United States
Environmental Protection
Agency

Robert S. Kerr Environmental Research
Laboratory
Ada OK 74820

EPA-600/2-78-179
August 1978

Research and Development

EPA

Land and Water Use Effects on Ground-Water Quality In Las Vegas Valley

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the ENVIRONMENTAL PROTECTION TECHNOLOGY series. This series describes research performed to develop and demonstrate instrumentation, equipment, and methodology to repair or prevent environmental degradation from point and non-point sources of pollution. This work provides the new or improved technology required for the control and treatment of pollution sources to meet environmental quality standards.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

EPA-600/2-78-179
August 1978

LAND AND WATER USE EFFECTS ON GROUND-WATER QUALITY IN LAS VEGAS VALLEY

by

Robert F. Kaufmann
Desert Research Institute
Las Vegas, Nevada 89109

Grant No. R800946

Project Officer

Fredric Hoffman
Region IX
San Francisco, California 94111

ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
ADA, OKLAHOMA 74820

DISCLAIMER

DEDICATION

Dr. George B. Maxey, an esteemed scholar and true friend, conducted and guided fundamentally important groundwater studies in southern Nevada for over three decades. His knowledge of groundwater occurrence, quality, and movement and his integration of geologic and hydrologic principles on local, basin and regional scales continues to permeate the theory and application of hydrogeology. In southern Nevada and especially in Las Vegas Valley, he was an unquestioned authority. His perception of science and people and his unwavering ability to conceive and implement responsive research programs are legend. With respect to the effort presented herein, he was intimately involved as a scientist, administrator, and above all, a cherished colleague whose encouragement, criticism and continual personal concern will always have my gratitude. His influence can best be fathomed and appreciated by those who had the pleasure to interact with him in the subject areas he so dearly loved. He was and is the rare being that one never forgets.

FOREWORD

Since the vast influx of population began poring into the Las Vegas Valley in the 1940's the hydrologic regime of the Valley has undergone significant change. The pristine environment of the Valley was desert with desert vegetation and no perennial flow out of the Valley. With increase in population came the proliferation of lawns, shrubs, and trees throughout the Valley. This domestic irrigation of vegetation together with waste-water return flows has created a perennial stream leaving the Valley through Las Vegas Wash. This study was implemented to determine what is happening in the shallow ground-water zone (0 to 300') within the Valley, its flow, and the main sources of contamination. Results of this study have been divided into three volumes, this publication, the first volume, deals with the problem of how ground-water quality is affected by land and water use throughout the Valley. Volume two entitled, "Las Vegas Valley Water Budget: Relationship of Distribution, Consumptive Use, and Recharge to Shallow Ground Water," gives a detailed picture of the input and outflow of the water being used in Las Vegas Valley. The third volume, "Simulation Modeling of the Shallow Ground-water System in Las Vegas Valley," discusses the problems and water level fluctuations in the shallow ground-water system.

These three volumes represent an assessment of the shallow ground-water system in Las Vegas Valley and should be of use to anyone dealing with that aspect of the hydrologic regime in Las Vegas Valley.

Gilbert F. Cochran
Acting Executive Director

ABSTRACT

The hydrogeologic study of the shallow ground-water zone in Las Vegas Valley, Nevada determined the sources and extent of ground-water contamination to develop management alternatives and minimize adverse effects. An extensive, computerized data base utilizing water analyses, well logs, head measurements, and surface flows was developed. Flow system analysis, gross chemical data and tritium analyses were used in combination with trend surface techniques to ascertain natural and contaminated ground-water quality to depths of 0 to 50, 51 to 100, and 101 to 300 feet. At depths below 100 feet, the distribution of all constituents reflects natural controls. Nitrate and chloride in the zone from 0 to 50 feet are closely related to waste disposal activities, chief of which are industrial effluent, treated sewage, and septic tanks. In addition, tritium is highly indicative of return flows associated with distribution of Colorado River water in the Valley. Localized contamination of shallow unconfined ground water and rapid appearance of return flows is accentuated by pronounced vertical hydraulic and stratigraphic boundary conditions present in the eastern and western parts of the Valley. Nonparametric testing of extremely limited historical water quality data to ascertain temporal changes, particularly for the very shallow aquifers, yielded generally insignificant results. This is believed due to the lack of data because changes are indicated by gross chemical, tritium, and water budget data. Although the rudiments of a monitoring program have been outlined, management objectives for shallow ground water are undefined by responsible agencies, thus complicating the reason(s) for monitoring and the level of effort required. Management of shallow ground water bears on valley-wide and regional water management objectives and will become increasingly important when nonpoint source return flows double or triple to about 80,000 to 120,000 acre feet per year in the next twenty to thirty years.

This report was submitted in fulfillment of Grant No. R800946 by Desert Research Institute under the sponsorship of the U. S. Environmental Protection Agency. This report covers the period November 1, 1969, to January 31, 1974, and work was completed as of December 31, 1976.

