STATE OF CALIFORNIA
The Resources Agency
Department of Water Resources

BULLETIN No. 74-8

Water Well Standards
SHASTA COUNTY

AUGUST 1968

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
Department of Water Resources

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FOREWORD

This bulletin demonstrates the need for adopting water well standards in Shasta County. It gives the results of a comprehensive ground water quality investigation conducted throughout Shasta County. The investigation was conducted under the authority of Section 231 of the Water Code and at the request of interested agencies operating in the county.

This is one of a series of reports designed to formulate and recommend water well construction and sealing standards for particular localities of the state where regulation is deemed necessary for the protection of ground water quality within the county for future beneficial uses. In Shasta County where no such regulation exists, many wells which have been improperly constructed or abandoned are contributing to the quality impairment of ground water. The report concludes that water well construction and sealing standards should be adopted and enforced. The standards presented in Bulletin No. 74, "Water Well Standards, State of California", are those recommended. Additional standards based on geologic, hydrologic, and water quality conditions and well construction practices found in Shasta County are also recommended.

William R. Gianelli
William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California
June 28, 1968

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AUTHORIZATION

The Water Well Standards Program under which this report was prepared is authorized by Section 231 of the Water Code, State of California which reads:

> "231. The department, either independently or in cooperation with any person or any county, state, federal or other agency, shall investigate and survey conditions of damage to quality of underground waters, which conditions are or may be caused by improperly constructed, abandoned or defective wells through the interconnection of strata or the introduction of surface waters into underground waters. The department shall report to the appropriate regional water quality control board its recommendations for minimum standards of well construction in any particular locality in which it deems regulation necessary to protection of quality of underground water, and shall report to the Legislature from time to time, its recommendations for proper sealing of abandoned wells."

In 1967 the Legislature established a procedure for implementing standards developed under Section 231 by enacting Chapter 323, Statutes of 1967, which added Sections 13800 through 13806 to the Water Code. In Section 13800, the Department of Water Resources' reporting responsibility is enlarged upon:

> "13800. The department, after such studies and investigations pursuant to Section 231 as it finds necessary, on determining that water well construction, maintenance, abandonment, and destruction standards are needed in an area to protect the quality of water used or which may be used for any beneficial use, shall so report to the appropriate regional water quality control board and to the State Department of Public Health. The report shall contain such recommended standards for water well construction, maintenance, abandonment, and destruction as, in the department's opinion, are necessary to protect the quality of any affected water."

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

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ACKNOWLEDGMENTS

Valuable assistance and data used in this report were contributed by agencies of the federal, state, and local governments. This cooperation is gratefully acknowledged. The assistance and cooperation rendered by numerous private companies and individuals are also very much appreciated.

We are particularly grateful for the assistance and counsel given during the course of this investigation by Mr. Arnold S. Rummelsburg, Director of Water Resources for Shasta County and Mr. Dale Watson, Sanitarian for Shasta County. We also want to thank the water well drillers of Shasta County who provided valuable information pertaining to water well construction and sealing practices.

ABSTRACT

Shasta County has several ground water basins which are an important and valuable resource to the area. In Shasta County, many wells which have been improperly constructed or abandoned are contributing to the quality impairment of ground water; water well construction and sealing standards should be adopted and enforced. The requisite standards, with suggested methods of implementing them, are included in this report.

CHAPTER I. INTRODUCTION

Ground water represents an important natural resource in parts of Shasta County. The utilization of ground water by extraction from storage through wells, and distribution through water supply systems, constitutes an excellent and economical water source in many parts of the county.

The protection and preservation of this valuable resource from pollution is of paramount importance. The parameters governing ground water movement are such that pollution of the ground water body is slow to occur, but when detected, pollution is usually widespread and very slow and difficult to rectify. Improperly constructed or abandoned wells can cause the degradation, pollution, or contamination of the ground water body. It is, therefore, very important that the construction and destruction of wells meet standards that will minimize impairment of the ground water and maintain its quality at a level commensurate with public requirements.

The present and historical quality of ground water in Shasta County is good; however, there is evidence that localized impairment of the ground water has occurred. The impairment is generally coincident with ground water use resulting from population growth. The reliance in suburban areas on individual water supply and waste disposal systems has increased the likelihood that man-produced wastes percolating through the soil have gained entry into improperly constructed, sealed, or abandoned wells. Several documented cases have occurred.

In February 1957, the Public Health Officer and Board of Supervisors of Shasta County requested that a well standards study for the county be initiated, as provided in Section 231 of the Water Code. Their request for a study stated: "Bacteriological samples of the water from a large majority of wells in the area show the presence of coliform organisms*. Many wells continued to yield coliform organisms despite all efforts to clear them up. This and other facts have given rise to a suspicion that some of the actual ground water strata are contaminated in some manner or other.... Recent work done by the Health Department indicates that some of the methods used locally in drilling wells allow the introduction of surface waters into underground waters and the interchange of waters between various underground water yielding strata."

Subsequent to correspondence and meetings with Shasta County authorities, the Department of Water Resources initiated a program to study the ground water quality conditions in Shasta County. The program included studies of geology, hydrology, water quality, water well drilling practices, sewage disposal methods, and their effect upon the ground water. The results of these studies are presented in this report. Recommendations are also presented which, if followed, will provide protection and prevent the further deterioration of the quality of ground water in Shasta County.

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* See Appendix B for definition.

Purpose and Scope of Investigation

The purpose of this investigation was to obtain, assemble, and correlate information necessary for the formulation and recommendation of water well construction and sealing standards to protect the ground water quality in Shasta County.

Information related to ground water and well construction in Shasta County, collected by the Department of Water Resources and other agencies, was reviewed and used to determine the amount of supplemental field work required. From the data assembled, the significance of the geology, hydrology, quality of water to the ground water body were determined. Water well drillers, water pump installers, and equipment suppliers throughout the county were interviewed to determine the type of well construction, sealing, and abandonment practices used in Shasta County.

Detailed geologic studies were conducted in the Redding Basin. The hydrogeological characteristics of the units comprising the basin were determined, and the basin was subdivided into several units based on geographic, geologic, and hydrologic parameters. Supplemental mapping was done in the Burney Creek Basin and Fall River Valley to augment published geologic information. Plate 1 shows the favorable areas for ground water occurrence. Hydrologic and geologic information on small alluvial filled valleys was not evaluated in detail. Much of the data for this investigation was obtained from Department of Water Resources Bulletin No. 22, "Shasta County Investigation". The Department of Water Resources ground water data program and all geologic and hydrologic material available were relied upon when pertinent to a specific problem. A list of references is presented in Appendix A.

During the course of this investigation a well construction survey was made. Coliform bacterial analyses of water from 88 wells were examined. A total of 440 ground water analyses from 201 wells, for both complete and partial mineral content, were examined to provide water quality information.

A compilation of the supporting data are presented in the Appendixes following the text.

Area of Investigation

Location

Shasta County is located in the north central portion of the state, at the northern extremity of the Sacramento Valley (Plate 1). The area of the county is about 3,847 square miles.

To aid in the analysis of ground water problems, the county has been divided into seven units, based on hydrologic, geologic, and physiographic parameters. This division was modifed when necessary to conform with the established hydrographic units. The names of the units have been cross-indexed with those used in the "Northeastern Counties Investigation", Bulletin No. 58; the "Shasta County Investigation", Bulletin No. 22; and "Water Utilization and Requirements of California", Bulletin No. 2. They are discussed in detail in later sections of this report.

Physiography

Parts of five of the eleven geomorphic provinces in California are found in Shasta County. The North Coastal Range province extends into the southwest corner of Shasta County as far as Clear Creek. The northwestern quarter and southwestern border of the county are in the Klamath Mountains province. Two of Shasta County's most important streams, the McCloud River and Squaw Creek, originate here. The Cascade province occupies most of the eastern half of Shasta County. Lassen Peak, which marks the southern terminous of the Cascade province, is located in the southeast corner of the county. The axis of the province extends northwest through Mount Shasta. The Pit River, which originates on the Modoc Plateau further east, has cut a steep canyon through the volcanic materials comprising the Cascade province. The northeast corner of the county is in the Modoc Plateau province. Fall River Valley, a portion of this area, is an ancient lakebed with an elevation of 3,500 feet. And finally, most of the southern half of Shasta County is included in the Great Valley province.

Hydrographic Units

The two principal areas of ground water importance are the Redding Basin and Fall River Valley. Of lesser importance are the Sacramento River Valley and its tributaries above Shasta Lake. In order to facilitate the discussion and to maintain continuity with previous reports in the area, the Redding Basin has been subdivided. These units are essentially similar to the hydrographic units used in Bulletin No. 22. Table 1 shows the correlation between the hydrographic units in Bulletin No. 22 and this report. Plate 1 outlines the Redding Basin and Fall River Valley. Plate 2 shows the subdivisions within the Redding Basin.

Climate

Shasta County has a variable climate dependent on its diverse physiography. Summers are warm and dry, winters are cool and moist. At Redding the annual precipitation averages about 37 inches, most of it falling during the rainy season, from November through April. In the mountains to the north and west the precipitation exceeds 80 inches. In the area around Fall River Mills, northeast of Redding, the precipitation averages 20 inches per year. Above elevation 3,500 feet snowfall can be expected in the winter months.

TABLE 1

CROSS-REFERENCE OF HYDROGRAPHIC UNITS

Bulletin 22	Bulletin 74-8
Cottonwood Creek	Happy Valley
Olinda	Happy Valley
Stillwater Plains	Stillwater Plains
Cow Creek	Cow Creek
Anderson	Sacramento River
McArthur	Fall River Valley
Cottonwood Creek	Cottonwood Creek

Culture

Shasta County had a population of 77,500 in 1966. Approximately 50,000 people are concentrated in the Redding Basin. The Burney-Fall River Mills area in the northeastern corner of the county has a population of approximately 7,000.

Agriculture and stock raising, lumber and forest products, recreation, and mining are the principal pursuits in the county. Redding, the county seat of Shasta County, is the trade and medical center of the northern Sacramento Valley.

Livestock is the most important component of the agricultural industry. Irrigated pasture, hay, and summer range, combined with livestock and livestock products, account for approximately 75% of the agricultural income in the county. Field, specialty crops, and orchards account for the balance.

Recently the acreage in potatoes has increased in the Fall River Valley. There have also been experiments with sugar beets, onions, and beans. One of the primary factors in the agricultural development of this valley would be the availability and quality of ground water.

In recent years the lumber industry has grown considerably. Remanufacturing, plywood, and paper pulp products have increased considerably and in 1964 the cash value was in excess of 35 million dollars.

Because of the wide range of geologic, topographic, and climatic conditions found within the county, a number of industries have grown which cater to recreational outlets. Special emphasis has been placed on water-oriented sports because of the numerous streams and water developments that have taken place on them.

CHAPTER II. GEOLOGY AND GROUND WATER HYDROLOGY

Shasta County is predominantly a mountainous area with only a few areas of low relief. Throughout the County there exists a wide variation in topography, climate, vegetation, soils, and rock types. However, within each of five areas or provinces, as defined below, certain similarities in rock types, ground water occurrence, and land forms are recognized. These provinces are: the Klamath Mountains, North Coastal Range, Great Valley or Central Valley, Cascade, and Modoc Plateau. These areas are delineated on Plate I and the geology of the significant ground water producing areas is shown on Plates 3 and 4.

In Shasta County, large amounts of ground water are found only in areas where the rocks are porous and capable of transmitting water in significant quantities. These rocks occur mainly in the Redding ground water basin and the Modoc Plateau. The remainder of the County is a mountainous area underlain mostly by nonwater-bearing rocks. These rocks may contain small quantities of ground water in local areas, but generally yields to wells are undependable and small.

The Klamath Mountains, occupying the entire northwest portion of the County, is an area of deep canyons and rugged ridges and peaks. Elevations range from about 500 feet near Redding to over 6,000 feet along the Trinity-Shasta County line. The rock types are ancient sedimendary, igneous, and metamorphic rocks which contain practically no ground water. Locally, small quantities of ground water occurring in fractures and joints may be yielded to shallow wells.

The North Coastal Range province occupies the area south of the Klamath Mountains, approximately between Ono and Platina. The topography is characterized by low, rounded, brush-covered hills and north-trending ridges. Rock types include predominantly sandstone and shale of marine origin. Ground water supplies are practically nonexistent because of the impermeable nature of the rocks, and any small supplies that might be available often have a high salt content.

The Cascade province lies immediately east of both the Klamath Mountains and the Central Valley provinces and extends from north to south through the eastern half of the county. The province is composed of a chain of volcanic cones dominated in Shasta County by Mt. Lassen. Elevations along the crest range from 4,000 feet to over 10,000 feet. From the crest area, located west of Hat Creek, the volcanic rocks extend westward as far as the Sacramento River and eastward to the Lassen County line (Plate 4). Occurrence of significant quantities of ground water in the Cascades is restricted to local areas in the southern portion. The western portion of the province south of the Pit River is dissected by west-trending canyons in which the streams of the Cow Creek drainage system flow. Some of these streams have eroded through the lava cover to expose older sedimentary and metamorphic rocks.

The Modoc Plateau province is situated in the northeast portion of the County. It is bounded on the west and south by the Cascade province. The Modoc Plateau province is made up of thick basaltic lava flows with some interbedded lake sediments (Plate 4). Structurally, the area is characterized by north-trending tilted fault blocks; the topographically low areas may contain lake sediments. Fall River Valley, Hat Creek, and Burney basin occupy low areas of tilted fault blocks. The majority of basaltic lavas contain joint and fracture systems, are generally highly permeable and store great quantities of ground water. The Fall River Valley ground water basin is an ancient lake bed surrounded and underlain by highly permeable volcanic rocks. Wells in this basin produce from both the lake sediments and the volcanic rocks.

The Great Valley province is an area of low relief in the south central portion of the county. It is essentially an interior plain, dissected by the stream valleys of the Sacramento River, Cow Creek, and its tributaries, Clear, Churn, Stillwater, and Cottonwood Creeks. Rock types in this province are all sedimentary, capable of storing and transmitting large quantities of ground water. The greatest concentration of wells and the greatest use of ground water for irrigation and domestic purposes are in this province.

Redding Ground Water Basin

The Redding ground water basin occupies the northernmost portion of the Central Valley in Shasta and Tehama Counties. It is within an area bounded on the north by the lowermost slopes of the Klamath Mountains, on the east by the foothills of the Cascade Range, and on the west by the foothills of both the Klamath Mountains and the Northern Coast Range. The southern boundary is formed by the Red Bluff Arch, a structural uplift located in northern Tehama County that trends east-northeast across the Central Valley.

The basin is composed of Quaternary and late Tertiary age water-bearing sediments which are underlain by nonwater-bearing or saline water-bearing rocks of Cretaceous age. The fresh-water-bearing sediments are contained in a north-south trough formed by a southward plunging synclinal structure in the Cretaceous rocks. The Cretaceous rocks, at a great depth beneath the surface near the center of the basin, rise to or near the surface around the west, north, and east margins. Pre-Cretaceous nonwater-bearing rocks, which are exposed in the Klamath Mountains, extend beneath the Cretaceous rocks. Pliocene volcanic rocks, some of which are water-bearing, overlie Cretaceous age rocks and older Pliocene formations on the east side (Plate 3).

The base of the fresh-water-bearing sediments is defined by the top of the Chico formation, a group of rocks of marine origin consisting chiefly of consolidated sandstone and shale. This formation is the uppermost member of the Cretaceous deposits. The thickness of the water-bearing sediments in the Redding basin varies from a feather edge near the west, north, and east margins, to at least 2,000 feet along Highway 99, six miles south of Anderson.

Geologic Formations and Water-Bearing Characteristics

Five water-bearing geologic formations are recognized in the basin. They are: alluvium, of Regent age; Red Bluff formation, of Pleistocene age; Tehama and Tuscan formations, both of upper Pliocene to lower Pleistocene age; and Nomlaki tuff, of upper Pliocene age. Geology of the basin is shown on Plate 3.

The Tuscan and Tehama formations together comprise the principal source of ground water in the Redding ground water basin. Alluvium and the Red Bluff formation are locally important sources of ground water.

Alluvium occurs along the streams which enter or pass through the basin. The Red Bluff formation is distributed throughout most of the area at the surface, and it directly overlies the eroded surface of the older Tehama and Tuscan formations beneath. The Tehama and Tuscan formations are distributed throughout the basin, and extend eastward beneath the Cascade volcanics, but are exposed only where the Red Bluff formation has been eroded away. The Tuscan and Tehama formations were deposited during approximately the same period of time, the Tehama on the west and north sides of the basin and the Tuscan on the east side. Approximately along the north-south axis of the basin, these formations interfinger and overlap. The Nomlaki tuff is a basal member of both the Tehama and Tuscan formations. The tuff directly overlies the Chico formation, or may be separated from it by thin beds of Pliocene sediments.

Alluvium. Alluvium occurs principally in Anderson Valley, Cottonwood Creek and overlies Tuscan and Tehama sediments and possibly Red Bluff gravels in some places. Generally, the alluvium is so thin that it is of little significance in regard to movement or storage of ground water. In the Churn Creek Bottoms area of Anderson Valley the greatest thickness, about 50 feet, is attained. West of the Sacramento River, in Anderson Valley, alluvium is thinner and continues to thin westwardly. Terraces of older alluvium are exposed along the west side of Anderson Valley and the north side of Cottonwood Creek toward Happy Valley. A high ground water table is maintained in Anderson Valley due to seepage of irrigation water and percolation from septic tanks and industrial ponds. Many shallow drilled and dug wells extract ground water from alluvium for domestic uses. The relatively few but deep high-yielding wells in Anderson Valley extract ground water from the Tehama and Tuscan formations beneath the alluvium.

Recharge of ground water in the alluvium of Anderson Valley is accomplished through percolation of water applied for irrigation, infiltration of precipitation, and influent stream flow. Hydrographs obtained by continuous water level recorders in Anderson Valley show rapid response to application of irrigation water in the summer and to precipitation in the winter.

Most alluvial deposits in the Redding basin are highly permeable and have a high water table. Ground water contained in the alluvium is more easily impaired. Care should be taken in locating water wells where these conditions prevail. They should not be located close to and down gradient from possible sources of impairment.

Red Bluff Formation. The Red Bluff formation blankets most of the basin as flat-lying beds, and overlies the Tuscan and Tehama formations in thicknesses up to 100 feet. It is chiefly composed of coarse gravel, with an iron oxide stained matrix of sand, silt, and clay. Permeability of the formation is generally low, although in places where clean gravels are present, a higher degree of permeability exists. It appears that those zones of higher permeability are localized channels which may have some continuity in a horizontal direction but little continuity in a vertical direction.

The Red Bluff formation is of little importance as a source of ground water. Many shallow domestic wells obtain water from perched water bodies which are commonly present, particularly in Stillwater Plains and Happy Valley. The bulk of the formation generally lies above the zone of saturation and high yielding wells must be drilled through the Red Bluff formation to the underlying Tehama or Tuscan formations.

Ground water obtained from perched water bodies in the upper portion of the Red Bluff formation may be easily impaired because of its generally shallow depth. Care should be taken in placement of domestic wells. They should not be located close to and down gradient from sources of impairment.

Tehama and Tuscan Formations. The Tehama Formation consists of compact mixtures of clay, silt, and gravel. Although the materials are poorly sorted, stratified beds are present in which finer-grained sediments such as clay predominate in some beds and coarse sediments such as gravel predominate in other beds. The finer-grained sediments are generally in massive beds with lenses and tongues of gravels occurring in them. The beds generally are in a horizontal or a nearly horizontal attitude.

The Tuscan volcanic sediments on the east side consist chiefly of relatively greater amounts of gravel, especially in the southeast portion and proportionately lesser amounts of fine-grained materials as compared with the Tehama sediments. From the area of Coleman Power House on Battle Creek, massive beds of extremely coarse volcanic gravel grade westerly and northwesterly into progressively thinner beds of smaller gravel and thence into finer gradations which interfinger with the Tehama formation in the central portion of the basin. Like the Tehama formation, the Tuscan formation is essentially flat-lying over most of the basin.

Permeability of the Pliocene sediments (Tehama and Tuscan formations) throughout the Redding basin is highly variable. In general, permeabilities of the sediments are higher in the southern portion of the basin than in the northern portion. The highest permeability probably occurs in the southeast portion of the basin where Tuscan volcanic gravels occur in large amounts.

Ground water in the Tehama and Tuscan formations occurs under both free and confined conditions. In the eastern area of the basin, particularly in Cow Creek Bottoms, Stillwater Plains, and the southern portion of the Anderson Valley, ground water is considered to be generally free but locally confined. More complete confinement probably occurs in the deeper zones. Deep well current meter measurement data obtained by the U. S. Bureau of Reclamation on their ground water test hole 31N/4W-25Q1 indicate that ground water is confined below a depth of 440 feet. A relatively impervious layer of Tuscan volcanic agglomerate (tuff breccia) overlies the confined zone between the depths of 367 and 440 feet.

The Tuscan and Tehama formations are believed to be recharged principally by percolation of stream flow into the slightly upturned edges of the more permeable stratified beds near the margin of the basin. From such areas of recharge, ground water flows by gravity to the confined aquifers at a greater depth. Infiltration of precipitation is an important source of replenishment to the shallow water-bearing zones. There are no known confining beds in the Tuscan or Tehama formations which have sufficient continuity throughout the basin to completely prohibit the downward percolation of rainfall. However, a confining bed of volcanic agglomerate was encountered in the U. S. Bureau of Reclamation test hole 31N/4W-25Q1 which may be extensive, and other beds restricting infiltration of precipitation undoubtedly occur in other areas. The Red Bluff formation blankets much of the basin, and because of its thickness and low permeability, there is probably a slow rate of downward percolation through it to the underlying formations.

Depth to ground water throughout the Redding Basin is highly variable due to the irregular ground surface elevations. In the Stillwater Plains area, for example, average depths between 1955 and 1958 ranged from 52 feet to 64 feet. The area of greatest depth to ground water is in Happy Valley where depths average 140 feet below ground surface. In the valley areas, including Cottonwood Creek, Cow Creek, Churn Creek Bottoms, and Anderson Valley, depths to water for the same period average 25 to 35 feet, 20 to 26 feet, 10 to 17 feet, and 13 to 17 feet respectively.

Direction of movement is generally from the basin margins toward the Sacramento River and then south and southeast toward the lowest point in the basin at Jelly Bend.

The quality of ground water in the Redding Basin is generally excellent. However, around the basin margins ground water from some wells is poor in quality and sodium chloride in character. Concentrations range from a small but discernible amount to as much as 22,000 ppm total dissolved solids. The source of the high concentration of sodium chloride responsible for the degradation of ground waters is the underlying Chico formation. This formation contains saline connate water; that is, water that was deposited with the sediments while under a marine environment. Saline waters of high concentration are mixed with ground waters of meteoric origin in the basal portion of the water-bearing sediments (Tehama and Tuscan formations). This condition may be prevalent throughout the Redding Basin. However, the data available pertain mostly to the northern portion of the basin where depth to the Chico formation is shallow (see Plate 4). Most of the data indicate a progressive deterioration of water quality with depth. Great care should be exercised by drillers when drilling in known areas of salt water. Sampling and testing of water should be done where possible. When it has been discovered in a completed well that saline water is present, the portion of the water-bearing zone contributing the water (usually the lower portion) should be sealed off. In extreme cases where flowing salt water wells are drilled, the entire well must be sealed.

Modoc Plateau

The Modoc Plateau area occupies the northeastern part of Shasta County. The region consists of a series of north-and-northwest-trending, tilted fault blocks. Intervening basin areas may be partly filled with Recent lava flows or often lake sediments or alluvium. The greater portion of Modoc Plateau is underlain by vast accumulations of permeable basaltic lava. Surface drainage is uncommon because of the high rate of stream percolation. Several streams disappear completely from the surface and reappear at some downstream area as a large spring.

The principal areas of ground water development are in the Burney area and Fall River Valley. Other wells are scattered throughout the region. Fall River Valley is the only area where ground water is obtained in significant quantities from lake sediments. Elsewhere ground water can be obtained usually in large quantities from permeable volcanic rocks. Most volcanic rocks in the Modoc Plateau contain numerous open joints, lava tubes, and void spaces between lava flows. Ground water moves through these rocks by means of interconnection of these crevices and cavities.

Discussion of ground water in the Modoc Plateau will be limited to areas of greatest use since these are the areas where well data and knowledge of occurrence and movement of ground water are available. These areas are the Burney area and Fall River Valley. Generalized geology of the Modoc Plateau is shown on Plate 3.

Burney Area

The Burney ground water area is situated at the west margin of the Modoc Plateau. Ground water is extracted from underlying basalt lava flows for domestic, municipal, industrial, and agricultural purposes. Volcanic rocks immediately underlie the surface throughout most of the area. However, along Burney Creek, there are several areas of alluvial fill known as Haynes Flat, Burney Valley, and Long Valley. The alluvial deposits in these areas are thin and are situated above the main water body.

Measurements of depths to ground water in various wells and corresponding elevations show that movement of ground water is to the north, or toward Burney Falls. Depths to water range from 90 to 200 feet near the town of Burney and at shallower depths toward the north.

Throughout the Burney area ground water occurs principally in porous and highly permeable basalt. Well yields and corresponding drawdowns indicate a high degree of permeability for the volcanic rocks. Yields of as much as 2,000 gallons per minute (gpm) with little drawdown are common in this area.

Ground water is replenished by the direct percolation of rainfall, stream infiltration, and subsurface inflow from adjacent areas. Ground water moves northward on a low hydraulic gradient and a portion is discharged to Burney Creek and to the Pit River.

The ground water body in the Burney area is unconfined and direct. Access from the surface exists for downward movement to the water table. No impervious barriers are known which would prevent or retard this movement. Consequently, there is a minimum of protection from surface sources of contamination or pollution. Furthermore, the void spaces are so large that little or no filtration of percolating waters takes place. Therefore, ground water in volcanics is generally more susceptible to pollution than ground water occurring in a stratified alluvial deposit.

Fall River Valley

Fall River Valley is located in northeastern Shasta County and partly in Lassen County. The valley is about 7 miles wide, north to south, and about 16 miles long, east to west. The valley floor, situated at an elevation of about 3,300 feet, is relatively flat except along the southern margin where the Pit River and its tributaries have eroded through the lake sediments to a level of about 100 feet below the general level of the valley.

Fall River Valley owes its origin to disruption of drainages either by volcanism or faulting or to a combination of such processes to form a large lake which existed in Pleistocene time. The ancestral lake may have extended north and south for some distance, but recent lavas have since filled in the trough north and south of the present valley. Overflow of the lake and subsequent down-cutting eventually resulted in drainage of the lake, leaving as evidence of its past presence, fine-grained lake deposits which now form the valley floor.

The lake sediments were deposited in a northwest-trending trough in the volcanic rocks probably during Pleistocene time. Permeable lava flows border the valley on the north and south and may overlie lake sediments. On the east and west borders, the volcanic rocks are older and probably less permeable. Lake sediments attain a maximum thickness of about 700 feet in the northern and central portions of the valley. Elsewhere the lake sediments are on the order of several hundred feet thick and less.

The lake sediments are in general only slightly to moderately permeable and therefore yield only small amounts of water to wells.

Occassionally, sand and gravel beds are penetrated by wells, and larger yields are obtained. The lake sediments for the most part are comprised of clay, silt, and fine sand.

Permeable volcanic rocks underlie the lake sediments and, where wells are deep enough to reach these rocks, large yields are attainable. In the eastern and western portions of the valley, these more productive aquifers are reached at depths of about 200 feet, but in the central portion only the deepest wells, generally over 500 feet, reach these rocks.

Both confined and unconfined ground water conditions exist in the valley. Most of the shallow wells used for domestic and stockwatering purposes and some irrigation wells tap unconfined ground water in the lake sediments. Volcanic rocks beneath the lake sediments contain confined ground water. Where wells penetrate these rocks, water flows to the surface under artesian pressure. Most of the wells in Fall River are nonflowing and extract water only from the unconfined bodies in the lake sediments. There are over 25 known flowing wells in the valley. Most of these are located in the eastern portion of the valley where depths to artesian aquifers are not great.

Depths to ground water are shallow, particularly in the northern portion of the basin. Depths in the spring, when the highest levels occur, are commonly 5 to 10 feet. Near the Pit River and south of the Pit River, ground water levels are 20 to 50 feet.

The general direction of movement is toward the Pit River. Thus, most of the ground water north of the Pit River moves in a southerly direction and on the east and west sides, movement is toward the center of the valley and thence southward. South of the Pit River ground water moves westerly. Sufficient information on elevations on the pressure surface is not available to determine direction of movement in the confined zone.

Ground water occurring in the lake sediments of Fall River Valley is easily impaired because of its generally shallow depth. However, ground water in the deeper zones of the lake sediments and in the underlying volcanic rocks appears to be well protected from contamination and pollution except through defective wells.

Mountainous Areas

The mountainous areas of Shasta County include portions of the Klamath Mountains, North Coastal Range, and Cascade Geomorphic provinces. Rock occurring in these areas is considered to be largely nonwater-bearing. A wide variety of igneous, metamorphic, and sedimentary rocks are found in all these provinces (see Plate 1).

The Klamath mountains consist of various types of schists, sandstone, shale, limestone, and volcanic rocks, intruded by granitic rocks and serpentine. The bedded sedimentary rocks and volcanic flow rocks are deeply weathered, usually forming a clayey residual soil mantle. All these rocks are considered to be essentially impermeable. However, ground water can be transmitted in small quantities through open joints and fractures, but these openings are confined to a shallow zone near the surface. Development of ground water is largely confined to valley areas near streams where small amounts of alluvium occur. Where wells penetrate only the fractured bedrock, yields are usually low and wells often go dry in late summer months. Because ground water occurs only at shallow depths in fractures which are open to the surface, contaminating or polluting waters have easy access to the well.

In the North Coastal Range rock types include stratified beds of sandstone, shale, and conglomerate. The stratified beds dip eastward toward the Sacramento Valley at low to moderate angles and extend beneath the water-bearing sediments of the Redding ground water basin. These rocks are not nearly as fractured or deformed as those in the Klamath mountains. Openings in which fresh ground water can occur and move are extremely sparse. Connate, saline water is present, however. Since these rocks were originally deposited in a marine environment, they still contain much of the original salt water. Wells drilled in these rocks rarely yield even minor amounts of fresh water. Saline waters can be found and occasionally flowing salt water wells are drilled. Salt-water-bearing formations beneath a fresh body can constitute a source of quality impairment to the fresh water body.

The Cascade province is a mountainous area built up by the eruption of lava and fragmental volcanic material from numerous vents. Most of the crest area of the Cascade Range is made up of coalescing peaks composed of andesite and dacite lava flows along with fragmental material such as cinders and ash. In the lower areas, particularly the westward sloping area between the crest of the Cascades and the Sacramento River, several large areas of younger basalt flows occur. These basalt flows were more fluid and spread out over greater areas in contrast to the andesite and dacite lavas which are more localized in occurrence.

In regard to the water-bearing properties, all these rocks are more permeable than the Klamath Mountains or North Coastal Range rocks as evidenced by the large number of springs occurring in the region. In some areas of the Cascades, evidence of surface runoff is absent, indicating that considerable infiltration of water into the rocks must occur. Void spaces through which ground water moves occur as shrinkage cracks or joints, as open fractures produced by earth movements or mechanical forces, and as cavities between lava flows. Lava tubes, the largest type of opening that can occur in volcanic rocks, are probably not as common in the Cascade province as they are in the Modoc Plateau volcanics.

Although low yielding wells may be obtained throughout most of the Cascade province, the most productive wells are found in the southern portion near Shingletown. The basaltic rocks shown on Plates 3 and 4 are in particular the most productive.

Most of the wells in the Whitmore-Shingletown area have yields of less than 100 gpm. Local conditions may exist where large quantities may be found, but such wells are uncommon. Depths to water in all areas of the Cascade Range are usually deep, ranging from 100 to 150 feet.

Ground water from wells in volcanic rocks are subject to contamination due to the ready access of surface waters to the ground water body through open joints and fractures.

A summary of the geologic formations and their water-bearing characteristics is shown on Table 2.

TABLE 2

GEOLOGIC UNITS OF SHASTA COUNTY

Geologic Unit and Symbol Used on Geologic Map	Approximate thickness (feet)	Physical Characteristics	Water-Bearing Characteristics
Alluvium (Qal)	0 - 50±	Unconsolidated gravel, sand, silt and minor amounts of clay along the active stream channels. Grades into finer grained floodplain sediments away from the stream channels. Thickest deposits occur in Anderson Valley.	Moderately permeable. Good well yields may be obtained locally, particularly near stream channels. Usually will provide adequate quantities of ground water for domestic, stockwatering, or limited irrigation purposes.
Recent Basalt (Qrb)	30 - 500±	Highly jointed flows of vesicular and blocky basalt. Flows contain lava tubes and zones of scoria (porous rock).	Permeability is high to very high. If adequately recharged will provide copious quantities of ground water to springs, streams, lakes, and wells.
Terraces (Qt)	0 - 50±	Unconsolidated clay, silt, sand, and gravel adjacent to and slightly above stream courses.	Usually permeable; ordinarily will yield moderate quantities of ground water to wells. May contain some perched water.
Red Bluff Formation (Qpr)	0 - 100±	Ill-sorted gravel in a reddish-brown sandy clay matrix.	Poorly to moderately permeable. Outcrop areas are frequently above the zone of saturation, but may contain small bodies of perched water. May yield fairly small to moderate quantities of ground water to wells.
Lake sediments (Qps)	0 - 700±	Partly consolidated sand, silt, clay, volcanic ash, and diatomite. Frequently cross-bedded. Largest occurrence is in Fall River Valley.	Slightly to moderately permeable. Sandy zones yield small to moderate quantities of ground water to wells.

TABLE 2 (Continued)

GEOLOGIC UNITS OF SHASTA COUNTY

Geologic Unit and Symbol Used on Geologic Map	Approximate thickness (feet)	Physical Characteristics	Water-Bearing Characteristics
Pleistocene basalt (Qpb)	50 - 750±	Slightly weathered flows of jointed, vesicular basalt.	Moderate to high permeability. May yield large quantities of ground water where adequately recharged.
Tehama Formation (Tte)	0 -2,500±	Massive poorly sorted, fluviatile clay and silt enclosing lenses of cross-bedded sand and gravel. In certain areas, cobble to pebble gravel enclosing lenses of sandy silt predominates. Sediments are locally cemented.	Most of formation is moderately permeable; more gravelly zones have higher permeability. Yields moderate to high quantities of ground water to wells. Some permeable zones near the base of the formation have become degraded with connate water derived from underlying marine sediments.
Tuscan Formation (Ttu, Ttus)	0 -1,000+	Numerous flows of massive tuff-breccia separated by thin beds of sand and gravel (Ttu). Beds of volcanic sand and gravel with a few thin beds of tuff and tuff-breccia (Ttus).	Massive tuff breccia is nearly impermeabl however, interflow sediments may yield sc ground water where located within the zon of saturation. The volcanic sediments contain some highly pervious zones. Thes yield large quantities of confined and unconfined ground water to wells where located within the zone of saturation.
Cretaceous marine sediments (K)	0-6,000+	Marine sedimentary rocks consisting mostly of shale, sandstone, and conglomerate.	Essentially impermeable; a few relatively permeable beds contain connate marine water. In some areas connate water under artesian pressure.

CHAPTER III. WATER SUPPLY

The development and use of ground water has occurred principally in two areas in Shasta County, the Redding Basin and Fall River Valley. Surface water development has taken place along the Sacramento and Pit River drainages. In the sparsely populated areas outside the Redding Basin and Fall River Valley, there are minor withdrawals of ground water from suitable host rocks such as the volcanics and alluvium. Surface water withdrawals occur along creeks. All summer flows in the Sacramento River Basin within Shasta County have already been appropriated; there are no surplus flows.

Ground Water

The two principal areas of ground water occurrence as previously mentioned are the Redding Basin and Fall River Valley. The Redding Basin is the largest of the two in the county. There are several water-bearing formations in the Redding Basin. The Tehama and Tuscan formations are the two most important. Permeable zones within the formation yield moderate to high quantities of both confined and unconfined ground water. The Red Bluff formation is moderately permeable and below the zone of saturation may yield moderate quantities to wells. Above the zone of saturation perched water may occur. The alluvium in the basin is moderately to highly permeable and areas adjacent to stream channels will usually yield adequate quantities for domestic purposes. The basin is underlain by Credaceous Marine sediments and permeable zones contain saline connate waters; they have encroached upon fresh water in the Tuscan and Tehama formations.

