravel. It is found mainly on the valley floor and along the channels of streams tributary to Vallecitos Creek (fig. 2).

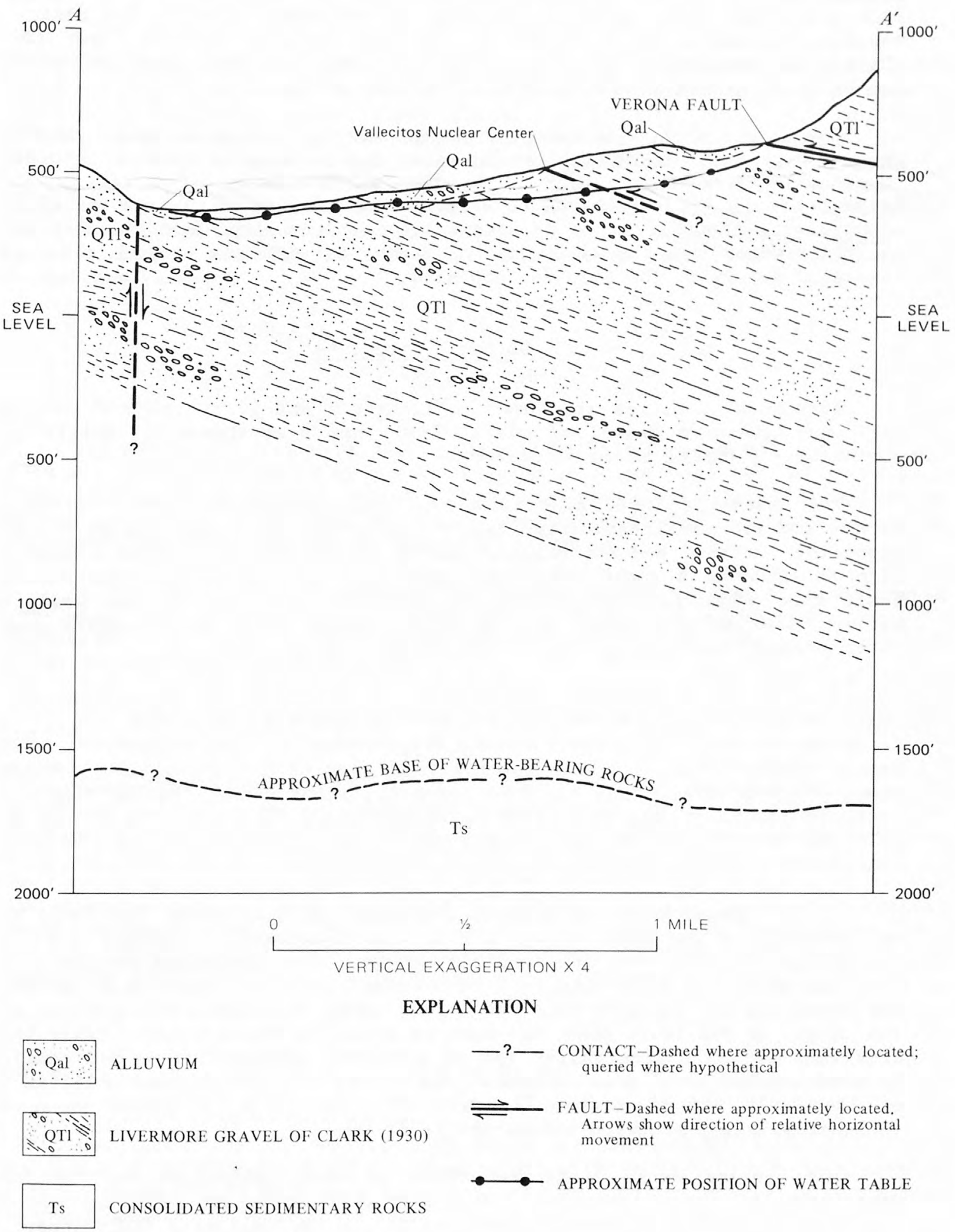


FIGURE 3.--Geologic section.

Because the alluvium and the underlying Livermore Gravel have similar lithologies, it is not possible to determine the thickness of the alluvium from drillers' logs. However, because of the small size of the basin, the maximum thickness of alluvium is probably nowhere greater than 100 ft (California Department of Water Resources, 1966, p. 64), and the thickness generally is probably no more than a few tens of feet.