CONTENTS

CONTENTS (continued)

FIGURES

FIGURES (continued)

FIGURES (continued)

TABLES

METRIC-ENGLISH CONVERSION*

A. LENGTH:

Unit	Equivalent(a) (b)					
	millimeter	inch	foot	meter(c)	kilometer	mile
millimeter	1	0.039 37	0.003 281	0.001 000	1 E-6	0.621 4 E-6
inch	25.40	1	0.083 3	0.025 40	25.40 E-6	15.78 E-6
foot	304.8	12	1	0.304 8	304.8 E-6	189.4 E-6
meter(c)	1 000	39.37	3.281	1	0.001	621.4 E-6
kilometer	1 000 000	39 370	3 281	1 000	1	0.621 4
mile	1 609 000	63 360	5 280	1 609	1.609	1

[1]Footnotes for all parts of Table 5
(a) Equivalent values are shown to 4 significant figures.
(b) Multiply the numerical amount of the given unit by the equivalent value shown (per single amount of given unit) to obtain the numerical amount of the equivalent unit (e.g.; 5 inches × 0.025 40 m/inch = 0.127 0 m).
(c) This is the SI expression, in base units or derived units, for the physical quantity.

B. AREA

Unit	Equivalent(a) (b)						
	sq. inch	sq. foot	sq. meter(c)	acre	hectare	sq. kilometer	sq. mile
sq. inch	1	0.006 944	645.2 E-6	0.159 4 E-6	64.52 E-9	645.2 E-12	249.1 E-12
sq. Foot	144	1	0.092 90	22.96 E-6	9.290 E-9	92.90 E-9	35.87 E-9
sq. meter(c)	1 550	10.76	1	247.1 E-6	1 E-4	1 E-6	386.1 E-9
acre	6 273 000	43 560	4 047	1	0.404 7	0.004 047	0.001 563
hectare	15 500 000	107 600	10 000	2.471	1	0.01	0.003 861
sq. kilometer	1.550 E+9	10 764 000	1 000 000	247.1	100	1	0.386 1
sq. mile	4.014 E+9	27 880 000	2 590 000	640	259	2.590	1

C. VOLUME:

Unit	Equivalent(a) (b)							
	cu. inch	liter	U.S gallon	cu. foot	cu. yard	cu. meter(c)	acre-foot	sec-foot-day
cubic inch	1	0.016 39	0.004 329	578.7 E-6	21.43 E-6	16.39 E-6	13.29 E-9	6.698 E-9
liter	61.02	1	0.264 2	0.035 31	0.001 308	0.001	810.6 E-9	408.7 E-9
U.S. gallon	231.0	3.785	1	0.133 7	0.004 951	0.003 785	3.068 E-6	1.547 E-6
cubic foot	1 728	28.32	7.481	1	0.037 04	0.028 32	22.96 E-6	11.57 E-6
cubic yard	46 660	764.6	202.0	27	1	0.764 6	619.8 E-6	312.5 E-6
cubic meter(c)	61 020	1 000	264.2	35.31	1.308	1	810.6 E-6	408.7 E-6
acre-foot	75.27 E+6	1 233 000	325 900	43 560	1 613	1 233	1	0.504 2
second-foot-day	149.3 E+6	2 447 000	646 400	86 400	3 200	2 447	1.983	1

D. DISCHARGE (FLOW RATE, VOLUME/TIME):

Unit	Equivalent(a) (b)					
	gallon/min	liter/sec	acre-foot/day	foot^3/sec	million gal/day	meter^{3}sec(c)
gallon/minute	1	0.063 09	0.004 419	0.002 228	0.001 440	63.09 E-6
liter/second	15.85	1	0.070 05	0.035 31	0.022 82	0.001
acre-foot/day	226.3	14.28	1	0.504 2	0.325 9	0.014 28
foot^3/second	448.8	28.32	1.983	1	0.646.3	0.028 32
million gallons/day	694.4	43.81	3.069	1.547	1	0.043 81
meter^3/second(c)	15 850	1 000	70.04	35.31	22.82	1

E. VELOCITY:

Unit	Equivalent(a) (b)				
	foot/day	kilometer/hour	foot/sec	mile/hour	meter/sec(c)
foot/day	1	12.70 E-6	11.57 E-6	7.891 E-6	3.528 E-6
kilometer/hour	78 740	1	0.911 3	0.621 4	0.277 8
foot/second	86 400	1.097	1	0.681 8	0.304 8
mile/hour	126 700	1.609	1.467	1	0.447 0
meter/second(c)	283 500	3.600	3.281	2.237	1

* Taken from System International D'Unites, Metric Measurement in Water Resources Engineering, prepared for the Universities Council on Water Resources, June 1976.