Fall River Valley is about 7 miles wide and 16 miles long and lies at an elevation of about 3,300 feet. It is bounded on the east by the Big Valley Mountains and on the west by a ridge. The northern and southern boundaries are poorly defined because of extensive lava flows of low relief. Fall River, the major stream draining the area, flows southerly to its confluence with the Pit River. Near Fall River Mills the Pit River enters the Valley from the southeast and flows southwesterly across the southern half of the valley. The valley is a structural depression in the Modoc Plateau, and is filled with lacustrine deposits. The lake sediments are of Pleistocene age and range from partly consolidated sand and clays with interbedded volcanic ash. The lake sediments are moderately to slightly permeable. Near shore, deposits containing a higher percentage of coarser detrital material will yield moderate to large quantities to wells. The lake sediments range up to 700 feet thick in the northern part of the valley and are interbedded with volcanic flows and pyroclastic rocks which may yield large quantities of water to wells.

Ground water occurs throughout the volcanic flows forming the Modoc Plateau; however, because of the nature of ground water movement in fractured and porous rocks, a thorough knowledge of the geology of the area is of great importance in predicting its occurrence.

Recharge

Each year during the rainy season, the ground water basins in Shasta County are recharged. Recharge is by infiltration of surface runoff. In the Cascade and Modoc Plateau provinces the permeable nature of the volcanics comprising this region permits direct infiltrating with a minimum of surface runoff. The western slopes of the Cascades and the uplands east and northeast of Redding serve as an important recharge area for the Redding Basin. The eastward dipping Tuscan formation which outcrops in this area is traversed by Cow Creek and Stillwater Creek which are influent most of the length and provide a source of water for recharge after the seasonal rains have ceased.

Ground Water Storage

There is an estimated 8 million acre-feet of ground water storage capacity from 20 to 200 feet for the Redding Basin. There are no detailed studies for the rest of the county from which a reliable estimate of the ground water in storage or safe yield in the county or the individual basins may be made. Safe yield is defined as the quantity that may be extracted from a basin without continuously depleting the amount in storage or damaging the basin. In the reach of the Sacramento River traversing the Redding Basin, the flow is augmented by an estimated 130,000 acre-feet of seepage from ground water. This indicates that the recharge exceeds withdrawals and that the safe yield is an additional 130,000 acre-feet over the present extractions.

Ground Water Basin Levels

Ground water levels vary considerably throughout the county and may vary considerably within a basin because of geological conditions.

The U. S. Geological Survey and the Department of Water Resources conduct a regular monitoring program of water level measurements in the Redding ground water basin and Fall River Valley. Records indicate that there has been no significant change in recent years and that any change in the level is due to seasonal variations. Between October and April the levels rise and from April to October the levels drop because of pumping in the basin. The long-term period shows no significant trend.

Use of Ground Water

The most frequent use of ground water is for domestic purposes. Numerous individual domestic installations scattered throughout the County and their concentration in the Redding Basin attest to the importance of this resource. Most of the ground water developed is used for irrigation and stock watering and industrial purposes. There are no accurate records available for the amount of ground water pumped in the county from the individual basins. The yield for wells in the county may vary from 20 to over 4,000 gallons per minute. For domestic wells a yield of 40 gpm is typical, and for irrigation wells 1,000 gpm is fairly typical. The evidence indicates that there is still an ample supply of good quality ground water for all beneficial uses in the Redding ground water basin.

CHAPTER IV. QUALITY OF WATER

Water, from the time of precipitation, acts as a solvent on minerals and soils. The solvent action may be increased by the presence of certain dissolved gases such as carbon dioxide. During the passage of water, whether on the surface or underground, the amount and kinds of suspended or dissolved constituents reflect the environmental factors present during the hydrologic cycle. In addition, salts or other undesirable substances may be added to water by industrial wastes, sewage, and irrigation return waters. The addition of these impurities may have a significant effect on the chemical behavior of the water and thereby alter its value.

Numerous chemical and bacteriological analyses of water samples were taken from representative water wells to evaluate the quality of ground water in Shasta County. Interpretation of these analyses combined with geologic and hydrologic studies and well construction surveys in Shasta County are the keys to formulating recommendations for water well construction and sealing standards. Established water quality criteria for beneficial uses are shown in Appendix H.

Quality of Ground Water

In the investigation of ground water quality in Shasta County, emphasis was placed on the two major areas of ground water use - the Redding Basin and the Fall River Valley area. Wells located in the Modoc Plateau and the Cascade geomorphic province in eastern Shasta County generally have fairly uniform chemical characteristics because of the high permeable nature of the volcanics. Most of the remaining wells in the County are found on small terraces adjacent to rivers and streams, and have very localized water quality characteristics.

To evaluate the water quality within the county, chemical analyses were made of ground water from representative wells. In addition, where applicable, samples collected through the state ground water quality data program were evaluated both as supplemental data and to determine any trends in ground water quality. The results of mineral analyses of ground water from wells in Shasta County are included in Appendix D. For individual well designation and the method of location, refer to Appendix C.

Fall River Valley

The ground water in Fall River Valley is generally calcium-magnesium-bicarbonate in character; however, there are well waters with high sodium content. Table 3 shows the ranges of concentration of mineral constituents in well waters from Fall River Valley. The table has been subdivided on the basis of depth of well and is representative of 109 analyses from 51 wells in Fall River Valley. Figure 1, a plot of the median value of the percent of sodium against depth of well shows an increase in sodium with depth. An examination of the logs of five wells which have water of sodium-bicarbonate character and are high in total dissolved solids, shows that they are drawing their water from lava beds, which are interbedded in the lake sediments or under the lake sediments. The wells with high sodium also have higher chloride concentrations, indicating that there may be some water of volcanic origin added to the ground water body.

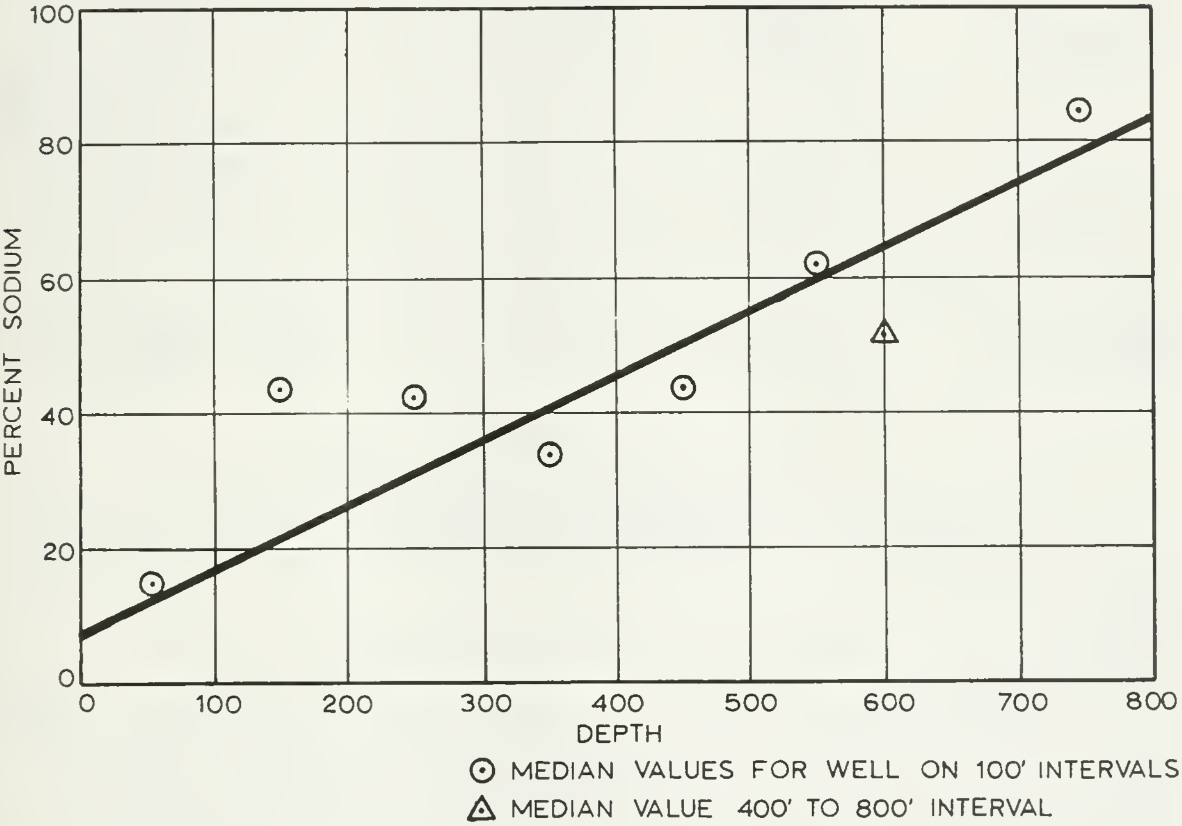
TABLE 3

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS IN WATER FROM WELLS IN FALL RIVER VALLEY

	Constituents (in parts per million)									Percent
Range	Ca	Mg	Na	HCO_3	SO_4	CL	NO_3	TDS	Hardness as $CaCO_3$	Na
				Depth 0 - 100'						
Max.	47	30	34	276	16.3	35	62.5	334	220	47
Med.	19	11.5	12	138	1.5	3.7	6.6	191	91	16
Min.	7.4	2.2	2.5	70	0	0	0	54	27	3
				Depth 100 - 200'						
Max.	40	22	133	448	13	32	12.4	474	167	64
Med.	17	8.8	22	118	3.8	7	2.7	163	99	45
Min.	8.1	3.6	10	94	0	0	0	130	50	14
				Depth 200 - 300'						
Max.	21	16	54	250	4.8	5.5	50	334	119	94
Med.	185	4.7	31.5	117	1.5	3.3	0.5	158	65	42.5
Min.	14	0.4	16	107	0	0	0	132	5	31
				Depth 300 - 400'						
Max.	18	9.0	30	155	11	60	9.0	197	93	79
Med.	14.5	7.3	19	115.5	5.1	3.9	2.1	164	71	33.5
Min.	6	0.1	9.6	73	0	0.3	0	126	6	22
				Depth 400 - 800'						
Max.	48	34	142	563	9.1	7.5	49	594	262	86
Med.	15	3.7	36	126	1.5	3.5	14.5	176	52	52.5
Min.	4.4	0	17	99	0	0	0	130	11	23

Ten wells in Fall River Valley have an iron concentration or a combined iron and manganese concentration that exceeds the 0.3-ppm standard for drinking water recommended by the U. S. Public Health Service. The wells are listed in Table 4. There are no toxicological effects from iron but it is highly objectionable in either domestic or industrial supplies. The domestic consumer complains of the brown stain both iron and manganese give laundered goods. Iron imparts a bitter, astringent taste to water which may be readily detected at a level of 1.8 ppm. It also affects the hardness of water when present in sufficient quantities. Both iron and manganese affect the taste of beverages. Complaints from manganese arise when the concentration exceeds 0.15 ppm.

FIGURE 1
PERCENT SODIUM VS. WELL DEPTH



There does not appear to be any relation between depth or areal distribution and iron concentration. Iron is one of the more common minerals in the earth's crust. The basaltic rocks found in the northeastern part of the county are iron-manganese rich silicates. It is material eroded from these rocks which comprise the lake sediments. Under certain conditions, ferrous iron is readily soluble in water. Certain types of bacteria can exist without oxygen and promote a reducing environment favorable to taking iron and manganese into solution. Upon exposure to air both iron and manganese are oxidized to a less soluble form which precipitates out. It is this finely divided precipitate which causes the objectionable stain.

TABLE 4

WELLS WITH HIGH Fe AND Mn IN FALL RIVER VALLEY

State Well No.	Date of Sample	Fe ppm	Mn ppm	Depth	Use
37N/4E-1K1	5-24-58	2.9	0.39	430'	Domestic
	9-5-61	1.5	0.52		
37N/4E-1N1	5-24-58	3.7	-	80'	Domestic
37N/4E-10G1	5-22-58	0.88	-	80'	Domestic
37N/4E-26G1	5-23-58	0.38	-	72'	Stock
37N/5E-9N1	9-6-61	0.12	0.41	155'	Domestic and Irrigation
37N/5E-19P2	5-24-58	3.3	-	225'	Irrigation
	9-7-61	1.2	0.01		
38N/4E-30H1	5-22-58	2.80	-	75'	Domestic
	9-5-61	3.0	0.61		
38N/4E-31C1	5-22-58	0.98	-	85'	Domestic
38N-4E-33L1	5-22-58	0.66	-	59'	Domestic
38N/5E-29J1	5-26-58	0.69	-	500'	Domestic and Stock

Iron-manganese rich sediments, interbedded with organic material from earlier lakes, cause the high iron concentrations in the ground water.

Redding Basin

The estimated 8,000,000 acre-feet of water in storage in the Redding Basin constitutes an important resource to the area. Approximately 210 analyses from 82 wells were available to determine the chemical parameters of the ground water in the Redding Basin. The water pumped is generally of calcium-magnesium bicarbonate character. There are differences to be noted depending on the local geology.

For the purpose of this discussion the basin has been divided into the following units (see Plate 2): (1) the Happy Valley area covering townships 30 and 31 north, range 5 west; (2) the Cottonwood Creek alluvial plain along the southern border of the county; (3) the Sacramento River alluvial plain, including the lower end of Churn Creek known as Churn Creek Bottoms; (4) the Stillwater Plains, the elevated plains east of the Sacramento River flood plain and bounded on the east by Cow Creek; and (5) the Cow Creek drainage, including Swede Creek and Millville plains east of Cow Creek.

Some wells in the Redding Basin have a high saline content. They are discussed separately later in this chapter.

Happy Valley Unit. The Happy Valley Unit is located west of Anderson and the wells grouped in this unit are located in townships 30 and 31 north, range 5 west. The unit also includes the southwest half of T30N/R4W and is outlined by the Red Bluff formation exposed north of Cottonwood Creek and west of the Sacramento River. (Plate 2).

Twenty-one analyses from six wells were examined. The wells varied from 30 to over 500 feet in depth. Table 5 shows the ranges of mineral constituents in the area. The predominant anion is bicarbonate, typical of the region as a whole; however, there is an increase in the percent sodium with depth. The percent sodium averaged 42 for wells over 100 feet, but the 30 foot well had water with 14 percent sodium. The Red Bluff formation is estimated to be 50 feet thick from the evidence of outcrop along Clear Creek and well log data available in the area. Well T30N/R5W/15R1, which is 505 feet deep, penetrated the underlying cretaceous formation at 500 feet but analyses do not indicate that there has been any contamination from marine saline waters to date. With the exceptions of several dug wells drawing water from the Red Bluff formation, well logs from the area indicate that drilled wells average 200 feet deep and that the quality of water is excellent.

TABLE 5

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS IN WATER FROM WELLS IN HAPPY VALLEY

Range	Constituents (in parts per million)									Percent
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	Na
				Depth 0 - 500'						
Max.	36	18	17	154	41	12	11	240	166	54
Med.	9.1	6.2	14.5	87	4.5	4.6	1.8	137	48	43
Min.	8.1	4.4	12	78	0	2.5	0	128	38	14

With the exception of the value for percent sodium, the maximum value in the above tables was obtained from a 30-foot well in the Red Bluff formation. These values for chemical constituents probably result from the low permeability of the Red Bluff formation. This low permeability allows water to dissolve more mineral constituents from the soil particles.

Cottonwood Creek Unit. The Cottonwood Creek Unit covers the broad alluvial plain formed by the creek along the southwest edge of Shasta County. The unit is located south of Happy Valley and includes Sections 1 through 12 in Township 29 North, Range 4 and 5 West. With the exception of the City of Cottonwood's municipal water supply, all waters sampled were from irrigation wells. Data from 13 wells and 16 analyses in the area were examined. The tabulation in Table 6 shows the excellent quality of ground water in this area.

TABLE 6

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS IN WATER FROM WELLS ALONG COTTONWOOD CREEK

	Constituents (in parts per million)									
Range	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	Percent Na
				Depth 100 - 500'						
Max.	23	9.7	16	108	5.0	3.9	2.3	154	65	35
Med.	11		12	94	2.2	3.6	1.5	139	58	32
Min.	10	2.3	11	90	0.5	1.8	0.0	127	52	26

An examination of the well logs in the Cottonwood Creek area indicates that most of the wells have penetrated the Tuscan and Tehama formations. Geologic evidence indicates that the Tuscan and Tehama formations are interfingered in this part of the basin.

Sacramento River Unit. The Sacramento River Unit includes those areas adjacent to the Sacramento River covered by recent or older terraced alluvial material (see Plate 3). It extends from Redding on the north to the southern boundary of Shasta County and averages more than 2 miles wide. Included in this area is the lower end of Churn Creek known as Churn Creek Bottoms and the wells located in canyons dissecting the terraces formed by the Red Bluff formation west of the Sacramento River. In local areas there is a high concentration of wells because of suburban development. Most of the wells in this unit are used for domestic purposes. Ninety-two analyses from 66 wells in the unit were examined. Table 7 shows the ranges of concentration of mineral constituents from wells in this part of the basin.

The alluvium in the Sacramento River flood plain averages 20 to 30 feet deep with a maximum of 50 feet in the Churn Creek Bottoms. Old terrace alluvium on the valley sides is probably 20 to 30 feet thick. Most wells in the area penetrate the alluvium and go into the Tehama and Tuscan formations. There are a number of wells in Churn Creek Bottoms whose depth varies from 40 to 80 feet. In some cases perforations start 20 feet below the surface. The wells draw water from the recent alluvium as well as the Tuscan and Tehama formations. This is an area that has undergone considerable housing development and most of the shallow wells are primarily for domestic purposes. The high percentage of sodium is probably caused by the addition of sodium chloride to the ground water supply from domestic discharge and irrigation.

TABLE 7

RANGES OF CONCENTRATIONS OF MINERAL
CONSTITUENTS IN WATER FROM
WELLS ADJACENT TO SACRAMENTO RIVER

	Constituents (in parts per million)									Percent
Range	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	Na
				Depth 0 - 100'						
Max.	31	22	71	176	17	30	8.1	203	167	96
Med.	14	18	9.4	148	7.2	3.2	0.3	186.5	118	15
Min.	1.7	0.5	4.9	90	5.1	3.0	0	126	6	13
				Depth 100 - 400'						
Max.	16	13	66	149	21	43	1.7	244	77	98
Med.	9.6	7.8	30	120	0.6	5.2	0.6	151	64	45
Min.	0.8	0.2	8.3	91	0	1.9	0.3	129	3	19

Stillwater Plains Unit. The Stillwater Plains Unit is an elevated terrace east of the Sacramento River. It extends from the northern end of the basin south to the confluence of the Sacramento River and Cow Creek. It includes the drainages of Churn and Stillwater Creeks. Most of the area is underlain by the Red Bluff formation. The marine cretaceous Chico formation is exposed at the head of Churn Creek. Both Churn and Stillwater Creeks have cut through the Red Bluff formation, and the Tucsan formation is exposed along the margins of the alluvium. The upper reaches of Stillwater Creek are underlain by Plio-Pleistocene gravels.

The northern portion of this unit is one of the areas where the Chico formation is encountered at a relatively shallow depth. Wells penetrating the Chico formation constitute a potential hazard because the connate waters of the Chico formation could enter and impair the ground water in other formations. Adequate protection is necessary to prevent this. One hundred and nineteen analyses from 32 wells were examined. Table 8 shows the ranges of concentration of mineral constituents found.

TABLE 8

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS IN WATER FROM WELLS ON THE STILLWATER PLAINS

Range	Constituents (in parts per million)									Percent
	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	Na
				Depth 0 - 100'						
Max.	36	21	500	201	26	744	3.5	1460	125	94
Med.	7.4	8.0	30	148	8.0	68	1.6	164	72	35
Min.	40	0.7	8.8	58	0.8	2.1	0.0	80	13	25
				Depth 100 - 200'						
Max.	20	14	226	237	118	200	3.4	732	85	98
Med.	8.3	6.5	14	118	17	53	1.0	143	52	33
Min.	2.5	0.6	7.7	19	0.0	0.6	0.0	89	8	26
				Depth 200 - 400'						
Max.	244	51	8470	254	7.7	13400	5.3	22400	818	95
Med.	11	8.0	18	137	2.0	9.8	1.0	168	71	35
Min.	8.0	6.3	9.9	76	0.5	6.6	0.1	113	53	27

Although the median values indicate an excellent quality water, the maximum analyses on the above table illustrate clearly the potential hazards to the ground water basin from wells which have penetrated the Chico formation.

Cow Creek Unit. The Cow Creek Unit includes the drainage area of Cow Creek and its numerous tributaries. The area is bounded by the Klamath Mountains on the north and the Sacramento River on the south. The Tuscan formation is exposed over most of the area, but the Chico formation outcrops extensively in the east and to some extent in the north. The area is an important recharge zone for the Redding Basin.

The majority of the wells are located close or adjacent to Cow Creek and its tributaries. The marine Chico formation within portions of this area can be found close to the surface; its connate waters cause impairment to the ground water body if penetrated by a well. Sixty-seven analyses of water from 17 wells were examined. Table 9 shows the variation in mineral constituents found in well waters in the area.

The high values for sodium chloride and percent sodium illustrates clearly the possible impairment of the ground waters by the connate waters in the underlying Chico formation.

TABLE 9

RANGES OF CONCENTRATIONS OF MINERAL CONSTITUENTS IN WATER FROM WELLS IN THE COW CREEK UNIT

	Constituents (in parts per million)									Percent
Range	Ca	Mg	Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness as $CaCO_3$	Na
				Depth 0 - 200'						
Max.	38	16	546	182	128	744	33	1590	159	92
Med.	17	8.0	12	145	60	7.0	0.7	220	79	43
Min.	4.5	0.5	4.8	18	3.0	3.8	0.3	45	13	17
				Depth 200 - 700'						
Max.	21	96	615	221	95	881	3.9	1600	79	94
Med.	18	68	18	115	4.9	3.6	1.0	172	72	34
Min.	13	21	2.0	60	0	0.5	0	66	41	9

Salt Water Wells

The cretaceous Chico formation is of marine origin. It consists of interbedded shales and sandstones. Marine waters were trapped when the Chico formation was deposited. In some cases the connate water is under greater hydrostatic pressure than ground water in the overlying Tuscan and Tehama formations. This is due to pressures from higher recharge elevations or burden on the overlying formations and confinement by the shale members in the Chico formation which act as aquicludes. The Chico formation outcrops extensively in the western and northwestern portion of the basin along the tributaries feeding Cow Creek and the upper reaches of Cow Creek. It is also exposed along the headwaters of Churn and Stillwater Creeks north of Redding. There are also exposures of the Chico formation in the Clear Creek drainage and other creeks draining into the Sacramento River from the west (see Plate 5).

Well logs along Cow Creek near Palo Cedro and discussions with drillers indicate that there are wide areas in the western part of the Redding Basin where the Chico formation underlies the Tuscan formation at depths of 50 feet below ground surface. Plate 5 shows approximate contours of the depth to the Cretaceous based on well log information available. Plate 2 shows the location of some of the saline wells.

Table 10 shows the high chloride content encountered in wells which have penetrated the Chico formation; a comparison of these values with the values shown in Tables 5 through 9 emphasizes the difference in quality between the connate waters in the Chico formation and the

TABLE 10

SALINE WELLS IN REDDING BASIN

Location	Date	Depth to Chico Formation	TDS ppm	Cl ppm	Na ppm	%Na	E.C.
30N/5W-15R1	5-27-63	500	137	2.5	17	40	179
	8-25-64	---	---	2.3	18	--	187
	8-23-65	---	---	---	16	--	187
31N/3W-3K1	10-16-57	---	310	80	79	70	477
31N/3W-17E1	7-53	---	---	4750	3040	--	---
31N/4W-22H1	8-15-57	705	---	3.9	14	34	197*
	8-15-57	---	---	72	84	32	2555**
	8-15-57	---	---	197	198	96	1042***
31N/4W-25Q1	9-10-57	775	---	244	170	78	1002
	9-17-57	---	---	149	104	73	708
31N/4W-25Q2	9-17-57	---	---	237	156	79	1135
31N/4W-31D1	12-21-64	---	148	22.1	34.1	--	---
	7-25-65	---	---	138	---	--	---
	8-5-66	---	408	124	86	--	---
31N/5W-12N3	6-25-62	182	261	54	57	64	404
	5-27-63	---	278	65	65	69	440
	8-25-64	---	---	66	68	--	458
31N/5W-14E2	10-18-56	148	553	224	164	79	951
	2-2-60	---	8800	5290	2890	83	14400
31N/5W-14E5	8-27-59	241	26900	16400	9220	87	40500
32N/3W-17E2	10-25-55	65	3310	1620	1170	92	5740
(This well within a few feet of 17E1. 17E1 log used.)	9-25-57	---	2330	1160	830	92	4170
	8-14-58	---	728	329	256	93	1370
	3-30-59	---	2090	1030	750	93	3770
	7-14-59	---	2820	1420	995	92	5050
	7-25-60	---	2530	1260	892	92	4370
	2-27-62	---	485	211	167	92	905
	6-25-62	---	1730	839	615	93	3191
	6-24-63	---	2440	1200	862	92	4320
	8-26-64	---	1590	744	546	92	2860
32N/3W-20P1	7-25-60	125	135	15	18	39	203
	6-25-62	---	117	7.4	12	30	175
	6-24-63	---	122	8.9	13	31	182
	8-26-64	---	---	34	45	--	322
	8-23-65	---	---	---	14	--	213
	7-26-66	---	162	14	21	--	274
32N/3W-32E2	7-27-56	500	128	2.5	16	41	154
	7-24-57	---	1600	887	615	94	3050
32N/3W-32J2	7-25-60	---	305	32	34	32	463
	8-25-61	---	313	32	34	31	475
	6-25-62	---	246	28	30	36	368
32N/3W-32M1	4-17-56	114	1950	1010	579	74	3530
32N/3W-35C1	10-26-55	200	173	5.2	20	39	204
	8-13-58	---	176	3.4	17	33	213
	7-14-59	---	256	5.4	44	53	382
	7-25-60	---	290	74	55	57	440
	11-15-61	---	117	3.1	16	32	203
	6-25-62	---	236	44	40	51	353
	5-27-63	---	239	42	38	50	340
	8-25-64	---	---	51	43	--	388
	8-23-65	---	---	---	18	--	215
	8-26-66	---	---	3.9	--	--	208
32N/4W-9R1	10-25-55	---	22400	13400	8470	95	35100
32N/4W-13G1	7-26-56	---	737	200	266	97	1190
32N/4W-14F2	7-25-60	180	129	7.3	25	58	197
	8-8-61	---	144	2.4	46	92	197
	6-25-62	---	84	4.8	11	44	113
	6-24-63	---	79	5.0	8.2	33	110
	8-26-64	---	---	10	39	--	210
32N/4W-14G1	4-17-56	---	1350	476	515	98	2300
32N/4W-16B1	12-2-55	---	2140	1120	797	95	3820
32N/4W-20L1	4-17-56	---	1460	744	500	88	2640
32N/4W-27D1	10-22-59	230	162	2.8	29	56	224

* Sample interval 0-290
** Sample interval 320-550
*** Sample interval 580-735

waters found in the overlying formations. The median value for chlorides shown on Tables 10 through 14 range from 3.2 to 68 ppm in wells that do not have a high saline content, and TDS ranges from 137 to 186 ppm. These values are contrasted with the values obtained from saline wells in Table 15 where the median TDS is 500 ppm and values as high as 26,900 have been encountered and the median chloride value is 220 ppm and concentrations range up to 16,400 ppm. Tests have shown that the taste threshold concentration of NaCl is 345 ppm for the combined cation and anion.

The potential damage that can be done is illustrated by the case history of a well (31N/5W/14E5) drilled into the Chico formation in August of 1959. The well was drilled 500 feet deep and intercepted the Chico formation at 142 feet below ground surface. The water from the well was saline and under sufficient hydrostatic pressure to flow freely from the well. The well, although unusable, was not plugged and was allowed to discharge into Oregon Creek. Early in 1960 it became apparent that wells in the surrounding area were being degraded by saline water from this well. The TDS and chloride concentration in well No. 31N/5W/14E2, which is located a short distance east and down gradient from the flowing saline well, increased about 20 times between 1956 and 1960 (see Table 15). A well (31N/5W/14G4) 1/4 mile east, increased in chloride concentration from 6 ppm to 85 ppm between December 22, 1959 and January 25, 1960. The log from well No. 31N/5W/14E5 is incomplete and the location of perforations is not known. Since the well was artesian and allowed to flow, degradation of other wells may have taken place by the percolation of saline waters from the surface; however, even if the well had been capped, seepage could easily take place through perforations and along the casing into the overlying aquifers.

The ability of saline connate waters in the Chico formation to permeate the overlying Tehama formation is clearly illustrated by samples taken from well No. 31N/4W/22H1. The following chloride concentrations were obtained: 0-290 feet, 3.9 ppm; 320-550 feet, 72 ppm; 580-735 feet, 197 ppm. The values for sodium increased from 14 ppm to 198. These values illustrate the increasing concentration of NaCl with depth. The log of this particular well shows that the Chico formation was intercepted at 725 feet. The chemical data show that the saline waters have invaded the lower portion of the Tehama formation, probably because the connate waters are under a higher hydrostatic head.

Another illustration is the case of well No. 32N/3W/32E2. The well is reported to be 500 feet deep, the bottom 180 feet in cretaceous sediments. A sample taken July 27, 1956 showed 2.5 ppm chlorides. A sample taken on July 24, 1957, after a year of use, had a chloride concentration of 887 ppm. The cone of depression created during pumping lowers the head and allows the saline water to invade the overlying aquifers.

There are 27 water wells in the Redding Basin which appear to have penetrated the Chico formation; in four or five of these wells the saline waters have been allowed to degrade the ground water in the overlying aquifer. Well standards implemented in the county should be cognizant of this problem and include steps to eliminate it.

Methane was detected in two wells drilled by the Cascade Community Services District south of Redding. The wells are located in T31N/R4W, Section 31. The wells apparently did not penetrate to the Chico formation, but a log of one of the wells and other geological data (see Plate 5) indicate that the wells may have bottomed close to the Chico formation. The methane is believed to be due to diffision of methane present in the Chico formation upward into the overlaying Tehama formation.

Bacteriological Contamination

There are several areas in the Redding Basin with wells which have been reported to contain coliform bacteria. Ground water is an unnatural habitat for coliform organisms. Their presence in well water indicates that poor quality water or pollutants are affecting the well and should be investigated if the well is used for domestic purposes. The presence of coliform organisms indicates the possibility of pathogenic organisms.

Coliform organisms are an indication of contamination and suggest that surface waters are seeping into the well water. There are several causes for these pollutants: (1) inadequate disinfection during well development; (2) improper or poorly sealed casing, permitting surface water to percolate down along the side of the casing; (3) locating the well in close proximity to septic tanks, sewer lines, or leach lines; and (4) direct entry into the well of foreign matter or surface water because of improper capping of the casing or a poorly designed air vent.

From 1959 through 1965 a number of bacteriological analyses were made by the Shasta County Health Department. Plotting the analyses which showed a coliform count on a map of the Redding Basin area reveals a distinct pattern; the wells which have a coliform count are clustered in five distinct areas. One area is south of Redding adjacent to Oregon Gulch in T31N/R5W, Sections 13 and 14. Another area is in Churn Creek Bottoms T31N/R4W, Sections 21 and 28. The other three areas are located in the Stillwater Plains unit T31N/R4W, Sections 9, 16, and 18.

The area in T31N/R4W, Section 16, is a housing development where the wells have been buried. The wells vary from 140 to 180 deep, and the water level is approximately 80 feet. The casing is just about 6 inches below ground and capped. The water and air lines are run to a garage where the pressure tank is located. The disadvantage of this type of installation is that if access to the well develops along the casing or in the cap surface, infiltration would have a direct access to the ground water, carrying with it solutes from sewage surface water, fertilizing agents, pesticides, and herbicides.

The Churn Creek Bottoms area has been flooded on occasion. This illustrates the need for a properly designed surface installation, with venting that will allow air to enter the well, but exclude water and other foreign matter. Wells in this area are shallow, averaging about 50 feet, with perforations frequently starting within 30 feet of the surface; in two cases perforations commenced 4 feet below ground. In locations where the ground water is within 20 feet of the surface, proper sealing should be carried down to the ground water table to provide adequate protection.

The area south of Redding, T31N/R5W, Sections 13 and 14, is known locally as Bonnyview. The area has numerous houses on small lots with individual disposal and water systems. The area was repeatedly plagued with high coliform counts. The ground water table in the area is between 20 and 30 feet below ground level, and some wells indicate that there is perched water at 2 to 3 feet. The situation illustrates the possibility of contamination in a high density area without adequate spacing between water and septic systems. The area has since constructed a municipal water system.

CHAPTER V. WELL CONSTRUCTION PRACTICES IN SHASTA COUNTY

To formulate recommendations for minimum water well construction and sealing standards in Shasta County, the Department surveyed many of the existing wells to determine whether the well construction practices in use were adequate to protect the water user and the quality of the ground water. Among the items observed during these surveys of water wells were the condition and location of wells, local surface drainage, the presence of surface seals, the type of construction, and well dimensions. The distance from each well to the nearest health hazard, such as a waste disposal site, septic tank, or sewage line, was also determined where possible.

Through the winter and spring of 1966-67, seventeen licensed well drillers and two suppliers who were operating in Shasta County were interviewed to obtain information regarding the materials and methods used during well construction. These interviews provided valuable information on well construction practices in Shasta County. Tables 11 through 14 show a breakdown of the pertinent information obtained from the water well construction survey for Shasta County.

TABLE 11*

WATER WELL CONSTRUCTION SURVEY
SHASTA COUNTY

Survey Item	Redding Basin					Total Redding Basin No.	Fall River Valley No.	Shasta County No.
	Happy Valley No.	Cottonwood Creek No.	Sacramento River No.	Stillwater Plains No.	Cow Creek No.			
Type of Construction								
Churn Drill	161	32	229	133	89	644	76	720
Rotary Drill	0	0	4	0	0	4	0	4
Total	161	32	233	133	89	648	76	724
Depth in Feet								
0 - 50	36	0	114	20	5	175	4	179
51 - 100	39	13	88	42	55	237	37	274
101 - 200	56	13	17	63	25	174	19	193
201 - 300	25	2	10	5	3	45	5	50
300+	5	4	4	3	1	17	11	28
Diameter in Inches								
Less than 6	0	0	0	0	0	0	0	0
6 - 8	156	27	218	122	78	601	60	661
10+	5	5	15	11	11	47	16	63
Type of Casing								
Metal	159	32	233	132	89	645	74	719
Concrete	0	0	0	0	0	0	1	1
None	2	0	0	1	0	3	1	4
Depth of Casing								
Full	144	22	219	115	71	571	44	615
Partial	15	10	14	17	18	74	31	105
None	2	0	0	1	0	3	1	4

* No. denotes number of wells

Type of Well Construction

The methods of well construction may be classified as drilled, dug, driven, or jetted. Within Shasta County all of the above methods of well construction have been used, with the possible exception of jetting, but cable tool drilling is the most common. Each well construction method has certain economic advantages. Selection of the type of well construction is primarily based on the characteristics of the strata encountered, ground water conditions, sanitary protection required, and cost to produce a satisfactory well.

In the Redding Basin and Fall River Valley, cable tool drilling is the most predominant method used because of the gravelly nature of the sediments in the area. Occasionally rotary hydraulic methods have been attempted, but they have not proven very satisfactory in the basin sediments. Only one well driller reported using rotary methods in the valley. Rotary methods have been used in the volcanics of eastern Shasta County and one rotary percussion drill rig operating in the county confines his drilling exclusively to volcanic sediments or hard rock.

In the past, dug wells have been put in, but they are seldom constructed by licensed well drillers, and it is difficult to check on them. Dug wells generally require larger excavations, are limited to relatively shallow depths, and are confined to loosely consolidated deposits which are easily excavated. Although dug wells may furnish adequate ground water supply, satisfactory sanitary conditions are difficult to maintain due to the inherent construction limitations of this type of well.

The great majority of the wells in the Redding Basin are from 6 to 8 inches in diameter and are listed as domestic. One driller felt that 8 inches should be the minimum size for a domestic well. Three drillers said that 10 gauge should be the minimum weight of casing. Table 12 is a breakdown of the recommendations by most of the drillers in Shasta County for casing weights by hole diameter and depth.

Metal casing is the most common method of lining wells in Shasta County. Within the past 15 years none of the drillers interviewed had used any other method of lining their wells. All of the drillers stated that the well should be cased the full length of the hole in unconsolidated or semi-consolidated sediments. They also stated that, if possible, the well should be cased to an impervious formation in wells drilled in consolidated sediments. All of the drillers felt that watertight joints are essential. Fourteen of the drillers use butt-welded joints, five use threaded joints. Some drillers will use a collar welded at each end to the casing instead of a true butt weld.

