Dirk Vlot
P.O. Box 497
Wellington, Nevada 89444
(559) 731-3475

Intervenor

BEFORE THE STATE OF NEVADA, STATE ENVIRONMENTAL COMMISSION

In Re: *********

SOS, Inc. Appeal of NDEP Permit No. NS2014502

INTERVENOR'S ANSWERING BRIEF

Dirk Vlot ("Intervenor"): Dirk Vlot files the following as and for my Answering Brief in response to the Appellant's Opening Brief:

INTRODUCTION

This appeal concerns the Nevada Division of Environmental Protection ("NDEP") decision to issue Smith Valley Dairy's water pollution control permit (NS2014502) on March 9, 2015. Appellants' Opening Brief was filed with the State Environmental Commission ("SEC" or "Commission") on May 8, 2015 and exhibits associated with the brief were served to Intervenor on May 20, 2015 for the hearing scheduled July 23, 2015.

In their appeal, SOS, Inc. ("Appellant") states that (1) an out-of-state experienced dairy operator purchased lands in Smith Valley, Nevada to open an "industrial" dairy, (2) Confined Animal Feeding Operations ("CAFOs") pose an inherent and severe risk to the environment, (3) the operator commenced and completed construction of the dairy months before receiving a permit from NDEP, (4) the siting and design of the dairy is inconsistent with NDEP guidance, (5) NDEP's permit conformed to the already constructed dairy, and (6) SOS and its members are directly affected and injured (aggrieved) by the presence of the dairy. Despite Appellants' unsupported allegations, however, the record shows that Intervenor and NDEP complied with procedural and substantive requirements, and in some respects exceeded requirements in application for and issuance of the Smith Valley Dairy discharge permit. Appellants have failed to identify any material error in NDEP's decision to issue the permit. Accordingly, the Commission should affirm NDEP's decision, and reject the Appellant's appeal.

BACKGROUND

A. Intervenor and NDEP Resolved Notice of Violation and Cease and Desist Order

Intervenor's property was under construction for nearly a year. While the dairy was under construction, NDEP appeared, observed two constructed stormwater retention ponds, and determined Intervenor was in violation of Nevada Revised Statute ("NRS") NRS 445A.585 and Nevada Administrative Code ("NAC") NAC 445A.283.

Intervenor believed he was in compliance with Nevada law having constructed National Pollutant Discharge Elimination System ("NPDES") permitted stormwater retention ponds and subsequently filed an appeal pursuant to NRS 445A.690 and NAC 445B.890 with the Commission on March 4, 2015. Upon a show cause hearing on March 5, 2015, NDEP closed the formal enforcement [Exhibit A] of the alleged violations described in NDEP's February 18, 2015 correspondence. Upon closure of the formal enforcement, Intervenor agreed [Exhibit B]

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to withdraw the March 4, 2015 appeal before the Commission. NDEP issued the CAFO groundwater discharge permit to Intervenor on March 9, 2015.

B. Geology and Hydrogeology of Smith Valley, Nevada

Smith Valley Dairy (Dairy) is located in the Great Basin section of the Basin and Range Province consisting of valley fill resting on a basement complex of older sedimentary, meta-sedimentary and igneous rocks. The basin is characterized by a series of north-trending mountain ranges and intermontane valleys (Loeltz and Eakin, 1953) [Exhibit C].

The rocks in the surrounding ranges have been considerably deformed. The older rocks being folded and faulted and the younger rocks are faulted and only tilted. Surficial deposits are derived from the Pine Nut Mountains to the west, and the Singatse Range to the northeast, and generally consist of lake bed and alluvial deposits (Loeltz and Eakin, 1953).

During Quaternary time, deposition and erosion were largely controlled by faulting and variations in climate which interrupted the through-drainage and alternately increased and decreased stream erosion and carrying capacity. With the formation of the basin of Smith Valley, erosion along the marginal areas dissected or partly beveled the older valley fill. Predominately fine-grained sediments of the younger valley fill were deposited in this basin, partly in lakes and partly along streams.

The Dairy is located in the Smith Valley Basin and Walker Lake Hydrographic Region. The Walker Lake Basin is a closed basin that does not connect or discharge to waters of the United States. Much of the valley fill comprising the Basin consists of alternating, generally thin, layers of sand or sand and gravel, silt, sandy silt, or clay. The fine grained layers act as confining beds for groundwater, noted by the existence of flowing wells in parts of the valley.

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A groundwater divide, likely controlled by faults, separates the valley fill aquifer into two flow systems. The larger system occupies the southern two-thirds of the valley. In the northern one-third of the valley where the Dairy is located, groundwater flow is generally towards Artesia Lake.

There is a sizable area marginal to the flowing well areas in which groundwater is confined but is not under sufficient head to rise above the land surface in a well. Notably, wells have displayed artesian flows at depths as shallow as 15 feet and deeper than 500 feet below ground surface (bgs) (Loeltz and Eakin, 1953).

Groundwater, both confined and unconfined, occurs in the interbedded clay, silt, sand, and gravel composing the valley fill. Both the unconfined and confined water in the fill have common recharge sources, the primary ones being excess applied irrigation water and leakage from ditches or canals. Unconfined water is found at shallow depths in the irrigated areas and in and near Artesia Lake north of the Dairy. The unconfined aquifers are reported to be less than 100 feet below the ground surface, and in most places less than 50 feet bgs.

Artesian aquifer in the valley is composed of several sand and gravel strata interbedded with clay and silt. Some of the water-bearing strata may be relatively widespread. However, large variations in the character and permeability of the materials occur within relatively short distances. The artesian aquifer underlies not only the area of artesian flow but also the bordering area where groundwater is under artesian pressure, but the head is insufficient to cause wells to flow at the land surface.

Aside from evaporation, by far the greatest consumptive use of water within the Walker Lake Hydrographic Region is agriculture. Virtually all surface water flows within the basin are

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appropriated for agricultural use, and extensive ground water pumping is frequently required in order to meet the water needs of this important sector of the region's economy.

Materials of sufficient transmissivity that become saturated and are overlain and underlain by confining layers become aquifer units with trapped groundwater. The elevation of the zone of saturation propagates a pressure throughout the system from the weight of the water. When this occurs, there is sufficient pressure head within the system to lift the groundwater within cased wells above the bottom of the upper confining layer or top of the aquifer. The potentiometric surface is an imaginary plane representing the level to which groundwater would rise if it were completely pierced with cased wells [Exhibit D].

In some cases, ground water levels and seasonally saturated soils may be predicted (summer or winter) by the highest extent of soil mottling or gleying in the soil profile. On older landforms, however, mottling is more likely a remnant of prior geologic/climatic conditions, and may not reflect seasonal saturation. In this circumstance, as is the case in Smith Valley, the highest extent of saturation should be determined by direct observation.

C. <u>History of Agriculture and the Economy</u>

The Smith brothers from Stanislaus County, California settled the Smith Valley in August 1859 as a good place to winter their livestock. A year later, several others settled and began to produce crops in support of demanding local mining activities. During the 1860s, ditches were constructed for irrigation. The north end of the valley, nearest the Dairy, was settled in 1860 by J.C. Hinds who operated a ranch and resort around the hot springs. Approximately 6,000 acres of land were reportedly cultivated in the valley prior to 1881. Agricultural development continued throughout the 1890's and into the 20^{th} century.

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Early settlers produced hay (alfalfa), corn, potatoes and melons. In 1949, maps indicated that about 12,000 acres of cultivated land were irrigated and approximately 7,000 of the remaining 11,000 irrigated acres in the valley were mapped as irrigated pasture land. An estimated 39,000 and 55,000 head of livestock occupied the valley in 1959 and 1969, respectively (Rush and Schroer, 1972) [Exhibit E]. Comparatively, the Lyon County Agriculture Census in 2012 reports comparable cattle numbers of approximately 46,000. Nearby livestock operations include Smith Valley Cattle Feeders and the Desert Hills Dairy.

Agriculture represents a primary industry sector in Lyon County and particularly Smith Valley. Few could deny the extensive and pervasive economic benefits that agriculture has provided to the Lyon County economy in Smith Valley since the mid-1800s. In terms of economic importance, farm marketings from the sale of the Lyon Country's agricultural products provide revenues of between $40-50 million per year, making it the most important agricultural-producing county in the State of Nevada. Furthermore, due to the typical export nature of many of these sales from Nevada's farms, a significant portion of the revenues from Lyon County's farm marketings provide a healthy infusion of new capital and local spending for the county's local economy.

Throughout this century, farming, ranching, and agriculture have been an integral part of the Lyon County economy and a fundamental way of life for the residents of Smith Valley. It has been of crucial importance to agriculture, as well as the rural lifestyle it has fostered, that has made issues pertaining to the protection of existing water rights and the maintenance of a healthy agricultural sector, so sensitive to the local population in Smith Valley.

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FACTS

Dirk Vlot, a man and one of the people of Nevada, owns and operates the Smith Valley Dairy in Wellington, Lyon County, Nevada. As early as May 2013, Intervenor initiated preliminary inquiries to the NDEP regarding a proposed dairy. NDEP informed Intervenor on May 6, 2013, that NDEP requires Intervenor to submit an application and nutrient management plan ("NMP" or "Plan") to start the permit process.

In good faith, Intervenor voluntarily initiated a community outreach program in Smith Valley during summer 2013. Intervenor and representatives presented information to local community members at the Smith Valley Advisory Board [Exhibit F] meetings in May and June [Exhibit G] 2013. Intervenor and/or his representatives went door to door to meet with neighbors: Chris Murphy, Marshall Todd, Bob Lumbard, Frank and Linda Ely, and Kim Gattuso during the summer of 2013 to discuss concerns with the proposed dairy. Intervenor sited the facility in the area furthest north of the basin, a location placing the dairy downgradient in the groundwater flow path for almost all private well users in the vicinity. Thus minimizing the potential for groundwater quality impacts on neighboring water supply wells. Furthermore, the facility siting was also shifted from the initial design location upon hearing concerns of adjacent neighbors.

On September 3, 2013, Intervenor applied for a CAFO groundwater discharge permit and submitted a NMP. Intervenor voluntarily applied for and obtained a NPDES stormwater construction discharge permit from NDEP to construct the dairy. NDEP approved the notice of intent to discharge construction stormwater effective September 6, 2013. During construction, Intervenor implemented best management practices as described in the Stormwater Pollution Prevention Plan ("SWPPP"). The SWPPP describes the use of stormwater retention ponds to

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contain construction-related stormwater runoff. By right and permit, and without public funding, Intervenor constructed stormwater retention ponds prior to constructing the dairy to preclude discharges to waters of the State.

PERMIT CONDITIONS

Because Smith Valley Dairy is a CAFO and not an "industrial" Dairy – as defined by Nevada NAC 445A.228, and intended to apply process wastewater[1] to cropland associated with the dairy, it is a point source from which pollutants are or may be discharged and must obtain a CAFO discharge permit from NDEP as required by NRS 445A.465 to operate the dairy.

Nevada's water pollution control law was enacted in 1973 in response to the federal water pollution control law (Clean Water Act). *33 U.S.C.§1251 et seq.* Nevada law requires any person proposing to discharge any pollutant from a point source into waters of the State to obtain authorization from NDEP. *NRS 445A.465.*

The permit is conditioned upon appropriate agricultural use of the nutrients in the process wastewater and manure solids in accordance with an approved CAFO discharge permit and nutrient management plan. The issued permit authorizes Intervenor to land apply process wastewater from the Smith Valley Dairy in an amount that is controlled by the process wastewater's measured nutrient concentration and the annual industry-accepted nutrient uptake rates of the crops grown on the dairy's land application fields. Essentially, Intervenor is

[1] "water directly or indirectly used in the operation of the CAFO for any or all of the following: spillage or overflow from animal or poultry watering systems; washing, cleaning, or flushing pens, barns, manure pits, or other CAFO facilities; direct contact swimming, washing, or spray cooling of animals; or dust control. Process wastewater also includes any water which comes into contact with any raw materials, products, or byproducts including manure, litter, feed, milk, eggs, or bedding." – CFR § 412.2(d)

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authorized to discharge only as much nutrient load as will be taken up by a specific crop annually.

Additionally, the issued permit is conditioned upon accurate monitoring, sampling, and reporting. Under the terms of the permit, Smith Valley Dairy is required to collect samples of the manure, the green water, any storm related discharges, the soil from the land application area and the dairy's four groundwater monitoring wells. Tables within the permit list and describe in detail each parameter and monitoring point that must be measured, recorded, and reported to NDEP. Smith Valley Dairy is also required to submit quarterly Discharge Monitoring Reports ("DMR") in addition to more specific reporting requirements described in the permit. The permit requires groundwater monitoring in close proximity to the synthetically lined ponds to monitor groundwater conditions associated with the operation of the facility.

In addition to nutrient management and groundwater monitoring, the permit also contains requirements that dairy be properly designed, constructed, operated, and maintained to contain manure, green water, direct precipitation, and the runoff from a 25-year, 24-hour storm event or a chronic rainfall event in order to meet the Nevada guidelines for the potential agricultural stormwater discharge to surface water. NDEP complied with all applicable laws and regulations in reviewing Smith Valley Dairy's application and NMP in issuing the permit. The permit requires Intervenor to operate in compliance with all applicable State and federal requirements.

<u>ARGUMENT</u>

1. Discharge Permit Meets and Exceeds Statutory Provisions

Appellants assert that Technical Bulletins such as WTS-37 and WTS-38 are applicable

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to CAFOs and require specific actions from an applicant for discharge permit. Although Intervenor substantially complied with guidance provided in the technical bulletins in designing and siting the dairy, guidance documents such as these are not binding as regulations.[2] The term "regulation" does not include letters issued in relation to a permit or technical bulletins.[3] Technical Bulletin WTS-38 states: "this document provides *general assistance* regarding the construction ...." Technical Bulletin WTS-37 states: "this document is solely intended to provide *guidance* to the regulated community ...." NDEP uses guidance documents such as these to "encourage and promote the use of methods of waste collection and pollution control for all significant sources of water pollution." *NRS 445A.305*

Although sources of animal waste were not anticipated to be on site until the CAFO permit was issued, the constructed stormwater retention ponds were designed by Nevada Registered Professional Engineer in general accordance with the guidance described above to ultimately store process wastewater associated with the operation of the facility.

There is no evidence that Intervenor failed their duty to protect beneficial uses of waters of the State. Intervenor believes the dairy was properly sited and designed. In fact, Intervenor's Nevada Registered Professional Engineer designed and constructed the dairy to exceed standards set by EPA and the Natural Resource Conservation Service ("NRCS"). The production area and retention ponds are located outside of the 100-yr flood plain and have sufficient drainage to collect and retain stormwater that may come into contact with animal wastes. There is no evidence to suggest the bottom of the lined ponds is in direct connection with groundwater.

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[2] "Regulation means – An agency rule, standard, directive or statement of general applicability which effectuates or interprets law or policy." – NRS 233B.038(1)(a)

[3] "The term does not include: A technical bulletin" – NRS 233B.038(2)(i) and (p)

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2. Operation of a Dairy does not constitute a nuisance

Appellants assert that the Smith Valley Dairy constitutes a nuisance that will have a substantial adverse affect on the public health and safety, interfere with the comfortable enjoyment of life and property, and be injurious to health and offensive to senses. Intervenor proactively provided a nuisance management plan to preclude nuisance and neighbor complaints.

Lyon County is guided by a right to farm policy described in Title 10 Chapter 15 of the Lyon County Code. The right to farm is recognized to exist as a natural right. The Lyon County policy states:

> "No present or future agricultural operation or any of its appurtenances conducted or maintained for commercial purposes and in a manner consistent with proper and accepted customs and standards of the agricultural industry on agricultural land or commercial land used for the processing, packaging and distribution of agriculture products, shall become or be a nuisance, private or public, due to any changed condition of the use of adjacent land and water rights appropriated for that land in or about the locality thereof; provided, that the provisions of this section shall not apply whenever a nuisance results from the negligent or improper operation of any such agricultural operation and its appurtenances or if the agricultural activity or appurtenances obstruct the free passage or use in the customary manner of any navigable lake, stream, river, canal or basin or any public park, square, street or highway. (Ord. 514, 11-15-2007)"

3. NDEP Provided Extensive Opportunity for Public to Participate in Permit Process

NDEP published notice of intent to issue groundwater permit (NS2014502) in the December 3, 2014 edition of the Reno Gazette Journal and Mason Valley News on December 3, 2014. NDEP also posted the notice of intent to issue the permit and the Fact Sheet on the

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internet. All interested persons were invited to submit comments to NDEP or request a hearing. From the date of the notice described above, interested persons were provided 30 days to comment on the draft permit. Due to elevated public interest, NDEP conducted a public hearing in Smith, Nevada on January 7, 2015. Several comments were received during the public hearing, so NDEP extended the public comment period to January 30, 2015. Based on the comments received, NDEP modified the conditions of the permit.

Appellants argue that the public review process did not provide sufficient time and an opportunity to meaningfully participate in the public review process. However, interested persons provided suggestions that moved NDEP to modify[4] the conditions of the permit. Further, NDEP exceeded their duty by providing more than 30 days for interested persons to contribute.

CONCLUSION

Based on the foregoing, the Commission should affirm NDEP's decision to issue Smith Valley Dairy's water pollution control discharge permit and dismiss the Appellant's appeal.

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[4] "Modifications to the permit conditions proposed during the public notice period have been made and are discussed in the attached Notice of Decision and Amended Fact Sheet." NDEP correspondence to Dirk Vlot; March 9, 2015

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AFFIRMATION

Pursuant to NRS239B.030, the undersigned hereby affirms that the preceding document does not contain the Social Security number of any person.

Dated this 3rd day of June, 2015

By: [signature]

Dirk Vlot

Dirk Vlot
P.O. Box 497
Wellington,
NV 89444

CERTIFICATE OF SERVICE

Pursuant to NRS 239B.030, the undersigned affirms that the preceding document does not contain the Social Security number of any person. I hereby certify that the foregoing Intervenor's Answer Brief was served on the parties a copy thereof on the 5th day of June 2015, by electronic mail:

Valerie King, Executive Secretary
Nevada State Environmental Commission
901 South Stewart Street, Suite 4001
Carson City, Nevada 89701
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Katie Armstrong
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Tom Haren
AGPROfessionals
Intervenor's Agent

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Intervenor

BEFORE THE STATE OF NEVADA, STATE ENVIRONMENTAL COMMISSION

In Re: **********

SOS, Inc. Appeal of NDEP Permit No. NS2014502

INTERVENOR'S ANSWERING BRIEF EXHIBITS

Exhibit A	NDEP letter to Dirk Vlot dated March 5, 2015
Exhibit B	Nevada AG letter to Dirk Vlot dated March 5, 2015
Exhibit C	USGS Water Supply Paper 1228 dated 1953; Geology and Water Resources of Smith Valley, Lyon and Douglas Counties, Nevada
Exhibit D	Diagram of Artesian Flow and Potentiometric Surface
Exhibit E	State of Nevada Water Resources Bulletin 43 dated 1976; Geohydrology of Smith Valley, Nevada with Special Reference to the Water-Use Period 1953-1972
Exhibit F	Smith Valley Advisory Board Website
Exhibit G	Smith Valley Advisory Board Agenda June 5, 2013

Dated: June 5, 2015

Respectfully submitted,

By______________________________

Tom Haren
AGPROfessionals
Intervenor's Agent

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CERTIFICATE OF SERVICE

Pursuant to NRS 239B.030, the undersigned affirms that the preceding document does not contain the Social Security number of any person. I hereby certify that the foregoing Intervenor's Answer Brief Exhibits was served on the parties a copy thereof on the 5th day of June 2015, by electronic mail:

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EXHIBIT A

NEVADA DIVISION OF
ENVIRONMENTAL PROTECTION

STATE OF NEVADA
Department of Conservation & Natural Resources
Brian Sandoval, Governor
Leo M. Drozdoff, P.E., Director
Colleen Cripps, Ph.D., Administrator

March 5, 2015

Mr. Dirk Vlot, Owner
Smith Valley Dairy
P.O. Box 497
Wellington, Nevada 89444

Re: Formal Enforcement#NOV021815W1 – Smith Valley Dairy

Dear Mr. Vlot:

The purpose of this letter is to close Formal Enforcement #NOV021815W1 ("Formal Enforcement") regarding the Smith Valley Dairy. As required by the Order, a Show Cause Hearing was held on March 5, 2015. As a result, NDEP has determined that because there was no environmental impact and the response to cease and desist construction until the permit is issued was satisfactory, NDEP will close the Formal Enforcement.

Sincerely,

Alan Tinney, P.E.
Chief, Bureau of Water Pollution Control
Division of Environmental Protection

Electronic cc: Colleen Cripps, Ph.D., Administrator, NDEP
Dave Gaskin, P.E., Deputy Administrator NDEP
Alan Tinney, P.E., Bureau Chief, BWPC
Joe Maez, Supervisor, BWPC
Katrina Pascual, BWPC
Michele Reid, BWPC

Cc: Tom Haren, CEO, AGPROfessionals, 3050 67th Avenue,
Greeley, CO 80634

EXHIBIT B

STATE OF NEVADA
OFFICE OF THE ATTORNEY GENERAL
100 North Carson Street
Carson City, Nevada 89701-4717

ADAM PAUL LAXALT
Attorney General

WESLEY K. DUNCAN
Assistant Attorney General

NICHOLAS A. TRUTANICH
Chief of Staff

March 5, 2015

Mr. Dirk Vlot, Owner
Smith Valley Dairy
P.O. Box 497
Wellington, Nevada 89444

Re: Formal Enforcement #NOV021815W1 – Smith Valley Dairy

Dear Mr. Vlot:

By signing the attached document, you, owner of Smith Valley Dairy, are agreeing to withdraw your appeal of Formal Enforcement #NOV021815W1 ("Formal Enforcement") that was received by NDEP on March 4, 2015. Your signature also acknowledges that you are waiving your thirty day rights to appeal the alleged violations in the Formal Enforcement pursuant to NRS 445A.690.

Sincerely,

ADAM PAUL LAXALT
Attorney General

By: Katie S. Armstrong
KATIE S. ARMSTRONG
Deputy Attorney General
(775) 684-1224
ksarmstr@ag.nv.gov

I, Dirk Vlot, owner of Smith Valley Dairy, hereby withdraw the appeal of Formal Enforcement #NOV021815W1 that was requested on March 4, 2015. I further waive the rights to appeal the alleged violations in Formal Enforcement #NOV021815W1 pursuant to NRS 445A.690.

Dirk Vlot, Owner Smith Valley Dairy

3/5/15
Date

EXHIBIT C

Geology and Water Resources of Smith Valley, Lyon and Douglas Counties Nevada

By O. J. LOELTZ *and* T. E. EAKIN

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1228

Prepared in cooperation with the
Office of the State Engineer
State of Nevada

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1953

UNITED STATES DEPARTMENT OF THE INTERIOR

Douglas McKay, *Secretary*

GEOLOGICAL SURVEY

W. E. Wrather, *Director*

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C.

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ILLUSTRATIONS

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GEOLOGY AND WATER RESOURCES OF SMITH VALLEY, LYON AND DOUGLAS COUNTIES, NEVADA

By O. J. Loeltz and T. E. Eakin

ABSTRACT

Smith Valley, in the Great Basin section of the Basin and Range province, lies about 35 miles east of the obtuse angle of the Nevada-California boundary. It has an area of about 510 square miles. Most of the valley is in Lyon County, but a small part along the west side is in Douglas County.

Farming and ranching are the principal activities. About 12,000 acres of cultivated land and about 7,000 acres of pasture land are irrigated annually. The water is supplied principally by diversion canals from the West Walker River.

The valley is enclosed by mountains except for Hoye Canyon, which transects the Pine Nut Range on the west, and Wilson Canyon, which cuts the Singatze Range on the east. The West Walker River, with headwaters in the Sierra Nevada, flows eastward across Smith Valley, entering through Hoye Canyon and leaving through Wilson Canyon.

The average annual flow of the West Walker River at the mouth of Hoye Canyon is about 180,000 acre-feet. Diversions from the river for irrigation in the valley range from about 50,000 to 100,000 acre-feet annually and average about 66,000 acre-feet for the period of record.

Precipitation on the valley floor averages about 7½ inches annually but is greater in the fringing mountains, particularly the Pine Nut Range on the west and the Sweetwater Mountains on the south.

Volcanic and associated rocks predominate in the mountains surrounding the valley and range in age from Triassic to late Tertiary. The Triassic rocks were intruded and locally metamorphosed by granitic rocks of Cretaceous age. Faulting during and after the intensive activity provided avenues along which ore-bearing solutions entered the older rocks. Tertiary rocks in the mountains are largely volcanic but include some fluvial gravels and, in areas that were topographically low in at least late Tertiary time, fine grain sediments. Quaternary sediments deposited in the basin of Smith Valley principally are fine-grained, but coarse stream gravels have been observed in the valley, at least locally, adjacent to the West Walker River.

The Mesozoic rocks generally do not transmit ground water freely. The conglomerate at the base of the Tertiary rocks—the loosely cemented gravel below the basaltic lava and broken zones within the Tertiary basalt—are believed to be capable of transmitting water freely. However, the distribution and extent of these rocks beneath the fill in Smith Valley, where they would be expected to be saturated, are not known.

The valley fill has a known maximum thickness of more than 500 feet. In general, it is relatively fine grained but locally contains beds of sand and grit, and probably beds of coarser sediments along the margins of the valley floor.

Ground water occurs in the valley fill under both unconfined (water-table) and confined (artesian) conditions. Unconfined ground water generally is found at rather shallow depths in the irrigated areas and near the perimeter of the alkali flat at the north end of the valley.

Confined ground water occurs in most parts of the valley floor at shallow to moderate depths, but the artesian pressure is not everywhere sufficient to produce flowing wells. High land just north of the West Walker River divides the valley into two areas of artesian flow. The larger area, about 31 square miles, lies in the north end of the valley. The other area, about 11½ square miles, is in general south of and adjacent to the West Walker River. The latter area of flow has increased considerably since about 1920 probably owing to increased recharge from additional water diverted for irrigation after Topaz reservoir was incorporated into the distribution system in 1922.

The total quantity of ground water discharged from Smith Valley probably exceeds 25,000 acre-feet annually. Of this amount about 3,000 acre-feet is discharged by flowing and pumped wells, 1,000 acre-feet by springs, and a few thousand acre-feet by evaporation from the land surface and transpiration of native vegetation. About 18,000 acre-feet is discharged into the West Walker River.

Although it is possible to salvage a large part of the 18,000 acre-feet it may not be practical to do so for legal and other reasons. Several thousand acre-feet of artesian water could be withdrawn each year south of the river without seriously lowering the piezometric surface provided that the withdrawal is not concentrated in a small area. An additional thousand acre-feet or more of ground water satisfactory for irrigation probably could be developed in the northern part of the valley.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

This report on Smith Valley is the result of one of a series of valley or area studies made under a Statewide cooperative program by the United States Geological Survey and the State Engineer of Nevada for the evaluation of the ground-water resources of the State. The State is represented in the joint program by Hugh A. Shamberger, State Engineer, and the work is under the direction of Thomas W. Robinson, District Engineer of the Ground Water Branch of the Federal Survey in Nevada.

At the request of the State Engineer, investigation of the valley was begun in February 1948. A reconnaissance of the geology of the valley was started in the summer of 1949 by D. A. Phoenix and the geology was further studied in August 1950 by the junior author, who prepared the section on geology. The senior author did the field work on the hydrologic phases of the investigation and prepared sections of the report other than that on geology. At various times the authors were assisted in the field by their colleagues, T. W. Robinson, D. A. Phoenix, and J. L. Poole.

Discussion of ground water—the occurrence, movement, chemical quality, recharge, utilization, and discharge of confined, unconfined, and spring water—forms the principal part of this report. The geology and water-bearing characteristics of the rocks are discussed in the report, as the geology is a prime factor in the occurrence and movement of ground water. Inflow, utilization, and outflow of surface water and its influence on ground water are outlined.

ACKNOWLEDGMENTS

The cooperation of all the residents of the valley in supplying data concerning their wells and allowing measurements and tests to be made is very much appreciated. Especial thanks are due Mrs. W. E. Allen and Fred Fulstone for allowing water-stage recorders to be installed on their wells, and Messrs. A. A. Chisholm and John Allen, who serviced the recorders. The writers also wish to thank the staffs of the Bureau of Land Management, the Soil Conservation Service, the Sierra Pacific Power Co., and the Walker River Irrigation District for the valuable data they supplied.

GEOGRAPHICAL SKETCH

Smith Valley is in the western part of Nevada, the central part of the valley being about 35 miles east of the obtuse angle of the Nevada-California boundary (see fig. 1). Most of the valley proper lies in Lyon County, but a small part along the western side is in Douglas County. The valley floor is elliptical, and the major axis trends north. It is about 23 miles long and 10 miles wide.

Wellington, a small community at the southwest side of the valley, is near the mouth of Hoye Canyon, through which the West Walker River enters the valley. The town is a local supply center for the ranchers and farmers of the valley.

Central, another small community, is in the south-central part of the valley. It also serves as a local supply center for the ranchers and farmers. A consolidated public high school and a grammar school there afford educational opportunities.

Smith Valley is an important farming and ranching district. Plate 3, showing land use, indicates that about 12,000 acres of cultivated land is irrigated. Of the remaining 11,000 acres delimited, about 7,000 acres is irrigated pasture land. Irrigation of these lands is accomplished largely by diversions of water from the West Walker River.

Mining today is inconsequential as compared to that of the past. The Nevada Copper Belt Railroad, which was abandoned in 1947, ran south from the Ludwig copper mine along the west side of the Singatze Range through Wilson Canyon and thence northward to

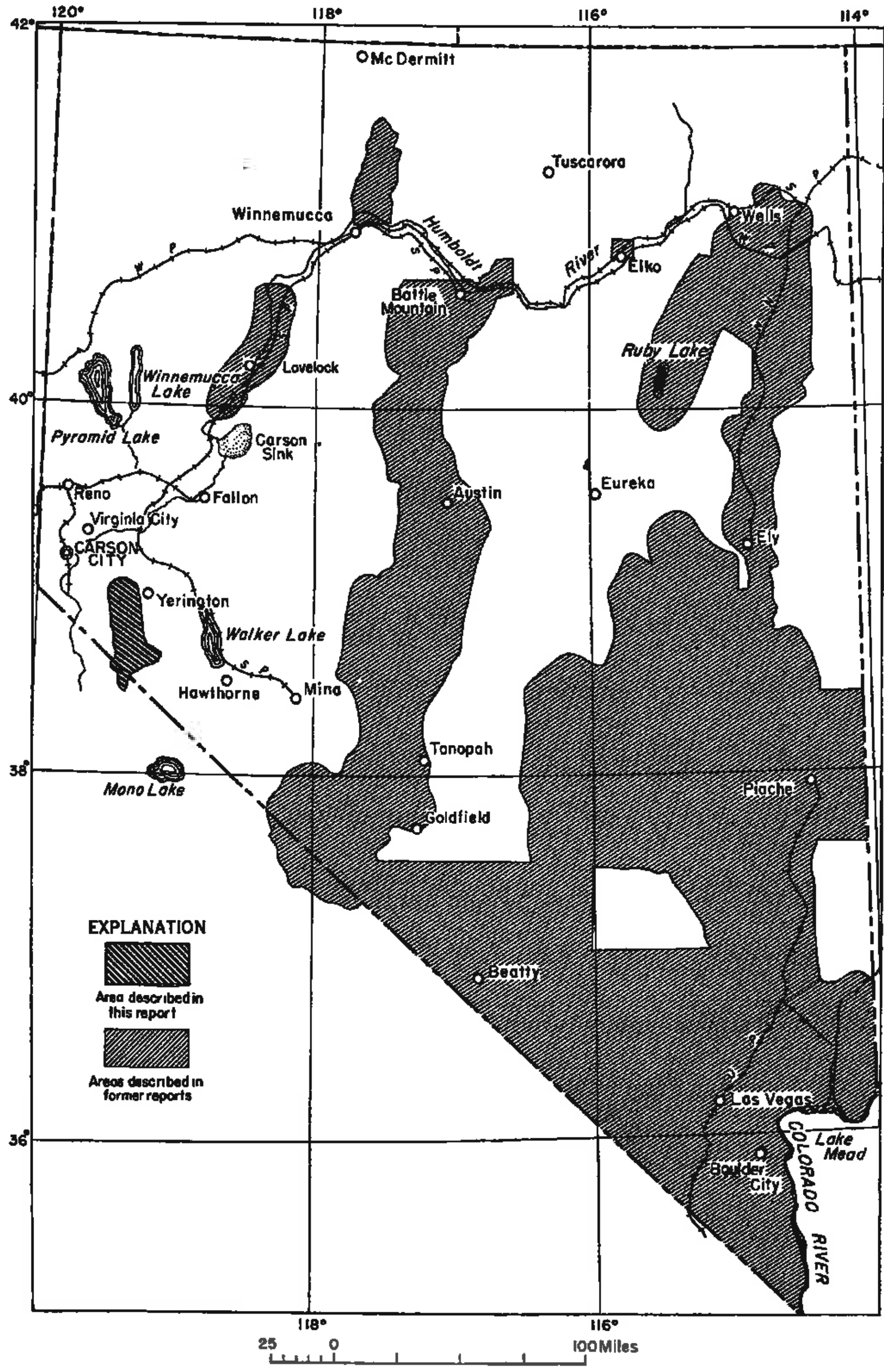

FIGURE 1.—Map of Nevada, showing areas covered by previous ground-water reports and by the present report.

Wabuska in Mason Valley, where it connected with the Southern Pacific Co. railroad. Extensive low-grade copper deposits are reported still to exist in the Singatze Range. Gypsum, of a commercial grade, and some iron ore and placer gold are found on the west slope of the Singatze Range. There are small gold-bearing quartz veins in the Pine Nut Range. Tungsten, copper, lead, zinc, and silver are known to occur in the southern part of the drainage basin, and there has been some production in the area.

State Highway 3, a bituminous-surfaced road, enters Smith Valley about 1 mile northwest of Wellington, continues northeast to Central, and then east, leaving the valley via Wilson Canyon. It forms a 40-mile link between U. S. Highways 395 and 95A. State Highway 22, another bituminous-surfaced road, extends southeast from Wellington to Bridgeport, Calif., 40 miles distant, where it joins U. S. Highway 395. Access to the developed part of the valley is made easy by a network of well-graded gravel roads.

HISTORICAL SKETCH

The following historical sketch is based largely on T. B. Smith's account (1881, pp. 412–413)[1] of the settlement of Smith Valley.

In August 1859 a party of herdsmen from Stanislaus County, Calif., consisting of R. B. Smith, T. B. Smith, S. Baldwin, and J. A. Rogers, decided to settle in the valley because it appeared to be a good place to winter stock. The valley was named Smith Valley in honor of the two men by that name. The first winter, a very severe one, was spent in a house built of tules near the center of the valley on the banks of the West Walker River.

In the summer of 1860 J. B. Lobdel, a farmer, arrived and settled about 6 miles south of the original camp. In the spring of 1861 he put in a crop of vegetables and barley, which he irrigated with water from Desert Creek, a small mountain stream. This was the pioneer crop. Soon after Lobdel made his settlement W. L. Hall and D. C. Simpson started a ranch 5 miles farther south. Soon after, Wright and Hamilton built a stage station at the site of Wellington. Daniel Wellington bought it in 1863 and established a post office there in 1865; subsequently it became an important stage station.

Lobdel's success in raising crops, and the greatly increased demand for farm products owing to a rapid growth in mining activities near Aurora, caused farming to become the leading industry. The first ditch, 4 miles in length, was constructed in 1862 by the two farming companies, Fuller & Mitchell and Hall & Simpson. Hall & Simpson

[1] See references, p. 88.

found a ditch half a mile long on their property when they first settled in the valley, which they thought the Indians had used for irrigation. In 1863 the Smith Co. built a ditch, also 4 miles long, to supply water to farms north of Wellington. In 1864 an incorporated company built 7 miles of the West Walker ditch, at a cost of $4,000, to supply water to about 1,500 acres of land a mile or two northeast of the area served by the Smith Co. ditch. In the same year Wellington built a ditch 2 miles long. In 1876 a capacious ditch 8 miles long was built to irrigate the ranches of M. C. Gardner and J. Irwin. It ran along the side of a very precipitous hill for 4 miles and may have been the beginning of either the Saroni or the Plymouth Canal. Prior to 1881 a large ditch owned by Hall & Simpson, J. N. Mann, and M. C. Gardner & Co. was being constructed on the north side of the river. It was to be about 8 miles long, and was to supply water to four or five thousand acres of land. Two reservoirs were to be incorporated into the system to provide water during low flows of the river. This ditch was probably the beginning of the Colony Canal.

The north end of the valley was first settled in 1860 by J. C. Hinds. He operated a ranch and hotel resort at Hinds Hot Springs, then celebrated for the medicinal properties of the water.

About 6,000 acres of land were cultivated in the valley prior to 1881. The staple product was hay, the greater part of which was alfalfa. Yields averaged 4 tons per acre. Vegetables, such as corn, potatoes, and melons were grown successfully also. Several orchards were planted and in years of favorable weather produced fruit of premium quality.

From the early history of the valley, as written by T. B. Smith (1881), one can see that the valley was an important agricultural district within a few years after the first settlers came to the region. Some historians give the credit for the early settlement of Smith Valley, and of Mason Valley to the east, to newly discovered mining districts. Of these, Aurora, a gold mining camp about 40 miles to the southeast, probably had the greatest influence on the early and rapid settlement of Smith Valley.

The agricultural activities of the valley continued to increase throughout the 90's and into the 20th century. Eventually so much water was being diverted from the West Walker River that downstream users were pleading infringement of rights. The rights to the natural flow of the Walker River were adjudicated and set forth in Decree 731 of the United States District Court for the District of Nevada on March 3, 1919. In order to administer properly the river diversions, the Walker River Irrigation District was organized on

April 14, 1919. The district comprises all the irrigable lands of the Walker River system in the State of Nevada, except for those on the Walker River Indian Reservation.

The continued application of large quantities of water for irrigation has caused serious drainage problems in some areas. To remedy conditions that were more or less local, improvement districts were organized. These districts ordinarily obtained necessary funds by a bond issue lienable only against the areas affected.

In order to increase the availability of water when needed, Topaz Reservoir, a natural off-stream reservoir with a usable capacity of about 45,000 acre-feet, was incorporated into the distribution system in 1922. The reservoir is near the west side of Antelope Valley and about 10 miles southwest of Smith Valley. The initial work, financed by a bond issue of $424,500, was augmented in 1937 by the construction of an earth-fill rock-faced levee. This increased the capacity of the reservoir to about 59,000 acre-feet.

The use of surface water after completion of Topaz Reservoir fell into a more or less fixed pattern. Ground-water development prior to 1948 was confined almost wholly to the utilization of water from small-diameter wells for domestic and stock use. In 1948, however, several newly drilled wells when pumped proved to be satisfactory sources of water for irrigation.

CLIMATE

The climate of Smith Valley is arid to semiarid. Precipitation on the valley floor averages about 7½ inches annually, and evaporation rates are probably between 50 and 60 inches a year. Inasmuch as only a small percentage of the annual precipitation occurs during the late spring and summer months, it is almost always necessary to irrigate all crops, even those having low water requirements. The relative humidity is normally low, and there is an abundance of sunshine. The prevailing wind is westerly and is strongest during late spring and early summer.

PRECIPITATION

The U. S. Weather Bureau records precipitation at the Wellington ranger station, near the south end of the valley floor, and at Smith, about 1 mile north of Central, Nev.

Table 1, showing precipitation data for the Wellington ranger station, was compiled from records of the U. S. Weather Bureau. The period of record is too short to establish a "normal" and the average monthly and annual precipitation rates given should be used with caution.

TABLE 1.—*Precipitation, in inches, during the period 1943–49, at Wellington ranger station, Lyon County, Nev., from records of U. S. Weather Bureau*

[Altitude 4,850 feet; location, SE¼ sec. 2, T. 10 N., R. 23 E.]

	1943	1944	1945	1946	1947	1948	1949	Monthly average
January	3.46	1.03	Tr.	0.20	0.10	0.02	1.13	0.85
February	.68	1.42	3.97	.36	.43	.51	.61	1.14
March	1.93	.75	2.40	.21	.27	.42	.69	.95
April	.56	.40	.35	.04	.19	.76	.10	.34
May	.10	.47	.78	.02	.68	1.21	3.01	.90
June	.78	.09	1.27	.04	.08	.30	.00	.37
July	.65	.00	.01	1.38	.00	.09	.02	.31
August	.00	.00	.08	Tr.	.35	.05	.17	.09
September	Tr.	.00	.10	.12	Tr.	.22	.00	.06
October	.27	.10	1.81	1.82	.33	.62	.00	.71
November	.17	2.50	.41	4.40	.37	.00	1.46	1.33
December	.73	.31	1.56	.05	.18	.52	.34	.53
Total	9.33	7.07	12.74	8.64	2.98	4.72	7.53	7.58

Table 2 shows the normal monthly and annual precipitation and the percentage of annual precipitation occurring each month at the station at Smith. The figures for "normal" were established by the U. S. Weather Bureau and are used in lieu of listing detailed data for the 42-year period of record.

TABLE 2.—*Normal monthly and annual precipitation at Smith, Lyon County, Nev., 1908–49, from records of U. S. Weather Bureau*

[Altitude 4,800 feet; location, NW¼SW¼ sec. 15, T. 11 N., R. 23 E., until June 1948; NE¼SE¼ sec. 18, T. 11 N., R. 24 E., after June 1948]

Month	Normal (inches)	Normal (percent of annual)	Month	Normal (inches)	Normal (percent of annual)
January	1.15	15.8	August	0.27	3.7
February	1.02	14.0	September	.16	2.2
March	.56	7.7	October	.45	6.2
April	.52	7.1	November	.58	7.9
May	.57	7.8	December	.99	13.5
June	.49	6.7			
July	.54	7.4	Annual	7.30	100.0

The months of greatest precipitation are January, February, and December, each having about 1 inch. August and September are the months of least precipitation, 0.27 inch and 0.16, respectively.

Figure 2 shows the annual precipitation, in inches, at Smith, as recorded by the U. S. Weather Bureau for the period 1909 to 1949, inclusive, and a graph showing the cumulative departure, in inches, from the mean (or average) annual precipitation for the same period. The slope of the graph is a measure of the excess or deficiency of precipitation compared to the average annual precipitation. A positive or upward slope to the right indicates above-average precipitation, and a negative or downward slope to the right indicates below-average precipitation. It will be seen that in general the precipitation during the 16-year period 1919-35 was below average, whereas during

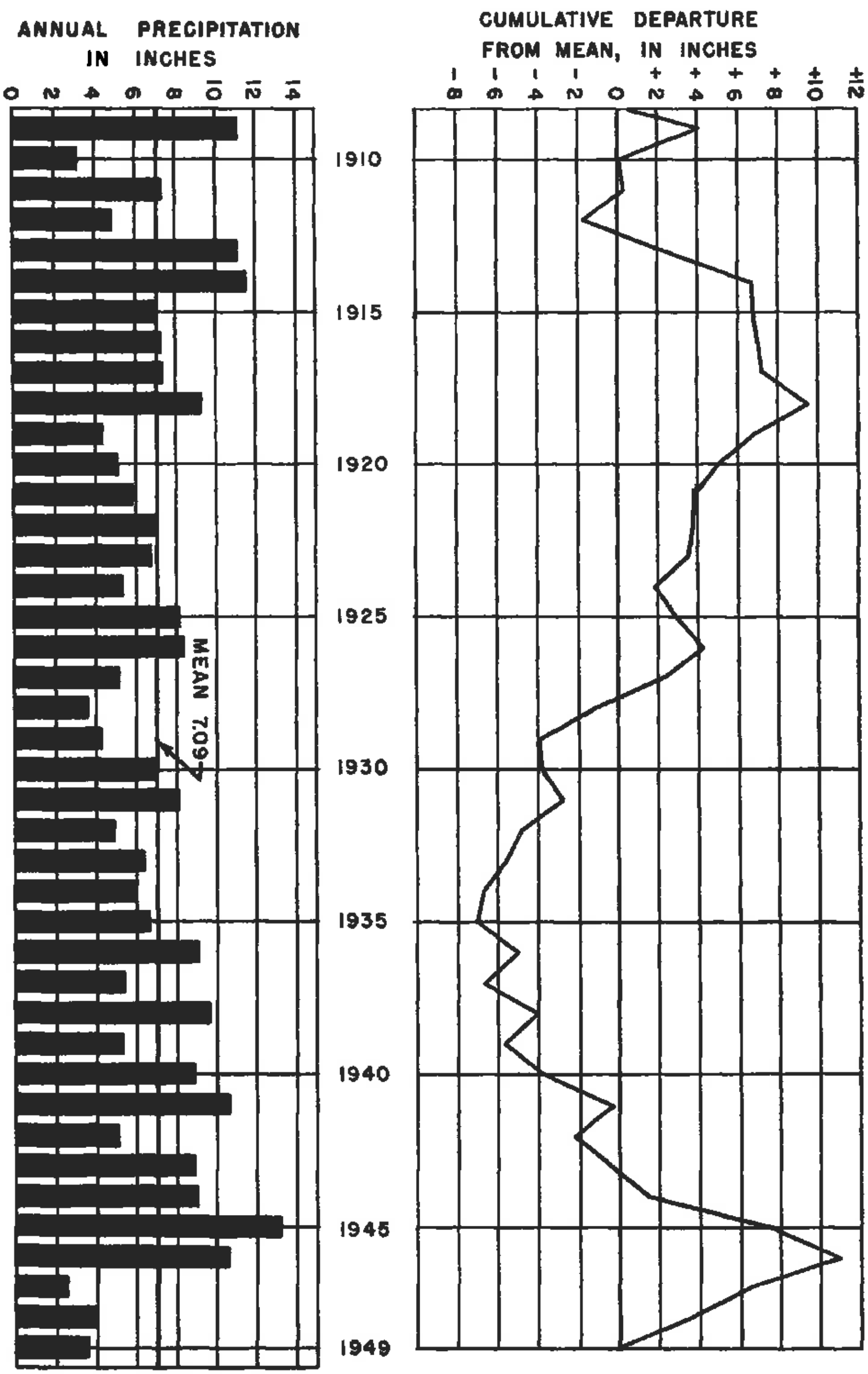

FIGURE 2.—Annual precipitation and cumulative departure from mean precipitation at Smith, Lyon County, Nev., 1909–49.

the 11-year period 1935-46 it was above average. The accumulated excess in the latter period was about 18 inches.

From 1946 to 1949 there was a serious and persistent deficiency in precipitation, as shown by the accumulated deficiency of 11 inches during that 3-year period.

These figures are significant because they indicate periods of above-average and below-average precipitation not only in the valley proper but in the drainage basins of the West Walker River and Desert Creek. A series of years in which the precipitation generally is below average reduces the flow of the streams, which in turn reduces the amount of water available for irrigation. As a result there is a reduction in the water available for ground-water recharge.

TEMPERATURE

Long-term records of temperature are not available. The U. S. Weather Bureau has recorded temperatures at the Wellington ranger station since July 1942 and at the station at Smith since January 1938. The records at both stations are incomplete. However, using available data, an average monthly, average maximum monthly, average minimum monthly, and average annual temperature were computed for each station. The data are shown in table 3.

TABLE 3.—*Average, average maximum, and average minimum monthly and annual temperatures, in degrees Fahrenheit, at Wellington ranger station and Smith, Nev. (From records of U. S. Weather Bureau)*

[Wellington ranger station is at an altitude of 4,850 feet; it is located in the SE¼ sec. 2, T. 10 N., R. 23 E.; and the length of record was from July 1942 to Dec. 1949, inclusive. Smith is at an altitude of 4,800 feet; located in the NW¼SW¼ sec. 15, T. 11 N., R. 23 E., until June 1948, and after June 1948, in the NW¼SE¼ sec. 18, T. 11 N., R. 24 E.; and the length of record is from Jan. 1938 to Dec. 1949, inclusive]

Month	Wellington ranger station			Smith		
	Average	Average maximum	Average minimum	Average	Average maximum	Average minimum
January	30.5	35.2	13.9	30.5	36.0	10.6
February	35.8	42.5	30.7	35.5	40.4	30.6
March	41.4	45.4	37.8	41.1	45.4	34.6
April	50.1	53.3	45.2	48.7	52.6	44.8
May	56.7	60.5	54.5	55.4	59.8	52.3
June	62.0	66.4	58.2	62.2	68.0	59.0
July	71.3	75.2	67.4	69.9	72.5	66.5
August	69.1	72.6	66.8	67.8	71.2	64.0
September	63.6	65.1	61.0	60.4	66.0	55.6
October	52.4	55.8	47.2	50.2	53.4	47.2
November	40.7	47.6	34.9	38.3	43.4	32.6
December	34.0	38.6	32.6	33.2	39.8	25.7
Annual	50.6	51.5	49.7	49.6	51.8	46.2

As shown in the table, the average annual temperature is about 50° F. Occasional wide differences in minimum daily temperatures between the two stations were observed. For example, the minimum temperature on December 2, 1948, was 7° F. at Smith and 37° F. at

Wellington, which is only 4 miles south and approximately 50 feet higher—a difference of 30 degrees. On November 8, 1948, corresponding temperatures were 2° and 36° F.—a difference of 34 degrees. It is possible that occasional wide differences in minimum temperature are due to the location of the stations. The Wellington ranger station is close to a fault zone where warm and hot waters are encountered at shallow depth in wells drilled in the vicinity. Some of the subsurface heat may reach the land surface and locally maintain abnormally high air temperatures near the land surface. Inasmuch as the station at Smith is approximately 50 feet lower, relatively cold, and thus heavier, air occasionally may envelop it.

The highest temperature recorded at the Wellington ranger station was 100° F. on July 22, 1942, and the lowest, −18° F. on January 26, 1949. Corresponding extremes at Smith were 102° F. on July 19, 1947, and −27° F. on January 26, 1949.

The average growing season at the Wellington ranger station for the 7-year period 1943–49, inclusive, was 138 days; whereas at Smith the average growing season for the 11 years for which records are available during the 12-year period 1938–49, inclusive, was 101 days. It is not known which figure more nearly represents the average growing season for the valley as a whole. It would appear reasonable, therefore, to assume a mean figure of about 120 days as the average growing season.

PHYSIOGRAPHY AND DRAINAGE

GENERAL FEATURES

Smith Valley lies in the Great Basin section of the Basin and Range province, which is characterized by a series of north-trending mountain ranges and intermontane valleys filled with detrital material washed from the adjacent mountains.

It is in western Nevada, between 30 and 50 miles eastward from the angle in Nevada's western boundary. The drainage basin, exclusive of that of the West Walker River above Hoye Canyon, is roughly rectangular in shape and trends north. (See pl. 1.) It is about 40 miles long, averages about 13 miles wide, and has an area of about 510 square miles. For all practical purposes it can be considered to lie between latitude 38°25′ and 39°05′ north and longitude 119°05′ and 119°30′ west.

MOUNTAINS

The Pine Nut Mountains bordering the west side of the basin are the most prominent mountains enclosing the valley. Beginning near Hoye Canyon, southwest of Wellington, and extending northwestward their crests rapidly increase in altitude from about 5,000 feet to 9,300 feet at Bald Mountain, 9 miles northwest of Wellington. Crest altitudes of about 9,000 feet persist to Oreana Peak, 4½ miles farther north, where the altitude is 9,380 feet. Northward from Oreana Peak for a distance of about 7 miles the crest is somewhat lower, generally between 7,500 and 8,000 feet. In the next 7 miles the crest altitude is generally more than 8,000 feet, and at Como Peak it reaches 9,000 feet again.

Low-lying spurs from these mountains and the Singatze Range, which forms the northeastern and eastern boundary of the valley, merge to form the northern boundary of the valley. Altitudes generally range from 5,300 to 6,500 feet.

Mount Wilson, in the Singatze Range, about 2 miles north of Wilson Canyon, has an altitude of 6,801 feet and is the highest point in the range. Generally, crest altitudes range from 5,300 to 6,500 feet. A few miles south of Wilson Canyon the crest attains somewhat higher altitudes and the range merges with the Pine Grove Hills, which form the southeastern boundary. In these hills, about 8 miles south of Wilson Canyon, the crest altitude is 8,000 feet; it gradually increases southward to Lobdell Summit, where it is about 8,500 feet. Southward from Lobdell Summit the crest altitudes increase and reach a maximum of 9,608 feet at an unnamed peak about 8 miles south of Lobdell Summit. From there the crest swings westward along the ridge separating Smith Valley and Sweetwater Valley, dropping to an altitude of almost 6,800 feet in the lowest part of the ridge. Continuing westward it rises rapidly up the slope of the Sweetwater Mountains, reaching an altitude of about 10,700 feet at an unnamed peak near the Nevada-California boundary line. The crest then swings southward for about 6 miles, following the Sweetwater Mountains, at altitude of about 11,000 feet, culminating in Mount Patterson, with an altitude of 11,654 feet, the highest point of the boundary. From Mount Patterson the crest swings westward for about 3 miles at altitudes above 10,000 feet, and then northward, losing altitude until at the Nevada-California boundary it is 8,000 feet. Crest altitudes continue to drop until 10 miles north of the State boundary the altitude is about 7,000 feet. Then follows a rather steep decline to about 5,000 feet at Hoye Canyon, 3 miles farther north.

The Pine Nut Mountains have relatively steep eastern slopes into which a number of steep canyons—Burbank and Red Canyons are most notable—have been cut. The slopes of the mountains bordering the northern side of the valley are gentle. Slopes along the west side of the Singatze Range are also relatively gentle except at a few places near the crest.

The Pine Grove Hills at the southeast corner of the basin are rugged in few places. However, the Sweetwater Mountains at the south end of the drainage basin are rugged and contain several steep-walled canyons.

ALLUVIAL FANS AND VALLEY FLOOR

Alluvial fans are poorly developed along the west side of the valley. The Burbank and Red Canyon fans are the largest, although they extend only about 2 miles from the range front. (See pl. 1.) An alluvial apron, generally small, separates the range fronts and valley floor on the north and east sides of the valley. Extensive north. sloping coalescing fans extend 7 or 8 miles from the mouths of Desert Creek and Dalzell Canyons. Both these fans contain considerable amounts of well-rounded, relatively clean gravels which should provide an excellent opportunity for infiltration of water.

The over-all slope of the valley floor is northward and slightly westward except where modified by the West Walker River, Desert Creek, and Dalzell Canyon drainage systems. These drainage systems have dissected the younger lacustrine deposits and formed lower-lying subvalleys. Most of the flowing artesian wells south of the West Walker River are in these lower-lying valleys. North of the river the land slopes northwestward from 15 to 20 feet per mile to within about 2 miles of the alkali flat, then drops rather rapidly to the flat about 100 to 150 feet below. This flat-lying alkali expanse of about 4 square miles receives practically all the runoff from that part of the valley north of the West Walker River. Occasionally the flat is covered with a thin sheet of water when large quantities of canal water are wasted to the flat or unusually heavy precipitation occurs in the northern part of the drainage basin. Usually, however, it is a dry, barren area with small fringes of water near the southern and northern margins. Sand dunes covering an area of about 3 square miles are prominent east of the flat.

A group of lakes or ponds known as the Beaman Lakes lie in secs. 11 and 15, T. 11 N., R. 23 E. It is belived that these lakes resulted from damming, by the coalescing Burbank and Red Canyon fans, of waste irrigation water, drainage water, and also the small amount of runoff that normally would flow northward to the alkali flat. Evidence for this is furnished by the General Land Office township plats surveyed in 1881, which do not show any lakes or swampy land in the area now occupied by the lakes. Neither do they show the Colony Canal, although other canals in existence at the time of the survey are shown.

In 1948, a drainage ditch was constructed to the West Walker River to lower the level of the lakes. The slope of the drainage ditch is opposite to the slope of the land surface, so that although the

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ditch is only 5 or 6 feet deep at the southernmost or lowest lake, it is more than 20 feet deep half a mile south of the lake where it passes under a county road. It is reported that this ditch lowered the lake level about 7 feet.

STREAMS

The West Walker River, which heads in the Sierra Nevada in Mono County, Calif., about 40 miles south of Smith Valley proper, is the principal stream of the valley. It has a drainage area of about 504 square miles above Hoye Canyon, through which it enters the southwest corner of the valley. The river follows a sinuous course northeastward through the valley and leaves it via Wilson Canyon on the east side.

South of the river from the mouth of Hoye Canyon to the vicinity of Hudson, the land slopes gently toward the river. On the north side of the river, in the same reach, a prominent bluff rises about 50 feet above the flood plain. From Hudson to Wilson Canyon, bluffs of comparable height are on both sides of the river. (See pl. 1.)

After entering the valley the gradient of the river decreases rapidly. At the mouth of Hoye Canyon it is about 30 feet per mile, whereas 2 miles downstream it is only about 10 feet per mile. The river meanders at this gradient within a rather narrow flood plain until it reaches the vicinity of Hudson, where meandering becomes negligible (pl. 2, figs. 3 and 4) and the gradient increases perceptibly to Wilson Canyon.

Desert Creek, a much smaller stream, heads near Mount Patterson in the Sweetwater Mountains in Mono County, Calif., at an altitude of more than 11,000 feet above sea level. Lobdel Lake, an offstream natural reservoir in the headwater region, regulates the flow of the stream, making a large percentage of the annual runoff available for irrigation.

Desert Creek, draining an area of youthful topography, drops about 3,000 feet in a distance of about 15 miles. It is characterized by many small rapids and, in many places, deep-cut canyons. It emerges abruptly from a canyon about 17 miles north of its headwaters and debouches onto its long alluvial fan at the south end of the valley. Prior to development of irrigation in the valley, Desert Creek discharged into the West Walker River. However, for many years all its water has been diverted for irrigation, and none reaches the river as surface flow.

Minor relatively short streams having steep gradients head in the Pine Nut Mountains bordering the west side of the valley. Only those in Burbank and Red Canyons are perennial from their headwaters to their canyon mouths. The water from these streams is used as supplemental irrigation water during a few months of the year. All

FIGURE 3.—Composite aerial photograph of the vicinity of Hudson, Nev., showing geologic and physiographic features.

FIGURE 4.—Composite aerial photograph of part of Smith Valley, Nev., 1 to 4 miles north of Wellington.

other streams are ephemeral and generally flow only during and for a short time after the snow-melt period in the spring or as a result of runoff from occasional heavy rains. The streams generally disappear by infiltrating the valley fill. Occasionally the streams at the north end of the valley discharge onto the alkali flat where the water evaporates.