ACKNOWLEDGMENT

The author is most grateful for the assistance received from many associates within Water Resources Center, Desert Research Institute. Particular recognition is owed to Messrs. Nate Cooper, Herbert N. Friesen, John Sanders, M. J. Miles, Robert J. McDonald, Ralph Patt and James Dinger for their assistance in data collection and reduction. Critical advice and manuscript review was generously provided by Drs. George B. Maxey, Gilbert F. Cochran, Martin D. Mifflin, Mr. Dale Schulke, and Ms. Karyn Fallon. Technical and clerical assistance was received from Judy Carpenter, Margaret Herndon, Hazel Dewey, John Brekke, Carolyn McNeill, Kenneth Zellers, and Lucy Dunaway Miller. Of the many student assistants, Peter Howells, Fenton Kay, Guy Johnson, Bernard Serofman, Richard Leoni, and Walter Douthett, deserve a special note of thanks.

Special recognition is given to Mr. Alan E. Peckham, the principal investigator for the first two years of the project, for his efforts in getting the study underway and in securing initial support within the Las Vegas community and the U. S. Environmental Protection Agency. The assistance of the first EPA project officer, Mr. Jim V. Rouse, is gratefully recognized.

Many outside agencies and individuals provided financial and other support, including the U. S. Bureau of Reclamation and the Nevada Division of Colorado River Resources (formerly Colorado River Commission, CRC). Messrs. Arleigh West, former Regional Director for the Bureau and Donald Paff, Administrator for the CRC, helped place the study in perspective relative to the local and regional water quality management situation. The Bureau and CRC provided financial and material support for establishing the water quality laboratory and for an extensive water sampling effort on Lake Mead. Mr. Carl Dewey, U. S. Bureau of Mines also helped in the establishment of the laboratory. Financial support was obtained from the National Park Service through Mr. Roger Allin, Superintendent of the Lake Mead Recreational Area, and from the Fleischmann Foundation of Reno, Nevada. The A & K Construction Company donated five ground-water monitoring wells in the Las Vegas Wash area.

Several State, Regional, and County government officials deserve mention. Among these are Drs. V. Ueckert and Otto Ravenholt of the District Health Department, Mr. Charles Brechler of the Regional Streets and Highway Commission, Mr. Francis Thorne of the State Engineer's Las Vegas Office, and Messrs. Louis Anton and James Parrott of the City and County Sanitation Districts, respectively.

The Las Vegas Valley Water District, under the direction of Mr. Thomas Rice, provided financial support for modeling in the Las Vegas Wash portion of the study. Staff members William Blackmer, Alan Bell, and Aldo Barozzi were particularly responsive to our requests.

Certain elements of private industry deserve specific credit. Basic Management, Inc. (BMI), under the direction of Mr. Glen Taylor and various companies in the Henderson industrial complex, provided access to private property, financial support for stream gaging, and historical records. Mr. James Zornes of Nevada Power Company furnished discharge and water quality data concerning wastewater discharges. Several local consulting engineering firms generously allowed the use of their borings logs to determine shallow geologic and water table conditions. Mr. Oscar Scherer of Nevada Testing Laboratories, Ltd., Mr. Robert Pride of Converse Davis and Associates, and Mr. Aldon Strobeck of Strobeck and Associates, Inc. were particularly helpful. The maintenance and engineering staffs of the Dunes, Stardust, Sahara, and Desert Inn Hotels assisted us in locating on-site ground-water drains as did officials of the Central Telephone Company, Montogomery Ward and Company, and Sears, Roebuck and Company.

Final and lasting recognition is reserved for certain U. S. Environmental Protection Agency personnel. Mr. Fredric Hoffman, the Project Officer, provided unfailing support and critical review. The administrative support of Dr. James P. Law, Jr. provided essential continuity in funding over a four year period necessary to accomplish the goals.

SUMMARY OF CONCLUSIONS

RESEARCH OBJECTIVES

Intensive study of land and water use patterns and hydrogeologic conditions in Las Vegas Valley focused on defining water quality conditions in the shallow sediments to depths of 300 feet. Water quality in parts of the near surface system of aquifers and aquitards is greatly affected by urban and industrial land and water use practices, cheif of which are liquid waste disposal, overdraft of deeper aquifers, irrigation return flows, infiltration of overland flow, and disruption of natural soil conditions. The study also sought to establish the relationship between such land and water use patterns on basin wide water quality management, particularly the ground-water aspects.

With the physical setting established in terms of natural conditions and in relation to developmental patterns, the essentials of a water resources systems response monitoring strategy were identified to assist in long-term water quality management within the Valley and in relation to realities of Las Vegas Wash and Lake Mead pollution problems. Hopefully the knowledge gained will be a contribution having local importance. In a more general sense, the objectives and study techniques have wider applicability and relevance to the mandates for ground-water protection embodied in Public Law 93-523 (Safe Drinking Water Act).

AQUIFER FRAMEWORK AND PATTERN OF FLOW

Las Vegas Valley is an intermontane arid basin which contains a thick sequence of alluvial sediments arranged vertically and laterally in a complex system of aquifers and aquitards. The most permeable sediments are in the northwestern and west-central parts of the Valley where the principal volume of ground-water extraction has occurred to data, primarily from confined aquifers at depths of 250 to 1,000 feet. Except in the west-central area, these aquifers are overlain by extensive layers of poorly permeable clay, silt, or caliche. Separating these productive zones from generally less permeable sediments to the east is a series of faults and associated scarps which impede eastward ground-water flow. The eastern part of the Valley is characterized by primarily fine-grained sediments and a shallow water table.