Three types of performations are used: 3/16-inch holes or slots cut in the casing with a welding torch, milled or chisel-punched slots, and holes punched with a casing perforator after placement. Holes cut

TABLE 12

SHASTA COUNTY WELL DRILLER RECOMMENDATIONS FOR WELL CASING

Well Casing Diameter in Inches

Well Depth in Feet	4		6		8		10		12		14		16		18		20+greater	
	Ga	No	Ga	No	Ga	No	Ga	No	Ga	No	Ga	No	Ga	No	Ga	No	Ga	No
50	12	10	12	9	12	9	12	1							A 3/16 - inch or thicker casing is used for wells 18 inches or greater in diameter, or where required by depth			
	10	3	10	4	10	5	10	9	10	8	10	1						
							8	1	8	3	8	5	8	5				
100	12	9	12	9	12	1												
	10	3	10	4	10	10	10	8	10	6	10	1						
					8	1	8	3	8	5	8	5	8	5				
150	12	9	12	4														
	10	3	10	8	10	8	10	7	10	1								
					8	3	8	5	8	5	8	5						
200	12	5																
	10	8	10	9	10	7	10	6	10	1								
			8	2	8	3	8	5	8	5								
300	10	9	10	7	10	4	10	1										
	8	1	8	3	8	5	8	5										
400	10	7	10	4	10	1												
	8	3	8	5	8	5												

Ga - Gage
No - Number of drillers recommending gage at a particular diameter and depth.

with a welding torch are the most common; one argument presented in favor of this method is that the oxide deposit minimizes corrosion around the holes. None of the drillers felt that well screens were necessary. Table 13 shows the type of perforations preferred by drillers. Frequently the specific conditions at the well dictate the type of perforation required.

TABLE 13*

TYPE OF CASING PERFORATIONS PREFERRED BY DRILLERS

Preperforated			Perforated After Placement	
Cut With Welding Torch	Milled Slots	Chisel-Punched Slots	Mills Knife	Total
8	2	6	3	19

* Number of drillers interviewed.

Surface Drainage

Any surface waters which enter wells can cause impairment to the quality of water in the well and to ground water in the vicinity of the well. Surface waters, depending on their previous environment, may carry pollutants from many sources, among which are barnyards, streets, irrigated fields, and sprayed or fertilized areas. Shallow wells are especially subject to impairment from surface flow. Natural surface flow should always be directed away from a well.

All well drillers reported that they try to prevent the entry of flood waters or surface waters into wells. Most of the drillers interviewed felt that 6 inches of casing extending above ground is the minimum; however, the variation in distance that was recommended ranged from 2 inches to 1 foot. In suburban areas, pump installations below ground level are not uncommon. These installations require a small excavation in the ground and the termination of the well casing below the natural ground surface. Most of the drillers felt that if cognizance was taken of the surrounding terrain and drainage conditions, such an installation was entirely satisfactory.

Surface Sealing

Openings into a well at the surface should be sealed or constructed in a manner to prevent surface water or other foreign matter from entering the well. To prevent surface water from moving down along the well casing, a concrete pedestal should be constructed around the well and extend several feet laterally. The platform of the pedestal also normally serves as a base for the pump. Surface construction features are shown in Figure 2. In cases where the pump is installed directly over the casing, watertight seals should be provided between the pump and the casing, the pump and the pedestal, and the pump and the column pipe. Figure 3 illustrates two typical properly constructed domestic well installations.

One of the drillers stated that he did not feel a concrete platform was necessary around the casing on domestic installations using a submersible pump or jet pump. He stated that it was not necessary for additional sealing from surface water impairment.

All of the drillers felt that an adequate seal could be achieved by pumping bentonite (hydrogel) into the annular space between casing and ground. The opinions expressed on the minimum depth of sealant required to produce a satisfactory seal varied from 10 feet down to water table, or 75 feet whichever was greater. Their recommendations are shown in Table 14.

Gravel-packed wells are rarely used in the Redding Basin, but all of the drillers felt that at least 10 feet of cement grout or clay on top of the gravel was necessary.

TABLE 14 *

DEPTH OF SANITARY SEAL USED IN SHASTA COUNTY

0' - 10'		11' - 20'		21' - 30'		31'+		Total	
No.	%	No.	%	No.	%	No.	%	No.	%
1	8	4	33	3	25	4	33	12	100

* Number of drillers interviewed.

All of the drillers interviewed recommended rubber gaskets for pumpseals. Present practice is to install them on a pump between the pump and the well casing (see Figures 2 and 3).

The results of interviews with well drillers indicate that the well owners dictate to a great extent the type of well, pump, and pedestal mounting that shall be used. To save money, the individual almost invariably requests the most economical, and a frequently ineffective type of installation.

Water Supply and Waste Disposal

The disposal of wastes upon or below the ground surface creates a potential source of impairment to ground water. In many cases, water supply systems and their related disposal facilities have been constructed by individuals without benefit of supervision or knowledge of the hazards involved. Proper design and overall layout of both these systems is necessary to safeguard the quality of underground water from industrial and domestic waste. The distance between the waste disposal and water supply should be sufficient to prevent transfer of deleterious chemical constituents or of bacteria.

In suburban areas, frequently the source of domestic water supply and the waste disposal systems are confined within the property lines of relatively small lots. Where this crowded condition exists, special attention should always be given to using the maximum natural purifying capacity of the ground through the design of well annular seal and depth of perforations. The relative locations of water supply and waste disposal systems also should be chosen to minimize any danger to or from neighboring water users.

Because ground water quality may be endangered by the disposal of wastes into the ground, it is essential to plan for, recognize, and understand the following factors: amount and type of waste water discharged, direction of the gradient of surface and underground flow, the

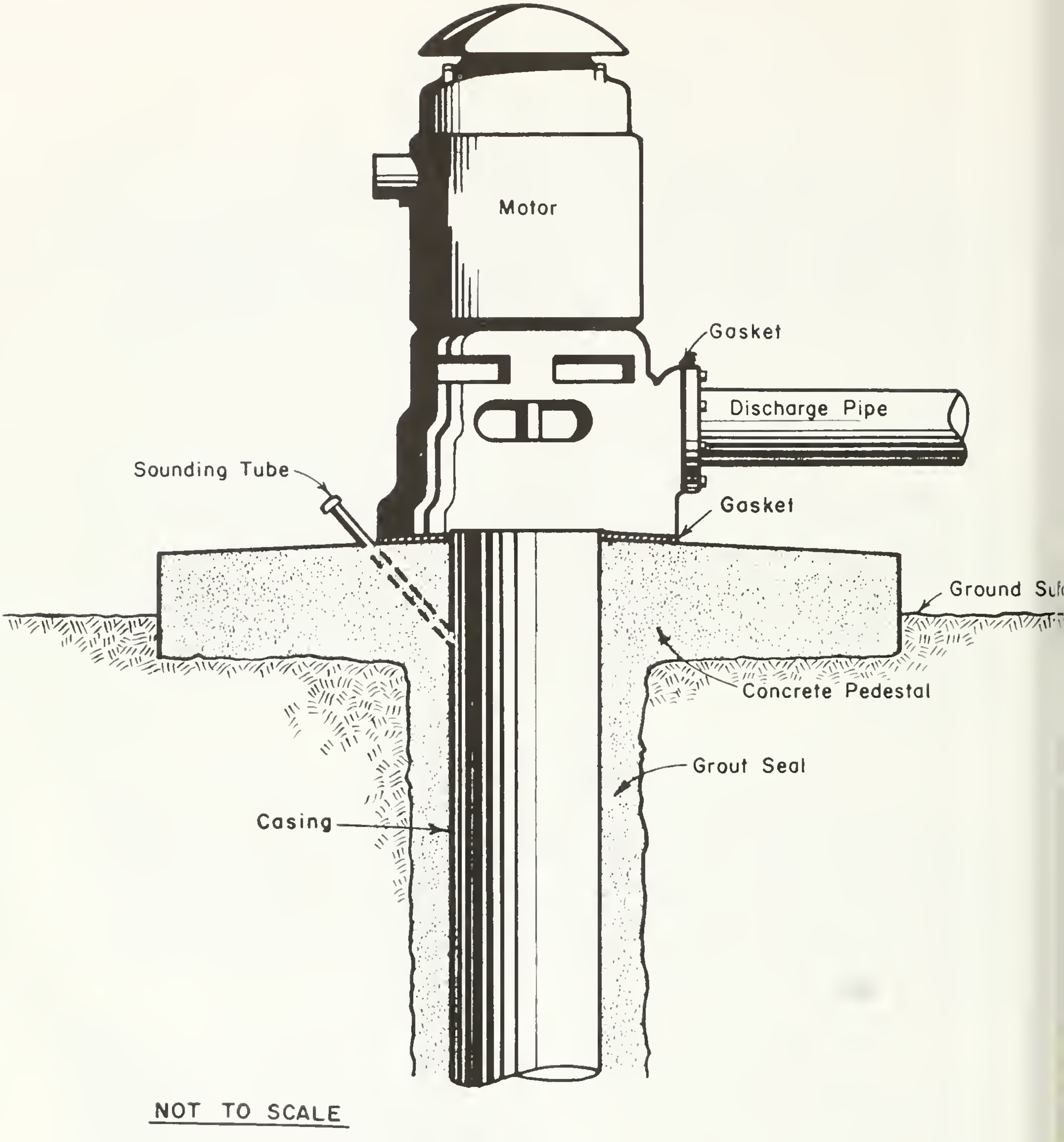


Figure 2

SURFACE FEATURES OF A PROPER
WATER WELL INSTALLATION

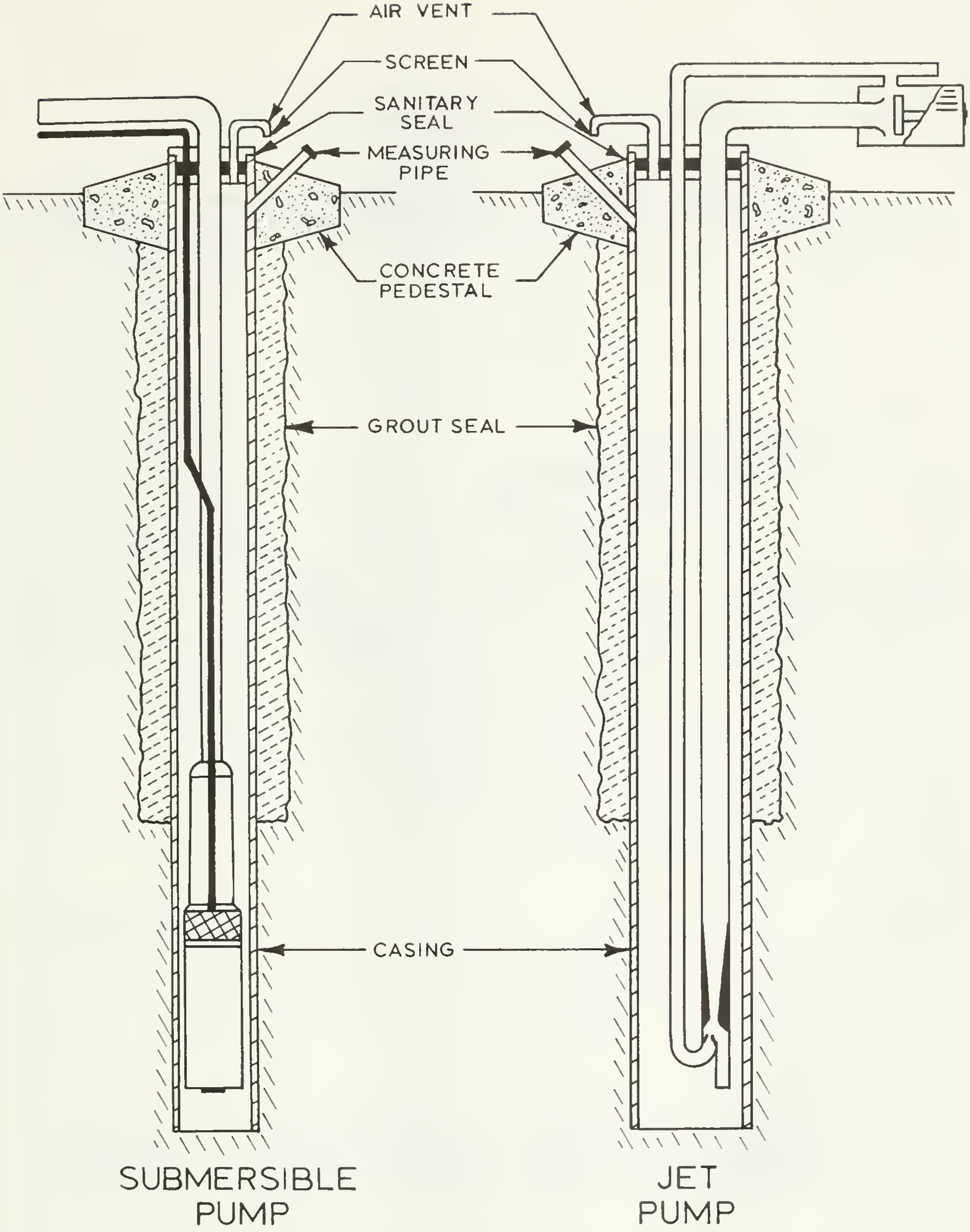


Figure 3

TYPICAL DOMESTIC WELL INSTALLATION

horizontal and vertical distance between the waste disposal and water supply sites, and the geologic nature of underground formations.

When water is pumped from a well, drawdown of the water level usually creates a cone of depression in the underground water surface. This drawdown cone of depression may cause a reversal of the ground water gradient in the vicinity of the well. Drawdown effects are illustrated in Figure 4.

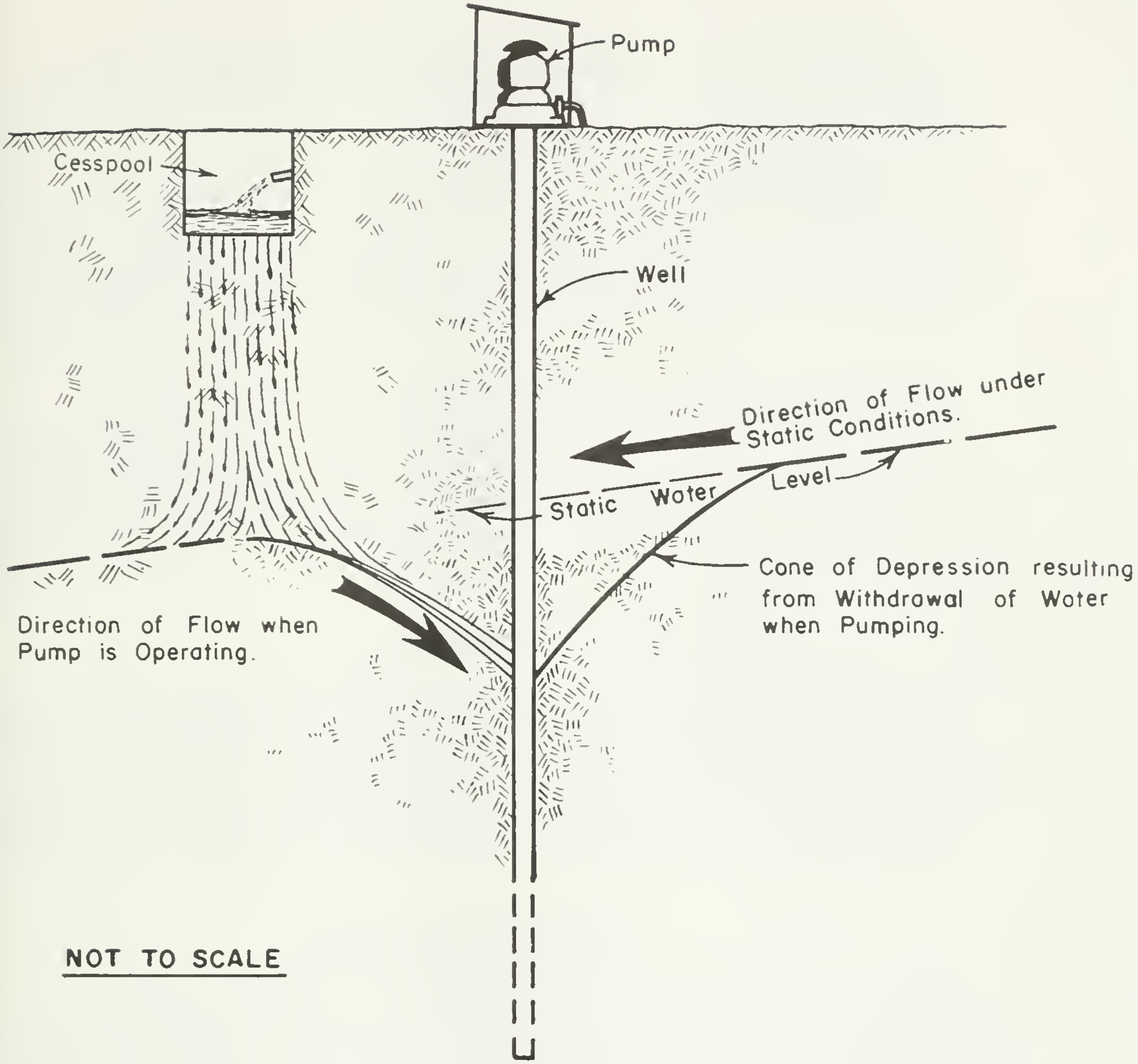


Figure 4

EFFECT OF REVERSAL OF GROUND WATER GRADIENT NEAR A WELL DUE TO PUMPING

CHAPTER VI. RECOMMENDED WATER WELL STANDARDS

The objective of prescribing minimum water well construction or abandonment standards is to provide reasonable protection for the ground waters of Shasta County as they exist and to assure that ground water being extracted through a well will not be unreasonably impaired before it can be put to beneficial use. As shown in previous chapters, there is considerable variation in present water well construction practices in Shasta County, and in many instances they are inadequate and provide little or no protection. Although geologic, hydrologic, and ground water conditions differ somewhat throughout the county, the standards recommended in this chapter should be satisfactory for water well construction and abandonment in all areas of the county.

Bulletin No. 74, "Water Well Standards, State of California", contains standards which are considered applicable and reasonable for use in Shasta County. They are included in Appendix F. Suggested procedures for achieving these standards are given in Appendixes G, H, and I. Where differences occur in recommended standards, it is because a situation unique to the county justifies the change. These standards are presented below.

Well Depth

It is recommended that a minimum well depth of 30 feet be established. This depth will give a minimum depth of seal of 22 feet, which should provide adequate protection to the ground water body. In those areas where the only available ground water is at a depth less than 30 feet (e.g., shallow terraces and alluvium overlying bedrock and adjacent to streams), wells should be permitted to a sufficient depth to develop an adequate water supply.

Saline Water Intrusion

Any well standards established by the county should be cognizant of the unique problems encountered because of the close proximity of the Cretaceous marine formation and the possibility of saline degradation of overlying aquifers. Conversely there are areas in the Chico formation which apparently contained little saline water initially, or have been flushed over the years.

Well standards for the Redding Basin will have to take into account both the quality of the ground water and the geologic structure. With these parameters in mind, the following recommendations are made:

1. Any well encountering water with a saline taste and where the electrical conductivity exceeds 1500 micromohos per centimeter will be sealed by grouting to a level where a four hour pumping test will produce water of acceptable quality.

2. Any well penetrating the Chico formation and pumping water from the aquifers above the Chico formation shall have the annular space surrounding the casing sealed with an acceptable clay or grout seal to a point 10 feet above the contact with the Chico formation (Plate 5).

3. Any well which intends to withdraw water from the Chico formation in an area where the water may be of acceptable quality shall be cased and have the annular space surrounding the casing sealed with an acceptable clay or grout seal to a point 10 feet below the contact with the Chico formation.

Recommended Standards for Destruction of Abandoned Wells

The following recommendations should govern the destruction of wells:

1. For purposes of definition a well is considered abandoned when it has not been used for a period of one year, unless the owner declares his intention to use the well again. As evidence of his declaration of intent, the owner shall properly maintain the well in such a way that:

    a. The well has no defects which will facilitate the impairment of quality of water in the well or in the water-bearing formations developed;

    b. The well is covered with an appropriate locked cap;

    c. The well is marked so that it can be clearly seen; and,

    d. The area surrounding the well is kept clear of brush or debris.

2. Any flowing artesian well that is abandoned and contains water with an E.C. in excess of 1500 micromhos per centimeter shall be sealed in such a manner that no water shall escape from the confinement of the casing.

Redeveloping, Deepening or Enlarging Existing Wells

Any existing well that is deepened, redeveloped, or recased shall be done in such a manner that the finished well will comply with these recommended standards.

CHAPTER VII. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Results of the studies of water quality in Shasta County are summarized in the following findings and conclusions. The recommendations are based on the findings and conclusions and emphasize the need for adopting well construction and sealing standards in Shasta County.

Findings and Conclusions

1. In parts of Shasta County, ground water, due to its general high quality, abundance, and ease of extraction, is presently and will remain one of the most important sources of water supply.

2. Ground water in Shasta County occurs primarily in two general areas: the Redding Basin and the Fall River Valley. Ground water is stored mainly within Tertiary and Quaternary sedimentary and volcanic deposits.

3. The Redding Basin is underlain by the Chico formation which contains marine connate saline water.

4. Mineral quality of the ground water in Shasta County is generally excellent and suitable for established beneficial uses. Saline water can be found at the base of Tertiary aquifers in the Redding Basin. Occasional high iron occurs in Fall River Valley water.

5. Ground water in the Redding Basin is found in unconfined aquifers at shallow depths adjacent to the Sacramento River. This increases the threat of ground water impairment by decreasing the distance wastes must travel in reaching ground water, thus limiting natural filtration provided by travel through soils.

6. Adequate rainfall and numerous streams and rivers provide an abundance of water for annual recharge of ground water basins. These recharge waters are generally excellent in quality and as long as they remain so they will tend to preserve the good quality of ground water by diluting and flushing the aquifers.

7. Even with favorable recharge conditions, both mineral and bacterial impairment of ground water has occurred in localized areas.

8. In many instances, present methods of well construction and sealing in Shasta County are inadequate to provide reasonable protection of valuable ground water supplies.

9. Improperly constructed and sealed wells probably have increased the instances of ground water impairment in Shasta County.

10. To minimize further ground water impairment in Shasta County, adequate water well construction and sealing standards must be employed.

11. As many existing wells in Shasta County are potential avenues for pollution due to their poor construction, it will be necessary to repair and improve these wells so that impairment can be minimized. This can be accomplished when a permit is issued to deepen, redevelop, or change an existing well.

Recommendations

To protect the valuable ground water resources in Shasta County, it is recommended that:

1. Adequate water well construction and sealing standards be adopted and enforced for the protection of ground water quality in Shasta County.

2. Shasta County Board of Supervisors initiate at an early date a coordinated program to provide for the adoption and enforcement of such standards.

3. The information provided in Department of Water Resources Bulletin No. 74 and in this bulletin be utilized as a guide to develop adopted standards.

4. The responsible agencies in Shasta County initiate a program to correct existing improperly constructed and abandoned wells.

It is requested that Shasta County keep the Central Valley Regional Water Quality Control Board and this Department informed of any steps taken pursuant to these recommendations.

APPENDIX A

BIBLIOGRAPHY

APPENDIX A

BIBLIOGRAPHY

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APPENDIX B

DEFINITION OF TERMS

DEFINITION OF TERMS

The following definitions apply to terms used in this report:

Abandoned Well - A well whose original purpose and use has been permanently discontinued or which is in such a state of disrepair that its original purpose cannot be reasonably achieved.

Active Well - An operating water well.

Anions - Anions are ions which carry a negative electrical charge. These usually are acids. Anion concentrations usually measured include carbonate and bicarbonate, sulfate, chloride, nitrate, and fluoride.

Annular Space - The space between two well casings or a well casing and the drilled hole.

Aquifer - A formation or part of a formation which transmits water in sufficient quantity to supply pumping wells or springs.

Aquiclude - A formation which, although porous and capable of absorbing water slowly, will not transmit it fast enough to furnish an appreciable supply for a well or spring.

Bentonite - A soft moisture absorbing clay of volcanic origin. Some bentonites swell on contact with water and are used for sealing the annular space in wells.

Casing - A tubular retaining structure, generally metal or concrete, which is installed in the excavated hole to maintain the well opening.

Cations - Cations are ions which carry a positive electrical charge. Usually these are metals. Cation concentrations usually measured include calcium, magnesium, sodium, and potassium.

Cement Grout - A fluid mixture of cement and water of a consistency that can be forced through a pipe and placed as required. Various additives, such as sand, bentonite, and hydrated lime are included in the mixture to meet certain requirements.

Churn Drilling (Cable-Tool) - The hole is drilled by a heavy bit which is alternately raised by a cable and allowed to drop, breaking and crushing the material which it strikes. The material is removed from the hole by bailing or sand pumping.

Clay - A predominantly fine-grained material (having a large proportion of grains less than 0.005 millimeter in diameter) which has very low permeability and is plastic.

Coliform Bacteria - Coliform bacteria grow in the intestinal tract of humans and warm-blooded animals and thus their presence in water indicates the presence of wastes from these sources. It is easy to test for the presence of coliform bacteria. This test has come to be widely accepted as an indicator for the sanitary quality of water.

Conductor Pipe or Casing - A tubular retaining structure installed between the drilled hole and the inner casing, generally in the upper portion of a well.

Cone of Depression - The water surface in the water-bearing formation within the area of influence of a pumping well. It resembles the shape of a cone with its apex at the water level in the well after drawdown.

Confined Ground Water - A body of ground water overlain by material sufficiently impervious to sever free hydraulic connection with overlying ground water except at the intake. Confined ground water moves in conduits under pressure due to the difference in head between the intake and discharge areas of the confined water body.

Connate Water - Water trapped in pore spaces of rocks at time rock material was deposited. It may be derived from either ocean water or land water, but is usually highly saline.

Contamination - Defined in Section 13005 of the California Water Code: "...an impairment of the quality of the waters of the State by sewage or industrial waste to a degree which creates an actual hazard to the public health through poisoning or through the spread of disease." Jurisdiction over matters regarding contamination rests with the State Department of Health and local health officers.

Degradation - Impairment in the quality of water due to causes other than disposal of sewage and industrial waste.

Destroyed Well - A well that has been filled or plugged so that it will not produce water nor act as a conduit for the movement of water.

Deterioration - An impairment of water quality.

Drilled Well - A well for which the hole is generally excavated by mechanical means such as the rotary or cable tool methods.

Formation - A fairly widespread group of rocks or unconsolidated materials having characteristics or origin, age, and composition sufficiently distinctive to differentiate the group from other units. The formation is the fundamental geologic unit.

Free Ground Water - A body of ground water moving under control of the water table slope.

Gravel-packed Well - A well in which a gravel envelope is placed in the annular space to increase the effective diameter of the well, and to prevent fine-grained sediments from entering the well.

Ground Water - That part of subsurface water which is in the zone of saturation.

Ground Water Basin - An area underlain by permeable materials which are capable of furnishing a significant water supply; the basin includes both the surface area and the permeable materials beneath it.

Impairment - A change in quality of water which makes it less suitable for beneficial use.

Industrial Waste - Defined in Section 13005 of the California Water Code: "...any and all liquid or solid water substance, not sewage, from any producing, manufacturing, or processing operation of whatever nature."

Jet Drilling - A method of well sinking where the casing is sunk by driving while the material inside is washed out by a water jet and carried to the top of the casing by the water.

Liner - A section of casing of reduced diameter permanently installed within an existing casing to seal openings in the existing casing.

Native Water - This term, when used with respect to quality of water, signifies the quality of waters prior to development of the area by man. As a practical matter, however, it is usually used to signify the quality found at the time of the first mineral analysis of the water in areas where there are not evidences of pollution or deterioration.

Packer - A device placed in a well which plugs or seals the well at a specific point.

Perched Water - A perched aquifer is the first unconfined water encountered above the general zone of phreatic water, marked by the water table, and is a more or less isolated body of water whose position is controlled by the structure of the formation.

Perforations - A series of openings in a well casing, made either before or after installation of the casing, to permit the entrance of water into the casing.

Permeability - The permeability (or perviousness) of a material is its capacity for transmitting a fluid. Degree of permeability depends upon the size and shape of the pores, the size and shape of their interconnections, and the extent of the latter.

Pollution - Defined in Section 13005 of the California Water Code: "...an impairment of the quality of the waters of the State by sewage or industrial waste to a degree which does not create an actual hazard to the public health, but which does adversely and unreasonably affect such waters for domestic, industrial, agricultural, navigational, recreational, or other beneficial use, or which does adversely and unreasonably affect the ocean waters and bays of the State devoted to public recreation." Regional Water Pollution Control Boards are responsible for prevention and abatement of pollution.

Pressure Grouting - A method of forcing impervious grout into specific portions of a well, such as the annular space, for sealing purposes.

Saline - Water containing more than 3000 parts per million total dissolved solids.

Sewage - Defined in Section 13005 of the California Water Code: "...any and all waste substance, liquid or solid, associated with human habitation, or which contains or may be contaminated with human or animal excreta or excrement, offal, or any feculent matter."

Transmissibility - The characteristic property of the entire saturated portion of the aquifer to transmit water.

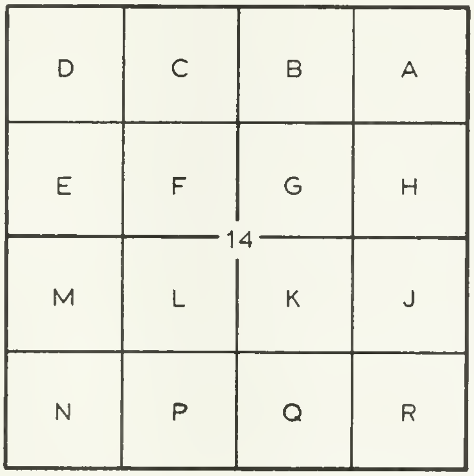
APPENDIX C

WELL NUMBERING SYSTEM

APPENDIX C

WELL NUMBERING SYSTEM

The well numbers used in this report are referenced by use of the U. S. Public Land Survey System, and to the Mt. Diablo Base and Meridian (DB&M). The well identification consists of a township, range, and section number, a letter which indicates the 40-acre plot in which the well is located, and a final number which indicates the identity of the particular well within the lot. The subdivision of a section 1 mile square is shown below:



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

For example, 31N/5W-14E2 is the second well to be identified in Lot E of Section 14 of Township 31 North, Range 5 West, Mt. Diablo Base and Meridian.

APPENDIX D

MINERAL ANALYSES OF GROUND WATER

MINERAL ANALYSES OF GROUND WATER

FALL RIVER VALLEY

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Dr. W.L. Bickel Domestic	37N/4E-1K1	5-24-58	58	912	7.7	51 2.54	32 2.62	95 4.13	8.2 0.21	0 0.00	576 9.44	1.9 0.04	1.5 0.04	27 0.44	0.1 0.01	0.1	52	Fe(dis)-0.05 Fe(total)=2.9 Al=0.12 Cu=0.02 Pb=0.0 Mn=0.39 Zn=0.12 Cr=0.0 As=0.00	553	43	258	0	DWR
		8-25-58	58	843	8.1	48 2.40	36 2.97	94 4.09	7.4 0.19	0 0.00	500 8.20	0.0 0.00	0.5 0.01	80 1.29	0.4 0.02	0.04	58		570	42	269	0	DWR
		7-27-60		869	8.0	50 2.50	35 2.85	96 4.18	7.2 0.18	0.0 0.00	0.9 8.90	0.0 0.00	0.9 0.02	52 0.84	0.2 0.01	0.25	55		564	43	268	0	DWR
		9-5-61	58	826	7.2	5.2 2.59	32 2.68	91 3.96	7.6 0.19	0 0.00	487 7.98	0 0.00	0.5 0.01	83 1.34	0.2 0.01	0.12	49	Fe(total)=1.5 Al=0.08 As=0.00 Cu=0.00 Pb=0.00 Mn-0.52 Zn=0.17	554	42	264	0	DWR
		2-20-62	52	948	7.9	50 2.50	33 2.75	96 4.18	6.8 0.17	0 0.00	648 10.62	0 0.00	0.0 0.00	0.8 0.01	0.2 0.01	0.11	50		556	43	263	0	DWR
		8-30-62		952	8.0	52 2.59	32 2.68	99 4.31	8.0 0.20	0 0.00	618 10.13	0 0.00	0 0.00	1.3 0.02	0.2 0.01	0.12	50	ABS=0.00	555	44	264	0	DWR
		8-13-63		775	7.8	48 2.39	34 2.84	95 4.13	4.3 0.11	0 0.00	511 8.39	0 0.00	0 0.00	49 0.79	0.1 0.01	0.0	42		594	44	262	0	DWR
		8-23-65		907				94 4.09					0 0.00	0.6 0.01							261	0	DWR
W.L. Bickel Domestic	37N/4E-1N1	5-24-58	55	310	7.0	30 1.50	19 1.56	26 0.11	7 0.18	0 0.00	189 3.10	0 0.00	4.0 0.11	0.5 0.03	0.6 0.01	0.0		Fe(total)=3.7	236	3	155	0	Morse Lab
R.Dimick Irrigation	37N/4E-4A1	8-10-56	55	181	7.7	12.0 0.60	5.0 0.41	20.0 0.87	3.5 0.09	0 0.00	111 1.82	1.9 0.04	4.7 0.13	0.7 0.01	0.0 0.00	0.06	51		154	44	51	0	USGS
G.E. Kelly Irrigation & Domestic	37N/4E-8G1	5-22-58	55	160	7.7	16 0.80	9.1 0.75	12 0.52	1.6 0.04	0 0.00	114 1.86	0 0.00	2.6 0.07	6.3 0.10	0.1 0.01	0.0	62	Fe(total)=0.19	166	25	78	0	Morse Lab
Pardicci & Domenici Irrigation	37N/4E-9F1	9-21-57	54	233	8.1	15 0.75	12 0.97	17 0.74	3.5 0.09	0 0.00	132 2.16	5.8 0.12	5.0 0.14	6.9 0.11	0.1 0.01	0.25	66	Sulfur smell	197	29	86	0	USGS
Laverne Parker Domestic	37N/4E-10G1	5-22-58	56	310	7.7	25 1.25	14 1.15	34 1.48	5.0 0.13	0 000	152 2.49	16 0.33	35 0.99	7.7 0.12	0.5 0.03	0.01	47	Fe(total)=0.88	259	37	122	0	DWR
Walter Callison Domestic	37N/4E-11E1	5-22-58	56	165	7.3	8.1 0.40	8.0 0.66	23 1.0	4.0 0.10	0 0.00	113 1.85	0 0.00	1.7 0.05	10 0.18	0.9 0.05	0.02	53	Fe(total)=0.10	164	46	53	0	DWR
Don Lee Irrigation	37N/4E-15C1	9-21-57	55	272	8.2	15.0 0.75	13.0 1.09	24 1.04	4.2 0.11	0 0.00	158 2.59	3.8 0.08	2.5 0.07	9.5 0.15	0.1 0.01	0.24	62		212	35	92	0	USGS
		5-22-58	59	215	8.2	22 1.10	9 0.74	21 0.91	3 0.08	0 0.00	155 2.54	0 0.00	0.3 0.01	9.0 0.15	1.1 0.06	0.0	57		197	32	93	0	Morse Lab

a Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

FALL RIVER VALLEY

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total dissolved solids in ppm[a]	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Andrew Matusk Irrigation	37N/4E-16J1	9-23-57	55	178	8.0	14.0 0.70	9.0 0.74	9.6 0.42	2.8 0.07	0 0.00	108 1.77	3.8 0.08	2.0 0.06	2.9 0.05	0.1	0.29	67		164	22	72	0	USGS
H.W. Bertholas Domestic	37N/4E-26A2	5-18-58	58	281	8.2	16 0.80	13 1.08	22 0.96	2.4 .06	0 0.00	150 2.46	9.2 0.19	3.7 0.10	7.4 0.12	0.9 0.05	0.08	53		202	33	94	0	DWR
		8-25-59		173	7.8	14 0.70	14 1.14	22 0.96	3.2 0.08	0 0.00	146 2.39	13 0.27	2.9 0.08	5.3 0.08	0.4 0.02	0.13	56		203	33	92	0	DWR
W. Jensen Stock	37N/4E-26G1	5-23-58	57	160	7.5	19 0.95	7.4 0.61	9.0 0.39	2.8 0.07	0 0.00	70 1.15	0.0 0.00	12 0.34	24 0.38	0.1 0.01	0.08	54	Fe(total)=0.38			77	0	Morse Lab
Norris Bethel Stock	37N/5E-1A2	10-7-57		328	8.4	32.0 1.60	14.0 1.16	20.0 0.87	3.9 0.10	8 0.27	206 3.38	2.9 0.06	3.0 0.08	0.6 0.08	0.0	0.03	56		241	23	138	0	USGS
Verna Cesana Irrigation	37N/5E-1C1	5-26-58	60	150	8.1	16 0.80	6.3 0.52	15 0.65	2.2 0.06	0 0.00	110 1.80	6.1 0.13	3.5 0.10	0.6 0.01	0 0.00	0.01	36	Fe(total)=0.00	140	32	66	0	USGS
		8-25-59	60	202	8.0	15 0.75	6.2 0.51	16 0.70	2.6 0.07	0 0.00	115 1.88	3.0 0.06	3.4 0.10	1.0 0.02	0.1 0.00	0.10	36		139	34	63	0	DWR
		7-27-60	60	199	7.9	16 0.80	6.6 0.54	16 0.70	2.7 0.07	0 0.00	115 1.88	74 0.15	3.7 0.10	0.4 0.01	0.1 0.00	0.04	38		147	33	67	0	DWR
		9-6-61	61	193	8.2	18 0.90	4.9 0.40	15 0.65	2.6 0.07	0 0.00	113 1.85	3.3 0.07	2.6 0.07	0.4 0.01	0.00 0.00	0.07	38		141	32	65	0	DWR
		8-30-62	62	193	8.0	18 0.90	5.6 0.49	18 0.80	3.6 0.09	0 0.00	123 2.05	4.3 0.09	2.8 0.08	0.00 0	0.1 0.01	0.03	40		126	35	70	0	DWR
Orval Cessna Irrigation	37N/5E-1P1	5-25-58	60	140	7.4	16 0.80	5.6 0.56	18 0.78	4.2 0.11	0 0.00	117 1.92	4.3 0.09	5 0.14	0 0.0	0.3 0.02	0.06	49	Fe(total)=0.00	160	35	63	0	DWR
Ross Cable Irrigation & Domestic	37N/5E-2G1	10-5-57		197	8.1	16 0.80	2.9 0.24	22.0 0.96	2.8 0.07	0 0.00	107 1.75	5.8 0.12	8.6 0.24	0 0.00	0.0 0.00	0.03	25		136	46	52	0	USGS
		5-26-58	63	150	8.1	17 0.85	1.8 0.15	19 0.83	2.4 0.06	0 0.00	100 1.64	9.1 0.19	4.0 0.11	0 0.00	.7 0.01	0.06		Fe(total)=0.00	130	44	51	0	DWR
W. Wiertzba Irrigation	37N/5E-9J1	9-25-57	58	633	8.5	22.0 1.10	22.0 1.84	84.0 3.65	6.3 0.16	16.0 0.53	331 5.43	1.9 0.04	32.0 0.90	6.4 0.10	0.1	0.03	60		414	54	147	0	USGS
Intermountain Fair Irrigation & Domestic	37N/5E-9N1	5-23-58	57	700	8.4	29 14.5	33 2.72	146 6.35	8.8 0.23	7.1	587 9.62	0.0 0.00	27 0.76	3.8 0.06	0.2 0.01	0.34	56	Fe(total)=0.11	600	59	210	0	Morse Lab
		8-25-59	60	534	8.3	23 1.15	15 1.23	74 3.22	4.4 0.11	0 0.00	330 5.41	3.0 0.06	12 0.34	4.0 0.06	0.2 0.01	0.14	62		360	56	119	0	DWR
		7-27-60	56	838	8.6	37 1.85	27 2.19	129 5.61	6.7 0.17	19 0.63	515 8.44	2.5 0.05	20 .56	3.9 0.06	0.2 0.01	0.24	58		556	57	202	0	DWR