GEOLOGY

GENERAL

The rocks in Smith Valley and the enclosing mountains may be divided into two general groups on the basis of their age, origin, and type structure, and their influence on the occurrence and movement of ground water (see pl. 1). These are: (1) the bedrock, consisting of older sedimentary and igneous rocks in the mountains and the foothills, and (2) the valley fill, consisting of lake beds and alluvial deposits.

The principal study of the older sedimentary and igneous rocks in the area was made by Knopf (1918) in the Yerington mining district, which is principally within the Singatze Range. In an earlier report, Smith (1904) described the general geology of the upper region of the main Walker River, which included the mountains on the north and east sides of Smith Valley. Others (including Ransome, 1909; Hill, 1915; Overton, 1947; and Stoddard and Carpenter, 1950) have reported on the geology of mining properties in districts in the Pine Nut Mountains along the west side of Smith Valley and in the mountains north, southeast, and southwest of the valley. The geologic sequence of the older rocks as outlined by Knopf appears to apply generally to all the mountains enclosing Smith Valley and is adapted for use in this report.

A reconnaissance study of the valley fill during the course of the present investigation indicates that the sedimentary deposits underlying the floor of the valley range in age from late Tertiary to Recent.

GEOLOGIC HISTORY

The oldest rocks that crop out in the area are of Triassic age. The sequence of these rocks indicates that about 4,000 feet of andesitic and dacitic lava, breccia, and tuff were erupted, and these were followed by about 1,200 feet of soda-rich rhyolite lava and tuff. Subsequently the area subsided beneath the sea, and limestone, sandstone, and some shale were deposited. The marine sequence includes a 450-foot bed of gypsum (anhydrite at depth) and occasional layers of volcanic rocks.

Folding and, probably, faulting of the Triassic rocks accompanied or preceded a series of intrusions by Cretaceous granitic rocks. The most widespread of these intrusives, at least in the Singatze Range, is quartz monzonite. In this process the adjacent Triassic rocks were intensely metamorphosed. Faulting also occurred during and after the intrusive activity, providing avenues along which ore-bearing solutions entered the rocks.

The intrusive and related activity was followed by a long period of erosion which removed a large volume of the Triassic rocks, to the extent that large areas of the intrusive rocks were exposed and eroded. It is likely that this erosion reduced the area to one of moderate or low relief. The eroded surface was mantled, at least locally, by fluvial deposits.

Volcanic eruptions resumed, possibly in Miocene time, with the extrusion of a flow of glassy latite which was followed in succession by perhaps 500 feet of quartz-latite flows, and approximately 4,000 feet of rhyolitic tuffs, breccias, and flows, of which the pyroclastics were dominant.

Subsequent to the deposition of these volcanic rocks strong diastrophism resulted in considerable displacement by faulting and related tilting of the Tertiary rocks. The deformation apparently developed basins—larger than present-day basins—in which alluvial detritus and lacustrine sediments were deposited.

Erosion of the rhyolitic rocks in the higher areas was followed by an eruption of andesitic rocks, including about 1,400 feet of breccia overlain by about 300 feet of lava flows, which were laid down with angular unconformity on the older Tertiary volcanic rocks.

After the andesitic eruptions erosion in the exposed areas resulted in the deposition of detritus in relatively low areas. Locally exposures in the Singatze Range indicate a thickness of as much as 300 feet of gravel (probably fanglomerate). The latest volcanism in the area resulted in a series of basalt flows.

Fine-grained sediments, in part lacustrine, were deposited in basins contemporaneously with the volcanic activity that produced the andesitic and basaltic rocks in the mountain area. These sediments, termed older valley fill, are now exposed, in part, in the crest areas of the mountains south of Wilson Canyon, high on the west flank of the mountains south of Hoye Canyon, and in Churchill Canyon at the north end of the valley.

After the latest basaltic extrusion, faulting and relatively simple tilting outlined the present basins. The faulting is developed notably along the eastern bases of the Pine Nut Mountains and the Singatze Range, although faulting probably occurred contemporaneously elsewhere. According to Knopf (1918, p. 30) the faulting marked the beginning of Quaternary time. Actually, although the beginning of this faulting may have marked the start of Quaternary time, it appears to have continued intermittently to the present.

Deposition and erosion in Smith Valley during Quaternary time almost surely have been controlled by a combination of faulting, which interrupted the through drainage, and climatic variations. This combination alternately increased and decreased stream activity, which in turn increased and decreased the carrying and erosion capacity of the streams. Thus, although the complete detail has not been worked out, the following approximate sequence is indicated in Smith Valley.

With the formation of the basin of Smith Valley, erosion along the marginal areas dissected or partly beveled the older valley fill. Predominantly fine-grained sediments of the younger valley fill were deposited in this basin, partly in lakes and partly along streams. These sediments include alternating layers of sandy silt, silt, and clay and occasional layers of fine- to medium-grained sand and, locally, gravel. At one locality (see p. 22) the upper part of this younger valley fill, which may have a maximum thickness of about 100 feet, consists of a bed of river cobble gravel perhaps 5 feet thick, overlain by fine-grained thin-bedded sediments 15 feet thick, which in turn are overlain by a bed of river cobble gravel about 10 feet thick. The sequence suggests that, for a large part of Quaternary time, there was little or no drainage from the valley, and predominantly fine-grained sediments about 70 feet thick were deposited. However, near the end of this depositional phase, stream activity was greatly increased and through-drainage was developed for a short time, as indicated by the 5-foot bed of river cobble gravel. Through-drainage did not last, or else the stream shifted, and deposition of fine-grained sediments was resumed. The top layer of cobble gravel indicates that through-drainage was again established and apparently has been maintained since. Temporary periods during which the streams flowed at grade are indicated by intermediate terrace levels along the present West Walker River in the vicinity of Hudson.

Evidence of the existence of at least one lake in the valley is indicated by a narrow wave-cut bench in bedrock, and an associated bar, in sec. 23, T. 13 N., R. 23 E., and by an offshore bar in sec. 17, T. 13 N., R. 24 E., both in the northern part of the valley. Similar wave-cut benches, though not so obvious, are present on the bedrock hills in secs. 23 and 24, T. 13 N., R. 23 E., and in the west-central part of T. 12 N., R. 24 E. These features lie between about 4,850 and 4,900 feet above sea level, according to the topographic map of the Wellington quadrangle. Beach features at this approximate altitude were not observed elsewhere, suggesting either that they were not formed or that they have been destroyed.

It appears that the river has not cut far below its present level in Quaternary time, and river sediments of Recent age are essentially only a mantle along the flood plain. Dissection of the valley fill by the West Walker River and tributary drainage, particularly from Desert Creek and Dalzell Canyon, has effectively removed much of the younger valley fill from the area south of the river.

Erosion in the tributary canyons along the west side of the valley and in Desert Creek and Dalzell Canyons has resulted in deposition of detritus on their respective fans. Some deposition has occurred on the playa, and Recent sand dunes have been formed east and northeast of the alkali flat. At other localities Recent deposition has been minor. Relatively recent faulting has occurred in the vicinity of Hinds Hot Springs and possibly south and southeast of the playa.

PHYSICAL CHARACTERISTICS AND WATER-BEARING PROPERTIES OF THE ROCKS

BEDROCK

The oldest rocks in the area crop out in the mountains and include andesitic and soda-rhyolite lavas, limestone, and lesser amounts of quartzite, shale, and gypsum, totaling at least 8,000 feet in thickness. Limited fossil evidence indicates that these rocks are of Triassic age.

The Triassic rocks were profoundly altered by intrusive rocks—mainly quartz monzonite and granodiorite—into lime-silicate rocks including much garnetite and lesser amounts of wollastonite, tremolite, and vesuvianite, epidote, diopside, and other minerals. Ore-forming solutions produced primary sulfides of iron and copper, and other minerals in many areas, but only at a few localities were they of commercial importance.

The Mesozoic rocks are dominant in the Singatze Range from the vicinity of Wilson Canyon to about latitude 39° N., and also in the Pine Nut Mountains from about the same latitude to the vicinity of Hoye Canyon. In the other mountain areas around Smith Valley the Mesozoic rocks may be locally prominent, but more generally the Tertiary volcanic rocks form the principal exposures.

The general character of the Mesozoic rocks is such that they probably do not transmit water freely. Solution openings in limestone which transmit large quantities of water in other areas in the State, such as in the Egan and Snake Ranges in eastern Nevada, apparently are not present in the Singatze Range or Pine Nut Mountains. This may be due, in part, to the intense alteration of limestones and other Mesozoic rocks in this area. Some water probably is concentrated locally in the Mesozoic rocks in joints or in crushed areas adjacent to faults. Such concentration of water could cause difficulties in mining operations. Generally, however, these rocks act as barriers to ground-water movement, and precipitation that falls on the adjacent flanks of the mountains is diverted into the valley.

Tertiary rocks unconformably overlie the Mesozoic rocks and in the Yerington district (in the Singatze Range) their sequence is as follows: basal fluvial conglomerate, at least locally; a quartz-latite lava series; a thick rhyolite series of tuff, breccia, and flow rock; andesitic breccia; andesitic flows; a loosely cemented gravel; and, at the top of the series, several basalt flows. The Tertiary section, which is dominantly volcanic, in the Singatze Range has an aggregate thickness of about 7,000 feet.

These Tertiary rocks are predominant in the Singatze Range and the Pine Nut Mountains north of about latitude 39° N., and in the mountains south of Wilson and Hoye Canyons. In the vicinity of Wilson and Hoye Canyons fine-grained thin-bedded sediments are interbedded, in part, with the volcanics. In the valley the exposed Tertiary section consists entirely of fine-grained sediments which apparently were deposited under lake or playa conditions. Thus the bulk of the older part of the valley fill—late Tertiary in age—apparently is composed largely of fine-grained sediments.

The Tertiary flow rocks in the mountains are capable of transmitting some water through fractures. It is believed that the quartz-latite, rhyolite, and andesite flows ordinarily do not have scoriaceous or broken zones at their top or bottom which might act as aquifers below the zone of saturation. The basalt flows at the top of the volcanic sequence are more likely to be separated by such zones and these would be good aquifers if the basalt were in the valley and below the water table.

The pyroclastic rocks and fine-grained sediments should transmit at least small amounts of water unless consolidation or cementation has reduced their original permeability; they have not been studied thoroughly enough to settle this point.

The conglomerate at the base of the Tertiary rocks and the loosely cemented gravel below the basaltic lavas may be the most permeable of the Tertiary rocks in the mountains. However, the probable limited areal extent of these fluvial beds, particularly beneath the floor of Smith Valley, reduces their potential value as aquifers.

VALLEY FILL

Sedimentary deposits beneath the floor of the valley range in age from late Tertiary to Recent. The older valley fill is exposed in Wilson Canyon and beyond it for about a mile into the valley, locally in a bluff on the south side of the river about half a mile southeast of Hudson, and in Hoye Canyon, principally in the upstream or western part.

The sediments of the older valley fill generally are rather fine-grained but range from clay to coarse sand and some gravel. In the western part of Wilson Canyon the effect of rapid variations in local deposition is shown by the presence of interfingering layers of fanglomerate containing fragments of the local volcanic rocks and quartz monzonite. Approximately 3 miles south of Wilson Canyon, in about sec. 31, T. 11 N., R. 25 E., at least two beds of sand and grit are exposed in a bluff along a wash. They are 4 to 6 feet thick, black, cemented with calcium carbonate(?), relatively resistant to erosion, and consist of fine- to coarse-grained sand with small areas of grit or fine gravel which is, in part, cemented with limonite. The associated sediments are generally light-colored, gray and buff fine-grained sand and sandy silt, and some layers of coarser sand. On the south and southwest side of the same wash nearly spherical pebbles about 1 inch in diameter were noted in the surface debris; these were obviously derived from a bed in the older valley fill. However, the thickness of the gravel layer is probably not more than 1 or 2 feet.

About half a mile southeast of Hudson the older fill is exposed in a nearly vertical bluff cut by the river. (See fig. 3.) Here it is commonly sandy to silty material and occasionally coarser layers; the beds are usually no more than 2 or 3 feet thick and frequently less than 1 foot thick; and the color is generally a medium to light gray. These beds are slightly tilted and dip westward 3° to 5°. Overlying the older valley fill at this locality are nearly horizontal beds of the younger valley fill. There is a basal gravel ranging from a little less than 1 to about 5 feet in thickness. The thickness is variable and the gravel probably is not continuous throughout the valley. Above the basal gravel are beds of sand, sandy silt, silt, some clay, and gravel. The bulk of these deposits is rather fine grained and is in beds as much as 3 feet thick, but there are numerous layers only a few inches thick. The sediments are generally nearly white but range from buff to light gray. In the SW¼ sec. 14, T. 11 N., R. 24 E., a tributary drainageway immediately west of the gravel pit shown in figure 3 exposes what apparently is the top of the younger valley fill in this part of the valley. At this locality the uppermost bed is a cobble gravel 5 to 10 feet thick, lightly consolidated and with only a slight amount of caliche cement on the individual pebbles and cobbles in the upper 1 or 2 feet of the bed. The cobbles are usually less than 6 inches in diameter and average 3 to 4 inches. A relatively small amount of sand is present also. The well-rounded shape of the cobbles indicates deposition in a stream of moderate size—the size of material is about the same as that in the beds of the West Walker River in Wilson and Hoye Canyons at the present time. These cobble gravels, which apparently were deposited in a stream crossing an open valley, may well indicate a stream much larger than the present West Walker River.

Beneath the surficial cobble gravel is about 15 feet of fine-grained thin-bedded sediments, and these overlie another gravel bed only about 5 feet thick but otherwise similar to the upper gravel. Such a sequence has not been noted at any other locality. To the south a slight break in the north slope occurs near the highway, south of which the surficial Quaternary material is a fanglomerate which apparently overlies unconformably the older valley fill. Southwest toward Hoye Canyon erosion by streams issuing from Desert Creek and Dalzell Canyons appears to have removed most of the material that once may have lain at the same level as the cobble gravel. To the north and northwest the material represented by the cobble horizon either has been completely stripped, or was never deposited. It is more likely that the cobble gravel represents a segment of an older and more narrow channel of the West Walker River. The course of the streamway may have been parallel to, though somewhat south of, the present river. If this is so, high-level stream gravels of a through-flowing stream would not be expected at any great distance from the present course of the West Walker River.

Younger valley fill in the central part of the valley is exposed in the bluff at the south end of the alkali flat, at the north end of the valley, and in a large part of secs. 7, 8, and 18, T. 12 N., R. 24 E., southeast of the alkali flat. Smaller exposures of the younger valley fill were noted in some road cuts along the west side of the valley, and in breaks in slope in the central part of the valley south of the alkali flat. In most of these the sediments are predominantly fine-grained lacustrine deposits.

Alluvial-fan deposits are important locally. These deposits are principally those laid down by streams draining Red and Burbank Canyons, on the west side of the valley, and Desert Creek and Dalzell Canyons, on the south side of the valley. It is likely that the bulk of the sediments making up these fans are contemporaneous with the lacustrine deposits of the younger fill, but the surficial parts of these fans are younger.

Deposits of Recent age include surficial flood-plain sediments along the West Walker River, the mantling deposits of the alluvial fans along the west side and south end of the valley, wash material along the many normally dry drainageways, fine-grained sediments and saline deposits forming the alkali flat, and dune sand principally in the area east and northeast of the alkali flat but locally elsewhere.

The full thickness of the late Tertiary and Quaternary fill beneath the valley floor is not known. Well 12/23–24CC2[2] (for location see pl. 2), in the north-central part of the valley, reportedly was drilled to a depth of 500 feet, and was still in valley fill at the bottom. Ac-

[2] See well-numbering system, p. 62.

cording to the driller's log, well 11/23–3DC1 penetrated 3 feet of bedrock beginning at 272 feet below land surface. Also, well 10/24–4CD1, about 3 miles east of Wellington, may have bottomed on bedrock at 250 feet. However, well 11/24–32DC1, 1¼ miles north-northwest, reached a depth of 390 feet without encountering bedrock, and well 10/29–5CB1, 1 mile northwest, is reported to be 480 feet deep and to bottom in sediments. The bedrock hills of intrusive rock in the west-central part of T. 12 N., R. 24 E., show that the depth of fill is not great in that vicinity. On the basis of the general physiographic and geologic characteristics of Smith Valley, it is believed that the combined thickness of the older and younger valley fill may be greatest in a narrow, north-trending area in the west-central part of the valley, where it is probably more than 500 feet. The thickness of the lacustrine and fluvial sediments of the younger valley fill near Hudson approximates 100 feet, and this may represent about the full thickness of these deposits in the central part of the valley. The younger fill, at the edges of the valley including fan deposits beneath the fans of Red and Burbank Canyons and those of Desert Creek and Dalzell Canyons, may have a maximum thickness of much more than 100 feet.

Wells of moderate to large capacity have been obtained in the SW¼ sec. 4, T. 10 N., R. 24 E., the SE¼ sec. 3, T. 11 N., R. 23 E., the SE¼ sec. 32, T. 11 N., R. 24 E., and the SW¼ sec. 25, T. 13 N., R. 23 E. These wells range in depth from 250 to about 560 feet. Wells 10/24–4CD1 and 11/24–23DC1 are in an area underlain by sediments derived from Desert Creek or Dalzell Canyons, 11/23–3DC1 is on the Burbank-Red Canyon fan, and 13/23–25CB1 is on the lower alluvial slope north of the playa. All, except possibly well 13/23–25CB1, are in areas where the permeability probably is greater than average for valley-fill sediments in Smith Valley, whether the fill is of Tertiary or Quaternary age. The success of the Ambassador well (13/23–25CB1) probably results either from its gravel-pack type of construction, which can be more effective in the recovery of ground water than the type of construction ordinarily used for wells in the valley, or from the fact that it may penetrate bedrock of relatively high yield.

Much of the valley fill consists of alternating, generally thin, layers of sand or sand and gravel, silt, sandy silt, or clay. The fine-grained layers act as confining beds for the water, as shown by the existence of flowing wells in parts of the valley. There is a sizable area marginal to the flowing-well areas in which ground water is confined but is not under sufficient head to rise above the land surface in a well.

Wells have obtained artesian flows at depths as shallow as 15 feet in well 12/23–14AD1, and as much as 500 feet in well 12/23–24CC2 and 560 feet in well 13/23–25CB1. However, the depths of flowing wells ordinarily range from 80 to 200 feet. The largest yield of any flowing well is about 400 gpm from well 13/23–25CB1, which is gravel-packed and draws from several zones. Ordinarily the yields are relatively small and may average 5 to 10 gpm; few exceed 75 gpm.

STRUCTURE

The rocks in the mountains have been considerably deformed. The Mesozoic rocks have been both folded and faulted, whereas the Tertiary rocks have been faulted and tilted only.

The faulting after deposition of the Tertiary consolidated rocks defined the general form of the mountains of the present time—that is, faulting along the eastern part of the Singatze Range and the Pine Nut Mountains resulted in the development of short, steep slopes on the east flank, and long, relatively gentle slopes on the west flanks of the mountains.

Recent faulting is indicated along the eastern side of the Pine Nut Mountains by discordant breaks in slope on some of the alluvial fans, such as on the small fans just south of Hinds Hot Springs. These cross the fans about normal to their axes of deposition and do not curve around the fans on the same altitude contour; consequently, they are fault features and do not represent a nick developed by wave action along the shore of a lake. Further indication of Recent faulting is indicated locally by the lack of erosion, or lack of detritus, at the foot of steep bedrock slopes. Perhaps the best example is at Hinds Hot Springs. Here bedrock is an intrusive granitic rock and its surface rises steeply from the adjacent valley floor. The evidence of relatively recent movement along a fault in this vicinity and the position of Hinds Hot Springs strongly points to a close relation between the hot springs and the faulting.

Minor faulting within the valley may have produced offsets in the valley fill, with little or no surface evidence. However, the line of bluffs extending approximately east-west at the southern end of the alkali flat may result, in part, from faulting in that area. The bluffs are formed largely on fine-grained sediments typical of the lacustrine deposits. The bedrock hills, which are only 2 miles southeast of the alkali flat, suggest that the area south of the bluffs may be underlain by bedrock at relatively shallow depth. It is believed that north of the bluffs the fill is much thicker. Under such conditions, faulting along the present bluffs might have occurred as the result of compaction of the relatively thick valley fill beneath the alkali flat. If these bluffs actually indicate a fault, it is most likely that the north side dropped relative to the south side. Slight southward tilting of the alkali flat is indicated by the fact that the water discharged from Hinds Hot Springs into the flat tends to move along its southern margin near the foot of the bluffs, rather than toward its center.

SURFACE WATER

WEST WALKER RIVER

The West Walker River supplies most of the water used in the valley. It heads in the Sierra Nevada in Mono County, Calif., some 40 miles south of Smith Valley. A gaging station of the U. S. Geological Survey, 13 miles south of Coleville, Calif., in the SE¼ sec. 9, T. 6 N., R. 23 E., about 25 miles south of Smith Valley, is maintained to measure the flow past that point. (See pl. 1.) The average annual discharge from a drainage area of 182 square miles, based on 40 years of record, is about 176,000 acre-feet.

The river flows northward from the gaging station through a narrow canyon for about 10 miles, then enters the south end of Antelope Valley. There, considerable water is diverted for irrigation and also for temporary storage in Topaz Reservoir, an offstream reservoir near the west side of the valley which provides 59,440 acre-feet of usable storage. At the north end of Antelope Valley the river enters Hoye Canyon, through which it flows for about 2 miles before entering Smith Valley.

From records supplied by the Walker River Irrigation District, and from data published in water-supply papers of the U. S. Geological Survey, it is estimated that the average annual contribution to the flow of the West Walker River within the drainage basin of the river between the gaging station 13 miles south of Coleville and Smith Valley is about 50,000 acre-feet. Diversions for irrigation in Antelope Valley during the period 1943–48 averaged 62,600 acre-feet annually. The return flow to the river in Antelope Valley, as estimated in an oral communication of April 18, 1949, by Carl Gelmsted, secretary of the Walker River Irrigation District, is about 35 or 40 cfs (cubic feet per second or second-feet), or an average of about 27,000 acre-feet annually. The annual evaporation from Topaz Reservoir is estimated to be about 10,000 acre-feet. This estimate is based on records at Lahontan Reservoir and Fallon, both about 70 miles northeast of Topaz Reservoir, which indicate an average evaporation rate of about 5 feet a year.

The average annual quantity of water that enters Smith Valley via the Walker River is, therefore, estimated to be the average annual flow at the gaging station south of Coleville, 176,000 acre-feet, plus the inflow between the gaging station and Smith Valley, 50,000 acre-feet, plus the return flow in Antelope Valley, about 27,000 acre-feet, less the quantity diverted for irrigation in Antelope Valley, 62,600 acre-feet, less the evaporation loss from Topaz Reservoir, 10,000 acre-feet—or about 180,000 acre-feet.

Water for irrigating lands in Smith Valley is diverted from the West

Walker River at several points near the lower end of Hoye Canyon and at several points less than a mile beyond the canyon mouth.

Colony Canal, skirting the west side of the valley (pl. 2), is the main source of supply of West Walker River water to lands north of the river. It is used to irrigate about 3,000 acres 5 to 8 miles north of Hoye Canyon. As indicated in the historical sketch of the valley, construction of this ditch may have begun prior to 1881.

The Saroni Canal, in Local Improvement District No. 4, is another important ditch. The Improvement District was organized on September 5, 1925, partly to consolidate many of the older ditches then supplying water to about 3,800 acres of land. Because the point of diversion of Saroni Canal is at a higher elevation than the diversion points of other ditches in the valley, it is possible to irrigate the higher lands in the southeastern part of the valley. The canal is about 8 miles long, and any excess water is wasted into a dry wash about 7 miles northeast of Hoye Canyon. The canal has a capacity of 105 cfs but normally carries only 60 to 70 cfs during the irrigation season. During the nonirrigation season it carries only a few cubic feet per second, sufficient for stock watering.

Other ditches are the Plymouth Canal, supplying water for some 2,000 acres; the West Walker Ditch, supplying water for about 1,000 acres; the Gage Peterson Ditch, supplying water for about 1,200 acres; and the Fulstone, Burbank, and Rivers Simpson ditches, each supplying water for several hundred to a thousand acres of land. Lands irrigated from the Plymouth Canal and other ditches mentioned thereafter lie mainly in the southern and south-central parts of Smith Valley.

The range of annual diversions from the river in Smith Valley is rather wide. The amount diverted depends on the quantity of water available, as modified by prior rights outside of Smith Valley. Using available records, estimates were made of the amount diverted each year from 1941 to 1948, inclusive. The annual diversions ranged from about 50,000 acre-feet to about 100,000 acre-feet, the average annual diversion being about 66,000 acre-feet.

DESERT CREEK

Desert Creek lies in a north-trending drainage trough, averaging a little more than 3 miles in width and 15 miles in length, in the southwest corner of Smith Valley. It heads near Mount Patterson in the Sweetwater Mountains in Mono County, Calif., at an altitude slightly more than 11,000 feet above sea level. After flowing northward about 17 miles it emerges from a canyon onto the apex of a north-trending alluvial fan 7 or 8 miles long.

Ever since the valley was first settled in the 1860's, water has been diverted from Desert Creek for irrigation. Recently, Lobdel Lake (pl.1), an offstream reservoir only a few miles below the headwaters, was incorporated into the irrigation system. It has a reported capacity of 600 acre-feet.

Water is diverted to the Desert Creek Ranch near the apex of the fan and to the Ambro Rosaschi ranch (Mathar on pl. 1) about 4 miles farther down the fan. The decreed rights date from 1860 to 1885 and total 28 cfs. Mr. J. W. Simpson, owner of the Desert Creek Ranch, reported that a total of about 1,800 acres of land is irrigated during a year of normal runoff.

Mr. Rosaschi estimated that the discharge of the stream during peak flow in the spring had been as much as 150 cfs, but that the "normal" flow during the irrigation season was about 20 cfs. From 11 observations of head at the Simpson-Rosaschi diversion weir in the SW¼ sec. 8, T. 9 S., R. 24 E., about a quarter of a mile south of the headquarters of the Desert Creek Ranch, it is estimated that the flow in 1949 averaged only about 10 cfs. However, 1949 was a year of below-normal runoff and it is possible that in normal years the flow may be twice that of 1949.

The creek channel extends northward from the toe of the fan some 8 miles to the West Walker River. Only rarely, however, is there any flow past the Rosaschi ranch.

MINOR STREAMS

A few small ephemeral streams—those flowing only part of the year—flow in the larger canyons of the Pine Nut Mountains bordering the west side of the valley. The streams in Burbank Canyon and Red Canyon probably flow for longer periods than any others. Water from Red Canyon was diverted for irrigating small fields prior to 1881. On rare occasions the stream channels that enter the valley from the hills and mountains bordering the north and east sides of the valley carry water for short periods of time.

The upper part of the large area east of the Desert Creek drainage, known as Dalzell Canyon, contains a number of spring areas, some of which are linked together by small streams that flow during most of the year. It is reported that occasionally large flows of short duration have come down the canyon. Ordinarily, however, there is no surface flow into Smith Valley from Dalzell Canyon. The small streams connecting the spring areas disappear before emerging from the canyon.

GROUND WATER

GENERAL CONDITIONS

Ground water, both confined and unconfined, occurs in the interbedded clay, silt, sand, and gravel composing the valley fill. There are indications that water may, at least locally, occur also in fractured rocks underlying the valley fill.

Both the unconfined and the confined water in the fill have common sources, the principal ones being excess irrigation water and leakage from ditches or canals. Although water originally enters the aquifers under unconfined or water-table conditions, it generally becomes confined before reaching a point of discharge, owing to the prevailing northward dip of the confining layers. This report is concerned mainly with confined, or artesian, water which constitutes the most important type of ground water in the valley.

Unconfined water is found at rather shallow depths in the irrigated areas and in and near the alkali flat at the north end of the valley. The unconfined aquifers are generally less than 100 feet below the land surface and in most places less than 50 feet.

Confined, or artesian, water seems to be present in most parts of the valley except perhaps at the extreme southern part of the Desert Creek fan.

Springs and seeps are found for the most part in the western half of the valley. A few small springs also arise in the bordering hills and mountains. Thermal springs—that is, springs whose water temperature is appreciably higher than the mean annual temperature of the atmosphere—are limited to a narrow belt along the toe of the Pine Nut Mountains.

ARTESIAN WATER

ARTESIAN RESERVOIR

For the most part the artesian reservoir of Smith Valley is composed of several sand and gravel strata interbedded with clay and silt. Some of the water-bearing strata may be relatively widespread but available well logs indicate that large variations in the character and permeability of the material occur within relatively short distances. The artesian reservoir underlies not only the area of artesian flow but also the bordering area where the water is under artesian pressure but the head is insufficient to cause wells to flow at the land surface.

AREA OF ARTESIAN FLOW

The two areas of artesian flow are shown on plate 2. The limits of the areas were not defined at all points but were inferred, in part, from the altitude of water levels in nearby wells and from the topography.

The larger area of artesian flow, about 31 square miles, lies mainly in the northern part of the valley, much of which is still unexplored by wells. It includes the alkali flat and a bordering area which is ½ to 1½ miles wide, the width depending to a large degree on the topography. From the alkali flat the area of flow extends southward in the west half of the valley to within half a mile of the West Walker River. Within this area there may be a few small hills and knolls where wells would not flow. Its width has been reduced from about 3 miles to a quarter of a mile or less by the encroachment of the alluvial fan opposite the mouths of Burkank and Red Canyons. Thus, in T. 11 N., R. 23 E., opposite the fan, the area of flow includes only Beaman Lakes and the low-lying land extending a mile northward; the total area of the narrow projection is only about 0.8 square mile (pl. 2).

According to local residents the area of artesian flow north of the river has been quite stable during recent years. However, from 1933 to 1938 the artesian heads in wells on the north side of the alkali flat, and consequently the area of artesian flow, were reduced considerably because of large withdrawals from well 13/23–25CB1, known as the Ambassador well. According to the testimony of Mr. E. W. Mollart during a hearing held by the State Engineer's office in 1938 regarding the granting of a water right to the Ambassador Gold Mining Co. for its well, the following events took place between 1933 and 1938: A hole 2 feet in diameter and about 540 feet deep was drilled by the Ambassador Gold Mining Co. in 1933. A 12-inch casing was installed and the annular space between the casing and drill hole was filled with loose gravel. The casing was perforated from 150 to 540 feet below the land surface. Prior to the time large withdrawals were pumped from this well, beginning in 1933, Mr. Mollart was able to irrigate more than 60 acres of alfalfa and 150 acres of pasture land from flowing wells in the S½ sec. 26, T. 13 N., R. 23 E. When the Ambassador well was being pumped he was able to irrigate very little land because the flows from his wells were greatly diminished.

The combined flow from the group of wells owned by Mr. Mollart in the SW¼SE¼ sec. 26, T. 13 N., R. 23 E., measured in 1933 by means of a weir, was as follows:

	Flow (gpm)
Aug. 6	111. 94
13	74. 27
27	52. 3
Oct. 21	0

The discharge for 1933 of Mr. Mollart's well in the SW¼SW¼ sec. 26, T. 13 N., R. 23 E., was similarly measured:

	Flow (gpm)
July 22	74. 95
Aug. 6	69. 2
13	47. 78
27	43. 53

The flows of other wells farther west also were reduced but by a smaller amount. When pumping from the Ambassador well for mining purposes was discontinued in January 1938, the flow of Mr. Mollart's wells increased sufficiently to irrigate 20 to 25 acres.

The flow from the Ambassador well, measured by the senior author on September 20, 1948, was 405 gpm. The water flowing from this well was being used for irrigation and had been flowing for several months, so the measured discharge probably represents approximately an average rate of discharge. It is believed that the discharge from this well exceeds the combined discharge of all other wells in the northern part of the valley. It is understandable, therefore, why the well had such a marked influence on the other artesian wells in the vicinity.

Failure of the artesian pressure to recover to its pre-1933 level after the Ambassador well was shut off probably is due to the method of construction of the well.

According to Mr. Mollart's testimony, it appears there is no seal of impervious material to prevent discharge from artesian strata with high heads into artesian strata with lower heads, or even into non-artesian strata. Thus, even when the valve on the discharge pipe is closed, underground discharge still occurs. Springs that arise in the vicinity of the well when the discharge valve is closed for some time are evidence of such underground leakage.

During the past year or two considerable water from this well has been used for irrigation. The increased utilization by allowing the well to flow freely for irrigation use undoubtedly reduces the amount of nonbeneficial underground leakage. However, the increased withdrawals will tend to lower somewhat further the artesian head in this part of the valley and thus reduce the area of artesian flow.

The area of artesian flow south of the West Walker River, about 11.5 square miles, evidently increased during the period from about 1920 to 1948. This conclusion is based on reports by local residents of changes in water levels during that time. Mr. A. A. Chisholm reported that the water level in well 11/24–27CB1 was about 90 feet below the land surface when the well was completed in 1919. In digging the well he encountered a hard layer of "slick" rock about 8 inches thick at a depth of 110 feet, beneath which was a sand from which water rose about 20 feet. In 1932, at the time of a rather severe earthquake, the water level was about 85 feet below the land surface, and in 1946 it was 35 feet below the land surface. On March 2, 1948, when measured by the senior author, the water level was only 27 feet below the land surface. Mr. Chisholm reported that well 11/24–29AB1, owned by Bruno Fenili, was drilled in 1919 and that the water level originally was 30 or 40 feet below the land surface.

When Mr. Fenili was interviewed on March 3, 1948, he reported that the well was equipped with a hand pump until 1936 and that about 1934 the well began to flow. On March 3, 1948, the well was flowing about 15 gpm from a pipe extending 5 feet above the land surface. Mr. Fenili stated that the water level would rise to a height of about 15 feet above the land surface if the flow were stopped.

Mr. A. Nutti reported that the water level in his domestic well, 11/24–32CA1, was 27 feet below the land surface in 1937. When measured during the present investigation in January 1948 the water level was at the land surface.

Mr. E. J. Alpers reported, in 1948, that "20 years ago" the water level in his well, 11/24–34BB1, was 80 feet below the land surface. When measured by the senior author on May 27, 1948, the water was 50.3 feet below land surface.

Many other residents reported rises of water level in their wells during the past 20 years, although the amount of rise generally was considerably less than the above examples might indicate. Mr. Charles Grosso reported that his well, 11/23–25CC1, drilled in 1917, originally flowed only half a gallon per minute. On October 20, 1948, the well was flowing at the rate of 6.6 gpm from a half-inch opening 1.5 feet above the land surface. The artesian head was 4.1 feet above the land surface. This indicates an increase of head of about 2½ feet and an increase of discharge of about 6 gpm.

As is to be expected, it appears that the water levels rose most near the points of recharge and least near the points of discharge. The rise was undoubtedly brought about by the greatly increased application of irrigation water to lands overlying the intake area of the artesian strata in the southeastern part of the valley after upstream storage at Topaz Reservoir became available in 1922.

The area of artesian flow thus has increased, principally to the southeast. Whether the area will continue to increase depends to a large extent upon recent and future developments for the withdrawal of ground water from artesian strata.

Until the ground-water reservoir is filled to the level at which additional recharge is rejected, the areas in which wells will flow will continue to increase if recharge exceeds discharge. The area of flowing wells will tend to remain constant only when the total discharge from the artesian aquifers equals the total recharge.

If the area of flowing wells in Smith Valley is to be maintained within its present limits it appears that the average annual discharge must be increased slightly. This could be effected by increasing the withdrawal from wells until total discharge equaled total recharge. If the increase in discharge were sufficient to cause the total discharge to exceed slightly the present annual recharge, artesian pressure would drop below present-day pressures. This in turn would reduce the discharge from some wells and also reduce the natural discharge, all of which would tend to again balance recharge and discharge.

PIEZOMETRIC SURFACE

The piezometric surface of an artesian aquifer may be considered an imaginary surface that everywhere coincides with the static level of water in the aquifer. Its position may be inferred by determining the static level of water in representative wells and then interpolating the differences in static level between wells. The shape and position of this surface is usually indicated by isopiestic lines—imaginary lines of equal altitude on the piezometric surface—plotted on a map of the area. The altitude of the lines is ordinarily expressed in feet above some datum, usually sea level. Points or areas of discharge are marked by depressions in the piezometric surface, whereas points or areas of recharge are marked by highs. The water moves at right angles to the isopiestic lines, the direction being toward the line of lower altitude.

Imperfectly connected artesian aquifers may have different heads at the same location, the deeper aquifers usually having higher heads. Such differences in head were observed in Smith Valley, but it was not practical to determine precisely the position of the piezometric surfaces of the several artesian aquifers. Accordingly, a map was prepared showing approximate isopiestic lines. (See pl. 2.) The position of the lines was determined by interpolating the differences in static water levels in representative artesian wells or, where data regarding the static water level were not available, by estimating the probable effects of recharge and discharge on the position of the piezometric surface.

The altitude of the land surface at most wells was not determined precisely. Many of the altitudes were determined by means of an altimeter. In order to reduce the error inherent in this method, several readings at each location were referred to the nearest undisturbed benchmark. Other altitudes were determined by hand leveling or were estimated from nearby benchmarks established by the Soil Conservation Service as a part of its farm-planning program. Where substantial anomalies in the piezometric surface were noted spirit levels were run to determine the altitude of the land surface within a few tenths of a foot.

Although the piezometric surface as shown on plate 2 may differ by several feet from the actual piezometric surface in some areas, the shape and position of the piezometric surface as shown are essentially correct.

South of the West Walker River the piezometric surface slopes toward the river at the rate of about 20 feet per mile. This shows a northwestward movement of artesian water, which must be maintained by recharge in the southeastern part of the valley. Much of this recharge probably results from percolation of water from canals and irrigated lands in that part of the valley. As the artesian water moves northwestward, part of it is discharged by wells, and part by upward percolation and natural discharge from seeps and springs.

A pronounced trough in the piezometric surface whose axis roughly coincides with the course of the West Walker River shows that artesian water is being discharged in the vicinity of the river. It is highly probable, therefore, that many of the springs and seeps along the river are discharging water from the artesian reservoir.

The bulge in the piezometric surface beneath the alluvial fan of the Red and Burbank Canyons (see pl. 2) probably represents recharge from the streams heading in those canyons. The abrupt change in both direction and gradient of the piezometric surface north of the fan probably results from the combination of an increase of natural discharge and a decrease in permeability of the sediments. Conditions are favorable for an increase of natural discharge because the slope of the land steepens northward in this area. This is also the area where most of the natural discharge—principally upward percolation of artesian water to the land surface or to a point where it is available for use by native grasses and phreatophytes—was observed.

It is believed that the piezometric surface in the region of the alkali flat resembles the shape of a saucer whose center coincides approximately with the center of the flat. In view of the conditions believed to exist in this part of the valley, the saucer shape probably is due to relatively great natural discharge near the margins of the playa and little or no discharge beneath the playa, and to some minor recharge from the hills bordering the north side of the valley. Natural discharge occurs principally through transpiration by phreatophytes, the dominant type at the higher elevations being greasewood (*Sarcobatus vermiculatus*). This plant habitually obtains its water supply from the water table and in other areas has been observed to send its roots as deep as 50 feet to obtain water. At lower altitudes, nearer the edge of the flat, rabbitbrush (*Chrysothamnus graveolens*) and, locally, saltgrass (*Distichlis spicata*) are the dominant types.

SOURCE OF RECHARGE

Recharge of the artesian aquifers is effected by downward percolation of (1) direct precipitation, (2) stream or flood runoff where it has an opportunity to enter the unconfined aquifers, and (3) irrigation water either directly from canals or ditches or after application to the land.

Recharge directly from precipitation is believed to be the least important source of recharge. However, it probably takes place all around the valley over some portion of the alluvial apron lying between the valley floor and the alluvium-bedrock contact.

Downward percolation of stream or flood runoff is believed to be a significant source of recharge. Considerable recharge by this means undoubtedly takes place on Desert Creek fan. Desert Creek is a perennial stream where it debouches onto its alluvial fan at the south end of Smith Valley, and approximately half its normal flow must cross more than 4 miles of this alluvial fan before reaching diversion points on the Rosachi ranch.

Ordinarily under these conditions the opportunity for recharge by infiltration is very favorable. In order to ascertain the magnitude of seepage losses across the fan under conditions estimated to be approximately normal, the flow in the stream channel was measured on April 22, 1949, at two points about 3.7 miles apart.

At a stream section in the SW¼NW¼ sec. 8, T. 9 N., R. 24 E., the flow was 8.80 cfs. At a section in the SE¼SE¼ sec. 20, T. 10 N., R. 24 E., 3.7 miles downstream, the discharge was measured as 6.23 cfs. The stage of the stream was essentially constant for at least an hour before and after the time of measurement. Inasmuch as the stream was generally confined to a gravelly channel only a few feet wide, there was little opportunity for loss by transpiration. Evaporation loss, likewise, was negligible owing to the low temperature of the water and atmosphere. It is believed, therefore, that most of the difference between the measured discharges, 2.57 cfs, can be attributed to seepage loss. Neglecting transpiration and evaporation, the rate of infiltration is thus 0.7 cfs per mile. This rate of infiltration, of course, will vary considerably. Ordinarily infiltration rates will change as the wetted perimeter of the channel changes. They will also change with changes in water temperature and with the condition of the land surface or channel over which the stream flows. Infiltration rates increase with increases in water temperature and decrease during periods of deposition of silt by the stream. However, if the average rate of infiltration were 0.7 cfs per mile, the quantity infiltrated from the section of the stream channel described would be about 1,350 acre-feet for the year, assuming that the ground and streamway remained unfrozen for 8 months, and using an estimated channel length of 4 miles.

Recharge by infiltration of streamflow and occasionally of flood water takes place on other fans also. Undoubtedly considerable recharge by infiltration of flood water from occasional local storms occurs on the fan below Dalzell Canyon. On the west side of the valley most of the recharge probably occurs just below the apexes of the fans at the mouths of Burbank and Red Canyons. Mr. John Neill, a rancher living downstream from Burbank Canyon, estimated the flow of perennial springs in the canyon to be 0.2 cfs, or about 90 gpm. The discharge of the springs sustains the flow of the small stream in the canyon for a short distance below the springs, but the stream soon disappears into the alluvium underlying its bed. For example, on December 30, 1949, the stream was flowing about 100 gpm at a point about half a mile upstream from the mouth of the canyon. The flow 300 yards downstream from the above-mentioned point was estimated at 30 gpm, and 50 yards still farther downstream the flow had disappeared entirely.

Occasionally, considerable recharge may occur by infiltration of water from flash floods coming down the normally dry channels at the northeast and northwest corners of the valley.

Irrigation water applied to lands in excess of soil-moisture requirements in areas where the excess water can percolate downward to artesian aquifers is believed to constitute the greater part of the annual recharge to the artesian aquifers.

The most favorable areas for recharge are the irrigated lands in the southeastern part of the valley. Although the limits of the recharge area have not been definitely ascertained, it is believed that the inner boundary of the outcrop of the principal artesian strata lies valleyward only a mile or a fraction of a mile from the Saroni Canal. Significant recharge from excess irrigation water is believed to occur on the Desert Creek fan. There, according to Mr. Simpson, about 1,800 acres of land is irrigated in a year of normal runoff. Most of the excess water has an opportunity to reach the artesian aquifers.

The artesian aquifers probably receive but little recharge from irrigated lands on the west side of the valley. Although the piezometric surface indicates that recharge does occur (see pl. 2), the geology does not favor a large recharge on the west side, inasmuch as the valley-fill sediments are tilted westward.

Infiltration of water from canals and ditches is also significant. The areas favorable for such recharge are generally the same as those favorable for the infiltration of excess irrigation water. The Saroni Canal is believed to be the principal source of recharge of this type.

Evidence to substantiate reports of exceptionally high losses in the Saroni Canal due to infiltration is lacking. Mr. A. A. Chisholm, who has distributed water from the canal for several years, estimated that the total loss in 1948 probably did not exceed 4 cfs for a period of 100 days, or about 800 acre-feet annually. When the quantity diverted into the canal is increased materially there is a large temporary loss that is due largely to bank storage. Much of this loss is regained when the flow in the ditch is reduced. Nevertheless, considerable recharge occurs by infiltration of water from the canal.

In order to check on the magnitude of these infiltration losses the flow of the canal was measured at two points about 2 miles apart on May 13, 1949. The measured discharge at a section in the SE¼SW¼ sec. 2, T. 10 S., R. 23 E., or about a quarter of a mile south of the mercantile store at Wellington, was 47.1 cfs. About 2 miles farther downstream, at a section in the SE¼SE¼ sec. 12, T. 10 S., R. 23 E., or 200 feet upstream from the bridge on State Highway 22, the discharge was measured as 44.0 cfs. The reading of the staff gage at the upstream point of measurement was essentially constant, at least from an hour before the first measurement to an hour after the second measurement.

A number of small diversions, whose flow was estimated to total about one-half cubic foot per second, were noted in the reach between the points of measurement. The canal was reasonably free from vegetation, and evaporation losses were considered to be insignificant. Evidently a loss at the rate of 1¼ cfs per mile was occurring at the time of measurement. This measurement, of course, should not be considered representative of the rate of infiltration all along the canal at all times. The rate of infiltration will change with changes in flow, water temperature, depth of silt in the canal, and character of the valley-fill sediments crossed by the canal.

Such infiltration apparently is not confined to the upper end of the canal, for there is evidence that water in the canal infiltrates to artesian aquifers at points as much as 10 miles below the point where water is diverted from the West Walker River. For example, the water level of well 11/24–22D1, on which a continuous water-stage recorder had been maintained since May 10, 1948, showed a remarkable uniform rate of decline in 1948 and until December 1949 except for a 0.5-foot rise in June 1949. Until December 1949 water from the Saroni Canal had not been diverted for any extended period into the natural north-trending drainageway about 500 feet east of the well. However, water had been diverted from the Saroni Canal on several occasions to irrigate lands half a mile south of the well.

In December 1949 water was diverted into the drainageway as a means of reducing the flow of the West Walker River at a point 1½ miles north of Central while repairs were in progress on a county bridge there. After a day or two of continuous flow in the ditch east of the recorder well, the water level in the well began to rise rapidly. The water level continued to rise until 1 or 2 days after diversion into the ditch was temporarily interrupted. A second sharp rise followed a resumption of the diversion. After repairs to the bridge were completed water was diverted to the drainageway less frequently, and after a week or so during which no significant diversions were made the water level in the well stabilized and then resumed its decline.

In order to show better the changes of water level in this well, a hydrograph showing the depth to water, in feet below measuring point, at noon daily, was prepared. (See fig. 5.) The depths to water as shown have been adjusted from actual chart readings to compensate for changes of water level caused by changes in atmospheric pressure.

The desirability of making an adjustment to compensate for atmospheric-pressure changes is also shown in figure 5. Here is plotted a 15-day record of the water-level fluctuation as recorded by an automatic water-stage recorder, and the atmospheric pressure of water, in feet, as compiled from charts of a microbarograph stationed about a mile southwest of the well. A remarkably good correlation between changes of water level in the well and changes of atmospheric pressure will be noted. The net result is that after suitable adjustments have been made for changes in atmospheric pressure the hydrograph of well 11/24–22DC1 loses most of its apparently erratic fluctuations and plots as a smooth line.

The upper part of figure 5 shows that during 1948 the water level declined at a remarkably uniform rate of about 3.6 feet per year. In 1949 until December the rate of decline was a little more than 2 feet per year, the uniformity being broken substantially only by a small rise of about 0.2 foot during the first half of June. This rise may have resulted from seasonal recharge or from downward percolation of irrigation water. In any event, the effect was to maintain the water level a few tenths of a foot higher for most of the remainder of the year than it would have been if no recharge had occurred. Thus, the hydrograph shows that, beginning with the first measurement of water level, March 31, 1948, until about December 10, 1949, there was a persistent decline in water levels except for a slight rise in June 1949. Seasonal recharge was almost wholly lacking. However, about December 10, 1949, an abrupt reversal of this trend occurred and water levels rose 2 feet before the middle of January. This rise was followed by a slight decline until the last week in January, after which a second rise of about 2 feet took place within 3 weeks. Thus, a total rise of about 4 feet occurred within 10 weeks. The rather direct response of water level in the well to flow in the drainageway leaves little doubt that the aquifers tapped by the well were being recharged by water infiltrating from the drainageway.

In view of the evidence of infiltration both near the upper end and

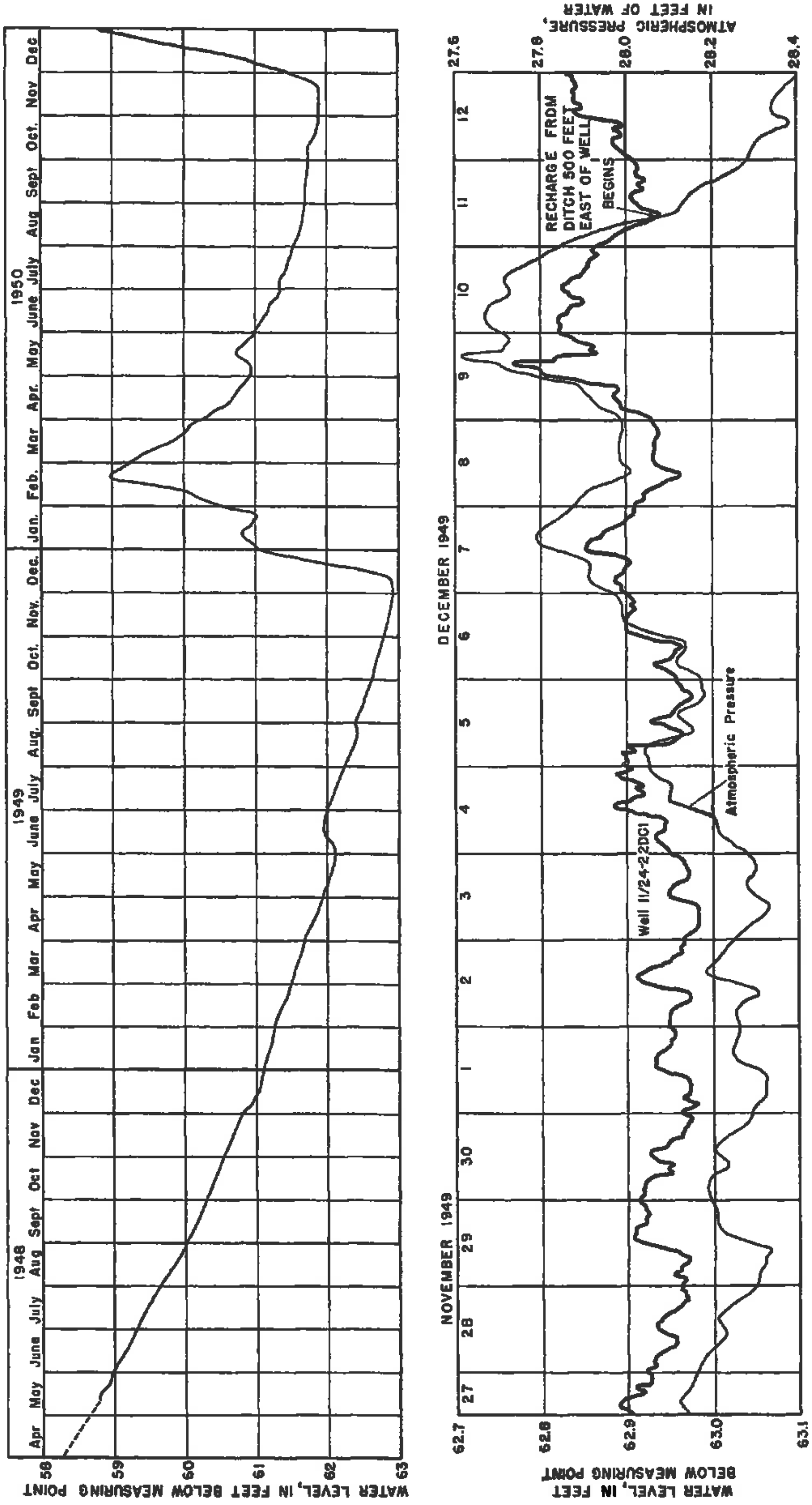

FIGURE 5.—Hydrograph of well 11/24–22DC1 and comparison with changes in atmospheric pressure.

at the lower end of the Saroni Canal, it seems reasonable to assume that this type of recharge may occur along other reaches of the canal, and along other canals where conditions are similar.

UTILIZATION AND NATURAL DISCHARGE

Where artesian water is easily obtained it is the principal source of domestic water supplies. It is also much used, especially in the area of flowing wells, to furnish a dependable supply for watering stock. Commonly wells are allowed to flow uncontrolled, any water in excess of stock requirements serving to support the growth of native grasses in the vicinity of the well.

Table 4 shows the estimated withdrawal of water from wells in 1950. The rate of withdrawal in gallons per minute is the equivalent rate of continuous withdrawal by the total number of wells to which the rate applies.

According to table 4, there are 111 flowing artesian wells in the valley having a total rate of flow equivalent to a continuous flow of 1,231 gpm or about 2,000 acre-feet per year. Perhaps a quarter of this discharge is used for domestic purposes, about a quarter for stock watering, about a sixth for fish rearing, and about a third for irrigation. In addition, according to table 4, there are about 43 nonflowing artesian wells equipped with pumps which withdraw water at a rate equivalent to a continuous withdrawal of 458 gpm or about 740 acre-feet annually. About three-quarters of the withdrawal from nonflowing artesian wells is for irrigation. The total withdrawal from artesian wells is estimated to be slightly less than 3,000 acre-feet annually.

As mentioned elsewhere in this report, considerable artesian water is discharged naturally. One way by which such discharge occurs is upward leakage along faults. For example, it is probable that the source of Hinds Hot Springs is artesian water escaping upward along a fault at the foot of the Pine Nut Mountains. Artesian water is discharged also by upward leakage through imperfectly confining beds. This type of discharge is believed to occur principally in the northern part of the valley around the alkali flat and is evidenced by seepage areas and small springs. Natural discharge also may occur where the confining beds have been dissected or eroded. This type of discharge is believed to occur along the West Walker River where the piezometric surface has a pronounced trough (see pl. 2). It is probable that dissection of the valley fill by the West Walker River to depths of 50 feet or more, and the accompanying erosion south of the river, resulted in removing or at least rendering less competent the shallower confining beds.

TABLE 4.—*Estimated rate of discharge from wells, Smith Valley, Lyon and Douglas Counties, Nev., 1950*

Well location			Artesian wells					Water-table wells		
Township north	Range east	Section	Flowing		Pumped		Unused	Pumped		Unused
			Number	Gpm	Number	Gpm	Number	Number	Gpm	Number
10	23	1						1	5	
		2			3	15		10	30	
		11			1	5		2	6	1
		12			1	3		3	15	
					5	23		16	56	1
10	24	3						1	1	
		4			1	70				
		5			3	8		2	2	
		7						1	2	
		9						1	2	
		20						1	3	1
					4	78		6	10	1
11	23	1						2	2	1
		2	3	2				3	7	
		3			4	40		3	6	
		10						1	3	
		11						2	7	1
		13	1	15						
		14								1
		15			2	4				1
		22						3	6	
		23						1	2	
		24	5	25			1			
		25	7	30				3	6	
		26	5	25						
		27	1	5				2	6	1
		35	1	32						
		36			3	9				
			23	134	9	53	1	20	45	5
11	24	2						1	1	
		7	2	28						
		9	1	1						
		17	6	50						
		18	10	264						
		19	12	65						
		20	4	12						
		21			2	4				
		22					2			
		27			3	9				
		28			1	3				
		29	1	5			1			
		30	4	20	1	3		2	4	1
		31						2	4	
		32			4	250				
		33			4	12	1			1
		34			2	4				1
			40	445	17	285	4	5	9	3
12	23	10	1	1						
		13	1	50			1			
		14	1	20						
		22	1	3	1	2	1			
		23	3	55						
		24	4	18				1	1	1
		25	1	2						1
		26	3	15						1
		27	2	10	2	6				
		28						1	3	
		34	2	10	3	9				
		35	2	16						
		36	3	9						2
			24	209	6	17	2	2	4	5

TABLE 4.—*Estimated rate of discharge from wells, Smith Valley, Lyon and Douglas Counties, Nev., 1950*—Continued

Well location			Artesian wells					Water-table wells		
			Flowing		Pumped		Unused	Pumped		Unused
Township north	Range east	Section	Number	Gpm	Number	Gpm	Number	Number	Gpm	Number
12	24	8	1	2						
		17	1	5						
		27			1	1				
		30								1
		31								1
			2	7	1	1				2
13	23	24	2	4			1			
		25	4	300						
		26	7	60						
		27	5	60			1			
		34	1	10						
			19	434			2			
13	24	16			1	1				
		19	2	1			2			
		30	1	1						
			3	2	1	1	2			
Total for valley			111	1,231	43	458	11	49	124	17

The magnitude of the discharge is difficult to ascertain. Measurement of pickup in the river in the area of discharge is a means of ascertaining the total quantity of unconfined and artesian water being discharged along the river if corrections are made for any surface-water inflows or diversions. Such corrections are smallest during the nonirrigation season, so, accordingly, a number of measurements of the flow of the river were made late in the fall of 1948 and in the spring of 1949. Table 5 shows the flow of the West Walker River as determined by means of a pigmy current meter at various points and times during the investigation. The points at which the measurements were made are shown on plate 2.

On November 10, 1948, the measured pickup between stations 1 and 2, a distance of about 3.8 miles by river, was 9.0 cfs; and between stations 2 and 3, a distance of about 3.5 miles, 10.6 cfs. Insofar as could be determined the pickup was essentially ground-water discharge. Two or three drainage ditches, each carrying a fraction of a second-foot of water, emptied into the river in these two stretches. No significant amount of water from canals or irrigation ditches was entering the river between stations 1 and 3. Therefore, the pickup of 19.5 cfs in 7.3 miles (an average of about 2.7 cfs per mile of river) is principally ground-water discharge.

TABLE 5.—*Flow of West Walker River at five places between Wellington and Hudson, Nev.*

Station, in down-stream order	Location	Date	Discharge (cfs)
1	SE¼NW¼ sec. 2, T. 10 N., R. 23 E., about 300 yards downstream from highway bridge.	Nov. 10, 1948	3.06
		Mar. 9, 1949	.40
2	SE¼NE¼ sec. 23, T. 11 N., R. 23 E.	Nov. 10, 1948	12.1
		Mar. 9, 1949	10.0
3	NE¼NE¼ sec. 18, T. 11 N., R. 24 E., ¼ mile upstream from county-road bridge 1½ miles north of Central.	Nov. 10, 1948	22.7
		Mar. 9, 1949	21.5
		Mar. 14, 1949	19.8
4	SE¼NE¼ sec. 9, T. 11 N., R. 24 E., about 1½ miles upstream from Hudson.	Apr. 4, 1949	46.5
5	SE¼SE¼ sec. 3, T. 11 N., R. 24 E., 500 feet downstream from bridge at Hudson.	Mar. 14, 1949	29.2
		Apr. 4, 1949	46.1

NOTE.—Numbered stations are shown on plate 2.