Immediately west of the main scarp in Las Vegas Valley, the near surface zone consists of a thin layer of shallow alluvium underlain by extensive caliche and other aquitard materials. The alluvium grades westward into fan sediments and the zone is stratigraphically and hydraulically indistinguishable from the deeper aquifer. Northeast of the scarp there is no lithologic basis for separation of a near surface zone. In the southeastern part of

Las Vegas Valley, the near surface zone consists of saturated, unconsolidated sands and gravels ranging in thickness from 20 to 100 feet. This area is underlain by an unknown thickness of poorly permeable fine-grained sediments, probably belonging to the Muddy Creek Formation.

The near surface flow system is unconfined except possibly in a few very localized areas. It is in hydraulic continuity with underlying saturated sediments. Although perched water is locally present, it is not significant in the context of water resources management in the Valley or relative to the present study. Previous to ground-water development which effectively began in 1907 and constituted overdraft by the 1940's, recharge was principally by upward movement from underlying aquifers. Because of pumping from deep aquifers, the potential gradient in the near surface zone in the northwest subarea has been reversed, causing shallow ground water to move downward into underlying aquifers. In the southwest subarea, downward movement occurs principally in the vicinity of heavy pumping while in other parts of the subarea there is still upward movement into the near surface zone. In the northeast subarea there is probably little downward movement of ground water at depth. In lower Las Vegas Valley, ground water moves from the near surface zone into underlying sediments on upper parts of the fan near Henderson and the BMI industrial complex. In topographically lower parts of this area there is upward movement with discharge to Las Vegas Wash and(or) as evapotranspiration.

Under natural conditions, recharge to the valley fill was believed a result of precipitation in the surrounding mountains, primarily those to the west and north. Flow from the recharge areas via a deep aquifer system involved an easterly or southeasterly path incorporating lateral and then upward movement in the valley fill either as diffuse seepage or as localized flow towards springs discharging in close proximity to fault planes. There is some recent evidence that the recharge area may extend beyond the topographic basin and involve the deep-seated limestone strata to a greater degree than previously believed. Both the seepage and reinfiltration of the spring discharges resulted in recharge of the near surface zone, discharge from which was by evapotranspiration. There was no surface water flow of ground water from the Valley and the principal discharge areas such as the Meadows (Las Vegas) were well removed from the present locus of surface discharge, Las Vegas Wash.

NATURAL WATER QUALITY

Ground-water quality in the deeper part (101 to 300 feet) of the shallow zone largely reflects the combined influence of rock type, length of flow path, and the effects of decreasing permeability and increased residence time in an eastward direction along the flow path. Progressive increase in salt content along the flow path in the deeper part of the shallow system (depths of 101 to 300 feet) is a result of the aforementioned factors. These are also influential at very shallow depths (0 to 50 feet), but the principal influence on salt concentration is evapotranspiration.

Available chemical analyses of ground water for the period 1962 to 1968 for depth intervals 0 to 50, 51 to 100, and 101 to 300 feet were interpreted using trend surfaces and a large data base, consisting of about 4,000 water analyses cross-referenced to over 6,300 wells. This base was developed from existing records, and supplemented with additional analyses for gross chemistry and nutrients. Total dissolved soldis (TDS) in the depth interval from 101 to 300 feet increase in an eastward direction from 300 mg/ℓ on the western and northwestern fringes of the suburban area to 3,000 mg/ℓ in the vicinity of Las Vegas Wash. Variations in this interval are solely from natural causes which include the basic flow system configuration, the geologic matrix, and the position of the principal recharge and discharge areas in the Valley. Whereas the distance from the recharge area in the Spring Mountains to the 1,000 mg/ℓ TDS contour line is about 30 miles, dissolved solids increase from 1,000 mg/ℓ to 3,000 mg/ℓ in a distance of about four miles in the area of concentrated ground-water discharge. Gypsiferous sediments in the Paradise Valley area and adjacent to the Sunrise-Frenchman Mountain complex account for the rapid increase in sulfate and calcium in the southern and northeastern portions of the Valley. The effects of reduced permeability and consumptive discharge in these areas are additive. The trend surfaces for TDS at depths of 101 to 300 feet also infer that a previously undescribed and relatively undeveloped zone of good quality water trends eastward across the northern portion of the study area. Additional exploration will be necessary to substantiate this inference.

Nitrate[1] (as NO_3) and chloride concentrations at depths of 101 to 300 feet show little systematic variation. As a result of natural factors, chloride gradually increases from 10 mg/ℓ to 185 mg/ℓ near the area of ground-water discharge. However, nitrate at this depth remains in low concentration of about two to seven mg/ℓ throughout the area studied. Nitrate concentrations exceeding ten mg/ℓ are locally present, indicating that in localized areas sewage effluent has contaminated aquifers deeper than 100 feet.