The alluvium is moderately permeable and contains water under unconfined conditions. Small bodies of ground water may be perched above fine-grained, impermeable material, which occurs as discontinuous beds in the alluvium. All or part of the water supplied to a few shallow dug wells is from the alluvium along stream channels. Two drilled wells in the valley floor probably obtain all their water from the alluvium. No production data are available for wells completed solely in the alluvial deposits.

Geologic Structure

Structural features are shown in figures 2 and 3. Throughout the study area the Livermore Gravel of Clark (1930) has a northwesterly strike and a northeasterly dip of 10 to 30 degrees.

The Calaveras fault zone is about 1 mi west of Vallecitos Valley; the Verona and two small associated thrust faults are near the base of the hills along the northern and northeastern parts of the valley; and an unnamed dip-slip fault offsets rocks along the south side of the valley. The Calaveras fault zone significantly affects the flow of ground water from Vallecitos Valley. The dip-slip fault and the Verona thrust fault do not affect ground-water movement in any way significant to this study.

The Calaveras fault is a relatively narrow zone of subparallel faults that can be traced from the Vallecitos area south to Hollister and north to Carquinez Strait. The fault zone, represented by two subparallel faults, trends northwest through the southwestern part of the study area. Movement along the Calaveras fault has been primarily right lateral strike slip, but a vertical component has displaced rocks upward on the west side of the fault relative to rocks on the east side (California Department of Water Resources, 1966, p. 35).

In the Dublin area, about 8 mi northwest of Vallecitos, the fault zone, as revealed in an exploration trench, is described by Harding (1979) as consisting of soft, wet, sheared clay gouge. The impervious nature of this material makes it a barrier to ground-water movement, creating an offset in the water table. Because impervious clay gouge is present in exposures along the length of the fault zone, the barrier effect of the Calaveras fault in the area west of Vallecitos Valley can be inferred, although it is not confirmed by ground-water-level measurements. The non-water-bearing rocks uplifted west of the fault act to further inhibit subsurface flow of ground water from Vallecitos Valley westward across the fault zone.

The Maguire Peaks fault was shown by Hall (1958) and the California Department of Water Resources (1966 and 1974) to exist near the mouth of Vallecitos Valley, 1 mi east of and parallel to the Calaveras fault zone. The Maguire Peaks fault is not shown in figure 2 because recent studies by Herd (1977) and Earth Sciences Associates (1978) found no evidence of offset in rocks exposed along this trace. Thus, it has been concluded that the Maguire Peaks fault does not extend into this area.

WATER RESOURCES

The study area occupies the central part of the Vallecitos subbasin of the Sunol Valley ground-water basin (California Department of Water Resources, 1974, fig. 1). The valley floor of the Vallecitos subbasin (fig. 1) is somewhat bowl-shaped; a narrow gap in the bounding hills at the southwest end of the valley allows both surface water and ground water to flow out of the valley. The ground-water subbasin is coincident with the surface-water drainage basin, and no surface water or ground water flows in from adjacent basins. Ground-water inflow from adjacent basins is inhibited by the low permeability of the Livermore Gravel, which makes up the hills surrounding Vallecitos Valley.

Surface Water

Surface runoff in the valley is drained by Vallecitos Creek and tributary streams, which flow generally westward and out the mouth of the valley to join with Arroyo de la Laguna before entering Alameda Creek (fig. 1). The low hills that border Vallecitos Valley on the northwest are drained westward by an unnamed stream tributary to Arroyo de la Laguna.

In the study area, an unknown part of precipitation directly infiltrates the soil and percolates downward to recharge the ground-water basin. Infiltration of water along stream courses provides additional ground-water recharge while decreasing streamflow.

Hydrologic data are unavailable for the unnamed tributary receiving the effluent from the Nuclear Center.

Since December 1974 the U.S. Geological Survey has periodically made discharge measurements on Vallecitos Creek, about 700 ft upstream from the confluence with Arroyo de la Laguna (fig. 1). The discharge measurements are made as part of a water-quality study of Alameda Creek drainage basin. Because of controlled releases to Vallecitos Creek from the South Bay Aqueduct and releases of effluent from the Vallecitos Nuclear Center, streamflow measurements provide little information on the natural discharge conditions. Without these releases, it is doubtful that perennial flow would be maintained along the reach of Vallecitos Creek near the measuring site.

Ground Water

The source of ground-water recharge in the study area is direct infiltration of precipitation and seepage along Vallecitos Creek; some seepage along a canal which is a part of the South Bay Aqueduct may be an additional recharge source.