On March 9, 1949, a second series of measurements was made in order to ascertain if the pickup measured during the previous fall had been due in large part to return flow from lands irrigated 2 or 3 months previous to the date of the fall measurement. By March about 5 months had elapsed since any sizable acreage in the area had been irrigated; consequently, it was believed that any return flow from canals and ditches would be negligible. Referring again to table 5, it will be seen that the measured pickup between stations 1 and 2 on March 9, 1949, was 9.6 cfs and between stations 2 and 3, 11.5 cfs. The total pickup of 21.1 cfs in 7.3 miles, or at the rate of 2.9 cfs per mile, is somewhat larger but nevertheless closely approximates the average pickup of 2.7 cfs per mile measured during the previous fall.

To ascertain the pickup between stations 3 and 5, a distance of approximately 4½ miles by river or 3¼ miles by air line, measurements were made on March 14, 1949, at these points and at in-between points where surface water was entering the river. At station 3 the flow was 19.8 cfs and at station 5, 29.2 cfs. Inflows of 1.55 cfs from a drainage ditch in the NE¼NE¼ sec. 18, T. 11 N., R. 24 E.; 1.35 cfs from a drainage ditch in the NW¼NW¼ sec. 17, T. 11 N., R. 24 E.; 0.51 cfs from a ditch in the NE¼SW¼ sec. 9, T. 11 N., R. 24 E.; and 1.63 cfs from a ditch entering the river in the NE¼SE¼ sec. 9, T. 11 N., R. 24 E., were measured. The pickup resulting from ground-water discharge near the river was thus the increase in flow between stations 3 and 5 (9.4 cfs) less the sum of the measured inflows (5.0 cfs), or about 4.4 cfs.

To bracket the pickup more closely, measurements of streamflow were made at stations 4 and 5 on April 4, 1949. As shown in table 5, the measured difference in flow in this 1½-mile reach was only 0.4 cfs and represented a loss rather than a gain. As this is less than 1 percent of the total flow, or well within the limit of error even of high-grade stream measurements, one cannot be positive that the figure represents a small loss between these points. It does indicate, however, that most of the pickup measured between stations 3 and 5 occurs between stations 3 and 4. The topography near the river supports this conclusion. Between stations 3 and 4 the flood plain of the river is half a mile or more wide and supports a good growth of native grasses irrigated in part with water from drainage ditches but substantially by upward leakage of ground water. Between stations 4 and 5 the flood plain becomes relatively narrow and has only a narrow strip of native grasses.

Thus, as it passes through the valley, the West Walker River appears to have a pickup in flow of about 25 cfs that is attributable to ground-water discharge. More than three-fourths of this pickup occurs in the west half of the valley between points 1 and 3. As indicated on plate 2, the flood plain of the river is widest between these points, and spring and seepage areas are common. The water table is so near the land surface in many places that only saltgrass and native grasses can be grown successfully. The soil contains much alkali and extensive tracts have an alkali crust.

As stated previously, it is extremely difficult to determine how much of the pickup represents upward leakage from artesian strata and how much is seepage from shallow, unconfined aquifers. Undoubtedly a large portion represents excess irrigation water applied on the large cultivated areas south of the river, which percolates to the water table and then moves slowly riverward. However, a significant part must also be artesian water, as indicated by the piezometric surface shown on plate 2.

It will be noted that south of the river the piezometric surface has an average gradient of about 20 feet per mile northwestward toward the river. Immediately north of the river the gradient is southeastward and eastward and much less, perhaps more nearly 10 feet per mile. A definite trough thus exists in the piezometric surface that more or less coincides with the course of the river. This trough is unmistakable evidence that artesian water is being discharged along the river in significant amounts.

A general idea of the magnitude of this discharge may be obtained from the fact that an incomplete pumping test of well 11/24–32DC1 indicated a transmissibility of about 50,000 gpd per foot.[3] A similar test of well 10/24–4CD1 indicated a transmissibility of about 20,000 gpd per foot. From observations made of the performance of other wells during the investigation it is believed that the average transmissibility does not exceed 50,000 gpd per foot. Then, measuring

[3] Gallons per day flowing across a section of the aquifer 1 mile wide for each foot per mile of hydraulic gradient.

the length of the contours on the piezometric surface in the area where most of the movement is toward the river, it is found that the section is about 5 miles long. Plate 2 shows the gradient at right angles to this section to be 20 feet per mile or more riverward. Multiplying a transmissibility of 50,000 by the length of section by the gradient gives 5,000,000 gpd (about 7.7 cfs) as the quantity of artesian water moving northwestward toward the river. On the basis of information in table 4, it is estimated that withdrawals from artesian wells south of the river average about 920 gpm or slightly more than 2 cfs. The shape of the piezometric surface indicates that only a small part of the artesian water moves northward beyond the river. Thus, in round figures, it appears that 5.7 cfs, or about 4,000 acre-feet annually, is approximately the natural discharge of artesian water in the vicinity of the river. This is somewhat less than a quarter of the estimated annual pickup in flow of the river. Even though the figure of 4,000 acre-feet is only an approximation, it suggests that natural discharge of artesian water is responsible for only a minor part of the total pickup.

UNCONFINED WATER

SOURCE OF RECHARGE

Recharge to the unconfined ground-water aquifers is effected in much the same manner and from the same general sources as recharge to the artesian aquifers. Recharge directly from precipitation and from stream or flood runoff is a minor part of the total recharge. Some recharge is also effected by seepage from canals and ditches. However, the recharge from that source probably is not large because many of the canals and ditches have been lined with impervious material in the reaches where large seepage losses formerly occurred. Then, too, there is a tendency for the beds of canals and ditches to become partly sealed with fine silt, clay, and organic material if left undisturbed for some time; this has probably happened to many of the older canals and ditches.

The principal source of recharge, then, is irrigation water in excess of soil-moisture requirements.

MOVEMENT

During the investigation it was determined that, in general, unconfined water south of the West Walker River is moving toward the river. North of the river is a ground-water divide. Although the position of the divide was not definitely ascertained, it appears to lie 1 or 2 miles north of and more or less parallel to the river. The water south of the divide moves toward the river but a substantial part is discharged from the group of small water-table lakes, known

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as the Beaman Lakes, in secs. 11 and 12, T. 11 N., R. 23 E. North of the divide the unconfined water moves toward the alkali flat at the north end of the valley.

UTILIZATION AND NATURAL DISCHARGE

Some shallow or unconfined water is utilized for domestic purposes but generally artesian water is utilized where it is available at depths not greatly exceeding 100 feet. Where flowing wells are not readily obtained, shallow or unconfined water is often used for watering stock. Only insignificant amounts are pumped for irrigation, usually for lawns or gardens. The total amount of unconfined water pumped for all uses is estimated to be equivalent to a continuous withdrawal of 124 gpm, or about 200 acre-feet annually. (See table 4.) Shallow or unconfined water intercepted by drainage ditches is utilized extensively for the irrigation of meadowland and saltgrass tracts south of the alkali flat.

South of the river, most of the unconfined or shallow water not intercepted by drainage ditches percolates toward the river. As it comes within reach of the root system of native vegetation, principally grasses, some of it is transpired. The remainder continues to move riverward until discharged by evaporation from the moist land surface, or through seeps or springs. Thus a substantial part of the water may be evaporated or transpired before reaching the river. The discharge of unconfined water into the river is estimated to be about 15,000 acre-feet annually. This estimate is based in part, on measurements of the invisible contribution to the pickup in flow of the river (see pp. 42–43), less an estimate of the portion of this pickup that comes from artesian strata. If the flow from drainage ditches were included, the discharge would be substantially more.

The Beaman Lakes collect much of the shallow or unconfined water that originates west of the lakes. The greater part either evaporates from the lake surface or drains to the river by a recently completed drainage ditch. A small quantity probably percolates downward and laterally and eventually reaches the river.

To accelerate the northward movement of unconfined water north of the ground-water divide, several drainage ditches have been constructed.

One of the drainage units, known as the Long unit, was begun prior to 1923. It was constructed to drain excess irrigation water from lands in secs. 25, 26, 35, and 36, T. 12 N., R. 23 E. E. W. King, assistant engineer of the Walker River Irrigation District, in 1923, reported (in a letter to J. A. Bemer, Chief Eng., Walker River Irrigation Dist., June 25, 1923) that a stratum of "hardpan" ranging in thickness from 1 to 5 feet was encountered along nearly the entire length of the canal (then completed only through secs. 35 and 36, T. 12 N., R. 23 E.). Numerous test holes bored to depths of 5 to 15 feet indicated that the hardpan was overlain and underlain by strata of water-bearing sand. According to King's report, test holes were bored at distances of 100 to 500 feet ahead and on each side of the canal as it was being dug and the height of ground water noted; in most cases it was within a few inches of the land surface. As the canal progressed, the water level in the test holes dropped very rapidly, and after completion of the canal the water table in no place was less than 4 feet below the land surface. The actual flow of ground water from this portion of the canal, when completed, was about 6 cfs.

Two other drainage systems, known as the Jensen and Connell units, were almost completed by 1923. They were designed to drain lands lying for the most part in secs. 21, 22, 23, 26, 27, and 28, T. 12 N., R. 23 E. In his letter to Bemer, King reported:

> These two units which are now nearly completed, have intercepted or headed off a large flow of ground water, a portion of which comes from waste water and a considerable portion which undoubtedly comes from the supply of water which sinks in Red and Burbank Canyons and later rises to the surface and has already done a great damage to over 2,000 acres of land, included in which is a large acreage owned by U. S. Connell and the Hunnewell Land and Cattle Co.
>
> A large portion of this land, a few years ago, was good alfalfa land but during the past few years, nothing but salt grass or marsh hay has grown on it.
>
> From the drainage work already completed, these lands are drying up very rapidly and it is fair to presume that within a year or two, they can all be made to successfully grow alfalfa again.

The above accounts indicate that the discharge of unconfined water in this part of the valley was considerable. Although the combined flow of the drainage ditches at the time of completion was considerably more than 6 cfs, this rate of discharge did not persist. As the water table was lowered the flow to the drains decreased. In 1948 and 1949 the largest flow observed in the lower reaches of any one of these drains was about 2 cfs. As stated previously, much of the water intercepted by these drains is used to irrigate meadows and saltgrass tracts south of the alkali flat. Only a small part reaches the alkali flat, where it evaporates.

SPRINGS

NONTHERMAL

Springs are found at favorable localities in the hills and mountains bordering Smith Valley. However, the flows are small and they are important hydrologically only in that they help sustain the flows of small streams or contribute to the recharge of the ground-water reservoir by augmenting the underflow of streams and normally dry canyons.

In the valley proper, spring and seepage areas generally are found in and along the margin of the flood plain of the West Walker River. Individual discharges ordinarily are less than 1 or 2 gpm but the combined discharges in a given area of discharge, such as a short section along the toe of a terrace, may be 100 gpm or more. In a few places the flows are ditched to a small reservoir or otherwise made available for irrigation, but ordinarily no development has been made and the springs flow to waste or supply the moisture requirement of small but luxuriant patches of native grasses.

THERMAL

By far the most important group of springs are the thermal springs along the toe of the Pine Nut Mountains in sec. 16, T. 12 N., R. 23 E., known as Hinds Hot Springs. They were named after J. C. Hinds, the first settler in the north end of the valley, who, recognizing their value for agricultural and resort purposes, utilized their flow as early as 1860. Today, the flow of several springs has been combined to obtain an adequate head for irrigating pasture land. On October 21, 1949, the flow of the several springs was 550 gpm. The flow was measured by means of a pigmy current meter in one irrigation ditch and a 3-inch Parshall flume in another. The highest water temperature observed was 143° F. at one of the larger spring orifices. On March 3, 1948, about 20 months prior to this measurement, a maximum temperature reading of 144° F. was observed.

Peale (1886, p. 199) gave the following data on these springs: "location, 10 miles north of Wellington, Lyon County; temperature, 40–140° F.; flow, 91,000 gallons per hour; remarks, resort." Owing to the fact that Peale's compilation, of necessity, included much reported data rather than data he personally collected, most of the large difference in discharge between the 1,500 gpm reported prior to 1886 and the measurement in 1948 probably can be attributed to an overestimation of the flow by local residents prior to 1886. It is also possible that the early report included the flow of all the springs in the vicinity, whereas the later measurement included only the main flow area. The combined flow of all the other smaller springs in the area may be as much as a few hundred gallons per minute.

The origin of the water coming from the springs is not known. Some of the main points of discharge are at an altitude of about 4,663 feet above sea level. Even with orifices at this altitude it is possible that the source of the flow is deep-seated artesian water in the valley fill rising along a fault. The possibility of thermal water issuing from an orifice at a higher altitude than the piezometric surface of the nonthermal water from which it may be derived is understandable because the average density of fresh water at ordinary pressure is 0.980

at 150° F., whereas it is 0.999 at 60° F., a decrease in density of almost 2 percent. Thus, a nonthermal water coming in contact with a formation sufficiently warm to raise its temperature to 150° F. at a depth 1,000 feet below the normal piezometric surface would be able, by following a conduit or otherwise percolating upward with essentially no cooling, to reach an altitude almost 20 feet higher than the normal piezometric surface. It is not known if the orifices of the hot springs are definitely above the normal piezometric surface, but the above example shows that, even if it were definitely established that they are, this in itself would not preclude the possibility of the water originating from artesian aquifers commonly tapped by wells in the valley.

A second possible source is precipitation in the Pine Nut Mountains. Immediately west of Hinds Hot Springs and just beyond the crest of the mountains is a relatively flat triangular area of about 5 square miles containing several depressions and small ephemeral lakes. The granitic rocks forming the mountains ordinarily would be expected to be unfavorable for deep percolation of water from these depressions and lakes. However, the proximity of this unique high catchment area to the equally unique springs may be more than coincidental.

The waters contain a very high percentage of sodium and are therefore unsatisfactory for irrigating all except the most salt-tolerant crops (see quality-of-water section). For many years the flow of the springs has been used to irrigate pasture land, consisting in large part of native grasses and saltgrass.

A few other thermal springs rise along the margin of the valley floor, beginning at a point about half a mile south of Hinds Hot Springs and extending northward to a point about due north of the alkali flat. Generally, the flow of each spring is less than 5 gpm and the temperature is a little less than 70° F.

In the NE¼ sec. 34, T. 13 N., R. 23 E., a group of springs have a combined flow estimated at 60 to 70 gpm. A reservoir encircles the springs and can be used to store the water, thus providing a considerably greater head of water for irrigating adjacent fields. The springs are not utilized intensively today. However, records in the office of the State Engineer and the now-dilapidated improvement structure at the site indicate that 20 acres or more of alfalfa and pasture land were irrigated by the springs in the 1930's. It is probable that the flow of these springs decreased during the years following the use of the Ambassador well in the NW¼SW¼ sec. 25, T. 13 N., R. 23 E., beginning in 1933, inasmuch as the flow of artesian wells bordering the north side of alkali flat were reduced greatly or stopped altogether. The temperature of the water inside a 2-foot-diameter section of culvert pipe, evidently placed over one of the better spring orifices, was only 63½° F. on May 26, 1950. Owing to the considerable length of time the water was inside the well casing before being discharged, and its susceptibility to temperature changes caused by changes in air temperature, it is possible that the water temperature would be several degrees higher were it possible to measure it nearer one of the larger orifices.

QUALITY OF WATER

GENERAL CHARACTER

Natural water varies greatly in the concentration and composition of dissolved constituents and correspondingly in its suitability for irrigation and other uses. Some of the constituents are beneficial to plants; others seem to have little or no effect on either plants or soils; and still others either impair plant growth or have a harmful effect on the soil, or both. The major constituents include the cations—calcium, magnesium, and sodium—and the anions—bicarbonate, sulfate, and chloride. Constituents usually present only in relatively low concentrations include potassium, carbonate, nitrate, silica, and boron. Other constituents in low concentration may be present but oftentimes are not determined.

SIGNIFICANCE OF DISSOLVED CONSTITUENTS

Silica.—Silica is a major constituent of all soils, but the small quantity found in irrigation water seems to have little effect on the physical or chemical properties of the soil. Usually natural water contains from 10 to 60 parts per million of silica.

Calcium.—Calcium is found in nearly all natural waters, soils, and plant tissue. It is essential to normal plant growth and is beneficial to the soil. A calcium soil is friable, easily worked, and does not "run together" or become impermeable when wet.

Magnesium.—The reaction of the magnesium ion with the soil is much like that of calcium. It is essential to plant nutrition and is an important constituent of the chlorophyll of green plants.

Sodium.—Sodium, like other cations, reacts with certain base-exchange materials in clay soils, resulting in a change in both the physical and chemical characteristics of the soil.

When sodium is the predominant cation certain unfavorable conditions develop. When wet, the soil deflocculates or "runs together" and becomes sticky and impermeable. Upon drying, the soil becomes hard and large cracks appear. So called "slick spots" may appear in irrigated fields and black alkali—sodium carbonate—may also be formed.

For these reasons the concentration of sodium in a water is one of the three most important criteria for judging the suitability of a water for irrigation. Inasmuch as the adverse effect on the soil is related more closely to the ratio of sodium to the total cations than to the absolute concentration of sodium, the sodium concentration is expressed as percent sodium. To do this it is necessary to express the cations in equivalents per million, which for practical purposes is accomplished by dividing the concentration of calcium, magnesium, and sodium, expressed in parts per million, by their combining weights, 20, 12.2, and 23, respectively. The percent sodium is then 100 times the ratio obtained by dividing sodium by the sum of calcium, magnesium, and sodium, all expressed in equivalents per million.

Potassium.—Potassium in most natural waters is found in concentrations of less than 10 parts per million. Because of the low concentration it is usually not determined separately but is included (expressed as sodium) with the reported concentration of sodium. Its reaction with the soil is similar to that of sodium, although not quite so harmful. It is essential to the growth of plants, being one of three major plant-food elements.

Carbonate.—Alkali carbonates, such as sodium and potassium, are often present in mineral springs but only as traces in natural water. These carbonates are soluble in water, whereas the carbonates of calcium and magnesium are relatively insoluble in water. If a soluble alkali carbonate in irrigation water is applied to a soil that does not contain an excess of soluble calcium salts such as gypsum, the soil structure will be impaired, taking on the characteristics described in the paragraph on sodium. Sodium carbonate is undesirable in an irrigation water for this reason, as it forms "black alkali" and it is extremely toxic to plants.

Bicarbonate.—Calcium bicarbonate is contained in most irrigation water. It is a desirable constituent in that it ultimately forms calcium carbonate when carbon dioxide is liberated by a rise in temperature or upon evaporation. Calcium carbonate probably affects plant nutrition very little but it is of vital importance in maintaining desirable soil characteristics.

Sulfate.—Sodium and magnesium sulfates are readily soluble whereas calcium sulfate (gypsum) is relatively insoluble. Sulfate has no characteristic action on the soil, other than to increase the salinity. Sulfur is essential to plant nutrition and is readily available to plants in the form of sulfate.

Chloride.—The common chloride salts are all soluble. Plants seem to develop normally in solutions containing only traces of chloride, but are injured and even killed when subjected to high concentrations. Low concentrations of chloride are therefore desirable in irrigation water. There is no practical method for removing chloride from irrigation water.

Fluoride.—In the low concentrations found in most water fluoride has no noticeable effect on either plants or soils. It is important in human nutrition, however, as a small quantity—about 1.0 part per million—is beneficial in preventing decay of teeth. If the concentration is greater than about 1.5 parts per million, use of such water by children during the formative period of their permanent teeth results in a dental disorder known as mottled enamel. Teeth injured by fluoride erupt, exposing a dull chalky surface which later may be stained brown. The higher the fluoride content of the water the greater is the probability for mottled enamel. There is no evidence that normally formed teeth are endangered by drinking water having fluoride concentrations in excess of 1.5 parts per million.

Nitrate.—Nitrate is one of the three major elements in plant nutrition. It promotes succulant growth of forage crops adequately supplied with water. In the concentrations found in most water it has little effect on the soil structure. When nitrate in excess of a few parts per million occurs in shallow wells it may be an indication of past or present pollution, as one source of nitrate is the complete oxidation of nitrogeneous organic matter. Nitrate may also be leached from rocks, including some caliche deposits. If nitrate fertilizer is used some of the nitrate may be leached from the soil and taken into solution by the ground water.

Boron.—Boron is a constituent of almost all irrigation water, although the concentration is small, generally ranging from a trace to several parts per million. In the concentrations generally found in irrigation water boron has no noticeable effect on the soil. Some boron is essential to plant growth, but concentrations slightly above optimum can be exceedingly toxic.

Accordingly, it is necessary to consider the concentration of boron when classifying waters for irrigation. Scofield (1935) proposed the following limits for boron:

TABLE 6.—*Permissible limits for boron of several classes of irrigation water*

Classes of water		Sensitive crops (ppm)	Semitolerant crops (ppm)	Tolerant crops (ppm)
Rating	Grade			
1	Excellent	<0.33	<0.67	<1.00
2	Good	0.33 to 0.67	0.67 to 1.33	1.00 to 2.00
3	Permissible	0.67 to 1.00	1.33 to 2.00	2.00 to 3.00
4	Doubtful	1.00 to 1.25	2.00 to 2.50	3.00 to 3.75
5	Unsuitable	>1.25	>2.50	>3.75

In determining the suitability of a water for irrigation the kind of crop to be irrigated must also be considered. Eaton (1935) has grouped crops according to their tolerance to boron. Some of the crops for which relative tolerances of boron have been listed are shown in the following table.

TABLE 7.—*Relative tolerances of crop plants to boron*

[In each group the plants first named are considered to be more sensitive than those that follow]

Sensitive	Semitolerant	Tolerant
Apricot	Lima bean	Carrot
Peach	Sweet potato	Lettuce
Cherry	Bell pepper	Cabbage
Grape	Tomato	Turnip
Apple	Pumpkin	Onion
Pear	Oat	Broad bean
Plum	Milo	Alfalfa
Navy bean	Corn	Garden beet
	Wheat	Sugar beet
	Barley	Asparagus
	Field pea	
	Radish	
	Potato	

Reference to tables 6 and 7 will show that a concentration of 1 ppm (part per million) of boron may put a water in the "doubtful" class if used to irrigate crops extremely sensitive to boron, whereas the same concentration would permit the water to be classified as "excellent" if used to irrigate plants or crops tolerant to boron.

EXPRESSION OF TOTAL MINERAL CONCENTRATION

The total concentration of the mineral constituents is indicated by one or more of the following values: electrical conductivity, dissolved solids, or total cations or anions.

Electrical conductivity.—The fact that a large proportion of the inorganic salts in natural water are ionized and thus permit passage of an electric current, has led to the practice of measuring the electrical conductivity of a solution as an indication of the concentration of the constituents. The standard unit of conductivity is the mho/cm (reciprocal ohms per centimeter). However, this unit is so large that for convenience of reporting it was deemed desirable to express conductivity in micromhos/cm, thus giving most natural water electrical conductivities in units of hundreds or thousands. Electrical conductivity is ordinarily reported as micromhos at 25° C. or $EC \times 10^6$ at 25° C., both of which have the same numerical value.

Dissolved solids.—The concentration of dissolved solids is obtained by evaporating to dryness a definite quantity of the filtered water and

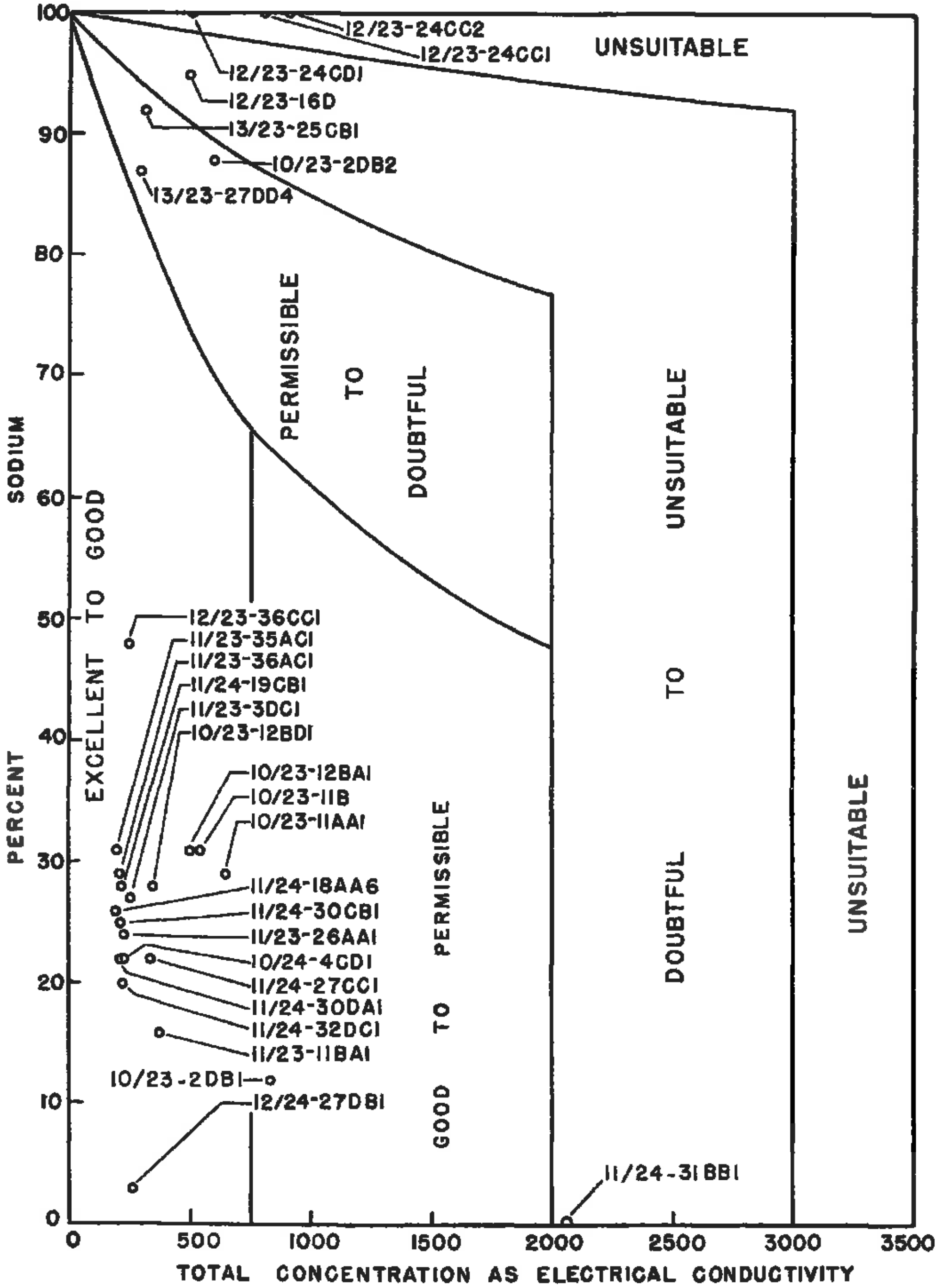

FIGURE 6.—Diagram for use in interpreting the chemical analysis of an irrigation water.

weighing the residue. The weight of the residue is then converted to parts per million. A crude relationship between dissolved solids and electrical conductivity has been noted; multiplying the EC $\times 10^6$ at 25° C. by 0.7 gives an indication of the approximate content of dissolved solids in parts per million for most natural water.

Total cations or anions.—The total cations in a solution equal the total anions if both are expressed as equivalents per million. While this relationship is used mostly to check the accuracy of an analysis, it also has been found that a reasonably consistent relationship exists between total cations or anions and the concentration of dissolved constituents. Thus, for approximate values, it can be assumed that EC $\times 10^6$ at 25° C. divided by 100 equals the sum of the cations or anions, expressed as equivalents per million.

CLASSIFICATION OF WATER FOR IRRIGATION

The suitability of a water for irrigation can usually be determined if the following characteristics are known: the total concentration, the percent sodium, and the concentration of boron. The total concentration can be expressed in any of the three ways outlined in the discussion of determination of total concentration of constituents (pp. 53–55). Percent sodium is defined under Sodium (p. 50). Limits for boron are set forth in table 6 (p. 52).

Wilcox (1948) has proposed the use of a diagram for classifying irrigation water on the basis of total concentration and percentage of sodium. This diagram is shown in figure 6. On the left margin of the diagram are shown values for percent sodium, and at the lower margin are plotted values for electrical conductivity (EC $\times 10^6$ at 25° C.) ranging from 0 to 3,500. Five classifications of water, ranging from excellent to unsuitable, are delimited. To use the diagram, move vertically up the left-hand margin to a point corresponding to percent sodium, and then move horizontally to the right a distance equal to the electrical conductivity. This point indicates the classification of the irrigation water.

It should be remembered that the limits for the various classifications are empirical and that other investigators of the percent sodium-total concentration relationship have advocated limits differing somewhat from those given in figure 6. Then, too, other factors such as soil texture, type of soil, and drainage may change the limits considerably. The diagram sets limits for water applied to crops having a moderate tolerance for dissolved salts, growing under average conditions of soil texture and drainage.

CLASSIFICATION AND INTERPRETATION OF ANALYSES OF GROUND WATER

In June 1950, water from 17 selected wells and 1 spring was collected and analyzed to determine the suitability for irrigation. The results of these analyses, plus 9 other analyses made by the Department of Food and Drugs, University of Nevada, previous to that date, are listed in table 8. The analyses show only the dissolved mineral content of the water and are not an indication of the sanitary condition of the water.

TABLE 8.—*Chemical analyses, in parts per million, and classification of waters in Smith Valley, Lyon and Douglas Counties, Nev.*

A.—Analyses by University of Nevada, Agricultural Experiment Station, Department of Food and Drugs, Public Service Division; B.—Analyses by Geological Survey, U. S. Department of the Interior.

Classification for irrigation: E, excellent; G, good; P, permissible; D, doubtful; U, unsatisfactory.

Well or spring number and location	Depth (feet)	Temperature (° F.)	Date collected	Specific conductance (micromhos at 25° C.)	Dissolved solids	Constituents: Silica (SiO_2)	Iron and aluminum (Fe and Al)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na and K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness as $CaCO_3$: Total	Noncarbonate	Percent sodium	Analyst	Classification for irrigation
10/23-2DB1	65	Warm	3-19-37		579	55	Tr.	108	28	38	0	293	175	32				385		[1]12	A	G
10/23-2DB2	200	117	6-15-50	581		62				115	22	41	157	28	3.5	0.4	1.0	33	0	88	B	U
10/23-11AA1	163	Warm	2- 2-42		450	63	Tr.	61	17	65	0	281	109	13				222		[1]29	A	G
10/23-11B			11- -46		376	18	3	51	11	56	0	256	51	22				218		[1]31	A	G
10/23-12BA1	82	Warm	7- -35		350	49	Tr.	33	10	36	0		41	29				124		[1]31	A	G
10/23-12BD1	122	Cold	6-15-50	342		62				24	0	198	11	5	.4	1.3	.12	131	0	28	B	G
10/24-4CD1	250	57	6-15-50	222		57				12	0	115	13	4	.2	3.4	.00	91	0	22	B	G
11/23-3DC1	275	60	6-13-50	254		22				17	0	135	19	3	.4	.5	.00	99	0	27	B	G
11/23-11BA1	70		6-15-50	375		29				15	0	207	15	8	.2	6.8	.08	170	0	16	B	G
11/23-26AA1	126	54	6-15-50	223		64				13	0	134	8.8	2	.2	.4	.00	94	0	24	B	G
11/23-35AC1	127	58	6-15-50	199		55				15	0	112	10	1	.4	.2	.00	72	0	31	B	G
11/23-36AC1	423		6-15-50	202		60				15	0	116	10	2	.2	1.1	.00	78	0	29	B	G
11/24-18AA6	219	58	6-13-50	197		67				13	0	112	11	1	.2	.7	.00	78	0	26	B	G
11/24-19CB1	150	57	6-15-50	201		65				14	0	116	11	1	.2	.5	.00	79	0	28	B	G
11/24-27CC1	123		6-13-50	337		67				16	0	107	28	24	.2	11	.02	125	38	22	B	G
11/24-30CB1	170	60	6-15-50	211		58				13	0	124	7.7	1	.2	.8	.00	84	0	25	B	G
11/24-30DA1		Cold	6-13-50	204		60				12	0	125	6.3	1	.2	1.5	.00	87	0	22	B	G
11/24-31BB1	80	Cold	4- -38		2,070	55	Tr.	360	98	2	0	188	660	330				1,300		[1]0	A	D
11/24-32DC1	390	58	6-15-50	222		65				11	0	120	12	4	.2	4.1	.04	96	0	20	B	E
11/24-34BB1	134	Cold	5- -48		450						0	127	65	78			.02				A	
12/23-16D [2]		143	6-15-50	495		61				103	[3]28	0	145	18	2.7	.0	.04	71	0	95	B	U
12/23-24CC1	200?	62	6- -30		560	82	Tr.	Tr.	0	217	Tr.	549	Tr.	15				Tr.	0	[1]100	A	U
12/23-24CC2	500?	65	6- -30		635	94	Tr.	Tr.	0	250	0	656	Tr.	4				Tr.	0	[1]100	A	U
12/23-24CD1	100+	59	6- -30		349	64	Tr.	Tr.	0	137	0	342	Tr.	12				Tr.	0	[1]100	A	U
12/23-36CC1	187	62	6-13-50	248		67				30	0	158	25	1	1.0	.4	.04	71	0	48	B	P
12/24-27DB1	317		8-21-39		182	25	Tr.	30	11	2	0	122	25	15				143		[1]3	A	G
13/23-25CB1	540	82	6-13-50	307		86				71	0	162	22	7	1.0	.2	.16	14	0	92	B	U
13/23-27DD4	127	68	6-13-50	282		68				59	16	82	41	6	.8	.0	.16	19	0	87	B	U

[1] Determined by O. J. Loeltz from computed values for sodium and potassium.
[2] Hinds Hot Springs.
[3] Hydroxyl ion (OH), 2.2 ppm.

The chemical character of the water of the several samples is indicated by the plotted positions shown in figure 6. Points were located on the basis of the computed percentage of sodium and measured conductivity except for 10 samples for which the conductivity was determined by dividing the determined value for dissolved solids by 0.7, the conversion factor generally used.

It will be seen that most of the analyses plot within the excellent-to-good class. Only two exceptions were observed in the southern part of the valley. One was water from well 10/23–2DB2. It is believed that this water represents, in part at least, the quality of the water rising along a fault near the toe of the mountains bordering the south side of the valley floor. A temperature of 143° F. was observed after the well was pumped for a few minutes. Water from other wells along the southern edge of the valley having abnormally high temperatures may have a similar composition. The water is classified as "permissible" to "doubtful" for irrigation use because of the high percentage of sodium.

The chemical composition of this water is very different from that of the artesian water generally found in the southern part of the valley but quite similar to water at Hinds Hot Springs, about 10 miles to the north. The similarity of these waters may be due to the fact that both probably are associated with faults. They may have a common source different from the major part of the ground-water supply, or they may be derived from the main body of ground water but are greatly changed in composition as a result of the high temperature, and perhaps the composition of the rocks, near the faults.

The composition of water from well 11/24–31BB1 appears to be anomalous. The water is classified as being doubtful to unsuitable for irrigation because, although the percentage of sodium is almost zero, the water contains excessive soluble salts. Mr. A. Mencarina, owner of the well reports that the well is 80 feet deep. That the water is excessively hard is shown by the fact that the sample analyzed had a hardness of 1,300 ppm, expressed as calcium carbonate. The occurrence of a highly mineralized water in an area where most of the water generally has a low mineral concentration may be explained, in part, by noting that the depth of the well is reported as 80 feet. The well presumably does not tap the artesian aquifers from which most of the ground water is withdrawn in Smith Valley. The analysis shows that the mineral matter in the water is composed largely of calcium sulfate and magnesium chloride. It seems likely that the well taps a localized deposit of soluble mineral salts containing appreciable amounts of sulfates and chlorides of calcium and magnesium. Gypsum deposits are often found in semiarid regions where water containing calcium sulfate, often derived in large part from iron and other metallic sulfide, has evaporated sufficiently to precipitate the calcium sulfate. It is possible that other deposits containing similar soluble salts may be found locally at shallow depths. It is believed, however, that water having low mineral concentrations can be obtained in these localized areas by casing off the shallow aquifers and drilling to a depth sufficient to tap the relatively extensive artesian aquifers.

Water in the northern half of the valley generally contains a high percentage of sodium. Percentages of sodium approaching 100 were indicated for water from wells 12/23–24CC1, 12/23–24CC2, and 12/23–24CD1. The principal mineral constituent of the water from these wells is sodium bicarbonate, the concentration evidently increasing with depth of the well. Continued use of the water for irrigation probably would prove toxic to most plants and would deflocculate most soils.

Water from Hinds Hot Springs, 12/23–16D, contains 95 percent sodium and for that reason is classified as doubtful to unsuitable for most irrigation uses. As previously mentioned, it is similar in chemical composition to water from well 10/23–2BD2.

Water from wells 13/23–25CB1 and 13/23–27DD4 is classed as permissible to doubtful because of its high percentage of sodium. These wells border the north side of the alkali flat and the water from them probably represents the quality of water one might expect from wells several hundred feet deep in that part of the valley.

Only 2 of the 18 waters analyzed during the present investigation contain fluoride in concentrations exceeding 1.5 ppm. Significantly, both are samples of thermal water, with which high concentrations of fluoride are often associated. Water from well 10/23–2DB2, used as the supply for a public swimming pool, contained 3.5 ppm of fluoride. A temperature reading of 117° F. was observed after the well was pumped for a short period. It is probable that an even higher temperature would have been obtained after a longer period of pumping.

Water from one of the main spring orifices at Hinds Hot Springs, 12/23–16D, contained 2.7 ppm of fluoride. The temperature of the water was 143° F. Most water whose temperature indicates little if any mixing with thermal water contained only 0.2 to 0.4 ppm of fluoride.

From the limited data available, it appears that high contents of fluoride are associated with the thermal water found along the south and west sides of the valley, presumably along fault planes. The fluoride content of water in and adjacent to these belts probably depends in large part on how much dilution occurs by mixing of the thermal water with other water having insignificant concentrations of fluoride. To the extent that temperature might be considered as a measure of such dilution, it appears desirable that the water in these belts having temperatures considerably above normal be analyzed to determine the fluoride content if such water is to be used habitually by children during the formative period of their permanent teeth.

GROUND-WATER DEVELOPMENT

STATUS OF DEVELOPMENT, 1950

Most of the ground-water development has been for domestic and stock use. The drilling of small-diameter wells in the area of artesian flow has been popular since the valley was first settled in the 1860's. To date 110 or more flowing wells have been drilled. (See table 4 and pl. 2.) The yields of these wells range from less than a pint to several hundred gallons per minute, although the yields of a majority of the wells range between 10 and 50 gpm. In addition, some 40 artesian wells and about 50 water-table wells are pumped for domestic and stock use.

Development of ground water for irrigation on a significant scale was begun in 1948 with the drilling of well 11/24-32DC1. This well is being used successfully to supplement surface water in growing alfalfa, potatoes, and grain. The well yields 900 gpm with a lift of less than 100 feet. The lift was considerably less than 100 feet at the same rate of pumping prior to a cave-in and consequent sinking of the casing, which occurred a few months after the well was first pumped.

Later in 1948 well 10/24-4CD1 was drilled to a depth of 250 feet. The yield of this well is about 700 gpm, and the pumping lift is about 145 feet. The only well drilled so far for irrigation of the area north of the West Walker River is well 11/23-3DC1. It was drilled in 1948 on the lower part of the Burbank-Red Canyon fan to a depth of 275 feet. The well yields about 500 gpm with a lift of about 130 feet.

Only well 13/23-25CB1 (Ambassador well) has a flow large enough for extensive irrigation. It was drilled in 1932 to obtain water for mining operations but has not been used for this purpose since 1938. In recent years the well has been used for irrigation. The rather large flow of about 400 gpm can, in part, be attributed to its depth of at least 540 feet, with the possibility that it penetrates fractured volcanic bedrock, and to the gravel-pack type of construction. However, referring to figure 6, it will be noted that the quality of the water is not suitable for many crops commonly grown in the valley.

To date, it is estimated that the withdrawals from flowing artesian wells total about 2,000 acre-feet annually; from pumped artesian period 1948 through 1950. Included in the group are two wells on which continuous water-stage recorders were maintained.

Available well logs are listed on pages 80–88. For the most part the logs were obtained from drillers' logs filed in the office of the State Engineer.

NUMBERING SYSTEM

The number assigned to a well or spring in this report is both an identification and a location number. It is based on the Mount Diablo base and meridian of the General Land Office. A typical number consists of three units. The first unit is the number of the township north of the Mount Diablo base line. The second unit, separated from the first by a slant, is the number of the range east of the Mount Diablo meridian. The third unit, separated from the other two units by a dash, lists the number of the section and is followed by a letter designating the quarter section, a second letter designating the quarter of the quarter section, and finally a number to show the order in which the well or spring was recorded within the subdivision. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarters of the section and of the quarter section. For example, well number 11/23–25AD2 designates the second well recorded in the SE¼NE¼ sec. 25, T. 11 N., R. 23 E., Mount Diablo base and meridian.

On plate 2, owing to space limitation, only that part of the number designating the subdivision of the section and the order in which the well or spring was recorded in that subdivision is shown. The section number is shown near the center of each section in T. 12 N., R. 23 E. The section number in any other township can be determined by noting the corresponding section number in T. 12 N., R. 23 E. Township and range numbers are shown on the edges of the plate

DESCRIPTION OF WELLS

Type of well: Dg, dug; Dr, drilled; J, jetted; B, bored.

Use of water: D, domestic; F, fish rearing; I, irrigation; N, unused; O, observation; S, stock.

[Location of wells as shown on pl. 2]

Well number and location	Owner	Type of well and year completed	Diameter (inches)	Depth (feet)	Land-surface altitude (feet)	Measuring point: Above (+) or below (−) land-surface (feet)	Measuring point: Description	Pressure head or water level: Above (+) or below (−) measuring point (feet)	Pressure head or water level: Date	Use	Temperature (° F.)	Remarks
10/23-1BA1	Mackey and Mackey.	Dr, 1946	6	62		−1.8	Top of casing collar.	−37.37	3-30-48	D, S		
10/23-2AC1	H. D. Neddenreip.	Dg	48	15		−2.0	Top of 6- by 6-inch stringer.	−5.17	12-28-49	D		
10/23-2BC1	James Compston, Jr.	Dr, 1948	6	36		−.8	Top of casing	−22.30	11- 2-48	D, S		
10/23-2BD1	Henry Fulstone	Dg		20						D		
10/23-2DB1	James Compston	Dr, 1927	3	65		−5.5	Top of casing	−32.92	12-22-49	D		Analysis.
10/23-2DB2	E. W. Johnson	Dr, 1928	5	[1] 200	4,834	−6.0	Top of casing	(2)		[2] D	117	Water level reportedly 15 feet below measuring point, 7-1-48; water supply for public swimming pool; analysis.
10/23-2DC1	Mrs. Hattie Holbrook.	Dr, 1946	6	62	4,855	.0	Top of casing	−45.02	12-27-49	N		
10/23-2DD1	U. S. Forest Service.	Dr		217	4,843	−6.5	Top of casing	[1] −25.75		D	(2)	Reported very hot.
10/23-2DD2	Barbara Carlson	Dr, 1947	6	40		+.6	Top of casing	−23.16	4-26-50	D	(2)	Reported warm. Log.
10/23-11AA1	Nevada Dept. of Highways.	Dr, 1946	6	57	4,847	.0	Top of casing	−24.40	12-27-49	N	93	
10/23-11AA2	Heyday Inn	Dr, 1912?	8	163	4,845	−2.0	Top of casing	−20.67	9- 8-48	D	(2)	Reported warm; analysis.
10/23-12BA1	Mrs. Albert Gonder.	Dr	4	[1] 82	4,870			(2)		D	(2)	Water level reportedly about 40 feet below land surface several years ago; reported warm; analysis.
10/23-12BB1	Mrs. Hattie Holbrook.	Dr	4	[1] 65	4,835	+.5	Top of 6- by 6-inch pump support.	−12.74	12-27-49		(2)	Reported 65 feet deep; reported warm.

See footnotes at end of table.

Well number and location	Owner	Type of well and year completed	Diameter (inches)	Depth (feet)	Land-surface altitude (feet)	Measuring point: Above (+) or below (−) land-surface (feet)	Measuring point: Description	Pressure head or water level: Above (+) or below (−) measuring point (feet)	Pressure head or water level: Date	Use	Temperature (° F.)	Remarks
10/23-12BB2	Carter	Dg	([1])	9	4,833	−1.8	Top of wood platform.	−4.89	12-27-49	D		3 by 3 feet.
10/23-12BD1	L. L. Wedertz	Dr, 1931		122	4,907	.0	Top of casing	−59.28	12-27-49	D, S		Analysis.
10/24-3BA1	Dr. Ross	Dr	4		4,918	−6.0	Top of casing	−61.28	5-28-48	S		
10/24-4CD1	Herb Rowntree	Dr, 1948	14	250	4,910	+2.0	Top of casing	−61.66	11-30-48	I	57	Log; analysis; specific capacity after several months pumping about 11 gpm per foot of drawdown.
10/24-5AB1	Herb Rowntree	Dr, 1940	4	[1] 106	4,866	−4.0	Edge of pump base.	−23.73	5-27-48	D		
10/24-5AD1	Herb Rowntree	Dr	4		4,882	.0	Top of casing	−37.47	5-24-48	D		
10/24-5BB1	J. H. Hardie	Dr, 1947	4	[1] 148	4,885	−.2	Top of casing	−48.10	3-3-48	D		
10/24-5CB1	Fred Fulstone	Dg, Dr	([1])	[1] 480	4,898	.0	Top of concrete curb.	−55.28	5-8-49	D, S		4 by 5 feet, 0 to 60 feet; reported 8 inches, 60 to 480 feet.
10/24-7BD1	S. Strieby	Dr	4	[1] 128		+.4	Top of concrete block.	−63.20	5-6-49			
10/24-20AB1	Ambro Rosaschi	Dr	6		5,030	−3.0	Top of casing	[1] −93.75				
11/23-1AB1	C. G. Smith	Dg, 1934	42	30		+2.0	Top of concrete casing.	−23.97	3-10-49	S		
11/23-1DB1	Howard Dickson	J, 1948	6					[1] −25	3- -49	N		
11/23-2AB1	R. W. Diehl	Dr	3	240		+2.0	Top of casing				55	Head at least 2 feet above land surface; flows about 1 pint per minute.
11/22-2AB2	R. W. Diehl	Dr	8	22		.0	Land surface	[1] −7				
11/23-2CB1	A. Mencarini	Dg	48	33		+1.2	Top of 4- by 8-inch curb.	−19.33	12-22-49	D, S		
11/23-2DC1	A. Bunkowski	Dr, 1918	3	[1] 225		+1.0	Top of casing		12-30-49	S		Flows about 1 gpm.
11/23-2DC2	A. Bunkowski	Dr, 1924	3	[1] 325			Land surface	+1.6	12-30-49	S	55	Flows about 0.5 gpm from opening 1 foot above land surface.
11/23-3DC1	R. B. Day	Dr, 1948	12	242	4,829	+1.2	Top of casing	−49.98	11-30-48	I	61	Log; analysis; pumped 500 gpm, lift 130 feet to land surface, 5-24-50.

11/23-3DD1	R. B. Day	Dr			4,805	−4.0	Top of casing	−17.85	3-4-48	D		
11/23-10DB1	John Neill	Dr	6	[1] 70		−.1	Top of casing	−40.22	12-30-49	D		
11/23-11BA1	A. Bunkowski	Dr	3	[1] 70		−2.0	Top of casing	−8.68	12-30-49	D		
11/23-11CC1	A. Bunkowski	Dg	24	14	4,790	.0	Top of casing	−11.42	3-4-48	N		
11/23-13AD1	J. R. Steeley	J	3	(2)						D, S	58	Reported 80 to 125 feet deep; flows about 15 gpm from 4-inch pipe 8 feet above land surface.
11/23-14BC1	John Dickson	Dr	3	(2)		+1.4	Top of casing	−9.78	3-10-49	N		More than 40 feet deep.
11/23-15BC1	Wm. Toner	Dr	3	[1] 200		+1.0	Top of flange	−9.30	12-30-49	D		
11/23-15CB1	Wm. Toner	Dr	3							D, S		
11/23-22AB1	H. E. Carter	Dr	6	[1] 100	4,835	−2.5	Top of casing	−47.6	3-29-48	D		Pump shut off 10 minutes prior to measurement.
11/23-23BB1	A B C Ranch	Dr					Land surface	[1] −15	1948	D		
11/23-24CA1	Walter R. Schwake	Dr	4		4,749	.0	Land surface	+38.9	3-30-48	D	56	
11/23-24CD1	Mrs. Kate Gallaner.	Dr	3			+2.0	Top of 3-inch tee	+32.0	8-22-49	D		
11/23-24DB1	A. M. Nesmith	Dr	3	[1] 145	4,746	+2.0	Top of 3-inch tee	+36.8	3-10-49	D, S	56	
11/23-25AA1	Sayre	Dr	2	[1] 168	4,775	.0	Land surface	(2)	10-20-48	D, S	57	Water level rose more than 20 feet above land surface.
11/23-25AD1	Mrs. Rex Roberson	Dr	3		4,778	.0	Land surface	+23.0	10-20-48	D, S	57	Flows about 40 gpm from 1¼-inch diameter pipe 3 feet above land surface.
11/23-25AD2	A. Miller	Dr		[1] 150		+1.2	Top of 2-inch pipe	+18.3	12-29-49	D, S	58	
11/23-25CA1	E. Leveille				4,797	.0	Land surface	+10.0	10-20-48	D, S	57	
11/23-25CC1	Chas. Groso	Dr, 1917	3	[1] 120	4,793	+1.8	Top of tee	+2.3	10-20-48	D, S	56	
11/23-25CD1	Amos Mencarini	Dr	3						10-20-48	D, S	57	Sulfur water reported at shallow depth, good water at greater depth.
11/23-25DA1	San Filippo—Freeman.	Dr	2	[1] 150		+1.0	Top of concrete block.	+12.0	12-27-49		57	Flows 1.2 gpm from 2-inch pipe 4 feet above land surface.
11/23-25DA2	San Filippo—Freeman.	Dr	4	[1] 300						D, S		Flows few gallons per minute from opening 6 feet below land surface.
11/23-25DA3	San Filippo—Freeman.	Dr	2½	[1] 150		+.2	Top of concrete block.	+8.5	12-27-49	S	56	Flows 8 gpm from 2-inch pipe 3.2 feet above land surface.
11/23-25DA4	San Filippo—Freeman.	Dg	48	20		+.5	Top of concrete curb.	−7.94	12-27-49	S		
11/23-26AA1	A. C. Sayre	Dr, 1913	4	[1] 126	4,756	.0	Land surface	+33.0	11-4-49	D, S	55	Flows 5.5 gpm with 8-foot drop in head.
11/23-26AB1	A. C. Sayre	Dr	7	195		+1.3	Top of casing		10-22-48	S, I	58	Flows several gallons per minute.
11/23-26DA1	C. F. Chidwick	Dr	3						3-30-48	D	57	Flow estimated as 50 gpm.

See footnotes at end of table.

Well number and location	Owner	Type of well and year completed	Diameter (inches)	Depth (feet)	Land-surface altitude (feet)	Measuring point		Pressure head or water level		Use	Temperature (° F.)	Remarks
						Above (+) or below (−) land-surface (feet)	Description	Above (+) or below (−) measuring point (feet)	Date			
11/23-26DD1	Chas. Groso	Dr, 1917	3	[1] 180		.0	Land surface	+16.0	10-20-48	S	57	Flowed 10 gpm through 150 feet of 1½-inch pipe.
11/23-27AC1	A. C. Sayre	Dr, 1928	6	[1] 120		.0	Land surface	[1] −60	1945	D		Owner reports water level rose from 85-foot level to 60-foot level when drilled.
11/23-27DB1	C. I. Everett	Dr, 1946	6	[1] 105	4,830	.0	Top of casing	−65.63	3-29-48	D		
11/23-27DC1	C. & M. Groso	Dr, 1945	4	89	4,830	+4.3	Top of casing	−72.09	10-22-48	N, O		
11/23-27DD1	Glen Fulstone	Dr	3	(1)	4,768	+2.6	Top of 3-inch tee	(2)		D		Reported more than 200 feet deep by owner; also reports head about 10 feet above land surface.
11/23-35AC1	A. Fulstone	B, 1923	6	[1] 127	4,780	.0	Land surface	+12.5	9-8-48	S	58	Flows 32 gpm from pipe 2.5 feet above land surface; analysis.
11/23-36AC1	John H. Wichman	Dr, 192?	3	[1] 423	4,809	−3.7	Top of casing	−3.27	3-4-48	D, S		Analysis.
11/23-36BC1	Joe Roberti	Dr	4	[1] 197	4,810	−4.4	Top of casing	−1.83	12-28-49	D		
11/23-36CB1	Wm. Christenson	Dr	3	190	4,809	+.5	Top of casing	−8.42	3-4-48	D		
11/24-2CC1	At abandoned Hudson Station.	Dr	12	78	4,720	−2.8	Top of casing	−26.70	5-28-48	S		
11/24-7DA1	Plymouth Land, Stock Co.	Dr	4		4,737	.0	Top of 4-inch tee	+20.0	6-2-48	S, I	60	Flows 25 gpm continuously.
11/24-7DC1	George C. McVicar.	Dr	2		4,748	+2.0	Top of 2-inch elbow.	+9.2	11-2-48	S	61	Flows 2 gpm.
11/24-9BB1	Plymouth Land, Stock Co.	Dr	6	81	4,724	+1.0	Top of casing	+3.10	7-15-48	S, I	65	Flows 1.8 gpm.
11/24-18AA1	Nevada Fish and Game Commission.	Dr, 1935	8	73		+3.0	Top of casing			F	56	Flows 50 gpm from top of casing.
11/24-18AA2	Nevada Fish and Game Commission.	Dr, 1948	8	88						F	56	Log.
11/24-18AA3	Nevada Fish and Game Commission.	Dr, 1948	8	88						F	56	Flows estimated 40 gpm; log.

11/24-18AA4	Nevada Fish and Game Commission.	Dr, 1948	8	88						F	56	Flows estimated 25 gpm; log.
11/24-18AA5	Nevada Fish and Game Commission.	Dr, 1948	8	103	4,726		Top of casing			F	57	Flows 52 gpm; log.
11/24-18AA6	Nevada Fish and Game Commission.	Dr, 1949	8	219						F	58	Flows 52 gpm from opening 4 feet above land surface; log; analysis.
11/24-18AD1	Mrs. W. E. Allen	J, 1932	2	[1] 80	4,728	+.1	Top of 2-inch collar.	+21.3	10- 7-49	N, O		Flows 25 gpm from opening 2 feet above land surface.
11/24-18AD2	C. G. Wines	Dr	2		4,735.5	.0	Land surface	+26.8	11- 2-48	D	56	
11/24-18AD3	C. G. Wines, Jr.	Dr	2	(²)	4,739	.0	Land surface	+28.0	11-15-49	D		Reported about 100 feet deep.
11/24-18BB1	J. R. Steeley	Dr, 1914	3						6- 2-48	S, I	58	Flows 25 gpm continuously from elbow 1.5 feet above land surface.
11/24-18DA1	Mrs. Mary Harrison.	Dr, 1914	3	[1] 81	4,740	+1.5	Top of 3-inch tee	+26.2	3-10-49	D, I, O		Flows about 100 gpm.
11/24-19AA1	G. C. McVicar	J, 1917	3	[1] 110	4,763				11- 2-48	S	57	Flow reported as about 10 gpm.
11/24-19AB1	John McVicar	Dr	2	[1] 130		+.5	Top of 2-inch tee	+25.5	12-22-49	D, I	56	Flow reported as about 10 gpm.
11/24-19AB2	John McVicar	J	3	[1] 120					12-22-49	D, S	56	Flow reported as about 100 gpm.
11/24-19AD1	G. C. McVicar	J, 1920	2	[1] 110	4,764	.0	Land surface	+20.0	11- 2-48	D, I	56	Flow reported as about 20 gpm.
11/24-19CB1	Fred Settlemeyer	Dr	3	[1] 150		+2.0	Top of 3-inch tee	+30.0	12-30-49	D, S, I	57	Flow reported as about 100 gpm; analysis.
11/24-19DA1	B. A. Harrison	Dr	2	[1] 115	4,778	+1.0	Top of 2-inch tee	+14.6	11- 2-48	D		
11/24-19DA2	G. C. McVicar	J, 1920	3	[1] 180	4,777	.0	Land surface	+16.4	11- 2-48	D, I	57	Flow reported as about 25 gpm.
11/24-19DB1	T. Linscott	Dr	3			+2.0	Top of 3-inch tee	+25.5	12-30-49	D		Flow reported as about 50 gpm.
11/24-19DB2	Chas. W. Hinds	Dr, 1947	2	[1] 122		+1.4	Top of 2-inch tee	+19.6	4-25-50	D	57	Flow reported as 30 gpm.
11/24-19DD1	Fred Fulstone	Dr, 1912	4	[1] 129	4,786	.0	Land surface	+15.3	3-30-48	D, S		Flow reported as about 50 gpm.
11/24-20AC1	Norman Brown	Dr	3			+2.2	Top of casing		4-25-50	N	57	Flows 1 gpm.
11/24-20DB1	Chas. W. Hinds	Dr, 1948	4	140		−6.8	Top of casing	−35.73	4-25-50	D	58	Log.
11/24-21BC1	Hastings	Dr	3	131	4,841	+.8	Top of casing	−41.82	3-31-48	N		
11/24-22DA1	Fred Fulstone	Dg, 1927	(²)	95	4,888	+1.0	Top of concrete well curb.	−88.50	12-29-49	N		Opening, 18 by 30 inches.
11/24-22DC1	Fred Fulstone	Dg, 1925	(²)	[1] 130	4,888	+.6	Top of concrete well curb.	−60.88	12-29-49	N, O		Opening, 20 by 30 inches.

See footnotes at end of table.