Soil conditions have an important bearing on shallow ground-water management. The soils data and the recent study by Cooley et al. (1973), support the thesis that significant in-valley recharge by precipitation is small and probably is on the order of several thousand acre feet or less (Patt, 1977). In addition, the precipitated salts in surficial soils in the central portion of the Valley are both allogenic and authigenic, the latter originating as precipitation from ground water and/or former standing water bodies. Return flow from irrigation water and liquid waste disposal is likely to dissolve these constituents and increase the salinity of shallow ground water. Also, the presence of essentially impermeable but discontinuous caliche and hard pan layers near the land surface limits the available storage of return flows and diverts them laterally. Fine-grained soils present on interfluvial surfaces in much of the urban and suburban portions of the Valley are characterized by low infiltration rates and high salt content.

Minimal TDS concentrations occur in ground water associated with the granular, less mineralized soils present on the medial and distal portions of alluvial fans surrounding the urbanized areas and in the major drainage courses such as Duck Creek and Las Vegas Wash. Maximum concentrations occur in the central and southeastern areas underlain by finer-grained,

[1] All nitrate data are expressed as nitrate

mineralized soils, upward moving ground water, and evapotranspiration from near surface ground water. The combined effect of these three factors plus gradual enrichment along the flow path are evident from the steeper concentration gradient in the area surrounding the lower reach of Las Vegas Wash. Recharge by concentrated industrial wastes from the industrial complex in Henderson also accounts for abnormally saline ground water in those portions downgradient from the plant area and tailings ponds.

In general, ground water to depths of 50 feet is not potable because of high salt content. Where primary or secondary treated sewage effluent has been applied to the land surface, nitrate occasionally exceeds the commonly accepted limit of 45 mg/ℓ (as NO_3). Therefore, expanded use of wastewater for irrigation should procede with caution because of the deleterious effects demonstrated with respect to very shallow ground water and associated potential adverse effects on deeper aquifers. Use in areas with lateral or upward flow gradients is favored because hydraulic drive to transport contaminants to productive aquifers is absent. However, extensive application of wastewater in certain areas is likely to result in waterlogging and(or) development of a base flow component in area drainage. Extensive reuse of sewage effluent in portions of the western and northern sectors of the Valley is not recommended because deterioration of shallow, relatively high quality water could occur. Thick caliche layers and extensive clay and silt sediments at shallow depths favor lateral migration and local perching of return flows in much of the developed portions of the Valley. Without deliberate management renovative effects of local soil columns will decrease and noxious return flows may occur. In summary, additional hydrogeologic and sanitary engineering studies will be necessary to select areas for reuse and to monitor the effects.

EFFECTS OF LAND AND WATER USE ON SHALLOW GROUND WATER

Although in-valley precipitation is not an appreciable source of recharge to shallow ground water, infiltration of various return flows into the near surface aquifer as a result of water development has been going on continuously ever since 1907 when the first artesian wells were developed. Excess irrigation water infiltrated and many wells flowed freely until the mid to late 1930's when the work of Livingston (1938) prompted the State Engineer to require that abandoned wells be properly sealed and owners limit the discharge to beneficial uses. The present study shows that return flows from a variety of water and land use categories now amount to 46,000 acre feet per year (Patt, 1977).

Prior to extensive water use in the Valley, total ground-water outflow via Las Vegas Wash was estimated at about 250 acre feet per year. As a result of extensive industrial effluent disposal on the order of 11,000 to 17,000 acre feet per year from the early 1940's to date, ground-water discharge to the Wash in 1972 was about 12,000 acre feet and contributed roughly 60 to 70 percent of the measured salt flux leaving the Valley other than in flood flows. In the urban and suburban areas, extensive mesquite groves, stands of salt bush and tules have been removed and replaced with suburban sprawl and the ubiquitous green lawn. Former discharge (by evapotranspiration) of 25,000 acre feet per year has been replaced by ground-water recharge of 46,000 acre feet per year. This recharge is believed to: 1) go into storage in the near surface aquifer, 2) move downward to recharge overdrafted, formerly artesian aquifers, and 3) flow laterally toward Las Vegas Wash.

Recharge to the near surface zone now is mainly a result of lawn, golf course, and agricultural irrigation throughout the Valley and from sanitary and industrial waste disposal practices adjacent to Las Vegas Wash. Of the 143,000 acre feet of water delivered in the Valley during 1973, about 46,000 acre feet or 32 percent were recharge to the near surface zone (Patt, 1977). Of the total recharge in the Valley, about 27,000 acre feet were from irrigation and about 1,750 acre feet were from septic tanks. About 14,000 acre feet of recharge occurred in the Las Vegas Wash area as a consequence of municipal and industrial waste disposal and irrigation return flow.