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

FALL RIVER VALLEY

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 37N/5E-9N1	9-6-61	60	614	7.6	33 1.65	15 1.21	88 3.82	4.8 0.12	0 0.00	384 6.29	3.3 0.07	16 0.45	5.3 0.08	0.3 0.02	0.20	59	Fe(total)=0.12 Al=0.00 As=0.00 Cu=0.02 Pb=0.00 Mn=0.41 Zn=0.02	414	56	143	0	DWR
		8-30-62		690	8.6	40 2.01	13 1.05	133 5.80	5.7 0.15	0 0.80	448 7.35	3.4 0.07	23 0.65	1.0 0.02	0.4 0.02	0.2	48		474	64	153	0	DWR
Intermountain Fair Irrigation & Domestic	37N/5E-9P1	8-10-56	58	1010	7.9	50.0 2.50	28.0 2.34	157 6.83	7.0 0.18	0 0.00	663 10.87	3.8 0.08	25.0 0.70	5.4 0.09	0.2	0.22	65		669	58	242	0	USGS
		5-24-58		616	8.2	28 1.40	15 1.20	95 4.13	5.4 0.14	0 0.00	380 6.23	3.8 0.08	17 0.48	2.7 0.04	0.1 0.01	0.2	60	Fe(dis)=0.00 Fe(total)=0.18 Al=0.07 As=0.00 Cr=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.18	414	60	130	0	DWR
Albert Albaugh Irrigation	37N/5F-11K1	8-10-56		474	7.7	47.0 2.35	25.0 2.04	17.0 0.74	5.0 0.13	0 0.00	276 4.54	1.9 0.04	8.5 0.24	23.0 0.37	0.0 0.00	0.09	71		334	14	220	0	USGS
Albert Albaugh Domestic & Irrigation	37N/5E-11Q1	5-23-58	59	157	8.2	14 0.70	5.6 0.46	20 0.87	5.4 0.14	0 0.00	104 1.70	9.0 0.19	5.6 0.16	1.2 0.19	.1 0.01	.14	30	Fe(total)=0.12	142	40	59	0	Morse Lab
		5-26-58	61	147	7.4	19 0.95	6.3 .52	16 .70	2.8 .07	0 0.00	119 1.93	4.8 0.10	5.5 0.16	0 0.00	0.4 0.02	0	34	Fe(total)=0.00	157	31	72	0	DWR
Don Crumb Domestic	37N/5E-13M1	5-23-58	59	180	8.2	21 1.05	9.0 0.74	17 0.74	3.6 0.09	0 0.00	131 2.15	3.5 0.07	2.8 0.08	13.3 0.21	0.1 0.01	0.05	43	Fe(total)=0.00	172	28	88	0	Morse Lab
R. Straub Domestic	37N/5E-14R1	5-23-58	56	140	9.1	2.5 0.12	0.1 0	39 1.70	1.0 0.03	13 0.43	75 1.23	4.3 0.09	2.9 0.08	.8 0.1	.1 0.1	0.11	34	Fe(total)=0.00	101	77	4.6	0	Morse Lab
		8-25-59		190	8.2	1.7 0.09	0.1 0.00	42 1.83	1.4 0.04	0 0.00	106 1.74	5.3 0.11	3.8 0.11	0.5 0.01	0.2 0.01	0.04	41		148	93	4.4	0	DWR
		7-26-60	68	189	7.9	3.4 0.17	0.0 0.00	40 1.74	1.5 0.04	0 0.00	104 1.70	5.3 0.11	3.7 0.10	0.3 0.00	0.2 0.01	0.17	47		152	89	8	0	DWR
		9-6-61	60	177	8.2	0.7 0.03	0.8 0.07	40 1.74	1.6 0.04	0 0.00	100 1.64	4.8 0.10	2.9 0.08	0.1 0.00	0.2 0.01	0.06	46	Fe(total)=0.01 Al=0.00 As=0.01 Cu=0.02 Pb=0.0 Mn=0.00 Zn=0.02	146	92	5	0	DWR
		8-30-62		189	8.1	1.4 0.07	0.4 0.03	46 2.00	0.9 0.03	0 0.00	114 1.87	1.4 0.03	1.1 0.03	0.0 0.0	0.2 0.01	0.1	31		132	94	5	0	DWR
		8-13-63		186	8.1	1.6 0.08	0.5 0.04	42 1.83	0.9 0.02	0.0 0.00	106 1.74	3.4 0.07	4.3 0.12	0.0 0.0	0.1 0.01	0.1	29		136	93	6	0	DWR

a Determined by addition of constituents unless otherwise noted

b Analysis by indicated laboratory:
U. S. Geological Survey, Quality of Water Branch (U. S. G. S.)
State Department of Water Resources (D. W. R.)

MINERAL ANALYSES OF GROUND WATER

FALL RIVER VALLEY

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 37N/5E-14R1	8-4-64		195	9.5			40 1.74		26 0.87	53 0.87		3.3 0.09						5				DWR
		8-24-65		188				40 1.74													5.2	0	DWR
Bruce Brothers Irrigation	37N/5E-15F1	9-26-57	57	216	8.2	17.0 0.85	4.3 0.35	22.0 0.96	2.9 0.07	0 0.00	110 180	13.0 0.27	7.0 0.20	0.5 0.01	0.0 0.00	0.12	39		160	43	60	0	USGS
Albert Bruce Stock and Irrigation	37N/5E-15G2	5-23-58	61	120		6 0.30	0.1 0.00	30 1.31	1.8 0.05	0 0.00	73 1.19	11 0.23	6.0 0.17	0.7 0.01	0 0.00	0.16	46	Fe(total)=0.0		79	6	0	Morse Lab
Joseph W. Bruce Irrigation	37N/5E-15L1	10-24-57	55	199	8.2	14 0.70	3.6 0.30	20 0.87	2.[illegible] 0.06	0 0.00	94 1.54	11 0.23	53 0.15	0.4 0.01	0.1	0.09	27		130	45	50	0	DWR
Joseph W. Bruce Domestic & Irrigation	37N/5E-15L2	5-23-58	59	155	8.0	18 0.90	1.8 0.15	20 0.87	2.2 0.06	0 0.00	95 1.56	11 0.23	6.5 0.18	0.6 .01	0 0.00	0.15	25	Fe(total)=0.0	132	44	51	0	Morse Lab
Fall River Joint Unified School Dist. Domestic & Irrigation	37N/5E-16F2	5-23-58	57	390	8.5	35 1.75	19 1.56	46 2.00	4.6 0.12	11.0 0.37	230 3.77	12 0.24	15.5 0.48	27 0.44	0.3 0.02	0.04	62	Fe(total)=0.03		37	163	0	Morse Lab
Bert Peters Domestic	37N/5E-17J1	5-24-58	58	160	8.2	19 0.95	8.6 0.71	12 0.52	2.4 0.06	0 0.00	109 1.79	4.6 0.1	1.0 0.03	12.4 0.20	0.3 0.05		59	Fe(total)=0.12	173	23	82	0	Morse Lab
Reginald Reynolds Irrigation	37N/5E-19P2	5-24-58	58	340	8.2	21 1.05	16 1.32	54 2.35	5.6 0.14	0 0.00	250 4.10	0 0.00	0 0.00	50 0.81	1.1 0.06		64	Fe(total)=3.3	334	48	119	0	Morse Lab
		8-28-59	50	494	7.6	19 0.95	19 1.53	57 2.48	5.5 0.14	0 0.00	300 4.92	0.0 0.00	2.7 0.08	1.1 0.02	0.6 0.03	0.13	66		319	49	124	0	DWR
		7-27-60	59	449	8.0	21 1.05	17 1.43	49 2.13	6.0 0.15	0 0.00	252 4.13	0.6 0.01	0.5 0.01	31 0.50	0.6 0.03	0.02	66		316	45	124	0	DWR
		9-7-61	58	489	7.7	23 1.15	15 1.27	57 2.48	5.4 0.14	0 0.00	317 5.20	0.0 0.00	2.4 0.07	1.2 0.02	0.6 0.03	0.11	65	Fe(total)=1.2 Al=0.03 As=0.0 Cu=0 Pb=0 Mn=0.01 Zn=0.04	326	47	121	0	DWR
		8-13-63	59	430	7.6	19 0.96	16 1.34	56 2.43	4.8 0.15	0 0.00	248 4.06	4.8 0.10	1.8 0.05	3.2 0.52	0.2 0.01	0.1	52		180	50	115	0	DWR
		8-4-64		513	7.6			47 2.04		0 0.00	314 5.15		0.0 0.00								124	0	DWR
		8-24-65	64	500				54 2.35													120	0	DWR
Mesonic Lodge Domestic	37N/5E-20L1	5-24-58	62	150	8.2	18 0.90	11 0.91	8 0.35	4.2 0.11	0 0.00	122 1.99	6.9 0.14	0 0.00	3.3 0.05	0.2 0.1		56	Fe(total)=0.04	167	15	90	0	Morse Lab

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U. S. G. S.)
State Department of Water Resources (D. W. R.)

MINERAL ANALYSES OF GROUND WATER

FALL RIVER VALLEY

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Per-cent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Tom Hill Domestic	37N/5E-21M1	5-23-58	58	190	7.3	24 1.20	12 0.99	8 0.35	3.4 0.09	0 0.00	146 2.39	1.6 0.03	3.0 0.08	6.8 0.11	0.5 0.03	0.01	66	Fe(total)=0.00	197	13	108	0	Morse Lab
Edward Bruce Domestic & Irrigation	37N/5E-22F1	5-23-58	64	135	8.1	10 0.5	0.1 0	33 1.44	3.2 0.08	0 0.00	100 1.64	4.1 0.08	7.5 0.21	0.6 0.01	0.1 0.01	0.11	36	Fe(total)=0.14	143	71	15	0	Morse Lab
George Ingram Irrigation	37N/5E-23K1	5-23-58	52	370	8.2	35 1.75	23 1.89	28 1.22	9.2 0.23	0 0.00	202 3.29	16.3 0.34	6.5 0.18	62.5 1.04	1.2 0.06	0.01	53	Fe(total)=0.00	332	24	182	0	Morse Lab
Orville Crum Irrigation	37N/5E-24F1	5-23-58	59	150	8.2	12 0.60	6.4 0.53	22 0.96	2.4 0.06	0 0.00	116 1.90	2.5 0.05	0.9 0.03	5.4 0.09	0.1 0.01		34	Fe(total)=0.01	143	25	56	0	Morse Lab
		8-25-59	59	197	7.8	10 0.50	6.6 0.54	22 0.96	2.1 0.05	0 0.00	108 1.77	2.6 0.5	1.7 0.05	8.1 0.13	0.1 0.00	0.04	37		143	47	52	0	DWR
		7-26-60	60	186	8.0	13 0.65	4.7 0.39	20 0.87	1.9 0.05	0 0.00	105 1.72	1.2 0.02	2.3 0.06	7.9 0.13	0.1 0.00	0.10	37		140	44	52	0	DWR
		8-30-62	62	185	8.1	14	4.9	23	1.6	0 0.00	115	0.19	0.4	0.70	0.20	0	33		142	47	55	0	DWR
		8-13-63	62	185	7.8	14 0.69	3.9 0.32	22 0.95	2.1 0.05	0 0.00	109 1.78	1.4 0.03	0.0 0.00	9.2 0.15	0.1 0.01	0.0	28		132	47	50	0	DWR
		8-24-65	58	198				20 0.87													53	0	DWR
Dr. Paul Bulpitt Domestic	37N/5E-29D1	5-24-58	58	180	8.2	22 1.10	11 0.90	10 0.43	4.6 0.12	0 0.00	137 2.25	6.2 0.13	0.5 0.01	3.7 0.06	0.3 0.02	0.05	54		179	17	99	0	Morse Lab
U.S. Forest Service Domestic	37N/5E-30Q2	9-27-57		387	8.5	33.0 1.65	22.0 1.83	12.0 0.52	7.0 0.18	9.0 0.30	205 3.36	5.8 0.12	10.0 0.28	16.0 0.26	0.0 0.00	0.0	55		271	12	174	0	USGS
		5-24-58		280	8.5	34 1.70	20 1.65	13 0.57	5.8 0.15	4 0.13	210 3.44	3.9 0.08	6.7 0.19	12.4 0.01	0.2 0.01	0	57	Fe(total)=0.01	260	14	167	0	Morse Lab
Elmer A. Campbell Irrigation	37N/6E-30N1	9-25-57	63	231	8.3	7.2 0.36	1.9 0.16	43.0 1.87	2.4 0.06	2.0 0.07	139 2.28	1.9 0.04	4.2 0.12	1.9 0.03	0.00 0.00	0.00	56		188	76	26	0	USGS
Jack Kennedy Domestic	38N/3E-13M1	5-24-58	60	50	6.7	7.4 0.37	2.2 0.18	2.5 0.11	1.6 0.04	0 0.00	39 0.64	0.3 0.01	1.5 0.04	0 0.00	0.1 0.01	0.01	19	Fe(total)=0.04	54	16	27	0	Morse Lab
R.A. Peters Domestic	38N/3E-24F1	5-24-58	56	105	7.2	13 0.65	8.5 0.70	4 0.17	1.8 0.05	0 0.00	91 1.49	0 0.00	2 0.06	0.6 0.01	0.1 0.01	0	28	Fe(total)=0.03	103	11	68	0	Morse Lab
		8-25-59	68	144	7.4	11	8.6	3.6	1.0	0 0.00	84	0 0.00	1.0	1.2	0.0 0.00	0.01	37		104	11	63	0	DWR
		7-27-60		152	7.9	11 0.57	10 0.80	4 0.18	0.7 0.02	0 0.00	85 1.40	0 0.00	5 0.13	4 0.06	0.0 0.00	0	16		93	11	68	0	DWR

a Determined by addition of constituents unless otherwise noted

b Analysis by indicated laboratory:
U.S Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

FALL RIVER VALLEY

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 38N/3E-24F1	9-5-61	60	139	7.3	13 0.65	7.8 0.64	4.0 0.17	0.9 0.02	0 0.00	84 1.38	0 0.00	0.3 0.01	2.8 0.04	0.0 0.0	0.03	34	Fe(total)=0.03 Al=0.01 As-0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.48	104	11	65	0	DWR
		8-30-62		141	8.0	12 0.60	10 0.84	4.0 0.17	0.7 0.02	0 0.00	98 1.60	0 0.00	0.7 0.02	1.0 0.02	0.2 0.01	0.1	29		100	10	71	0	DWR
		8-13-63		146		13 0.65	8.0 0.66	4.5 0.20	1.0 0.03	0 0.00	90 1.48	0 0.00	0 0.00	1.3 0.02	0.1 0.01	0.0	26		106	13	66	0	DWR
		3-4-64		146	7.6			3.8 0.16		0 0.00	87 1.42		0 0.00								68	0	DWR
		8-23-65		148				4.1 0.18													66	0	DWR
Dr. Bulpitt Irrigation	38N/4E-27Q1	7-27-60	55	176	8.0	12 0.60	5.6 0.46	17 0.74	2.9 0.07	0 0.00	99 1.62	1.0 0.02	5.7 0.16	1.0 0.02	0.1 0.00	0.09	39		133	40	53	0	DWR
		8-23-65	56.5	167	8.2	12 0.60	5.4 0.44	15 0.65	2.9 0.07	0 0.00	97 1.59	1.3 0.03	6.0 0.17	0.6 0.01		0.1			132	37	52	0	DWR
C.Whipple Domestic	38N/4E-28P1	5-22-58	54	140	7.8	18 0.90	3.2 0.26	17 0.74	3.0 0.08	0 0.00	107 1.75	1.6 0.03	5.5 0.16	0.9 0.01	0.1 0.01	0	58	Fe(total)=0.00	160	37	58	0	Morse Lab
E.B.Johnson Domestic	38N/4E-30H1	5-22-58	54	180	7.8	19 0.95	14 1.12	9.0 0.39	1.4 0.04	0 0.00	144 2.36	2.0 0.04	3.5 0.10	0.8 0.01	0.04 0.00	0	69	Fe(total)=2.80	190	16	106	0	Morse Lab
		8-25-59	56	208	7.4	13 0.65	9.6 0.79	14 0.61	3.4 0.09	0 0.00	118 1.93	0 0.00	4.4 0.12	2.4 0.04	0.2 0.01	0.07			171	28	72	0	DWR
		7-27-60		213	8.1	12 0.62	10 0.83	16 0.67	3.1 0.08	0 0.00	116 1.91	0 0.00	9 0.24	3 0.05	0 0.00	0	35		146	30	72	0	DWR
		9-5-61	56	213	7.0	7.8 0.39	14 1.17	14 0.61	3.0 0.08	0 0.00	124 2.03	0.0 0.00	3.8 0.11	3.2 0.05	0.1 0.05	0.08	58	Fe(total)=3.0 Al=0.02 As=0.00 Cu=0.00 Pb=0.03 Mn=0.61 Zn=0.08	165	27	78	0	DWR
		8-30-62		208	8.1	14	11	16	2.9	0 0.00	122	0.5	5.3	2.0	0.2	0.1	49		160	30	79	0	DWR
		8-13-63	57	280	8.0	25 1.27	17 1.41	12 0.50	1.7 0.04	0 0.00	187 3.06	1.4 0.03	5.7 0.16	0 0.00	0.01 0.01	0	29		186	16	134	0	DWR
		8-4-64		228	7.0			15 0.65		0 0.00	133 2.18		5.9 0.17								83	0	DWR
		8-23-65		221				12 0.52													82	0	DWR

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by [b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Clarance Pope Domestic	38N/4E-31C1	5-22-58	51	140	7.7	19 0.95	7.7 0.63	8 0.35	0.2 0.05	0 0.00	101 1.66	0 0.00	6.0 0.17	5.3 0.09	0.05 0	0	36	Fe(total)=0.98	132	18	78	0	Morse Lab
M. Palmer Domestic	38N/4E-33L1	5-22-58	58	180	7.9	12 0.60	7.5 0.62	27 1.17	4.2 0.11	0 0.00	127 2.07	0 0.00	3.5 0.10	15.0 0.24	0.5 0.03	0	41	Fe(total)=0.66	172	47	61	0	Morse Lab
Harry Horr Domestic	38N/4E-35B1	5-22-58	60	140	8.1	6.5 0.32		41 1.78	1.8 0.05	0 0.00	117 1.92	0 0.00	3.5 .10	2.2 0.04	0.2 0.01	0.01	49	Fe(total)=0.03	162	83	5.8	0	Morse Lab
		8-25-59	58	201	7.6	2.4 0.12	0.7 0.06	41 1.78	2.3 0.06	0 0.00	114 1.87	0 0.00	41 0.12	2.4 0.04	0.2 0.01	0.09	66		175	88	9	0	DWR
		7-27-60		217	8.2	3 0.15	2 0.22	41 1.80	2.4 0.06	0 0.00	119 1.95	0 0.00	7 0.18	7 0.11	0.11 0.01	1.60	27		149	81	18	0	DWR
		9-5-61	59	192	8.1	4.4 0.22	0.0 0.00	30 1.70	2.2 0.06	0 0.00	112 1.84	0 0.00	2.4 0.07	2.9 0.05	0.2 0.01	0.09	57	Fe(total)=0.18 Al=0.00 As=0.00 Cu=0.00 Pb=0.00 Mn=0.02 Zn-0.06	163	86	11	0	DWR
A.R. Kolb Irrigation	38N/5E-25J1	8-10-58		180	8.0	13.0 0.65	7.9 0.65	15.0 0.65	3.1 0.08	0 0.00	112 1.84		1.3 0.04			0.00				32	65	0	USGS
P.G.&E. Domestic and Stock	38N/5E-29J1	5-26-58	60	610	7.5	29 1.45	24 1.98	142 6.18	17 0.43	0 0.00	563 9.22	1.2 0.02	2.5 0.07	2.3 0.04	0.4 0.02	0	63	Fe(total)=0.69	558	61	171	0	Morse Lab
P.G.&E. Stock	38N/5E-32H1	5-26-58	60	160	8.7	3 0.15	0.1 0.00	38 1.65	2.0 0.05	9.2 0.31	81 1.33	12 0.25	4.0 0.11	0.6 0.01	0.1 0.01	0	26	Fe(total)=0.00	135	89	5	0	Morse Lab
		8-25-59	60	194	8.0	0.9 0.04	0 0.00	42 1.83	1.9 0.05	0 0.00	97 1.59	8.4 0.17	5.4 0.15	0.9 0.01	0.1 0.00	0.09	24		134	95	2.0	0	DWR
		7-27-60	60	192	7.9	2.2 0.11	0.1 0.01	40 1.74	1.6 0.04	0 0.00	97 1.59	8.9 0.08	5.1 0.14	0.7 0.01	0.1 0.00	0.08	24		131	92	6	0	DWR

a Determined by addition of constituents unless otherwise noted

b Analysis by indicated laboratory:
U.S Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

HAPPY VALLEY

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Happy Valley School Domestic	30N/5W-15R1	9-17-56		166	7.7	[illegible] 0.47	7.1 0.58	17 0.74	0.7 0.02	0 0.00	105 1.72	2.9 0.06	2.6 0.07	0.1 0.00	0.2	0.00	46		138	40	53	0	USGS
		9-24-57	70	165	7.6	9.0 0.45	7.2 0.59	16 0.70	1.2 0.03	0 0.00	99 1.62	1.6 0.03	3.9 0.11	0.2 0.00	0.1	0.04	45		133		52		DWR
		8-12-58	80	168	7.9	9.6 0.50	6.1 0.50	17 0.74	0.7 0.02	0 0.00	100 1.64	1.6 0.03	2.2 0.06	0.4 0.01	0.02 0.01	0.00	40	Fe(dis)=0.20	127	42	50	0	DWR
		7-13-59		180	7.7	8.7 0.43	6.4 0.53	20 0.87	10 0.02	0 0.00	101 1.65	5.8 0.12	3.1 0.09	0.3 0.00	0.3 0.02	0.03	45		141	47	48	0	DWR
		2-20-60		163	7.9	9.2 0.46	6.3 0.52	17 0.74	0.8 0.02	0 0.00	97 1.59	1.0 0.02	3.2 0.09	0.5 0.02	0.3 0.01	0.01	46	Fe(dis)=0.09 Fe(total)=3.1 Al=0 As=0 Cr=0 Cu=0 Pb=0 Mn=0.02 Zn=0.02	132	42	49	0	DWR
		11-14-61		171	7.6	10 0.50	6.8 0.56	17 0.74	0.8 0.02	0 0.00	96 1.57	7.6 0.16	3.3 0.09	0.3 0.00	0.2 0.01	0.00	46		139	41	53	0	DWR
		6-25-62	69	169	7.8	11 0.55	6.0 0.49	16 0.70	0.8 0.02	0 0.00	92 1.51	7.6 0.16	1.8 0.05	0.3 0.00	0.3 0.02	0.00	46		135	40	52	0	DWR
		5-27-63	68	179	7.9	9.6 4.8	7.3 0.60	17 0.74	0.8 0.02	0 0.00	93 1.52	9.5 0.20	2.5 0.07	0.0 0.00	0.3 0.02	0.02	44		137	40	54	0	DWR
		3-25-64	72	187	7.7			18 0.78		0 0.00	93 1.52		2.3 0.06					Fe(total)=0.14 Al=0.01 As=0 Cu=0 Pb=0 Mn=0 Zn=0.05			57	0	DWR
		8-23-65	73	187		11		16 0.70													56		DWR
C.A. Young Domestic	30N/5W-17R1	9-24-57	67	151	7.0	9.0 0.45	5.5 0.45	15 0.65	1.1 0.03	0 0.00	89 1.46	0.2 0.00	5.3 0.15	0.1 0.00	0.7	0.02	54		135		45		DWR
		8-12-58		150	7.7	9.6 0.50	3.6 0.30	16 0.70	0.5 0.01	0 0.00	83 1.36	0.5 0.01	4.3 0.01	0.2 0.12	1.1 0.02	0.00	55		132	46	40	0	DWR
		7-13-59		152	7.0	7.7 0.38	5.4 0.44	16 0.70	0.9 0.02	0 0.00	83 1.36	0.3 0.01	4.2 0.12	0.7 0.01	0.1 0.00	0.24	56		132	45	41	0	DWR
		7-20-60		145	7.9	8.6 0.43	4.5 0.37	16 0.70	0.5 0.01	0 0.00	82 1.34	0.0 0.00	4.6 0.13	1.8 0.03	0.1 0.00	0.02	56	Fe(dis)=0.05 Fe(total)=0.36 Al=0 As=0 Cr=0 Cu=0.01 Pb=0 Mn=0 Zn=0.22	132	46	40	0	DWR

[a] Determined by addition of constituents unless otherwise noted

[b] U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total dissolved solids in ppm [a]	Percent sodium	Hardness as $CaCO_3$		Analyzed by [b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 30N/5W-17R1	11-14-61		147	7.6	9.4 0.47	4.2 0.35	16 0.70	0.6 0.02	0 0.00	83 1.36	2.5 0.05	4.3 0.12	2.1 0.03	0.1 0.00	0.02	53		133	45	41	0	DWR
		6-25-62	69	147	7.4	10 0.50	3.4 0.28	16 0.70	0.6 0.02	0 0.00	82 1.34	0.3 0.01	3.7 0.10	1.4 0.02	0.1 0.00	0.02	54		130	47	39	0	DWR
		5-27-63	66	148	7.8	8.1 0.40	4.4 0.36	16 0.70	0.6 0.02	0 0.00	82 1.34	0.0 0.00	4.4 0.12	1.0 0.02	0.3 0.02	0.06	52		137	47	38	0	DWR
		8-25-64	68	143	8.1			17 0.74		0 0.00	82 1.34		1.8 0.05					Fe(total)=0 Al=0 As=0 Cu=0.02 Pb=0 Mn=0 Zn=0.22			37	0	
		8-23-65	68	147				15 0.65													37	0	DWR
[illegible].C. Prigmore Domestic	30N/5W-22E1	8-22-59	65	146	6.9	8.6 0.43	5.2 0.43	13 0.56	0.7 0.02	0 0.00	78 1.08	0.0 0.00	4.7 0.13	2.7 0.04	0.1 0.00	0.06	55		128	39	43	0	DWR
Carl Lechner Domestic	31N/5W-18K1	1-18-62		364	7.3	36 1.80	18 1.51	12 0.52	0.1 0.00	0 0.00	154 2.52	41 0.85	12 0.34	11 0.18	0.1 0.01	1.1	33		240	14	166	40	DWR

a Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S Geological Survey, Quality of Water Branch (U. S. G. S.)
State Department of Water Resources (D. W. R.)

MINERAL ANALYSES OF GROUND WATER

COTTONWOOD CREEK

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total dissolved solids in ppm[a]	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Cottonwood Water Dept. Municipal	29N/4W-2P1	9-24-57	68	182	7.0	11 0.55	8.6 0.71	15 0.65	1.6 0.04	0 0.00	110 1.80	0.7 0.01	3.9 0.11	0.2 0.00	0.0 0.0	0.03	54		149		63	0	DWR
		8-12-58		182	8.0	14 0.70	6.6 0.54	14 0.61	0.9 0.02	0 0.00	104 1.70	1.2 0.02	2.6 0.07	2.0 0.03	0.3 0.02	0.04	53	Fe(dis)=0.00	[illegible]	33	62	0	DWR
		7-13-59		181	7.3	10 0.50	7.5 0.62	16 0.70	1.0 0.02	0 0.00	100 1.64	1.0 0.02	4.4 0.12	2.4 0.04	0.2 0.01	0.04	52		144	38	56	0	DWR
		7-20-60		169	8.0	12 0.60	7.3 0.60	13 0.56	0.8 0.02	0 0.00	95 1.56	1.0 0.02	4.0 0.11	2.4 0.04	0.2 0.01	0.03	52	Fe(total)=0.07 Fe(dis)=0.01 Al=0.0 As=0.0 Cr=0.01 Cu=0.01 Pb-0.0 Mn=0.0 Zn=0.04	140	31	60	0	DWR
		6-13-62	67	171	8.0	11 0.55	8.1 0.67	12 0.52	0.8 0.02	0 0.00	95 1.55	1.2 0.02	3.2 0.09	3.5 0.06	0.1 0	0.06	53		140	30	61	0	DWR
		5-27-63	68	193	8.0	10 0.50	9.7 0.80	16 0.70	1.0 0.02	0 0.00	108 1.77	2.5 0.05	3.9 0.11	2.3 0.01	0.2 0.04	0.04	48		143	35	65	0	DWR
		8-25-64		188	8.2			16 0.70		0 0.00	109 1.79		3.3 0.09					Fe(total)=0.00 Al=0.06 As=0.0 Cu=0.0 Pb=0.01 Mn=0.0 Zn=0.01			63	0	DWR
		8-23-65	78	196		16		16 0.70													65	0	DWR
A.E. Garcia Not Used	29N/4W-4R1	12-1-55	68	159	8.0	11 0.55	7.4 0.61	12 0.52	0.7 0.02	0 0.00	90 1.48	1.4 0.03	3.1 0.09	2.3 0.04	0.1 0.01	0.04	53		135	31	58	0	USGS
Max Hurley Irrigation	29N/4W-6N1	9-24-57	68	160	7.1	11 0.55	6.0 0.49	13 0.57	1.3 0.03	0 0.00	95 1.56	0.5 0.01	3.4 0.10	0.0 0.0	0.3 0.02	0.03	44		127		52	0	DWR
		10-12-58		164	7.9	13 0.65	5.7 0.47	12 0.52	0.7 0.02	0 0.00	93 1.52	2.0 0.04	2.0 0.06	1.3 0.02	0.2 0.01	0.05	62		145	31	56	0	DWR
		7-14-59	68	169	7.8	11	7.4	13	1.4	0 0.00	93	2.5	3.8	1.2	0.2	0.03	56		142	32	58	0	DWR
Max Hurley Irrigation	29N/4W-7F1	3-3-55	64	173	6.8	23 1.15	2.3 0.19	11 0.48	0.8 0.02	0 0.00	100 1.64	5.0 0.10	3.8 0.11	1.9 0.03	0.1	0.00	57		154	26	67	0	USGS
City of Cottonwood Municipal	29N/4W-11G4	10-10-57	66	214	7.4	17 0.85	6.9 0.57	16 0.70	1.4 0.04	0 0.00	108 1.77	1.5 0.03	11 0.31	0.7 0.01	0.3 0.02	0.16	22		130	32	71	0	DWR
Walther Irrigation	29N/5W-11C1	10-26-55	66	157	7.4	10 0.50	7.3 0.60	12 0.52	0.7 0.02	0 0.00	94 1.54	2.0 0.04	1.8 0.05	0.9 0.02	0.1	0.03	54		135	32	55	0	USGS

a Determined by addition of constituents unless otherwise noted

b Analysis by indicated laboratory:

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Jack Marlin Domestic	30N/3W-27P1	10-26-55		430		31 1.55	22 1.79	14 0.61	4.9 0.12	0 0.00	128 2.10	17 0.35	30 0.85			0.06					167	62	USGS
Balls Ferry Resort Domestic	30N/3W-34D1	9-26-57	64	211	7.5	17 0.85	12 1.01	6.9 0.30	1.3 0.03	0 0.00	115 1.88	13 0.27	2.0 0.06	1.0 0.02	0.1 0.01	0.02	46		156	14	93	0	DWR
		10-12-58		255	8.0	25 1.25	12 1.03	9.5 0.41	1.0 0.02	0 0.00	147 2.41	6.6 0.14	2.4 0.07	3.7 0.06	0.2 0.01	0.03	47		179	15	114	0	DWR
		7-13-59		256	7.5	18 0.90	13 1.06	13 0.56	1.0 0.02	0 0.00	140 2.29	4.0 0.08	3.2 0.09	6.1 0.1	0.1 0.00	0.16	49		176	22	98	0	DWR
		8-5-60		226	8.2	18 0.90	13 1.10	9.0 0.39	1.1 0.03	0 0.00	129 2.11	4.3 0.09	3.2 0.09	4.4 0.07	0.2 0.01	0.06	48	Fe(dis)=0.00 Fe(total)=0.07 Al=0 As=0 Cr=0 Cu=0.01 Pb=0 Mn=0.00 Zn=0.0	164	15	100	0	DWR
		11-14-61		267	7.4	22 1.10	16 1.34	9.0 0.39	1.2 0.03	0 0.00	165 2.70	4.6 0.10	0.4 0.01	0.5 0.01	0.2 0.01	0.05	44		179	14	122	0	DWR
		6-13-62	61	261	7.9	21 1.05	16 1.33	9.0 0.39	1.2 0.03	0 0.00	143 2.34	6.6 0.14	3.2 0.09	9.3 0.15	0.0 0.0	0.07	46		183	14	119	2	DWR
		5-27-63	62	264	8.2	12 0.60	21 1.76	9.2 0.40	1.0 0.02	0 0.00	148 2.42	7.2 0.15	3.1 0.09	4.0 0.06	0.1 0	0.09	44		175	14	118	0	DWR
		8-24-64	64	238	8.3			9.4 0.41		0 0.00	143 2.34		2.6 0.07					Fe(total)=0.01 Al=0.0 As=0.0 Cu=0 Pb=0 Mn=0 Zn=0.04			107	0	DWR
		8-23-65	74	273		22		9.9 0.43													118	0	DWR
Taylor Domestic	30N/4W-4F1	9-17-56	65	279	7.9	24 0.5	18 0.66	9.4 0.48	0.3 0.01	0 0.00	168 1.48	6.1	3.0 0.04	8.1	0.1	0.0	51		203	13	133	0	DWR
U.S. Plywood Green Veneer Plant Industrisl	30N/4W-5K1	9-17-56	63	151	7.3	10 0.50	8.0 0.66	11 0.48	0.5 0.01	0 0.00	90 1.48		1.3 0.04			0.00				29	58	0	USGS
		9-24-57	62	242	7.1	13 0.65	12 0.99	10 0.44	1.1 0.03	0 0.00	115 1.88	4.6 0.10	2.9 0.08	0.4 0.01	0.2	0.04	42		143	21	82		DWR
		8-12-58	61	191	8.0	14 0.70	11 0.88	9.2 0.40	0.7 0.02	0 0.00	108 1.77	5.6 0.12	2.5 0.07	0.9 0.01	0.0 0.0	0.03	49	Fe(dis)=0.02	146	20	79	0	DWR

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S Geological Survey, Quality of Water Branch (U. S. G. S.)
State Department of Water Resources (D. W. R.)