Well number and location	Owner	Type of well and year completed	Diameter (inches)	Depth (feet)	Land-surface altitude (feet)	Measuring point: Above (+) or below (−) land-surface (feet)	Measuring point: Description	Pressure head or water level: Above (+) or below (−) measuring point (feet)	Pressure head or water level: Date	Use	Temperature (° F.)	Remarks
11/24-27CB1	J. C. Sanders	Dg, 1919	([2])	[1] 110	4,870	−5.1	Top of concrete curb.	−22.14	3-3-48	D		Former owner and digger reports water level 90 feet below land surface in 1919; 85 feet in 1932; 35 feet in 1946. Opening, 24 by 36 inches.
11/24-27CC1	A. A. Chisholm	Dr, 1943	4	[1] 123	4,587	−3.8	Top of casing	−41.18	12-21-49	D, O		
11/24-28CD1	Pasquale Acciari	Dr, 1928	4	[1] 125		−5.0	Top of casing	[1]–55	1946	D		
11/24-29AB1	Bruno Fenili	Dr, 1919		[1] 70					3-3-48	D, S	57	Flows about 15 gpm; water level reported to have been 30 to 40 feet below land surface in 1919.
11/24-29AD1	Bruno Fenili	Dr	3	78		+1.2	Top of casing	−23.97	3-3-48	N		
11/24-30AA1	Fred Fulstone	Dr, 1917	4	[1] 35	4,792	.0	Top of concrete floor.	+6.1	3-30-48	S		Owner reports water level at land surface in 1917.
11/21-30CB1	Ivan O. Hall	Dr	4	[1] 160		.0	Land surface					Owner reports water level about 2 feet below land surface.
11/24-30CB2	Howard Wilkerson	Dr, 1949	6	170		+0.5	Top of casing collar.	+6.5	4-25-50	D	61	Flows about 10 gpm; log; analysis.
11/24-30DA1	Wolfson and Hicks	Dr	3	[1] 150	4,810	+0.7	Top of casing	−2.43	12-22-49	D		Analysis.
11/24-31BB1	A. Mencarina	Dr, 1924	6	[1] 80		.0	Land surface	([2])	12-22-49	D		Owner reports water level 24 feet below land surface in 1947; analysis.
11/24-31BD1	David Cedestrom	Dr, 1931	7	45		−6.0	Top of casing	−12.99	12-27-49	D, S		
11/24-32AB1	Mrs. Nellie Albright.	Dr	3	[1] 130	4,824	+.8	Top of casing	−1.74	3-29-48	D, O		Owner reports water level rose considerably during past 24 years.
11/24-32CA1	A. Nuti	Dr	4	[1] 180		.0	Land surface	0.0	1-22-47	D		Owner reports water level 27 feet below land surface in 1937.
11/24-32DA1	D. S. Albright	Dr	4	[1] 180	4,895					D, S		
11/24-32DC1	A. Nuti	Dr, 1948	16	390	4,865	+2.9	Top of casing	−26.52	3-28-48	I, O	58	Log; analysis.

11/24-33AD1	R. M. Arnold	Dr	5	121	4,900	−5.5	Top of casing	−56.94	5-26-48	D, S		
11/24-33CC1	S. Maritorena	Dr, 1949	6	168		+.3	Top of casing	−64.24	4-19-49	D		Log.
11/24-33DA1	Dr. Ross	Dr, 1924	6	[1] 240	4,910	−6.5	Top of casing	−63.30	8-30-50	D		
11/24-34BB1	E. J. Alpers	Dr	6	[1] 134	4,895	−5.5	Top of casing	−44.78	5-27-48	D		Owner reports water level was 80 feet below land surface 20 years ago; analysis.
11/24-34DB1	E. J. Alpers	Dr	8	90		+.2	Top of casing	−85.72	5-26-48	N		
12/23-10BC1	A. Castaing	Dr	4	59		.0	Land surface	+32.0	10-21-48	S	70	Flows 0.8 gpm from opening 2 feet above land surface.
12/23-13CC1	A. Castaing	Dr	8	118						S, I	57	Flows about 50 gpm.
12/23-14AD1	Wm. Mollart	Dr	8	16		.0	Top of casing collar.	+4.3	6-17-48	S	56	
12/23-22AC1	S. H. Hunnewill	Dr, 1947	6	61	4,690	+.5	Top of casing	−30.22	8-6-48	D		Log.
12/23-22AC2	S. H. Hunnewill	Dr, 1947	6	109	4,690	−.5	Top of casing	−15.40	8-6-48	N		
12/23-22AC3	S. H. Hunnewill	Dr, 1947	6	50	4,678	+2.0	Top of casing	+7.0	8-6-48	S	54	Log.
12/23-22DD1	S. H. Hunnewill	Dr	4	[1] 79						D, S		Owner reports water level 2 or 3 feet above land surface; flow reported as about 15 gpm.
12/23-23CB1	E. L. Hoskins	Dr	8	74	4,710				8-6-48	I	54	Flows about 50 gpm.
12/23-24BC1	Wm. Toner	Dr	8	112	4,710	.0	Land surface	+7.0	8-5-48	S	58	Flows 15 gpm.
12/23-24CC1	Wm. Toner	Dr	8	201	4,745					S	62	Flows one-quarter gallon per minute from opening 0.5 foot above land surface; analysis.
12/23-24CC2	Wm. Toner	Dr	4	[1] 500	4,745							Flows one-quarter gallon per minute from opening 3.5 feet above land surface; analysis.
12/23-24CC3	Wm. Toner	Dr, 1923	6	20	4,743	+.6	Top of casing	−8.98	8-9-50	D		
12/23-24CC4	Wm. Toner	Dr	8	39	4,745	−.3	Top of casing	−11.57	8-10-50	N		
12/23-24CD1	Wm. Toner	Dr, 1930	6	138	4,729	+1.0	Top of casing	+10.0	4-25-50	S	59	Flow about 2 gpm.
12/23-25CD1	C. C. Perrin	Dr, 1924	3	[1] 245	4,773	+2.0	Top of casing	−1.10	6-26-50	D, S	60	Strong H_2S odor.
12/23-26BC1	G. Markovitch	Dr	3	103	4,750				8-6-48	S	58	Flows 7.5 gpm from opening 0.5 foot above land surface.
12/23-26CD1	Wm. Jaschke	Dr	3	[1] 200	4,765				6-30-48	D, S	62	Owner reports water level 7 feet above land surface; flows 4 gpm.
12/23-26DA1	C. C. Perrin	J	4	12		+1.5	Top of casing	−10.83	6-17-48	N		
12/23-26DD1	C. C. Perrin	Dr	5	255	4,759	+1.3	Top of casing	+10.0	7-15-48	D		Flows 3.7 gpm from opening 2.3 feet above land surface. Strong H_2S odor.
12/23-27AA1	S. H. Hunnewill	Dr, 1948	6	87		+.8	Top of casing	−0.92	11-6-50	D		Log.

See footnotes at end of table.

Well number and location	Owner	Type of well and year completed	Diameter (inches)	Depth (feet)	Land-surface altitude (feet)	Measuring point: Above (+) or below (−) land-surface (feet)	Measuring point: Description	Pressure head or water level: Above (+) or below (−) measuring point (feet)	Pressure head or water level: Date	Use	Temperature (° F.)	Remarks
12/23-27CD1	Leon Grivel	Dr, 1949	6	279	4,767	.0	Land surface			D		Water level 2 feet below land surface according to driller's log; log.
12/23-34AB1	L. M. Farias	Dr, 1914	8	[1] 250	4,765	.0	Land surface	+16.4	3-4-48	D, S	60	Flows about 1 gpm; log.
12/23-35DA1	G. G. Smith	J, 1948	3	214	4,776				10-29-48	S	60	
12/23-36AB1	A. and H. Bunkowski.	Dg	([3])	28	4,771	+1.5	Top of plank cover	−18.54	8-22-49	N		6- by 6-foot opening.
12/23-36BB1	Cross	Dr	4	162	4,760	.0	Top of 4-by 1-inch bushing.	+7.2	10-22-48	S	60	Flows about 3 gpm.
12/23-36CC1	G. C. Smith	J, 1918	3	[1] 187	4,774				6-13-50		62	Owner reports water level 3.5 feet above land surface; flows about 3 gpm from opening at land surface; analysis.
12/24-8DA1	Unknown	Dr	6		4,635	.0	Land surface	+1.5	6-30-48	N	62	Flow 1.5 gpm.
12/24-17BA1	Unknown	Dr	6		4,640				6-30-48	S	58	Flows about 5 gpm from pipe 2 feet above land surface.
12/24-27DB1	U. S. Bureau of Land Management.	Dr, 1939	8	318		+.8	Top of 3-inch channel supporting pump.	−279.14	8-11-50	S		Analysis.
12/24-30CD1	Unknown	Dr	8	70	4,798	+1.5	Top of casing	−47.95	5-28-48	N, O		
12/24-31BB1	Unknown	Dg	([3])	22	4,775	+1.5	Top of wood curbing.	−22.18	8-22-49	N		4- by 4-foot opening.
13/23-25AB1	C. A. Blair	Dr	8	214	4,605				6-1-48	S	67	Flows about 2 gpm.
13/23-25BC1	C. A. Blair	Dr	10	201	4,600	+1.0	Top of casing	−1.42	3-10-49	N		
13/23-25CB1	C. A. Blair	Dr, 1932	14	540	4,580	.0	Land surface	+23.0	3-31-48	I	82	Ambassador well; flow, 400 gpm, Sept. 20, 1948; H_2S odor; analysis.
13/23-27DC1	James H. Day Estate.	Dr, 1942	8	230					5-24-50	I	70	Flows about 12 gpm at land surface.

13/23-27DD1	James H. Day Estate.	Dr, 1927	6	170		.0	Top of casing	+2.7	5-24-50	I	73	Flows about 10 gpm at land surface.
13/23-27DD2	James H. Day Estate.	Dr, 1927	8	155		−1.0	Top of casing		5-24-50	I	76	Flows 26 gpm at land surface.
13/23-27DD3	James H. Day Estate.	Dr, 1927	8	127		.0	Top of casing		5-24-50	I	68	Flows 12 gpm; H_2S odor; analysis.
13/23-27DD4	James H. Day Estate.	Dr, 1927	6	119		−1.0	Top of casing	−0.52	5-24-50	N		Well is reported to have flowed prior to 1933.
13/24-16CD1	U. S. Bureau of Land Management.	Dr, 1939	6	[1] 285		−6.0	Top of casing	[1] −235	12- -39	S		Log.
13/24-19CD1	A. G. Sharp	Dr	3	80	4,625	+1.5	Top of 2- by 1-inch bushing.	−0.46	6- 1-48	N		
13/24-19CD2	A. G. Sharp	Dr	10		4,620				6- 1-48	S	64	Flows about 0.5 gpm from opening 2 feet above land surface.
13/24-30BD1	A. G. Sharp	Dr	10	370	4,610	.0	Land surface	+8.5	6- 1-48	D	66	Flows 1.8 gpm from 2-inch opening 3 feet above land surface.
13/24-30BD2	A. G. Sharp	Dr	3		4,610				6- 1-48	D, S	66	Flows about 3 gpm from 2-inch pipe 7 feet above land surface.

[1] Reported.
[2] See remarks column.

MEASUREMENTS OF WATER LEVEL AND ARTESIAN PRESSURE, 1948–50

[See Description of wells (pp. 63–71) for other details of wells]

10/23–11AA1. Nevada Dept. of Highways. Unused drilled well.

Water level, in feet below measuring point, 1949–50

Date	Water level	Date	Water level	Date	Water level
1949		*1950*		*1950*	
Dec. 27	24.40	May 26	24.02	Sept. 28	20.58
1950		Aug. 9	19.73	Nov. 29	23.01
Apr. 24	26.04				

10/24–3BA1. Dr. Ross. Drilled stock well. Equipped with jet-type pump powered by gasoline engine. Water levels, in feet below measuring point: May 28, 1948, 61.28; Aug. 23, 1948, 61.45; Dec. 21, 1949, 61.56.

10/24–4CD1. Herb Rowntree. Drilled irrigation well, diameter 14 inches, from 0 to 150 feet, 12 inches, from 150 to 250 feet; depth 250 feet. Equipped with turbine pump and direct-drive electric motor. Pumping rate, May 5, 1949, 800 gpm, drawdown 50 feet; June 8, 1949, 700 gpm, drawdown 70 feet.

Water level, in feet below measuring point, 1948–50

Date	Water level	Date	Water level	Date	Water level
1948		*1949*		*1950*	
July 21	65.54	Mar. 9	62.48	May 26	[1] 75.64
Aug. 5	63.64	Aug. 17	72.11	Aug. 18	68.79
Nov. 2	61.61	Nov. 4	67.99	Sept. 28	68.46
Nov. 30	61.66	*1950*		Nov. 29	67.87
		Mar. 30	68.46		

[1] Pump shut off 24 hours prior to measurement.

10/24–5AB1. Herb Rowntree. Drilled domestic well. Equipped with jet pump and electric motor. Water levels, in feet below measuring point: May 27, 1948, 23.73; June 17, 1948, 28.56; Aug. 5, 1948, 28.6 (irrigation well, 11/24–32DC1, about 350 feet northeastward had been pumping continuously at rate of about 900 gallons per minute 3½ days prior to measurement).

10/24–5AD1. Herb Rowntree. Drilled domestic well. Equipped with lift-type pump. Water levels, in feet below measuring point: Mar. 29, 1948, 36.10; May 10, 1948, 39.00; May 24, 1948, 37.47 (well 11/24–32DC1 not pumped during week preceding measurement); June 8, 1949, 39.75 (well 10/24–4CD1 had been pumping at rate of 750 gallons per minute for about 12 hours daily beginning June 1. Well 11/24–32DC1 had not been pumped during the week prior to June 8).

10/24-5BB1. J. H. Hardie. Drilled domestic well. Equipped with jet pump and electric motor.

Water level, in feet below measuring point, 1948

Date	Water level	Date	Water level	Date	Water level
Mar. 3	48.10	May 24	50.04	July 21	50.00
May 10	[1] 51.43	June 17	49.70	Aug. 5	[1] 50.92

[1] Well 11/24-32DC1 pumping.

10/24-5CB1. Fred Fulstone. Dug and drilled domestic and stock well, 4- by 5-foot opening, 0 to 60 feet, 8-inch casing, 60 to 480 feet. Equipped with jet pump and electric motor.

Water level, in feet below measuring point, 1949-50

Date	Water level	Date	Water level	Date	Water level
1949		*1949*		*1950*	
June 8	55.28	Aug. 17	53.82	Aug. 18	53.18
July 6	54.77			Sept. 28	52.66
		1950			
		May 26	55.44		

10/24-7BD1. Fred Strieby. Drilled domestic well. Equipped with jet pump and electric motor.

Water level, in feet below measuring point, 1949-50

Date	Water level	Date	Water level	Date	Water level
1949		*1950*		*1950*	
May 6	63.20	May 26	64.93	Sept. 28	62.94
Aug. 17	62.80	Aug. 18	63.00	Nov. 29	63.68

11/23-1AB1. C. G. Smith. Dug stock well (used infrequently), diameter 3½ feet, depth 29.6 feet. Equipped with lift-type pump and gasoline engine. Measuring point, top of concrete well casing, 2.0 feet above land surface.

Water level, in feet below measuring point, 1949-50

Date	Water level	Date	Water level	Date	Water level
1949		*1950*		*1950*	
Mar. 10	23.97	Mar. 30	23.97	Sept. 28	23.00
Aug. 22	23.22	May 26	24.35	Nov. 29	22.97
Nov. 4	23.34	Aug. 9	23.11		

11/23-3DC1. R. B. Day. Drilled irrigation well. Equipped with turbine pump and direct-drive electric motor. Pumping rate, May 24, 1950, 500 gpm, drawdown, 81 feet.

Water level, in feet below measuring point, 1948–50

Date	Water level	Date	Water level	Date	Water level
1948		*1949*		*1950*	
July 15	49.98	Mar. 10	51.69	Aug. 9	49.82
Nov. 30	50.44	June 8	50.75	Nov. 29	50.66
		Aug. 22	49.60		
1949		Nov. 4	50.98		
Jan. 31	51.34				

11/23-11BA1. A. Bunkowski. Drilled domestic well. Equipped with lift-type pump and electric motor.

Water level, in feet below measuring point, 1949–50

Date	Water level	Date	Water level	Date	Water level
1949		*1950*		*1950*	
Dec. 30	8.68	May 24	7.80	Nov. 29	7.37
		Aug. 9	6.37		
1950					
Mar. 30	10.18				

11/23-24CD1. Mrs. Kate Gallaner. Drilled domestic well.

Water level, in feet above measuring point, 1949–50

Date	Water level	Date	Water level	Date	Water level
1949		*1950*		*1950*	
Aug. 22	32.0	Mar. 30	34.3	Sept. 28	35.2
Nov. 4	32.3	Aug. 9	[1] 31.2	Nov. 29	35.2

[1] Withdrawal for several hours at rate of about 5 gpm 5 minutes prior to measurement.

11/23-26AA1. A. C. Sayre. Drilled domestic and stock well. Water levels, in feet above land surface: Mar. 30, 1948, 35.3; Nov. 30, 1948, 32.5; Aug. 22, 1949, 31.2; Nov. 4, 1949, 33.0.

11/23-27DC1. C. and M. Groso. Unused drilled domestic well. No equipment.

Water level, in feet below measuring point, 1948–50

Date	Water level	Date	Water level	Date	Water level
1948		*1949*		*1950*	
Oct. 22	72.09	Aug. 22	62.81	Aug. 9	60.54
Nov. 30	72.97	Nov. 4	68.01	Sept. 28	65.92
				Nov. 29	71.16
1949		*1950*			
Jan. 31	74.17	Mar. 29	76.20		
Mar. 10	75.99	May 24	71.05		

11/24-18AD1. Mrs. W. E. Allen. Unused jetted well. Equipped with continuous pressure recorder. Water level, in feet above measuring point: May 26, 1948, 18.8 (well had been flowing continuously for several years at rate of 25 gallons per minute until 10 minutes prior to measurement).

Water level, at noon, in feet above measuring point, 1949

[From recorder charts]

Day	Month				
	August	September	October	November	December
1	------	21.3	23.0	23.3	24.6
2	------	20.8	23.0	23.4	24.6
3	------	20.9	22.9	23.3	24.6
4	------	21.7	22.9	23.6	24.5
5	------	21.9	23.0	24.0	24.5
6	------	22.6	21.3	24.2	24.5
7	------	21.5	21.3	24.2	24.5
8	------	22.2	21.3	24.3	24.5
9	------	22.7	21.6	24.4	24.5
10	------	22.6	21.9	24.4	24.4
11	------	22.5	21.7	24.6	24.5
12	------	22.5	21.7	24.5	24.5
13	------	22.6	21.6	24.4	24.5
14	------	22.8	21.4	24.5	24.5
15	------	22.7	21.5	24.6	24.5
16	------	22.7	21.4	24.7	24.5
17	------	22.7	21.4	24.6	24.6
18	------	22.9	21.2	24.7	24.6
19	------	22.9	21.3	24.6	24.6
20	20.7	22.9	21.8	24.6	24.6
21	20.7	23.0	22.4	24.6	24.6
22	20.8	23.2	23.0	24.6	24.6
23	20.7	23.0	24.0	24.6	24.6
24	21.0	23.1	23.4	24.6	24.6
25	21.0	23.0	23.5	24.6	24.6
26	20.9	23.0	23.5	24.6	24.6
27	20.7	23.0	23.4	24.7	24.6
28	21.2	23.0	23.4	24.7	24.6
29	20.8	23.0	23.4	24.7	24.6
30	21.2	23.0	23.3	24.6	24.6
31	21.2	------	24.0	------	24.6

Water level, at noon, in feet above measuring point, 1950

[From recorder charts]

Day	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	24.6	24.2	------	24.7	26.8	------	------	------	25.6	25.0	24.7	26.3
2	24.6	24.5	------	24.6	26.8	------	------	------	23.8	25.0	24.7	26.1
3	24.6	24.5	------	24.6	26.4	------	------	------	24.9	25.0	24.7	26.4
4	24.6	24.4	------	24.5	26.2	------	------	------	25.4	23.8	24.7	26.6
5	24.6	24.6	------	24.6	26.0	------	------	------	25.5	23.0	24.7	26.5
6	24.6	24.5	------	24.5	25.0	------	------	------	25.5	22.9	24.6	26.6
7	24.6	24.5	24.7	24.7	23.8	------	------	------	25.5	23.1	24.7	26.7
8	24.6	24.5	24.8	24.6	23.8	------	------	------	25.5	24.5	24.6	26.7
9	24.6	24.2	24.8	24.5	23.7	------	------	25.5	23.8	24.6	24.6	26.8
10	24.6	24.0	24.7	24.4	23.9	------	------	26.0	23.7	24.5	24.6	26.6
11	24.6	24.0	24.7	24.5	23.8	------	------	26.0	25.5	24.6	24.6	26.9
12	24.6	24.0	24.7	24.6	23.7	------	------	25.9	23.8	24.6	24.6	26.9
13	24.6	23.9	24.7	24.9	22.8	------	------	25.8	23.9	24.5	24.6	26.8
14	24.6	23.9	24.8	24.9	23.4	------	------	25.9	25.5	24.6	24.6	26.8
15	24.6	24.0	25.0	24.9	23.4	------	------	26.0	25.0	24.6	24.6	26.8
16	24.7	23.9	25.0	24.9	23.5	------	------	26.0	25.3	24.6	------	26.6
17	24.7	23.9	24.8	24.8	23.4	------	------	26.0	25.6	24.5	------	26.6
18	24.7	23.9	24.7	24.9	23.3	------	------	25.9	25.6	24.5	------	26.6
19	24.7	------	24.7	24.9	23.4	------	------	25.8	25.7	24.7	------	26.8
20	24.7	------	24.8	25.5	23.6	------	------	25.9	25.8	24.7	------	26.7
21	24.7	------	25.0	26.0	23.5	------	------	25.6	25.8	24.7	24.7	26.8
22	24.7	------	25.0	26.7	23.4	------	------	25.5	25.8	24.8	24.9	26.8
23	24.7	------	25.0	26.7	23.5	------	------	24.5	25.7	23.4	25.0	26.8
24	24.7	------	24.8	26.5	23.4	------	------	24.2	25.4	23.0	25.3	26.7
25	24.7	------	24.8	26.8	23.4	------	------	25.2	25.0	22.9	25.6	26.7
26	24.7	------	24.9	26.9	23.3	------	------	25.2	25.0	22.9	25.7	26.7
27	24.7	------	24.9	26.9	22.7	------	------	25.6	25.0	22.9	25.9	26.5
28	24.6	------	25.0	26.7	23.0	------	------	25.6	25.0	24.1	26.1	26.7
29	24.6	------	25.0	26.9	23.2	------	------	25.7	25.0	24.4	26.1	26.7
30	24.4	------	25.0	27.1	23.5	------	------	25.6	25.0	24.4	26.3	26.7
31	24.6	------	24.8	------	23.3	------	------	25.6	------	24.5	------	26.7

11/24–18AD2. C. G. Wines. Drilled domestic well. Measuring point, top of 1-inch pipe plug, 1.0 foot above land surface, 4,736.5 feet above mean sea level.

Water level, in feet above measuring point, 1948–49

Date	Water level	Date	Water level	Date	Water level
1948		*1948*		*1949*	
Mar. 3	31.6	Nov. 30	27.0	Aug. 17	21.8
May 26	26.4			Nov. 4	23.3
Nov. 2	25.8	*1949*			
		May 11	23.1		
		June 8	21.1		

11/24–18DA1. Mrs. Mary Harrison. Drilled domestic and irrigation well.

Water level, in feet above measuring point, 1948–50

Date	Water level	Date	Water level	Date	Water level
1948		*1950*		*1950*	
June 2	24.5	Mar. 30	25.7	Nov. 29	26.5
		Aug. 9	24.5		
1949		Sept. 28	24.3		
Mar. 10	26.2				
May 11	23.4				

11/24–19DA1. B. A. Harrison. Drilled domestic well. Equipped with jet-type pump and electric motor. Water levels, in feet above measuring point: June 2, 1948, 16.0; Nov. 2, 1948, 14.6; May 11, 1949, 10.5; June 8, 1949, 13.5.

11/24–21BC1. Hastings. Unused drilled domestic well. Water levels, in feet below measuring point: Mar. 31, 1948, 41.82; Nov. 30, 1948, 43.23; Jan. 31, 1949, 43.34; Mar. 10, 1949, 43.49.

11/24–22DC1. Fred Fulstone. Unused dug well. Equipped with Stevens Type F continuous recorder. Measuring point, top of floor of recorder shelter, 0.1 foot above concrete well curb, 0.7 foot above land surface, 4,889.2 feet above mean sea level.

Water level, at noon, after adjustment for barometric fluctuation, in feet below measuring point, 1948

[From recorder charts]

Day	May	June	July	August	September	October	November	December
1	----------	59.01	59.33	59.65	60.01	60.29	60.53	60.78
2	----------	59.02	59.33	59.66	60.02	60.30	60.57	60.78
3	----------	59.03	59.34	59.68	60.03	60.31	60.55	60.79
4	----------	59.03	59.34	59.69	60.04	60.32	60.56	60.80
5	----------	59.06	59.35	59.70	60.05	60.33	60.57	60.81
6	----------	59.08	59.37	59.71	60.06	60.33	60.58	60.82
7	----------	59.10	59.39	59.72	60.07	60.33	60.59	60.83
8	----------	59.10	59.40	59.73	60.08	60.33	60.61	60.92
9	----------	59.11	59.41	59.75	60.09	60.33	60.62	60.92
10	58.80	59.12	59.42	59.77	60.10	60.33	60.63	60.93
11	58.80	59.13	59.42	59.78	60.11	60.33	60.64	60.94
12	58.80	59.14	59.43	59.79	60.12	60.33	60.65	60.95
13	58.80	59.15	59.44	59.80	60.13	60.37	60.66	60.96
14	58.80	59.16	59.46	59.81	60.14	60.38	60.67	60.97
15	58.80	59.16	59.47	59.82	60.15	60.39	60.68	60.97
16	58.81	59.17	59.48	59.84	60.16	60.40	60.69	60.98
17	58.83	59.18	59.49	59.86	60.17	60.41	60.69	60.99
18	58.85	59.19	59.50	59.87	60.18	60.42	60.70	61.00
19	----------	59.20	59.51	59.88	60.18	60.43	60.70	61.00
20	----------	59.21	59.52	59.89	60.18	60.44	60.71	61.01
21	58.90	59.22	59.53	59.90	60.18	60.45	60.71	61.02
22	58.91	59.24	59.54	59.91	60.19	60.46	60.72	61.02
23	58.91	59.25	59.56	59.92	60.20	60.47	60.72	61.03
24	58.91	59.26	59.58	59.93	60.21	60.49	60.73	61.04
25	58.91	59.28	59.60	59.95	60.22	60.50	60.74	61.04
26	58.91	59.29	59.61	59.96	60.23	60.50	60.75	61.05
27	58.92	59.31	59.62	59.97	60.24	60.50	60.76	61.05
28	58.94	59.32	59.63	59.98	60.25	60.51	60.76	61.06
29	58.96	59.32	59.64	59.99	60.27	60.51	60.77	61.07
30	58.99	59.33	59.64	60.00	60.28	60.52	60.77	61.08
31	59.01	----------	59.65	60.01	----------	60.53	----------	61.09

Water level, at noon, after adjustment for barometric fluctuation, in feet below measuring point, 1949

[From recorder charts]

Day	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	61.10	61.27	61.53	61.73	61.93	62.12	61.99	62.26	62.45	62.63	62.81	62.94
2	61.10	61.28	61.53	61.74	61.94	62.12	62.00	62.26	62.45	62.64	62.82	62.94
3	61.10	61.29	61.54	61.75	61.94	62.11	62.01	62.27	62.46	62.65	62.83	62.94
4	61.11	61.31	61.54	61.76	61.95	62.10	62.03	62.27	62.46	62.65	62.84	62.94
5	61.11	61.32	61.55	61.77	61.95	62.08	62.04	62.28	62.47	62.66	62.84	62.94
6	61.11	61.33	61.55	61.78	61.96	62.07	62.05	62.29	62.47	62.66	62.85	62.94
7	61.12	61.35	61.55	61.79	61.96	62.06	62.06	62.30	62.48	62.67	62.85	62.94
8	61.12	61.36	61.56	61.80	61.97	62.05	62.07	62.30	62.49	62.67	62.86	62.93
9	61.12	61.37	61.56	61.80	61.98	62.03	62.08	62.30	62.50	62.68	62.86	62.93
10	61.13	61.39	61.56	61.81	62.01	62.02	62.09	62.31	62.51	62.68	62.87	62.92
11	61.13	61.40	61.57	61.82	62.02	62.00	62.10	62.32	62.51	62.69	62.87	62.91
12	61.14	61.41	61.57	61.82	62.03	61.98	62.11	62.33	62.52	62.69	62.88	62.83
13	61.15	61.42	61.58	61.83	62.04	61.96	62.12	62.34	62.53	62.69	62.88	62.73
14	61.16	61.42	61.59	61.83	62.05	61.91	62.12	62.35	62.53	62.70	62.89	62.60
15	61.17	61.43	61.59	61.84	62.06	61.92	62.13	62.36	62.54	62.70	62.89	62.48
16	61.18	61.43	61.60	61.84	62.06	61.90	62.14	62.37	62.54	62.70	62.90	62.39
17	61.19	61.44	61.61	61.85	62.07	61.90	62.14	62.37	62.55	62.71	62.90	62.30
18	61.19	61.44	61.62	61.86	62.07	61.90	62.15	62.38	62.56	62.71	62.91	62.20
19	61.20	61.45	61.62	61.86	62.08	61.91	62.16	62.39	62.56	62.72	62.91	62.10
20	61.20	61.45	61.63	61.87	62.09	61.91	62.17	62.39	62.57	62.72	62.91	62.01
21	61.20	61.46	61.64	61.87	62.10	61.91	62.17	62.40	62.57	62.73	62.92	61.87
22	61.21	61.47	61.65	61.88	62.11	61.91	62.18	62.41	62.58	62.73	62.92	61.70
23	61.21	61.48	61.65	61.89	62.12	61.91	62.18	62.41	62.58	62.74	62.92	61.50
24	61.21	61.49	61.66	61.90	62.12	61.91	62.19	62.42	62.59	62.74	62.93	61.41
25	61.22	61.50	61.67	61.90	62.12	61.92	62.20	62.42	62.59	62.75	62.93	61.33
26	61.23	61.51	61.68	61.91	62.11	61.93	62.20	62.43	62.60	62.76	62.93	61.27
27	61.23	61.52	61.69	61.91	62.11	61.94	62.21	62.43	62.61	62.77	62.93	61.20
28	61.24	61.52	61.70	61.92	62.11	61.95	62.22	62.44	62.61	62.78	62.94	61.13
29	61.24	-------	61.70	61.92	62.11	61.96	62.23	62.44	62.62	62.78	62.94	61.08
30	61.25	-------	61.71	61.93	62.12	61.98	62.24	62.45	62.62	62.79	62.94	61.03
31	61.26	-------	61.72	-------	62.12	-------	62.25	62.45	-------	62.80	-------	60.98

Water level, at noon, after adjustment for barometric fluctuation, in feet below measuring point, 1950

[From recorder charts]

Day	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	60.90	60.50	59.28	60.31	60.93	61.01	61.33	61.58	61.70	61.77	61.88	61.35
2	60.90	60.40	59.33	60.32	60.94	61.02	61.34	61.59	61.70	61.77	61.88	61.27
3	60.90	60.29	59.38	60.34	60.96	61.03	61.35	61.60	61.70	61.78	61.89	61.20
4	60.90	60.22	59.40	60.35	60.98	61.03	61.36	61.60	61.70	61.78	61.89	61.18
5	60.90	60.17	59.43	60.36	60.98	61.04	61.37	61.61	61.70	61.78	61.90	61.10
6	60.87	60.18	59.45	60.38	60.98	61.05	61.38	61.61	61.70	61.79	61.90	61.00
7	60.83	60.18	59.49	60.40	60.98	61.07	61.39	61.62	61.70	61.79	61.91	60.91
8	60.81	60.15	59.52	60.43	60.96	61.09	61.40	61.62	61.70	61.80	61.91	60.87
9	60.82	60.05	59.57	60.52	60.91	61.10	61.41	61.63	61.70	61.80	61.92	60.83
10	60.83	59.95	59.62	60.58	60.85	61.12	61.42	61.63	61.71	61.81	61.92	60.73
11	60.84	59.88	59.67	60.58	60.83	61.13	61.43	61.63	61.71	61.81	61.92	60.65
12	60.86	59.78	59.73	60.58	60.80	61.14	61.43	61.64	61.71	61.81	61.92	60.53
13	60.89	59.64	59.77	60.62	60.77	61.15	61.44	61.64	61.72	61.82	61.92	60.37
14	60.92	59.50	59.81	60.66	60.74	61.16	61.44	61.65	61.72	61.82	61.91	60.26
15	60.94	59.35	59.85	60.69	60.74	61.17	61.45	61.65	61.72	61.83	61.91	60.16
16	60.95	59.23	59.88	60.70	60.75	61.17	61.46	61.65	61.73	61.83	61.91	60.04
17	60.98	59.12	59.91	60.71	60.77	61.18	61.47	61.66	61.73	61.83	61.91	59.91
18	61.00	59.05	59.95	60.73	60.80	61.19	61.48	61.66	61.74	61.83	61.91	59.74
19	61.04	58.97	59.99	60.74	60.82	61.20	61.49	61.66	61.74	61.83	61.91	59.62
20	61.06	58.97	59.99	60.76	60.84	61.21	61.49	61.66	61.74	61.84	61.92	59.52
21	61.08	58.98	60.00	60.78	60.85	61.23	61.50	61.66	60.75	61.84	61.92	59.46
22	61.09	58.99	60.01	60.79	60.87	61.24	61.51	61.66	61.75	61.84	61.91	59.41
23	61.09	59.02	60.02	60.80	60.89	61.26	61.52	61.67	61.75	61.85	61.90	59.36
24	61.08	59.06	60.02	60.82	60.91	61.27	61.53	61.67	61.75	61.85	61.87	59.29
25	61.06	59.09	60.06	60.83	60.93	61.29	61.53	61.67	61.75	61.85	61.76	59.21
26	60.98	59.12	60.16	60.85	60.94	61.30	61.54	61.67	61.76	61.86	61.69	59.14
27	60.80	59.16	60.18	60.87	60.96	61.31	61.54	61.68	61.76	61.86	61.65	59.08
28	60.72	59.22	60.23	60.89	60.98	61.31	61.55	61.68	61.76	61.86	61.58	59.01
29	60.67	-------	60.26	60.91	60.99	61.32	61.55	61.69	61.76	61.87	61.48	58.92
30	60.60	-------	60.30	60.92	61.00	61.33	61.56	61.69	61.77	61.87	61.42	58.83
31	60.57	-------	60.31	-------	61.00	-------	61.57	61.69	-------	61.88	-------	58.73

11/24–27CB1. J. C. Sanders. Dug domestic well. Equipped with jet-type pump and electric motor. Water levels, in feet below measuring point: Mar. 3, 1948, 22.24; Mar. 10, 1949, 26.70; Aug. 29, 1950, 19.60.

11/24–27CC1. A. A. Chisholm. Drilled domestic well. Equipped with jet-type pump and electric motor.

Water level, in feet below measuring point, 1948–50

Date	Water level	Date	Water level	Date	Water level
1948		*1949*		*1950*	
Mar. 3	38.73	May 19	44.06	Mar. 30	42.47
Mar. 31	39.47	May 31	43.48	June 13	42.37
May 10	41.12	June 8	43.22	Aug. 29	39.75
May 24	41.07	Aug. 22	42.42	Sept. 28	39.07
1949		Dec. 21	41.18	Nov. 29	39.29
Mar. 9	42.64				
May 11	44.30				

11/24-32AB1. Mrs. Nellie Albright. Drilled domestic well. Equipped with centrifugal pump and electric motor.

Water level, in feet below measuring point, 1948-50

Date	Water level	Date	Water level	Date	Water level
1948		*1948*		*1949*	
Mar. 29	1.74	Aug. 5	[1] 4.75	Aug. 22	[1] 6.92
May 10	[2] 4.81	Nov. 2	2.85	Nov. 4	4.28
May 24	3.45	Nov. 30	2.88		
May 27	3.15			*1950*	
June 16	3.06	*1949*		Mar. 30	5.11
June 30	3.32	Jan. 31	3.35	May 26	[1] 3.25
July 21	3.40	Mar. 10	3.61	Aug. 17	4.60
		May 11	[1,2] 7.06	Sept. 28	4.16
		May 11	[1,3] 6.61	Nov. 29	3.70

[1] Well 11/24-32DC1 pumping at rate of about 900 gpm.
[2] Pumping at rate of few gallons per minute.
[3] Pump shut off 10 minutes.

11/24-32DC1. A. Nuti. Drilled irrigation well. Equipped with deep-well turbine pump and 40-horsepower direct-drive electric motor.

Water level, in feet below measuring point, 1948-50

Date	Water level	Date	Water level	Date	Water level
1948		*1948*		*1949*	
Mar. 3	26.52	July 15	32.69	Nov. 4	30.66
May 24	30.92	July 21	32.77		
May 27	30.56	Nov. 30	32.52	*1950*	
June 2	30.88			Mar. 30	31.50
June 30	33.90	*1949*		Aug. 18	31.00
		Jan. 31	32.94	Sept. 28	30.23
		Mar. 9	33.36	Nov 29	29.92

11/24-33CC1. S. Maritorena. Unused drilled domestic well. Equipped with jet-type pump and electric motor.

Water level, in feet below measuring point, 1949

Date	Water level	Date	Water level	Date	Water level
Apr 19	57.94	June 8	57.90	Aug. 17	[2] 56.44
May 11	[1] 59.64	July 6	57.14		

[1] Well 11/24-32DC1 pumping about 900 gpm and well 10/24-4CD1 pumping about 750 gpm.
[2] Well 11/24-32DC1 pumping about 900 gpm.

11/24-34DB1. E. J. Alpers. Unused drilled well. Depth to water, in feet below measuring point: May 26, 1948, 85.72; Aug. 23, 1948, 86.78; Dec. 21, 1949, 88.82.

12/23–10BC1. A. Castaing. Drilled stock well. Water levels, in feet above land surface: Oct. 21, 1948, 32.0 (after stopping flow for 20 minutes); Mar. 10, 1949, 32.0 (after 20 minutes); Aug. 22, 1949, 33.3 (after 40 minutes); Aug. 9, 1950, 23.2 (after 5 minutes), 27.1 (after 10 minutes), 30.5 (after 20 minutes), 33.0 (after 40 minutes).

12/23–22AC3. S. H. Hunnewill. Drilled stock well.

Water level, in feet above measuring point, 1948–50

Date	Water level	Date	Water level	Date	Water level
1948		*1949*		*1950*	
Aug. 6	7.0	June 8	7.2	Sept. 28	7.0
		Aug. 22	6.8	Nov. 29	8.2
1949					
Jan. 31	7.4				

12/24–30CD1. Unused drilled well.

Water level, in feet below measuring point, 1948–50

Date	Water level	Date	Water level	Date	Water level
1948		*1949*		*1950*	
May 28	47.95	June 8	49.42	June 26	50.08
June 30	48.30	Aug. 22	49.84	Aug. 9	50.04
Nov 30	48.78	Nov. 4	49.90	Sept. 28	49.83
				Nov. 29	49.86
1949		*1950*			
Jan. 31	48.70	Mar. 30	49.37		
Mar. 10	48.77	May 26	49.52		

LOGS OF WELLS

[See Description of wells (pp. 63–71) for other details of wells]

10/23–2DD2. Barbara Carlson. Domestic well, perforated from 20 to 40 feet with ⅛-inch wide slots. First water at 33 feet; static level at 18 feet; temperature, warm; yield, 30 gpm by bailer test. Drilled by Harvey Meyer, Carson City, Nev. Completed Oct. 29, 1947. Driller's log.

	Thickness (feet)	*Depth (feet)*
Clay, dark	2	2
Clay, yellow, sandy	24	26
"Hardpan"	7	33
Sand and gravel	7	40
Total	------	40

10/24–4CD1. Herb Rowntree. Irrigation well; casing diameter, 14 inches, to 100 feet, 12 inches from 100 to 250 feet; factory perforated with ³⁄₁₆- by 2-inch openings. First water at 43 feet; static level at 38 feet. Drilled by Scott Bros. Drilling Co., Bakersfield, Calif. Completed July 1948. Driller's log.

	Thickness (feet)	*Depth (feet)*
Sand	18	18
Rock	2	20
Sand	8	28
Clay	7	35
Sand and gravel	8	43
Sand; water	22	65
Rock	5	70
Sand	10(?)	80(?)
Rock and coarse gravel	7	87(?)
Sand and gravel	31(?)	118(?)
Rock	2	120(?)
Clay, sandy	10	130(?)
Sand and gravel; water	18	148(?)
Gravel, coarse, and rock	4	152(?)
Rock	4	156(?)
Sand, coarse, and gravel	62	218(?)
Sand, hard	12	230(?)
Sand, coarse	10	240(?)
Sand, hard, and hard rock	10	250(?)
Total depth	------	250(?)

NOTE.—Thickness and depth figures in driller's log could not be reconciled. Adjustments of thickness figures between depths of 70 and 118 feet were made to arrive at above figures.

11/23-3DC1. R. B. Day. Irrigation well; casing diameter, 12 inches, to 266 feet; factory perforations from 101 to 266 feet, with 3/16- by 2-inch slots. First water at 66 feet; static level at 38 feet. Drilled by Scott Bros. Drilling Co., Bakersfield, Calif. Completed July 1948. Driller's log.

	Thickness (feet)	*Depth (feet)*
Sand and gravel, coarse	25	25
Gravel	41	66
Sand and gravel, coarse	22	88
Sand, coarse	22	110
Sand, hard	22	132
Sand, loose; water	22	154
Sand, fine	22	176
Sand, loose	22	198
Sand, with streaks of blue clay	12	210
Sand, loose	10	220
Sand, fine	7	227
Clay	7	234
Sand, coarse, with some rock	6	240
Sand, coarse, and gravel	15	255
Clay and gravel, streaks of	7	262
Sand and rock, hard	10	272
Rock, hard, basement	3	275
Total depth	------	275

11/24–18AA2. Nevada Fish and Game Commission. Fish-rearing supply well; casing diameter, 8 inches, to 48 feet. No perforations. First water at 5 feet; well flows. Drilled by J. B. Reynolds, Fallon, Nev. Completed Mar. 27, 1948. Driller's log.

	Thickness (feet)	*Depth (feet)*
Topsoil	5	5
Sand, coarse	12	17
Gravel	6	23
Clay, blue	46	69
Sand, and gravel	19	88
Total depth	------	88

11/24–18AA3. Nevada Fish and Game Commission. Fish-rearing supply well; casing diameter, 8 inches, to 41 feet. No perforations. First water at 5 feet; well flows. Drilled by J. B. Reynolds, Fallon, Nev. Completed April 5, 1948. Driller's log same as for well 11/24–18AA2.

11/24–18AA4. Nevada Fish and Game Commission. Fish-rearing supply well; casing diameter, 8 inches, to 34 feet. No perforations. Drilled by J. B. Reynolds, Fallon, Nev. Completed April 12, 1948. Driller's log same as for well 11/24–18AA2.

11/24–18AA5. Nevada Fish and Game Commission. Fish-rearing supply well; casing diameter, 8 inches, to 41 feet; 6-inch casing inside 8-inch casing 0 to 103 feet. No perforations. First water at 8 feet; well flows. Drilled by J. B. Reynolds, Fallon, Nev. Completed April 24, 1948. Driller's log.

	Thickness (feet)	*Depth (feet)*
Topsoil	8	8
Sand	14	22
Clay, gray	48	70
Sand	9	79
Clay, gray	16	95
Gravel and sand	8	103
Total depth	------	103

11/24–18AA6. Nevada Fish and Game Commission. Fish-rearing supply well; casing diameter, 8 inches, to 53 feet, 6-inch casing inside 8-inch casing 0 to 212 feet; perforated from 162 to 178 feet with ⅜- by 2½-inch slots. First water at 3 feet 6 inches; flow, 45 gpm. Drilled by J. B. Reynolds, Fallon, Nev. Completed Feb. 27, 1949. Driller's log.

	Thickness (feet)	*Depth (feet)*
Sand	22	22
Clay	45	67
Sand; small flow of water	17	84
Gravel, clay, and sand	34	118
Clay, hard	6	124
Sandstone	5	129
Clay, brown	35	164

	Thickness (feet)	*Depth (feet)*
Gravel; artesian flow	14	178
Sand	7	185
Clay	4	189
Sand	2	191
Clay, brown	21	212
Sand; flows at 5 gpm	7	219
Total depth	------	219

11/24–20DB1. Chas. W. Hinds. Domestic well; casing diameter, 4 inches, to 140 feet. Static level at 42 feet. Drilled by Allen Bros., Smith, Nev. Completed Aug. 28, 1948. Driller's log.

	Thickness (feet)	*Depth (feet)*
"Surface dirt"	18	18
Gravel	7	25
Sand	10	35
"Hardpan"	3	38
Sand and gravel	69	107
Clay, white and blue	33	140
Total depth	------	140

11/24–30CB2. Howard Wilkerson. Domestic well; casing diameter 6 inches, to 170 feet. No perforations. Water coming from small layers of very fine sand below 160 feet. First water at 15 feet; flow estimated between 30 and 50 gpm. Static head approximately 14 feet. Drilled by Mel Meyer, Carson City, Nev. Completed April 25, 1949. Driller's log.

	Thickness (feet)	*Depth (feet)*
Topsoil	15	15
Sand, coarse	17	32
Sand, fine	21	78
Clay, blue	36	114
Sand, fine blue	40	154
Clay, blue	6	160
Clay, sandy, blue	10	170
Total depth	------	170

11/24–32DC1. A. Nuti. Irrigation well; original depth 342 feet. Casing diameter, 16 inches, to 295 feet; uncased 295 to 342 feet; perforated from 92 to 100, 104 to 112, 120 to 125, 170 to 175, 190 to 212, 225 to 242, 270 to 285, and 293 to 295 feet with ½- by 3-inch slots, 10 slots per round, 9-inch spacing between rounds. First water at 20 feet; static level at 26 feet. Well completed and test pumped Mar. 30, 1948 at 1,050 gpm with a drawdown of 33 feet.

After pumping about 6 weeks, well caved, and sand filled casing to within 140 feet of surface. Casing settled about 2 feet, and land surface sank within a 10-foot radius of well.

Well cleaned and deepened on June 29, 1948 to 390 feet. Casing liner, 12 inches in diameter, installed from 105 to 390 feet; perforated from 150 to 390 feet with ¼- by 3-inch slots, 12 slots per round, 3-inch spacing between rounds. Yield Aug. 5, 1948, 900 gpm with a drawdown of more than 45 feet. Drilled and deepened by R. L. Norris and Son, Reno, Nev. Driller's log.

	Thickness (feet)	Depth (feet)
Sand	4	4
Clay, sandy	2½	6½
Clay; some gravel	13½	20
Clay, brown, and sand	8	28
Quicksand	22	50
Sand, coral	12	62
Sand, fine	4	66
Sand, fine, and mud; some clay	2	68
Sand, fine, and streaks of clay	10	78
Clay	16	94
Gravel, small, and clay	4	98
Sand, fine, and clay	6	104
Gravel, (3-inch)	1	105
Clay	2	107
Quicksand	3	110
Gravel	2	112
Clay, brown, streaked with red clay and gravel	8	120
Gravel, small, and sand	3	123
Clay, brown, streaked with gravel	22	145
Clay, brown, showing of fine gravel	19	164
Clay, brown	10	174
Gravel and sand, coarse	½	174½
Clay, sandy	10½	185
Clay, brown	8	193
Gravel, coarse	4	197
Gravel, fine, and sand; showing of black sand	13	210
Clay and sandy shale, small streaks of clay (dry)	14	224
Clay	2	226
Gravel, coarse (1-inch); streaks of cemented gravel with soft spots	6	232
Gravel, cemented	2	234
Clay, light-gray	6	240
Gravel, coarse, and clay (sticky)	2	242
Clay	8	250
Clay and sand	18	268
Clay and small gravel	5	273
Gravel	10	283
Clay and small gravel	9	292
Clay (sticky)	3	295
Gravel, 1-inch, smooth	2	297
Clay (sticky)	13	310
Clay	3	313
Sand, tight-packed	6	319
Clay, sandy	9	328
"Hard cropping"	2	330
Gravel, firm	3	333
Sand, loose brown	9	342
Sand	5	347
Clay, hard yellow	5	352
Gravel, coarse	36	388
Clay	2	390
Total depth	----	390

The following log of well 11/24–32DC1 is by D. A. Phoenix, geologist, U. S. Geological Survey, determined from samples submitted by driller.

	Thickness (feet)	Depth (feet)
Soil, sandy	5	5
Silt; 10 percent sand	23	28
Sand, fine	24	52
Silt and fine sand; 10 percent gravel	10	62
Sand, fine to medium	18	80
Clay, light-gray, chalky	19	99
Silt, light-brown; 10 percent grit	5	104
Gravel, coarse	3	107
Silt and clay; 5 percent pebbles	1	108
Sand, fine to medium	2	110
Gravel, fine; subrounded to round	13	123
Clay and silt, light-brown; 2 percent pebbles	22	145
Clay, light-brown	19	164
Silt and fine sand, light-brown	21	185
Silt and clay, light-brown	7	192
Gravel, coarse; fine to coarse sand; rounded to subrounded gravel.	5	197
Sand, fine	13	210
Sand, fine, medium, and coarse	13	223
Gravel, coarse	8	231
Silt and clay, mica flakes	9	240
Gravel, medium	2	242
Silt and clay, chocolate-brown	26	268
Silt and clay; 10 percent gravel	24	292
Silt, light-yellow	3	295
Gravel, coarse	2	297
Silt and clay, light-yellow	13	310
Silt and clay, light-brown	3	313
Clay, silt, and fine sand	6	319
(Sample missing)	9	328
Gravel, fine	14	342
Total depth	------	342

11/24–33CC1. S. Maritorena. Domestic and stock well; casing diameter, 6 inches, to 168 feet; perforated from 89 to 166 feet with ¼- by 6-inch openings. First water at 79 feet; static level at 60 feet; yield, 15 gpm by bailer test. Drilled by Mel Meyer, Reno, Nev. Completed March 11, 1949. Driller's log.

	Thickness (feet)	Depth (feet)
Clay, red sandy	79	79
Sand; water	11(?)	92
Clay, coarse sandy	16	108
Clay, sandy	20(?)	132
Clay, coarse	24	156
Sand, coarse; water	12	168
Total depth	------	168

NOTE.—Two discrepancies between figures for thickness of material and depth are apparent. It is believed that the thickness figures are computed figures, in which case the depth figures are more likely to be correct.

12/23–22AC1. S. H. Hunnewill. Domestic well; casing diameter, 6 inches, to 78 feet; casing perforated from 66 to 78 feet with ⅛-inch wide slots. Static level at 31 feet; yield, 20 gpm by bailer test. Drilled by Harvey Meyer, Carson City, Nev. Completed Sept. 1947. Driller's log.

	Thickness (feet)	*Depth (feet)*
"Hardpan"	4	4
Yellow clay	28	32
Sand; water	4	36
Granite sand	42	78
Total depth	------	78

12/23–22AC3. S. H. Hunnewill. Domestic and stock well; casing diameter, 6 inches, to 46 feet; perforated from 23 to 46 feet with ⅛-inch wide slots. Flow 35 gpm. Drilled by Harvey Meyer, Carson City, Nev. Completed Sept 16, 1947. Driller's log.

	Thickness (feet)	*Depth (feet)*
Clay, yellow	12	12
Sand; little water	2	14
Clay, sandy blue	36	50
Total depth	------	50

12/23–27AA1. S. H. Hunnewill. Domestic well; casing diameter, 6 inches, to 87 feet; perforated from 60 to 70 feet, and from 77 to 87 feet with ⅛-inch wide slots. Plugged and cemented, 85 to 100 feet. First water at 4 feet; static level at 7 feet; yield, 25 gpm. Drilled by Harvey Meyer, Carson City, Nev. Completed Apr. 17, 1948. Driller's log.

	Thickness (feet)	*Depth (feet)*
Loam, dark	4	4
Sand; water	2	6
Clay, sandy	20	26
"Hardpan"	2	28
Clay, sandy	7	35
Sand; water	39	74
Sand	13	87
Sand, fine	13	100
Total depth	------	100

12/23–27CD1. Leon Grivel. Domestic well, depth 95 feet. Casing diameter, 6 inches, to 94 feet. No perforations. First water at 7 feet; static level at 15 feet. Approximately 20 cubic yards of fine sand and clay removed during development with compressed air. Yield, 30 gpm, Sept. 29, 1948.

Well deepened Oct. 23, 1948, to 279 feet. Casing diameter, 6 inches to 259 feet. No perforations. Flowed about 20 gpm. Sand filled casing to within 200 feet of surface after a few weeks of pumping and well ceased to flow.

Feb. 2, 1949, well cleaned and casing liner 4 inches in diameter installed from 171 to 279 feet; perforated from 259 to 279 feet with ¼- by 6-inch slots. Six-inch casing also perforated from 93 to 100 feet with ¼- by 6-inch slots. Static level at 2 feet. Drilled and deepened by Mel Meyer, Reno, Nev. Driller's log.

	Thickness (feet)	Depth (feet)
"Surface soil"	5	5
Clay, sandy, blackish	20	25
Clay	3	28
Clay, sandy	32	60
Sand	5	65
Sand, hard	15	80
Sand (tule), very little clay	3	83
Clay (tule)	3	86
Clay, brown	3	89
Clay, brown, and sand	3	92
Sand, coarse	3	95
Sand, "quick"	91	186
Gravel, fine	20	206
Clay, blue	9	215
Sand and clay	18	233
Sand, brown; water	2	235
Clay, brown sandy	7	242
Clay, blue	3	245
Clay, brown sandy	34	279
Total depth	------	279

12/23-35DA1. G. C. Smith. Domestic and stock well; casing diameter, 3 inches, to 208 feet. No perforations. First water at 208 feet; flow, 4 gpm. Drilled by owner. Completed Dec. 1, 1948. Driller's log.

	Thickness (feet)	Depth (feet)
Loam, sandy	30	30
Sand	12	42
Clay	8	50
Sand	150	200
Clay	8	208
Sand; water	2	210
Silt, tight	6	216
Sand; water	2	218
"Hardpan"	4	222
Sand; water	2	224
"Hardpan"	1	225
Sand; water	4	229
Total depth	------	229

13/24-16CD1. U. S. Bureau of Land Management ("Snyder" well). Stock well; casing diameter, 6 inches, to 280 feet; perforated from 260 to 280 feet. First water at 246 feet; static level, 235 feet. Drilled by owner. Completed Dec. 29, 1939. Driller's log.