Sewage effluents have freely infiltrated the near surface zone at numerous municipal and privately operated sewage treatment plants. In 1955 alone, 7,000 acre feet of effluent infiltrated in the eastern part of the Valley. Total recharge in the same year was 14,000 to 18,000 acre feet. Irrigation of alfalfa with sewage from 1955 to 1969 caused water levels to rise 14.6 feet or 1.04 feet per year. A severe waterlogging problem has been recognized in a farm area of about 1,200 acres irrigated with sewage. In 1973 there were over 5,000 irrigated acres in the Valley receiving 46,000 acre feet per year, only about 40 percent of which was consumptively used.

Available nitrate data clearly reflect the widespread addition of sanitary wastes from septic tank leachate and sewage effluent. In the southeastern part of the Valley, industrial wastes have caused extensive contamination. Return flows from areas irrigated with sewage effluent or infiltration of treated effluent from lagoons and outfall ditches have raised nitrate concentrations in native ground water. Locally, concentrations exceed the U. S. Public Health Service (1962) maximum recommended level to 45 mg/ℓ of nitrate. There is a coincidence of above background concentrations of nitrate in shallow ground water with known septic tank areas. The available analyses, taken from throughout the developed portions of the Valley containing septic tanks, indicate increased nitrate both at the top of the zone of saturation and within the shallow potable aquifers. Additional study is necessary to determine whether nitrate is locally widespread in the shallow aquifer or if it is appearing as leakage along well casings. The available data base is inadequate in terms of lateral and vertical control. Nitrate concentrations in very shallow ground water commonly exceed natural (background) values of 10 mg/ℓ, and occasionally this occurs within a few years after wastes are first introduced. For most of the Valley, concentrations are less than 45 mg/ℓ but occasional peaks of 50 to 70 mg/ℓ occur in some wells and constitute a health hazard.

The widespread occurrence of increased concentrations of tritium in shallow ground water is associated with known sources of recent recharge, thus underscoring the marked hydrologic response to urbanization, and particularly irrigation and waste disposal practices. Septic tanks, irrigation with sewage effluent, disposal of effluent by spreading on the land and industrial waste disposal to unlined ponds are the most significant sources. Contaminated return flows from the sources mentioned appear in ten years or less and, in the case of most sources, are persistent for an even longer time period after disposal ceases. Tritium is particularly apparent in shallow ground water in areas served by water derived wholly or in part from the Colorado River. In these instances, the shallow aquifer an average of 49.4 tritium units (TU) compared to 20 TU in the western half of the Valley, largely served by deep ground water containing 3 to 6 TU. Infiltration of overland flow either from storm events or as tail water from lawn irrigation in housing areas also contributes to chemical pollution and increased tritium concentrations in shallow ground water. Ground-water return flow from the BMI complex, which uses only Colorado River water that has undergone little dilution, contains 200 to 400 TU.

Five subareas of the Valley having similar hydrogeologic and water quality settings and patterns of water development were designated so the analyses within each area could be statistically tested for temporal change in water quality. With few exceptions, the testing procedures revealed no significant change in ground-water quality regardless of the time periods or areas considered in the Valley. Significant change in TDS and chloride occurred in the northwest part of the Valley where heavy pumping may have induced vertical or lateral inflow of more saline shallow ground water. The data base to assess temporal change is woefully inadequate, however.

DATA AVAILABILITY AND ANALYSIS TECHNIQUES

For three separate depth intervals or "slices", the use of trend surfaces and their associated statistical measures proved very useful for evaluating several hundred water analyses selected to depict the nature of lateral variations so as to clarify regional and local trends. By simplifying otherwise complex patterns of ion distribution, variations attributable to natural and man-related sources of water quality deterioration were identified. The influences of natural and man-related sources of pollution are most evident from the tritium, chloride and nitrate data and, to a lesser extent, from variations in TDS. Tritium and nitrate, in particular, were useful indicators of return flows associated with irrigation and effluent disposal.

Through 1967, only 412 analyses are available from wells ranging in depth from 8 to 1,700 feet to document ground-water quality over an area of 150 square miles. Previous scientific studies account for 156 analyses with the balance from the period 1964-1967 and, therefore, of limited historical significance. Forty-four percent of the data are from wells of unspecified depth, thereby reducing their scientific value. Only 2 percent of the analyses are from the interval 0 to 100 feet. For areas in the eastern part of the Valley where in places there is a rising water table from return flows, there are essentially no analyses for the unconfined aquifer. Large areas undergoing rapid suburban growth are essentially devoid of baseline water quality data, hence future water quality changes associated with ongoing development will be extremely difficult to assess.