MINERAL ANALYSES OF GROUND WATER

SACRAMENTO RIVER BASIN

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total^a dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by^b
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 30N/4W-5K1	8-5-60		186	8.1	13 0.65	11 0.91	9.8 0.43	0.6 0.02	0 0.00	110 1.80	4.1 0.08	2.8 0.08	0.7 0.01	0.1 0.00	0.04	60	Fe(dis)=0.01 Fe(total)=0.42 Al=0 As=0.01 Cr=0.0 Pb=0.0 Mn=0.0 Cu=0.0 Zn=0.0	146	21	78	0	DWR
U.S. Plywood Domestic	30N/4W-5K2	9-17-56	71	167	7.3	11 0.55	71 0.90	8.8 0.38	0.5 0.01	0 0.00	101 1.66		1.0 0.03			0.04				21	72	0	DWR
27 Dist. Agr. Assn. Irrigation	30N/4W-15N3	9-24-57	65	197	7.1	15 0.75	13 1.05	11 0.48	1.4 0.04	0 0.00	115 1.88	9.4 0.20	6.7 0.19	0.6 0.01	0.2	0.02	52		166	21	90		DWR
Anderson Water Co. Municipal	30N/4W-16R1	9-24-57	66	188	7.1	12 0.60	9.7 0.80	11 0.48	1.0 0.03	0 0.00	101 1.66	0.8 0.02	4.8 0.14	3.2 0.05	0.5	0.02	53		146	25	70	0	DWR
Paul Bunyon Lumber Co. Industrial & Irrig.	30N/4W-25N1	10-26-55	63	162	7.7	9.6 .48	7.6 0.62	12 0.52	0.8 0.02	0 10.0	87 1.43	2.0 0.04	4.0 0.11	1.5 0.02	0.1 0.01	0	47		128	32	55	0	USGS
		9-24-57	76	151	6.9	9.0 0.45	7.7 0.63	11 0.48	0.8 0.02	0 0.00	90 1.47	1.2 0.02	4.6 0.13	0.0 0.0	0.1 0.01	0.04	43		121		54	0	DWR
		10-18-58	65	164	7.9	13 0.65	5.7 0.47	13 0.56	0.7 0.02	0 0.00	94 1.54	2.0 0.04	2.6 0.07	0.9 0.01	0.2 0.01	0.11	48	Fe(dis)=0.00	132	33	56	0	DWR
		7-13-59	71	114	7.4	10 0.50	7.8 0.64	14 0.61	0.9 0.02	0 0.00	92 1.51	3.3 0.07	4.3 0.12	0.9 0.01	0.2 0.01	0	46		132	34	57	10	DWR
		8-5-60		155	7.9	9.4 0.47	7.9 0.65	12 0.52	0.7 0.02	0 0.00	91 1.49	1.0 0.02	3.4 0.10	0.8 0.01	0.2 0.01	0.03	49	Fe(dis)=0.00 Fe(total)=0.21 Al=0 As=0 Cr=0 Cu=0 Pb=0 Mn=0 Zn=0	129	31	56	0	DWR
		6-13-62	68	169	7.8	16 0.80	5.4 0.44	11 0.48	0.8 0.02	0 0.00	89 1.46	4.9 0.10	2.7 0.08	3.7 0.06	0.2 0.01	0.04	51		140	28	62	0	DWR
C.H. Hoeft Domestic	31N/4W-18N1	2-2-60		298	8.4	1.7 0.08	0.5 0.04	71 3.09	0.5 0101	3 0.10	176 2.88	5.1 0.11	3.2 0.09	0.3 0.00	0.1 0.00	3.2	23		198	96	6	0	DWR
Charles Hunt Irrigation	31N/4W-21E1	9-7-56	60	178	7.7	14 0.70	9.0 0.74	11 0.48	0.6 0.02	0 0.00	90 1.48	7.7 0.16	6.8 0.19	0.1 0.01	3.5 0.06	0.04			126	25	72	0	DWR
Farmer's Market Domestic	31N/5W-12N3	2-2-60		275	7.9	20	15	15	1.7	0 0.00	166	0.8	3.8	1.0	0.4	0.05			185	22	111	0	DWR
Meyer Motels Inc. Domestic	31N/5W-12N3	9-18-56		357	7.2	16 0.80	7.8 0.64	49 2.13	1.3 0.03	0 0.00	149 2.44	0 0.00	43 1.21	0.3 0.00	0.0	0.25	53		244	59	72	0	USGS

a. Determined by addition of constituents unless otherwise noted

U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total° dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by b
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
D. . Stutsman Domestic	31N/5W-14E2	10-18-56	69	951	7.3	28.0 1.40	5.8 0.48	164.0 7.13	2.7 0.07	0.0 0.00	147.0 2.41	0.70 0.01	224.0 6.32	0.10 0.00	0.30 0.02	0.75	55		553	79	94		DWR
		2-2-60		14,400	7.7	430 21.46	36 2.92	2,890 125.72	20 0.51	0.0 0.00	116 1.90	0.3 0.01	5,290 149.18	0.8 0.01	0.5 0.03	23	51		8,800	83	1,220	1,120	DWR
D.S. Stutsman Domestic	31N/5W-14E5	8-27-59		40,500	7.5	1,040 51.90	52 4.24	9,220 401.07	78 2.00	0.0 0.00	56 0.92	0.2 0.00	16,400 462.48	4.0 0.06	1.6 0.08			$NH_4 = \frac{44}{2.44}$	26,900	87	2,810	2,764	DWR
		2-1-60		41,700									16,900 476.58										DWR
		7-7-60																Fe(total)=1.91					DWR
		7-21-60		42,300	7.5	1,010 50.40	50 4.08	4,530 414.56	7.0 0.18	0.0 0.00	59 0.97	270 5.62	16,100 454.02	19.0 0.31		54		$Fe(total)=\frac{3.4}{0.12}$ $Mn=\frac{1.0}{0.04}$	27,800	88	2,270	2,670	DWR
A.H. Overman Domestic	31N/5W-14G1	2-2-60		154	7.2	13 0.65	5.2 0.43	8.2 0.36	1.0 0.02	0 0.00	69 1.13	4.9 10	3.0 0.08	7.2 0.12	0.3 0.02	0.04	34		111	25	54	0	DWR
		7-21-60		418	7.0	31 1.55	19 1.58	16 0.70	0.9 0.02	0 0.00	126 2.07	3.0 0.06	5.7 1.61	16 0.26	—	0.10			336	18	156	53	DWR
A.H. Overman Domestic	31N/5W-14G2	2-2-60		269	6.5	22 1.10	10 0.82	9.4 0.41	0.9 0.02	0 0.00	62 1.02	9.5 0.20	26 0.73	24 0.39	0.1 0.00	0.04	22		154	17	96	45	DWR
		7-7-60																Fe(total)=0.24					
Gore Not Used	31N/5W-24N2	7-26-55			7.5	34.2	3.5	220	3.0	0 0.00	74	2.64	360		0.3				716				Dept. Public Health
Indian Reservoir Domestic & Irrigation	31N/5W-25K1	9-24-57	70	395	7.3	7.4 0.37	2.8 0.23	40 1.74	1.3 0.03	0 0.00	113 1.85	0.5 0.01	15 0.42	0.5 0.01	0.3 0.02	0.07	35	Gas in Water	159	73	30	0	DWR
		8-13-58		220	7.8	8.1 0.40	2.2 0.18	37 1.61	0.8 0.02	0 0.00	113 1.85	0.0 0.00	13 0.37	0.3 0.0	0.1 0.0	0.03	37	Fe(dis)=0.03	154	73	29	0	DWR
		7-13-59		218	7.5	6.1 0.30	3.2 0.26	38 1.65	0.9 0.02	0 0.00	114 1.87	0.0 0	13 0.37	0.3 0.0	0.0 0.0	0.23	37		155	74	28	0	DWR
		7-20-60		113	7.7	10 0.50	4.4 0.36	6.3 0.27	1.3 0.03	0 0.00	60 0.98	3.0 0.06	2.4 0.07	0.8 0.01	0.0 0.0	0.06	23	Fe(dis)=0.06 Fe(total)=0.35 Al=0.02 As=0.0 Cr=0.01 Cu=0.0 Pb=0.0 Mn=0.0 Zn=0.03	81	23	43	0	DWR

o Determined by addition of constituents unless otherwise noted

b Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U. S. G. S.)
State Department of Water Resources (D. W. R.)

MINERAL ANALYSES OF GROUND WATER

SACRAMENTO RIVER BASIN

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 31N/5W-12N3	9-23-57	68	201	7.6	15 0.75	8.4 0.69	5.3 2.31	1.4 0.04	0 0.00	147 2.41	0.3 0.01	44 1.24	0.4 0.01	0.5	0.30	50		245	61	72	0	DWR
		8-19-58		384	8.3	15 0.75	7.7 0.63	53 2.30	1.2 0.03	2 0.07	143 2.34	0.0 0.0	46 1.30	1.0 0.02	0.4 0.02	0.30	52		249	62	69	0	DWR
		7-14-59		386	7.7	14 0.70	8.8 0.72	54 2.35			149 2.44	0.8 0.02	46 1.30	0.4 0.01	0.4 0.02	0.33	52		252	62	71	0	DWR
		2-2-60		381	7.7	17 0.85	6.2 0.51	52 2.26	1.2 0.03	0 0.00	151 2.47	0.6 0.01	43 1.21	0.5 0.01	0.4 0.02	0.30	51		246	62	68	0	DWR
		7-7-60		443	7.4	14 0.70	5.8 0.48	68 2.96	1.9 0.05	0 0.00	150 2.46	1.0 0.02	66 1.86	0.00 0.00					323	71	59	0	DWR
		7-21-60		448	7.7	14 0.70	7.5 0.62	67 2.91	1.4 0.04	0 0.00	154 2.52	2.6 0.05	66 1.86	0.3 0.00		0.6		Mn=0.03	310	68	66	0	DWR
		11-14-61		424	7.9	14 0.70	7.0 0.58	62 2.70	1.3 0.03	0 0.00	142 2.33	1.0 0.02	58 1.64	0.1 0.00	0.4 0.02	0.41	54		268	67	64	0	DWR
		6-25-62	74	404	7.4	15 0.75	7.7 0.63	57 2.48	1.4 0.04	0 0.00	143 2.34	0.3 0.01	54 1.52	1.0 0.02	0.3 0.02	0.33	54	Al=0.00 As=0.00 Cu=0.00 Pb=0.00 Mn-0.14 Zn-0.00	261	64	69	0	DWR
		5-27-63	68	440	7.7	14 0.70	6.3 0.52	65 2.83	1.4 0.04	0 0.00	142 2.33	0.0 0.00	65 1.83	1.3 0.02	0.4 0.02	0.48	51		278	69	61	0	DWR
		8-25-64		458	8.0		1.22	68 2.96		0 0.00	143 2.34		66 1.86					Al=0.01 As=0.00 Cu=0.02 Pb=0.00 Mn=0.00 Zn=0.05			61		DWR
		8-23-65	72	427			1.38	59 2.57								0.3					69		DWR
Bonnyview School Domestic	31N/5W-13B1	9-26-57	60	185	7.9	17 0.85	8.4 0.69	10 0.43	2.4 0.06	0 0.00	108 1.77	0 0.00	5.9 0.17	0 0.0	0.4	0.00	39		136	21	77	0	USGS
McMurray Nursery Domestic	31N/5W-13H3	2-2-60		294	8.6	0.8 0.04	0.2 0.02	66 2.87	0.5 0.01	10 0.33	144 2.36	0.3 0.01	7.0 0.20	0.4 0.01	0.6 0.03	1.8	30		189	98	3	0	DWR
Shasta Terrace Water Co. Domestic	31N/5W-14B1	2-2-60		229	7.4	12 0.60	13 1.08	11 0.48	2.0 0.5	0 0.00	124 2.03	1.0 0.2	2.9 0.8	1.5 0.02	0.3 0.02	0.03	40		145	22	84	0	DWR
		7-7-60																Fe(total)=0.57 Mn=0.15					
		7-21-60		220	7.5	11 0.55	15 1.24	12 0.52	0.4 0.01	0 0.00	145 2.38	2.0 0.04	2.5 0.07	0.8 0.01	0.02	0.0		Fe(total)=$\frac{3.4}{0.12}$ Mn=0.03	211	21	90	0	DWR

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total^a dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by b
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 31N/5W-25K1	6-25-62	66	214	7.7	7.3 0.36	2.7 0.22	38 1.65	0.8 0.02	0 0.00	111 1.82	0.2 0.00	15 0.42	0.9 0.01	0.0 0.00	0.06	37	Fe(total)=0.08 Al=0.0 As=0 Cu=0 Pb=0 Mn=0.16 Zn=0.03	156	73	29	0	DWR
		5-27-63	70	236	7.9	7.8 0.39	3.3 0.27	40 1.74	0.8 0.02	0 0.00	115 1.88	0.0 0.00	19 0.54	0.5 0.01	0.3 0.02	0.07	38		166	72	33	0	DWR
		8-24-64		261	7.1			42 183		0 0.00	112 1.84		24 0.68					Fe(total)=0.07 Al=0.02 As=0 Cu=0 Pb=0 Mn=0 Zn=0.07			37	0	

a Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

STILLWATER PLAINS

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total dissolved solids in ppm[a]	Per-cent sodium	Hardness as $CaCO_3$		Analyzed by b
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
George Bibbens Irrigation	30N/3W-6J1	2-28-55	66	174	7.3	11 0.55	7.9 0.65	14 0.61	1.4 0.04	0 0.00	91 1.49	3.0 0.06	7.2 0.20	1.8 0.03	0.2	0.07	58		150	33	60	0	USGS
Tim Loftus Irrigation	30N/4W-1E1	3-1-55	65	87.8	6.5	5.1 0.25	3.6 0.30	7.0 0.30	0.6 0.02	0 0.00	38 0.62	3.5 0.07	3.5 0.10	4.1 0.07	0.1	0.00	48		94	35	28	0	USGS
		9-24-57	67	142	7.0	7.4 0.37	8.1 0.67	9.1 0.40	1.0 0.03	0 0.00	65 1.07	5.8 0.12	6.8 0.19	1.3 0.02	0.2 0.01	0.02	36		108		52		DWR
		8-12-58		157	7.7	10 0.50	7.0 0.58	9.0 0.39	0.6 0.02	0 0.00	67 1.10	8.7 0.18	6.3 0.18	3.6 0.06	0.1 0.00	0.00	36	Fe(dis)=0.00	114	26	54	0	DWR
		7-13-59	70	150	7.7	8.5 0.42	6.6 0.54	12 0.52	1.1 0.03	0 0.00	62 1.02	7.1 0.15	7.7 0.22	3.9 0.06	0.2 0.01	0.04	37		114	34	48	0	DWR
		8-1-60		152	7.9	8.8 0.44	8.3 0.68	10 0.44	0.5 0.01	0 0.00	67 1.10	7.2 0.15	7.4 0.21	4.2 0.07	0.1 0.00	0.07	38	Fe(dis)=0.00 Fe(total)=0.06 Al=0.00 As=0.00 Cr=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.00	118	28	56	1	DWR
		11-15-61		58	7.0	2.7 0.13	1.6 0.13	5.6 0.24	0.6 0.02	0 0.00	20 0.33	2.0 0.04	0.0 0.00	8.2 0.13	0.2 0.01	0.02	49		80	46	13	0	DWR
		6-25-62	62	151	7.8	11 0.55	6.2 0.51	9.4 0.41	0.5 0.01	0 0.00	64 1.05	7.6 0.16	6.4 0.18	4.3 0.07	0.1 0.00	0.04	38		114	28	53	1	DWR
		6-24-63	66	152	7.7	8.0 0.40	8.0 0.66	9.2 0.40	0.6 0.02	—	64 1.05	6.9 0.14	6.6 0.19	3.6 0.06	0.1 0.00	0.09	35		113	27	53	1	DWR
		8-26-64	66	153	8.1		1.08	9.2 0.40		0 0.00	69 1.13		7.2 0.20					Al=0.08 As=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.01			54		DWR
		8-23-65	68	68		3.2	 0.32	5.7 0.25													16		DWR
Ronald Colosio Domestic	30N/4W-3Q1	9-11-56		90.8	7.3	5.1 0.25	4.7 0.39	7.7 0.33	1.1 0.03	0 0.00	57 0.93	1.0 0.02	0.6 0.02	2.9 0.05	0.2 0.01	0.00	49		100	33	32	0	USGS
Kenneth C. Dennis Irrigation	31N/3W-1881	10-21-53			7.8	1.5 0.7	10 0.82	15 0.65		0 0.00	140 2.3	0 0.00	5.0 0.10			0.01							U.C.
G.W. Stelter Irrigation	31N/4W-5F1	7-26-56	69	151	7.7	8.8 0.44	8.0 0.66	13 0.57	1.0 0.03	0 0.00	99 1.62	2.0 0.04	2.0 0.06	0 0.00	0.2 0.01	0.06	47		131	33	55	0	USGS
		9-23-57	68	162	7.5	11 0.55	6.4 0.53	13 0.57	1.4 0.04	0 0.00	96 1.57	1.0 0.02	2.4 0.07	0.6 0.01	0.8 0.04	0.05	46		130	34	54		DWR
		8-12-58	68	158	7.9	10 0.50	7.0 0.58	12 0.52	0.8 0.02	0 0.00	93 1.52	1.0 0.02	2.0 0.06	0.2 0.00	0.4 0.02	0.02	46		125	32	54	0	DWR

a. Determined by addition of constituents unless otherwise noted

U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total a dissolved solids in ppm	Per-cent sodium	Hardness as $CaCO_3$		Analyzed by b
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 31N/4W-5F1	7-14-59		160	7.8	8.9 0.44	7.8 0.64	13 0.56	1.0 0.02	0 0.00	96 1.57	0.8 0.02	3.0 0.08	0.1 0.00	0.4 0.02	0.21	46		128	34	54	0	DWR
		8-1-60		152	8.1	8.5 0.42	7.8 0.64	13 0.56	0.9 0.02	0 0.00	93 1.52	0.2 0.00	2.4 0.07	0.1 0.00	0.4 0.02	0.03	46	Al=0.00 As=0.00 Cr=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.00	125	34	53	0	DWR
		11-15-61		177	7.4	9.9 0.49	8.6 0.71	15 0.65	0.9 0.02	0 0.00	110 1.80	0.6 0.01	1.9 0.05	0.5 0.01	0.4 0.02	0.00	44		136	35	60	0	DWR
		6-25-62	69	155	7.8	12 0.60	5.8 0.48	12 0.52	1.0 0.02	0 0.00	94 1.54	0.0 0.00	1.8 0.05	0.3 0.00	0.4 0.02	0.04	47		126	32	54	0	DWR
Enterprise School Dist., School Use	31N/4W-7A1	9-23-57	66	154	7.3	20 1.00	6.8 0.56	15 0.65	1.5 0.04	0 0.00	123 2.02	1.3 0.03	5.8 0.16	0.4 0.01	0.0 0.0	0.28	27		138	29	78		DWR
		8-13-58		207	8.0	22 1.10	5.1 0.42	14 0.61	1.0 0.02	0 0.00	121 1.98	2.1 0.04	3.2 0.09	0.5 0.01	0.1 0.00	0.04	28		135	28	76	0	DWR
		7-14-59		127	7.5	9.7 0.48	5.4 0.44	7.0 0.30	1.4 0.04	0 0.00	61 1.00	5.4 0.11	4.0 0.11	0.4 0.01	0.0 0.00	0.20	24		88	24	46	0	DWR
		8-1-60		211	8.2	20 1.00	7.0 0.58	15 0.65	1.0 0.02	0 0.00	128 2.10	1.2 0.02	4.2 0.12	0.7 0.01	0.2 0.01	0.07	30	Al=0.00 As=0.01 Cr=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.00	142	29	79	0	DWR
		11-15-61		137	7.5	11 0.55	6.0 0.49	7.4 0.32	1.4 0.04	0 0.00	64 1.05	7.2 0.15	6.3 0.18	0.7 0.01	0.1 0.00	0.04	26			23	52	0	DWR
		6-25-62	78	219	7.6	24 1.20	5.8 0.48	15 0.65	1.1 0.03	0 0.00	132 2.16	2.0 0.04	2.7 0.08	0.5 0.01	0.2 0.01	0.04	30		146	28	84	0	DWR
		6-24-63	66	220	8.1	20 1.00	8.3 0.68	14 0.61	1.0 0.02		133 2.18	1.6 0.03	3.2 0.09	0.3 0.00	0.2 0.01	0.08	29		143	26	84	0	DWR
		8-26-64		225	8.4		1.80	15 0.65		3 0.10	138 2.26		3.4 0.10					Al=0.00 As=0.01 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.06			90	0	DWR
		8-23-65	78	215		17	1.60	15 0.65													80		DWR
Oscar Matson Domestic	31N/4W-7R1	10-21-59	65	224	7.3	16 0.80	11 0.88	14 0.61	0.6 0.02	0 0.00	126 2.06	5.6 0.12	3.9 0.11	0.8 0.01	0.2 0.01	0.01	31		145	26	84	0	DWR
L.A. Stayer Irrigation	31N/4W-15B1	2-24-55	62	217	6.9	11 0.55	9.9 0.81	24 1.04	0.6 0.01	0 0.00	124 2.03	2.3 0.05	10 0.28	0.2 0.00	0.2	0.07	48		167	43	68	0	USGS

a Determined by addition of constituents unless otherwise noted

b Analysis by indicated laboratory:
U.S Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

STILLWATER PLAINS

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as CaCO$_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO$_3$)	Bicarbonate (HCO$_3$)	Sulfate (SO$_4$)	Chloride (Cl)	Nitrate (NO$_3$)	Fluoride (F)	Boron (B)	Silica (SiO$_2$)	Other constituents			Total ppm	N.C. ppm	
	"continued" 31N/4W-15B1	9-25-57	68	229	6.8	12 0.60	10 0.84	19 0.83	1.3 0.03	0 0.00	122 2.00	1.0 0.02	11 0.31	0.0 0 00	0 0.00	0.09	50		164	36	72	0	DWR
		8-13-58	69	230	8.0	12 0.60	10 0.86	20 0.87	0.7 0.02	0 0.00	122 2.00	1.6 0.03	10 0.28	0.6 0.01	0.3 0.02	0.09	53		168	37	73	0	DWR
		7-14-59	68	228	7.9	10 0.50	11 0.90	21 0.91	0.9 0.02	0 0.00	122 2.00	0.3 0.01	11 0.31	0.2 0.01	0.6 0.01	0.30	52		167	39	70	0	DWR
		8-1-60		213	7.3	11 0.55	11 0.89	19 0.83	0.6 0.02	0 0.00	120 1.97	0.6 0.01	9.2 0.26	0.9 0.01	0.3 0.02	0.09	52	Fe(dis)=0.00 Fe(total)=0.08 Al=0.0 As=0.0 Cr=0.0 Cu=0.0 Pb=0.01 Mn=0.0 Zn=0.00	164	36	72	0	DWR
		11-15-61		215	7.6	11 0.55	11 0.89	18 0.78	0.8 0.02	0 0.00	113 1.85	1.6 0.03	9.2 0.26	0.6 0.01	0.2 0.01	0.08	54		162	35	72	0	DWR
		6-25-62	71	217	8.0	13 0.65	4.6 0.79	20 0.87	0.8 0.02	0 0.00	119 1.95	0.5 0.01	10 0.28	0.9 0.01	0.3 0.02	0.09	52		165	37	72	0	DWR
		6-24-63	69	220	8.0	9.9 0.49	11 0.93	18 0.78	1.2 0.03	0 0.00	119 1.95	0.5 0.01	9.8 0.28	0.3 0.00	0.4 0.02	0.15	50		168	35	71	0	DWR
		8-26-64	69	213	7.8			19 0.83		0 0.00	122 2.00		8.5 0.24								72	0	DWR
		8-23-65	70	220		12		18 0.78													71	0	DWR
Phil Templeton Irrigation & Domestic	31N/4W-16Q1	9-25-57	64	165	7.4	9.8 0.49	9.6 0.79	9.1 0.40	1.5 0.04	0 0.00	93 1.52	1.2 0.02	5.3 0.15	0.9 0.01	0 0.00	0.03	32		115		64		DWR
		8-13-58	64	159	7.8	9.8 0.49	8.1 0.67	10 0.44	0.6 0.02	0 0.00	89 1.46	1.6 0.03	3.5 0.10	1.7 0.03	0.2 0.01	0.02	33		112	27	58	0	DWR
		7-14-59		171	7.6	9.3 0.46	9.0 0.74	12 0.52	0.8 0.02	0 0.00	94 1.54	0.6 0.01	3.6 0.10	1.3 0.02	0.2 0.01	0.21	32		115	30	60	0	DWR
		8-1-60		160	8.0	7.8 0.39	9.8 0.81	11 0.48	0.6 0.02	0 0.00	91 1.49	1.[illegible] 0.03	3.7 0.10	1.8 0.03	0.2 0.01	0.03	32	Fe(dis)=0.00 Fe(total)=0.10 Al=0.0 As=0.0 Cr=0.0 Cu=0.0 Pb=0.0 Mn=0.0 Zn=0.01	113	28	60	0	DWR
		11-15-61		168	7.0	9.9 0.49	9.6 0.79	17 0.74	0.7 0.02	0 0.00	114 1.87	1.8 0.04	3.4 0.10	2.2 0.04	0.2 0.01	0.02	33		134	36	64	0	DWR

a Determined by addition of constituents unless otherwise noted

b Analysis by indicated laboratory:

MINERAL ANALYSES OF GROUND WATER

STILLWATER PLAINS

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 31N/4W-16Q1	6-25-62	62	153	7.9	8.4 0.42	8.8 0.72	10 0.44	0.5 0.01	0 0.00	85 1.39	2.1 0.04	4.1 0.12	2.6 0.04	0.2 0.01	0.04	30		109	28	57	0	DWR
		6-24-63	64	144	7.8	7.5 0.37	8.1 0.67	9.2 0.40	0.6 0.02	0 0.00	77 1.26	1.6 0.03	3.6 0.10	3.3 0.05	0.2 0.01	0.04	31		108	27	52	0	DWR
		8-26-64	64	166	8.0		1.24	11 0.48	0 0.00	92 1.51			3.8 0.11					Fe(total)=0.07 Al=0.00 As=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.01			62	0	DWR
		8-23-65	65	176		10 0.50	1.30	12 0.52													65		DWR
C.H. Haley Domestic	31N/4W-21C1	9-17-56		184	7.4	10 0.50	13 1.04	8.3 0.36	0.4 0.01	0.0 0.00	96 1.57	2.1 0.04	1.9 0.05	1.7 0.27	0.1	0.00	44		144	19	77	0	DWR
Charles Hunt Irrigation	31N/4W-21M1	9-17-56	60	178	7.7	14 0.70	9.0 0.74	11 0.48	0.6 0.02	0.0 0.00	90 1.48	7.7 0.16	6.8 0.19	3.5 0.06	0.1 0.01	0.04	29		126	25	72	0	USGS
USBR Test Well	31N/4W-22H1	8-15-57		197	8.0	13 0.67	6.7 0.55	14 0.63	0.0 0.00	0.0 0.00	99 1.62	4.8 0.10	3.9 0.11	0.0 0.00		0.00				31			USBR 0-290'
		8-15-57		2555	11.4	157 7.85	0.0 0.00	84 3.67	2.7 0.07	37 1.23	138 8.14	24 0.49	72 2.02	0.0 0.00		0.50				32			USBR 320-550'
		8-15-57		1042	7.4	4.0 0.20	1.1 0.09	198 8.60	2.0 0.05	0.0 0.00	201 3.30	11 0.23	197 5.55	0.0 0.00		1.25				96			USBR 580-735'
USBR Test Well	31N/4W-25Q1	9-10-57		1002	8.3	21 1.06	11 0.94	170 7.40	3.9 0.10	0.0 0.00	138 2.26	15 0.31	244 6.89	0.0 0.00		0.66					78	0	USBR
		9-17-57		708	8.1	18 0.90	9.3 0.76	104 4.52	2.0 0.05	0.0 0.00	107 1.76	10 0.21	149 4.20	0.0 0.00		0.48					73	0	USBR
USBR Test Well	31N/4W-25Q2	9-17-57		1135	7.0	21 1.03	8.5 0.70	156 6.80	4.3 0.11	0.0 0.00	135 2.22	14 0.29	237 6.69	0.0 0.00		0.65				79			USBR
Frank Scholz Irrigation	31N/4W-27P1	9-11-56	64	161	7.5	11 0.55	7.9 0.65	9.9 0.43	0.5 0.01	0.0 0.00	76 1.25	7.7 0.16	6.6 0.19	5.3 0.09	0.1 0.01	0.00	38		124	26	60	0	USGS
Cascade Community Services District	31N/4W-31D1	12-21-64			7.7	9.5	3.6	34.1	0.9	0.0 0.00	74.4	4.3	22.1	0.4	<0.05			Fe=0.06 Mn=0.05	148		38.5		SDPH
Well #5 Municipal		7-25-65											138					Fe=0.04 Mn=0.10					SDPH
		8-5-66			7.4	22.4	5.9	86	2.1	0.0 0.00	83	1.7	124	<0.44	0.05			Fe=0.03 Mn=<0.05	408		80		SDPH
Wayne Ross Stock	32N/4W-9R1	10-25-55	61	35,100	7.6	244 12.18	51 4.22	8470 368.44	65 1.66	0.0 0.00	254 4.16	2.0 0.04	13,400 377.88	0.1 0.00	3.0	11	9.9		22,400	95	818	610	USGS

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

STILLWATER PLAINS

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total dissolved solids in ppm [a]	Per-cent sodium	Hardness as $CaCO_3$		Analyzed by [b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Cromack, Domestic, Stock & Irrigation	32N/4W-13G1	7-26-56		1190	8.1	5.2 0.26	1.2 0.10	266 11.57	1.6 0.04	0.0 0.00	327 3.88	118 2.46	200 5.64	0.0 0.00	1.4	0.17	26		737	97	18	0	USGS
Hills & Dales Rest Home Irrigation	32N/4W-14F2	3-16-56	51	63	6.9	4.5 0.23	0.6 0.05	9.4 0.41	0.6 0.02	0.0 0.00	41 0.67	0.6 0.01	0.0 0.0	0.9 0.02	0.4 0.02	0.15	17		54	59	14	0	USGS
		9-25-57	65	226	7.0	14 0.70	6.8 0.56	25 1.09	1.4 0.04	0.0 0.00	121 1.98	2.6 0.05	11 0.31	0.2 0.0	0.1 0.01	0.08	35		155	46	63	0	DWR
		8-14-58	63	167	8.0	12 0.60	4.4 0.36	15 0.65	0.6 0.02	0.0 0.00	86 1.41	1.8 0.04	7.2 0.20	1.0 0.02	0.0 0.00	0.03	31		115	40	48	0	DWR
		7-14-59		216	7.0	14 0.70	5.1 0.42	24 1.04	0.4 0.01	0.0 0.00	111 1.82	0.5 0.01	10 0.28	3.8 0.06	0.1 0.00	0.12	34		146	48	56	0	DWR
		7-25-60		197	8.1	8.5 0.42	4.4 0.36	25 1.09	0.5 0.01	0.0 0.00	95 1.56	2.0 0.04	7.3 0.20	2.4 0.04	0.1 0.00	0.22	32	Al=0 As=0 Cr=0 Cu=0 Zn=0.07 Fe(dis)=0.04 Fe(total)=1.1	129	58	39	0	DWR
		8-8-61		197	8.0	1.4 0.07	1.0 0.08	46 2.00	0.6 0.02	0.0 0.00	116 1.90	4.9 0.10	2.4 0.07	0.5 0.01	0.6 0.03	0.71	28		144	92	7.7	0	DWR
		6-25-62	72	113	7.6	8.7 0.43	2.1 0.17	11 0.48	0.6 0.02	0.0 0.00	50 0.82	4.4 0.09	4.8 0.14	4.9 0.08	0.1 0.00	0.12	23		84	44	30	0	DWR
		6-24-63	62	110	7.5	9.4 0.47	2.8 0.23	8.2 0.36	0.8 0.02	0.0 0.00	48 0.79	3.4 0.07	5.0 0.14	3.4 0.05	0.0 0.00	0.13	22		89	33	35	0	DWR
		8-26-64		210	8.3			39 1.70		0.0 0.00	91 1.49		10 0.28					Al=0.31 As=0.01 Cu=0 Pb=0 Mn=0 Zn=0.18			20	0	DWR
		8-23-65						15 0.65					7.6 0.21								54	0	
Whitehurst Domestic	32N/4W-14G1	4-17-56		2300	8.1	8.7 0.43	0.6 0.05	515 22.40	1.0 0.03	0.0 0.00	395 6.47	109 2.27	476 13.42	2.1 0.03	0.1 0.01	31	14		1350	98	24	0	DWR
Wayne Ross Domestic	32N/4W-16B1	1945			7.5	20 1.1	5.0 0.5	500 21.8			230 3.8	15 0.3	720 20.2			9.90			1490				UC
		12-2-55	57	3820	7.0	22 1.10	5.7 0.47	797 34.67	8.0 0.20	0.0 0.00	244 4.0	12 0.25	1120 31.58	1.5 0.02	0.4	17	34		2140	95	78	0	USGS
		9-25-57	72	208	6.9	13 0.65	7.9 0.65	14 0.61	1.0 0.03	0.0 0.00	60 0.98	1.3 0.03	29 0.82	2.1 0.03	0.4	0.38	20		119	31	65		DWR
		8-14-58		212	8.0	12 0.60	5.6 0.46	24 1.04	1.1 0.03	0.0 0.00	100 1.64	1.5 0.03	15 0.42	0.6 0.01	0.1 0.00	0.05	34		143	49	53	0	DWR

a [illegible]

b Analysis by indicated laboratory:

MINERAL ANALYSES OF GROUND WATER

STILLWATER PLAINS

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total dissolved solids in ppm[a]	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 32N/4W-16B1	7-14-59		276	7.9	15 0.75	19.6 1.61	15 0.65	1.0 0.02	0.0 0.00	167 2.74	4.4 0.09	4.3 0.12	1.2 0.02	0.2 0.01	0.02	46		189	21	118	0	DWR
		7-25-60		236	8.2	16 0.80	18 1.44	13 0.56	0.8 0.02	0.0 0.00	160 2.62	1.8 0.04	3.8 0.11	1.9 0.03	0.2 0.01	0.02	47	Fe(dis)=0.00 Fe(total)=0.20 Al=0.01 As-0.00 Cr=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.02	182	20	112	0	DWR
		8-8-61		337	8.0	4.7 0.23	2.1 0.17	69 3.00	1.4 0.04	0.0 0.00	157 2.57	2.5 0.05	27 0.76	0.3 0.00	0.3 0.02	0.76	35		220	87	20	0	DWR
		6-25-62	81	487	7.8	4.7 0.23	1.1 0.09	97 4.22	1.3 0.03	0.0 0.00	160 2.62	0.6 0.01	68 1.92	0.5 0.01	0.3 0.02	1.4	37		291	92	16	0	DWR
		6-24-63	73	559	8.1	4.0 0.20	0.7 0.06	114 4.96	1.7 0.04	0.0 0.00	159 261	0.8 0.02	96 2.71	1.6 0.02	0.3 0.02	2.0	45		351	94	13	0	DWR
Wayne Ross Not Used	32N/4W-16B2	7-25-60		11	7.1	5.9 0.29	4.5 0.37	8.0 0.35	0.3 0.01	0.0 0.00	19 0.31	0.0 0.00	13 0.37	18 0.29	0.0 0.00	0.53	23	Fe(dis)=0.00 Fe(total)=0.07 Al=0 As=0 Cr=0 Cu=0 Pb=0 Mn=0 Zn=1.3	82	34	33	17	DWR
		8-8-61		94	7.1	4.5 0.22	3.4 0.28	7.0 0.30	0.3 0.01	0.0 0.00	21 0.34	1.3 0.03	7.0 0.20	15 0.24	0.0 0.00	0.53	31		80	37	25	8	DWR
		6-25-62	80	133	6.8	6.9 0. 4	5.1 0.42	8.0 0.35	0.2 0.00	0.0 0.00	16 0.26	0.5 0.01	10 0.28	34 0.55	0.0 0.00	0.44	20		93	32	38	25	DWR
		6-24-63	75	138	6.9	7.3 0.36	5.4 0.44	9.4 0.41	0.3 0.01	0.0 0.00	19 0.31	1.2 0.02	10 0.28	33 0.53	0.0 0.00	0.44	21		114	34	40	24	DWR
		8-23-65	74	132		6.8		11 0.48													32	0	DWR
Levi Jones Domestic	32N/4W-20G1	3-16-56	68	235	7.3	7.4 0.37	41. 0.34	44 1.91	1.2 0.03	0.0 0.00	148 2.43	7.0 0.15	2.1 0.06	0.9 0.02	0.1 0.01	0.20	29		169	72	35	0	USGS
Levi Jones Irrigation & Domestic	32N/4W-20H1	9-25-57	80	266	7.3	16 0.80	18 1.46	16 0.7	1.7 0.04	0.0 0.00	166 2.72	2.8 0.06	3.9 0.11	0.2 0.01	0.0 0.00	0.08	42		183	23	113		USGS
D.E. Bonner Domestic	32N/4W-20L1	4-17-56		139	7.6	36 1.80	12 0.98	500 21.75	7.0 0.18	0.0 0.00	196 3.21	8.8 0.18	744 20.90	1.2 0.02	0.1 0.01	45	46	Tastes Salty	1,460	88	139	0	USGS
Dan D. Davis Domestic	ewN/4W-21B1	9-11-56	67	923	8.0	2.5 0.12	0.6 0.05	190 8.26	1.2 0.03	0.0 0.00	189 3.10	0.6 0.01	199 5.61	1.4 0.02	0.5	3.0	40		532	98	8	0	USGS

a Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

STILLWATER PLAINS

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO₃)	Bicarbonate (HCO₃)	Sulfate (SO₄)	Chloride (Cl)	Nitrate (NO₃)	Fluoride (F)	Boron (B)	Silica (SiO₂)	Other constituents	Total[a] dissolved solids in ppm	Per-cent sodium	Hardness as CaCO₃ Total ppm	Hardness as CaCO₃ N.C. ppm	Analyzed by[b]
McGintee Irrigation	32N/4W-21C1	9-11-56		103	7.1	5.0 0.25	5.7 0.47	8.8 0.38	0.1 0.00	0.0 0.00	58 0.95	1.0 0.02	5.6 0.16	0.1 0.00	0.1	0.0	25		80	35	36	0	USGS
M.H. Olinger Domestic	32N/4W-21H1	9-11-56		124	7.5	3.0 0.15	1.8 0.15	25 1.09	0.3 0.01	0.0 0.00	77 1.26	0.4 0.01	2.8 0.08	0.2 0.00	0.5 0.03	0.29	46		118	78	15	0	USGS
Scoma	32N/4W-25R1	9-11-56	69	217	7.8	14 0.70	11 0.89	17 0.74	2.1 0.05	0.0 0.00	137 2.25		2.4 0.07			0.0				31	80	0	USGS
Harvey Courtois	32N/4W-26H1	7-26-56		183	7.2	6.0 0.30	6.1 0.50	28 1.22	0.9 0.02	0.0 0.00	118 1.93	1.0 0.02	3.0 0.08	0.0 0.00	0.2	0.35	41		145	60	40	0	USGS
Louis Nash	32N/4W-27D1	10-22-59	64	224	7.5	14 0.70	3.2 0.26	29 1.26	1.1 0.03	0.0 0.00	131 2.15	1.3 0.03	2.8 0.08	0.4 0.01	0.2 0.01	0.11	46		162	56	48	0	DWR
F.X. Kesterson Domestic	32N/4W-32F1	7-26-56	68	341	7.7	16 0.80	21 1.70	30 1.30	1.1 0.03	0.0 0.00	201 3.29	8.0 0.17	12 0.34	0.0 0.00	0.2	0.19	35		222	34	125	0	USGS
L. Strahand Domestic	32N/4W-33J1	7-26-56		206	7.2	11 0.55	14 1.15	15 0.65	0.9 0.02	0.0 0.00	140 2.30	1.0 0.02	2.0 0.06	0.1 0.00	0.1 0.01	0.00	63		176	27	85	0	USGS
G. Sorenson Domestic	32N/4W-34B1	9-11-56		169	7.7	13 0.65	7.3 0.60	12 0.52	0.7 0.02	0.0 0.00	102 1.67		4.0 0.11			0.00				29	62	0	USGS
Columbia School Dist. Irrigation & Domestic	32N/4W-34P1	10-18-56		244	7.7	14 0.70	8.3 0.68	28 1.22	1.5 0.04	0.0 0.00	128 2.10	1.6 0.03	14.0 0.40	0.7 0.01	0.2 0.01	0.16	43		174	46	69	0	DWR
		9-25-57		253	7.6	14 0.70	8.0 0.66	28 1.22	1.6 0.04	0.0 0.00	128 2.10	1.3 0.03	18.0 0.51	0.0 0.00	0.2 0.01	0.32	34		168	47	68	0	DWR
		8-14-58		252	8.2	14 0.70	6.6 0.54	29 1.26	1.3 0.03	0.0 0.00	123 2.02	0.0 0.00	17.0 0.48	0.7 0.01	0.0 0.00	0.22	30		159	50	62	0	DWR
		7-14-59		282	8.3	17 0.85	6.2 0.51	32 1.39	1.9 0.05	3.0 0.10	136 2.13	0.3 0.01	21.0 0.59	0.2 0.00	0.1 0.00	0.46	32		178	50	68	0	DWR
		8-1-60		264	8.1	16 0.80	7.8 0.64	29 1.26	1.3 0.03	0.0 0.00	133 2.18	0.5 0.01	1 .0 0.54	0.3 0.00	0.1 0.00	0.24	35	Fe =0.05 Al=0.0 As=0.0 Cr=0.0 Cu=0.0 Pb=0.02 Mn=0.0 Zn=0.04	174	46	72	0	DWR
		6-25-62		320	8.1	14 0.70	8.0 0.66	39 1.70	1.1 0.03	0.0 0.00	132 2.16	0.2 0.00	32.0 0.93	0.5 0.01	0.1 0.00	0.46	32		193	55	68	0	DWR
		6-24-63		312	8.1	18 0.90	6.3 0.52	38 1.65	1.4 0.04	0.0 0.00	137 2.24	0.8 0.02	31.0 0.87	1.0 0.02	0.2 0.01	0.42	34		198	53	71	0	DWR
Twiss Irrigation & Domestic	32N/4W-34R5	7-26-56		140	7.6	7.2 0.36	7.6 0.62	13 0.57	0.9 0.02	0.0 0.00	81 1.33	5.0 0.10	5.5 0.16	0.3 0.01	0.0 0.00	0.0			148	36	49	0	USGS
H. Snow, Jr. Domestic	32N/5W-26M1	8-14-58		291	8.2	2 .0 1.00	7.3 0.60	30 1.30	0.9 0.02	0.0 0.00	124 2.03	25 0.52	9.7 0.27	2.1 0.03	0.3 0.02	0.57	29	Fe(dis)=0	186	44	80	0	DWR

a. Determined by addition of constituents unless otherwise noted

b. U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)

STILLWATER PLAINS

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million												Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 32N/5W-26M1	7-14-59		293	8.1	19 0.95	9.1 0.75	27 1.17	1.1 0.03	0.0 0.00	126 2.06	26 0.54	10 0.29	2.0 0.03	0.3 0.02	0.47	29		186	40	85	0	DWR
		7-25-60		278	8.1	17 0.85	10 0.85	26 1.13	1.0 0.02	0.0 0.00	121 1.98	24 0.50	10 0.28	0.3 0.02	1.5 0.02	0.54	30	Fe(dis)=0 Fe(total)=0.07 Al=0 Cr=0 Pb=0 Cu=0 As=0 Mn=0 Zn=0.02	179	40	85	0	
		8-8-61		396	8.4	27 1.35	7.2 0.59	48 2.09	1.2 0.03	4.0 0.13	168 2.75	38 0.79	11 0.31	1.4 0.02	0.5 0.03	0.71	31		252	51	97	0	DWR
		6-14-62	67	268	7.1	20.0	8.3	23	1.3	0.0 0.00	111	23	10	8.8	0.3	0.44	27		176	37	84	0	DWR
		6-6-64	67	258	7.9	20.0 1.00	8.0 0.66	21 0.91	1.0 0.02	0.0 0.00	114 1.87	26 0.54	7.0 0.20	1.9 0.03	0.3 0.02	0.36	31		164	35	83	0	DWR
		8-26-64		282	8.3			27 1.17		0.0 0.00	125 2.05		9.3 0.26					Fe(total)=0.00 Al=0 As=0 Cu=0 Pb=0 Mn=0 Zn=0.03			83	0	DWR
		8-23-65	66	274				24 1.04					7.8 0.22								83	0	DWR

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

COW CREEK

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Per-cent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
Merrill Reynolds Irrigation	31N/3W-3K1	10-16-57	66	477	7.1	16 0.8	6.8 0.56	79 3.44	3.6 0.09	0 0.00	146 2.39	3.0 0.06	80 2.26	0.8 0.01	0.3	0.38	48		310	70	68	0	DWR
R.M. Gilbert Irrigation	31N/3W-7K1	1947			6.8	15 0.7	10 0.7	25 1.2			130 2.1		15 0.5										USGS
		9-26-57	66	212	8.2	16 0.8	8.0 0.66	17 0.74	2.2 0.06	0 0.00	131 2.15	0.8 0.02	3.9 0.11	0.0 0.00	0.2	0.04	53		165	33	73		DWR
		8-13-58	68	238	8.0	14 0.7	8.0 0.66	25 1.09	1.6 0.04	0 0.00	129 2.11	1.5 0.03	11 0.31	0.2 0.00	0.2 0.01	0.20	53		178	44	68	0	DWR
		7-14-59	68	239	7.9	12 0.60	8.8 0.72	25 1.09	1.5 0.04	0 0.00	130 2.13	0.3 0.01	12 0.34	0.0 0.00	0.2 0.01	0.47	52		176	44	66	0	DWR
		7-25-60		235	8.1	13 0.65	8.4 0.69	25 1.09	1.5 0.04	0 0.00	128 2.10	0.8 0.02	11 0.31	0.5 0.01	0.1 0.00	0.30	54	Al=0.00 As=0.00 Cr=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.00	178	44	67	0	DWR
		6-25-62	65	233	8.1	15 0.75	7.2 0.59	24 1.04	1.5 0.04	0 0.00	124 2.03	0.8 0.02	12 0.34	0.2 0.00	0.1 0.00	0.28	52		174	43	67	0	DWR
		6-25-63	67	214	8.1	13 0.65	9.6 0.79	18 0.78	1.4 0.04		132 2.16	1.0 0.02	3.0 0.08	0.0 0.00	0.2 0.01	0.09	54		162	34	72	0	DWR
		8-25-64	68	233	8.4			25 1.09		2 0.07	124 2.03		13 0.37					Al=0.00 As=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.00	233		66	0	DWR
Vern Shufelberger Irrigation (Abandoned)	31N/3W-9G1	3-13-56		98.3	7.0	13 0.65	2.1 0.17	2.0 0.09	4.0 0.10	0 0.00	60 0.98	0.0 0.00	0.5 0.01	1.0 0.02	0.2	0.11	13		66	9	41	0	USGS
Millville Cemetary Irrigation	31N/3W-10J1	10-26-55	64	200	7.3	18 0.90	10 0.82	8.2 0.36	2.1 0.05	0 0.00	120 197	4.0 0.08	3.8 0.11	0.3 0.00	0.1	0	81		187	17	86	0	USGS
Millville Cementary District Irrigation	31N/3W-11J1	10-26-55	62	237	7.2	22 1.10	11 0.94	11 0.48	1.7 0.04	0 0.00	144 2.36	4.0 0.08	5.1 0.14	0.6 0.01	0.2	0.01	78		205	19	102	0	USGS
Gimblin Domestic & Irrigation	31N/3W-12E1	9-26-57	62	198	7.8	20 1.00	8.0 0.66	8.0 0.35	2.2 0.06	0 0.00	111 1.82	1.5 0.03	5.9 0.17	2.7 0.04	0.1	0.02	67		170	17	83	0	DWR
		8-13-58	63	208	7.9	22 1.10	7.5 0.62	7.6 0.33	2.3 0.06	0 0.00	106 1.74	6.4 0.13	4.7 0.13	4.3 0.07	0.1 0	0.00	70		177	16	86	0	DWR
		7-25-60		189	8.1	18 0.90	8.0 0.66	8.2 0.36	2.5 0.06	0	104 1.70	3.8 0.08	4.3 0.12	2.2 0.04	0.1 0.00	0.04	74	Fe(dis)=0 Fe(total)=0.05 Al=0 As=0 Cr=0 Cu=0 Pb=0.02 Mn=0 Zn=0.01					

a Determined by addition of constituents unless otherwise noted

b Analysis by indicated laboratory:

MINERAL ANALYSES OF GROUND WATER

COW CREEK

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total^a dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by^b
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 31N/3W-12E1	11-15-61		195	7.6	19 0.95	8.1 0.67	8.0 0.35	2.5 0.06	0 0.00	104 1.70	6.2 0.13	3.9 0.11	3.8 0.06	0.1 0.00	0.06	71		174	17	81	0	DWR
		6-25-62	70	192	7.3	21 1.05	6.4 0.53	8.0 0.35	2.4 0.06	0 0.00	101 1.66	4.9 0.10	3.6 0.10	3.9 0.06	0.1 0.00	0.03	72		172	18	79	0	DWR
		5-27-63	70	201	8.0	19 0.95	8.4 0.69	7.7 0.33	2.3 0.06	0 0.00	106 174	4.6 0.10	4.4 0.12	4.2 0.07	0.1 0.00	0.09	72		180	16	82	0	DWR
		8-25-64	65	391	8.3			43 1.87		0 0.00	128 2.10		52 1.47					Fe(total)=0.01 Al=0 As=0 Cu=0 Pb=0.01 Mn=0.00 Pb=0.02			81	0	DWR
		8-23-65	71	196		18															77	0	
W.H. Johnson Not Used	32N/3W-17E1	7-53			7.7	250 17.6	35 3.0	3,040 132			75 1.2	835 17.4	4,750 133.7										DWR
Leonard Pierce Domestic & Irrigstion (Formerly W.H.Johnson)	32N/3W-17E2	10-25-55		5,740	7.7	73 3.64	8.8 0.72	1,170 50.90	6.0 0.15	0 0.00	162 2.66	320 6.60	1,620 45.68	0.0 0.00	1.0	13	16		3,310	92	218	85	USGS
		9-25-57	70	4,170	7.7	49 2.45	5.7 0.47	830 36.11	3.1 0.08	0 0.00	150 2.46	191 3.98	1,160 32.71	1.4 0.02	0.8	10.2	13		2,330	92	146		UC
		8-14-58	63	1,370	8.1	14 0.70	1.2 0.10	256 11.14	1.5 0.04	0 0.00	91 1.49	54 1.12	329 9.28	3.7 0.06	0.4 0.02	5.3	18		728	93	40	0	DWR
		3-30-59		3,770	7.5	41 2.04	5.1 0.42	750 32.62	2.6 0.07	0 0.00	155 2.54	171 3.56	1,030 29.05	1.6 0.02	0.9 0.05	1.5	12		2,090	93	123	0	DWR
		7-14-59	66	5,050	7.8	67 3.34	5.8 0.48	995 43.28	3.1 0.08	0 0.00	164 2.69	223 4.64	1,420 40.04	4.8 0.08	1.0 0.05	1.1	14		2,820	92	191	57	DWR
		7-25-60		4,370	8.3	54 2.69	6.7 0.55	892 38.80	2.5 0.06	0 0.00	149 2.44	195 4.06	1,260 35.53	12 0.05	1.0 0.19	18	20	Al=0.0 As=0.0 Cr=0.0 Cu=0.0 Pb=0.0 Mn=0.15 Zn=0.0	2,530	92	162	40	DWR
		2-27-62		905	7.5	8.9 0.44	1.9 0.16	167 7.26	1.2 0.03	0 0.00	78 1.28	35 0.73	211 5.95	2.3 0.04	0.4 0.02	4.1	15			92	30	0	DWR
		6-25-62	63	3,190	8.1	38 1.90	1.2 0.10	615 26.75	1.8 0.05	0 0.00	143 2.34	134 2.78	839 23.66	2.4 0.04	1.2 0.06	14	13		1,730	93	100	0	DWR
		6-24-63	62	4,320	8.3	53 2.64	5.1 0.42	862 37.50	3.0 0.08	0 0.00	167 2.74	192 4.00	1,200 33.85	3.0 0.05	1.2 0.06	19	15		2,240	92	153	16	DWR

a Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U. S. G. S.)
State Department of Water Resources (D. W. R.)

MINERAL ANALYSES OF GROUND WATER

COW CREEK

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million: Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents	Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$: Total ppm	Hardness as $CaCO_3$: N.C. ppm	Analyzed by[b]
	"continued" 32N/3W-17E2	8-26-64	63	2,860	8.4	37 1.85	0.8 0.07	546 23.75	2.6 0.07	2 0.07	151 2.47	128 2.66	744 20.99	4.1 0.07		12		Al=0.0 As=0.0 Cu-0.02 Pb=0.0 Mn=0.0 Zn=0.02	1,590	92	96	0	DWR
		8-23-65	72	3,450			2.08	682 29.67					908 25.61			13			1,770		104		DWR
Leonard Pierce Domestic (formerly W.H.Johnson)	32N/3W-17E3	10-25-55		121	6.1	5.6 0.28	1.5 0.12	12 0.52	1.0 0.03	0.0 0.00	27 0.44	5.0 0.10	14 0.40	1.3 0.02	0.1	0.22	20		74	55	20	0	USGS
		3-30-59		64.5	6.2	4.5 0.22	0.5 0.04	4.8 0.21	6.8 0.02	0.0 0.00	18 0.30	3.0 0.06	4.1 0.12	2.1 0.03	0.00 0.00	0.22	16		45	43	13	0	DWR
W.E. Pike Domestic & Irrigation	32N/3W-20P1	3-16-56	52	176	6.5	17 0.85	4.3 0.35	13 0.57	1.1 0.03	0.0 0.00	72 1.18	13 0.27	11 0.31	5.1 0.08	0.0 0.00	0.15	27		127	32	60	1	USGS
		9-25-57	68	212	7.3	14 0.70	7.8 0.64	15 0.65	1.6 0.04	0.0 0.00	77 1.26	6.4 0.13	20 0.56	0.5 0.01	0.4 0.02	0.10	31		135	32	67		DWR
		8-13-58		208	8.0	16 0.80	7.3 0.60	13 0.56	1.5 0.04	0.0 0.00	88 1.44	5.9 0.12	14 0.39	2.1 0.03	0.0 0.00	0.14	32	Fe(dis)=0.01	135	28	70	0	DWR
		7-14-59	65	204	7.2	21 1.05	0.4 0.03	20 0.87	1.1 0.03	0.0 0.00	80 1.31	7.4 0.15	16 0.45	3.7 0.06	0.2 0.01	0.33	30		139	44	54	0	DWR
		7-25-60		203	8.0	14 0.70	6.1 0.50	18 0.78	1.3 0.03	0.0 0.00	83 1.36	9.4 0.20	15 0.42	1.2 0.02	0.1 0.00	0.27	29	Fe(dis)=0.01 Fe(total)=0.30 Al=0.0 Mn=0.00 Cr=0.00 Zn-0.03 Cu=0.00 Pb=0.00 As=0.00	135	39	60	0	DWR
		6-25-62	74	175	7.2	14 0.70	6.1 0.50	12 0.52	1.2 0.03	0.0 0.00	78 1.28	9.0 0.19	7.4 0.21	4.0 0.06	0.1 0.00	0.20	25		117	30	60	0	DWR
		6-24-63	63	182	7.8	14 0.70	6.1 0.50	13 0.56	1.4 0.04	0.0 0.00	73 1.20	8.1 0.17	8.9 0.25	5.1 0.08	0.1 0.00	0.23	27		120	31	60	0	DWR
		8-24-64	66	322	8.3			45 1.96		0.0 0.00	103 1.69		34 0.96					Fe(dis)=0.58			46	0	DWR
		8-23-65	70	213		16	 1.40	14 0.61													70		DWR
		7-26-66	76	274	7.0	27 1.35	5.7 0.47	21 0.91	1.5 0.04	0.0 0.00	129 2.11	17 0.35	14 0.39	0.0 0.00					162		91	0	DWR
Steggar Irrigation	32N/3W-32E1	6-25-57	69	167	7.0	5.5 0.27	1.8 0.15	30 1.31	1.0 0.04	0.0 0.00	87 1.43	2.5 0.05	11 0.31	0.0 0.0	0.2 0.01	0.18	43		139	74	21	0	DWR
		8-13-58	66	186	8.0	4.4 0.22	1.7).14	32 1.39	0.9 0.02	0.0 0.00	85 1.39	1.8 0.04	12 0.34	0.6 0.01	0.4 0.02	2.23	33		129	78	18	0	DWR

a Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)

MINERAL ANALYSES OF GROUND WATER

COW CREEK

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 32N/3W-32E1	8-26-64	66	322	8.3			45 1.96		0 0.00	103 1.69		34 0.96					Fe(total)=0.58 Al=0.15 As=0 Cu=0 Pb=0 Mn=0 Zn=0.11			46	0	DWR
		8-23-65	70	213		16		14 0.61													70	0	DWR
Stegger Not Used	32N/3W-32E2	7-27-56		154	7.6	8.0 0.40	7.1 0.58	16 0.70	1.4 0.04	0 0.00	101 1.66	0 0.00	2.5 0.07	0 0.00	0.0	0.08	43		128	41	49	0	USGS
		7-24-57	77	3,050	6.6	20 1.00	6.8 0.56	615 26.75	4.0 0.10	0 0.00	221 3.62	9.5 0.20	88.7 25.01	0.2 0.00	0.6	3.0	13		1,600	94	78	0	DWR
Carrol Boyle Domestic-Not Used	32N/3W-32J1	4-17-56		3,530	7.2	106 5.29	39 3.20	579 25.19	6.0 0.15	0 0.00	120 1.97	114 2.37	1,010 28.48	2.3 0.04	0.1	4.1	29		1,950	74	424	326	USGS
		9-26-57	64	441	8.2	29 1.45	16 1.35	36 1.57	3.0 0.08	0 0.00	178 2.92	9.9 0.21	48 1.35	0.5 0.01	0.3 0.02	0.13	69		300	35	140		DWR
		8-13-58	66	603	8.3	38 1.90	20 1.66	47 2.04	2.8 0.07	3 0.10	156 2.56	13 0.27	98 2.76	1.4 0.02	0.0 0.00	0.23	66	Fe(dis)=0.00	366	36	178	45	DWR
		7-14-59		729	7.8	42 2.10	24 1.98	62 2.70	2.9 0.07	0 0.00	166 2.72	17 0.35	136 3.84	1.1 0.02	0.1 0.00	0.39	68		434	39	204	68	DWR
		7-25-60		463	8.3	36 1.80	16 1.36	34 1.48	2.1 0.05	0 0.00	182 2.98	13 0.27	32 0.90	28 0.45	0.1 0.00	0.16	55	Fe(dis)=0.00 Fe(total)=0.04 Al=0.02 As=0.00 Cr=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.03	305	32	158	9	DWR
		8-25-61		475	8.1	38 1.90	16 1.28	34 1.48	2.2 0.06	0 0.00	182 2.98	14 0.29	32 0.90	33 0.53	0.1 0.00	0.07	55		313	31	159	10	DWR
		6-25-62	74	368	8.0	24 1.20	13 1.10	30 1.30	2.1 0.05	0 0.00	162 2.66	7.9 0.16	28 0.79	1.1 0.04	0.0 0.00	0.14	58		246	36	115	0	DWR
Carrol Boyle Domestic	32N/3W-32J2	9-26-57	64	441	8.2	29 1.45	16 1.35	36 1.57	3.0 0.08	0 0.00	178 2.92	9.9 0.21	48 1.35	0.5 0.01	0.3	0.13	69		300	35	140		DWR
		6-25-62	74	368	8.0	24 1.20	13 1.10	30 1.30	2.1 0.05	0 0.00	162 2.66	7.9 0.16	28 0.79	2.3 0.04	0.1 0.00	0.14	58			36	115	0	DWR
		6-24-63	67	350	8.2	25 1.25	11 0.93	30 1.30	2.3 0.06	0 0.00	159 2.61	8.2 0.17	24 0.68	4.8 0.08	0.0 0.00	0.16	60		242	37	109	0	DWR
		8-26-64		445	8.3			39 1.70		0 0.00	167 2.74		43 1.21								127		DWR

a Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

MINERAL ANALYSES OF GROUND WATER

COW CREEK

Owner and use	State well number and other number	Date sampled	Temp in °F	Specific conductance (micromhos at 25° C)	pH	Mineral constituents in parts per million / equivalents per million													Total[a] dissolved solids in ppm	Percent sodium	Hardness as $CaCO_3$		Analyzed by[b]
						Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Fluoride (F)	Boron (B)	Silica (SiO_2)	Other constituents			Total ppm	N.C. ppm	
	"continued" 32N/3W-32J2	8-23-65	70	347		24		28 1.22													110		DWR
Vance Phipps Irrigation	32N/3W-32L1	8-5-60		580	8.1	9.4 0.47	4.7 0.39	103 4.48	2.1 0.05	0 0.00	132 2.16	4.3 0.09	111 3.13	0.4 0.01	0.6 0.03	0.82	47	Fe(dis)=0.01 Fe(total)=0.18 Al=0.0 As=0.0 Cr=0.0 Cu=0.0 Pb=0.0 Mn=0.0 Zn=0.00	348	83	43	0	DWR
		6-25-62	70	1,790	8.1	53 2.64	14 1.18	280 12.18	4.0 0.10	0 0.00	128 2.10	12 0.25	485 13.68	0.9 0.01	0.6 0.03	1.2	42		956	76	191	86	DWR
		10-16-62	60-65	485	8.0	15 0.75	6.0 0.49	73 3.18	2.0 0.05	0 0.00	93 1.52	6.4 0.13	97 2.74	2.1 0.03	0.4 0.02	0.44	45		295	71	62	0	DWR
		6-24-63	68	761	7.9	18 0.90	6.8 0.56	123 5.35	2.4 0.06	0 0 00	115 1.88	8.6 0.18	175 4.94	0.9 0.01	0.6 0.03	1.0	46		435	78	73	0	DWR
Nugget Farm Irrigation	32N/3W-35C1	10-26-55	66	204	7.3	13 0.65	7.7 0.63	20 0.87	2.5 0.06	0 0.00	122 2.00	4.0 0.08	5.2 0.15	0.3 0.01	0.1 0.01	0.04	60		173	39	64	0	USGS
		8-13-58	63	213	8.3	13 0.65	9.4 0.77	17 0.74	2.2 0.06	2 0.07	125 2.05	0.3 0.01	3.4 0.10	0.7 0.01	0.1 0.00	0.08	67	Fe(dis)=0.06	176	33	71	0	DWR
		7-14-59		382	7.8	16 0.80	10 0.84	44 1.91	2.6 0.07	0 0.00	129 2.11	0.3 0.01	54 1.52	0.1 0.00	0.1 0.00	0.27	65		256	53	82	0	DWR
		7-25-60		440	8.2	18 0.90	10 0.86	55 2.39	2.6 0.07	0 0.00	128 2.10	1.5 0.03	74 2.09	0.7 0.01	0.1 0.00	0.15	65	Fe(dis)=0.01 Fe(total)=0.72 Al=0.02 As=0.01 Cr=0.00 Cu=0.00 Pb=0.00 Mn=0.44 Zn-0.02	290	57	88	0	DWR
		11-15-61		203	7.7	13 0.65	9.1 0.75	16 0.70	2.3 0.06	0 0.00	124 2.03	2.1 0.04	3.1 0.09	0.0 0.00	0.2 0.01	0.04	70		177	32	70	0	DWR
		6-25-62	70	353	8.0	15 0.75	10 0.83	40 1.74	2.3 0.06	0 0.00	126 2.06	1.8 0.04	44 1.24	0.1 0.00	0.2 0.01	0.12	60		236	51	79	0	DWR
		5-27-63	66	340	8.1	16 0.80	9.5 0.78	38 1.65	2.5 0.06	0 0.00	130 2.13	21 0.04	42 1.18	0.6 0.01	0.2 0.01	0.12	64		239	50	79	0	DWR
		8-25-64	68	388	8.5		1.62	43 1.87		2 0.07	135 2.05		51 1.44					Fe(total)=0.00 Al=0.01 As=0.00 Cu=0.00 Pb=0.00 Mn=0.00 Zn=0.02			81	0	DWR
		8-23-65	68	215			1.40	18 0.78													70	0	DWR

a. Determined by addition of constituents unless otherwise noted

b. Analysis by indicated laboratory:
U.S. Geological Survey, Quality of Water Branch (U.S.G.S.)
State Department of Water Resources (D.W.R.)

APPENDIX E

WATER QUALITY CRITERIA

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APPENDIX E

TABLES

Water contains solids which have been dissolved from its environment. Most of the dissolved constituents in water are dissociated into ions. The positively charged ions are cations. The negatively charged ions are anions. These dissolved constituents determine the mineral character of the water. Table 1 below lists the most common constituents.

TABLE 1

CHEMICAL CONSTITUENTS OF GROUND WATER

Major Constituents		Minor Constituents
Common Cations	Common Anions	
Calcium (ca)	Carbonate (CO_3)	Iron (Fe)
Magnesium (mg)	Bicarbonate (HCO_3)	Aluminum (Al)
Sodium (Na)	Sulfate (SO_4)	Silica (SiO_2)
Potassium (k)	Nitrate (NO_3)	Boron (B)
	Chloride (Cl)	Fluoride (F)

The mineral character or type of water is determined by the predominate cation and anion in terms of their chemical equivalents per million (epm). The name of the cation is used when its chemical equivalents constitute 50 percent or more of the total cations. This applies to the anion group also. For example, if in a sample of water, magnesium ions constitute more than half of the total cations present, and the bicarbonate ions constitute more than half of the anions present, the water is magnesium bicarbonate in character. If there is no single constituent that constitutes more than 50 percent of the individual totals of cations and anions, hyphenated combinations are used. As an example, if the magnesium and calcium cations are present in the water in nearly equal amounts, the water would be designated a magnesium-calcium-bicarbonate water. Minor constituents (e.g., iron, boron, flouride) may be present. They can sometimes be deleterious for certain specific uses if present in the water in sufficient quantity.

The ions impart an electrical conductivity to the water. This property can be measured easily and is usually proportional to the total dissolved solids in solution. Within a given area where the water is of similar character, a definite relationship can be established between the electrical conductivity and total dissolved solids. By measuring the electrical conductivity, the amounts of total dissolved solids can be estimated very accurately.

This appendix presents a summary of water quality criteria, quality of ground water, and an interpretation of ground water quality conditions. Mineral analyses of ground water samples collected from wells in Shasta County are listed in Appendix D.

The quality of water must be maintained at proper levels in order to satisfy a wide variety of beneficial uses. Criteria have been established for protection of the public health and to provide a reasonable measure of suitability of various waters for many beneficial uses. Water quality criteria are discussed in this appendix for municipal, domestic, irrigation, and industrial uses. The limits presented are the result of continuing experience and research by various state, local, and federal agencies. Although these recommended limits are subject to change as our knowledge in the field of water quality increases, they do provide a reasonable guide for the evaluation of the suitability of a particular water for its use. Waters which have an excess of the recommended limiting values may be used in some instances, with judgment, until more suitable supplies are developed and made available. The following criteria are guides for appraisal of the quality of water for various uses.

Municipal and Domestic

The criteria presented for municipal and domestic purposes should be used as guides for evaluating the mineral quality of water relative to existing or potential uses. Except for those constituents which are considered toxic to human beings, these criteria should be considered as suggested limiting values. The drinking water standards most widely accepted are those proposed by the U. S. Public Health Service. These standards state that water shall contain no impurities which are offensive to sight, taste, or smell. In addition, the water must be consistently free from toxic compounds or pathogenic organisms. Drinking water should not contain excessive concentrations of dissolved mineral solids. Health standards for drinking water are predicated on two groups of limits:

1. Mandatory limits which constitute grounds for rejection of the water supply. These limits are specified to protect the consumer from increased build-up of toxic constituents.

2. Recommended maximum limits are applicable when chemical substances are present in excess and consideration should be given for more suitable supplies which are, or can be made, available; however, they are still permissible.

The U. S. Public Health Service standards of 1962 apply to water as finally delivered to the consumer. They are presented in Table 2.

Another factor with which water users are concerned is the hardness of water. Hardness is caused principally by the compounds of calcium and magnesium, but excessive amounts of iron, manganese, aluminum, barium, silica, strontium, and free hydrogen can also contribute to the total hardness. Excessive hardness in water increases the use of soap, which it coagulates to form a precipitate, leaving an undesirable scum in clothing

TABLE 2

LIMITING CONCENTRATIONS OF CHEMICAL CONSTITUENTS FOR DRINKING WATER

U. S. Public Health Service, Drinking Water Standards 1962

Constituents - Mandatory	Parts per Million
Arsenic	0.05
Fluoride	0.8 - 1.7*
Lead	0.05
Hexavalent Chromium (Cr^{+6})	0.05
Cyanide	0.2
Selenium	0.01
Barium	1.0
Cadmium	0.01
Silver	0.05

Constituents - Recommended	Parts per Million
Alkyl Benzene Sulfate (A.B.S.)	0.5
Arsenic	0.01
Chloride	250.0
Copper	1.0
Carbonchloroform Extract (C.C.C.)	0.2
Cyanide	0.01
Fluoride	0.7 - 1.2*
Iron	0.3
Manganese	0.05
Nitrate	45.0
Phenols	0.001
Sulfate	250.0
Total Dissolved Solids	500.0
Zinc	5.0

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* Varies with temperature

and washing facilities. Hard water also forms a scale, thereby reducing the efficiency of boilers and plumbing systems. Total hardness is expressed as calcium carbonate ($CaCO_3$) in parts per million (ppm). It is calculated by multiplying the sum of the equivalents of calcium and magnesium by 50. If significant amounts of iron and manganese are present, they are included. A relative classification of hardness is shown in Table 3.

TABLE 3

HARDNESS CLASSIFICATION OF WATER

Range of Hardness Expressed as $CaCO_3$ (in ppm)	Relative Classification
0 - 100	Soft
101 - 200	Moderately soft
over 200	Hard

Agricultural

The limits of quality of water for irrigation purposes vary according to the climate, crops, soils, and the irrigation practices in the area. The values presented here were developed by the Regional Salinity Laboratories of the U. S. Department of Agriculture in cooperation with the University of California.

Three broad classes of judging the suitability in chemical quality of water for irrigation purposes are listed below:

Class 1 - excellent to good - regarded as safe and suitable for most plants under most conditions of soil or climate.

Class 2 - good to injurious - regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.

Class 3 - injurious to unsatisfactory - regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant plants.

Suggested limiting values for total dissolved solids (TDS), chloride concentration, percent sodium, and boron concentration for the three general classes of irrigation water are shown in Table 4.

Industrial

The quality of water required for industrial purposes varies widely according to the many industrial processes or uses to which it may be put. The two largest industrial uses of water are for cooling and processing. No single tabulation of water quality requirements will suffice as a common measure for suitable limits. Most industrial

TABLE 4

QUALITATIVE CLASSIFICATION OF IRRIGATION WATER

Chemical Properties	Class 1	Class 2	Class 3
Total Dissolved Solids (in ppm)	Less than 700	700 - 2000	More than 2000
Chloride (in ppm)	Less than 175	175 - 350	More than 350
Sodium in Percent of Total Cations	Less than 60	60 - 75	More than 75
Boron (in ppm)	Less than 0.5	0.5 - 2.0	More than 2.0

operations normally require a water which is clear, relatively soft, low in iron and manganese, and of approved bacteriological quality. Because the ways of purifying water for industrial purposes are many, a treatment process usually can be selected for the particular need of a specific industry. Generally, water which meets drinking water standards is satisfactory for industrial use. Table 5 shows some typical standards for selected industries.