	Thickness (feet)	Depth (feet)
Boulders, hard, in pinkish-brown formation	69	69
Sand	3	72
Ground, hard black dry	6	78
Gravel, black fine	1	79
Gravel, black coarse	2	81
Sandstone, hard yellow	3	84
Sandstone, brown (softer mixture)	1	85
Hard reddish-brown formation	27	112
Water strata	1	113
Clay, light-colored	3	116
Clay, light-colored, mixed with gravel	14	130
Gravel, loose	3	133
Boulders, hard, in pinkish-brown formation	7	140
Clay, light-colored, mixed with gravel	24	164
Sand, dry muddy	7	171
Hard dark-brown formation	46	217
Light-brown formation	5	222
Dark-brown fine formation	2	224
Sand, very fine brown, with two thin strata of coarser sand	61	285
Total depth	------	285

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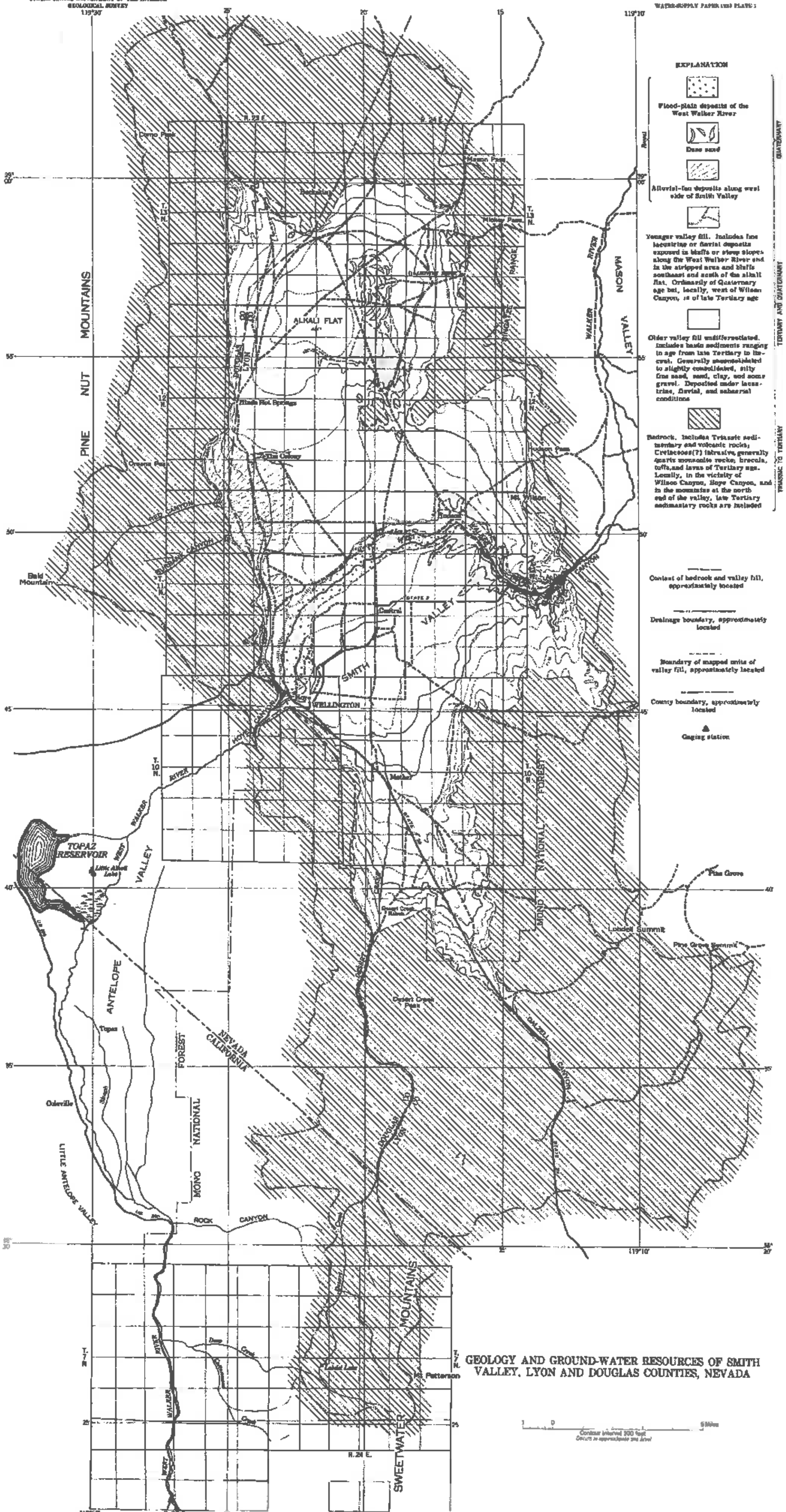
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-SUPPLY PAPER 1183 PLATE 1



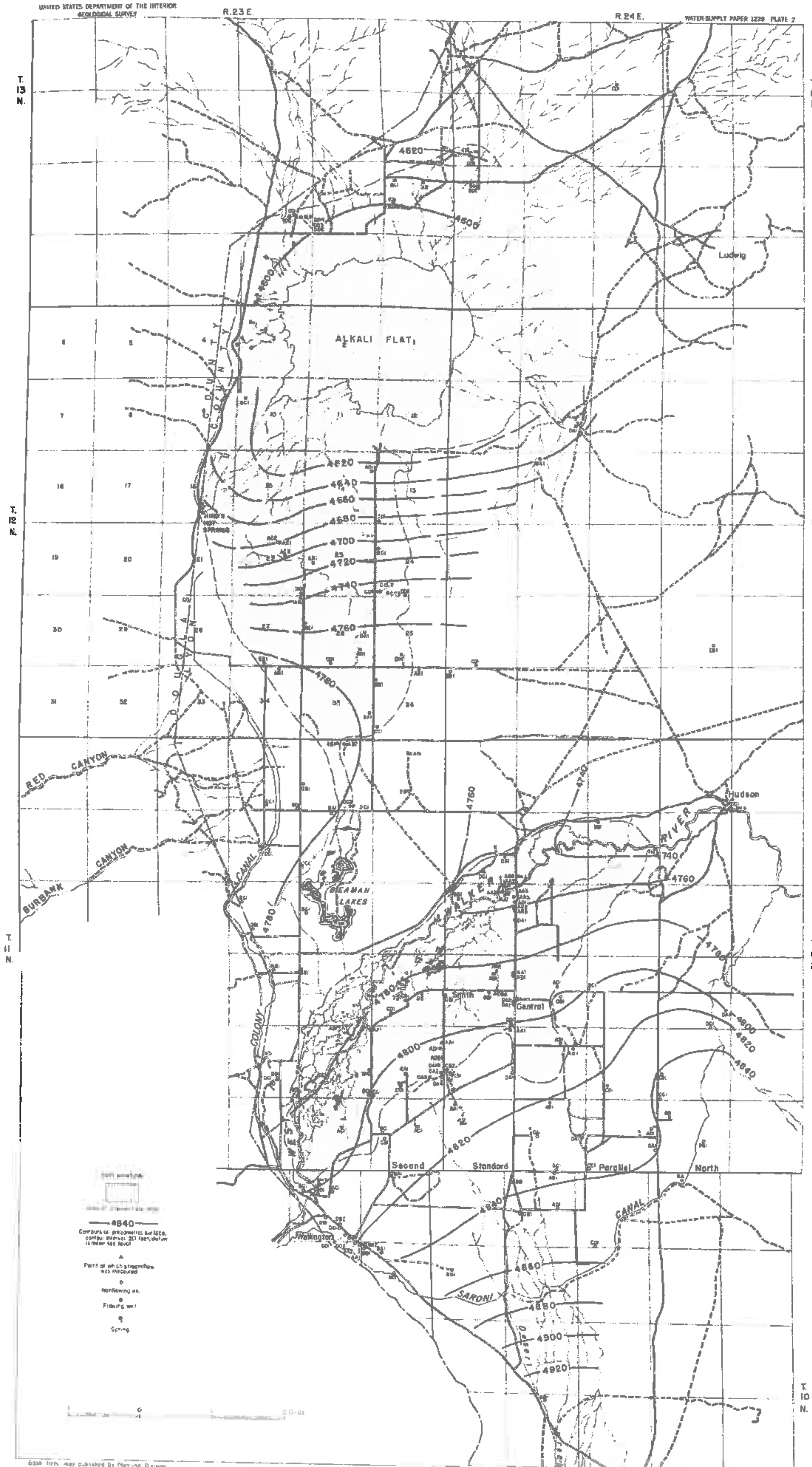
GEOLOGY AND GROUND-WATER RESOURCES OF SMITH VALLEY, LYON AND DOUGLAS COUNTIES, NEVADA

Base from U. S. Geological Survey topographic maps

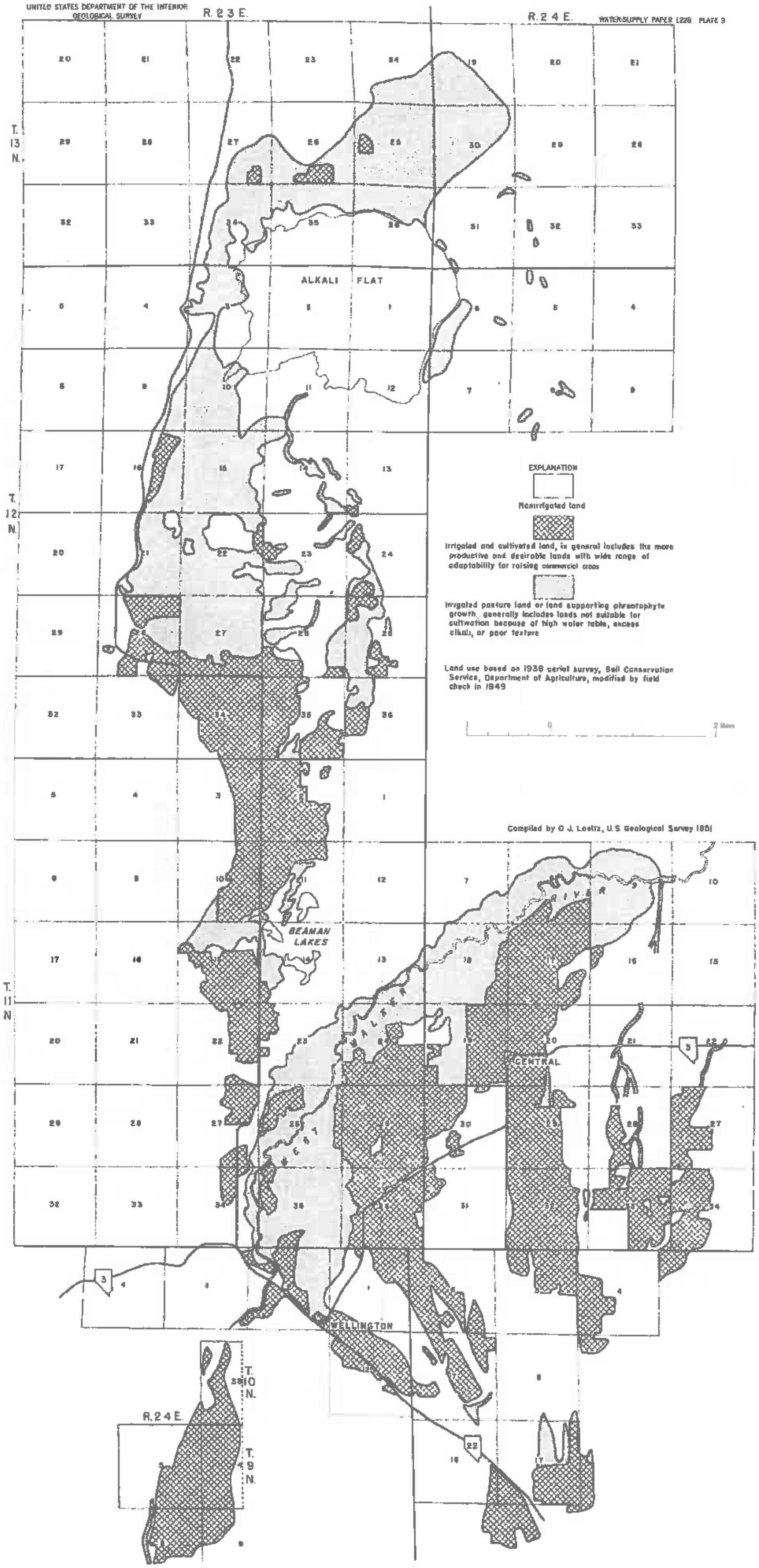
Geology by T. E. Eakin

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-SUPPLY PAPER 1228 PLATE 2



MAP OF SMITH VALLEY, LYON AND DOUGLAS COUNTIES, NEVADA, SHOWING LOCATION OF WELLS AND SPRINGS, PIEZOMETRIC SURFACE, AND AREA OF ARTESIAN FLOW, 1950



MAP OF SMITH VALLEY, LYON AND DOUGLAS COUNTIES, NEVADA, SHOWING LAND USE, 1949

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EXHIBIT D

Exhibit F – Diagram of Artesian Flow and Potentiometric Surface

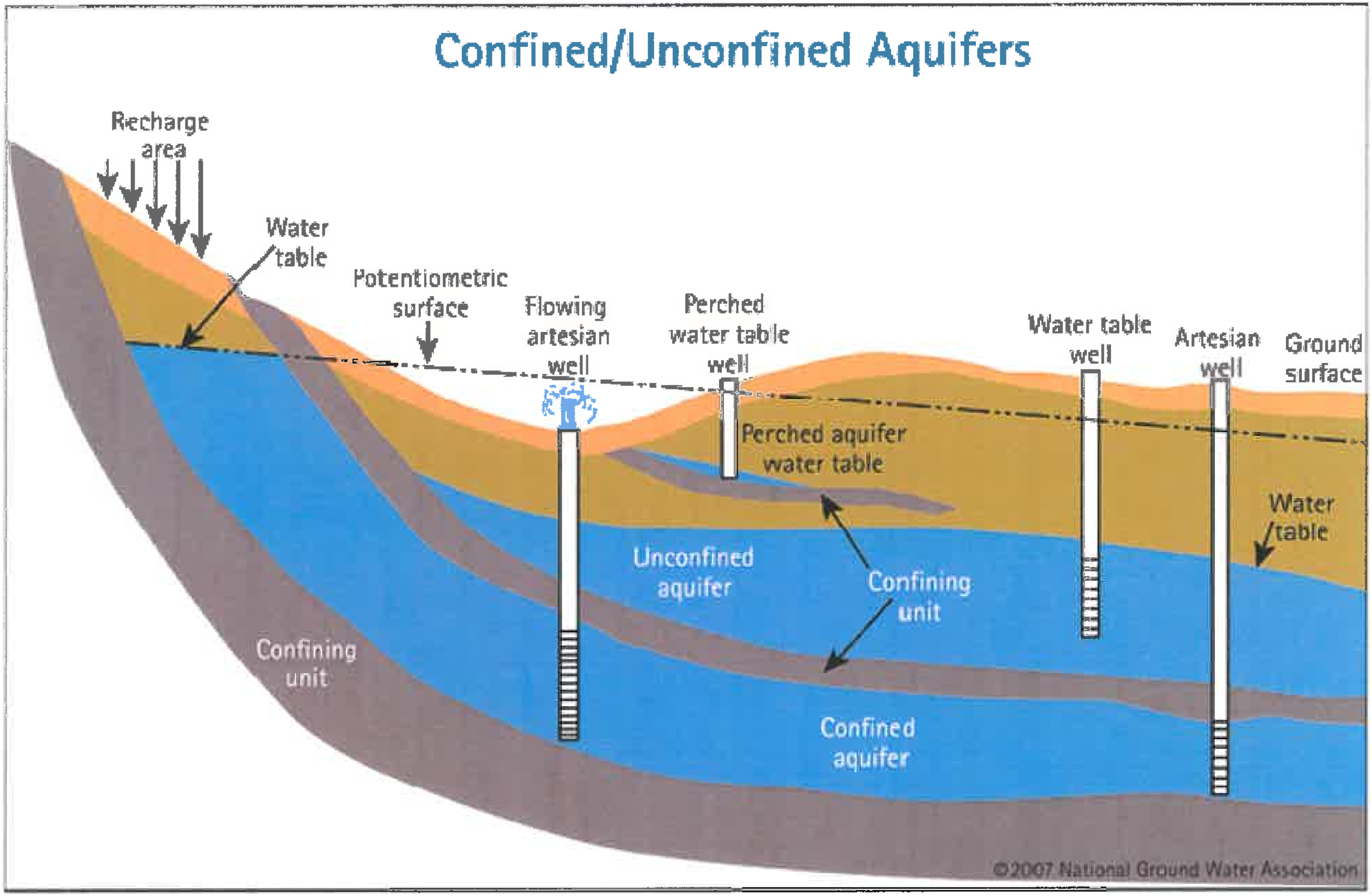

EXHIBIT E

STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

DIVISION OF WATER RESOURCES

WATER RESOURCES BULLETIN NO. 43

GEOHYDROLOGY OF SMITH VALLEY, NEVADA, WITH SPECIAL REFERENCE TO THE WATER-USE PERIOD, 1953-72

By

F. E. RUSH

and

C. V. SCHROER

Prepared cooperatively by the

United States Department of the Interior

GEOLOGICAL SURVEY

1976

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES

GEOHYDROLOGY OF SMITH VALLEY, NEVADA, WITH SPECIAL REFERENCE TO THE WATER-USE PERIOD, 1953-72

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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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TABLES

CONVERSION FACTORS

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

English unit	Metric unit	Multiplication factor to convert from English to metric quantity
Acres	Square metres (m^2)	4,050
Acre-feet (acre-ft)	Cubic metres (m^3)	1,230
Cubic feet per second (cfs)	Litres per second (l/s)	28.3
Do.	Cubic metres per second (m^3/s)	.0283
Feet (ft)	Metres (m)	.305
Gallons	Litres (l)	3.78
Gallons per minute (gpm)	Litres per second (l/s)	.0631
Inches (in)	Millimetres (mm)	25.4
Miles (mi)	Kilometres (km)	1.61
Square miles (mi^2)	Square kilometres (km^2)	2.59

GEOHYDROLOGY OF SMITH VALLEY, NEVADA, WITH SPECIAL REFERENCE TO THE WATER-USE PERIOD, 1953-72

By F. E. Rush and C. V. Schroer

ABSTRACT

The principal source of water for Smith Valley is the West Walker River. Most ground-water replenishment is infiltration from cropland and canals.

The average annual inflow of the West Walker River for the period of record (1958-72) was 179,000 acre-feet; outflow was 133,000 acre-feet. The amount of water stored in the upper 100 feet of saturated alluvium is about 1,500,000 acre-feet.

Most waters sampled were suitable for their intended use, but fluoride and arsenic concentrations in many samples were higher than desirable if these waters were to be used for human consumption.

About 160,000 acre-feet of water moved through the hydrologic system in 1972. Of this amount, 46,000 acre-feet was consumed by irrigation, although 93,000 acre-feet reached the irrigated areas. During 1972, a ground-water pumpage of 20,000 acre-feet contributed to a ground-water storage depletion of 6,000 acre-feet.

The system yield is estimated to be 62,000 acre-feet per year. About 9,000 acre-feet per year of ground water and 6,000 acre-feet per year of surface water remain to be developed in the Artesia Lake area.

The conjunctive-use volume during near normal years is about 90,000 acre-feet.

INTRODUCTION

Purpose and Scope

This is the second report on the hydrology of Smith Valley prepared by the U.S. Geological Survey in cooperation with the Office of the State Engineer. The first report was made by Loeltz and Eakin (1953) and described conditions in the valley as of 1950.

This study of the geohydrology of Smith Valley is concerned principally with the effects of water use on the hydrologic system for the period 1953 to 1972. The purposes of the study are to define the geohydrology, the effects of water use since 1953, the effects during the calendar year 1972, and the effects that might be expected with continued increase in water use and consumption.

The scope of the report includes: (1) a description of the geohydrologic setting, (2) appraisal of the elements of inflow and outflow in the hydrologic system, (3) a description of the surface-water supply and the ground-water storage systems, (4) estimation of surface-water and ground-water use, (5) effects of this use on the hydrologic system, (6) definition of the chemical character of water, and (7) an evaluation of future water supply and effects of its development.

The field work began in October 1970 and has been conducted intermittently through the winter of 1973-74. The year 1972 is the base year for water budgets developed in this study.

The numbering system used for hydrologic sites is explained in the appendix.

Location and General Features

Smith Valley is in the central part of the Walker River drainage basin of Nevada and California, as shown in figure 1. Most of the flow in the river is generated in the Sierra Nevada from melting snow. The river terminates at Walker Lake, a remnant of ancient (Pleistocene) Lake Lahontan. The north boundary of the valley is 40 miles southeast of Reno. Mountains that generally range in altitude from 6,000 feet to over 10,000 feet surround the valley. The highest peak in the area is Mt. Patterson, at the south end of the basin. The lowest point in the valley is Artesia Lake. The West Walker River crosses Smith Valley from west to east (fig. 1). Smith, a small community near the center of the valley, is at an altitude of 4,780 feet. The valley has an area of about 479 square miles (Rush, 1968, p. 19).

The population of the valley in 1972 was between 300 and 500. Most people's employment is directly or indirectly related to the approximate 80 farming and ranching units.

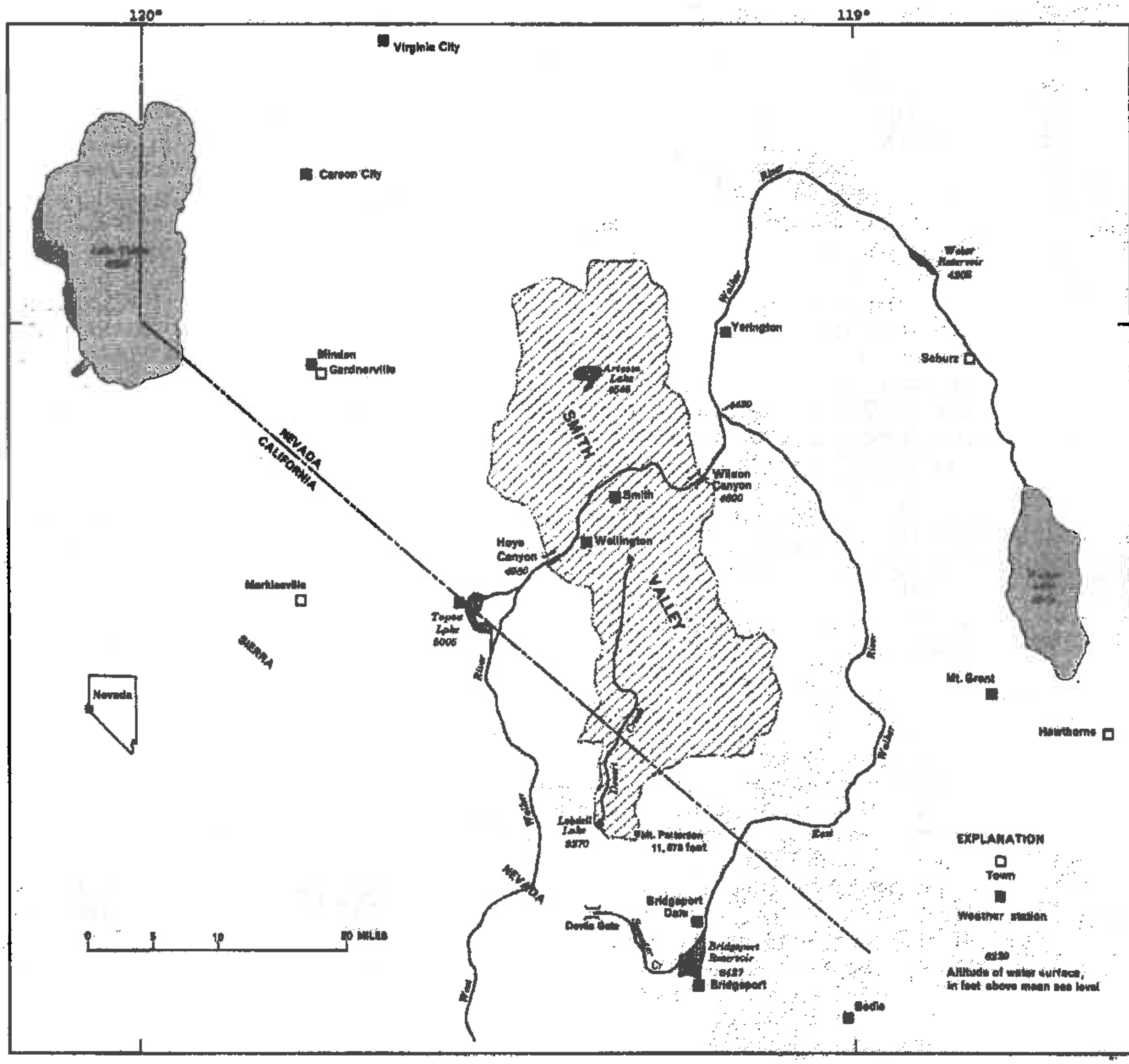

Figure 1.--Index map of Smith Valley and adjacent areas.

Previous Work

Several reports that describe various aspects of the geology or hydrology of Smith Valley have been published. The following is a brief summary of the more important publications. Miller and others (1953, p. 36) listed 34 chemical analyses of water samples collected in Smith Valley from 1933 to 1952. Of these samples, 16 were from wells and five from springs.

Loeltz and Eakin (1963) authored a semiquantitative report on the geology and hydrology of the valley. This report contains descriptions of most aspects of the hydrologic system and 27 pages of well and water-quality data.

A preliminary geologic map, which includes Smith Valley, was authored by Moore (1961). More recently, a report describing the geologic development of the basin was published by Gilbert and Reynolds (1973).

Domenico and others (1966) evaluated the economic and physical aspects of pumping irrigation wells to supplement diversions from the West Walker River. They concluded that more water could be pumped cheaper with the existing wells if the operation were centralized to provide water for the benefit of the entire area.

The U.S. Department of Agriculture (Nevada River Basin Survey Staff, 1969) made a survey of the Walker River Basin in which they presented findings and conclusions concerning water and related land resources. They concluded that (1) economic activity could be increased, (2) water quality could be improved, (3) streams could be better regulated and flood damage decreased, (4) land productivity could be increased, and (5) recreational opportunity could be enhanced.

The present report is one of a series that describes the hydrology of the Walker River Basin. The other reports in this series are, in downstream order: (1) Glancy (1971), Antelope Valley and the East Walker Area; (2) Rush and Hill (1972), bathymetry of Topaz Lake; (3) Huxel (1969), Mason Valley; (4) Everett and Rush (1967), Walker Lake Valley; (5) Katzer and Harmsen (1973), bathymetry of Weber Reservoir; and (6) Rush (1970), bathymetry of Walker Lake.

In addition, continuously recorded streamflow gaging data have been published for the valley. These data are presented in various U.S. Geological Survey Water-Supply Papers and open-file reports.

Acknowledgments

During this study the authors received abundant cooperation and help from many farmers and ranchers, especially irrigation-well owners. In addition, the Walker River Irrigation District was helpful in providing stream and canal diversion data. All help was greatly appreciated.

HISTORY OF WATER-RESOURCES DEVELOPMENT

Surface Water

Apparently the first irrigation diversion of surface water in Smith Valley was from Desert Creek by J. B. Lobdel in 1861. The first large diversion ditch was constructed in 1862, followed by the construction of several ditches during the next few years. In 1876, south of the river, an 8-mile long ditch was dug, which may have been the beginning of either the Saroni or the Plymouth Canal. In the next few years the Colony Canal, the principal ditch extending northward from the river was constructed (Loeltz and Eakin, 1953, p. 27).

Prior to 1881, about 6,000 acres was cultivated. The principal crops were hay, vegetables, and fruit. By 1919, river diversions were becoming so large that the Walker River Irrigation District was formed to administer the diversions. In 1922, Topaz Lake was added to the river system as an off-channel reservoir west of and upstream from Smith Valley (fig. 1). In 1937, the usable storage capacity of Topaz Lake was increased from 45,000 acre-feet to 59,000 acre-feet (Loeltz and Eakin, 1953, p. 7).

Annual natural-flow appropriations for Smith Valley from the West Walker River amount to about 45,000 acre-feet, with storage rights in Topaz Lake adding an additional 28,000 acre-feet (Domenico and others, 1966, p. 6).

Ground Water

In general terms, the history of ground-water development in Smith Valley is summarized in figure 2 and table 1. Most of the development has been in the last 20 years. Two types of irrigation development can be identified: (1) Water from ground-water sources to supplement diversions from the West Walker River and Desert Creek, and (2) pumping of wells as the sole source of water for irrigation. Supplemental ground water was the objective of most of the well construction through about 1965. These wells were constructed throughout the areas where surface water is used (pl. 2). Because of drought conditions during the period 1959-61, many supplemental wells were drilled and pumped. Since about 1965, a growing proportion of the new wells has been constructed to irrigate areas not supplied with surface water. North of the river, these lands are mostly in sec. 12, T. 11 N., R. 23 E., and sec. 31, T. 12 N., R. 24 E. South of the river, two such wells are in secs. 16 and 21, T. 10 N., R. 24 E.

In addition, Nevada Hot Springs (12/23-16dc; see p. 122 for location system), the Ambassador Gold Mining Company well (13/23-25ca), and many low-yield flowing wells (Loeltz and Eakin, 1953, p. 29 and 48) remain sources of ground water.

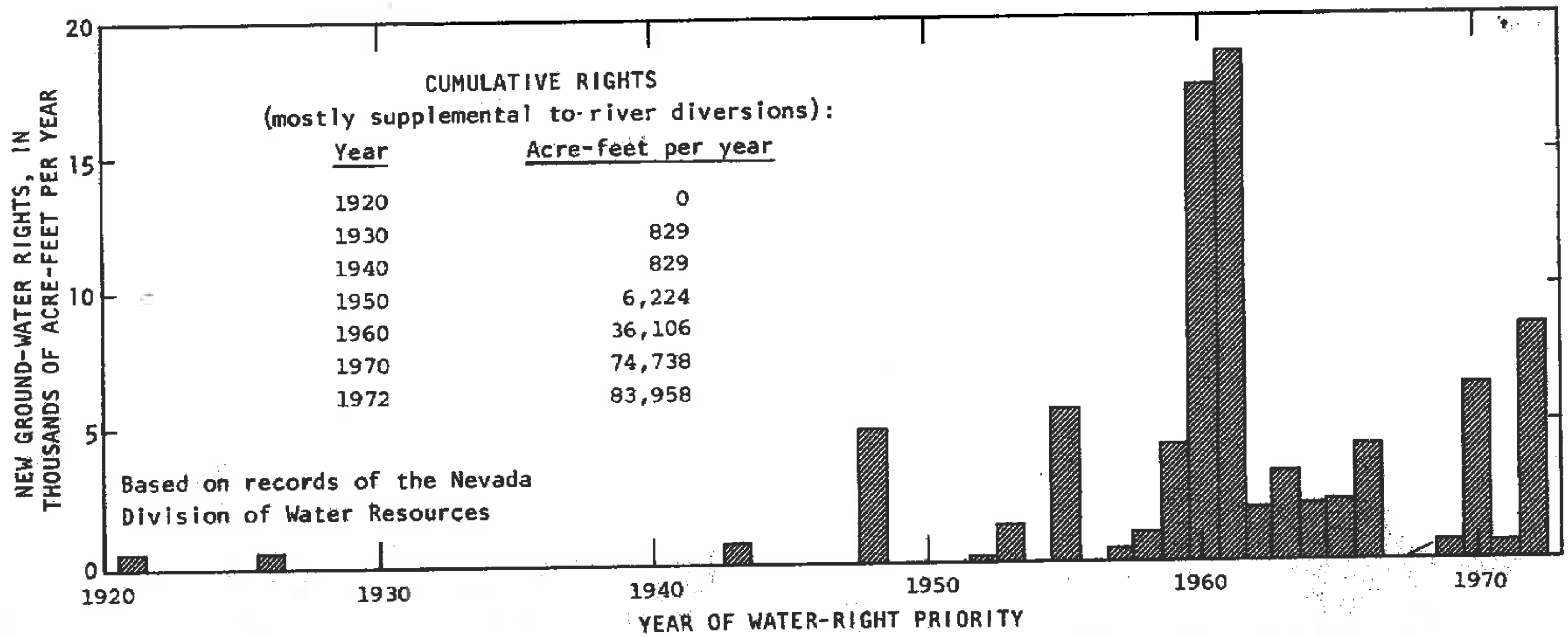

Figure 2.--Growth of ground-water rights for irrigation.

Table 1.--*Ground-water use chronology*

Year	Item
1921	Ground-water rights totaled 430 acre-feet per year to irrigate 88 acres according to DWR (Nevada Division of Water Resources).
1932	First large-diameter (14-inch), deep well (155 feet), drilled by Ambassador Gold Mining Co. Later and currently used for irrigation.
1949	Irrigated crop land was 18,290 acres (Hardman and Mason, 1949, p. 36).
1952	Ground-water rights totaled 6,395 acre-feet per year to irrigate 1,610 acres according to DWR.
1958-60	Ground-water pumpage for each year was 3,000 acre-feet, according to DWR.
1960-61	Seventeen irrigation wells drilled. Only 11 previously in existence. Ground-water pumpage in 1961 was 18,000 acre-feet, according to DWR.
1964	Ground-water pumpage was 13,500 acre-feet from 24 irrigation wells, according to DWR.
1965	Irrigated land equaled 22,199 acres (U.S. Department of Agriculture, Nevada River Basin Survey Staff, 1969, p. 52). Ground-water rights totaled 63,722 acre-feet per year to irrigate 16,045 acres, according to DWR.
1972	Irrigated crop land was 22,600 acres, on the basis of an inventory made as part of this study. Forty-eight irrigation wells have been drilled to date; 39 were pumped during 1972. Estimated ground-water pumpage for irrigation was 20,000 acre-feet. Ground-water rights totaled 83,958 acre-feet for 21,102 acres (fig. 2).

1977 - GROUND-WATER RIGHTS FOR IRRIGATION TOTAL APPROXIMATELY 59,000 A-F/Y TO IRRIGATE 15,000 AC. PROOF OF BENEFICIAL USE HAS BEEN SHOWN FOR 39,000 A-F/Y TO IRRIGATE 10,000 AC.

HYDROLOGIC ENVIRONMENT

Climate

Smith Valley is arid to semiarid. Average annual precipitation on the valley floor probably ranges from about 6 to 10 inches. The annual potential lake evaporation is about 48 inches (Kohler and others, 1959, pl. 2). The surrounding mountains receive somewhat more precipitation--in some areas as much as 20 inches. To the west, in the headwater area of the West Walker River, a thick snowpack accumulates in most winters.

The highest monthly rates of precipitation generally are in the period November to March, as shown in figure 3. Long-term trends in precipitation are shown in figure 4. Based on records from nearby areas, the period 1860-1919 probably had above-normal precipitation.

Air temperatures in Smith Valley are moderate. Overnight lows in January average about 10°F (-12°C); daytime highs in July average near 90°F (32°C). Day to night fluctuations are commonly 30 to 40°F (17 to 22°C) throughout the year.

Table 2 summarizes growing season data for the valley. It shows that a 28°F (-2°C) growing season generally lasts between 110 and 140 days.

Table 2.--*Growing-season temperature data for stations in and near Smith Valley*
[Compiled from published records of the National Weather Service]

Station1/	Period of record (years)	Average number of days above specified temperature		
		24°F (-4°C)	28°F (-2°C)	32°F (0°C)
Smith	1948-66	149	118	75
Topaz Lake	1959-71	155	132	99
Wellington Ranger Station	1948-71	181	154	129
Yerington	1948-71	170	139	108
Estimate for most of Smith Valley floor		140-170	110-140	70-120

1. For locations, see figure 1.

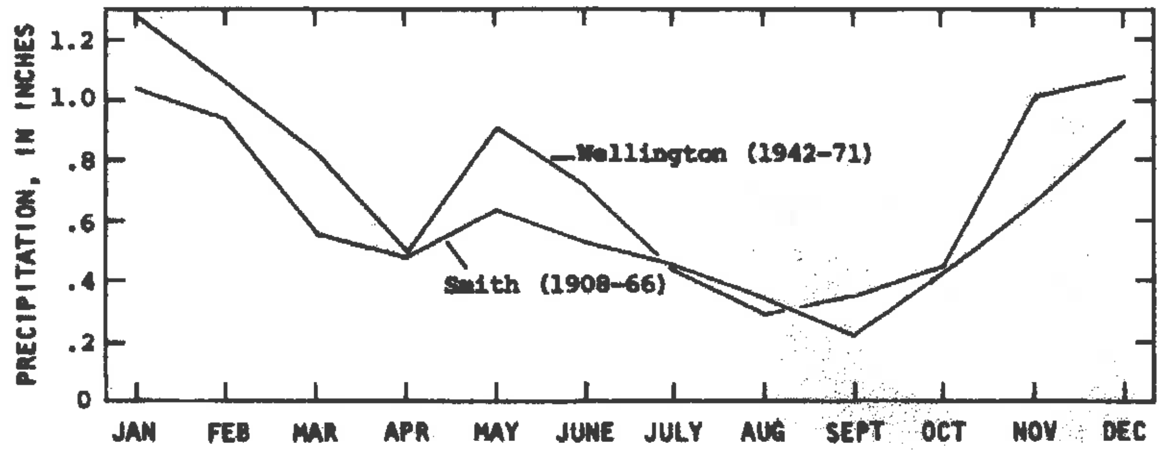

Figure 3.--Average monthly distribution of precipitation at Smith and Wellington.

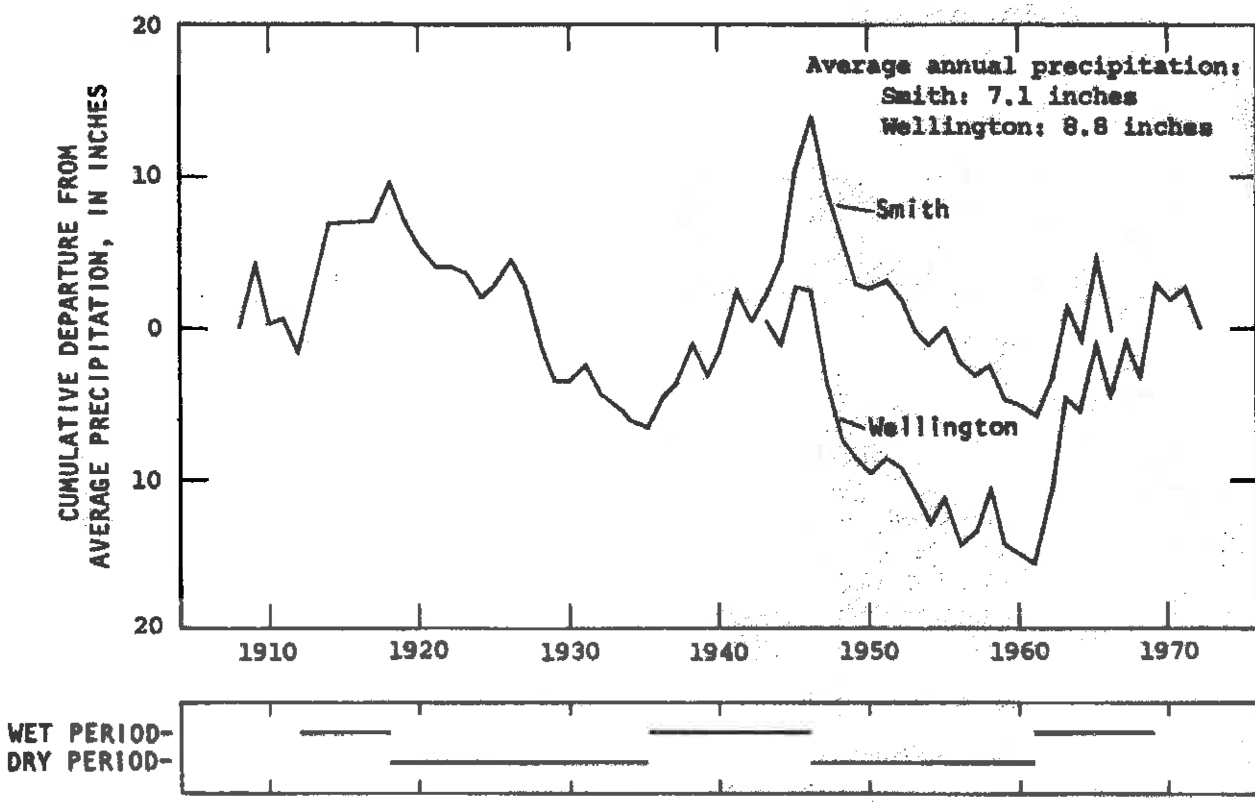

Figure 4.--Cumulative departure from average annual precipitation at Smith and Wellington.

Lithologic Units and Structural Features

For the purposes of this report, the rock types of Smith Valley were grouped into four consolidated-rock units and three alluvial units, as shown on plate 1. The division was made on the basis of the published geologic map of the area (Moore, 1961), aerial photograph interpretation, and field inspection of a few alluvial outcrops. Table 3 is a summary of these lithologic units.

The structural features of principal interest in the hydrologic study were the range-front faults and those that cut alluvium. Both may be important hydrologically in that they may either be avenues along which ground water flows or barriers to across-fault flow of ground water. Both types of faults are shown on plate 1. Other faults are present in the mountains, but are not shown. Undoubtedly many additional faults remain to be identified and mapped.

Source, Movement, and Discharge of Water

Sources of water for the valley are precipitation that falls within the topographic basin, especially snow in the mountains, and inflow of West Walker River from the west. In addition, a small amount of streamflow is diverted from a high-altitude tributary of West Walker River in California to Lobdell Lake, near the headwaters of Desert Creek, at the south end of the valley (pl. 1).

Ground-water movement is generally perpendicular to the water-level contours shown on plate 2. A ground-water divide separates the valley-fill reservoir into two flow systems. The larger system occupies the southern two-thirds of the valley; ground-water flow in this system is generally toward the river from both the north and the south. In the northern one-third of the valley, flow is generally toward centrally located Artesia Lake.

In both flow systems, the immediate source of most of the subsurface flow is infiltration from fields and canals. A secondary source of flow is from recharge due to precipitation in the mountains.

Irrigated land is a discharge area for irrigation water diverted from West Walker River, wells, and Desert Creek, and, as described above, it is also a source area for ground water. The distribution of irrigated land in 1972 is shown on plate 2. Most irrigated lands receive water through canals from West Walker River. The phreatophyte (native ground-water consuming plants) areas, shown on plate 2, are also discharge areas. Diverted river water is supplemented with pumped well water in many irrigated areas.

A minor but significant geothermal heating of ground water is indicated in parts of the area (table 4). The most impressive discharge of hot water in the valley is Nevada Hot Springs (12/23-16dc), in the northwestern part of the valley (table 5, and pl. 2). The springs, like most hot springs in Nevada, are on a fault which probably forms a permeable zone for upward flow.

Table 3.--Principal lithologic units

Age		Unit designation		Thickness (feet)	Lithologic units shown on plate 1		General hydrologic properties
QUATERNARY	Pleistocene and Holocene	Playa deposits	Valley fill	Up to several hundred	Silt, clay, and evaporites. Occur beneath Artesia Lake.		Very high porosity and very low permeability. Yield only small quantities of water to wells.
QUATERNARY	Pleistocene and Holocene	Younger alluvium	Valley fill	0-100±	Unconsolidated lenses of gravel, sand, silt, and clay in stream channel and lake deposits; represents detritus from adjoining mountains. Includes dune sand east of Artesia Lake.	Valley-fill reservoir	Sand and gravel deposits, moderately to highly permeable, and capable of yielding moderate to large quantities of water to wells. Lake-bottom deposits of fine-grained sand, silt, and clay are much less capable of yielding water to wells.
TERTIARY AND QUATERNARY	Pliocene and Pleistocene	Older alluvium	Valley fill	Probably up to several thousand	Semiconsolidated to unconsolidated lenses of gravel, sand, silt, and clay underlying alluvial fans, slope-wash areas, and upland alluvial surfaces. Occurs at depth beneath playa deposits and younger alluvium.	Valley-fill reservoir	Sand and gravel deposits have moderate permeability and are capable of yielding moderate quantities of water to wells. Yields of large-diameter wells are as much as 2,800 gal/min.
TERTIARY AND QUATERNARY	Pliocene and Pleistocene	Volcanic rock	Consolidated rocks	--	Mostly flow breccia, lava flows, and agglomerate of andesite, dacite, and basalt. Some rhyolite tuff.		Not tapped by wells. Scoriaceous and interflow zones may be good aquifers where saturated.
TERTIARY		Sedimentary rock	Consolidated rocks	--	Mostly sandstone, mudstone, and shale. Some minor outcrops of limestone.		Not tapped by wells. Generally does not readily transmit water, except in areas of intense structural deformation where some water may be transmitted along fractures.
CRETACEOUS		Granitic rock	Consolidated rocks	--	Mostly quartz monzonite, granodiorite, and granite porphyry.		Not tapped by wells. Virtually no interstitial porosity and permeability. May transmit small amounts of water through near-surface fractures and weathered zones. Transmits large amounts of water to Nevada Hot Springs through a fault zone.
TRIASSIC AND JURASSIC		Meta-sedimentary rock	Consolidated rocks	--	Mostly green schist, shale, slate, siltstone, sandstone, and graywacke.		Same as for Tertiary sedimentary rocks.

Warm water from wells that penetrate alluvium probably is a mixture of normal-temperature water of 54-59°F (12-15°C) with much warmer thermal water. The thermal water probably reaches the alluvium through fracture zones or faults in the underlying bedrock. Many of these faults or fracture zones have not been located, other than by the presence of warm water.

Table 4.--*Range and distribution of ground-water temperatures*

Temperature classification[1]	Temperature range (°F)	(°C)	Number of samples	Location
Normal	54-59	12-15	25	Mostly along axis of valley
Slightly warm	60-64	16-18	16	Mostly along valley margins south of river and west of Owens Fault (pl. 2)
Moderately warm	65-69	18-21	3	Scattered occurrences
Very warm	70-100	21-38	5	East of Owens Fault and north of Artesia Lake
Hot	>100	>38	2	Nevada Hot Spring and a well at Wellington
Summary:	54-144°F	12-62°C	Total 51	

1. Classification designed for hydrologic conditions in Smith Valley.

Table 5.--*Measured discharge and water temperature of Nevada Hot Springs*

Date	Discharge (cfs)	Temperature of water (°F)	(°C)
8-17-72	1.26	128	53
2- 8-73	1.14	122	50
4-26-73	.93	108	42
7-23-73	1.29	--	--
Average (rounded)	1.2 = 540 gal/min	--	--
6-30-72	Highest temperature measured at a spring orifice	144	62

Streamflow Characteristics

The principal stream in Smith Valley is the West Walker River, which enters the valley through Hoye Canyon from the west and flows eastward out of the valley through Wilson Canyon (fig. 1). Desert Creek drainage (fig. 1) is entirely within the valley, having its headwaters in the mountains at the south and flowing northward toward the West Walker River. Under native conditions, some flow from Desert Creek, reached the West Walker River in most years. Under present conditions, most of the flow of Desert Creek is diverted, and little reaches the river.

Minor streams, such as Sheep Creek, and flow in Burbank, Red, and Pipeline Canyons, are only a trickle during most of the year (pl. 2). Other channels have flow only during short periods of rapid winter or spring snowmelt, or intense summer thunderstorms. An approximate areal distribution of annual streamflow in Smith Valley follows:

Stream	Percent of total
West Walker River	94
Desert Creek	5
All others	1
Total	100

In addition to the usual stream-gaging and streamflow measurements made during hydrologic studies, estimates of mean annual flow were made using a channel-geometry method described by Moore (1968). This method was used mostly on ephemeral channels, but also was used on perennial streams to provide additional checks on values of mean annual flow determined from flow data.

VALLEY-FILL RESERVOIR

Extent and Boundaries

The valley-fill reservoir consists of the older and younger alluvium and playa deposits that underlie the valley floor and apron (pl. 1). Its areal extent is shown on plate 2. Its full thickness is unknown, because no well fully penetrate it, other than near its margins where it is thin. The reservoir is probably several thousand feet thick along the western side of the valley and thinner to the east. The external hydraulic boundaries are formed by low-permeability consolidated rocks which underlie and form the sides of the reservoir. Recharge boundaries are formed by West Walker River, Desert Creek, the flow from Nevada Hot Springs, canals, irrigated fields, and thermal water rising from consolidated rocks. Because of the low permeability of the bed of Artesia Lake, ponded water in the lake probably cannot be considered a significant source of recharge.

The principal internal hydrologic boundaries are faults (pls. 1 and 2) and extensive lithologic changes in the alluvium, such as transition from sand and gravel to the fine-grained playa deposits underlying Artesia Lake. Because of the extensive cultivation and land leveling in the valley, more faults probably are present than have been detected. The Owens fault in the northern part of the valley (pl. 2) has been established during this study as an effective boundary to lateral ground-water flow, yet the fault zone is a conduit of rising thermal water. The result is that on the east side of the fault, two irrigation wells (12/24-31bd and 12/24-31db, table 25) have experienced excessive drawdowns. This is discussed further in a later section of the report that describes the effects of man's activities. Indirect evidence indicates that another fault may be present near or between wells 10/24-21ba and 10/24-20ab in the southern part of the valley, and may be an extension of a fault farther to the south (pl. 1). The first well yielded water with a temperature of 67°F (19°C); the latter, 54°F (12°C). The latter temperature is near that expected without geothermal input. The wells are slightly less than one mile apart.

Hydraulic Properties

Transmissivity and permeability of aquifers in the upper 500 feet of saturated alluvium have been evaluated; the results are presented in figures 5-7. Twenty-seven short-term pumping tests of irrigation wells were the principal bases for the evaluation, but in addition, well logs, pumping rates, and general geologic interpretations were used.

The transmissivity map (fig. 5) shows that the Red Canyon-Burbank Canyon fan is the area where water can most easily be transmitted to wells by pumping. The area of the flood plain of the West Walker River and Desert Creek are intermediate in value. The bulk of the valley-floor area generally has values less than 50,000 gpd/ft (gallons per day per foot).

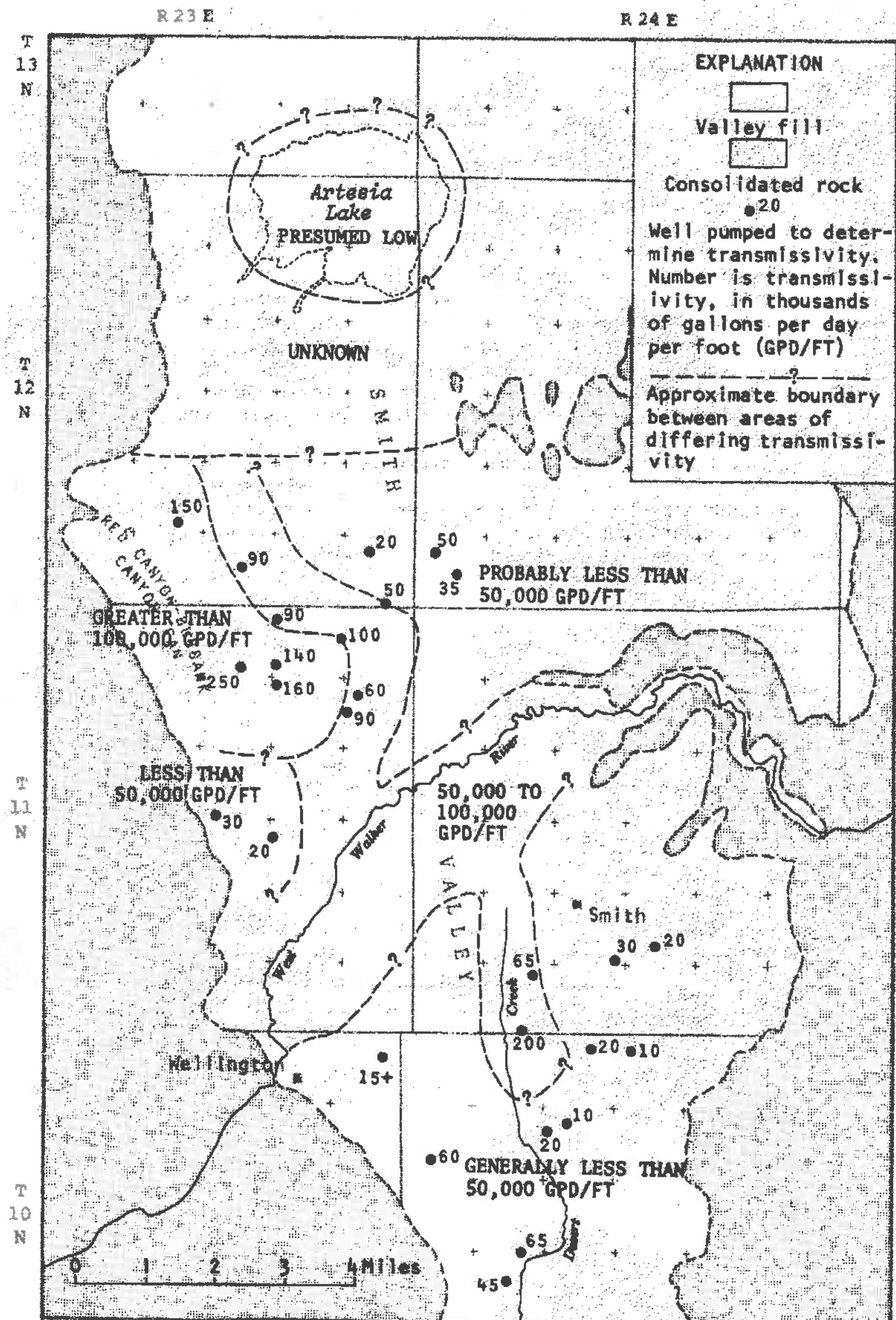

Figure 5.--Generalized transmissivity of the upper 500 feet of saturated valley fill.

Within any one area, the data in figure 5 show a large numerical variation in transmissivity. As a result, the map should be used only as a general guide. For any specific site, the transmissivity of the upper 500 feet of saturated alluvium could be within a fairly wide range of values.

To translate the transmissivity shown in figure 5 to terms a well owner could use, the following approximate relation exists for a well at the end of 24 hours of continuous pumping:

$$\text{Specific capacity} \approx \frac{\text{Transmissivity in gpd/ft}}{2{,}000}$$

where specific capacity is the yield of the well, in gallons per minute per foot of drawdown. This assumes that there are no nearby subsurface restrictions (boundaries) to flow, and that well efficiency is high. For example, assume that a pumping test yielded a transmissivity value of 100,000 gpd/ft. At the end of 24 hours of pumping, the well would have a specific capacity of about 50 gal/min per foot of drawdown. If the well were pumping 2,000 gpm, then the drawdown would be about 40 feet below the prepumping (static) water level if the efficiency of the well is high. After a longer period of time the specific capacity would be smaller because of the continuous, slow decline in pumping level. The relation of transmissivity and specific capacity to pumping rates and pump size for the existing irrigation wells is given in figure 6. Generally, to maintain a given discharge, wells in lower-transmissivity materials require larger pumps than wells in high-transmissivity materials.

Figure 7 shows the distribution of permeability of the average aquifer material in the upper 500 feet of saturated alluvium. This map is based on transmissivity values obtained from pumping tests and an evaluation of sand and gravel (aquifer) thicknesses as reported in drillers' logs. The relation between transmissivity and permeability is:

$$\text{Transmissivity} = \text{permeability} \times \text{aquifer thickness}.$$

The map shows that the aquifers associated with the Red Canyon-Burbank Canyon fan have permeabilities equivalent to well-sorted beds of sand or sand and gravel. Cautions regarding the use of figure 7 are the same as those described above for the transmissivity data.

The storage coefficient for most of the valley-fill reservoir, for a prolonged period of pumping, will equal the specific yield, or about 0.15. In the short term, semiconfined (artesian) aquifers, where present in the area east of Owens fault (fig. 7), have coefficients several orders of magnitude smaller.

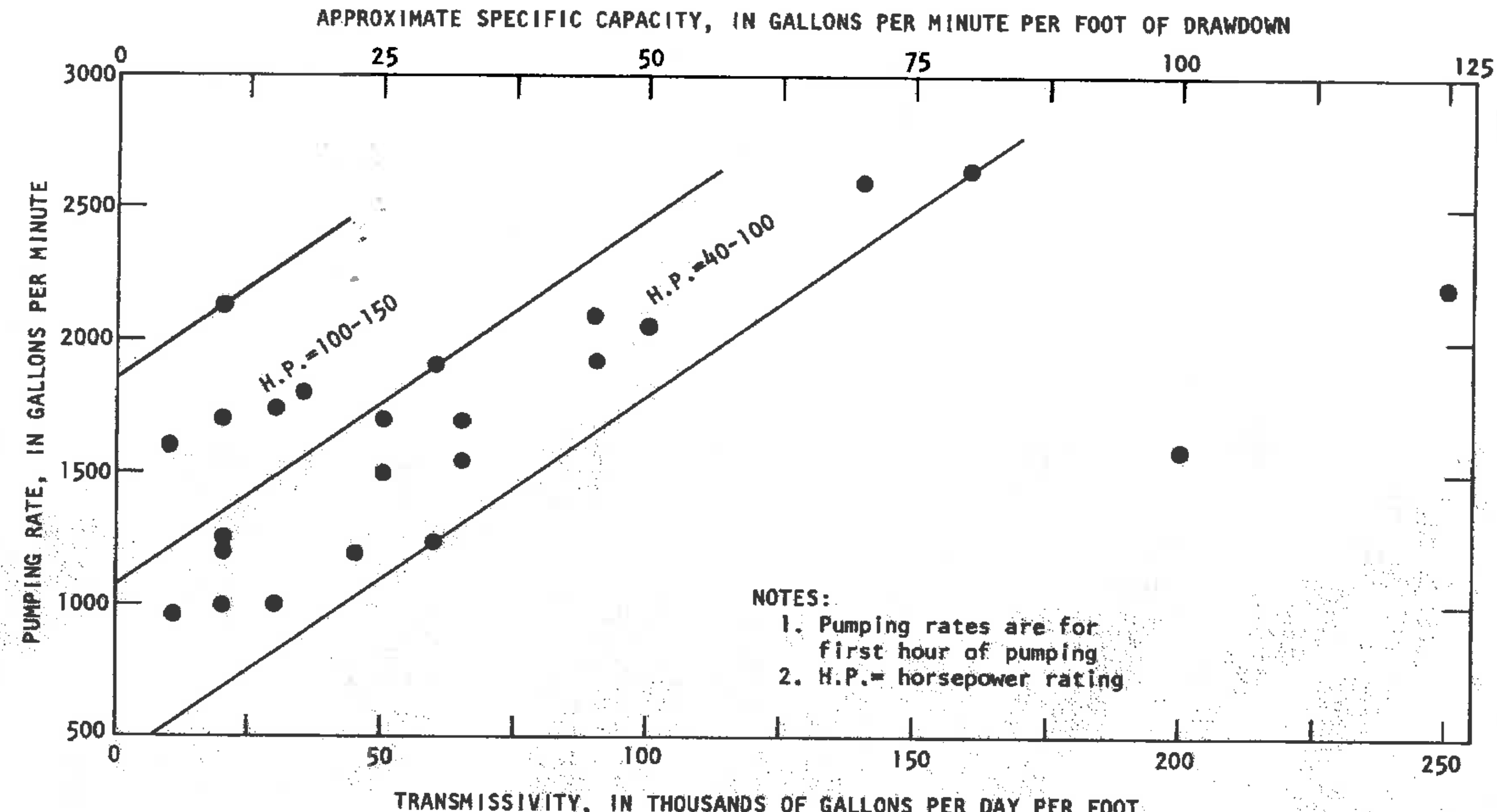

Figure 6.--General relation of well-pumping rate to transmissivity, specific capacity, and pump horsepower in Smith Valley.

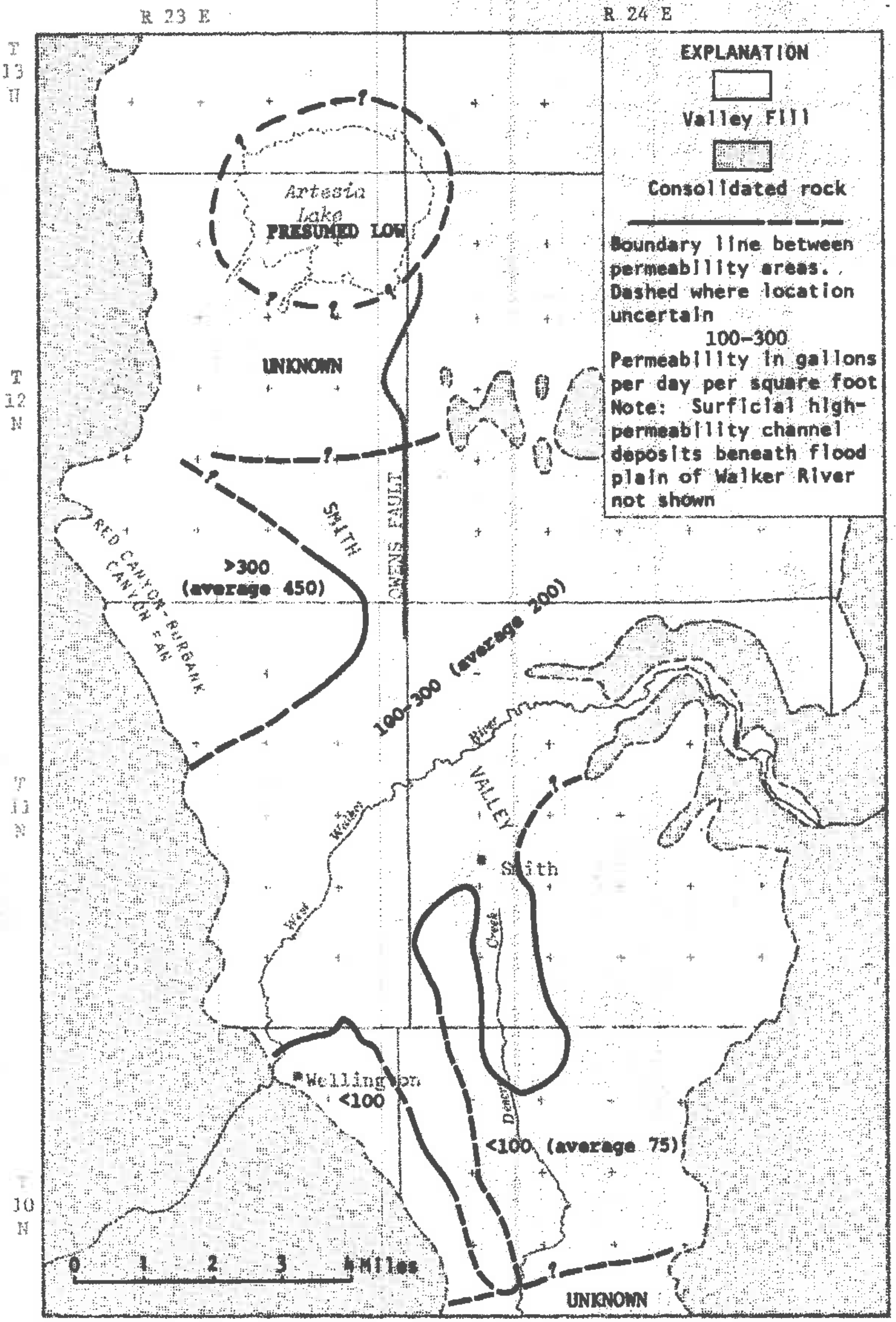

Figure 7.--Generalized distribution of average aquifer permeability in the upper 500 feet of saturated valley fill.