An insufficient data base exists to define long-term trends in water quality with respect to both the deep and the shallow aquifers. Nevertheless, vertical downward movement of poorer quality water into the deeper aquifers on the western side of the Valley is indicated by static water level measurements and hydrologic budget analysis (Harrill, 1976), lumped parameter simulation modeling by Cochran and Wilson (1971), and the distributed digital simulation model of this study (Westphal, in prep.). The profusion of agencies involved in water quality management might lead one to conclude the historically weak effort in data collection is no longer a problem in Las Vegas Valley. However, with the exception of efforts by the water utilities with respect to municipal wells, ground-water quality data are not being collected and plans to do so are not evident. Considering the type and amount of data presently being collected, it is unlikely that a ground-water specialist of the future will have any added advantage in terms of a data base compared to that which now exists.

SHALLOW GROUND-WATER MANAGEMENT IMPLICATIONS

Management of water quality in a rapidly growing urbanized arid basin involves surface water and ground-water components. In the southwest there commonly is overdraft of ground water and, subsequently, importation of surface water to meet increasing demands. Return flows associated with water usage recharge shallow aquifers. Hydrologic effects are often pronounced because natural hydraulic equilibrium is severly disrupted and a host of water quality impacts are realized, some of which are adverse.

Results of the water budget phase of this study (Patt, 1977) indicate that recharge of the near surface aquifer from in-valley water use amounted to about 38,500 acre feet in 1973. By comparison, the estimated total flux of ground water under predevelopment conditions ranged from 21,000 to 35,000 acre feet per year. Water demands have steadily increased, particularly in the last 30 years. Overdraft of the deeper, artesian aquifers probably began in the 1940's when pumpage exceeded 40,000 acre feet per year. More recently, pumpage approached 88,000 acre feet per year or roughly a 3 or 4:1 overdraft. Increasing amounts of Lake Mead water, first used in the Henderson area in the 1940's and in the eastern part of Las Vegas in the late 1950's, have reduced the use of ground water to about 73,000 acre feet per year in 1975. Planned water use in the Valley for Lake Mead water will be as much as 350,000 acre feet per year. Aside from the fact that Lake Mead water has about twice the TDS of ground water most widely used, there likely will be pronounced changes in return flow quantity associated with a water budget which is at least a ten-fold increase over predevelopment conditions. This study has demonstrated that important hydraulic and water quality changes have already occurred in the area of Las Vegas Wash.

Development of Las Vegas Valley has been and probably will continue to be rapid. Principal long-term water planning efforts in the past have focused on provision of adequate water supplies, and to a considerably lesser extent, on secondary treatment of sanitary wastes. Essentially no concern or action has been shown with respect to nonpoint sources of return to the shallow aquifers or to ground-water impacts on wastewater management and vice versa. Despite the expenditure of several million dollars for water quality management planning, recognition of the ground-water resource and its active and passive roles in these planning objectives is not yet evident in any comprehensive program.

Deep ground-water quality is related to overall water quality management in several ways. It has long been known that the best quality water already developed or potentially availabile in the Valley is from the deeper aquifers. Therefore, improved knowledge of this resource and the factors which may result in changes in quality, particularly adverse changes, are of importance. Secondly, it is apparent that overdraft of ground water has largely been a local phenomenon with the result that large areas of the Valley have potable ground water that is largely underdeveloped. With increasing distribution of Lake Mead water and a stated management objective of annual ground-water pumpage reduced to 50,000 acre feet per year, the trend toward underdevelopment is likely to continue and even increase. At some future time, estimated to occur in the period 1990 to 2000, Las Vegas Valley is expected to again face a potential water shortage. Beside importation of ground water from other valleys and in-valley water conservation programs, moderate ground-water mining on a much more distributive basis than at present is also an alternative to help meet future water demands and to maximize the use of high quality ground water. Maintenance of this option necessitates that preservation of existing high quality ground water be a prime consideration in the adoption of a water quality management program in the interim.

Documentation of ground-water quality conditions necessitates continued collection of water samples from the principal production zones throughout the Valley and from very shallow or near surface zones. Although the latter are not presently considered a prime resource, their continued neglect may render them a liability to other water quality management goals. The ground-water monitoring network developed in the course of the study, in conjuction with the data storage and retrieval system, has potential value for future ground-water quality investigations. This network and data system is the beginning of a program but should not be considered adequate on a valley-wide basis or in terms of potential water management objectives.

PROBLEM AREAS OF SHALLOW GROUND-WATER MANAGEMENT

Overland flow as sheet runoff plus flooding via diffuse systems of dry wash channels removed much of the surficial accumulations of salt during geologic time. With urbanization, drainage courses are improved, sheet flow is reduced or eliminated and recharge from return flows constitutes the net moisture flux through the soil profile. At present, salt removal is restricted to the wash flood plains, which are being reduced through channel improvement, and to selected areas where sheet flow is still possible; the expected impact of these trends is increased ground-water return flow and decreasing water quality.