The amount of water that infiltrates to the zone of saturation depends on the permeability of the earth materials at the surface and the steepness of the surface slope. Soils in the area are generally well drained but the subsoil has low permeability. Runoff is rapid on hillsides and slow on more level ground. Little infiltration occurs where the Livermore Gravel is exposed on the hills around the valley. Infiltration on the alluvial deposits is relatively high because of the moderate permeability and because the alluvium is present mainly along the more level parts of the valley floor.

Ground water in Vallecitos Valley occurs in the alluvium and the Livermore Gravel of Clark (1930). The consolidated upper Miocene sedimentary rocks underlying the Livermore Gravel are not considered to be an aquifer in this area.

Within the Livermore Gravel and the alluvium, beds of coarse-grained material (coarse sand, gravel, and boulders) are interbedded with beds of fine-grained material (clay and silt). The beds of coarse-grained material, where saturated, yield water to wells; the beds of fine-grained material, even where saturated, do not yield significant quantities of water to wells but do store water that may be slowly released to the coarse-grained materials, and ultimately to wells.

A few wells in the study area tap ground water under confined conditions. That is, ground water rises in well casings to a level above that at which water was first encountered during drilling. Within the thickness of the Livermore Gravel penetrated by wells, confined ground-water conditions are of only local extent, however, and ground water occurs mostly under unconfined conditions.

The water-level contour map (fig. 4) is based primarily on measurements made, in May 1979, of water levels in wells tapping the Livermore Gravel. A ground-water divide approximately coinciding with the surface-water drainage divide along the north and east sides of the valley prevents ground water from flowing between Vallecitos Valley and Livermore Valley on the north and northeast. The ground-water divide is created by the effects of topography and the low average hydraulic conductivity of the Livermore Gravel. Precipitation falling on the Vallecitos side of the divide moves by gravity toward the Vallecitos Valley floor. Movement of ground water is shown perpendicular to the water-level contours. The water generally moves toward the southwest, more or less following the topographic slope from the hills to the valley floor. No water-level contours are shown in figure 4 in the southwestern part of the area because no water-level data are available. However, the flow of ground water probably continues uninterrupted southwesterly out the mouth of the valley.

An area of high-water-table conditions exists in sec. 10 south of Vallecitos Road (Highway 84 on map) in a belt of land along the unnamed tributary to Vallecitos Creek and in places along the valley floor next to Vallecitos Creek. Streams crossing this area of high water table almost certainly are gaining but elsewhere they are losing; seasonal fluctuations probably significantly influence this interaction. The extent to which ground water is discharged to, or recharged from, Vallecitos Creek and tributary streams cannot be determined from data currently available.

The water-level gradient ranges from 300 ft/mi to about 50 ft/mi. The gradient is steepest at the northeast end of the valley where the Livermore Gravel is exposed and flattens toward the southwest along the valley floor where alluvium is present.