Table 5

Suggested Water Quality Tolerances for Industrial Uses

						(Allowable limits in ppm)						
Industry or Use	Turbidity	Color	Odor and Taste	Iron as Fe	Manganese as Mn	Total Solids	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	Hydrogen Sulfide	Health	pH	Other Requirements
Air Conditioning			Low	0.5	0.5				1.0			No corrosiveness or slime formation
Baking	10	10	Low	0.2	0.2				0.2	Potable		
Brewing and Distilling												
Light Beer, Gin	10		Low	0.1	0.1	500		75	0.2	Potable	6.5-7.0	NaCl 275
Dark, Beer, Whiskey	10		Low	0.1	0.1	1000		150	0.2	Potable	7.0	NaCl 275
Canning												
Legumes	10		Low	0.2	0.2		25-75		1.0	Potable		
General	10		Low	0.2	0.2				1.0	Potable		
Carbonated Beverages	2	10	Low	0.2	0.2	850	250	50-100	0.2	Potable		Organic matter infinitesimal; oxygen consumed 1
Confectionery			Low	0.2	0.2	100			0.2	Potable	7.0	
Cooling	50			0.5	0.5		50		5			No corrosiveness or slime formation
Food, General	10		Low	0.2	0.2					Potable		
Ice	5	5	Low	0.2	0.2	1300				Potable		SiO_2 10
Laundering				0.2	0.2		50					
Paper and Pulp												
Ground Wood	50	20		1.0	0.5		180					No grit or corrosiveness
Kraft Pulp	25	15		0.2	0.1	300	100					
Soda and Sulfite Pulp	15	10		0.1	0.05	200	100					
High-Grade Light Papers	5	5		0.1	0.05	200	50					No slime formation
Tanning	20	10-100		0.2	0.2	50-135	135					OH 8

APPENDIX F

WATER WELL STANDARDS
STATE OF CALIFORNIA

CHAPTER II OF BULLETIN NO. 74

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APPENDIX F

FIGURES

CHAPTER II. STANDARDS

The standards presented in this chapter are intended to apply to construction (including reconstruction) or destruction of wells throughout the State of California. Under certain circumstances, adequate protection of ground water quality may require more stringent standards than these presented here; under other circumstances, it may be necessary to deviate from the standards or substitute other measures which will provide protection equal to that provided by these standards. Since it is impractical to prepare standards for every conceivable situation, provision has been made in the succeeding material for deviation from the standards as well as for addition of appropriate supplementary standards. The need to deviate from general recommendations and to apply additional standards are the principal reasons that the Department is also investigating the development of different or supplemental water well construction standards for various subareas within the State. However, the Department believes that the standards presented in this report are satisfactory under most conditions for the construction and destruction of water wells in all areas of this state.

Part I. General

Section 1. Definitions.

A. Well or Water Well. As defined in Section 13710 of the Water Code, well or water well:

> " ... means any artificial excavation constructed by any method for the purpose of extracting water from, or injecting water into, the underground. This definition shall not include: (a) oil and gas wells, or geothermal wells constructed under the jurisdiction of the Department of Conservation, except those wells converted to use as water wells; or (b) wells used for the purpose of (1) dewatering excavation during construction, or (2) stabilizing hillsides or earth embankments."

B. Community Water Supply Well. A water well used to supply water for domestic purposes in systems subject to Chapter 7 of Part 1 of Division 5 of the California Health and Safety Code. (This definition includes wells commonly referred to as "Municipal Wells" or "City Wells".)

C. Individual Domestic Well. A water well used to supply water for domestic needs of an individual residence or commercial establishment such as an apartment house, cafe, gas station, etc.

D. Industrial Wells. Water wells used to supply industry on an individual basis (in contrast to supplies provided through community systems).

E. Agricultural Wells. Water wells used to supply water for irrigation or other agricultural purposes, including so-called "stock wells".

F. Recharge or Injection Wells. Wells constructed to introduce water into the ground as a means of replenishing ground water basins or repelling intrusion of seawater*.

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* Injection wells are also used to dispose of unusable waste water into unusable ground water bearing formations or dry, nonproductive formations. These wells can penetrate usable ground water zones; however, Water Code and Division 5 of the Health and Safety Code), such wells are no permitted to open into usable waters.

G. Air-conditioning Wells. Wells constructed to return to the ground, water which has been used as a coolant in air conditioning processes. Because the water introduced into these wells is degraded (from the standpoint of temperature), these wells have been construed as waste discharges and are therefore subject to the water quality control laws (Division 7 of the Water Code and Division 5 of the Health and Safety Code).

H. Horizontal Wells. Water wells drilled horizontally or at an angle with the horizon (as contrasted with the common vertical well). This definition does not apply to horizontal drains or "wells" constructed to remove subsurface water from hillsides, cuts, or fills (such installations are used to prevent or correct conditions that produce land slides).

I. Enforcing Agency. An agency designated by duly authorized local, regional or state government to administer laws or ordinances pertaining to well construction.

Section 2. Application to Type of Well.

Except as prescribed in Sections 3 and 4 (following) these standards shall apply to all types of wells described in Section 1. Before a change of use is made of a well, compliance shall be made with the requirements for the new use as specified herein.

Section 3. Exemption Due to Unusual Conditions.

If the enforcing agency finds that compliance with any of the requirements prescribed herein is impractical for a particular location because of unusual conditions and would result in construction of an unsatisfactory well, the enforcing agency may prescribe alternative requirements which are "equal to" these standards in terms of protection obtained.

Section 4. Exclusions.

The standards prescribed in Part II, "Construction", do not apply to test holes, observation wells, exploratory holes, salt-water (hydraulic) barrier injection or extraction wells. Note however that, Part III, "Well Destruction", does apply to these wells or holes.

Springs are excluded from these standards*.

Section 5. Special Standards.

A. In locations where existing geologic or ground water conditions require standards more restrictive than those described herein, or in addition to them, such special standards may be prescribed by the enforcing agency.

B. Special standards are necessary for the construction of injection wells, horizontal wells and other unusual types of wells, including galleries and other similar excavations. Design of these wells is subject to the approval of the enforcing agency.

Section 6. Well Drillers.

Wells shall be constructed by contractors licensed in accordance with the provisions of the Contractors License Law (Chapter 9, Division 3, of the Business and Professions Code) unless exempted by that act.

Section 7. Reports.

Reports concerning the construction of water wells shall be filed in accordance with the provisions of Sections 13750 through 13755 (Division 7, Chapter 7, Article 2) of the Water Code.

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* Methods which can be used to protect water supplies furnished by springs are described in "Manual of Individual Water Supply Systems", United States Public Health Service Publication No. 24, 1962.

PART II. Well Construction

Section 8. Well Location with Respect to Contaminants and Pollutants.

A. All wells shall be located an adequate horizontal distance from potential sources of contamination and pollution. Most of the factors involved in determining safe distances are usually not known. However, the following horizontal distances, which are based on past experience and general knowledge, are safe where dry upper unconsolidated formations, less permeable than sand, are encountered:*

	Community Water Supply Wells	Other Wells
Sewer, watertight septic tank, or pit privy	50 feet	50 feet
Subsurface sewage leaching field	100 feet	50 feet
Cesspool or seepage pit	150 feet	100 feet

Where in the opinion of the enforcing agency adverse conditions exist, the above distances shall be increased or special means of protection, particularly in the construction of the well, shall be provided.

B. In addition, if possible, the well shall be up the ground water gradient (upstream) from the specified sources of contamination.

C. When possible, the top of the casing shall terminate above any known conditions of flooding by drainage or runoff from the surrounding land.

D. Where a well is to be near a building, it shall be far enough from the building to be accessible for repair, maintenance, etc.

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* Because of the many variables involved in determination of the safe horizontal distance of a well from potential sources of contamination and pollution, no one set of distances will be adequate and reasonable for all conditions. In areas where adverse conditions exist, the distances listed should be increased. Conversely, where especially favorable conditions exist or where special means of protection, particularly in construction of the well, are provided, lesser distances may be acceptable if approved by the enforcing agency.

Section 9. Sealing the Upper Annular Space.

The space between the well casing and the wall of the drilled hole (the annular space) shall be effectively sealed to protect against contamination or pollution by surface and/or shallow, subsurface waters as set forth below.

A. Depth of Seal. Following is the minimum depth of seal below ground surface for various uses of wells:

Type	Depth of Seal (below ground surface)
Community Water Supply Wells	50 feet
Individual Domestic Wells	20 feet 1/
Industrial Wells	50 feet 1/ 2/
Agricultural Wells	None 3/
Air-Conditioning Wells	20 feet

1/ Exceptions are shallow wells where the water to be developed is at a depth less than 20 feet. In this instance, the depth of seal may be reduced but in no case less than 10 feet and special precautions shall be taken in locating the well with respect to possible sources of contamination.

2/ This requirement is necessary only where the water is used intentionally or incidentally for domestic purposes (drinking, washing, etc.) or the water must meet strict quality requirements for its intended uses.

3/ The annular space shall be sealed a minimum depth of 20 feet from the surface of the ground when the well is close to individual domestic wells or 50 feet when the well is close to sources of contamination or pollution described in Section 8. Local conditions, such as the existence of shallow, subsurface waters of undesirable quality, may warrant consideration of sealing the annular space around agricultural wells.

B. Sealing Conditions.* Following are requirements to be observed in sealing the annular space:

1. Wells that are fully situated, or at considerable depth, in unconsolidated, caving material.

a. Where the cable-tool method of drilling is used, an outer casing (conductor casing), may function as the seal provided the length of the conductor casing corresponds to the depth of seal specified in Part A of this section. (See Figure 1).

b. Where the rotary method of construction is used, the annular space shall be filled with sealing material to the depth specified in Part A of this section. When a temporary conductor casing is used to hold out the caving material during placement of the seal, it may be left in place or withdrawn as the sealing material is placed. (See Figure 1).

2. Wells that penetrate stratified formations. If an impervious (consolidated) formation is encountered within 5 feet of where the bottom of the seal described in Part A of this section should terminate, the seal should be extended into the impervious formation. (See Figure 1).

3. Gravel packed wells. In wells constructed without a conductor casing, the gravel pack shall terminate at the base of the seal. Gravel fill pipes may be installed in the seal. In wells constructed with a conductor casing (which allows the gravel pack to extend to the top of the well), the annular space between the conductor casing and the wall of the drilled hole shall be sealed to the depth specified in this section. (See Figure 1).

4. Wells that are fully situated in consolidated rock. (Open-bottom wells), An over-sized hole must be constructed to the depth and diameter required for the seal and casing installed to retain the seal (See Figure 1).

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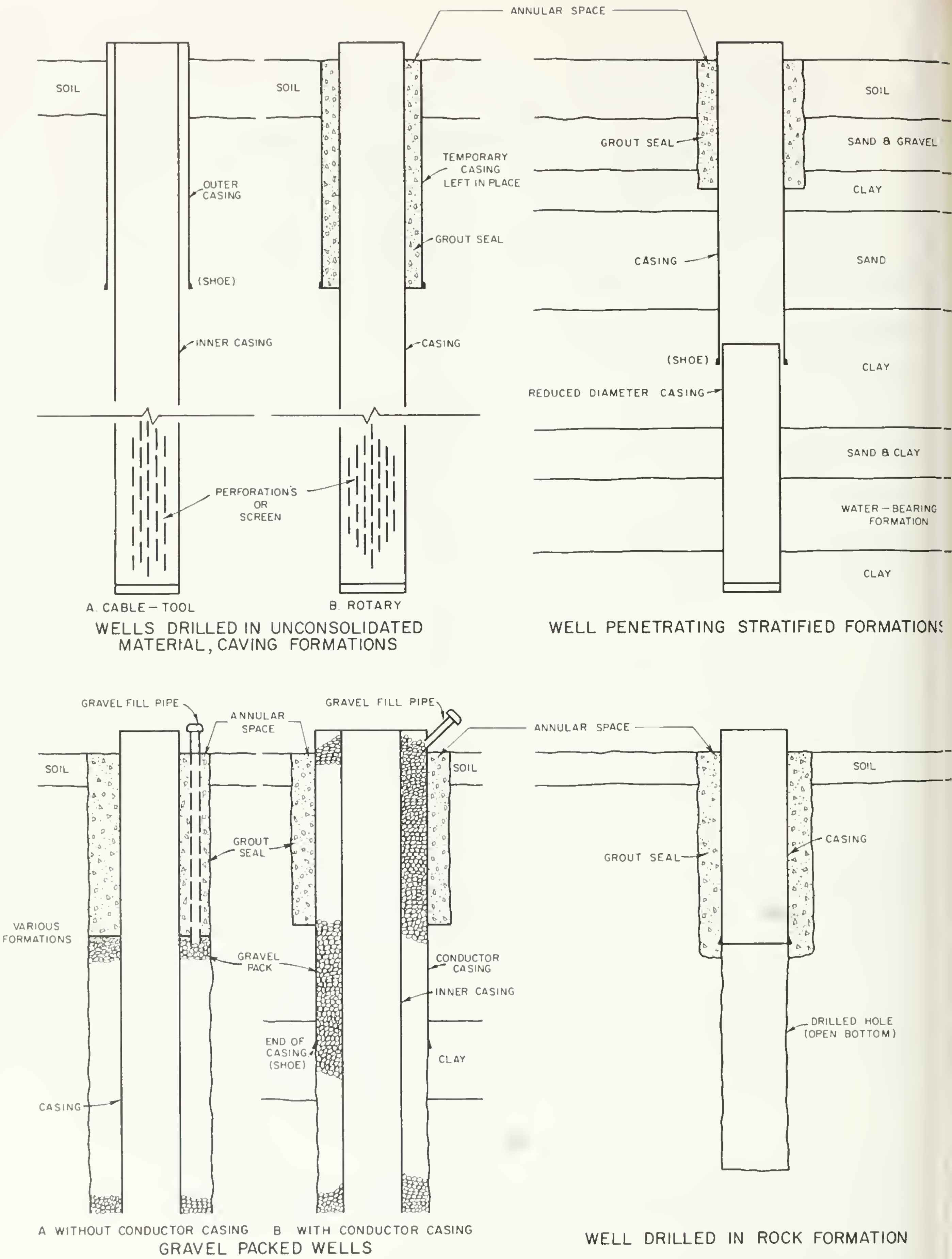
* Methods of sealing are described in Appendix G.



WELLS DRILLED IN UNCONSOLIDATED MATERIAL, CAVING FORMATIONS

WELL PENETRATING STRATIFIED FORMATIONS

GRAVEL PACKED WELLS

WELL DRILLED IN ROCK FORMATION

Figure l. SEALING CONDITIONS FOR UPPER ANNULAR SPACE

C. Conductor Casing. For community water supply wells, the minimum thickness of steel conductor casing shall be 1/4 inch for single casing or a minimum of No. 10 U. S. Standard Gage for double casing. Steel used for conductor casing shall conform to the specifications for steel casing described in Section 12.

D. Sealing Material. The sealing material shall consist of neat cement, cement grout, puddled clay, or concrete.* The neat cement mixture shall be composed of one bag of Portland Cement (94 pounds) to 5 to 7 gallons of clean water. Cement grout shall be composed of not more than two parts by weight of sand and one part of cement (per bag of cement) to 5 to 7 gallons of clean water. Quick-setting cement, retardents to setting, and other additives, including hydrated lime to make the mix more fluid (up to 10 percent of the volume of cement), and bentonite (up to 5 percent) to make the mix more fluid and to reduce shrinkage, may be used. Concrete used shall be "Class A" (6 sacks of Portland Cement per cubic yard) or "Class B" (5 sacks per cubic yard).

E. Thickness of Seal. The thickness of the seal shall be at least two (2) inches, and not less than three (3) times the size of the largest coarse aggregate used in the sealing material.

F. Placement of Seal. The sealing material shall be applied, if possible, in one continuous operation from the bottom of the interval to be sealed to the top.

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* Clay in the form of a mud-laden fluid is similar to and has the advantages of neat cement and cement grout. There is a disadvantage in that clay may separate out from the fluid. A bentonite-gelatenous mud is recommended. Concrete is useful in sealing large diameter wells, particularly where the width of annular ring is several inches or more. However, unless care is exercised during placement, the coarse aggregate may become separated from the cement.

Section 10. Surface Construction Features.

A. Openings. Openings into the top of the well which are not constructed to provide access to the well shall be sealed. Openings designed to provide access into well casings for making measurements, adding gravel, etc. shall be protected against entrance of surface waters by installation of watertight caps, and against entrance of foreign matter by installation of caps, plugs, screens, or downturned "U" bends.

1. Where the pump is installed directly over the casing, an annular watertight seal shall be placed between the pump head and the pump base (slab), or a watertight seal shall be placed between the pump base and the rim of the casing, or a seal or "well cap" shall be installed to close the annular opening between the casing and the pump column pipe.

2. Where the pump is offset from the well or where a submersible pump is used, the opening between the well casing and any pipes or cables which enter the well shall be closed by a watertight seal or "well cap".

3. All holes in the base of the pump which open into the well shall be sealed.

4. If the pump is not installed immediately upon completion of the well, or if there is a prolonged interruption in construction of the well, a watertight cap shall be provided at the top of the casing.

5. Pump discharge piping shall be located above the ground where possible; however, in the event of a below-ground discharge (below pump base), there shall be a watertight seal or gasket between the discharge pipe and well casing.

6. If a concrete base or slab (sometimes called a pump block or pump pedestal) is to be constructed around the top of the casing, it shall

be free from cracks or other defects likely to detract from its watertightness.

7. Where the well is to be gravel packed, a watertight cover shall be installed between the conductor pipe and the inner casing (if a conductor pipe is used) or between the casing and the well of the drilled hole, at the top of the well.

B. Well Pits. Because of their susceptability to contamination and pollution, the use of well pits should be avoided whenever possible. However, when a pit is necessary, the following requirements must be observed:

1. The bottom of the pit shall not extend below the water table.

2. The casing shall extend at least six inches above the pit floor.

3. The pit shall be constructed and protected so that rain, flood, or seepage waters cannot enter it.

4. The pit shall be provided with a drainage sump and an automatic sump pump (or, if topography permits, a "gravity" discharge). The discharge pipe from this sump shall not be connected to any sewer or pipe drain. The outlet of the discharge pipe shall not be below ground level, shall be above known conditions of flooding and protected against entry of small animals.

5. The top of the pit shall be provided with a watertight cover such as a concrete slab, metal cover, or house of equivalent watertight construction.

6. Each pit shall have easy access for proper operation, maintenance, and inspection of the equipment, and shall have a locked door or hatch to insure the public safety.

C. Enclosure of Well and Appurtenances. For community water supply wells, the well and pump shall be located in a locked enclosure to exclude access by unauthorized persons.

D. Pump Blowoff. When there is any blowoff or drain line from the pump discharge, it shall be so located that there is no hazard to the safety of the water supply by reason of flooding, back siphonage, or back pressure. The blowoff or drain line shall not be connected to any sewer.

Section 11. Disinfection and Other Sanitary Requirements.

A. Disinfection.* All community water supply, individual domestic, and industrial wells shall be disinfected following construction, repair, or when work is done on the pump, before the well is placed in service.

B. Gravel. Gravel used in gravel-packed wells shall come from clean sources and, except for agricultural wells, should be thoroughly washed before being placed in the well. Gravel purchased from a supplier should be washed at the pit or plant prior to delivery to the well site.

C. Lubricants. Mud and water used as a drilling lubricant shall be free from sewage contamination. Oil and water used for lubrication of the pump and pump bearing shall also be free from contamination.

Section 12. Casing.

A. Casing Material. Requirements pertaining to well casing are to insure that the casing will perform the functions for which it is designed, i.e., to maintain the hole by preventing its walls from collapsing, to provide a channel for the conveyance of the water, and to provide a measure of protection for the quality of the water pumped.

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* A procedure for disinfecting a well is described in Appendix E.

1. Well casing shall be strong and tough enough to resist the forces imposed during installation and those forces which can normally be expected after installation.

2. Steel is the material most frequently used for well casing, especially in drilled wells. There are three principal classifications of steel materials used for water well casing, and all are acceptable for use so long as they meet the following conditions.

a. Standard and line pipe.* This material shall meet one of the following specifications, including the latest revision thereof:

(1) API Std. 5L, "Specification for Line Pipe".

(2) API Std. 5LX, "Specification for High-Test Line Pipe".

(3) ASTM A53, "Standard Specification for Welded and Seamless Steel Pipe".

(4) ASTM A120, "Tentative Specifications for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses".

(5) ASTM A134, "Standard Specifications for Electric-Fusion (Arc)-Welded Steel Plate Pipe (sizes 16 inches and over)".

(6) ASTM A135, "Tentative Specifications for Electric-Resistance-Welded Steel Pipe".

(7) ASTM A139, "Standard Specifications for Electric-Fusion (Arc)-Welded Steel Pipe (sizes 4 inches and over)".

(8) ASTM A211, "Standard Specifications for Spiral-Welded Steel or Iron Pipe".

(9) AWWA C201, "AWWA Standard for Fabricated Electrically Welded Steel Pipe".

(10) AWWA C202, "Tentative Standard for Mill Type Steel Water Pipe".

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* Abbreviations used are: API-American Petroleum Institute; ASTM-American Society for Testing and Materials; AWWA-American Water Works Association

b. Structural Steel. This material shall meet one of the following specifications of the American Society for Testing and Materials including the latest revision thereof:

(1) ASTM A36, "Tentative Specification for Structural Steel".

(2) ASTM A242, "Tentative Specification for High Strength Low Alloy Structural Steel".

(3) ASTM A245, "Standard Specification for Flat-Rolled Carbon Steel Sheets of Structural Quality".

(4) ASTM A283, "Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates of Structural Quality (Plate 2 inches and under in thickness)".

(5) ASTM A440, "Tentative Specification for High-Strength Structural Steel".

(6) ASTM A441, "Tentative Specification for High-Strength Low Alloy Structural Manganese Vanadium Steel".

c. High strength carbon steel sheets referred to by their manufacturers and fabricators as well casing steel. At present, there are no standard specifications concerning this material. However, the major steel producers market products whose chemical and physical properties are quite similar. Each sheet of material shall contain mill marking which will identify the manufacturer and specify that the material is well casing steel which complies with the chemical and physical properties published by the manufacturer.

d. The thickness of steel used for well casing shall be selected in accordance with good design practice as applied to conditions encountered in the area where the well is located. However, the thicknesses selected shall not be less than those set forth in the following table:

RECOMMENDED MINIMUM THICKNESSES
for
STEEL WELL CASING*
(single casing)

Diameter (inches)	Thickness (inches)
6	0.1046 (12 gage)
8	0.1046 (12 gage)
10	0.1046 (12 gage)
12	0.1345 (10 gage)
14	0.1345 (10 gage)
16	0.1644 (8 gage)
18	0.1644 (8 gage)
20	0.1644 (8 gage)
22	0.2500
24	0.2500
30	0.2500

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* Selection of casing depends on its ability to resist external forces as well as factors affecting the casing serviceability. The maximum theoretical external pressure under which a particular well casing of a specific diameter and thickness will collapse can be calculated. However, other considerations such as the effect of driving the casing into place or other impact forces which may have an effect on the ability of a particular casing to resist external pressures, cannot be calculated with accuracy. Good design practice precludes the selection of a casing of a particular thickness for use where it will experience external pressures approaching the maximum or where unknown forces might magnify the effect of the external forces. Instead it is customary for designers to introduce factors of safety which tend to insure that the casing selected will resist all probable forces imposed upon it. Consequently, experience and sound judgment, coupled with these factors of safety, have so far proved to be the best guide in selecting the proper casing. Suggested thicknesses for steel casing for various depths and diameters are to be found in material published by the various steel manufacturers and fabricators and in "Recommended Standards for Preparation of Water Well Construction Specifications", a publication of the Associated Drilling Contractors of the State of California. The suggested thicknesses contained in such publications are not to be considered a part of these standards.

3. Other materials*, except as listed in No. 4 below, may be used as casing for water wells, subject to the approval of the enforcing agency.

Concrete pipe should conform to the following specifications, including the latest revision thereof:**

(a) ASTM C14, "Standard Specifications for Concrete Sewer, Storm Drain, and Culvert Pipe".

(b) ASTM C76, "Tentative Specifications for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe".

(c) AWWA C300, "AWWA Standard for Reinforced Concrete Water Pipe-Steel Cylinder Type, Not Prestressed".

(d) AWWA C301, "AWWA Standard for Reinforced Concrete Water Pipe-Steel Cylinder Type, Prestressed".

4. Galvanized sheet metal pipe ("downspout"), or natural wood shall not be used as casing.

B. Installation of Casing. All casing shall be placed with sufficient care to avoid damage to casing sections and joints. Where casing is driven, (as is generally the case when the cable tool method of construction is used), the casing shall be equipped with a drive shoe at the lower end. All joints in the casing above perforations or screens shall be watertight. The uppermost perforations shall be at least below the depth specified in Section 9, Part A, "Depth of Seal".

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* Such as stainless steel, wrought iron, asbestos cement pipe, plastic pipe, fiber-glass pipe and synthetic woods, all of which have been successfully employed as casing in California or elsewhere. Their present use has been limited to special cases. Specifications for most of these materials are published by either ASTM or AWWA.

** ASTM - American Society for Testing and Materials.
AWWA - American Water Works Association.

Section 13. Sealing-off Strata.*

In areas where a well penetrates more than one aquifer and any of the aquifers contain water of a quality such that, if allowed to mix in sufficient quantity, will result in a significant deterioration of the quality of water in the other aquifer(s) or the quality of water produced, the strata producing such water shall be sealed off to prevent entrance of the water into the well or its migration to other aquifer(s).

A. The producing strata shall be sealed off by placing impervious material opposite the strata and opposite the confining formations for a sufficient vertical distance (but no less than 10 feet) in either direction, or, in the case of "bottom" waters, in the upward direction. Sufficient sealing material shall be applied to fill the annular space between the casing and the wall of the drilled hole in the interval to be sealed, and to fill the voids which might absorb the sealing material. The sealing material shall be placed from the bottom to the top of the interval to be sealed.

B. Sealing material shall consist of neat cement, cement grout, or other suitable impervious material. (See Section 9, Part D).

C. Sealing shall be accomplished by a method approved by the enforcing agency.*

Section 14. Well Development.

Developing, redeveloping, or conditioning of a well shall be done with care and by methods which will not cause damage to the well or cause adverse subsurface conditions that may destroy barriers to the vertical movement of water between aquifers.

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* Suggested methods for sealing-off strata are presented in Appendix F.

The following methods used in developing, redeveloping, or conditioning a well when done with care are acceptable: (a) overpumping, (b) surging by use of a plunger or compressed air, (c) backwashing or surging by alternately starting and stopping the pump, pouring water in the well or jetting with water, (d) introduction of chemicals designed for this purpose, and (e) a combination of the above.

Methods which produce an explosion are not prohibited; however, they should be used with care particularly where two or more distinct aquifers have been penetrated.

Where chemicals or explosives have been used, the well shall be pumped until all trace of these agents has been removed.

Section 15. Water Quality Sampling.*

The requirements to be followed with respect to water quality sampling are:

A. Community Water Supply Wells and Certain Industrial Wells. The water from all community water supply wells and industrial wells which provide water for use in food processing shall be sampled immediately following development and disinfection, and appropriate analysis shall be made. Approval of the enforcing agency must be obtained before the well is put into use.

1. Sample Tap. Except where there is free discharge from the pump (that is, there is no direct connection to the water delivery system), a sample tap shall be provided on this discharge line so that water representative of the water in the well may be drawn for laboratory analysis.

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* The collection of water quality samples is described in Appendix G.

2. Laboratory Analysis. The appropriate analysis shall be performed by a laboratory certified by the California Department of Public Health. A copy of the laboratory analysis shall be forwarded to the California Department of Public Health or to the Local Health Department.

3. Bacterial Quality. Where the water is to be used for domestic purposes, samples shall be collected for bacteriological analysis (presence of coliform organism) after all traces of development and disinfectant chemicals have been removed from the well.

4. Chemical (Mineral) Quality. Where the water is to be used for domestic purposes or for food processing, samples shall be collected for chemical analysis.

B. Other Types of Wells. To determine the quality of ground water which will be available from the well and its suitability for intended uses, the water in all wells should be sampled immediately following construction and development, and appropriate analyses based upon the intended uses should be made. Where the water is to be used for domestic purposes, samples should be collected for bacteriological analysis (presence of coliform organism) after all traces of development or disinfectant chemicals have been removed from the well. Determination of the mineral quality of the water produced by the well is desirable from the standpoint of all uses.

Section 16. Special Provisions for Large Diameter Shallow Wells.

A. Use as Community Water Supply Wells. The use of bored or dug wells, or wells less than 50 feet deep, to provide community water supplies shall be avoided unless there is no other feasible means for obtaining water. When used for this purpose, these wells shall be located at least 250 feet from any underground sewage disposal facility.

B. Bored Wells. All bored wells shall be cased with concrete pipe or steel casing whose joints are watertight from 6 inches above surface to the depths specified in Section 9, Part A. The space between the wall of the hole and the casing shall be filled with concrete to the depths specified in Section 9, Part A. The minimum thickness of the surrounding concrete seal shall be 3 inches.

C. Dug Wells. All dug wells shall be "curbed" with a watertight curbing extending from the surface to the depths specified in Section 9, Part A. The curbing shall be of concrete poured-in-place or of casing (either precast concrete pipe or steel) surrounded on the outside by concrete.

If the curbing is to be made of concrete, poured-in-place, it shall not be less than six inches thick. If precast concrete pipe or steel casing is used as part of the curbing, the space between the wall of the hole and the casing shall be filled with concrete to the depths specified in Section 9, Part A. The minimum thickness of the surrounding concrete shall be four inches.

D. Casing Material. Either steel or concrete may be used for casing bored or dug wells.

1. Steel used in the manufacture of casing for bored and dug wells should conform to the specifications for casing material described in Section 10. Minimum thickness of steel casing for dug wells shall be in accordance with the following table:

MINIMUM THICKNESS OF STEEL
CASING FOR BORED AND DUG WELLS

Diameter, in inches	U. S. standard gage or plate thickness
18	8 gage
24	1/4 inch
30	1/4 inch
36	1/4 inch
42	1/4 inch
48	1/4 inch

2. Concrete casing can consist of either poured-in-place concrete or precast concrete pipe. Poured-in-place concrete should be sufficiently strong to withstand the earth and water pressures imposed on it. It should be properly reinforced with steel to furnish tensile strength and to resist cracking, and it should be free from honeycombing or other defects likely to impair the ability of the concrete structure to remain watertight. Aggregate small enough to insure proper placement without "bridging" should be used.

Precast concrete pipe is usually composed of concrete rings from 1 to 6 feet in diameter and approximately 3 to 8 feet long. To serve satisfactorily as casing, these rings should be free of any blemishes that would impair their strength or serviceability. In the portion of the well that is to be sealed (see paragraphs B and C of this section), the joints shall be made watertight. Concrete pipe shall conform to the specifications listed in Section 12, Part A, item 3.

E. Covers. All bored and dug wells shall be provided with a structurally sound, watertight, cover made of concrete or steel.

Section 17. Special Provisions for Driven Wells.

A. If the well is to be used as an individual domestic well, an oversize hole with a diameter at least three inches greater than the diameter of the pipe shall be constructed to a depth of six feet and the annular space around the pipe shall be filled with neat cement, cement grout, or a bentonite mud.

B. The minimum wall thickness of steel drive pipe shall be not less than 0.140 inches.

Section 18. Repair or Deepening of Wells.

A. All casing used in the deepening or repair of wells shall meet the requirements of Section 12, "Casing", of these provisions.

B. If the old casing is removed, the well shall be recased and sealed in accordance with the requirements of Section 9, Part A.

Section 19. Temporary Cover.

Whenever there is an interruption in work on the well such as overnight shutdown, during inclement weather, or waiting periods required for the setting up of sealing materials, for tests, for installation of the pump, etc., the well opening shall be closed with a cover to prevent the introduction of undesirable material into the well and to insure the public safety.

During interruptions of one week or more, a semipermanent cover shall be installed. For wells cased with steel, a steel cover, tack-welded to the top of the casing, is adequate.

Part III. Destruction of Wells

Section 20. Purpose of Destruction.

Proper destruction of a well that is no longer useful serves two main purposes:

1. To assure that the ground water supply is protected and preserved for further use.

2. To eliminate the potential physical hazard that exists.

Section 21. Definition of "Abandoned" Well.

A well is considered "abandoned" when it has not been used for a period of one year, unless the owner declares his intention to use the well again for supplying water or other associated purpose* (such as an observation well or injection well). As evidence of his intentions for continued use, the owner shall properly maintain the well in such a way that:

1. The well has no defects which will facilitate the impairment of quality of water in the well or in the water-bearing formations penetrated.
2. The well is covered with an appropriate locked cap.
3. The well is marked so that it can be clearly seen.
4. The area surrounding the well is kept clear of brush or debris.

If the pump has been removed for repair or replacement, the well shall not be considered "abandoned", provided that evidence of repair can be shown. During the repair period, the well shall be adequately covered to prevent injury to people and to prevent the entrance of undesirable water or foreign matter.

Observation wells used in the investigation or management of ground water basins by governmental agencies or other appropriate engineering or research organizations are not considered "abandoned" so long as they are maintained for this purpose. However, such wells shall be covered with

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* Although it should be obvious, the reader is reminded that an "abandoned" well should <u>never</u> be used for the disposal of trash, garbage, sewage (except where sewage is reclaimed for recharging the ground water basin, and then only in accordance with the provisions of Section 4458 of the California Health and Safety Code), etc.

an appropriate cap, bearing the label, "Observation Well", and the name of the agency or organization, and preferably shall be locked when measurements are not being made. When these wells are no longer used for this purpose or for supplying water, they shall be considered "abandoned".

Section 22. General Requirement.

All "abandoned" wells shall be destroyed in such a way that they will not produce water or act as a channel for the interchange of waters, when such interchange will result in significant deterioration of the quality of water in any or all water-bearing formations penetrated, or present a hazard to the safety and well being of people and of animals.

Destruction of a well shall consist of the complete filling of the well in accordance with the procedures described in Section 23 (following).

Section 23. Requirements for Destroying Wells.

A. Objective. The objective of the requirements described in this section is to restore as nearly as possible those subsurface conditions which existed before the well was constructed taking into account also changes, if any, which have occurred since the time of construction. (For example, an aquifer which may have produced good quality water at one time but which now produces water of inferior quality, such as a coastal aquifer that has been invaded by seawater.)

B. Preliminary Work. Before the hole is filled, the well shall be investigated to determine its condition, details of construction, and whether there are obstructions that will interfere with the process of filling and sealing.

1. If there are any obstructions, they shall be removed, if possible, by cleaning out the hole or by redrilling.

2. Where necessary, to insure that sealing material fills not only the well casing but also any annular space or nearby voids, the casing should be perforated or otherwise punctured.

3. In drilled wells, it may be necessary or desirable to remove some of the casing. However, in some cases this can be done only as the well is filled. In dug wells, as much of the lining as possible should be removed prior to filling.

C. Filling and Sealing Conditions. Following are requirements to be observed when certain conditions are encountered:

1. Well wholly situated in unconsolidated material in an unconfined ground water zone. If the ground water supplies are within 50 feet of the surface, the upper 20 feet shall be sealed with impervious material and the remainder of the well shall be filled with clay, sand, or other suitable inorganic material.

2. Well penetrating several aquifers or formations. In all cases the upper 20 feet of the well shall be sealed with impervious material.

In areas where the interchange of water between aquifers will result in a significant deterioration of the quality of water in one or more aquifers, or will result in a loss of artesian pressure, the well shall be filled and sealed so as to prevent such interchange. Sand or other suitable inorganic material may be placed opposite the producing aquifers (or formations) and other formations where impervious sealing material is not required. Impervious material must be placed opposite confining formations for a sufficient vertical distance (but in no case less than 10 feet) in either direction to prevent the vertical movement of water from the producing formation. The formation producing the deleterious water shall be sealed by placing impervious material opposite the formation, and opposite the confining formations for a sufficient vertical distance (but no less than 10 feet) in either direction, or, in the case of "bottom" waters, in the upward direction.*

In locations where interchange is in no way detrimental, suitable inorganic material may be placed opposite the formations penetrated. When the boundaries of the various formations are unknown, alternate layers of impervious and pervious material shall be placed in the well.

3. Well penetrating creviced or fractured rock. If creviced or fractured rock formations are encountered just below the surface, the portions of the well opposite this formation shall be sealed with neat cement, cement grout, or concrete. If these formations extend to considerable depth,

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* Determining the significance of interchange of waters whose qualities vary and of the loss of artesian pressures, requires extensive knowledge of the ground water basin in question. The Department of Water Resources has over the years, and frequently in cooperation with agencies such as the United States Geological Survey, undertaken a number of ground water studies and amassed considerable information and data about the subject. Although much is known about the State's ground water supplies, detailed studies sufficiently accurate to define interchange problems have been made only in certain areas. In still other areas, there is only partial definition of the problem. Example of areas where definition has been made are the coastal plain of Los Angeles County and the eastern part of the Santa Clara Valley in Alameda County. Recommendations for water well standards for these areas have been published by the Department. (Alameda County, Bulletin No. 74-2; Central, Hollywood, and Santa Monica Basins, Los Angeles County, Bulletin No. 74-4; and West Coast Basin, Los Angeles County, Bulletin No. 107). An excellent example of a "bottom" water is the saline connate water underlying the Central Valley at varying depths.

alternate layers of coarse stone* and cement grout or concrete may be used to fill the well. Fine grained material shall not be used as fill material for creviced or fractured rock formations.