The valley-fill reservoir contains water both semiconfined by overlying, relatively impermeable beds and under unconfined conditions. Semiconfined conditions are: (1) east of Owens fault in the area of wells 12/24-31ba and 12/24-31db, and (2) in low-lying areas of flowing wells and springs (a) around Artesia Lake and extending southward along the valley floor to about the south boundary of T. 12 N., and (b) extending southward from the West Walker River about 2 miles. The area of artesian-well flow was mapped by Loeltz and Eakin (1953, pl. 2). In 1972 it remained about the same size and shape, except for seasonal reduction in head and the consequent diminishing of flow associated with the pumping of nearby irrigation wells. The wells east of Owens fault do not flow.

Ground Water in Storage

The valley-fill reservoir contains a large amount of water that is slowly moving through the system; the direction of flow is generally downgradient and perpendicular to the water-level contours shown on plate 2. The estimated volume of this water, using a specific yield of 0.15 and an effective area of valley fill of 100,000 acres, is about 15,000 acre-feet per foot of saturated material, or 1,500,000 acre-feet in the upper 100 feet of saturated valley fill. This is a very large amount of water in relation to the volume of water moving through the hydrologic system each year. For example, the storage in the upper 100 feet of saturated alluvium is nearly four times larger than the average annual precipitation that falls in the basin, and roughly 10 times larger than the inflow to the valley in the West Walker River in 1972 (table 6). The storage in the entire thickness of alluvium is not known because the alluvial thickness is not known; however, only a fraction of the total stored water would be available to wells. The main sources of this water are infiltration of (1) precipitation that falls principally in the mountains of the basin, (2) water that has been diverted by irrigation canals from West Walker River, and (3) Desert Creek. The depth to this mass of stored water is shown in figure 8.

Loeltz and Eakin (1953, p. 29-34) documented large-scale water-level rises prior to 1950. These rises were attributed mostly to percolation of irrigation water. The rise in ground-water level has been much smaller since 1950, and changes are more localized. Figure 9 shows a gradual rise in the water level of well 11/24-27cb from 1919 to about 1935, then a dramatic rise of about 65 feet from 1935 to 1950, but only about a 5-foot rise from 1950 to 1973. Well 11/24-32ca, a few tens of feet southeast of Ralph Nuti's home, has a similar water-level history: 27-foot depth to water in 1937 (Loeltz and Eakin, 1953, p. 32) but a water level at land surface in 1948 and 1973.

Some lowering of water levels has resulted from two factors: (1) reduced infiltration of irrigation water and natural recharge during a drought period and (2) increased pumping for irrigation during the same period. In figure 10, wells 11/24-32dc and 11/23-3dc show this type of water-level decline during the drought period 1959-62, resulting in a lowering of 20 and 16 feet, respectively. Well 10/24-4cd possibly has a similar history, as interpolated from the incomplete record (fig. 10).

Table 6.--*Annual flows of, and diversions from, West Walker River, calendar years 1953-72*

[Based on published records of the U.S. Geological Survey except as indicated; all values in acre-feet, rounded.]

Calendar year	Inflow to Smith Valley (1)	Outflow from Smith Valley (2)	Net decrease in flow (3)=(1)-(2)	Diversions to canals in Smith Valley 1/ (4)
1953	--	131,000	--	87,000
1954	--	98,000	--	78,000
1955	--	98,000	--	52,000
1956	--	218,000	--	99,000
1957	--	118,000	--	81,000
1958	246,000	190,000	56,000	96,000
1959	120,000	80,000	40,000	62,000
1960	80,000	64,000	16,000	29,000
1961	71,000	57,000	14,000	19,000
1962	151,000	91,000	60,000	79,000
1963	216,000	161,000	55,000	82,000
1964	125,000	85,000	40,000	61,000
1965	229,000	167,000	62,000	91,000
1966	148,000	100,000	48,000	73,000
1967	286,000	217,000	69,000	90,000
1968	146,000	106,000	40,000	62,000
1969	338,000	300,000	38,000	104,000
1970	195,000	135,000	60,000	88,000
1971	186,000	135,000	51,000	92,000
1972	142,000	101,000	41,000	69,000
Average 1958-72	179,000	133,000	46,000	73,000
Average 1953-72	--	133,000	--	75,000

1. Data from Walker River Irrigation District records.

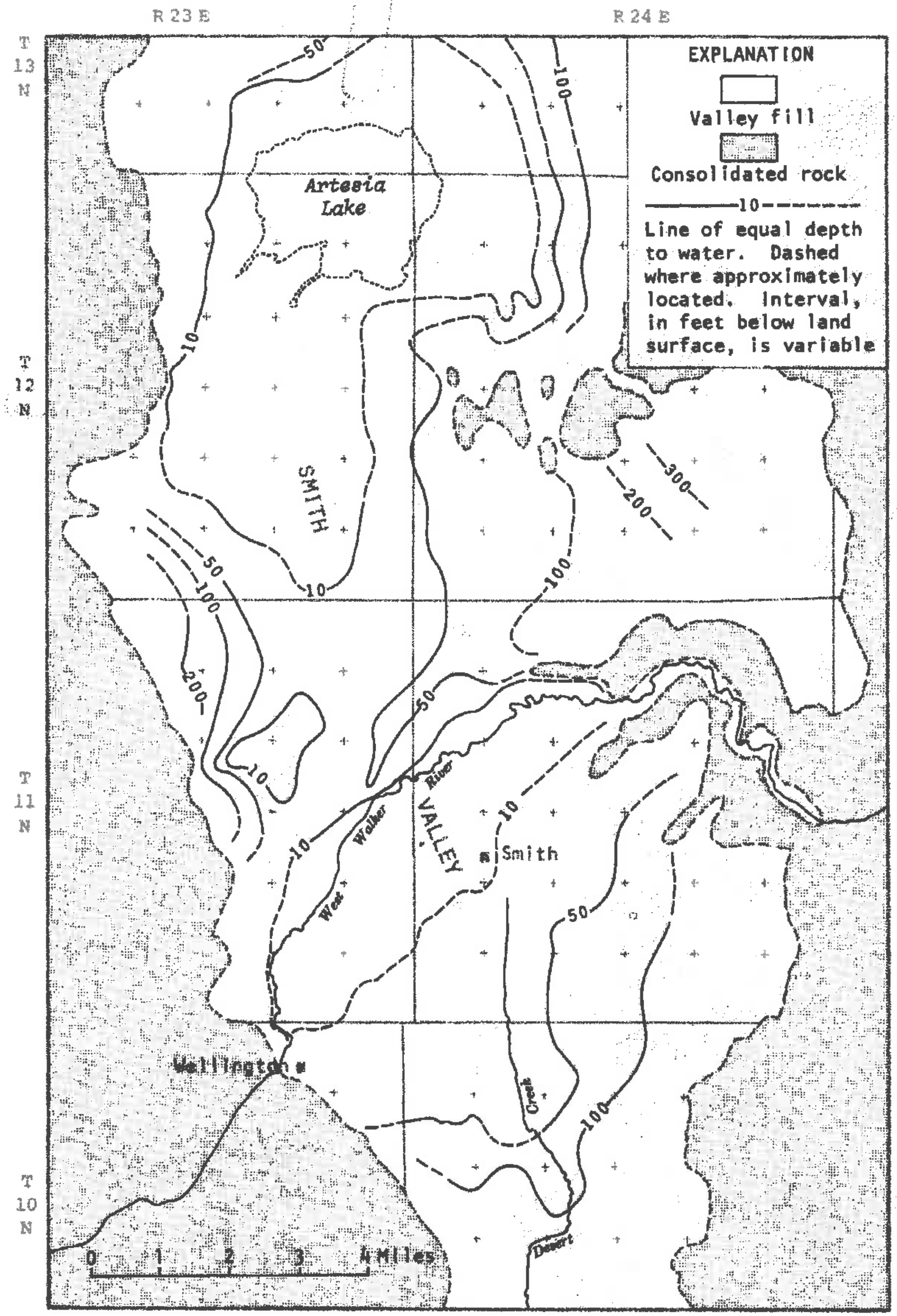

Figure 8.--Depth to ground water, Spring 1972.

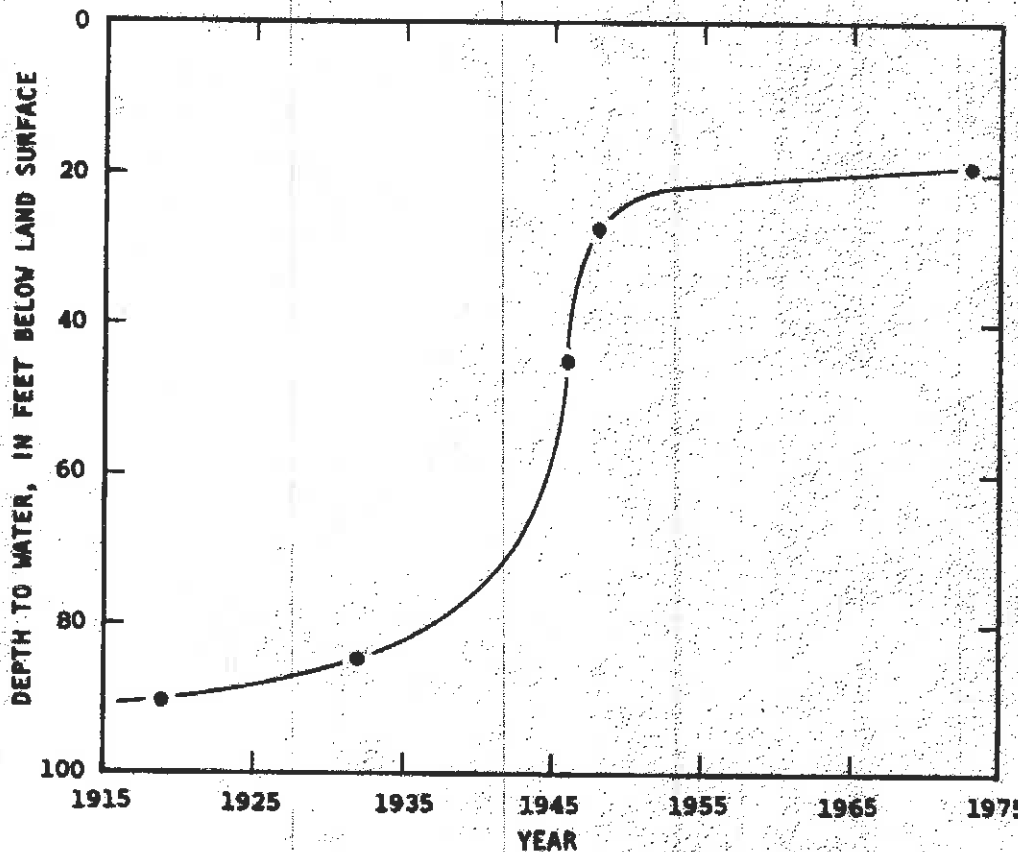

Figure 9.--Water-level rise in well 11/24-27cb.

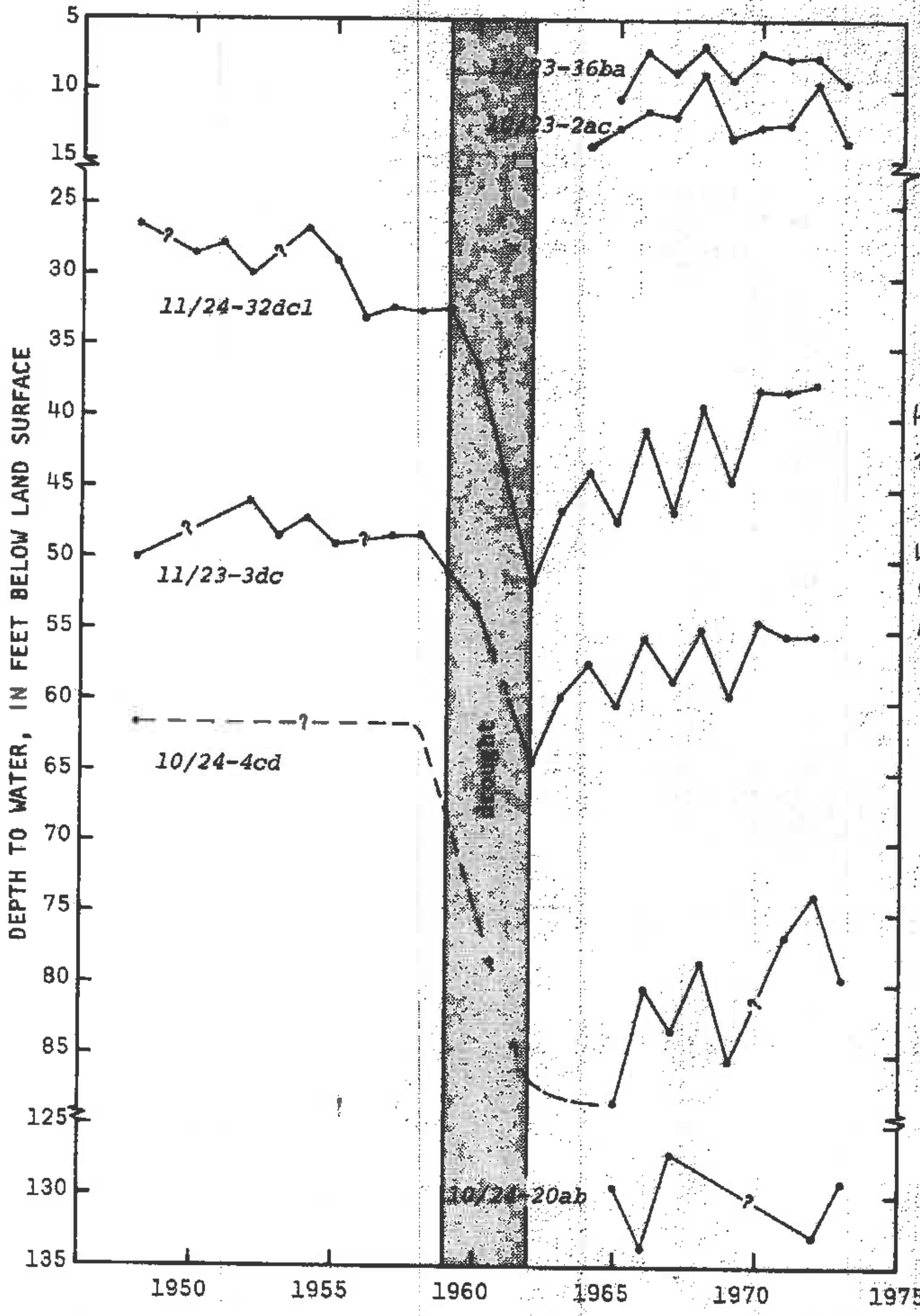

Figure 10.--Changes in water level in selected wells, on basis of measurements prior to irrigation season.

NOTE WELLS HAVE NOT RECOVERED TO PRE DROUGHT LEVELS - 13 YEARS LATER MANY OF WHICH WERE ABOUT AVERAGE IN PRECIP & STREAMFLOW

All three wells show a slow recovery since 1962, with the recovery process still incomplete by 1973. No additional data are available to show the extent of this dewatering and slow recovery; therefore, no estimate can be made of the net decrease of stored water in the valley. However, the distribution of heavy pumping and dewatering were somewhat the same. The general distribution of existing irrigation wells in those years can be determined from drilling dates listed in table 25. The other three wells shown in figure 10 have records too short to show the effects, if any, of the drought period. However, during their period of record, 1964 or 1965 to 1973, the net change in water levels has not been significant. Water-level changes in 1972 and their causes are evaluated in a later section of the report.

CHEMICAL QUALITY OF THE WATER

Relation to the Flow System

Because virtually all the water moving through the hydrologic system in Smith Valley originates as precipitation, the water initially has a very low dissolved-solids concentration. As the water moves through the system, either over the land surface or through the subsurface, it dissolves rock and soil constituents. The farther it flows and the longer the length of time it is in contact with rock and soil, generally the greater the concentration of dissolved solids. Rock and soil types and the activities of man also have a strong influence on dissolved solids.

West Walker River, where it enters Smith Valley, has a specific conductance commonly between 200 and 250 micromhos (table 26)1/. Desert Creek, where it crosses the bedrock-alluvium contact, has similar if not lower values. Outflow in the West Walker River to Mason Valley has higher values--as great as 500 micromhos--because of the return flow of water through the ground-water system. Highest concentrations probably are in the fall, when return flow constitutes the largest part of the total river flow. Return flow to the river also carries fertilizer and other agricultural wastes such as those from feed lots.

The ground water beneath the agricultural areas has a specific conductance ranging between 170 and 900 micromhos, as determined from data in table 26. Because the human population of the valley is small, domestic and commercial wastes are small sources of mineralization of either ground water or streamflow. Figure 11 shows the distribution of specific conductance of ground water in the valley.

The ground water of the valley can be classified on the basis of the predominant cation and anion expressed in milliequivalents per litre. The generalized distribution of ground-water types is shown in figure 12. Mixed bicarbonate type dominates the agricultural areas, with two major exceptions--calcium-magnesium bicarbonate is the principal type beneath the Red Canyon-Burbank Canyon fan and an area southeast of Smith. The ground water in this latter area also has rather high dissolved-solids concentrations, as shown in figure 11. Sodium bicarbonate water is possibly the dominant type in the Artesia Lake area, whereas Nevada Hot Springs and well 10/23-2db (Miller and others, 1953, p. 36) yield hot water dominated by sodium and sulfate.

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1. Specific conductance, which is a measure of a water's ability to conduct electric current, is closely related to dissolved-solids concentration. The dissolved-solids concentration, in milligrams per litre, is generally 55-70 percent of the specific-conductance value. The complete unit of measure for specific conductance is "micromhos per centimeter at 25°C (Celsius)." For convenience, the abbreviation "micromhos" is used in this report.

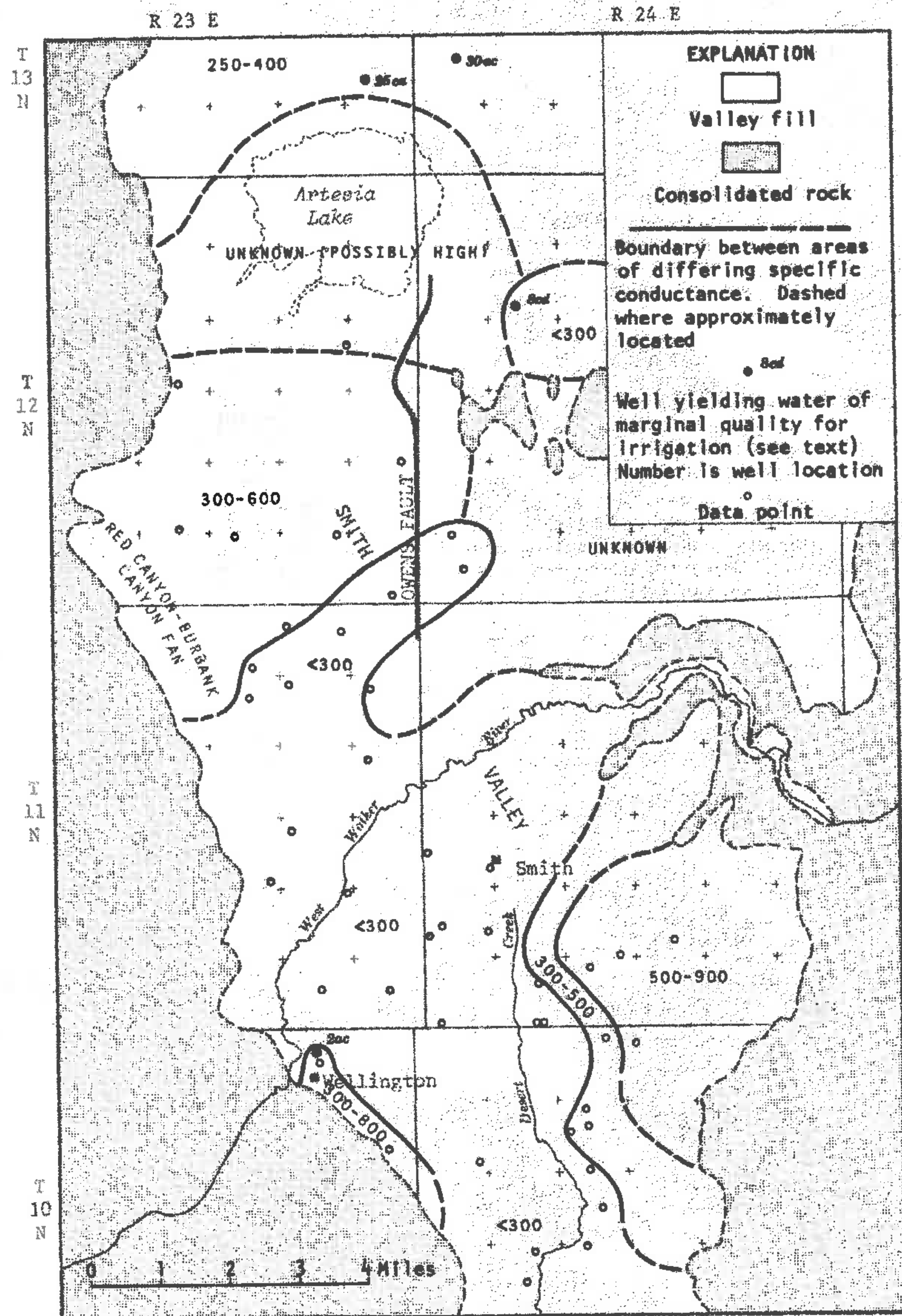

Figure 11.--General distribution of specific conductance of ground water.

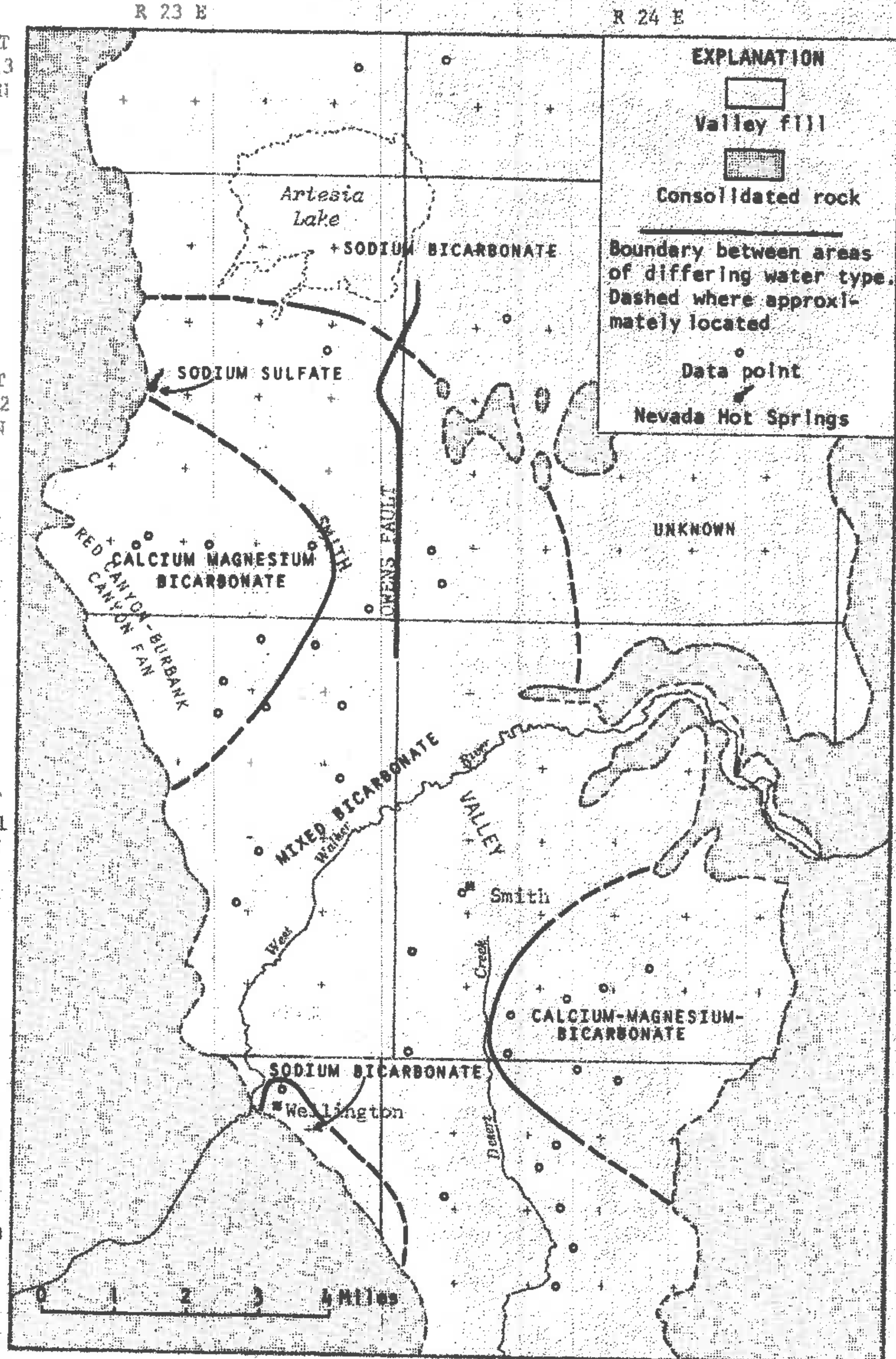

Figure 12.--Generalized distribution of water types.

Suitability for irrigation

The concentration and composition of dissolved constituents in a water determine its quality for any use. Much of the following discussion of irrigation water is based on chapter 4 of Diagnosis and Improvement of Saline and Alkaline Soils (U.S. Salinity Laboratory Staff, 1954). The characteristics of an irrigation water that appear to be most important in determining its quality are: (1) total concentration of dissolved solids, as indicated by salinity hazard of the water; (2) relative proportion of sodium to other cations, as indexed by sodium hazard; (3) concentration of boron and other elements that may be toxic; and (4) under some conditions, the bicarbonate concentration as related to the concentration of calcium plus magnesium, as indexed by residual sodium carbonate (RSC). Recommendations as to the use of a water of a given quality must take into account such additional factors as drainage and management practices of croplands. These two factors are beyond the scope of this survey.

The following scale is used to rate salinity hazard in table 26 (Committee on Water Quality Criteria, 1973, p. 335):

Specific conductance (micromhos)	Hazard class
<750	Low (no detrimental effects usually noticed)
750-1,500	Medium (can have detrimental effects on sensitive crops)
1,500-3,000	High (can have adverse effects on many crops; requires careful management practices)
3,000-7,500	Very high (can be used for tolerant plants on permeable soils with careful management practices)
>7,500	Unsuitable

Sodium hazard is rated on a scale of low, medium, high, and very high. This classification is based primarily on the effect of sodium on the physical condition of the soil and secondarily on plant sensitivity to sodium. High sodium hazard would require special soil management, such as good drainage, high leaching, and the addition of organic matter. RSC is rated on a scale of safe, marginal, and unsafe. Based on limited data, the Salinity Laboratory Staff believes that good management practices and proper use of additives might make it possible to use successfully some marginal waters for irrigation.

Water supplies that are known to have some water-quality limitations for irrigation are listed below and are shown in figure 11:

Well	Limiting factor	Classification
10/23-2ac	RSC	Unsafe
12/24-8cd	RSC	Marginal
13/23-25ca	RSC	Marginal
13/24-30ac	RSC	Marginal

If crops that are irrigated by these wells appear to have less than satisfactory yields, advice on management practices should be requested from the local County Agricultural Extension Agent.

The toxic element boron was analyzed in 39 samples. The concentrations ranged from 0.00 mg/l (milligrams per litre) to 1.0 mg/l, with all but one of the values less than 0.4 mg/l. None of the crops grown in Smith Valley during 1972 were sensitive to these low concentrations of boron; therefore, these waters were not a problem. However, concentrations of 1 mg/l could be a problem for sensitive crops, such as most fruit trees.

Suitability for Domestic Use

The U.S. Public Health Service (1962, p. 7-8) has formulated standards that are generally accepted as a guideline for drinking waters; in fact, these standards have been adopted by the Nevada Bureau of Environmental Health as regulations for public supplies. The standards, as they apply to data listed in table 26, are as follows:

Constituent	Recommended maximum concentration (milligrams per litre)
Arsenic (As)	a/ 0.01
Iron (Fe)	.3
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	b/ About 1
Nitrate (NO_3)	45
Dissolved-solids concentration	c/ 500

a. Water containing more than 0.05 mg/l of arsenic should not be consumed regularly.

b. Based on annual average maximum daily air temperature.

c. Equivalent to a specific conductance of about 750 micromhos.

The arsenic concentration in drinking water is particularly important because of the possibility of cumulative poisoning. The element's concentration was determined on 23 irrigation and stock waters (fig. 13). Eleven of the samples contained more than 0.01 mg/l of arsenic, and two, from wells 13/23-25ca and 13/23-30ac, contained more than 0.05 mg/l. The latter two waters would not be suitable for drinking. Because of the limited number of samples collected and analyzed for arsenic, a further study should be made before conclusions are drawn as to the distribution of arsenic in the ground-water system and its potential effect on human health.

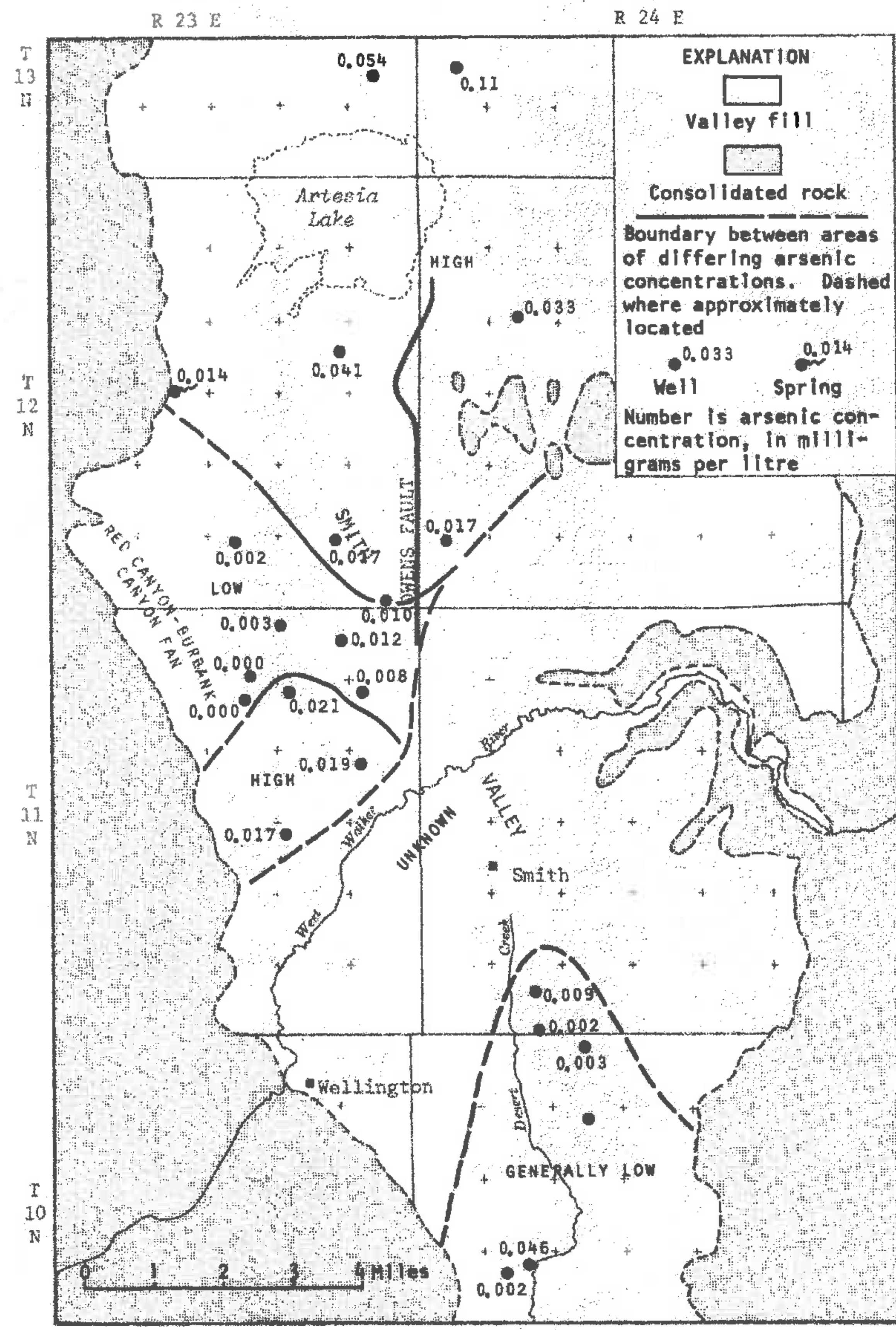

Figure 13.--Generalized distribution of arsenic in ground water.

Excessive fluoride tends to mottle teeth, especially those of children. Fluoride concentrations were determined for 33 samples, and wells 10/23-2db (Loeltz and Eakin, 1953, p. 56) and 11/24-18aa (incorrectly reported by Loeltz and Eakin (1953, p. 56) as 0.2 mg/l), Nevada Hot Springs (12/23-16dc) and 13/23-30ac had higher than desirable concentrations; that is greater than about 1 mg/l.

Of the 26 samples analyzed for nitrate, only one--from irrigation well 11/24-28dd--contained more than the Public Health Service's recommended limit. The source of the nitrate is unknown, but probably is from one of two sources, fertilizer applied to irrigation fields or naturally occurring nitrate minerals.

Concentrations of all other analyzed constituents affecting water quality were very near or within the limits set by the Public Health Service.

Water hardness, a factor that affects soap consumption, is shown for ground water in figure 14. The hardness scale used (from Hem, 1970, p. 225) is as follows: soft, 0-60 mg/l; moderately hard, 61-120 mg/l; hard, 121-180 mg/l; and very hard, 180 mg/l. The entire range is present in Smith Valley; from soft to very hard. The map was based on 54 samples.

Salt Balance

Over the long term, dissolved salts not extracted by plants from soil and water will generally increase in concentration unless leaching occurs. The increase will gradually lower the productivity of a soil. Salt balance generally is not a problem in the part of Smith Valley that drains to the West Walker River. In this area, surface water of low salt content is used for irrigation. The water not consumed by crops percolates to the water table, transporting much of the salt with it. As a result, the ground water has slightly higher salt concentrations than the water applied to the fields, but for agricultural use, still quite low. This ground water generally flows toward the river and flows from the valley. Because of the pumping of wells, some of the ground water is recycled across fields, but because pumpage represents only a small part of the total quantity of water percolating to the water table beneath the agricultural areas, the water quality had not been degraded appreciably as of 1972.

In the Irrigation section of this report, leaching requirements are quantified. As of 1972, more than enough water was moving through the ground-water system to meet this general leaching need.

In the Artesia Lake ground-water basin, salt is slowly accumulating because this area is hydrologically closed. For a successful farming operation, salt must be leached from cropland soils. In a closed basin, the leached salts are flushed to a "storage area;" the "tail end" of this flow system at Artesia Lake. Over the long term the basin's salt balance probably would have to be managed accordingly if the water resource is developed principally through irrigation agriculture. As a result, ground-water flow to the lake area, and the accompanying transport of salts, probably should not be entirely prevented by ground-water development.

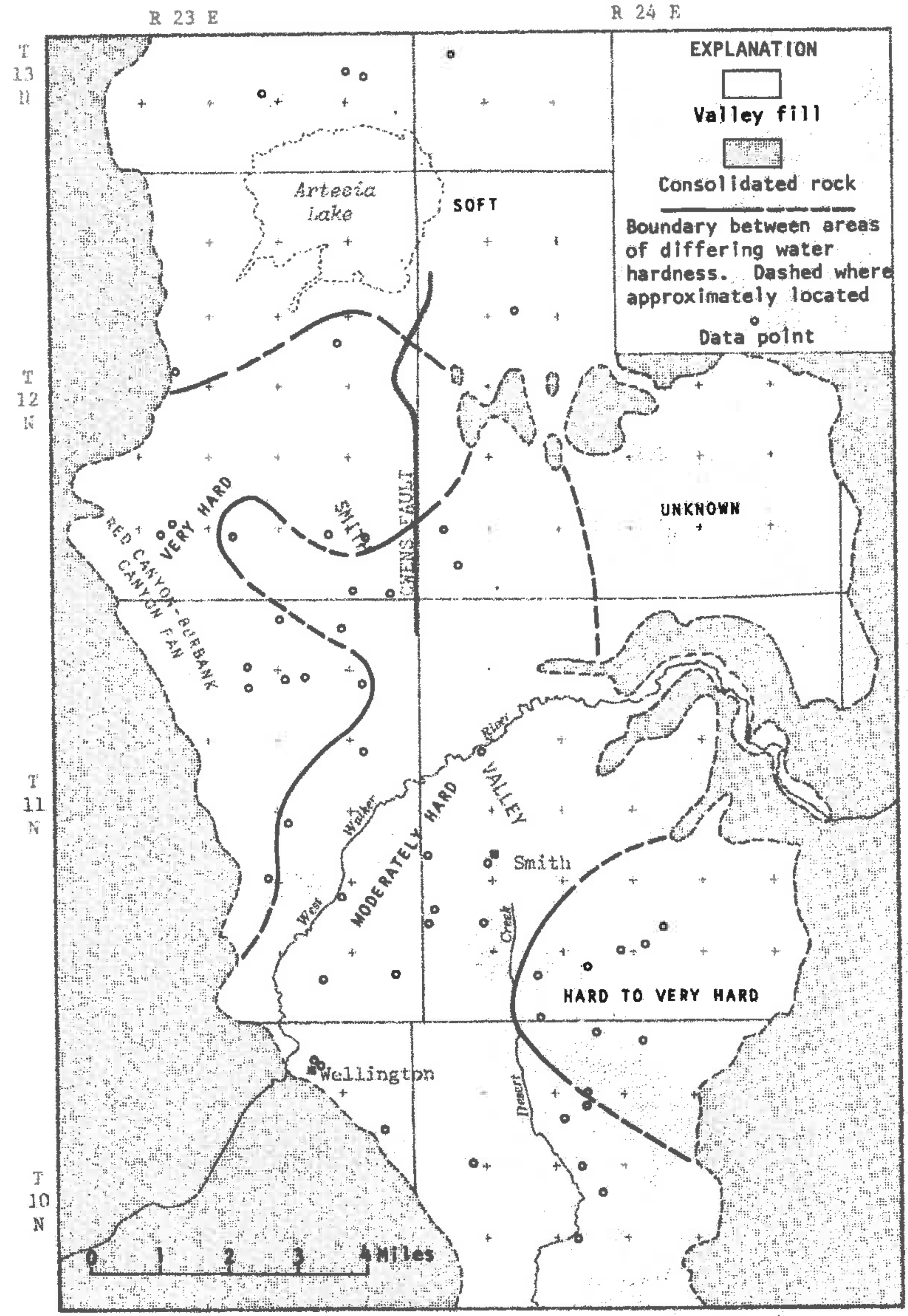

Figure 14.--Generalized distribution of ground-water hardness.

Because salt accumulates at the surface of the dry lake bed during the evaporation process, and subsequently is partly blown away, not all salt flushed to this area remains in the lake or in its underlying beds.

INFLOW TO THE VALLEY

Within this section of the report, quantitative estimates are made of the primary sources of water for Smith Valley (fig. 23): Precipitation, importation, and inflow of West Walker River. In addition, the secondary sources of water for the valley--surface-water runoff from the mountains and ground-water recharge--are evaluated.

Elements of inflow, as well as the elements of outflow, are evaluated for the base year 1972. If antecedent conditions are not important in the relation between an element of inflow and the hydrologic system in the hydrologic budget, that element, such as river inflow or importation of water, is evaluated on the basis of data from 1972. If, however, antecedent conditions are an important factor in the relation, average annual values have been developed, such as for precipitation, runoff, and ground-water recharge.

Precipitation

In the Great Basin, a strong relation exists between altitude of land surface and amount of precipitation. The higher altitudes receive more precipitation, as shown in figure 15. The Pine Nut and Sweetwater Mountains, on the west side of the valley, receive about twice as much rain and snow as the eastern mountains, the Singatse Range and Pine Grove Hills. As a result, two curves were used to characterize each general precipitation condition (fig. 15). The altitude-precipitation relations represented by these lines are used in this study to estimate the average annual precipitation for the basin. The volume of precipitation is computed in table 8 to average about 260,000 acre-feet per year.

Streamflow

West Walker River

The average annual inflow to Smith Valley in the West Walker River (at Hoye Canyon) is 179,000 acre-feet for the period 1958-72. The average annual outflow from the valley (at Wilson Canyon) is 133,000 acre-feet for the same period. Data on which these values are based are presented in table 6. The decrease in flow is principally the result of extensive diversions from the river for irrigation. However, of the amount diverted and applied to crops, a substantial part returns to the river as ground-water return flow (table 6, columns 3 and 4). Little tailwater was observed to return to the river.

Inflow of the West Walker River to Smith Valley during 1972 was 142,000 acre-feet, or 79 percent of the annual average of 179,000 acre-feet for the base period 1958-72, as listed in table 6. The average for 1958-72 probably was almost equivalent to the long-term average, on the basis of comparisons using a partly synthesized 50-year record (1919-69) for the West Walker River below Little Walker River, near Coleville, Calif. (data from D. O. Moore, U.S. Geol. Survey, 1970).

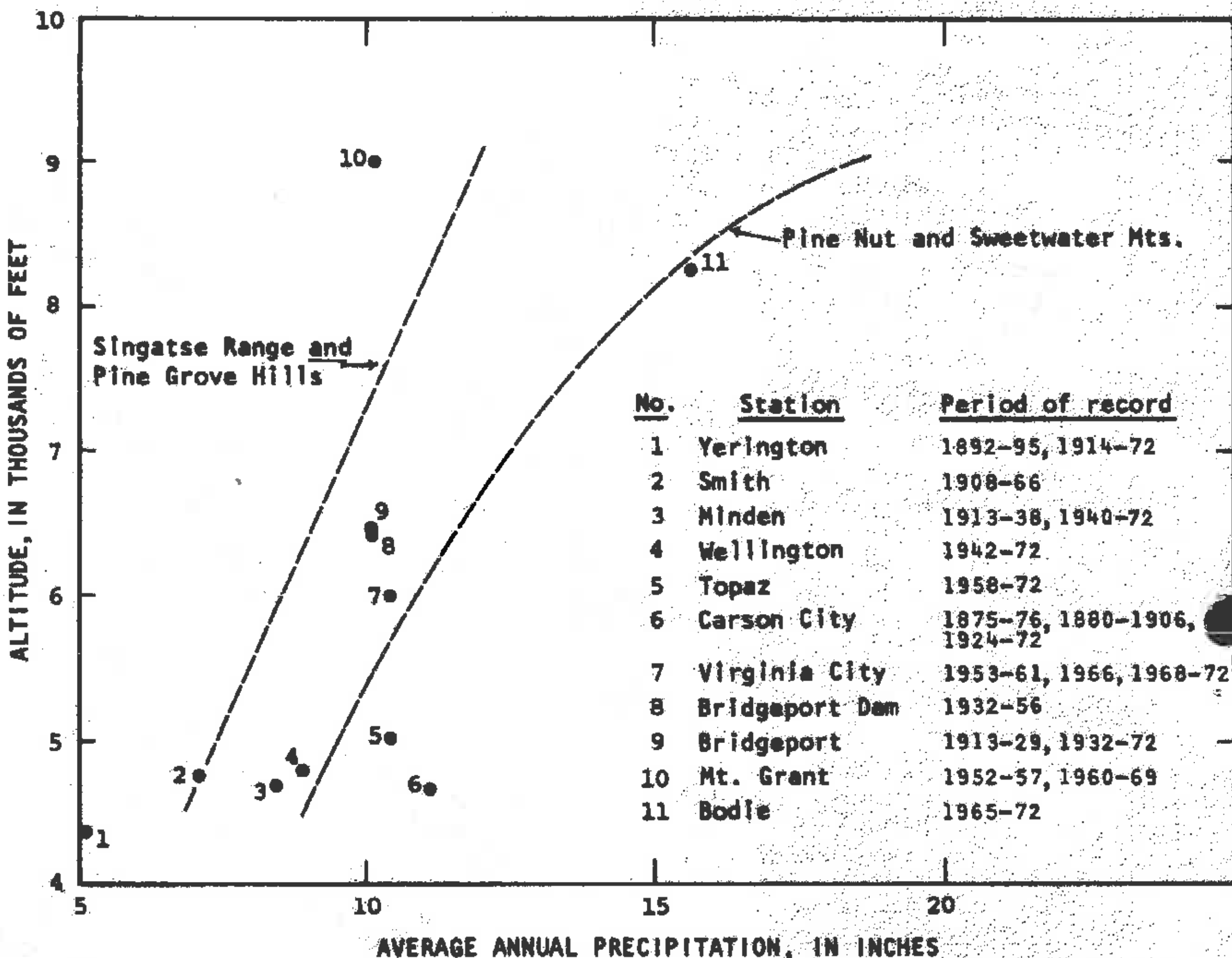

Figure 15.--Precipitation-altitude relation.

The distribution of flow during the year is shown in figure 16. Peak flows generally occur during the period May through July, and are subject to upstream regulation at Topaz Lake. Monthly inflow exceeds monthly outflow, except during the low-flow months of November through March. The gain in the river during these months is due to ground-water return flow exceeding diversions.

Instantaneous flow of the river ranges from less than 5 cfs to more than 2,000 cfs.

Desert Creek

Because the period of streamflow record is only 5 years (1965-69) and 2 of these years were extremely wet (1967 and 1969), the available data are not representative of long-term flow. As a result, statistical correlations were made with flow of two nearby gaged streams, Buckeye Creek, and Little Walker River near Bridgeport, Calif., a few miles south of the valley. These streams have 10 and 28 years of recorded flow data, respectively. The computed long-term average discharge for Desert Creek is 8,500 acre-feet per year at the mountain front. Recorded flow for the short period of record on Desert Creek, as measured at the mountain front (pl. 2), averaged 12,000 acre-feet per year. The estimated flow in 1972 was 66 percent of the long-term average annual flow, or 5,600 acre-feet. Of this amount, 4,500 acre-feet or 80 percent occurred during the growing season.

Monthly distribution of flow during the 5-year period of record is shown in figure 17. This distribution is generally representative of long-term flow of this stream and other small perennial streams in the valley.

A duration curve for Desert Creek, figure 18, was developed for the year 1971, based on periodic discharge measurements, runoff data for 1971, and records on streams outside but near Smith Valley. This curve provides an approximation for individual rates of flow that can be expected in an average year, and a graphic comparison of base-flow characteristics with additional streams described below. Desert Creek has a relatively high direct surface runoff in relation to base flow.

Instantaneous flow of Desert Creek during the period 1965-72 had a range from less than 1 cfs to 260 cfs.

Other Streams

Flow was measured periodically in Sheep Creek and Burbank, Red, and Pipeline Canyons (pl. 2). Using these measurements and data from Desert Creek, duration curves were synthesized for these streams (fig. 19). Like Desert Creek, flow in Burbank and Red Canyons has a relatively high direct surface runoff in relation to base flow, whereas Pipeline Canyon and Sheep Creek are characteristically spring-fed streams, having a high base flow in relation to direct surface runoff.

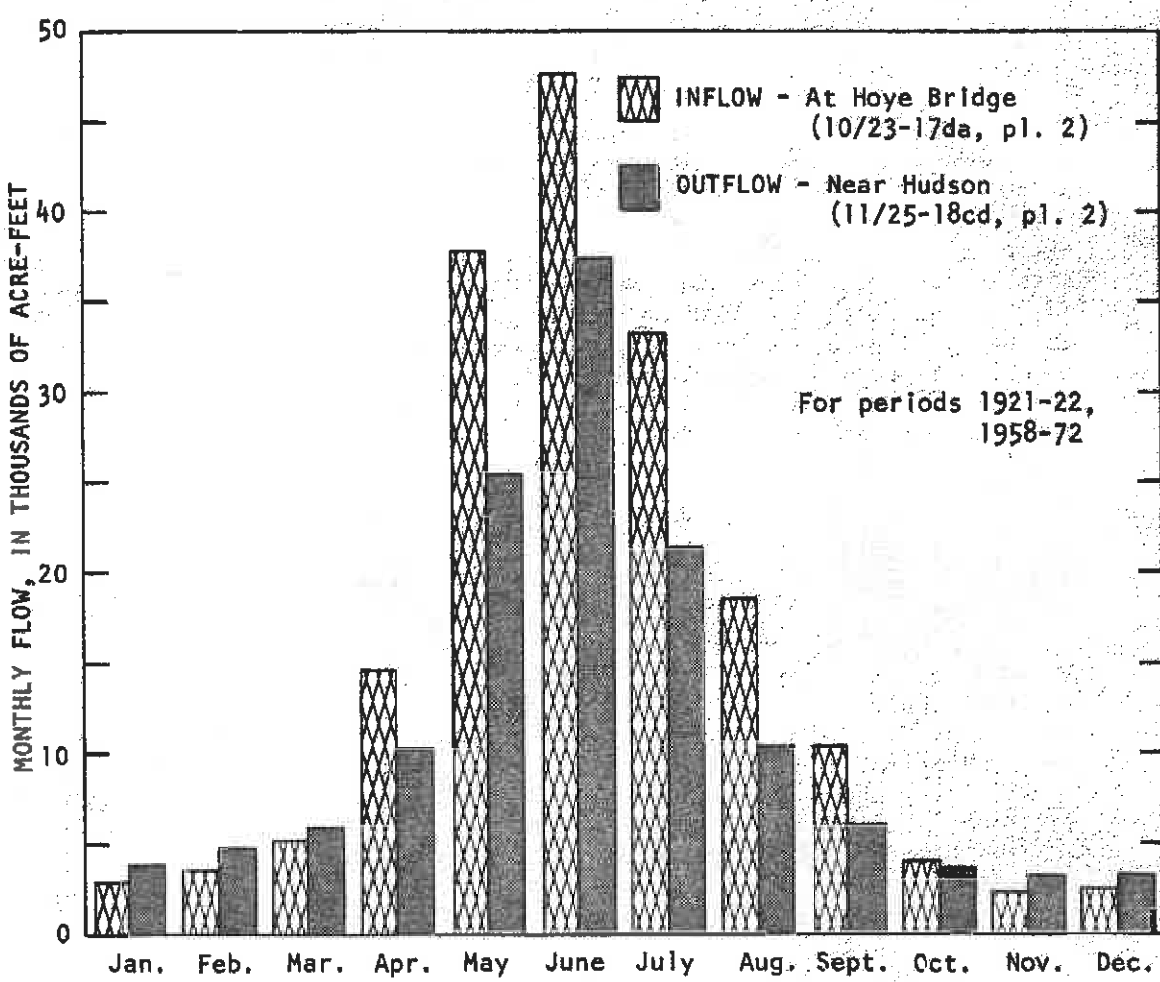

Figure 16.--Average monthly flows of West Walker River entering and leaving Smith Valley.

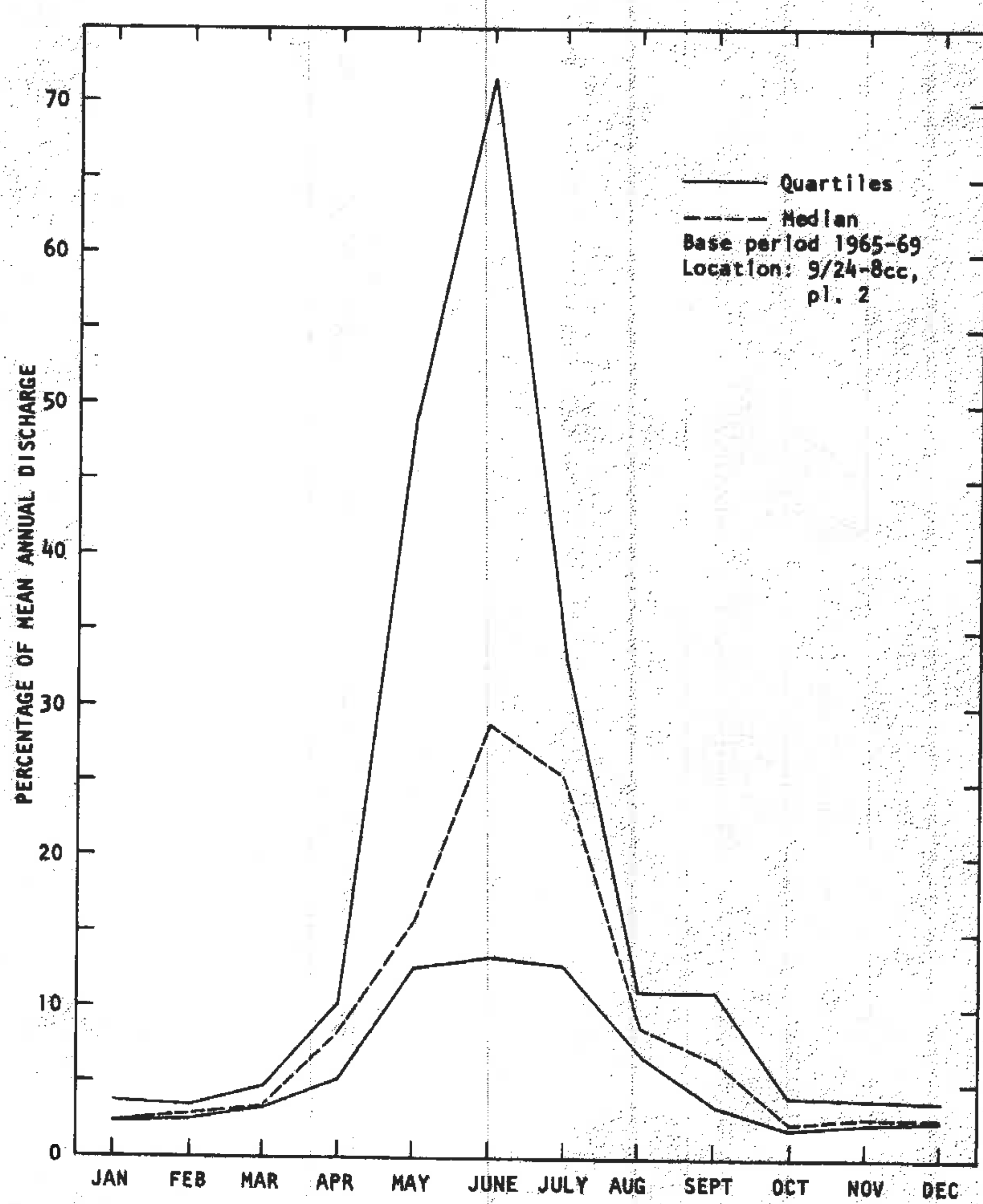

Figure 17.--Monthly discharge of Desert Creek as a percentage of mean annual discharge.

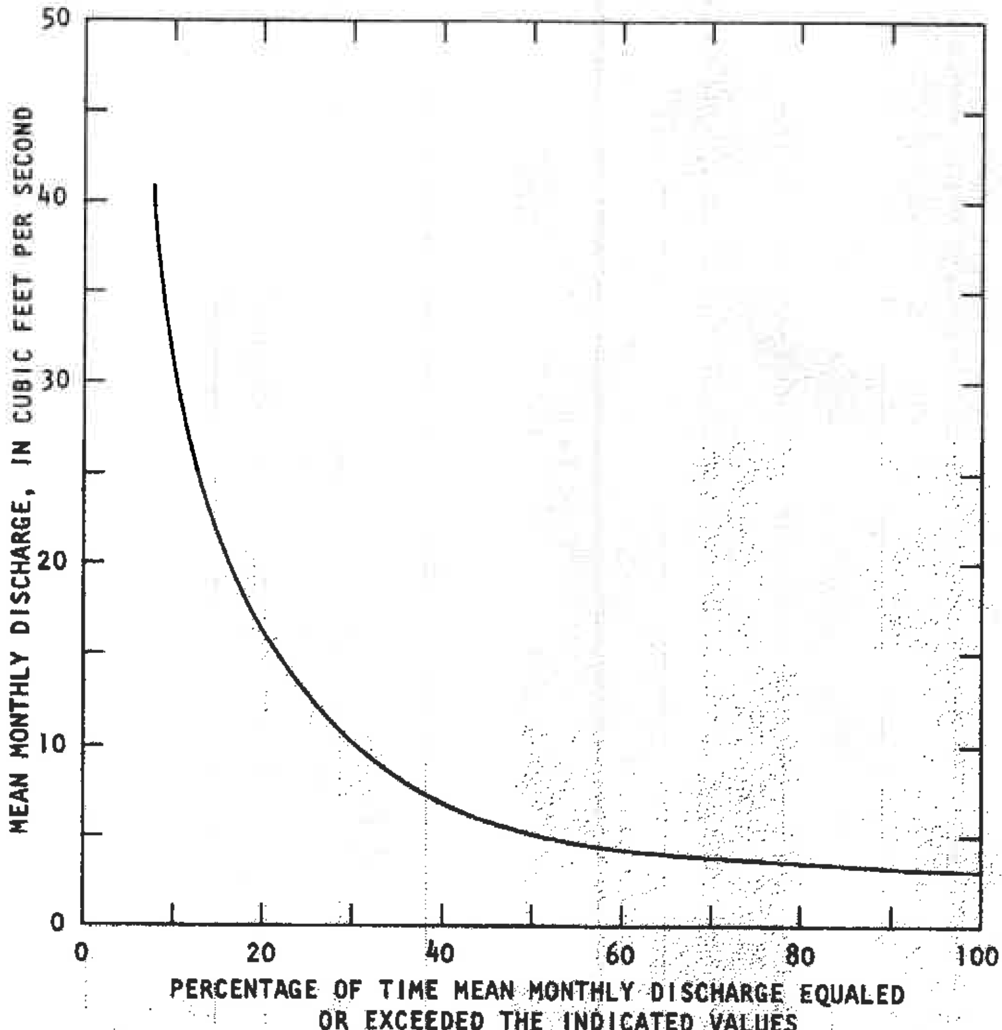

Figure 18.--Flow-duration curve for Desert Creek during 1971.