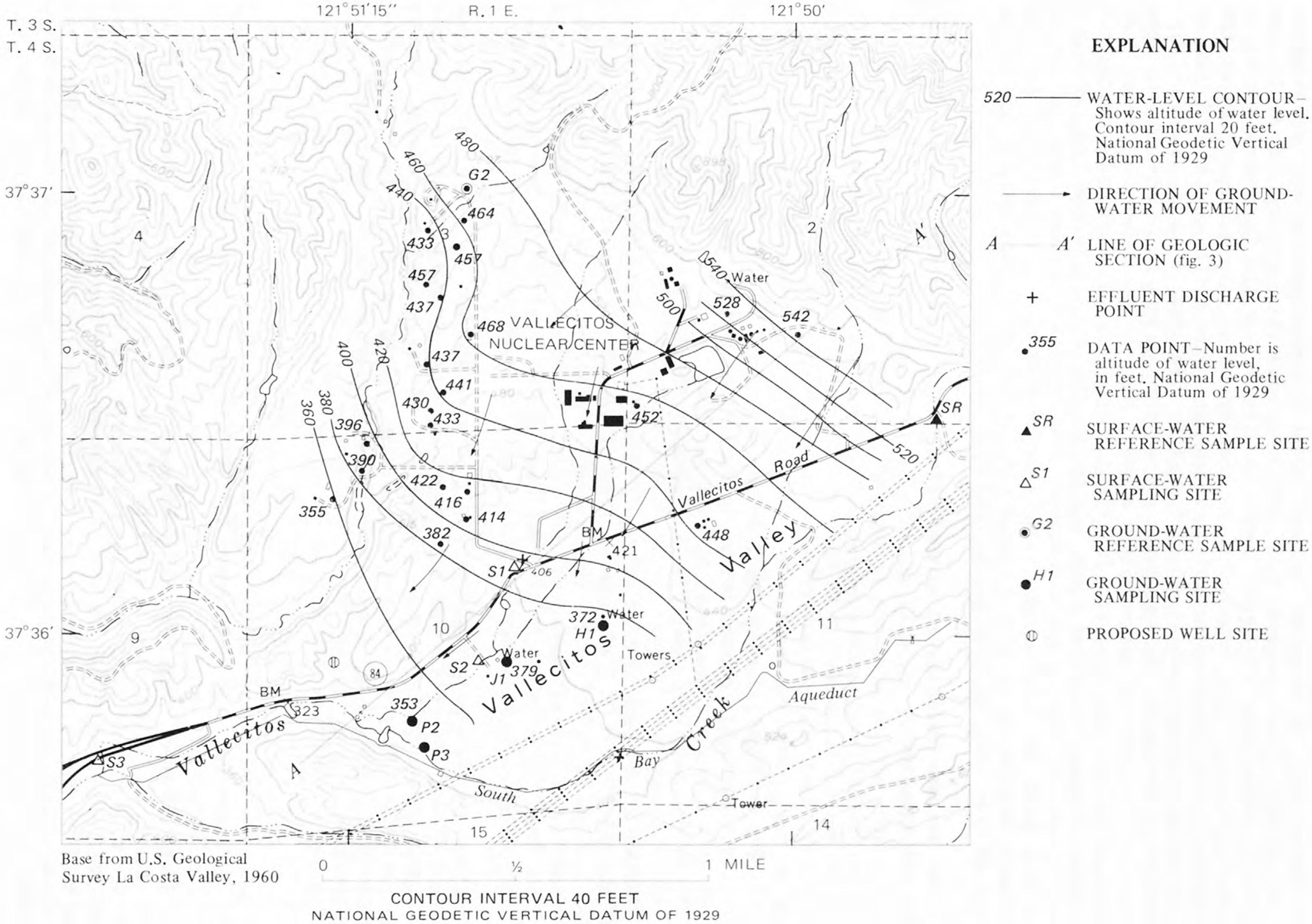


FIGURE 4.--Water-level contours and direction of ground-water movement, May 1979.

The velocity of ground-water movement varies from place to place in the study area because of the considerable lithologic variations in the saturated earth materials. An average value of ground-water velocity can be estimated by using data from permeability and transmissivity studies, made by the California Department of Water Resources (1974), of the Livermore Gravel in Livermore Valley. The data indicate that the hydraulic conductivity of the clay beds in the Livermore Gravel averages less than 1 $(ft^3/d)/ft^2$ and that of the gravels averages about 80 $(ft^3/d)/ft^2$. Because of the regional dip, ground water moving to the southwest passes through but is impeded by the less permeable clay beds which constitute a major part of the Livermore Gravel. An average hydraulic conductivity for the Livermore Gravel cannot be calculated by averaging the hydraulic conductivity of the clay beds and the hydraulic conductivity of the gravels because the relative proportions of these materials must be considered. The average hydraulic conductivity for the Livermore Gravel is probably about 20 $(ft^3/d)/ft^2$, considering the large amount of clay that is reported on drillers' logs.

The average velocity of ground water may be calculated (Lohman, 1972) by using the equation

$$\bar{v} = -\frac{Kdh/dl}{\theta}$$

where

$\bar{v}$ = average velocity, in feet per day,
K = hydraulic conductivity, in cubic feet per day per square foot,
dh/dl = hydraulic gradient, in feet per foot,
θ = effective porosity as a decimal fraction.

Using an average hydraulic conductivity of 20 $(ft^3/d)/ft^2$, a hydraulic gradient of 0.02 ft/ft (average in area of Vallecitos Nuclear Center), and an effective porosity of 0.2, the average velocity of ground water in the Livermore Gravel is estimated to be 2 ft/d. Based on hydraulic conductivities of less than 1 $(ft^3/d)/ft^2$ for clay beds and 80 $(ft^3/d)/ft^2$ for gravels the velocity of ground water may range from 0.01 ft/d to 8 ft/d.

Although average ground-water velocity in the alluvium, calculated from hydraulic conductivities for alluvium and stream-channel deposits in the Livermore Valley area (California Department of Water Resources, 1974), ranges from 0.1 ft/d to 2 ft/d, the average velocity may be greater. The uncertainty arises from the lack of hydraulic-conductivity measurements, specifically in Vallecitos Valley alluvium.