4. Well in noncreviced, consolidated formation. The upper 20 feet of a well in a noncreviced, consolidated formation shall be filled with impervious material. The remainder of the well may be filled with clay or other suitable inorganic material.

5. Well penetrating specific aquifers, local conditions. Under certain local conditions, the enforcing agency may require that specific aquifers or formations be sealed off during destruction of the well.

D. Placement of Material. The following requirements shall be observed in placing fill or sealing material in wells to be destroyed:

1. The well shall be filled with the appropriate material (as described in item E of this section) from the bottom of the well up.

2. Where neat cement, cement grout, or concrete is used, it shall be poured in one continuous operation.

3. Sealing material shall be placed in the interval or intervals to be sealed by methods that prevent free fall, dilution, and/or separation of aggregates from cementing materials.

4. Where the head (pressure) producing flow is great, special care and special methods must be used to restrict the flow while placing the sealing material. In such cases, the casing must be perforated opposite the area to be sealed and the sealing material forced out under pressure into the surrounding formation.

5. In destroying gravel-packed wells, the casing shall be

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* The limiting dimensions of coarse stone are usually considered to range between $\frac{1}{4}$ and 3 inches.

perforated or otherwise punctured opposite the area to be sealed. The sealing material shall then be placed within the casing, completely filling the portion adjacent to the area to be sealed and then forced out under pressure into the gravel envelope.

6. When pressure is applied to force sealing material into the annular space, the pressure shall be maintained for a length of time sufficient for the cementing mixture to set.

7. To assure that the well is filled and that there has been no jamming or "bridging" of the material, verification shall be made that the volume of material placed in the well installation at least equals the volume of the empty hole.

E. Materials. Requirements for sealing and fill materials are as follows:

1. Impervious Sealing Materials. No material is completely impervious. However, sealing materials shall have such a low permeability that the volume of water passing through them is of small consequence.

Suitable materials include neat cement, cement grout, concrete, bentonite clays (muds), silt and clays, well-proportioned mixes of silts, sands, and clays (or cement), and native soils and natural material that have a coefficient of permeability of less than 100 feet per year.* Used drilling muds are not acceptable.

A neat cement mixture shall be composed of one bag of Portland Cement to 5 to 7 gallons of clean water. Cement grout shall be composed of not more than two parts of sand and one part of cement (per bag of cement) to 5 to 7 gallons of clean water. Concrete used shall be "Class A" (6 sacks

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* Examples of materials of this type are: very fine sand with a large percentage of silt or clay, inorganic silts, mixtures of silt and clay, and clay. Native materials should not be used when the sealing operation involves the use of pressure.

of Portland Cement per cubic yard) or "Class B" (5 sacks per cubic yard).

2. Fill Material. Many materials are suitable for use as a filler in destroying wells. These include clay, silt, sand, gravel, crushed stone, native soils, mixtures of the aforementioned types, and those described in the preceding paragraph. Material containing organic matter shall not be used.

F. Additional Requirements for Wells in Urban Areas. In incorporated areas or unincorporated areas developed for multiple habitation, to make further use of the well site, the following additional requirements must be met:

1. A hole shall be excavated around the well casing to a depth of six feet below the ground surface and the well casing removed to within six inches of the bottom of the excavation.

2. The sealing material used for the upper portion of the well shall be allowed to spill over into the excavation to form a cap at least one foot thick.

3. After the well has been properly filled, including sufficient time for sealing material in the excavation to set, the excavation shall be filled with native soil.

G. Temporary Cover. During periods when no work is being done on the well, such as overnight or while waiting for sealing material to set, the well and surrounding excavation, if any, shall be covered. The cover shall be sufficiently strong and well enough anchored to prevent the introduction of foreign material into the well and to protect the public from a potentially hazardous situation.

APPENDIX G

SUGGESTED PROCEDURE FOR DISINFECTING WELLS

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SUGGESTED PROCEDURE FOR DISINFECTING WELLS

The procedure described in this appendix, is satisfactory for disinfecting a well; however, other methods may be used provided it can be demonstrated that they will yield comparable results.

1. The proper amount of chlorine solution, such that the concentration of chlorine in the well water shall be at least 50 parts per million (ppm) available chlorine, is added to the well. Table 5 lists quantities of various chlorine compounds required to dose 100 feet of water-filled casing at 50 ppm for diameters ranging from 2 to 24 inches.

2. The pump column or drop pipe shall be washed with the chlorine solution as it is lowered into the well.

3. After it has been placed into position, the pump shall be operated so as to thoroughly mix the disinfectant with the water in the well. Pump until the water discharged has the odor of chlorine. Repeat this procedure several times at one-hour intervals.

4. The well shall be allowed to stand without pumping for 24 hours.

5. The water shall then be pumped to waste until the odor or taste of chlorine is no longer detectable.

6. A bacteriological sample shall be taken and submitted to a laboratory for examination (See Appendix G).

7. If the laboratory analysis shows the water is not safe to use, the disinfection procedure should be repeated until the tests show the water is safe to use.

TABLE 1

CHLORINE COMPOUND REQUIRED TO DOSE 100 FEET OF WATER-FILLED CASING AT 50 PARTS PER MILLION

Diameter of Pipe or Casing (in inches)	Chlorine Compounds		
	(70%) HTH, Perchloron, etc. (Dry Weight)*	(25%) Chloride of Lime (Dry Weight)*	(5.25%) Purex Clorox, etc. (Liquid Measure)
2	1/4 ounce	1/2 ounce	2 ounces
4	1 ounce	2 ounces	9 ounces
6	2 ounces	4 ounces	20 ounces
8	3 ounces	7 ounces	2-1/8 pints
10	4 ounces	11 ounces	3-1/2 pints
12	6 ounces	1 pound	5 pints
16	10 ounces	1-3/4 pounds	1 gallon
20	1 pound	3 pounds	1-2/3 gallons
24	1-1/2 pounds	4 pounds	2-1/3 gallons

NOTE:

It is suggested that where wells to be treated are of unknown depth or volume, at least one pound of calcium hypochlorite (70% available chlorine) or two gallons of household bleach (sodium hypochorite) such as Clorox or Purex (5.25% chlorine) may be added in lieu of the use of the above table.

* Where a dry chemical is used it should be mixed with water to form a chlorine solution prior to placing it into the well.

APPENDIX H

SUGGESTED METHODS FOR SEALING THE UPPER PORTION OF THE ANNULAR SPACE AND FOR SEALING OFF STRATA

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APPENDIX H

SUGGESTED METHODS FOR SEALING THE UPPER PORTION OF THE ANNULAR SPACE AND FOR SEALING OFF STRATA

Following are listed several methods for sealing the upper portion of the annular space (the "sanitary seal") and for sealing off strata containing undesirable water. They are suggested methods only and are not a part of the standards for well construction presented in this report. There are, of course, other methods and variations to the methods described herein.

General

1. No drilling operations or other associated work in the well should be conducted for at least 12 hours, (some prefer 24 to 72 hours), after sealing operations have been completed.

2. Before installing or reinstalling the pump assembly, the well casing should be inspected and cleaned out if necessary.

3. Grout used in sealing should consist of one part of cement to five to six gallons of water (neat cement grout) per sack of cement or one or two parts of sand to one part of cement, and from five to seven gallons of water per sack of cement. Neat cement (cement and water only) is preferred over other grouts, as it eliminates the possibility of separation of sand and cement during placement. Additives, such as hydrated lime (up to 10 percent of the volume of cement) and bentonite (up to 5 percent) may be used.

Sealing the Upper Portion of the Annular Space

The following methods can be used to seal the upper portion of the annular space. The first method is the method most often used and appears to be the most successful.

Grouting Pipe Method. In this method, a seal is placed in the annular space from the bottom up through a grout pipe (similar to a tremie) suspended in the annular space.

1. Drill the hole large enough to accommodate the grout pipe (at least four inches greater in diameter than the diameter of the casing).

2. In caving formations install a conductor pipe.

3. Provide a grout retainer in the annular space below the interval to be sealed.

4. Extend the grouting pipe down the annular space between the casing and the wall or conductor pipe to the bottom of the interval to be sealed just above the retainer.

5. Add grout in one continuous operation, beginning at the bottom of the interval to be sealed at the same time pulling out the conductor pipe (if one is used). The grouting pipe should remain submerged in the sealing material during the entire time it is being placed.

If the annular space is restricted, it may be necessary to jet the grout pipe to the required depth. Quite frequently when a conductor casing is used, it is left in place. Where the annular space between the hole and the conductor casing and the conductor casing and inner casing are to be sealed, a common procedure is to place a five foot depth of grout into the hole, drive the conductor into the grout about one-half way, and pump grout into the annular space outside the conductor casing. Finally, upon installation of the inner casing, the annular space between the two casings is filled with grout.

Pressure Cap Method. In the pressure cap method, the grout is placed in the bottom of the hole through a grout pipe set inside the casing.

1. The casing or other inner pipe is suspended about two feet above the bottom of the drilled hole and filled with water.

2. A pressure cap is placed over the casing and grout pipe extended through the cap and casing to the bottom of the hole.

3. The grout is forced through the pipe, up into the annular space around the outside of the casing, to the ground surface.

4. When the grout has set, the plug formed during grouting is removed and drilling of the rest of the well is continued.

Dump Bailer Method. In the dump bailer method, the grouting is done with the hole drilled only slightly below the bottom of the casing and drilling is completed after the grout is in place and set.

1. Enough impervious grout is placed in the casing to fill the lower 20 to 40 feet of the hole by lowering a bailer filled with grout into the casing and opening the bottom valve which dumps the load of grout at the desired level.

2. The casing is raised 20 to 40 feet with the bottom of the casing remaining in the grout.

3. The casing is filled with water and capped, and the water-filled casing is then lowered to the bottom of the hole. This action should force the grout up the annular space between the casing and the drilled hole. The casing must remain capped until the grout is set. If it is anticipated that there will be difficulty in maneuvering the capped, water-filled casing, water can be put in on top of the grout without lifting the casing. Continue to add water to the casing until a quantity equal to the volume of grout has been put in. This should force most of the grout out of the lower end of the casing.

4. When the grout is set, drill through the hardened cement in the lower end of the casing and continue drilling the well.

Sealing-off Strata

The following methods can be used in sealing-off strata or zones.

The Pressure-Grouting Method. This method can be employed where an annular space exists between the well casing and the wall of the drilled hole.

1. Perforate the casing opposite the interval to be sealed.
2. Place a packer or other sealing device in the casing below the bottom of the perforated interval.
3. Place grout in the casing opposite the interval to be sealed by means of a dump bailer or grout pipe.
4. Place a packer or other sealing device in the casing above the perforations.
5. Apply pressure to the top packer to force the grout through the perforations into the interval to be sealed.
6. Maintain pressure until the material has set.
7. Drill out the packer and other material remaining in the well.

Frequently an assembly consisting of inflatable (balloon) packers and grout pipe is used. The packers are placed so as to enclose the interval to be sealed, they are inflated and the grout pumped down the hose (which passes through the upper packer) into interval to be sealed. Water is then pumped into the interval, squeezing the grout through the perforations. When the grout is sufficiently hardened the packers are deflated and removed.

Liner Method. Where an annular space does not exist between the well casing and the wall of the drilled hole, the liner method can be employed.

1. Place a smaller diameter metal liner (about two inches less in diameter) inside the casing opposite the perforated interval to be sealed, and extend it at least 10 feet above and below the perforated interval.
2. Provide a grout retaining seal at the bottom of the annular space between the liner and the well casing.

3. Extend the grouting pipe to the top of the opening between the liner and casing or connect it to the inside of the liner at the bottom via a tee (or other device), and fill the annular space between the well casing and the liner with grout in one continuous operation.

4. The grouting pipe should remain submerged in the sealing material during the entire time it is being placed.

APPENDIX I

COLLECTION OF WATER QUALITY SAMPLES

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APPENDIX I

APPENDIX I
COLLECTION OF WATER QUALITY SAMPLES

Bacterial Sampling

Sampling of community water supply wells, is covered by requirements of the State Board of Health and the local health department. For individual domestic wells, technical assistance or advice regarding the collection of bacteriological samples may be obtained from the local health department or from the laboratory that will examine the sample.

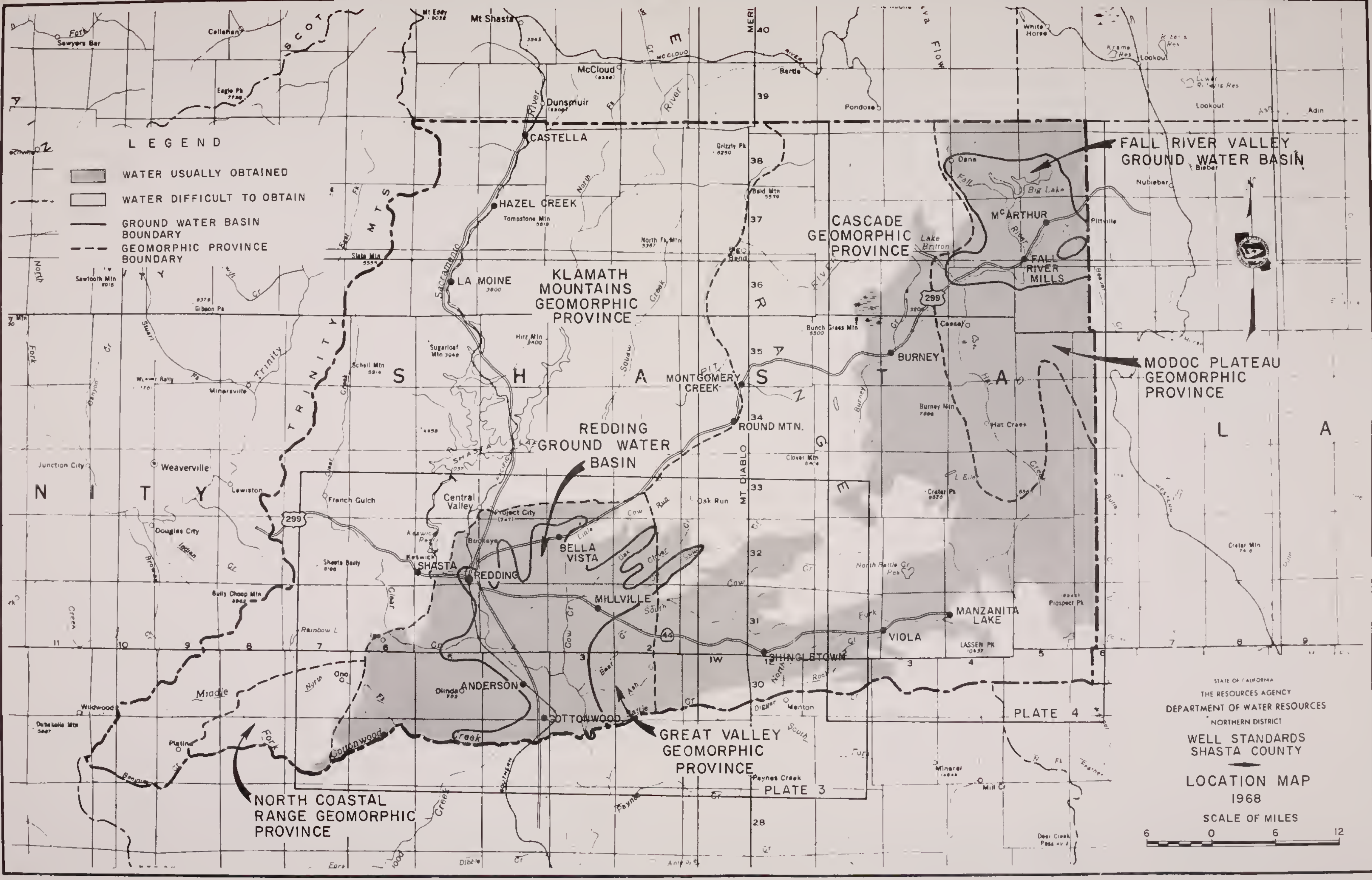
If no technical assistance is available, the following procedure will suffice: A sterile sample bottle, preferably one provided by the laboratory that will make the determination, must be used. It is extremely important that nothing except the water to be analyzed come in contact with the inside of the bottle or the cap; the water must not be allowed to flow over an object or over the hands while the bottle is being filled. Do not rinse the sample bottle. The sample should be delivered to the laboratory as soon as possible and in no case more than 24 hours after its collection. During delivery, the sample should be kept as cool as possible (but not frozen).

Chemical (Mineral) Sampling

Generally, a routine mineral analyses (determination of the concentrations of the common minerals) will suffice, particularly where there is no prior knowledge of the chemical quality of the water in the area where the well is located. Where quality conditions in the surrounding area are known, a more selective analysis may be made. For certain uses it may also be desirable to make analysis for concentrations of the heavy metals (such as iron and manganese in the case of domestic water) or other constituents not routinely determined. Information or advice on chemical quality conditions may be obtained from local agencies such as the county farm advisor's office, health department, and water service agency (irrigation or water district, for example).

The sample should be collected after the well has been pumped long enough to remove standing water and development and disinfectant chemicals, and to insure that water from the producing formation(s) has entered the well. The water sample should be obtained in a chemically clean container preferably one obtained from the laboratory which has been selected to perform the analysis. The container should be rinsed several times with the water to be sampled prior to collecting the sample. The laboratory performing the analysis should issue instructions regarding the quantity of sample required. However, one-half gallon is usually sufficient for a routine mineral analysis; one gallon when analysis for heavy metals is also required.

PLATE I

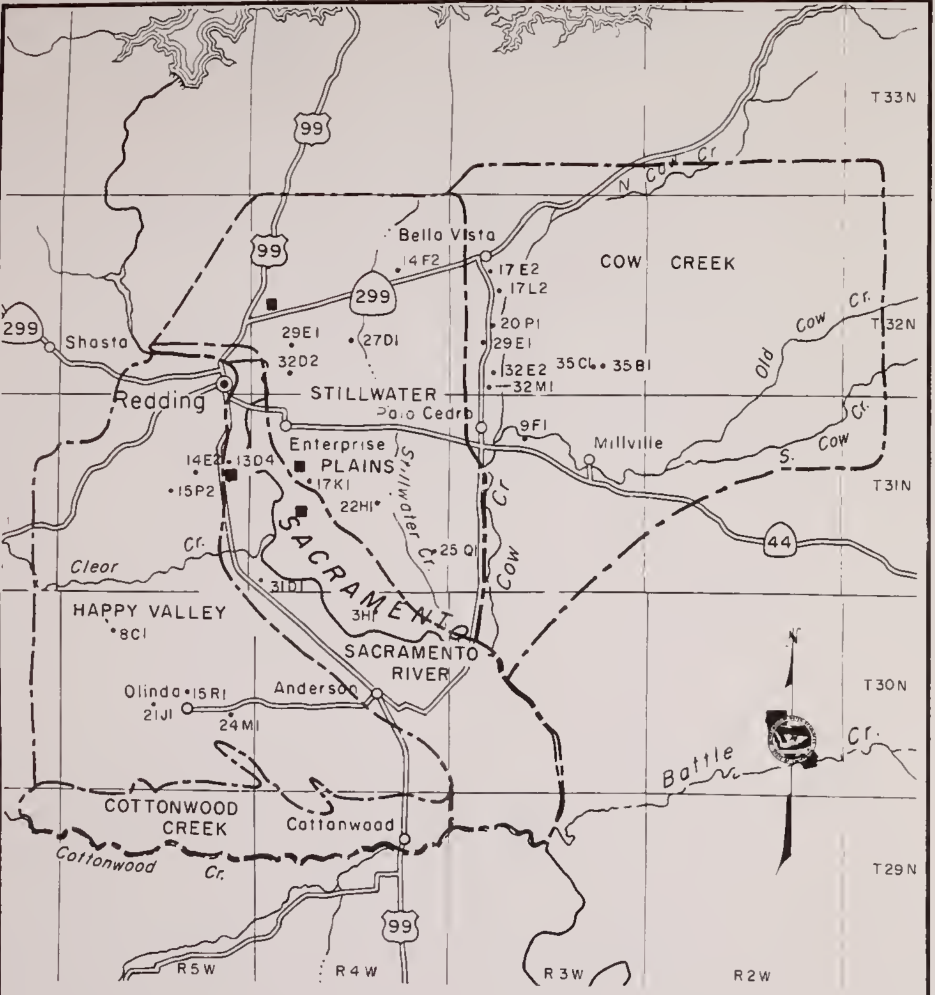


STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

WELL STANDARDS
SHASTA COUNTY

LOCATION MAP
1968

SCALE OF MILES



L E G E N D

— - — HYDROGRAPHIC UNIT BOUNDARY

•21J1 SALINE WATER WELL

■ WELLS WITH BACTERIAL POLLUTION

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

WELL STANDARDS
SHASTA COUNTY

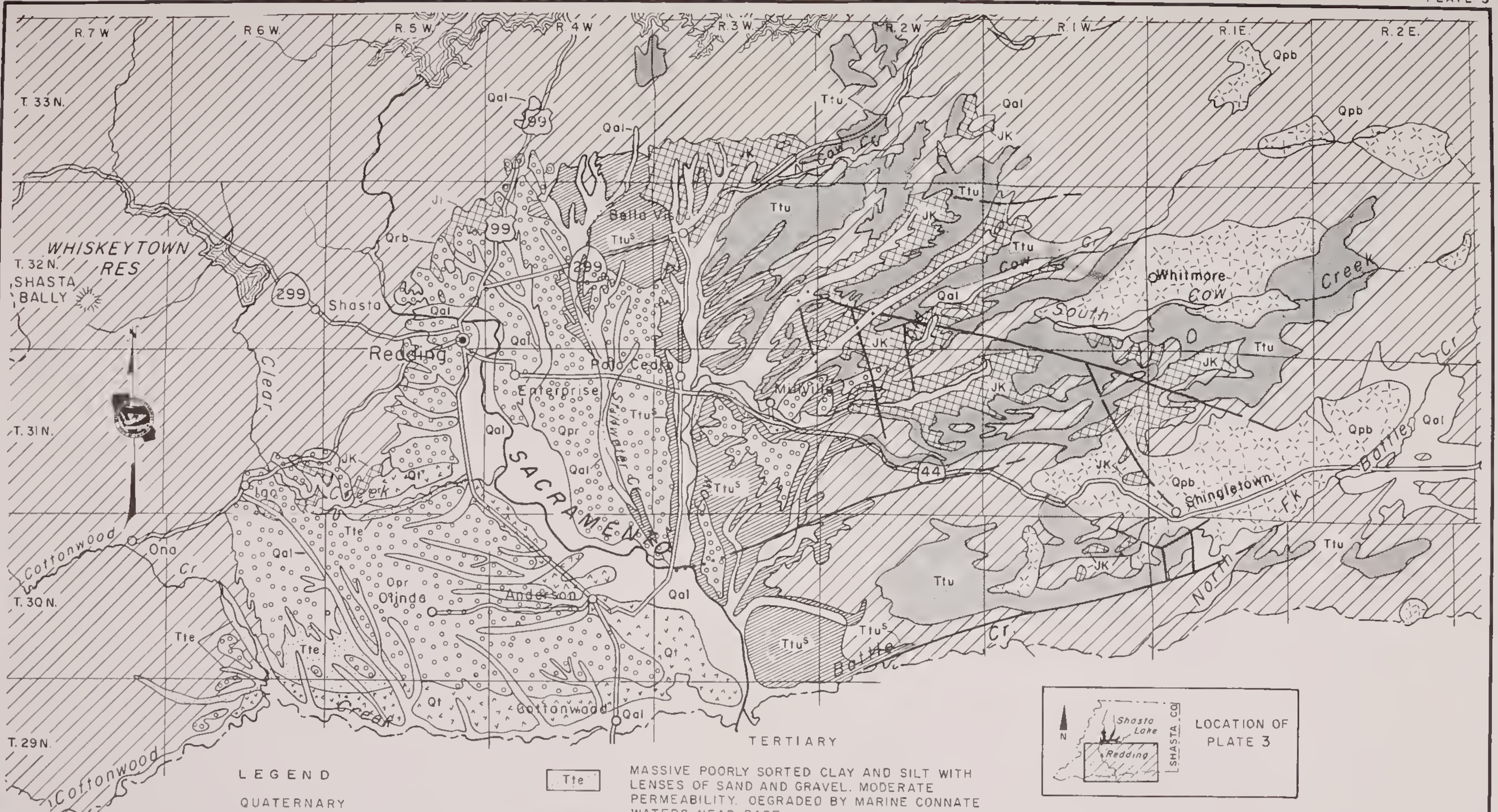
REDDING BASIN HYDROGRAPHIC UNITS AND SALINE WELLS

1968

SCALE OF MILES

0 5 10

PLATE 3



TERTIARY

LEGEND

QUATERNARY

Qal	ALLUVIUM; UNCONSOLIDATED GRAVEL AND SAND, WITH MINOR SILT AND CLAY. MODERATELY TO HIGHLY PERMEABLE.
Qt	TERRACES, UNCONSOLIDATED CLAY, SILT, SAND AND GRAVEL. MODERATELY PERMEABLE. PERCHED WATER ABOVE ZONE OF SATURATION OFTEN PRESENT.
Qpr	RED BLUFF FORMATION; POORLY SORTED GRAVEL IN SANDY CLAY MATRIX. MODERATELY PERMEABLE. PERCHED WATER ABOVE ZONE OF SATURATION.
Qpb	BASALT FLOWS; SLIGHTLY WEATHERED, JOINTED AND VESICULAR. MODERATELY TO HIGHLY PERMEABLE.
▨	NON WATERBEARING AREA. ROCK OF VOLCANIC ORIGIN, YIELDS LITTLE OR NO WATER TO WELLS.
Tte	MASSIVE POORLY SORTED CLAY AND SILT WITH LENSES OF SAND AND GRAVEL. MODERATE PERMEABILITY. DEGRADED BY MARINE CONNATE WATERS NEAR BASE.
Ttu	MASSIVE TUFF-BRECCIA FLOWS SEPARATED BY THIN SANDY GRAVEL BEDS. LOW PERMEABILITY.
Ttu^s	BEDS OF VOLCANIC SANDS AND GRAVELS INTERBEDDED WITH TUFF BRECCIA; MODERATELY TO HIGHLY PERMEABLE.

CRETACEOUS

JK	MARINE SEDIMENTARY ROCKS OF INTERBEDDED SHALE AND SANDSTONE; CONTAINS CONNATE MARINE WATERS.

SYMBOLS

~	GEOLOGIC CONTACT
—···	FAULT; DOTTED WHERE CONCEALED.

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

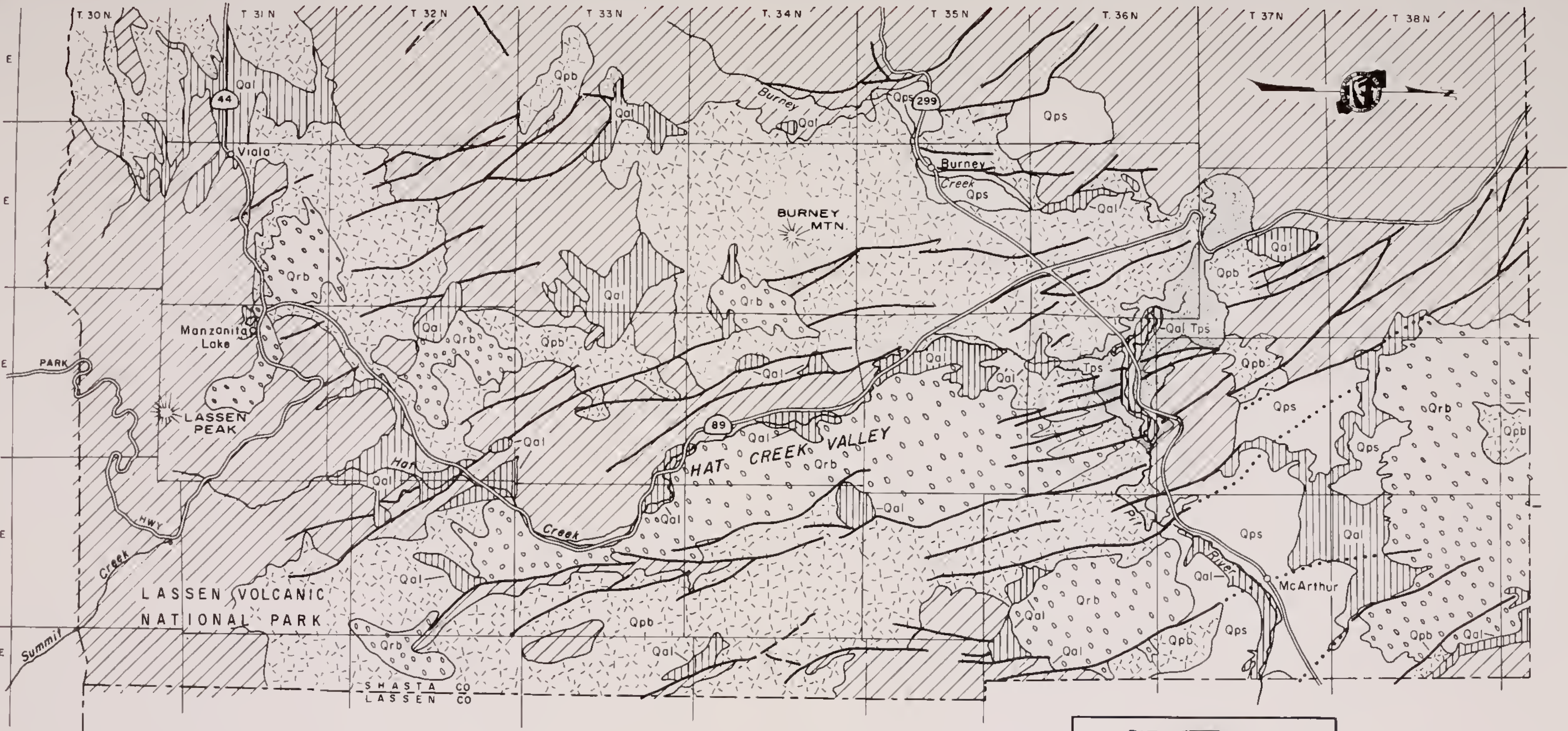
WELL STANDARDS
SHASTA COUNTY

GEOLOGY OF THE REDDING BASIN

1968

SCALE OF MILES
0 5 10

PLATE 4



L E G E N D

QUATERNARY

Qal	ALLUVIUM; UNCONSOLIDATED GRAVEL, SAND, SILT AND CLAY. MODERATELY PERMEABLE. INCLUDES GLACIAL GRAVELS
Qrb	BASALT FLOWS; VESICULAR BLOCKY AND JOINTED, QUATERNARY PYROCLASTICS INCLUDED HIGHLY PERMEABLE
Qpb	BASALT FLOWS; SLIGHTLY WEATHERED, JOINTED AND VESICULAR MODERATELY TO HIGHLY PERMEABLE
Qps	PARTLY CONSOLIDATED SAND, SILT CLAY, VOLCANIC ASH AND DIATOMITE. LAKE SEDIMENTS SLIGHTLY TO MODERATELY PERMEABLE.

TERTIARY

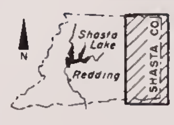
Tps	DIATOMACEOUS LAKE SEDIMENTS WITH SAND AND GRAVEL VERY SLIGHTLY PERMEABLE TO MODERATELY PERMEABLE WHERE SANDY AND GRAVELLY.

S Y M B O L S

~	GEOLOGIC CONTACT
—…	FAULT; DOTTED WHERE CONCEALED

NON-WATERBEARING AREA

▨	ROCK OF VOLCANIC ORIGIN, YIELDS LITTLE OR NO WATER TO WELLS



LOCATION OF PLATE 4

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

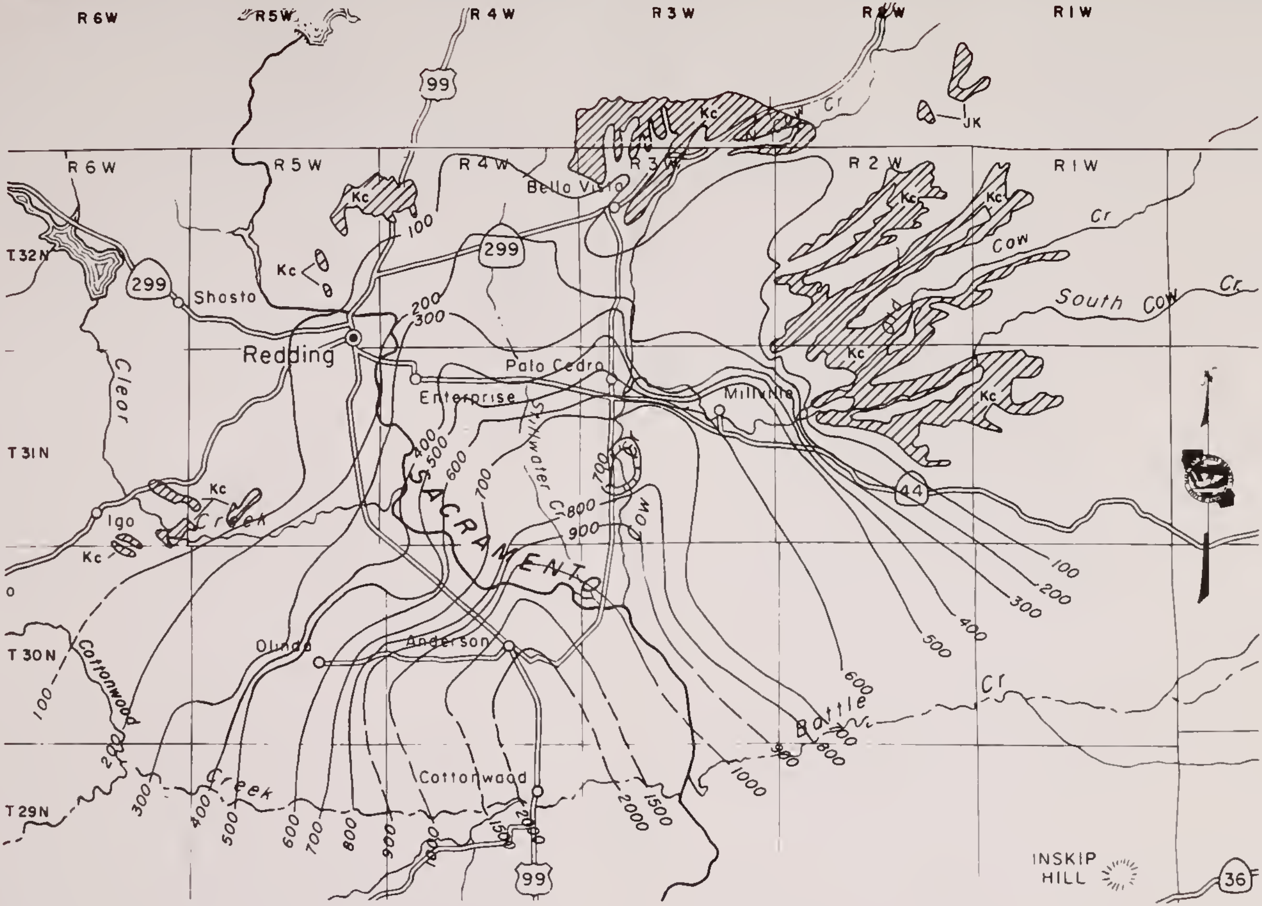
WELL STANDARDS
SHASTA COUNTY

GEOLOGY OF EASTERN
SHASTA COUNTY

1968

SCALE OF MILES
0 5 10

PLATE 5



LEGEND

▨ Kc CHICO FORMATION; CRETACEOUS, MARINE SEDIMENTARY ROCKS CONTAINING SALINE CONNATE WATER (SURFACE EXPOSURES, ZERO DEPTH)

— LINE OF EQUAL DEPTH TO CHICO FORMATION (APPROXIMATE, AS DETERMINED BY AVAILABLE DATA)

– – – PROBABLE PROJECTION OF LINE OF EQUAL DEPTH.

100-FOOT CONTROL INTERVAL

WELL STANDARDS
SHASTA COUNTY

APPROXIMATE DEPTHS TO CHICO FORMATION IN THE REDDING BASIN

1968

SCALE OF MILES

0 5 10