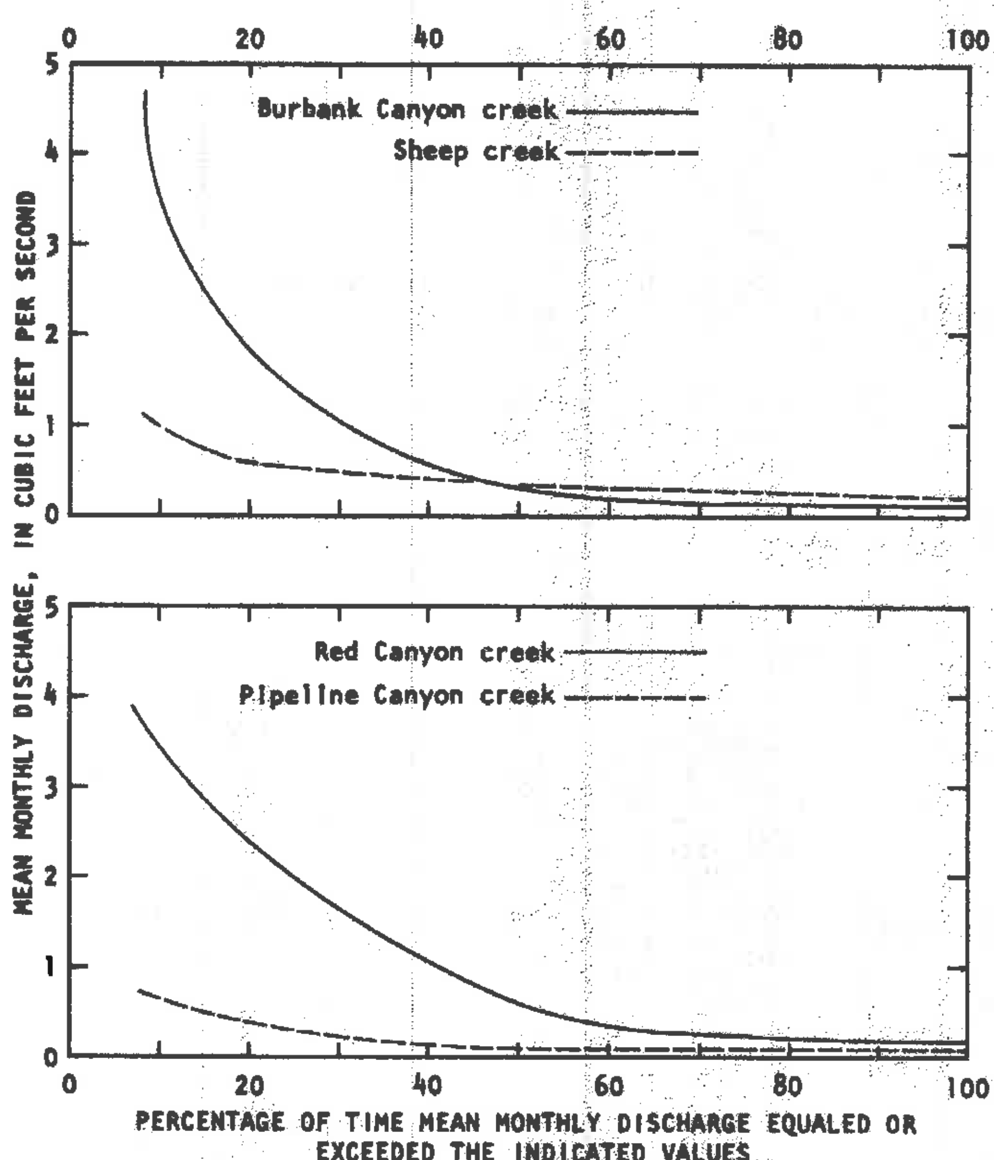

Figure 19.--Flow duration curves for several small streams during 1971.

Runoff from the Mountains

Snowmelt produces most of the streamflow that is generated within Smith Valley. This flow is characteristically at its peak during May-July (fig. 16).

Most mountain streams generally have their maximum flow at the mountain front, which is shown on plate 1 as the consolidated rock-alluvium contact. Thus, flow across the consolidated rock-alluvium contact is an index to the amount of surface water generated within the basin that is potentially available for development. Streamflow generally decreases with flow distance down the alluvial apron, due to infiltration.

Small local streams occasionally flow for short periods on the alluvial aprons as a result of high-intensity storms, but this type of streamflow is so erratic in frequency and duration that without storage structures it has little potential for direct use.

The method used to estimate runoff from the mountains was described in detail by Moore (1968). In this method, altitude-runoff relations for regions in Nevada have been developed on the basis of long-term records of streamflow and precipitation, along with supplementary streamflow data and measurements of stream-channel geometry as related to long-term flow.

The runoff estimated using the above method was compared with computed streamflow for individual drainage areas. The computed streamflow had been estimated from synthesized hydrographs based on periodic discharge measurements and hydrographic comparison with other streams, in addition to channel-geometry measurements. An adjustment factor was then used to determine runoff from the remaining ungaged parts of individual subareas of the valley.

A summary of estimated average annual runoff from individual subareas of the basin is presented in table 7; the total generated within the valley is about 12,000 acre-feet per year. The 1972 runoff probably was about 8,000 acre-feet. Due to (1) the seasonal distribution of flow, (2) infiltration to the ground-water reservoir, and (3) evapotranspiration, the percentage of this flow that is diverted for use can not be estimated. The Buckskin and Singatse Ranges on the north and northeast sides of the valley reach only low altitudes and yield little runoff. In contrast, the Desert Creek drainage area, which comprises only 12 percent of the total drainage area, contributes three-fourths of the runoff generated within the valley. It is the principal source of water within the valley.

The northern part of the Pine Nut Mountains, though high in altitude and substantial in area, contributes negligible surface runoff. The alluvial apron and valley floor below this area contain numerous springs, the largest being Nevada Hot Springs. Water that might otherwise run off may be infiltrating fractured rocks and in part migrating to the springs.

Table 7.--*Estimated long-term average annual runoff from surrounding mountains of Smith Valley*

Area	Percent of runoff area (311,700 acres)	Estimated average annual runoff	
		Acre-feet1/	Percent of total runoff
Buckskin and Singatse Ranges	20	50	small
Pine Grove Hills and eastern part of Sweetwater Mountains	34	1,300	12
Sweetwater Mountains (Desert Creek drainage area)	12	8,500	73
Wellington Hills	9	100	1
Pine Nut Mountains	25	a 1,600	14
Total (rounded)	100	12,000	100

1. Runoff values for 1972 were about two-thirds of these values.

a. Most of this runoff, 1,300 acre-feet, is generated in the Burbank, Red, and Pipeline Canyon drainage areas.

Recharge from Precipitation

Recharge to the ground-water reservoir results from precipitation and percolation losses of irrigation water from canals and fields. As of 1972, the West Walker River did not directly recharge the ground-water reservoir, but rather acted as a drain, continuously receiving water from the ground-water system (pl. 2).

A method developed by Eakin and others (1951) has been used to compute the estimated average annual recharge from precipitation. These computations are summarized in table 8, and show that an estimated 7 percent of the precipitation, or 17,000 acre-feet per year, recharges the ground-water system over the long term.

No direct determination was made of the overall seepage losses from canals and fields, but an indirect method is used to determine the quantity in a later section of the report.

Importation to Lobdell Lake

At the headwaters of Desert Creek, diversions are made into the Smith Valley basin from an unnamed creek that flows westward to the West Walker River in California. This diverted water is stored in Lobdell Lake (T. 7 N., R. 24 E.; pl. 1), a small reservoir with a surface area of about 35 acres and a stage of about 9,200 feet above sea level. Releases from the reservoir are made to Desert Creek. No records are available of the diversions to or the releases from the reservoir, but they probably are only a few hundred acre-feet in most years, including 1972.

Table 8.--*Estimated long-term average annual precipitation and ground-water recharge*

Precipitation zone (feet)	Area (acres)	Estimated precipitation 1/			Estimated recharge	
		Range (inches)	Average (feet)	Average (acre-feet)	Percentage of precipitation	(acre-feet per year)
PINE NUT AND SWEETWATER MOUNTAINS AND THE WELLINGTON HILLS 2/						
9,000-11,673	12,300	>20	2.0	25,000	25	a 6,200
8,000-9,000	15,800	15-20	1.5	24,000	15	3,600
7,000-8,000 6,000-7,000	33,700 31,100	12-15	1.1	71,000	7	5,000
4,546-6,000	69,600	8-12	.8	56,000	3	1,700
Subtotal (rounded)	162,000			180,000		16,000
BUCKSKIN AND SINGATSE RANGES AND PINE GROVE HILLS2/						
9,000-9,544 8,000-9,000	500 7,900	>12	1.1	9,000	7	630
7,000-8,000	19,800	8-12	.8	16,000	3	480
6,000-7,000 4,546-6,000	22,600 98,800	<8	.5	61,000	Minor	--
Subtotal (rounded)	150,000			86,000		1,100
TOTAL (rounded)	312,000		0.8	260,000		b 17,000

1. Based on graphs in figure 15.
2. Includes adjoining parts of the valley floor.
a. A large part of this amount runs off in Desert Creek and is used for irrigation; there, some of it infiltrates to the ground-water system.
b. Of this amount, about 3,700 acre-feet is recharged to the Artesia Lake Ground-Water Basin.

OUTFLOW FROM THE VALLEY

Quantitative estimates are made for the several elements of discharge from the hydrologic system, which are shown diagrammatically in figure 23, for the base year 1972. The principal elements of outflow are surface-water outflow, irrigation, and evapotranspiration by low-value phreatophytes.

Surface-Water Outflow

Outflow of the West Walker River during 1972 was about 101,000 acre-feet, or about 76 percent of the 1958-72 annual average of 133,000 acre-feet, as listed in table 6.

Irrigation and Subirrigation

Water Application

Most water is spread across fields from irrigation head ditches. The amount of land irrigated by sprinklers was only about 440 acres in 1972; all the sprinkler water was from wells 11/23-12bb, 12/24-32ba, and 12/24-31db (table 23), in the northeastern part of the valley. Subirrigation is a significant source of water where the depth to the water table is less than 10 feet (fig. 8).

The amount of water delivered to the irrigated part of the valley is summarized in table 9. As shown in the table, the bulk of the irrigation water is from the West Walker River, delivered through an extensive canal system, the principal canals of which are shown on plate 2. About half the water delivered to the irrigated areas of the valley is lost, mostly by percolation to the ground-water system--an estimated 47,000 acre-feet, the difference between total delivery (table 9) and total crop consumption (table 14). Little tailwater flows directly to the West Walker River, but larger amounts flow to Artesia Lake.

Table 9.--*Water delivered to the irrigated part of Smith Valley in 1972*

Source	Amount (acre-feet)	Remarks
West Walker River	a 69,000	Total diversion to canals (from table 6).
Desert Creek	3,700	Estimated to be two-thirds of the 1972 flow of 5,600 acre-feet.
Pipeline Canyon	Small	
Irrigation wells	20,000	Pumpage from 38 wells plus one flowing well (from table 11).
Nevada Hot Springs	170	
Total (rounded)	93,000	

a. Of this total, 22,000 acre-feet was delivered through canals to the Artesia Lake Ground-Water Basin.

River diversions.--There are nine direct river diversions near the mouth of Hoye Canyon. The locations of these canals are shown on plate 2. Most of the diversions are measured by Parshall flumes with records maintained by the Walker River Irrigation District, Yerington, Nev. Current-meter discharge measurements were made on four of the major diversions in 1971-72 to provide a check on the accuracy of the flumes and a general measure of control for the purposes of this study. In general, the theoretical ratings for the Parshall flumes provided satisfactory results. A summary of spot checks comparing current-meter discharge versus flume discharge is provided in table 24 (at back of report). The consistently higher flume values on Saroni Canal probably indicate a 5 to 10 percent flume error. Data on the other flumes indicate reasonable flume accuracy, or were inconclusive due to conditions at time of measurements.

Table 10 is a summary of the average annual diversions to the nine canals. Of the 20-year average of 30,000 acre-feet diverted annually from the Colony Ditch, the average percentage used in each of the subareas north and south of the ground-water divide is unknown. However, during 1971 and 1972, 74 and 79 percent, respectively, were diverted to the Artesia Lake ground-water basin north of the divide.

Table 10.--*Diversions from West Walker River, 1953-72*

[All values in acre-feet, rounded]

Canal or ditch	Annual average, 1953-72 1/	1971 1/	1972 1/
	SOUTH OF RIVER		
Saroni Canal	a 19,000	a 24,000	a 17,000
Plymouth Canal	11,000	14,000	13,000
Dickerson Ditch	480	560	560
River Simpson ditch	3,400	4,000	2,900
Upper Fulstone ditch	2,600	3,100	2,000
West Walker Ditch	3,100	3,300	2,800
Gage Peterson ditch	3,800	3,600	3,000
Subtotal (rounded)	43,000	53,000	41,000
	NORTH OF RIVER		
Colony Ditch:			
Delivered to Artesia Lake Ground-Water Basin	--	29,000	22,000
Delivered within river basin	--	10,000	5,700
Colony Ditch total	30,000	39,000	28,000
Lower Fulstone ditch	830	690	630
Subtotal (rounded)	31,000	40,000	29,000
TOTAL (rounded)	74,000	93,000	70,000

1. Based on records of the Walker River Irrigation District.
a. Values may be high by 5 to 10 percent; see text.

Attempts to document the magnitude of canal losses within the valley provided inconclusive results. Most losses are believed to be small. Indeed, during the late summer months the reaches investigated often showed slight gains, indicating that many of the ditches were functioning to some degree as drains for the irrigated fields. Figure 20 summarizes the results of three seepage determinations. The mainstem Saroni Canal generally gained flow between points of diversion during the two-day study. Only the first and third reaches of the canal had seepage losses. The Plymouth Canal had a loss of about 5 percent in a 2.85-mile reach, not including diversions. The distributary ditch of Saroni Canal gained about 4 percent in flow in a 1.1-mile reach.

Wells.--During 1972, irrigation pumpage continued throughout the year, except for January, as shown in table 11. However, 88 percent of the 20,000 acre-feet pumped was during the period May through September. The areal distribution of this pumpage is shown in figure 21--about 11,000 acre-feet was pumped north of Walker River, and about 9,000 acre-feet was pumped south of the river. Flowing irrigation well 13/23-25ca, north of Artesia Lake, is also shown on the map. The well had an annual discharge of about 640 acre-feet, which is included in the 20,000-acre-foot total.

Table 11.--*Monthly irrigation-well pumpage during 1972*

[Based mostly on electric-power consumption]

Month	Wells pumped for irrigation	Percentage of total pumpage 1/	Acre-feet (rounded)
January	0	0	0
February	3	1	200
March	12	2	400
April	17	3	600
May	29	12	2,300
June	34	20	4,000
July	33	16	3,200
August	34	20	4,000
September	36	20	4,000
October	18	4	900
November	4	1	300
December	4	1	100
Year	a 39	100	b 20,000

1. Much of the pumpage during early spring and late fall is from the O'Banion well, 11/23-15cc. The water is used for raising fish during this time of the year and, in addition, for irrigation during the growing season.

a. Includes 38 pumped wells and one flowing well.

b. Includes 1972 flow from artesian well 13/23-25ca of about 640 acre-feet.

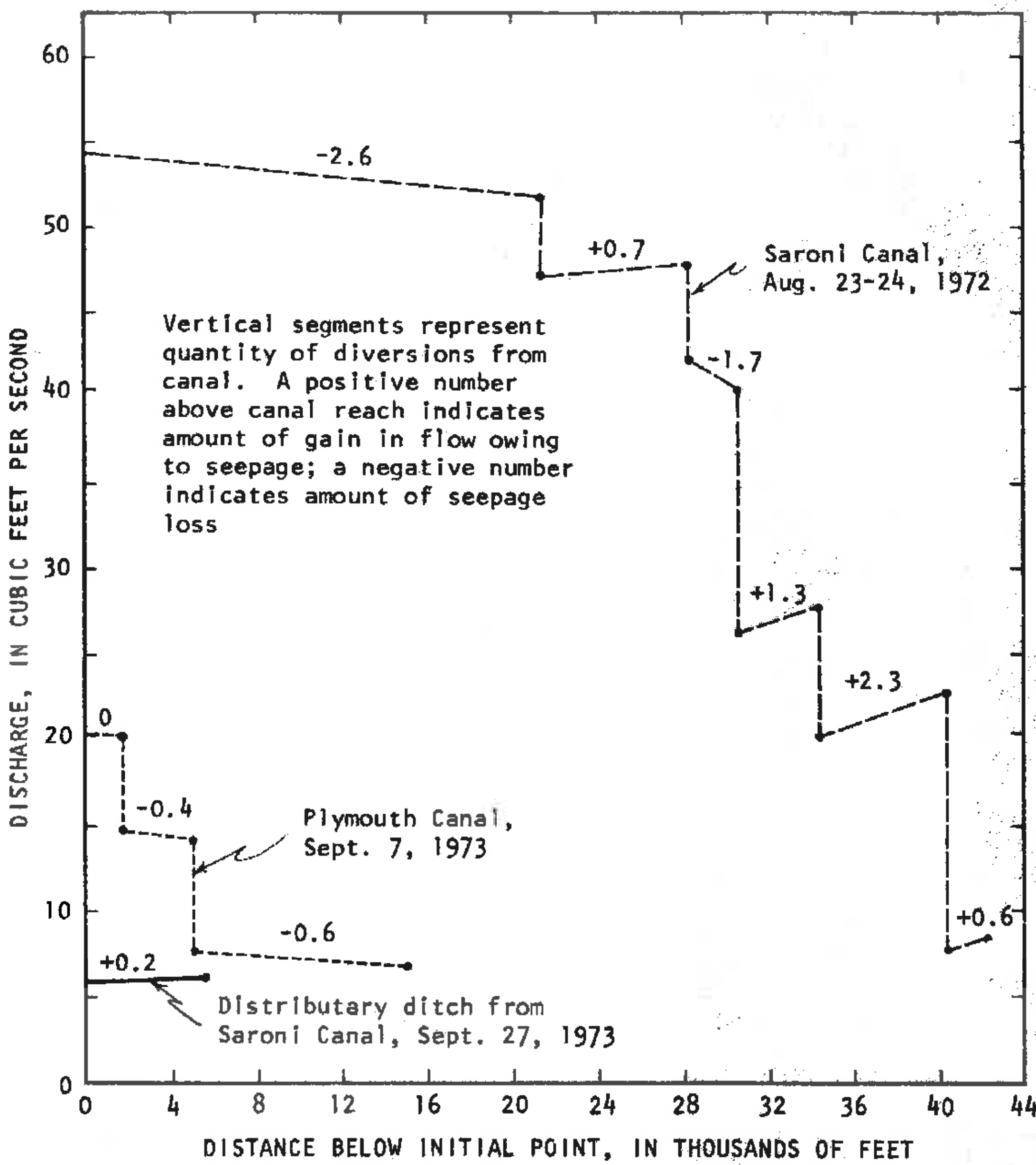

Figure 20.--Canal seepage losses and gains.

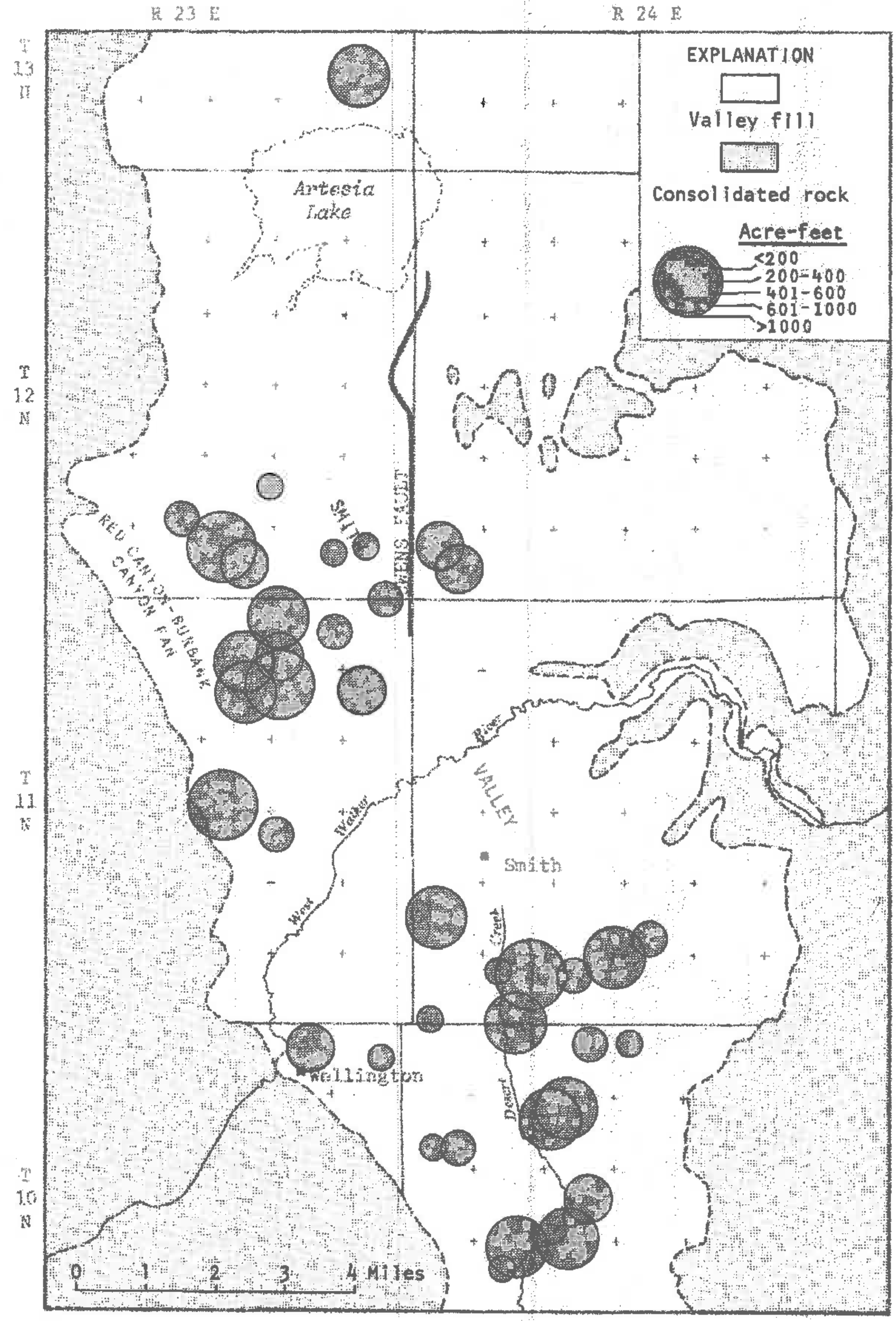

Figure 21.--Distribution of irrigation-well pumpage in 1972.

A summary of power consumption and well operation is given in tables 12 and 13. The average pumping cost of ground water in the valley is $4.00 per acre-foot, but the range in costs is considerable.

The "power-consumption rating" is lower north of the river than south. This is principally the result of shallower static water levels and a smaller drawdown (from pumping) due to generally larger transmissivities and storage coefficients north of the river.

Table 12.--*Summary of irrigation-well operation in 1972*

Wells:		
Electric powered	36	
Diesel powered	2	
Flowing	1	
Total	39	
Water pumped:	acre-feet	
Total discharge	20,000	
Minimum per well	27	
Maximum per well	1,400	
Mean (39 wells)	510	
Electric power consumed:		
Total (36 wells)	5,103,000 kwh (kilowatt-hour)	
Mean (33 wells) 1/	136,000 kwh	
Mean power consumption per acre-foot (33 wells)		270 kwh
(Also, see table 13)		
Mean pumping lift (feet below land surface)		140 ± 10 feet
Pumping costs per acre-foot (33 wells 2/):		
Minimum	$1.60	
Maximum	$8.25	
Mean	$4.00 3/	

1. Does not include wells pumping to sprinklers; average power consumption at these three wells was 211,000 kwh.
2. Based on an electric-power rate of 1.5 cents per kwh.
3. Average pumping cost per acre-foot for the three wells pumping to sprinklers was $5.90.

Table 13.--*Power-consumption ratings for irrigation wells in 1972*
[Electrically-powered pumps only]

Power consumption rating 1/	Range, in kilowatt-hours/ ac-ft 2/	Average lift (ft)	Total number of wells	Distribution	
				North of river	South of river
Very low	100-200	85	12	11	1
Low	200-400	165	18	6	12
Medium	400-480	245	4	0	4
High	480-550	285	2	0	2
Total	100-550		a 36	17	19

1. Rating developed for use in this report.
2. Does not include energy requirements for operating sprinklers.
a. In addition, two wells were pumped with diesel power; they are not included in this table.

Water Consumption

The irrigation-water consumption in the valley for 1972 is summarized in table 14. Approximately 22,600 acres were irrigated or subirrigated with an estimated 46,000 acre-feet of net consumption. About twice this amount of water, approximately 93,000 acre-feet (table 9), was diverted to the irrigated parts of the valley.

About 10,000 acres of land was subject to varying amounts of subirrigation. Most of this land supported either native-grass pasture or grass hay. Of the total water consumption on this land in 1972 (about 18,000 acre-feet), an estimated 5,000 acre-feet was supplied through subirrigation.

Leaching Requirements

Dissolved salts are present in the water used for irrigation in Smith Valley. Plant roots remove molecules of water from soil, but most of the salt remains in the root zone unless it is removed by percolating water. Crops differ in salt tolerance. Data on salt tolerance and leaching requirements are given in table 15. Requirements are for specific conductances of 200 and 450 micromhos, generally the highest values found for surface water and ground water, respectively, in the valley during this study. Average specific conductances for these waters are about half the maximum values. The leaching requirements listed in table 15 are for a crop-yield reduction of no more than 10 percent. On the basis of this information and the estimates in tables 14 and 26, the amount of water needed for leaching during 1972 was as follows:

Table 14.--*Consumption of water by irrigated and subirrigated crops in 1972*

[Crop acreage based on aerial photographs and field inventory]

Crop	Area irrigated (acres)	Average annual water-use rate 1/ (feet)	Consumed water (acre-feet, rounded)
RIVER BASIN, NORTH OF RIVER			
Alfalfa hay	1,470	2.3	3,400
Grass pasture and hay	1,970	1.8	3,500
Grain, mostly barley, wheat, and oats	30	1.2	40
Subtotal (rounded)	3,470		6,900
RIVER BASIN, SOUTH OF RIVER			
Alfalfa hay	7,710	2.3	18,000
Grass pasture and hay	4,190	1.8	7,500
Grain, mostly barley, wheat, and oats	660	1.2	790
Garlic	80	1.6	130
Potatoes	25	1.7	40
Subtotal (rounded)	12,700		26,000
RIVER-BASIN TOTAL (rounded)	16,200	2.0	33,000
ARTESIA LAKE GROUND-WATER BASIN			
Alfalfa hay	2,130	2.3	4,900
Grass pasture and hay	a 4,140	1.8	7,500
Grain, mostly barley, wheat, and oats	70	1.2	80
Garlic	100	1.6	160
ARTESIA BASIN TOTAL (rounded)	a 6,440	2.0	13,000
VALLEY TOTAL (rounded)	22,600	2.0	46,000

1. Net consumptive irrigation requirements as determined by Nevada River Basin/Watershed Planning Staff (Soil Conservation Service, written commun., 1973).

a. Includes 110 acres of subirrigated native grass west and north of Artesia Lake and 2,500 acres of partially subirrigated grass pasture south of Artesia Lake in T. 12 N., R. 23 E.

		Acre-feet
West Walker River Basin:		
	North of river	240
	South of river	1,100
	Subtotal (rounded)	1,300
Artesia Lake Basin:		400
	Valley total (rounded)	1,700

The leaching requirements add an additional 4 percent to the water-use needs for the cropland. Under present irrigation practices in the valley, the leaching requirements are generally satisfied.

Table 15.--*Leaching requirements*

[Based on findings of Fuller (1965) and Bernstein (1964)]

Crop	Specific conductance at 10 percent yield reduction (micromhos)	Leaching requirements 1/	
		200 micromhos (maximum for surface water)	450 micromhos (maximum for ground water)
Alfalfa	3,000	7	15
Grass, fescue	7,000	3	6
Barley	12,000	2	4
Wheat	7,000	3	6
Garlic	a 2,000	10	20
Potatoes	2,500	8	18

1. Requirements as a percentage of water consumed by crop.
a. For onions; assumed to apply to garlic also.

Percolation to the Ground-Water System

As part of the present irrigation process in Smith Valley, water is lost to the ground-water system from canals, ditches, and irrigated fields. The principal canals do not seem to lose very much water, as described in an earlier section of the report; rather, the principal losses probably are from fields. As a result, the irrigated areas are the principal areas of man-induced ground-water recharge. As stated previously, the percolation of irrigation water to the ground-water system was about 47,000 acre-feet in 1972, and resulted from a total delivery of 93,000 acre-feet and a net crop consumption of 46,000 acre-feet. Of the 47,000 acre-feet of percolation, only about 1,700 acre-feet is needed to maintain a desirable salt balance.

Return Flow

Under native conditions, both surface water and ground water flowed to Artesia Lake and the West Walker River. The ground-water flow was virtually constant, resulting from a low, constant gradient. Surface flow to the lake and the river was intermittent, generally restricted to periods when snowmelt was rapid or during summer thunderstorms.

Under native conditions, the ground-water flow equaled recharge minus discharge by evaporation and phreatophytes over a period of years. The amount of evapotranspiration under those conditions is unknown, but probably was somewhat less than the computed average recharge of 17,000 acre-feet per year.

With the construction of canals and extensive irrigation of crops, natural streamflow to the lake and river was reduced, but ground-water flow was increased greatly. This increase resulted from a steepening of the ground-water gradient toward the lake and river, in turn caused by mounding of ground water beneath croplands on both sides of the river (pl. 2).

As of 1972, the ground-water mound beneath croplands on both sides of the river had nearly stabilized. Therefore, in spite of heavy pumping at some distance from the river, there appeared to be little seasonal or year-to-year variation in ground-water gradient toward the river.

Return flow to the West Walker River was measured on Oct. 26, 1972; the results are summarized in table 16. The net return flow, as indicated by the flow increase in the river through the irrigated area, was about 41 cfs. The return flow may be about constant throughout the year; if so, the annual total would be about 30,000 acre-feet. Thus, the average net diversion from the river would equal the average total diversion of about 73,000 acre-feet per year (table 6) minus the return flow of 30,000 acre-feet (table 16), or 43,000 acre-feet annually. This agrees closely with the measured net decrease in streamflow of 46,000 acre-feet (table 6, column 3).

In the consolidated-rock areas and along the apron, river flow fluctuated on Oct. 26, 1972, due to gains and losses; however, across the main part of the valley floor, steady gains were measured. The maximum rate of gain per mile was between sites 11/23-26cc and 11/23-13cd.

Ground water flows northward within the Artesia Lake ground-water basin from the irrigated area toward Artesia Lake (pl. 2). A rough estimate of flow at the north end of the agricultural area (pl. 2) is based on a flow width (W) of 3 miles, an average gradient (I) of about 80 feet per mile, and a transmissivity (T) of perhaps 10,000 to 15,000 gpd per foot (1,340 to 2,000 ft^2/day). Based on the equation $Q = 0.00112\ TIW$, the flow (Q) possibly is on the order of 3,000 to 4,000 acre-feet per year.

Table 16.--*Ground-water return flow to the West Walker River in 1972*

[Data for October 26, 1972]

River location	Distance downstream from initial site (miles)	Measuring site (pl. 2)	River flow 1/ (cfs)	Increase (+) or decrease (-) (cfs)	Accumulated return flow through ground-water system (cfs)
10/23-17da	0	Gage in Hoye Canyon	43.5		
10/23-16aa	1.5	--	42.0	-1.5	--
10/23-10cc	1.7	Diversion to Saroni Canal (4.3 cfs)	39.3	+1.6	--
10/23-10aa	3.2	Diversion to Colony Ditch and Plymouth Canal (23.5 cfs)	13.4	-2.4	--
10/23-2cc	3.7	Diversions to Dickenson, Simpson, and Upper Fulstone ditches	14.8	+1.4	--
10/23-2ba	4.5	Diversions to West Walker Ditch and Gage Peterson (3.3 cfs)	10.5	-1.0	--
11/23-26cc	6.0	Lower Fulstone Diversion	14.3	+3.8	3.8
11/23-26aa	7.0	--	20.0	+5.7	9.5
11/23-13cd	8.5	Ditch from Beaman Lakes (inflow = 0.34 cfs)	30.8	+10.5	20.0
11/24-18aa	10.5	At bridge north of Smith	38.8	+8.0	28.0
11/24-8ac	11.7	--	43.4	+4.6	32.6
11/24-9ad	13.4	--	46.8	+3.4	36.0
11/24-3dd	14.7	At Hudson bridge	51.4	+4.6	40.6
11/24-13bc	16.7	--	50.4	-1.0	--
11/25-18cd	18.5	Gage near Hudson	49.4	-1.0	--
11/25-17ac	20.0	Wilson Canyon	50.6	+1.2	--
Net gain (rounded)				38	41
Equivalent net annual gain, in acre-feet (rounded)				28,000	30,000

1. At diversions, flow listed in that of river downstream from point of diversion.

Return flow to West Walker River can be used as a check on the aquifer transmissivity. Using the data in table 16, and assuming that the quantity of return flow was nearly constant throughout 1972 (p. 54), about 30,000 acre-feet of flow may have returned to the river during the year. With the existing average gradients toward the river from the north and south of about 25 to 30 feet per mile and a straight-line flow width of 7 miles on each side of the river (pl. 2), a transmissivity of about 70,000 gpd per foot (9,400 ft^2/day) is needed to transmit the flow of water to the river. This value agrees reasonably well with the range of 50,000-100,000 gpd per foot (fig. 5) derived from pumping-test data.

Evapotranspiration by Low-Value Phreatophytes

Much of the vegetation that grows in areas where the depth to ground water is less than about 50 feet commonly roots down to the water table and thus removes water directly from the ground-water system. These deep-rooting plants are called phreatophytes. Some of them, such as grasses, are of economic value, whereas others such as greasewood and rabbitbrush have low value. In areas of fine-grained soils, where the depth to water is less than about 10 feet, ground water is discharged by evaporation. These types of ground-water discharge are summarized in table 17. Evapotranspiration rates are based on research done by Lee (1912), White (1932), Young and Blaney (1942), Houston (1950), Robinson (1965), and Harr and Price (1972) in other areas.

In Smith Valley, these plants and discharging bare soil occupy an area of about 15,000 acres and discharge about 13,000 acre-feet per year (table 17). Some of this discharge might be salvaged for more beneficial use. This possibility is discussed in a later section of the report.

Evaporation of Surface Water

Water evaporates from Artesia Lake, Beaman Lakes, canals, and streams. During 1972, Artesia Lake contained water reportedly for a shorter-than-average period of time. During the 1971-72 winter, rising ground water plus stream and canal inflow flooded the playa; however, by mid-summer 1972 the lake had completely evaporated. No measurements were made of the evaporation rate or the inflow to the lake, but intermittent observations suggest that on the order of 1,000 acre-feet of surface water was evaporated. This is based on a flooded area of 2,000 acres and an estimated evaporation of 0.5 foot of water. During average years, probably about 6,000 acre-feet of surface water would be evaporated (3,000 acres x 2 feet of evaporation) in addition to the 6,000 acre-feet of ground water estimated in table 17. This latter estimate is based on descriptions of the lake by local residents. of water surface. The estimated evaporation from the lakes was about 400 acre-feet in 1972. Because a ditch drains the lakes at higher stages, the 1972 evaporation rate is probably near the long-term average.

Table 17.--*Evapotranspiration of ground water by low-value phreatophytes and from bare soil*

[Does not include meadow grass]

Type of water loss	Phreatophyte ground cover (percent)	Depth to water table (feet)	Area (acres)	Average annual Evapotranspiration: Acre-feet per acre	Average annual Evapotranspiration: Acre-feet (rounded)
		ARTESIA LAKE GROUND-WATER BASIN			
Mostly greasewood and rabbitbrush; mixed with various amounts of big sage, shadscale, and saltgrass	5-20	5-50	8,000	0.2	a 2,000
Mostly saltgrass and rabbitbrush near Artesia Lake		1-5	2,000	.5	1,000
Artesia Lake playa	0	0-1	3,000	b 2.0	c 6,000
Subtotal (rounded)			d 13,000		9,000
		WEST WALKER RIVER BASIN			
Tules around Beaman Lakes	--	0-5	300	1.0	300
Cottonwood, willow, and various types of brush on the West Walker River flood plain	--	0-5	d 1,000	4.0	e 4,000
Mostly greasewood and saltgrass. Mostly in 10/24-18 and 20, south of Saroni Canal	5-20	f 40-100	d 280	.2	60
Subtotal (rounded)			1,600		e 4,400
TOTAL (rounded)			15,000		e 13,000

a. Does not include discharge by 110 acres of meadow grass, supported by springs and flowing wells, northwest of Artesia Lake in township 13 N. Discharge by grass included in crop inventory.
b. Estimated rate of consumption of ground water only.
c. Includes evaporation of ground water and ponded water rising from the subsurface. Additional surface-water runoff collects in lake and evaporates. Entire area of 3,000 acres remains wet during most years and total evaporation of surface and ground water equals about 12,000 acre-feet per year.
d. Shown on plate 2.
e. Value is approximate.
f. Phreatophytes probably supported by percolating water perched above the water table.

Flowing water in the West Walker River, Desert Creek, canals, and the few small streams in the Pine Nut Mountains is subject to evaporation. The combined surface area of these streams is estimated to be about 300 acres and the evaporation rate about 4 feet per year; therefore, the total evaporation of flowing water is about 1,200 acre-feet per year during most years, including 1972. The estimated total of all surface-water evaporation for 1972 was about 3,000 acre-feet. For average years, the evaporation is estimated to be about 8,000 acre-feet.

Springs

Nevada Hot Spring is the principal spring in the valley. All other springs, mostly west and north of Artesia Lake (pl. 2), are small. During the period August 1972-July 1973, Nevada Hot Spring had an average flow of about 540 gpm (table 5), or a projected rate of 870 acre-feet per year. The total spring discharge for the valley is estimated to be about 1,000 acre-feet per year.

Most of the spring flow either seeps back to the water table or is discharged by crops or phreatophytes; the volume of spring flow is included in estimates of discharge in the water budgets (tables 19 and 20).

Domestic and Stock Use

The human population of Smith Valley, as estimated earlier in the report, was 300 to 500 in 1972. Per capita use of water, as based on estimates developed in other parts of northern Nevada, was probably about 100 gallons per day, giving a total of about 50 acre-feet per year. Of this total, about two-thirds, or 35 acre-feet, returns to the ground-water system from private, domestic sewage-disposal systems. The remainder, about 15 acre-feet per year, is the estimated net discharge for 1972.

The Soil Conservation Service (written commun., 1972) estimated that in Lyon County, which includes most of Smith Valley, the livestock population in 1969 was about 55,000 head, using about 500 acre-feet of water. The 1972 population and consumption rate is probably similar; therefore, from these data the stockwatering consumption of Smith Valley is probably about one-fourth the total use, or on the order of 125 acre-feet.

The domestic and stockwater consumption in Smith Valley in 1972 was about 140 acre-feet. Of this amount, less than 50 acre-feet was consumed in the Artesia Lake ground-water basin.

EFFECTS OF WATER USE ON THE HYDROLOGIC SYSTEM DURING 1972

The long-term effects of large-scale irrigation in Smith Valley are described in an earlier part of the report. Short-term effects were observed in 1972.

During the period extending from late March to early November 1972, the ground-water reservoir had a net water-storage decline of about 15,000 acre-feet. This was the result of two contributing factors: (1) a reduction in the amount of irrigation with water diverted from the West Walker River, and (2) the pumping of 20,000 acre-feet from irrigation wells. Because much of the pumping was in the same areas as reduced surface-water availability, the effects of the two factors cannot be separated. However, the principal factor was probably the large-scale pumping.

Throughout the 1972 irrigation season, in particular, and during the entire year, in general, irrigation water was percolating to the water table. Storage decline resulted from a faster rate of water removal than recharge to the system. When most of the irrigation wells were shut off, the inflow-outflow relation reversed, and storage in the ground-water reservoir began to increase. As a result, the 15,000-acre-foot depletion during the growing season was reduced to about 6,000 acre-feet by the beginning of the next growing season in late March 1973. About 1,000 acre-feet of the net 1972 depletion was in the Artesia Lake ground-water basin.

The area and depth of dewatering during the 1972 irrigation season are shown in figure 22. The factors that contribute to the shape are: (1) distribution of pumping, (2) distribution of areas where the amount of irrigation water available from the West Walker River was less than average during the year, (3) distribution of the hydraulic properties of the aquifer, and (4) location and effectiveness of hydraulic boundaries.

A comparison of figures 21 and 22 shows that south of the river, the center of dewatering mainly coincides with the center of pumping. However, north of the river the pattern is different. The pumping is greatest along the toe of the Red Canyon-Burbank Canyon fan, but the maximum dewatering is centered along the Owens fault several miles to the east. This distribution is caused by three factors: (1) the barrier effect of the fault to horizontal ground-water flow, (2) the very small storage coefficient associated with semiconfined conditions east of the fault, and (3) the lower transmissivity near the fault in contrast to the high values along the toe of the fan.

Table 18 is a summary of dewatering for the year from spring 1972 to spring 1973.

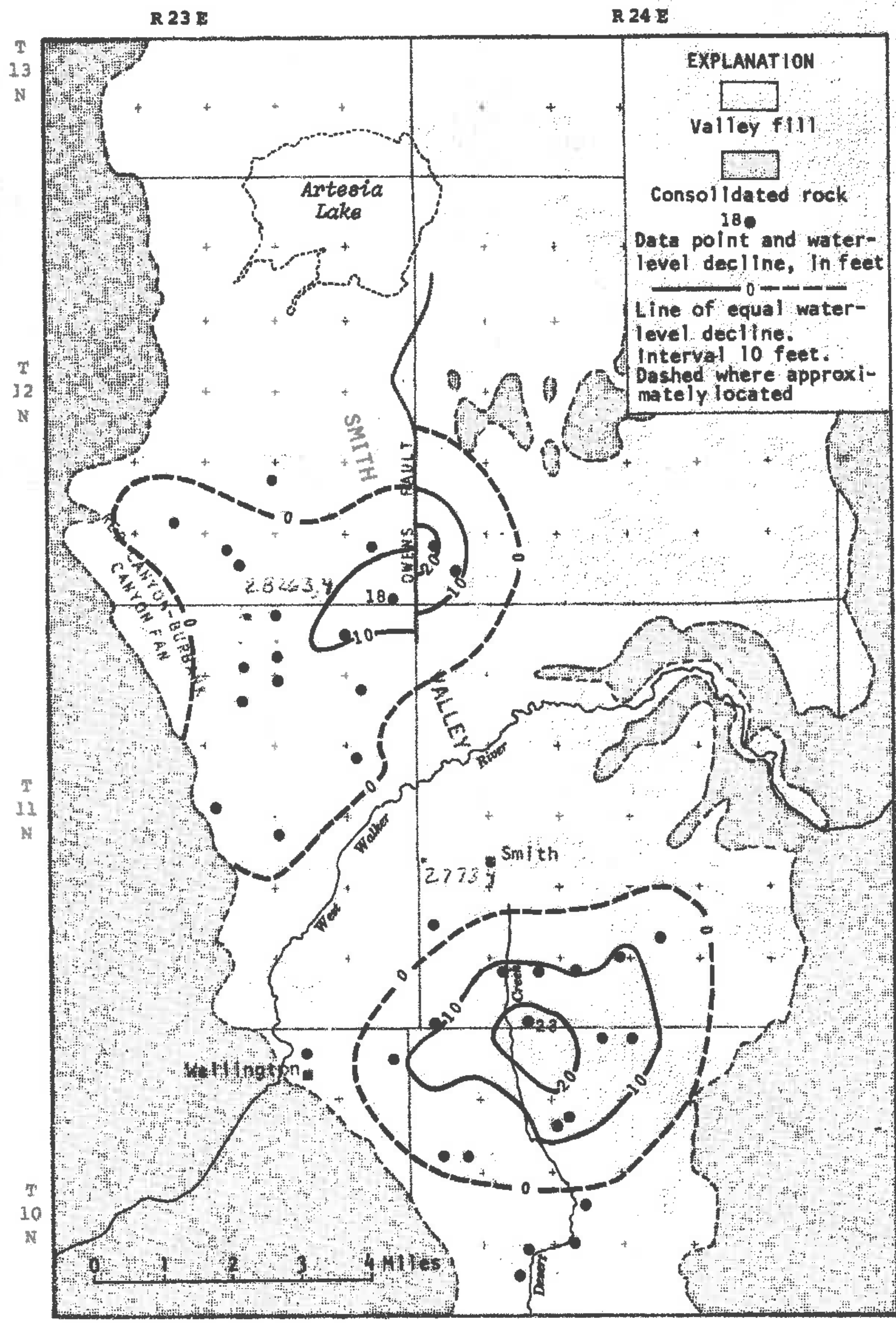

Figure 22.--Decline of ground-water levels during the 1972 irrigation season.

Table 18.--*Summary of water-level decline and reduction of ground water in storage, spring 1972 to spring 1973*

	Area north of river (fig. 22)	Area south of river (fig. 22)	Total
Pumpage (acre-feet)	a 10,000	9,000	a 19,000
Area of water-level decline (acres)	11,000	9,000	20,000
Net water-level change in wells (feet)			
Maximum	-5.5	-7.9	--
Minimum	0	0	--
Average	-1.2	-3.2	--
Storage reduction (acre-feet, rounded)	b 2,000	b 4,000	b 6,000

a. Does not include flow from well 13/23-25ca, north of Artesia Lake (fig. 21).

b. Estimated specific-yield value of 0.15 used in storage computations.

WATER BUDGET, 1972

During a multiyear period, most natural hydrologic systems approach dynamic equilibrium; that is, inflow equals outflow.

This means that although no single year will have a perfect balance, over the long term the inflow and outflow will approximately balance. If a large change is made in any of the flow elements, considerable time, perhaps as long as several decades, would be needed to again balance the system. If the system is out of balance, the amount of ground water in storage would be changing and the equation would be:

$$\text{Inflow} = \text{Outflow} \pm \text{storage change.}$$

During the early part of the twentieth century, when a large general rise in water levels occurred in Smith Valley (Loeltz and Eakin, 1953, p. 31), inflow was larger than outflow, resulting in a correspondingly large increase in storage. During the growing season of 1972 and the period from spring 1972 to spring 1973, outflow exceeded inflow, and some storage was removed from the system as indicated by the net decline in water levels (table 18 and fig. 22).

A water budget for Smith Valley for the calendar year 1972 is presented in table 19. The only element of inflow not included is local runoff within the valley, which is largely accounted for in the estimate of ground-water recharge. Discharge from springs is not included as an outflow element in the budget because it is accounted for by phreatophyte and crop evapotranspiration. Net irrigation consumption, rather than gross water application to the irrigated part of the valley, is used because infiltration to the water table is not a loss from the hydrologic system. Likewise, leaching of salts does not directly consume water.

Approximately 160,000 acre-feet of water moved through the system in 1972; consumption totaled about 60,000 acre-feet and depletion of stored ground water was about 6,000 acre-feet during the year. The budget nearly balances, with an imbalance of only 2,000 acre-feet, or about 1 percent.

The use of surface water in Smith Valley probably has been developed to its fullest extent within the water-right allocations. The use of ground water, on the other hand, has been increasing, not only to supplement the surface-water supply, but also to develop irrigated agriculture in areas not served by the surface-water supplies. Accordingly, a budget pertaining only to the ground-water system is given in table 20. In time, increased pumpage could salvage some of 13,000 acre-feet per year now consumed by evaporation and low-value phreatophytes.

Table 19.--*Water budget for 1972*

[All values in acre-feet]

Inflow to the valley-fill reservoir:	
West Walker River (table 6)	142,000
Recharge from precipitation (table 8)	17,000
Importation, Lobdell Lake (p. 42)	only a few
Total inflow (rounded) (1)	159,000
Outflow from the valley-fill reservoir:	
West Walker River outflow (table 6)	101,000
Irrigation and subirrigation consumption (table 14)	46,000
Transpiration by low-value phreatophytes (table 17)	13,000
Evaporation of surface water (p. 57)	3,000
Domestic and stock consumption (p. 57)	140
Total outflow (rounded) (2)	163,000
Inflow (1) - Outflow (2) = (3)	- 4,000
Depletion of ground water in storage (table 18) (4)	- 6,000
Budget imbalance: (3) - (4)	2,000

Table 20.--*Ground-water budget for 1972*

Budget element	Acre-feet
INFLOW:	
Recharge from precipitation (table 8)	17,000
Infiltration of irrigation water (p. 44)	47,000
Total inflow (1)	64,000
OUTFLOW:	
Pumpage (table 11)	20,000
Phreatophyte and bare-soil discharge (table 17)	13,000
Springs (p. 57)	1,000
Subirrigation (p. 50)	5,000
Ground-water return flow to the river (table 16)	30,000
Total outflow (2)	69,000
INFLOW (1) - OUTFLOW (2) = (3)	- 5,000
STORAGE DEPLETION: (4) (table 18)	- 6,000
BUDGET IMBALANCE: (3) - (4)	1,000

All the known elements of water inflow, outflow, and ground-water storage change have been identified and evaluated in the foregoing sections of the report for the year 1972. This information forms the basis for the conceptual model of water flow of Smith Valley for 1972 and is summarized in figure 23. Routing of water is shown by three weights of lines, the more substantial the line, the greater the relative flow. For example, "West Walker River" flows through the valley, with a major reduction by diversion to "canals and ditches" and ultimately to irrigated fields. Substantial amounts of the "field irrigation" water infiltrate to the ground-water reservoir; part of this infiltration flows toward the river in the subsurface, where it reenters the river and flows out of the valley to the east.

How does this model change for other years? What is the nature of the model for long-term average conditions? The second question can be answered more easily. A long-term average budget does not have much meaning in Smith Valley, because land use and water use are undergoing marked changes. The year 1972 was a period of increasing land cultivation and irrigation-well use. There is a transition from a dominant reliance on surface-water flow prior to about 1960 to more conjunctive use of surface water and supplemental ground water during years of low river flow and reliance on wells as the sole source of water for some croplands.

For years when more surface water is available than in 1972, the model would have the following characteristics: (1) river inflow, river through-flow, and canal diversions, crop consumption, evaporation from Artesia Lake, and percolation of irrigation water to the water table would be larger. Well discharge would be smaller in areas of surface-water deliveries. The amount of stored ground water would increase, or at least the decrease in storage would be smaller than in 1972, if other conditions remained constant. The principal controls on the hydrologic response during these short periods are the variations in annual flow in the West Walker River, the corresponding changes in the diversions from the river, and the amount of ground-water pumpage.

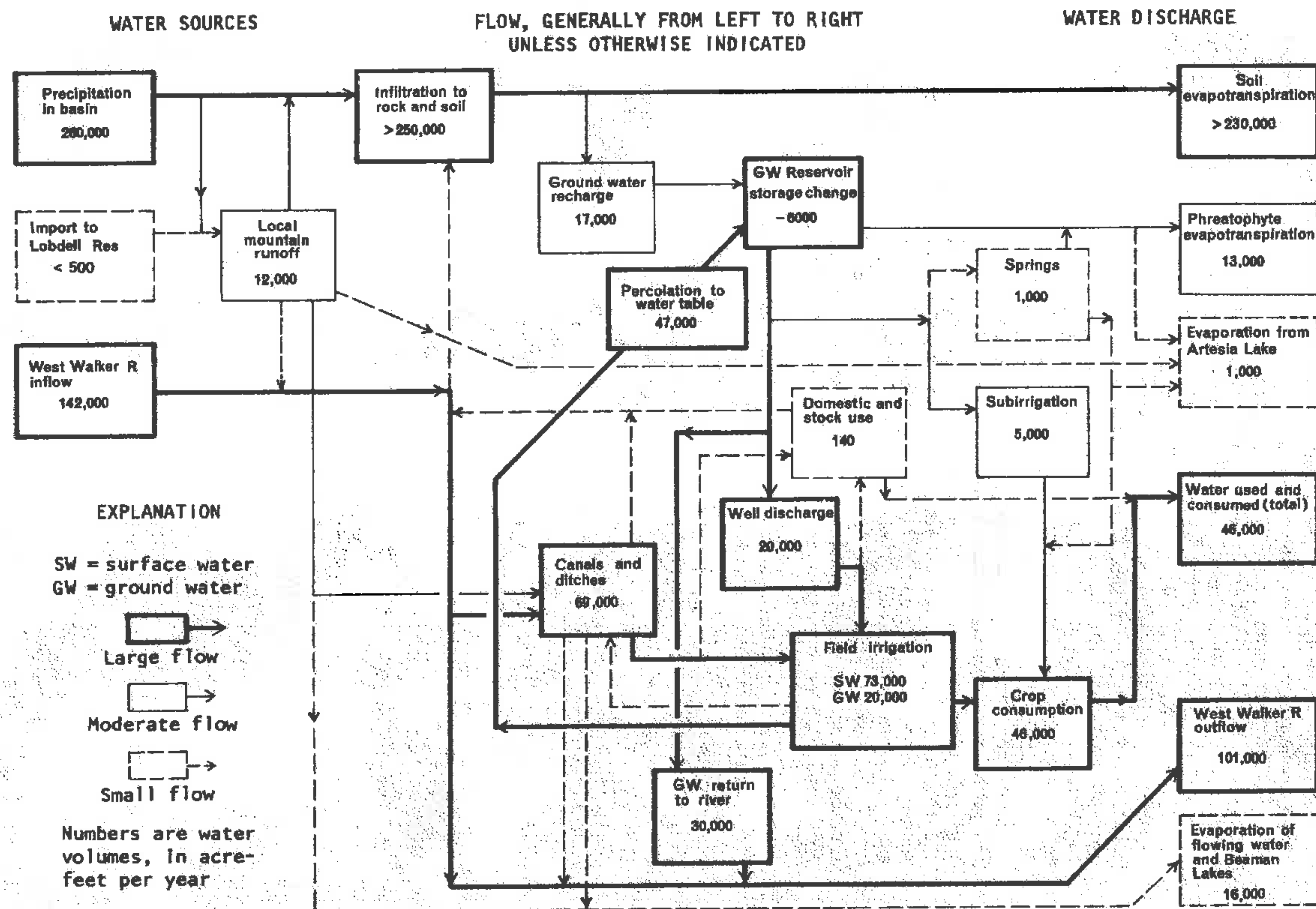

Figure 23.--Conceptual water-flow model of Smith Valley for 1972.

AVAILABLE WATER RESOURCES

System Yield

The yield of the hydrologic system of the valley is the maximum amount of water that could be consumed each year in the valley without continually removing ground water from storage or reducing outflow to downstream users. For the purposes of this report, the period of record 1953-72 is used as a basis for evaluating the system yield. This period is considered one of near-average precipitation and hence water supply, as described on page 34. Thus, the yield summarized below is representative for average conditions:

	Acre-feet
Average annual river diversions (table 6)	75,000
Recharge from precipitation (table 8)	17,000
Sum	92,000
Return flow to the river (table 16) (Part of downstream water rights)	-30,000
Long-term net storage change, considered to be	0
SYSTEM YIELD	62,000
Present water consumed	-46,000
Undeveloped water	16,000

The distribution of the available undeveloped water supply is discussed in the following sections.

West Walker River

The Walker River Irrigation District systematically distributes water from the West Walker River. As long as the operating criteria remain unchanged, the resulting distribution of water would remain generally the same, unless long-term river flow changes significantly. Therefore, the average annual diversion to Smith Valley from the river, about 75,000 acre-feet (tables 6 and 10), would be nearly constant over the long term.

Local Mountain Streams

Desert Creek, with an average annual flow of about 8,500 acre-feet (table 7), is the only source of appreciable streamflow originating within Smith Valley. During the 1972 growing season, most of its flow, about 3,500 acre-feet, was utilized for irrigation. The average annual use probably is larger. Most of the nongrowing-season flow has not been directly used and is available for further development; however, development of this additional water would reduce recharge to the ground-water reservoir. The amount not directly used is estimated to average about 4,000 acre-feet.

Red, Burbank, and Pipeline Canyons have very limited potential because of generally small, undependable flows.

Ground-Water System

Natural discharge could be captured to a limited extent. In the ground-water budget (table 20), the elements of natural discharge that remain to be captured are phreatophyte transpiration and bare soil evaporation. In the Artesia Lake basin, most of the phreatophyte and playa (bare soil) discharge, about 9,000 acre-feet (table 17), might be captured by lowering the water level from the shallow native equilibrium level to a new equilibrium level having a minimum depth to water of about 50 feet below land surface--the depth considered necessary to kill the deep-rooted phreatophytes.

Phreatophyte discharge in the Beaman Lakes area might be reduced by improving the present drainage-canal system, but the amount of reduction would be small. Trees and bushes on the flood plain of the West Walker River could be removed to eliminate their discharge, but large evaporation losses would continue. All these conservation measures taken together might salvage a part of the 13,000 feet (table 17), but their environmental effects, including erosion and effects in the river, probably would be considered unfortunate by many.

In summary, probably the least disruptive method of capturing ground-water discharge, from an environmental viewpoint, might be the reduction of phreatophyte and playa (bare soil) discharge in the Artesia Lake ground-water basin. If water quality imposed a severe constraint on use, it may not be feasible to capture the entire discharge of 9,000 acre-feet per year. For example, the annual capture would be somewhat less for irrigation because of the need to leach salts from cropland soils, as described on p. 31.