Water Quality

Surface-water quality data published by the California Department of Water Resources (1964) for a sampling station on Vallecitos Creek in the SE¼, sec. 9, T. 4 S., R. 1 E., show that dissolved-solids concentrations ranged from 219 to 983 mg/L for 28 samples collected during the period July 1959-June 1961. The predominant ions were sodium, calcium, magnesium, and chloride. Maximum and minimum values of specific conductance recorded daily at the U.S. Geological Survey water-quality station on Vallecitos Creek are 1,400 µmho and 117 µmho, respectively, for the period November 1974-September 1978.

The quality of ground water underlying Vallecitos Valley varies considerably. Based on published (California Department of Water Resources, 1964) and unpublished analyses, ground water in the southwestern part of the valley contains greater concentrations of dissolved solids than in the northwestern and eastern parts of the valley. Ground water in the southwestern part of sec. 10, T. 4 S., R. 1 E., contains as much as 3,390 mg/L dissolved solids. In the eastern part of the valley, dissolved-solids concentrations are as low as 230 mg/L. Throughout Vallecitos Valley, sodium, bicarbonate, and chloride are the predominant ions, and the boron concentration is unusually high, 21 mg/L in one sample. Based on 40 analyses, from 12 wells, no clear distinction in water quality can be made between ground water from the alluvium and ground water from the Livermore Gravel.

WATER-QUALITY MONITORING NETWORK

The proposed water-quality monitoring network is designed to detect nuclear and other contaminants and to make it possible to trace their movement in the surface water and ground water in the vicinity of Vallecitos Nuclear Center. The potential source of water-quality contamination is the General Electric Vallecitos Nuclear Center, north of Vallecitos Road in Vallecitos Valley, where commercial and research activities are conducted in several buildings in an area of about 100 acres. The main activity is production of radioisotopes.

The General Electric Co. operates a facility to treat the spent water from its research laboratories and nuclear reactor cooling systems. The treatment facility removes solids and reduces radioactivity sufficiently to meet permissible discharge concentrations (table 1). The treated water is stored in three 60,000-gallon reinforced-concrete retention basins. When the capacity of the basins is reached and the effluent has been analyzed for alpha- and beta-radiation emitting radionuclides, the treated wastewater is discharged into an unnamed tributary to Vallecitos Creek via a drainage ditch.

The amount of radioactivity in effluent discharged from the retention basins is reported to the California Regional Water Quality Control Board, San Francisco Bay Region, on a quarterly basis. The reported values are averages of daily samples collected over the 3-month period. Table 1 shows concentrations of radioisotopes measured in the samples collected during 1977 (Mohr, 1978). Concentration of radioisotopes in effluent discharged on any particular day may be greater or less than the averaged values shown in the table.

The volume of wastewater discharge varies according to the plant operation. During 1978 the reactor was shut down and the total industrial wastewater discharge was approximately 110 acre-ft. The discharge in previous years, when the reactor was operating, was approximately double the 1978 discharge.

During 1978 the average daily discharge of effluent to the hydrologic system was about 100,000 gal. Each 60,000-gallon retention basin requires about 1½ hours to drain. The effluent moves southwest in Vallecitos Creek; some of the effluent gets into the ground-water system through the streambed.

TABLE 1.--Concentration of radioisotopes, in picocuries per liter, in effluent (retention basins), 3-month average

Period	Plutonium Pu-239	Strontium Sr-89 and -90	Tritium H-3	Cesium Cs-137	Cobalt Co-60
Jan. 1-Mar. 31, 1977	<10	<10	37,800	<50	<50
Apr. 1-June 30, 1977	<10	<10	92,100	<50	<50
July 1-Sept. 30, 1977	<10	<10	29,200	<50	<50
Oct. 1-Dec. 31, 1977	<10	<10	--	<50	<50
Maximum permissible concentration (yearly average)[1]	5,000	300	3,000,000	20,000	30,000

[1]Maximum permissible concentrations for effluents released to uncontrolled areas, established by the Nuclear Regulatory Commission and the California Department of Health.

The rate of movement of the effluent in the surface-water environment varies considerably depending on streamflow conditions at the time of discharge. The traveltime of effluent will be reduced as the streamflow increases. During a storm of 1-inch precipitation in 1 hour, the traveltime of effluent from the discharge point to the confluence of Vallecitos Creek and Arroyo de la Laguna is estimated to be about 40 minutes. Traveltime during low-flow conditions in the summer and early autumn may be 3 to 4 hours.

Some of the effluent percolates into the ground-water system. The quantity percolated depends on flow conditions in Vallecitos Creek and tributaries. Upon entering the zone of saturation, the effluent mixes with the ground water and then moves down the ground-water gradient. Assuming that vertical movement of ground water is negligible, the mixed water moves mainly through the alluvium and not the underlying Livermore Gravel. The velocity of the mixed water depends on the hydraulic conductivity of the alluvium and the ground-water gradient. Because the velocity estimates have a wide range, caution must be exercised if they are used to determine traveltime between two points.

In addition to the controlled-effluent discharge, potential contamination of the hydrologic system from accidental spills must be considered. For this study, it is considered that accidental spills could occur anywhere within the approximately 100 acres of land occupied by the commercial and research facilities.

Accidentally spilled water on the Vallecitos Nuclear Center property would move through the hydrologic system under the same conditions as those outlined for the controlled-effluent discharges. The major difference is that a wider area of the valley could be affected; the area actually affected would depend on the location and volume of the spill.

Water-Quality Characteristics and Sampling Frequency

The effluent released at Vallecitos Nuclear Center contains a variety of radioisotopes (table 1). Each radioisotope emits alpha or beta particles, and some emit gamma radiation as well. The gross concentration of radioisotopes in the hydrologic system may be determined by measuring the alpha, beta, and gamma emissions of each sample from each site in the proposed network. Specific conductance measured for each sample could be used to monitor changes in dissolved solids.

Tritium, a radioisotope of hydrogen, is in the effluent from the Vallecitos Nuclear Center in the form of tritiated water molecules. Tritium moves at about the same rate as nontritiated water; most other radionuclides do not. Therefore, tritium is a good measure of the maximum extent of travel of effluent water, but not of the other radionuclides. Analysis for tritium concentration, made on each sample collected from each site in the proposed water-quality monitoring network, would allow tracing this potential contaminant in the hydrologic system.

Water samples collected monthly at each surface- and ground-water site in the network would be adequate to monitor potential changes in water quality caused by routine effluent discharges. Alteration of the sampling schedule might be appropriate if an accidental spill occurred.

Water levels could be measured monthly at each ground-water site to check for changes in head which might indicate changes in the ground-water gradient in Vallecitos Valley.

Water-Quality Sampling Sites

The proposed water-quality monitoring network consists of one surface-water reference sample site, three surface-water sampling sites downstream from the effluent-discharge point, one ground-water reference sample site for baseline data, and five ground-water sampling sites located downgradient from the Vallecitos Nuclear Center. Because contaminants which enter the ground-water system move downgradient only, no sampling sites to monitor contamination are needed upgradient (northeast) of the potential contamination source. Considering the structural attitude and transmissivity of the Livermore Gravel, even if some ground water did move to the northeast, down the dip of the Livermore Gravel, more than 100 years would be required for the ground water to reach the city of Livermore. Along this transect a large amount of dispersion and dilution could be expected to reduce the concentration of any contaminants present.

If significant changes in water use occur in the future, an evaluation of the response of the hydrologic system to the new stress would be appropriate. Changes in the location of sites in the network may be required to monitor water quality adequately.

Surface-Water Sampling Sites

The surface-water reference sample site located upstream from Vallecitos Nuclear Center is designated SR (fig. 4), and the three surface-water sampling sites downstream from the discharge point are designated S1, S2, and S3 (figs. 4 and 5).

Site SR is located on an intermittent tributary to Vallecitos Creek. (This site is currently used in General Electric's self-monitoring program as a surface-water reference sample site.) During seasons of sufficient streamflow, samples at SR can be collected to monitor possible changes in the background levels of selected characteristics in the surface-water regime. Samples collected at site S1 monitor surface-water quality at the point where effluent enters the unnamed tributary to Vallecitos Creek. Samples collected at site S2 monitor water quality from the downstream end of a pond that is fed by the unnamed tributary to Vallecitos Creek. Samples collected at S2 will include a mixture of water from Vallecitos Creek and effluent from a multiple number of releases from the retention basins. Each successive influx of effluent passing through the pond will be diluted by the mixture of creek water and effluent from previous discharges. In effect, the pond integrates the effluent discharges over time, and the water samples will reflect the effects of this integration. Samples collected at site S3 on Vallecitos Creek represent the quality of surface water leaving Vallecitos Valley just before dilution by water from an unnamed tributary and South Bay Aqueduct water. (This site has been monitored since 1956 by the General Electric Co. as part of an environmental self-monitoring program.)