Transitional Storage Reserve in the Artesia Lake Ground-Water Basin

In reducing phreatophyte and shallow ground-water discharge, a large volume of water would have to be removed from the ground-water system in order to lower water levels at least 50 feet below land surface. This volume of water is called the transitional storage reserve.

Transitional storage reserve also has been defined by Worts (1967, p. 50) as the quantity of water in storage in the ground-water reservoir that can be extracted and beneficially used during the transition period between native equilibrium conditions and new equilibrium conditions under perennial-yield water development. In the arid environment of the Great Basin, the transitional storage reserve of such a reservoir is the amount of stored ground water available for withdrawal by pumping during the nonequilibrium period of development--the period of lowering water levels. Therefore, transitional storage reserve is a specific part of the total ground-water resource that can be taken from storage; it is water that is available in addition to the perennial-yield supply, but on a once-only basis.

No ground-water source can be developed without causing storage depletion. The magnitude of depletion varies directly with distance of development from any recharge and discharge boundaries in the ground-water system.

To compute the transitional storage reserve of the Artesia Lake ground-water basin, several assumptions are made: (1) wells would be strategically situated in and around areas of natural discharge in the main alluvial area of the basin, so that natural losses could be reduced or stopped with a minimum of water-level drawdown in pumped wells; (2) an average water level about 50 feet below land surface would curtail virtually all evapotranspiration losses; (3) over the long term, pumping would cause a moderately uniform depletion of storage throughout most of the valley fill; (4) specific yield of the valley fill averages 15 percent; (5) water levels are within the range of economic pumping lift for the intended use; (6) development would have little or no effect on water in adjacent parts of Smith Valley; and (7) water is of suitable chemical quality for the intended use.

The estimated storage reserve in the Artesia Lake ground-water basin is the product of the area beneath which depletion could be expected to occur (23,000 acres), the average thickness of saturated valley fill to be dewatered (50 feet), and the specific yield (15 percent), or about 170,000 acre-feet.

The manner in which transitional storage reserve would augment the supply has been described by Worts (1967, p. 52). The relation is shown in its simplest form by the following equation:

$$Q = \frac{\text{Transitional storage reserve}}{t} + \frac{\text{Natural discharge}}{2}$$

in which *Q* is the selected rate of diversion (largely ground-water pumping), in acre-feet per year, and *t* is the time, in years, to exhaust the storage reserve. This basic equation, of course, could be modified to allow for changing rates of storage depletion and capture of natural discharge. The equation, however, is not valid for pumping rates less than the natural discharge.

Using the above equation and the natural discharge for the basin as an example (transitional storage reserve, 170,000 acre-feet; natural discharge, 9,000 acre-feet), and using a diversion rate (Q) equal to the natural discharge, the time (t) to deplete the transitional storage reserve is computed to be nearly 40 years.

At the end of the estimated time, the transitional storage reserve would be exhausted, subject to the assumptions given in the preceding section. The example does not show that in the first year, virtually all the pumpage would be derived from storage, and very little, if any, would be derived by salvage of natural discharge. In contrast, during the last year of the period, nearly all the pumpage would be derived from salvage of natural discharge, and virtually none from the storage reserve.

During the period of depletion, the ground-water flow nets of the basin would be substantially modified. The recharge that originally flowed to areas of natural discharge at and adjacent to Artesia Lake playa would ultimately flow directly to pumping wells.

To meet the needs of an emergency or other special purpose requiring ground-water pumpage in excess of the natural discharge for specific periods of time, the transitional storage reserve could be depleted at a more rapid rate than the example given. The above equation could be used to compute the time required to exhaust the storage reserve for any selected pumping rate equal to or in excess of the natural discharge. However, once the transitional storage reserve was exhausted, the pumping rate would have to be reduced to 9,000 acre-feet to prevent overdraft, otherwise pumping lifts would continue to increase and the amount of stored water would continue to be depleted.

Other Sources of Water

Salvage of surface-water evaporation in most cased probably is not practical. Evaporation from streams and canals will continue, with the only potential areas of salvage being Desert Creek and Artesia Lake. For Artesia Lake, the principal source of water probably is the irrigated areas to the south. The water reaches the lake as flow in ditches, fed in part by rising ground water. This flow, estimated to average 6,000 acre-feet per year (table 17), could be reduced by lowering the ground-water levels by pumping wells and by constructing storage reservoirs or by diversions upstream from Artesia Lake. Once the water reaches the lake, its value for irrigation is lost because of increased salinity and undesirable location.

Thus, under 1972 conditions, possible additional water sources are:

Additional water source	Acre-feet per year
Desert Creek (p. 65)	a 4,000
Artesia Lake ground-water basin:	
Phreatophyte and playa salvage (p. 66)	9,000
Surface flow to Artesia Lake (p. 68)	6,000
Subtotal	15,000
Smith Valley (total)	19,000

a. Development probably would cause a substantial decrease in ground-water recharge.

The above summation does not include possible reduction of discharge by trees and brush on the West Walker River flood plain (table 17).

Conjunctive-Use Areas

To maximize the use of irrigated land and water, the supplementing of streamflow diversions with irrigation-well pumpage has been demonstrated in Smith Valley to be a desirable procedure. Using data from 1972 and taking into consideration the storage depletion during that year, a conjunctive-use value of 90,000 ± 10,000 acre-feet per year is computed in table 21. This value is valid only if (1) no significant changes are made in irrigation practices that would affect the amount and distribution of water reaching the irrigated areas and the infiltration to the ground-water system, and (2) if annual diversions from the river are near the average of 73,000 acre-feet; that is, from about 80 to about 120 percent of average (table 6), or within the range of approximately 60,000 to 90,000 acre-feet. The corresponding well pumpage would be limited to a range from zero to about 30,000 acre-feet.

Table 21.--*Conjunctive-use volume*

[Based on hydrologic conditions in 1972]

	1972 Acre-feet	Desirable average under near-normal conditions (see text)
Diversions from river (table 6)	69,000	75,000
Desert Creek flow (p. 36)	4,500	
Ground-water pumpage (p. 46)	20,000	15,000
Sum (rounded)	94,000	90,000 ± 10,000
Draft on storage (p. 58)	6,000	0
Difference	88,000	

During years when it is not possible to divert as much as 80 percent of the average (that is, about 60,000 acre-feet), such as in 1955, 1960, and 1961, the total amount of irrigation water available would be less than the conjunctive-use volume if this scheme were followed. Larger pumping volumes than the limit described above, withdrawn over a multiyear period, would remove a very large volume of stored ground water and would have an adverse effect on pumping lifts and pumping costs. To refill the reservoir, correspondingly large volumes of river water would have to be infiltrated each year, and this apparently is not practical as indicated in table 6. For example, 1969 was a record year for flow in West Walker River, but only 104,000 acre-feet was diverted for irrigation. This was only 12,000 acre-feet more than in 1971 when the river flow was about 55 percent of the 1969 volume.

To further illustrate the significance of the conclusions in the above paragraph, an example can be given based on the diversion data in table 6. If irrigation wells had supplemented river diversions to maintain a constant conjunctive-use supply of 90,000 acre-feet annually during the drought period 1959-61, the net volume removed from ground-water storage would have been on the order of 100,000 acre-feet. This removal would have resulted in a net dewatering of about 700,000 acre-feet of aquifer. Scaled against the irrigated land of 22,600 acres, this would be a dewatering of about 30 feet of aquifer. By 1972, 11 years after the short drought, about 30,000 acre-feet of ground water would still have remained unreplenished. Several more years of greater-than-average diversion from the river and less-than-average well pumping would have been required to bring the ground-water storage back to equilibrium. Such a long recovery period for a short (3-year) drought indicates that a longer-term drought would require an even more expansive period of recovery to restore equilibrium.

The volume of water reaching the land surface in the conjunctive-use areas should be about 90,000 acre-feet during near-normal years if the "ideal" water-use scheme of table 21 is followed. Under the scheme, surface-water diversions and pumpage would average 75,000 and 15,000 acre-feet per year, respectively.

Domenico and others (1966) provide an extensive discussion of the physical and economic aspects of conjunctive use in Smith Valley.

Potential Overdraft Areas

Potential areas of local overdraft can be delineated, based on several criteria: observed dewatering during the 1972 irrigation season, effects of faults, hydraulic characteristics of the aquifer, and well spacing.

Figure 22 shows the effects of ground-water pumping during the 1972 irrigation season. Most pumps were shut off for the season in late September or early October. At the time of shutoff, drawdowns in wells were generally at their maximum, but the areal extents of the cones of depression resulting from pumping were localized to the vicinity of each well. In figure 22, areas where dewatering exceeded 15 to 20 feet may be subject to overdraft if additional pumping occurs, especially during drought periods extending over several years.

Faults that impede the lateral flow of ground water, such as Owens fault, have had undesirable effects on pumping levels where wells were located within a distance of half a mile. To minimize such barrier effects, limitations in locating high-yield wells in these areas may be desirable.

Table 22.--*Examples of well interference under various conditions at the end of a 100-day pumping period 1/*

[Computations assume absence of hydraulic boundaries]

Aquifer transmissivity (gpd/ft)	Pumping rate (gpm)	Distance between wells = 0.5 mile: Drawdown by pumping well (feet)	Interference by nearby wells 2/ (feet)	Total drawdown in pumped well (feet)	Distance between wells = 0.75 mile: Drawdown by pumping well (feet)	Interference by nearby wells 2/ (feet)	Total drawdown in pumped well (feet)
25,000	1,000	71	7	78	71	0	71
50,000	1,500	55	16	71	55	5	60
100,000	2,000	38	19	57	38	10	48
150,000	2,500	33	20	53	33	11	44
200,000	3,000	31	25	56	31	13	44

1. For a storage coefficient of 0.15. Data assumes 100 percent well efficiency.
2. Assuming a rectangular well-spacing pattern.

Wells pumped in areas of low aquifer transmissivity (that is, less than 50,000 gpd/ft as shown in fig. 5) generally would have excessive drawdowns, if discharge is not kept below 1,500 gpm. Low coefficients of storage, such as for the semiconfined aquifer east of Owens fault, also would contribute to large drawdowns. Where transmissivity exceeds 50,000 gpd/ft, most irrigation wells discharge more than 1,500 gpm. These variations in pumping rates have been included in calculations mentioned in the next paragraph.

Data on well interference for several ground-water development conditions are given in table 22, and are based on a drawdown chart of Theis (1963). If 15 feet of interference, that is the lowering of water level in a well resulting from the combined effects of nearby pumping wells, is judged to be a reasonable limit, then where transmissivity is more than 50,000 gpd/ft, irrigation wells should be spaced more than 0.5 mile apart. For lower transmissivities, 0.5-mile minimum spacing probably would be suitable for irrigation wells if no other overdraft factors are operating.

SUMMARY

This study describes the geohydrology and evaluates the effect that irrigation development has had on the surface-water and ground-water resources of Smith Valley during the period 1953-72. (A previous study by Loeltz and Eakin (1953) provided some quantitative information on the water supply and status of development as of 1950.) The principal findings of this study are listed below.

1. Sources of water for Smith Valley are precipitation that falls within the topographic basin, especially in the mountains, and inflow of West Walker River. The immediate source of most of the ground-water replenishment is infiltration of irrigation water from fields and canals.

2. The average annual inflow of the West Walker River to Smith Valley, for the period 1958-72 was 179,000 acre-feet. The average annual river flow from the valley is 133,000 acre-feet. Desert Creek, the only significant stream originating within the valley, has a long-term average flow of 8,500 acre-feet per year.

3. The amount of ground water stored in the upper 100 feet of saturated alluvium is about 1,500,000 acre-feet.

4. Most of the waters sampled in the valley were suitable for their intended uses; that is, in most instances, irrigation. For human consumption, fluoride and arsenic concentrations in some samples were higher than desirable. Because of the large amounts of irrigation-water infiltration, salt accumulation is not a problem in most parts of the valley.

5. Water budgets for Smith Valley show about 160,000 acre-feet of water moving through the hydrologic system during 1972. Of this amount, about 46,000 acre-feet was consumed through irrigation of crops, and 101,000 acre-feet left the area as river outflow. About half the 93,000 acre-feet of water reaching the irrigated areas from both surface-water and ground-water sources was consumed. Gross pumpage in 1972 was 20,000 acre-feet. The net ground-water storage depletion for the year was 6,000 acre-feet.

6. The system yield is estimated to be 62,000 acre-feet. About 9,000 acre-feet per year of ground water and about 6,000 acre-feet per year of surface water remain to be developed in the Artesia Lake area. Additionally, about 4,000 acre-feet of the annual flow in Desert Creek could be utilized more extensively, but such a development could reduce infiltration and ground-water recharge.

7. Local overdraft would occur if the spacing of irrigation wells is too close. Using 15 feet of interference from nearby wells as a reasonable limit, in areas where transmissivity is more than 50,000 gpd/ft, irrigation wells would have to be spaced more than 0.5 mile apart. For lower transmissivity values, if no other overdraft factors are operating, a 0.5-mile minimum spacing probably would be suitable.

8. The volume of water reaching the irrigated land in the conjunctive-use area would have to be about 90,000 acre-feet during near-normal years to enable the hydrologically ideal scheme of water-use to be followed.

p77 75 000 SW
15 000 GW
90 000 conjunctive use

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A P P E N D I X

Location Numbers for Hydrologic Sites

The numbering system for hydrologic sites in this report is based on the rectangular subdivision of the public lands, referenced to the Mount Diablo base line and meridian. The location numbers consist of three units: The first is the township north of the base line; the second unit, separated from the first by a slant, is the range east of the meridian; the third unit, separated from the second by a dash, designates the section number. The section number is followed by letters that indicate the quarter section and quarter-quarter section; the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters, respectively. For example, well 10/23-1cb is in the NW¼SW¼ sec. 1, T. 10 N., R. 23 E., Mount Diablo base line and meridian. For sites that cannot be located accurately to the quarter-quarter section, only that part of the location number is given that represents the ability to determine the location of the site.

Township and range numbers are shown along the margins of plates 1 and 2.

Tables of Basic Data

The following tables contain data on streamflow, flow in canals, well data, and results of chemical analyses of water samples. Table 23 lists periodic discharge measurements made during the period 1970-72 on eight streams. Tables 24 compares flume and current-meter measurements of flow in four canals. Table 25 contains selected data for all irrigation wells and a few stock and domestic wells. Table 26 contains 48 chemical analyses, most of which are for samples from irrigation wells. No well logs are included in the report because the Nevada Division of Water Resources (Carson City) has an extensive file, open to the public.

Table 23.--*Periodic streamflow measurements*

Stream	Location	Drainage area (sq mi)	Date	Discharge (cfs)
Dalzell Canyon 1/	9/24-14cd	89.4	10-26-70	0.06
			3-16-71	.03
			5- 5-71	.06
			6-12-71	.06
			7-27-71	.05
			4-24-72	.04
			9-15-72	.05
Sheep Creek	8/24-35 (unsurveyed)	1.78	10-26-70	0.30
			5- 5-71	.55
			6-12-71	1.22
			4-24-72	.39
			9-15-72	.25
Desert Creek	9/24-8cc	50.4	3-15-71	2.63
			4- 6-71	5.90
			5- 5-71	7.29
			5-13-71	14.0
			6-12-71	41.3
			7-30-71	15.1
			4-24-72	6.89
			9-15-72	3.84
			11-30-72	1.53
			2- 8-73	3.38
			7-23-73	22.5
Spring Gulch	10/23-15bd	3.04	10-26-70	0.16
			3-15-71	.25
			5- 5-71	.16
			6-12-71	.20
			7-27-71	.14
			4-24-72	.21
Burbank Canyon	11/23-9bd	4.24	10-27-70	0.15
			3-15-71	.46
			5- 5-71	.51
			6-12-71	5.21
			7-30-71	.22
			4-24-72	.23
			9-15-72	.06
Red Canyon	11/23-5ac	10.7	10-27-70	0.18
			3-15-71	1.44
			5- 5-71	2.18
			6-12-71	4.15
			7-30-71	.85
			4-24-72	1.33
			9-15-72	.76
Pipeline Canyon	12/23-29bc	3.10	10-27-70	0.19
			3-15-71	.28
			5- 5-71	.30
			6-12-71	.77
			7-30-71	.12
			4-24-72	.31
			9-15-72	.15

1. Fed by nearby spring flow.

Table 24.--*Accuracy of canal-flow data based on flume ratings, as determined by current-meter measurements*

Diversion	Date	Flume gage-height (feet)	Discharge (cfs) Flume	Discharge (cfs) Current meter	Remarks
Saroni Canal (two 6-ft Parshall flumes)	8-23-72	1.14	59.2	54.1	
	10-26-72	.24	4.92	4.29	
	9- 4-73	1.22	65.9	62.2	
Plymouth Canal (one 8-ft Parshall flume)	9-21-72	0.85	24.6	25.4	
Colony Ditch (two 6-ft Parshall flumes)	9-21-72	0.35	9.00	9.82	Light algae growth on flume.
	10-26-72	.60	21.2	21.9	
Gage Peterson ditch (one 4-ft Parshall flume)	10-26-72	0.32	2.65	3.11	Moss in upper end of flume.

Table 25.--Selected well data

Owner: BLM, U.S. Bureau of Land Management

Use: D, domestic; I, irrigation; M, mining or milling; S, stock; U, unused at time of study (intended use in parentheses)

Altitude: Determined from topographic maps

Water-level depth: Depth below ground level; R, reported by driller

Remarks: T, temperature of water from well (R, reported by driller)

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Static water level: Date	Static water level: Depth (feet)	Casing perforation interval (feet)	Used for irrigation in 1972	Remarks
10/23-1ad	Bill Canepa	1959	308	12	I	500/65	4,845	3-22-72 11- 1-72 3-30-73	41.45 69.93 42.96	127-308	X	Located along south bank of Plymouth Canal
-1cb	Ball Park	--	--	8	D	--	4,845	3-22-72 11- 1-72	26.92 25.58	--		Located along 3d-base line
-2ac near Wellington	Fred Fulstone	1964	252	16	I	--	4,808	1964 3-22-72 11- 1-72 3-20-73	14 R 13.63 12.50 12.66	--	X	Located along north side of Smith Gage Road
10/24-3bb	Roy Larg	1955	511	16,14	I	950/109	4,920	1955 3-24-72 11- 1-72 3-30-73	80 R 79.90 98.98 86.29	--	X	T=56°F(R, 1955). T=60°F (5-5-72). Located on north bank of Saroni Canal
-4ab (top well)	Ralph Nuti	1960	619	14	I	2,100/55	4,920	3-24-72 7- 3-72 11- 1-72 3-30-73	94.89 150.50 80.70 93.16	--	X	
-4cd (north well)	Rudy Amann	1948	250	14/12	U(I)	--	4,900	1948 11-30-48 3-24-72 11- 2-72 3-30-73	38 R 61.66 72.55 88.55 78.60	--		Unused for the past several years
-7cd	Sam Albright	1971	470	14	I	1,900/62	4,930	1971 3-22-72 5- 5-72 11- 1-72 3-30-73	65 R 79.30 73.20 82.83 80.03	150-470	X	T=65°F(R, 1971). T=60°F (1972). Located along north bank of Saroni Canal
-7dd	Double JA Ranch	1960	587	16	I	--	4,920	3-22-72 11- 1-72 3-30-73	46.50 58.25 54.42	--	X	Located along north bank of Saroni Canal
-9ba (east well)	Rudy Amann	1960	652	18	I	1,600/83	4,910	3-19-65 3-24-72 7- 5-72 11- 2-72 3-30-73	97.35 80.55 148.10 98.1 86.60	78-574	X	Located along north bank of Saroni Canal
-9bc (west well)	Rudy Amann	1955	507	16,14	I	1,700/122	4,910	1955 3-24-72 6-22-72 11- 2-72 3-30-3	90 R 86.69 113.20 101.90 91.10	143-507	X	T=41°F(R, 1955). Located along north bank of Saroni Canal
-16ac	Edmund Miller	1969	486	14	I	--	5,000	11- 2-72	106.67	196-486	X	
-21ba	Fred Fulstone, Jr.	1969	500	16	I	--	5,020	1969 3-20-72 11- 2-72 3-30-73	108 R 123.00 131.90 120.80	240-500	X	
-20ab (east well)	Sierra Vista Ranch	--	--	--	I	1,500/49	5,020	3- 2-72 3-30-73	132.71 128.70	--	X	Located 0.1 mile east of main house
-20bd (west well)	Sierra Vista Ranch	1968	422	16	I	1,600/94	5,050	1968 3-22-72 11- 2-72 3-30-73	161 R 161.30 162.72 158.74	241-422	X	Located west of Desert Creek Road
-22cb	BLM, Rossachi well	1955	176	8	S	--	5,080	1955 6-22-72 8-21-72 3-30-73	132 R 146.44 146.53 146.64	--		Windmill. Located on east side of road
-28bb	Unused ore mill	--	--	--	U(M)	--	5,120	8-22-72 3-30-73	175.03 165.10(?)	--		Located 50 ft north of mill
10/25-6ch	BLM	1953	625	6,5	S	--	5,270	1953	594 R	605-625		
11/23-2ad	Bliss Ranch	1969	537	14	I	1,500/61	4,780	1969 3-24-72 6-29-72 10-31-72 12-20-72 3-29-73	10 R 13.53 31.43 23.62 18.98 16.03	147-537	X	
-2bb	Harvey Neill	1960	412	14	I	2,000/75	4,790	1960 3-19-65 3-24-72 4-11-72 10-31-72 3-29-73	35 R 24.58 20.99 21.12 23.10 24.02	96-412	X	
-2cc	August Bunkowski	1970	546	14	I	2,600/35	4,800	1970 3-24-72 4- 4-72 10-31-72 3-29-73	20 R 26.24 27.22 34.05 30.11	138-546	X	
-3ac	Robert Griffin	1970	420	14	U(I)	small/--	4,800	1970 3-22-72 10-31-72 3-29-73	30 R 49.80 54.30 52.28	150-420		Well unsuccessful in construction

Table 25.—Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Static water level: Date	Static water level: Depth (feet)	Casing perforation interval (feet)	Used for irrigation in 1972	Remarks
11/23-3dc	Vernon Bryan	1961	486	14	I	2,200/24	4,830	1961 3-22-72 6-31-72 10-31-72 3-29-73	72 R 61.73 73.40 65.30 62.45	120-486	X	T=56°F(4-22-72). Unused irrigation well, 100 yds south-southeast
-10ac	Bob Batica	1961	385	16	I	2,600/--	4,830	3-24-72 10-31-72 3-29-73	60.74 68.35 65.00	100-385	X	
-10cb	--	--	--	8	U(D)	--	4,850	8-23-72 10-31-72 3-29-73	76.74 74.66 73.18	--		Located on west side of main road
-11bb	Ted Bacon	1961	510	14	I	2,600/29	4,800	1961 3-24-72 4-17-72 10-31-72 3-29-73	46 R 31 34 31 26.94	139-510	X	
-12bb (southeast well)	Bill Walker	1961	423	16	I	1,200/38	4,795	1961 4-12-72 10-31-72 3-29-73	35 R 20.5 22.24 20.37	--	X	T=55°F(4-12-72). Water applied with sprinkler
-12cb (southwest well)	Bill Walker	1972	590	14	U(I)	2,000/50	4,795	6-16-72 10-31-72 3-29-73	34.10 28.20 20.84	--		
-13bb (north well)	Joe Mathis	1969	250	12	I	800/54	4,800	1969 3-24-72 11- 2-72 3-29-73	36 R 39.45 44.07 41.54	130-250		
-13ca (south well)	Joe Mathis	--	140	8	U(I)	--	4,795	1962 3-24-72 3-29-73	60 R 55.88 56.16	70-140		Located southeast of house. Drilled to depth 204 ft
-15cc	James O'Banion	1965	430	16	I	1,000/47	4,860	1965 6-29-72	118 R 166	100-420	X	T=60°F(6-29-72)
-23bb	Sam Strieby	1961	420	14	I	1,200/118	4,800	1961 3-22-72 10-31-72	85 R 23.78 30.60	100-420	X	T=63°F(6-21-72). Reported water level probably in error
11/24-27cc (southeast well)	Garms	1961	479	16	I	900/75	4,820	1961 3-24-72 11- 1-72 3-30-73	80 R 67.81 72.18 72.20	154-474	X	T=61°F(6-9-72)
-28dd (south well)	Garms	1961	454	16	I	1,500/120	4,885	1961 3-24-72 11- 1-72 3-30-73	45 R 65.45 76.08 69.06	140-474	X	T=63°F(6-9-72)
-30bc (near cemetery)	Fred Fulstone	1960	408	16	I	2,800/95	4,800	1960 7-22-60 3-22-72 11- 1-72 3-30-73	54 R 12.5 See remarks 10.29 1.95	96-408	X	T=57°F(7-22-60). On 3-22-72, water level was 0.34 ft above ground level in casing
-31cc	John Urrea	1961	423	14	I	2,800/180	4,840	1961 3-22-72 11- 1-72 3-30-73	95 R 31.33 40.31 33.77	--	X	T=57°F
-32bb	Bob Compston	1964	480	16	I	--	4,830	1964 3-24-72 11- 1-72	61 R 20.28 32.23	120-480	X	
-32ac (near sump)	Ralph Nuti	1963	498	16,14	I	1,700/--	4,840	3-24-72 11- 1-72 3-30-73	16.56 28.49 20.15	150-498	X	
-32dc (Rountree Lane well)	Ralph Nuti	1955	507	16,14	I	1,500/70	4,865	1955 3- 2-72 11- 1-72 3-30-73	29 R 29.29 52.70 44.71	118-507	X	
-33ba (southwest well)	Garms	1966	600	14	I	1,000/--	4,885	1966 3-24-72 11- 1-72 3-30-73	71 R 64.20 71.68 65.80	107-600	X	T=55°F(6-9-72)
-33da	Roy Lerg	--	300	6	D	--	4,905	6- 5-72	94.65	--		
12/25-14ad	--	--	14	8	S	--	4,630	6-23-72	flowing	--		T=56°F(6-23-72)
-26cb (north well)	Three 2-Bar Ranch	--	--	16	U(I)	--	4,745	6-23-72 11- 2-72 3-29-73	4.50 4.52 5.23	--		Located on top of hill
-27aa	Hunewill Land and Livestock Co.	1960	400	14	I	2,300/110	4,735	1960 3-24-72 10-31-72 3-29-3	5 R flowing flowing flowing	100-400	X	Flows into ditch below ground level
-28dc	Charles Terrell	1961	448	14	I	1,900/--	4,790	3-22-72 10-31-72	20.80 26.34	115-448	X	T=63°F(4-22-72)
-34ac	Lester Farias	1960	413	14	I	1,930/40	4,790	1960 3-24-72 10-31-72	18 R 21.40 25.25	100-400	X	
-34ba (south well)	Three 2-Bar Ranch	--	423	16	I	2,200/40	4,785	3-22-72 10-31-72 3-29-73	13.25 18.09 18.70	--	X	
-35aa	Lou Rosaser	1956	152	10	I	360/12	4,760	1956 3-24-72 11- 2-72 3-29-73	2 R flowing flowing flowing	72-132	X	Flows into ditch below ground level
-36ba (north well)	Glen Smith	1960	425	14	I	1,200/95	4,760	1960 3-24-72 10-31-72 12-20-72 3-29-73	12 R 6.64 13.63 10.19 8.38	110-360	X	

Table 25.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Static water level Date	Static water level Depth (feet)	Casing perforation interval (feet)	Used for irrigation in 1972	Remarks
12/23-36dc (south well)	Glen Smith	1960	508	12,10	I	1,500/--	4,780	1960 3-24-72 10-26-72 12-20-72 3-29-73	20 R 21.61 39.49 33.12 24.87	147-508	X	T=61°F(4-14-72)
12/24-4ba	BLM, Delphi well	1968	140	6	S	--	4,700	1968	82 R	115-130		Located 50 yds southeast of road intersection
-27da	BLM, Hudson well	--	--	--	S	--	5,000	8-22-72	277.50	--		In metal shed
-30dc	BLM	--	--	--	S	--	4,795	6-9-72 10-31-72 3-29-73	133.70 76.11 60.44	--		Windmill
-31ba (north well)	Bill Walker	1968	540	14	I	1,500/--	4,800	1968 1-12-71 3-15-72 10-31-72 3-29-73	40 R 50 50 70.41 54.56	270-534	X	T=80.5°F(7-11-72). Water applied with sprinklers
12/26-31db	Dale Busboe	1971	587	14	I	1,700/63	4,810	1971 3-24-72 10-31-72 3-29-73	65 R 63.40 76.35 61.03	199-587	X	Water temperature reported as 72°F by driller. T=70°F (6-16-72). Water applied with sprinklers
13/23-25ca	Ambassador Gold Mining Co.	1932	155	14	I	400/--	4,590	8-23-72	flowing	--	X	Depth when drilled was 540 ft. Flowed 400 gpm in 1948 and 1973. T=80°F(8-23-72). H_2S smell
13/24-20bb	--	--	--	--	U(M)	--	4,730	8-22-72	81.93	--		In metal shed
-28bd	BLM	--	--	--	S	--	4,770	8-22-72	125.00	--		In metal shed
-30ac	Buckskin Ranch	--	--	--	I,D	--	4,615	8-23-72	flowing	--		Small flow supports native grass. T=63°F(8-23-72). H_2S smell. Located 15 ft northwest of house
14/24-31da	--	--	--	6	S	--	5,480	8-23-72	32.84	--		On concrete floor, 6 ft square. Another well in metal building 200 yds north

Table 26.--Chemical analyses of waters

Part A

Location	Source	Date completed	Temperature °F	Temperature °C	Milligrams per litre (upper number) and milliequivalents per litre (lower number) 1/: Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (Lab. determination)	Factors affecting suitability for irrigation 2/: Salinity hazard	Sodium hazard	Residual sodium carbonate (RSC)	SAR
10/23-2cc	West Walker River	10-26-72	48	9.0	20 1.00	5 0.38	25 1.09	111 1.82	0 0.00	15 0.31	12 0.34	69	230	8.1	low	low	safe	1.3
11/23-13cd	West Walker River	10-26-72	59	15.0	27 1.35	6 0.53	50 2.16	137 2.24	21 0.70	35 0.73	13 0.37	94	386	9.3	low	low	safe	1.5
11/24-3dd	West Walker River	10-26-72	47	8.5	39 1.95	15 1.21	42 1.83	210 3.44	5 0.17	46 0.96	--	158	457	8.5	low	low	safe	2.2
10/24-20ac 3/	Desert Creek	8-27-73	62	16.5	11 0.55	2 0.19	(3)	53 0.87	0 0.00	9.7 0.20	0 0.00	37	110	7.9	low	low	safe	.5
12/23-36ba	Irrigation ditch	6-30-72	90	32.5	20 1.00	6 0.48	(3)	130 2.13	0 0.00	--	4 0.11	74	241	7.5	low	--	--	--
10/23-2acb	Well (252 ft)	8- 2-73	68	20.0	14 0.70	2 0.14	160 6.94	348 5.70	0 0.00	70 1.46	22 0.62	42	777	8.1	medium	medium	unsafe	11
10/24-3bbd	Well (511 ft)	7-27-73	61	16.0	84 4.19	29 2.40	31 1.34	328 5.38	0 0.00	90 1.87	24 0.68	330	788	7.7	medium	low	safe	.7
-4ab 3/	Well (619 ft)	7- 3-72	64	18.0	35 1.75	13 1.05	(3)	130 2.13	0 0.00	51 1.06	16 0.45	140	400	7.9	low	low	safe	.9
-7ddb	Well (587 ft)	7-27-73	62	16.5	22 1.10	5 0.40	17 0.74	118 1.93	0 0.00	11 0.23	3 0.08	75	218	8.1	low	low	safe	.8
-9ba 3/	Well (652 ft)	7- 5-72	58	14.5	35 1.75	13 1.05	(3)	200 3.28	0 0.00	16 0.33	4 0.11	140	375	7.9	low	low	safe	.8
-9bcb	Well (507 ft)	8- 2-73	56	13.5	21 1.05	6 0.53	12 0.53	112 1.84	0 0.00	10 0.21	2 0.06	79	214	7.8	low	low	safe	.6
-9cdc	Well	8- 2-73	56	13.5	29 1.45	4 0.35	9 0.40	118 1.93	0 0.00	10 0.21	2 0.06	90	233	7.4	low	low	safe	.4
-16acc 3/	Well (486 ft)	8- 2-73	61	16.0	19 0.95	12 0.95	18 0.78	106 1.74	0 0.00	19 0.40	9 0.25	95	274	7.7	low	low	safe	.8
-16cdc	Well (500 ft)	8- 3-73	67	19.5	20 1.00	6 0.50	16 0.71	109 1.79	0 0.00	15 0.31	4 0.11	75	232	7.8	low	low	safe	.8
-20ab 3/	Well	8-27-73	54	12.5	20 1.00	7 0.56	(3)	100 1.64	0 0.00	9.2 0.19	2 0.05	78	198	7.5	low	low	safe	.5
-20bd 3/	Well (422 ft)	8-27-73	56	13.5	14 0.70	7 0.56	(3)	93 1.52	0 0.00	8.6 0.18	1 0.02	63	171	8.2	low	low	safe	.5
11/23-2add 3/	Well (537 ft)	6-30-72	63	17.0	25 1.25	3 0.27	(3)	126 2.07	0 0.00	15 0.31	3 0.08	76	242	8.2	low	low	safe	.1
-2bbc 3/	Well (412 ft)	6-30-72	57.5	14.5	62 3.09	16 1.31	(3)	289 4.74	0 0.00	19 0.40	5 0.14	220	497	8.2	low	low	safe	.4
-3dcc 3/	Well (486 ft)	6-30-72	58	14.5	48 2.40	10 0.80	(3)	193 3.16	0 0.00	24 0.50	6 0.17	160	366	8.0	low	low	safe	.6
-10acb 3/	Well (385 ft)	6-30-72	59	15.0	38 1.90	9 0.70	(3)	179 2.93	0 0.00	17 0.35	6 0.17	130	342	8.2	low	low	safe	.7
-11bb 3/	Well (510 ft)	6-30-72	63	17.0	26 1.30	3 0.26	(3)	127 2.08	0 0.00	13 0.27	2 0.06	78	233	8.2	low	low	safe	.9
-12bbd 3/	Well (423 ft)	6-30-72	58	14.5	58 2.89	13 1.11	(3)	198 3.25	0 0.00	62 1.30	36 1.02	200	554	8.3	low	low	safe	1.4
-13bbd 3/	Well (250 ft)	6-30-72	60	15.5	22 1.10	3 0.26	(3)	122 2.00	0 0.00	9 0.19	2 0.05	68	217	8.1	low	low	safe	.8
-22dd	Well	1-14-74	--	--	35 1.75	10 0.85	16 0.69	183 3.00	0 0.00	7 0.15	5 0.14	130	332	8.1	medium	low	safe	.6
-23bb 3/	Well (420 ft)	8-29-73	63	17.0	21 1.05	4 0.31	(3)	122 2.00	0 0.00	13 0.27	1 0.02	68	222	8.1	low	low	safe	.9
11/24-19dad	Well	8- 2-73	56	13.5	24 1.20	7 0.60	12 0.54	122 2.00	0 0.00	11 0.23	4 0.11	90	236	7.9	low	low	safe	.6
-27cad	Well	8- 2-73	64	17.5	48 2.40	14 1.20	35 1.51	231 3.79	0 0.00	39 0.81	18 0.51	180	518	7.8	medium	low	safe	.6
-28ddc 3/	Well (479 ft)	7-27-73	61	16.0	80 3.99	29 2.40	29 1.25	204 3.34	0 0.00	76 1.58	47 1.32	320	774	7.6	high	low	safe	1.1
-30bcd	Well (456 ft)	7-27-73	59	15.0	20 1.00	5 0.44	14 0.61	115 1.18	0 0.00	7 0.14	1 0.03	72	203	7.8	low	low	safe	.7
-31acd	Well (408 ft)	7-27-73	--	--	25 1.25	7 0.61	13 0.57	134 2.20	0 0.00	8 0.17	2 0.08	93	238	7.8	low	low	safe	.7
-32ac 3/	Well (423 ft)	7- 3-72	57	14.0	41 2.05	14 1.15	(3)	159 2.61	0 0.00	41 0.85	20 0.56	160	425	7.5	medium	low	safe	.6
-32dc 3/	Well (498 ft)	7- 3-72	58	14.5	23 1.15	8 0.65	(3)	120 1.97	0 0.00	11 0.23	4 0.11	90	235	7.6	low	low	safe	.7
-33bac	Well (507 ft)	7-27-73	55	13.0	79 3.94	25 2.05	76 3.30	421 6.90	0 0.00	82 1.71	24 0.68	300	882	7.8	high	low	safe	.5
12/23-14ad 3/	Well (600 ft)	8-31-73	55	13.0	51 2.34	18 1.46	(3)	278 4.56	0 0.00	47 0.98	16 0.45	200	581	8.0	medium	low	safe	1.9
-16dc 3/	Nevada Hot Springs	6-30-72	144	62.0	5 0.25	0 0.00	(3)	26 0.43	19 0.63	140 2.92	16 0.45	12	514	9.3	medium	low	marginal	22
-24ddc 3/	Well (120 ft)	8-31-73	58	14.5	--	--	(3)	--	--	2.5 0.05	2 0.05	--	379	--	medium	--	--	--
-28dcc	Well (448 ft)	7-27-73	58	14.5	74 0.91	11 0.79	18 4.65	284 4.65	0 0.00	29 0.60	5 0.14	230	508	7.7	medium	low	safe	.5
-33baa	Well (177 ft)	7-27-73	59	15.0	63 3.14	10 0.86	14 0.63	220 3.60	0 0.00	40 0.83	7 0.20	200	446	7.9	medium	low	safe	.4
-34ba 3/	Well	6-30-72	64	17.5	29 1.45	2 0.13	(3)	88 1.44	0 0.00	40 0.83	4 0.11	79	246	8.2	low	low	safe	1.1
-35aab 3/	Well (150 ft)	6-30-72	59	15.0	53 2.64	12 0.96	(3)	202 3.31	0 0.00	41 0.85	4 0.11	180	405	8.1	medium	low	safe	.4
-36bac	Well (425 ft)	8- 2-73	58	14.5	55 2.74	6 0.46	50 2.16	239 3.92	0 0.00	53 1.10	12 0.34	160	518	8.0	medium	low	safe	1.7
-36dc 3/	Well (508 ft)	6-30-72	65	18.0	21 1.05	3 0.23	(3)	120 1.97	0 0.00	9.6 0.20	2 0.06	64	215	8.0	low	low	safe	1.0

Table 26.--Chemical analyses of waters--Continued

Location	Source	Date completed	Temperature °F	Temperature °C	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as ($CaCO_3$)	Specific conductance (micromhos per cm at 25°C)	pH (laboratory determination)	Salinity hazard	Sodium hazard	Residual sodium carbonate (RSC)	SAR
					Milligrams per litre (upper number) and milliequivalents per litre (lower number) 1/										Factors affecting suitability for irrigation 2/			
12/24-8cd 3/	Well	8-31-73	59	15.0	10 0.50	1 0.06	(3)	124 2.03	1 0.03	15 0.31	3 0.08	28	240	8.4	low	low	marginal	3.2
-31ba 3/	Well (540 ft)	6-30-72	80	26.5	17 0.86	2 0.20	(3)	109 1.79	0 0.00	13 0.27	2 0.04	53	204	8.2	low	low	safe	1.2
-31dbb	Well (587 ft)	7-27-73	—	—	19 0.95	3 0.25	19 0.84	109 1.79	0 0.00	9 0.19	2 0.06	60	201	7.9	low	low	safe	1.1
13/23-25ca 3/	Well (155 ft)	8-31-73	80	26.5	2 0.09	1 0.07	(3)	142 2.33	2 0.07	26 0.54	5 0.14	8	309	8.4	medium	low	marginal	9.8
-25cb 3/	Well	4- 6-55	82	28.0	2.0 0.10	0.2 0.02	(3)	146 2.39	4 0.13	23 0.48	6.2 0.18	5	303	8.3	—	—	—	—
13/24-30ac 3/	Well	8-31-73	75	24.0	8 0.40	1 0.11	(3)	151 2.47	5 0.17	21 0.44	6 0.16	26	315	8.5	medium	low	marginal	5.2

Part B

Location	Silica (SiO_2)	Arsenic (As)	Sodium (Na)	Potassium (K)	Fluoride (F)	Nitrate (NO_3)	Total phosphorous (P)	Orthophosphate (as P)	Boron (B)	Dissolved solids (calculated)
10/24-4ab	66	0.003	24 1.04	8.6 0.22	0.4 0.02	13 0.22	0.04	—	0.01	290
-9ba	56	.001	23 1.00	6.0 0.15	0.4 0.02	9.7 0.16	.12	—	.03	260
-16acc	—	—	—	—	—	4/ 18 0.29	—	—	—	—
-20ab	43	.046	9.5 0.41	2.9 0.08	0.1 0.01	4/ 7.5 0.12	—	0.08	.03	151
-20ac	24	—	6.6 0.29	1.7 0.04	0.1 0.01	4/ 0.1 0.00	—	.05	.02	—
-20bd	39	.002	9.4 0.41	2.3 0.06	0.0 0.00	4/ 2.1 0.03	—	.07	.03	125
11/23-2add	40	.012	21 0.91	3.7 0.09	0.5 0.03	0.6 0.01	.05	—	.04	170
-2bbc	28	.003	15 0.65	3.9 0.10	0.3 0.02	9.7 0.16	.05	—	.10	300
-3dcc	22	.000	15 0.65	2.8 0.07	0.3 0.02	5.8 0.09	.04	—	.00	230
-10acb	21	.000	18 0.78	2.4 0.06	0.4 0.02	7.9 0.13	.05	—	.08	210
-11bb	26	.021	19 0.83	2.7 0.07	0.5 0.03	0.6 0.01	.06	—	.04	160
-12bbd	32	.008	45 1.96	4.6 0.12	0.4 0.02	12 0.20	.08	—	.13	360
-13bbd	57	.019	16 0.70	10 0.26	0.4 0.02	0.8 0.01	.55	—	.01	180
-23bb	59	.017	17 0.74	5.3 0.14	0.3 0.02	4/ 0.4 0.01	—	—	.08	181
11/24-28ddc	—	—	—	—	—	4/ 87 1.40	—	—	—	—
-32ec	59	.009	21 0.91	5.9 0.15	0.4 0.02	14 0.23	.11	—	.04	290
-32dc	56	.002	11 0.48	5.1 0.13	0.3 0.02	5.3 0.09	.12	—	.00	180
12/23-14ad	52	.041	42 1.83	7.3 0.19	0.1 0.01	4/ 12 0.19	—	.82	.18	385
-16dc	55	.014	96 4.18	2.1 0.05	3.2 0.17	0.2 0.00	.03	—	.21	350
-24ddc	64	—	18 0.78	8.2 0.21	0.3 0.02	4/ 19 0.30	—	.36	.06	—
-34ba	20	.002	23 1.00	2.6 0.07	0.4 0.02	1.7 0.03	.04	—	.00	170
-35aab	43	.017	14 0.61	7.0 0.18	0.4 0.02	0.5 0.01	.13	—	.01	270
-36dc	59	.010	19 0.83	6.0 0.15	0.6 0.03	1.2 0.02	.05	—	.03	180
12/24-8cd	61	.033	39 1.70	6.1 0.16	0.4 0.02	4/ 0.6 0.01	—	.12	.09	199
-31ba	67	.017	20 0.87	7.8 0.20	0.4 0.02	1.0 0.02	.05	—	.00	180
13/23-25ca	82	.056	64 2.78	2.2 0.06	0.9 0.05	4/ 0.3 0.00	—	.25	.19	256
-25cb	36	—	69 3.00	3.4 0.09	1.0 0.05	0.2 0.00	—	.20	—	218
-30ac	61	.11	60 2.61	3.2 0.08	1.1 0.06	4/ 0.8 0.01	—	.15	.30	242

1. Milligrams per litre and milliequivalents per litre are metric units of measure that are virtually identical to parts per million and equivalents per million, respectively, for all waters having a specific conductance less than about 10,000 micromhos. The metric system of measurement is receiving increased use throughout the United States because of its value as an international form of scientific communication. Therefore, the U.S. Geological Survey recently has adopted the system for reporting all water-quality data. Where only one number is shown, it is milligrams per litre.

2. Salinity hazard is based on specific conductance (in micromhos) as follows: 0-750, low hazard (water suitable for almost all applications); 750-1,500, medium (can be detrimental to sensitive crops); 1,500-3,000, high (can be detrimental to many crops); 3,000-7,500, very high (should be used only for tolerant plants on permeable soils); more than 7,500, unsuitable. SAR (sodium adsorption ratio) provides an indication of what affect an irrigation water will have on soil-drainage characteristics. SAR is calculated as follows, using milliequivalents per litre: SAR=Na/ (Ca + Mg)/2. Where sodium plus potassium are computed by difference rather than analyzed for, that value is used to compute SAR. Sodium hazard is based on an empirical relation between salinity hazard and sodium-adsorption ratio: low, medium, high, or very high. RSC (residual sodium carbonate): safe, marginal, or unsuitable. The several factors should be used as general indicators only, because the suitability of a water for irrigation also depends on climate, type of soil, drainage characteristics, plant type, and amount of water applied. These and other aspects of water quality for irrigation are discussed by the National Technical Advisory Committee (1968, p. 143-177), and the U.S. Salinity Laboratory Staff (1954).

3. Additional determinations from detailed analyses.

4. Nitrate plus nitrite, expressed as nitrate.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Prepared in cooperation with the
STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES

WATER RESOURCES BULLETIN NO 43
PLATE 1

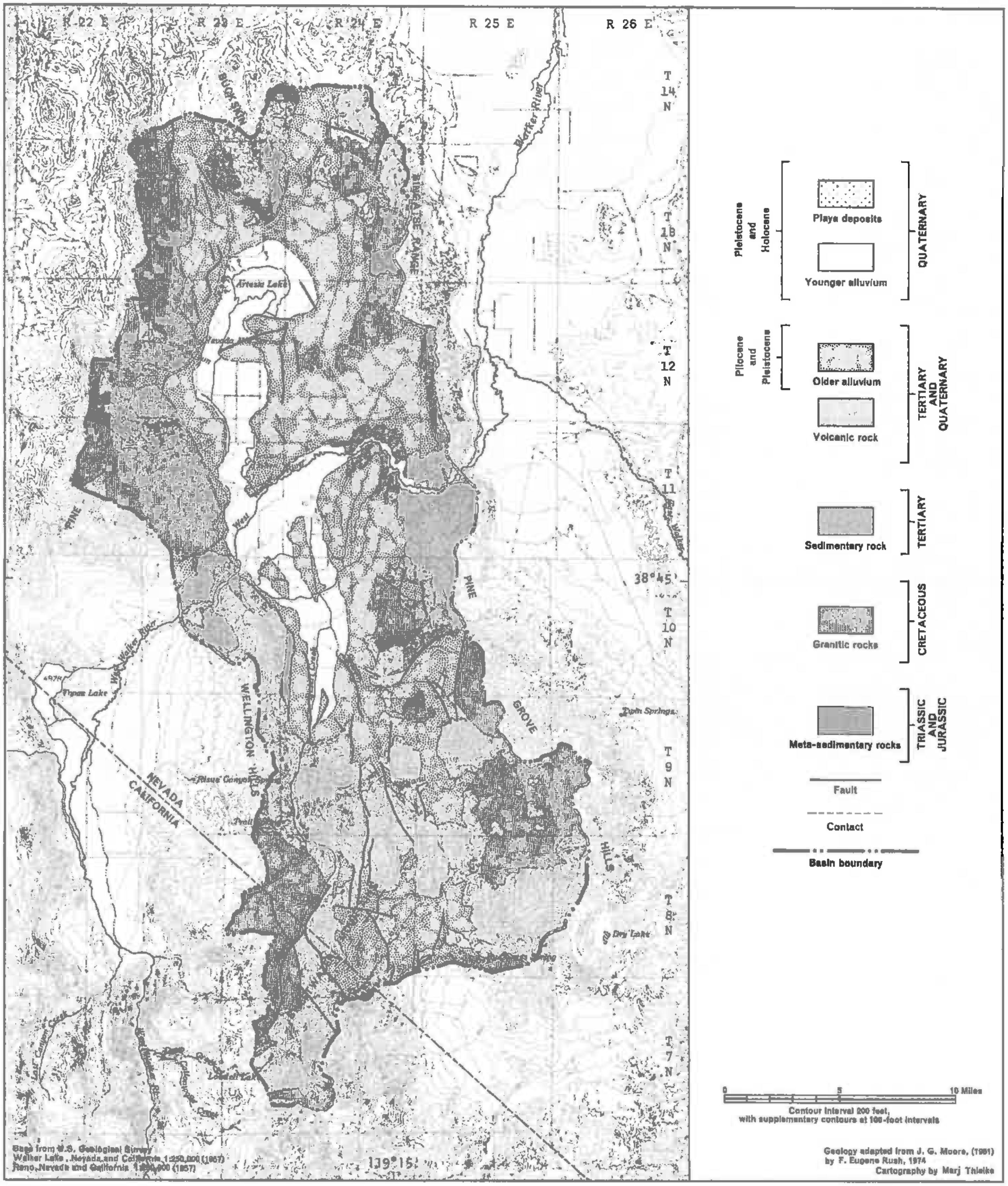

PLATE 1.--GENERALIZED GEOLOGY OF SMITH VALLEY, NEVADA AND CALIFORNIA.

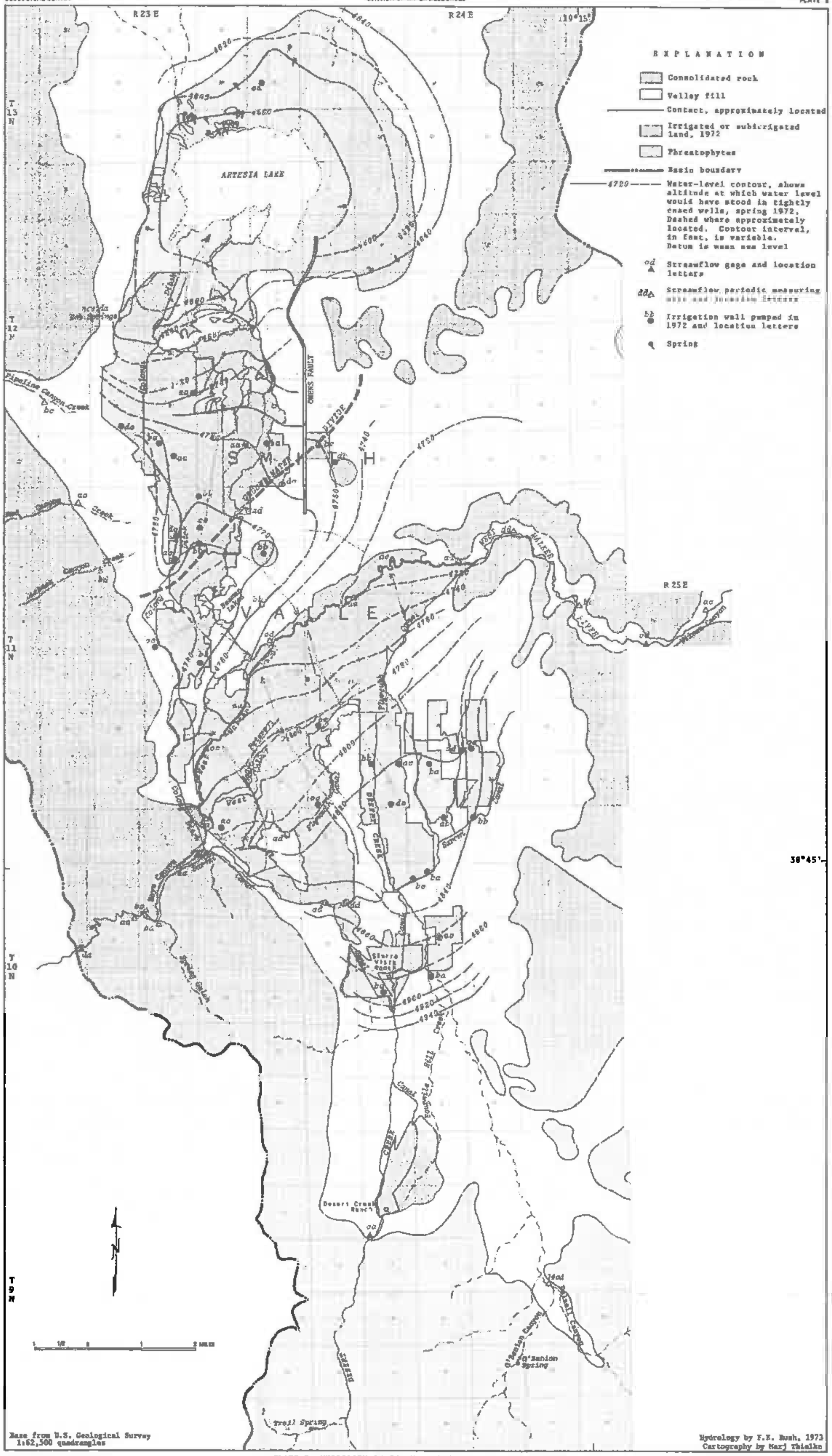

PLATE 2.-HYDROLOGY OF SMITH VALLEY, NEVADA AND CALIFORNIA.

EXHIBIT F

Agendas/Minutes/Planning Rec.

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TDD Number:
(800) 326-6868

Smith Valley Advisory Board

BOARD PURPOSE

Citizen Advisory Boards are established by the Lyon County Commission to represent residents of Lyon County in designated geographical areas. Citizen Advisory Boards provide information and recommendations to the Lyon County Commission and to other appointed Lyon County boards and commissions. Within their respective geographic area of responsibility, Citizen Advisory Boards:

- Provide advice on land use, services, budget, taxes and other matters;
- Represent the views and concerns of citizens in a fair and equitable manner;
- Serve as a liaison between the citizens of Lyon County and the County Commissioners; and,
- Disseminate information to the citizens on issues of concern.

The Smith Valley Advisory Board **also serves** as the Smith Valley Cemetery Board. The Cemetery Board meetings are held in conjunction with the Advisory Board meetings.

MEETINGS

The Smith Valley Advisory Board meets the Wednesday following the first Tuesday of every month at 7:00 pm at the Smith Valley Library located at 22 Day Lane, Smith, NV 89430.

CITIZEN ADVISORY BOARD HANDBOOK AND APPLICATION

The Citizen Advisory Board Handbook may be found here.
The Citizen Advisory Board application may be found here

CONTACT INFORMATION

For further information please contact the Citizen Advisory Board Liaison:
Maureen Williss
(775) 463-6531
Email: mwilliss@lyon-county.org

or contact a member of the Smith Valley Advisory Board:

K Garcia, Chair (775) 297-4648	Merle McMahon 720–6722
James Lovett (775) 220-3044	Richard Smolin (760) 486-8781

EXHIBIT G

SMITH VALLEY ADVISORY BOARD (SVAB)

MEETING AGENDA

Wednesday, June 5th, 2013
7:00 P.M.

SMITH VALLEY LIBRARY 22 Day Lane, Smith, Nevada

Note: The SVAB reserves the right to consider agenda items in a different order, combine items for consideration or delay discussion relating to an item to accomplish business in the most efficient manner.

Action will be taken on all items except where noted by an asterisk (*). No action will be taken on any item until it is properly agendized

1. *Call to order and Flag salute
2. Review and adoption of agenda –For Possible Action
3. Approval of minutes of the March 2013 and May 2013 meetings. –For Possible Action.
4. *Public Comment: Limited to items not on the agenda; 3 minute time limit. The SVAB may limit the total time for public comment if more than ten people wish to speak.
5. *Reports by public entity representatives (e.g., County Commissioner, Planning Commissioner, Sheriffs Dept., SV Volunteer Fire Dept., SV Parks and Rec, Upper Colony Chapter Fire Safe Council, etc.)
6. Discussion & action on Board members and open position –For Possible Action
7. **SPECIAL USE PERMIT REVIEWS:**
   Review Date: June 11th, 2013

A. **BROWN, DARROL J / DJB PROPERTIES - ZONING – M-1** - Special use permit issued June 2001 to construct and operate an enclosed flat floor transfer station on approximately 5.39 acres; located at 260 Day Lane, Smith Valley (APN 10-441-38)

STAFF OBSERVATIONS: Business license for D & S Waste Removal/ Darrol Brown is current and SUP appears to be in use and compliance. No complaints have been received.

–For Possible Action

B. **EVANGELISTA, GERARDO & LAURIE L. - ZONING - RR-5** - Special use permit issued June 2003 for a boarding kennel and June 2005 to modify their existing permit for a breeder's kennel and to increase the number of dogs housed to ten (10) adult dogs on approximately 20 acres; all located at 214 Artesia Road, Wellington (APN 10-081-27)

STAFF OBSERVATIONS: Business license for Vom Staab Kennel, Inc. is current and SUP appears to be in use and compliance. No complaints have been received.

–For Possible Action

8. **Public Hearing Item:**

SIERRA DESERT VIEW ESTATES – DEVELOPMENT AGREEMENT (for possible action) – Request for a Development Agreement to permit an extension of time within which to file a final map for the Sierra Desert View Estates Subdivision; located off of Highway 208 and Hudson Way, Smith, NV (APN's 10-451- 85, 10-451-86, 10-451-87, 10-451-88) PLZ-13-0028

–For Possible Action

9. **Discussion Item:**

Dairy Project : No Action will be taken

RECESS TO CONVENE AS SMITH VALLEY CEMETERY BOARD

1. *Public Comment: Limited to items not on the agenda; 3 minute time limit
2. Treasurer's report: review and accept claims as presented. –For Possible Action
3. Update on cemetery business/maintenance
4. *Public Comment: Limited to items not on the agenda; 3 minute time limit

RECONVENE AS SMITH VALLEY ADVISORY COUNCIL

1. *Public Comment
2. *Updates/Announcements/Correspondence
3. *Council Members Comments
4. Adjourn

Facilities in which this meeting is being held are accessible to the disabled. Persons with disabilities who require special accommodations or assistance (e.g. sign language, interpreters or assisted listening devices) at the meeting should notify the Lyon County Commissioner's office at 463-6531, 24 hours prior to the meeting.

I, K. Garcia, Chairman of the SVAB, do hereby certify that I posted, or caused to be posted, a copy of this agenda on or before 9:00 A.M, on May 31st, 2013 at the following locations: Smith Valley Library, Rosie's Restaurant, Wellington Post Office and Smith Post Office. K Garcia 775-297-4648