Ground-Water Sampling Sites

Ground-water sites are designated by the State well number, and the locations are shown in figures 4 and 5. The ground-water reference sample site, located upgradient from the effluent discharge point, is well 4S/1E-03G2. Samples collected from the reference well will serve to monitor possible changes in the background levels of selected constituents in the ground-water regime. Four ground-water sampling sites downgradient from the discharge point are at existing wells: 4S/1E-10H1, 10J1, 10P2, and 10P3. A new well would be needed at a fifth downgradient site, located in an area having no existing wells. A 100-foot well in the NE¼SW¼ sec. 10, T. 4 S., R. 1 E., would help to monitor water quality adequately. Well depth, perforated interval, and aquifer classification for the existing wells are given in table 2. The General Electric Co. has routinely sampled site 4S/1E-10H1 since 1956 and site 4S/1E-10P2 since 1978.

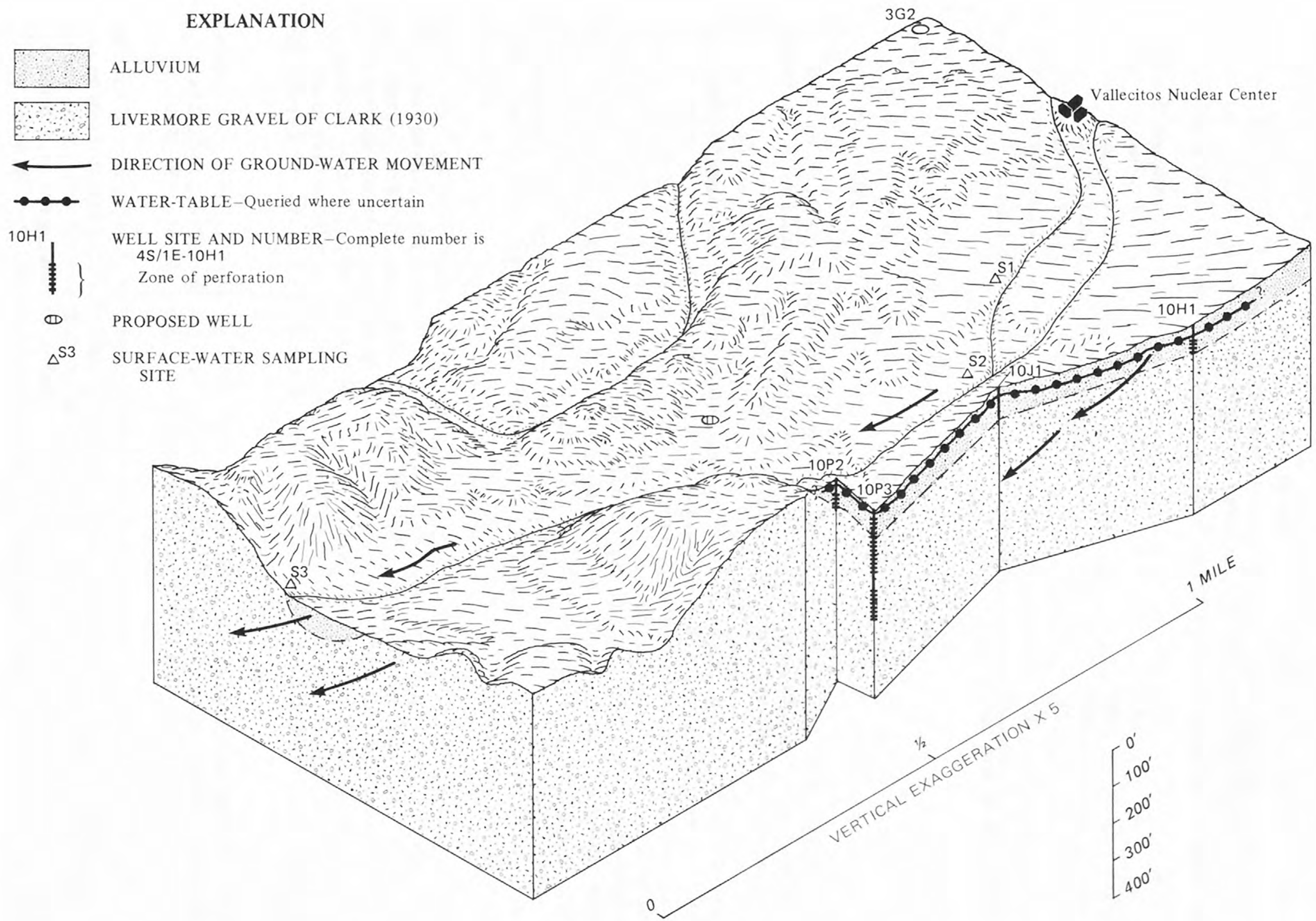


FIGURE 5.--Vallecitos Nuclear Center, location of sampling sites, and direction of ground-water movement.

TABLE 2.--Well data for ground-water sampling sites

Well No.	Depth of well, in feet below land-surface datum	Perforated interval, in feet below land-surface datum	Aquifer
4S/1E-03G2	153	65-140	Livermore Gravel
4S/1E-10H1	[1]80	[1]60-80	Alluvium
4S/1E-10J1	80	--	Alluvium
4S/1E-10P2	100	45-96	Alluvium
4S/1E-10P3	328	30-215 and 250-324	Alluvium and Livermore Gravel

[1]Reported value unverified.

SUMMARY

Vallecitos Valley includes about 900 acres of relatively flat valley floor lands. The valley, together with the surrounding low hills, constitutes the Vallecitos subbasin of the Sunol Valley ground-water basin.

Consolidated rocks of late Miocene age underlie the entire Vallecitos subbasin and act as the lower hydrologic boundary of the basin. Except for a small exposure in the northwestern part of the area, the upper Miocene rocks are overlain by the Livermore Gravel of Clark (1930). The Livermore Gravel is a heterogeneous formation consisting of clay, silt, sand, and gravel deposited by streams during Pliocene and Pleistocene time. The maximum thickness of the Livermore Gravel is more than 2,000 ft. On the valley floor, and in places on the surrounding hills, the Livermore Gravel is overlain by Quaternary alluvium. The alluvium, also consisting of clay, silt, sand, and gravel, has a maximum thickness of about 100 ft.

Some precipitation in the Vallecitos subbasin is absorbed by the thin cover of soil blanketing the valley and most of the hills. Most of the precipitation is not absorbed, however, but moves as surface water in tributary streams toward the valley floor. The tributaries join on the valley floor to form Vallecitos Creek, which flows westward out of the subbasin through a narrow gap in the hills. Surface runoff in the northwestern part of the subbasin is drained toward the west by an unnamed tributary of Arroyo de la Laguna.

Most of the precipitation absorbed by the soil is lost to the atmosphere by subsequent evapotranspiration. However, some of the absorbed precipitation percolates down to the water table and recharges the ground-water reservoir.

In Vallecitos Valley, the Livermore Gravel and the overlying alluvium contain permeable sand and gravel beds and together constitute the ground-water reservoir. Where saturated, the permeable coarse-grained beds yield water to wells. Ground water generally occurs under unconfined conditions to the depth penetrated by existing wells (as much as 328 ft) but ground water occurs locally under confined conditions in the Livermore Gravel.

The quality of ground water in Vallecitos Valley is variable. The dissolved-solids concentration ranges from 219 mg/L in the northeastern part of the valley to 3,390 mg/L in the southwestern part of the valley.

Water-level measurements made during May 1979 indicate that the gradient of the water table is toward the southwest. Unconfined and confined ground-water flow in Vallecitos subbasin is downgradient toward the southwest.

Processed industrial wastewater is discharged into an unnamed tributary of Vallecitos Creek. The wastewater contains low levels of radioisotopes. The effluent moves out of Vallecitos Valley by way of Vallecitos Creek and its tributaries, and an unknown quantity of the effluent infiltrates the alluvium along the stream course and percolates downward to the water table. After reaching the water table, the effluent mixes with the native ground water and moves in the subsurface with the ground water southwest and west out of the valley.

A water-quality monitoring network is proposed to detect the presence and movement of radioisotopes in the hydrologic system. The proposed network consists of four surface-water sampling sites and six wells used to sample the ground-water system. Three surface-water sampling sites are downstream from the effluent discharge point and one surface-water site, used as a reference, is on an adjacent tributary. Five ground-water sampling sites are downgradient of the discharge point and one ground-water sampling site, used as a reference, is upgradient. Samples collected monthly at each site and analyzed for tritium and for alpha, beta, and gamma radiation would adequately monitor the movement of radioisotopes in the hydrologic system.

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