Use of wastewater in an arid zone urban environment characterized by marked vertical boundary conditions and upward flow gradients results in the widespread contamination of shallow aquifers and relatively rapid emergence of return flows in surface water courses and as a contaminated veneer at the water table. Past disposal of liquid wastes to unlined ponds near Henderson has been unsuccessful for the most part. Although at least 230,000 acre feet of water have been disposed of to date, storage calculations show retention of only 3 to 6 percent of the amount infiltrated which is conservatively estimated at forty percent. Thus, true waste containment has been minimal and, environmentally, the disposal scheme is a failure insofar as wastes have migrated extensively into adjacent surface water and ground-water resources over an area of about 16 square miles. In response to an

EPA enforcement action, Stauffer Chemical Company and Montrose Chemical Corporation of California (1972) estimated that the cost of recovery and impoundment of wastes in the subsurface as well as anticipated future waste volumes would be $107,000,000. Noticeable reduction in flow volume and salt flux is expected to take years, and several decades are necessary before marked change in the total salt flux from ground water will occur after the disposal practice is terminated. In retrospect and in looking toward the future, such massive waste disposal operations must be critically examined relative to basin water quality management objectives and the spirit and letter of the Safe Drinking Water Act as it relates to ground-water protection.

Recharge originating as industrial and sanitary wastes and nonpoint sources of urban and agricultural return flows cannot migrate downward in the discharge portion of a ground-water flow system; they are not safely contained. Lateral migration is also necessarily short and the wastes typically reappear in the natural discharge areas on the Valley floor. Effluent disposal by surface spreading in the discharge portion of the flow system may conflict with other land uses if wastes are transported to the land surface. To minimize environmental impact, extensive liquid waste disposal in discharge areas should occur in lined, impermeable basins where evaporation to dryness occurs. Solid residues should then be safely landfilled or, possibly, recycled. Alternatively, recharge areas can be used to dispose of sanitary wastes to allow dilution and other processes to reduce or eliminate waste toxicity. Careful planning is essential to determine the extent and acceptability of effects on other existing and future water uses if this alternative is followed. Toxic wastes produced in the minerals processing industry are not generally amenable to disposal in this manner and complete containment becomes necessary.

Recharge to the shallow aquifer in the Valley proper has clearly increased with time. Annual accretion in 1943 was 21,000 acre feet compared to 26,650 acre feet in 1958, 27,600 acre feet in 1965, and 38,500 acre feet in 1973. Recharge to the shallow system now exceeds the total water budget for the Valley prior to settlement. Inefficient lawn watering accounts for much of the recharge to the near surface zone. If present water and land use patterns prevail, recharge associated with a future population of 750,000 may approach 75,000 acre feet per year, or roughly three times the total water flux prior to development. More efficient irrigation could reduce the present water demand by 15,000 acre feet per year and reduce annual return flows by 11,000 acre feet.

Generally speaking, however, it is probable that important changes in urban water use practices require institutional modifications and economic incentives. A poll of valley residents by Reichert and Leland (1971) indicated that price increases will probably result in reduced water usage, particularly uses outside the dwelling. Fitzsimmons (1973) concluded that tripling in water rates would be necessary to markedly reduce water demand. With increased unit prices for potable water and wastewater treatment, per capita water demand may decrease. However, total return flows can be expected to increase as a result of increased urbanization unless marked changes in landscaping practices are instituted.

MONITORING IN RELATION TO SHALLOW GROUND-WATER MANAGEMENT

This work clearly indicates the complexity of the shallow ground-water system in terms of existing character, past and present impacts of water development, urban land use, and various types of wastewater disposal and return flow impacts. Understanding of the shallow ground-water zone, while incomplete in some respects, is sufficiently detailed to allow qualitative estimation of likely responses to changing water and land use practices in the Valley. Although subtle and largely invisible, the present and potential importance of shallow ground-water problems necessitates their consideration in terms of hydraulic and water quality responses stemming from land and water use or waste disposal in the Valley. Considering projected water supply demands and expected uses (more than 350,000 acre feet per year, or over twice present water use) and the hydraulic and water quality responses documented herein, there is every reason to believe that shallow ground water will become increasingly relevant to basin wide water management.

If the foregoing is accepted, several options can be incorporated in management policy for the shallow ground-water zone:

1. Controlled wastewater disposal (this has been the actual practice in many parts of the Valley for industrial, municipal, and domestic wastewaters).

2. Further development of municipal or domestic water supply (this too, has been actual practice up to the present time in extensive areas of the Valley).

3. Development of supplemental water for irrigation and industrial purposes (where quality permits and economic development is feasible).

4. Stabilize, reduce or elimate saline ground-water effluent to Las Vegas Wash.

The above options illustrate possible management directions, each of which require monitoring programs and return flow management.

Unfortunately, it is unrealistic to specify a detailed shallow ground-water monitoring program including such specifics as well location, design, sampling intervals, etc., until basin wide water management policies are clearly defined, and wastewater disposal practices consonant with the basin wide water management policies are outlined. There is no general policy direction which indicates the uses to be made of the shallow ground-water system, and there is uncertainty with respect to development schemes for production aquifers in some parts of the Valley. Also unclear is the policy and management of return flow of water to the Colorado River in terms of amounts and quality constraints. Despite the foregoing uncertainties, the following known or extremely likely activities will affect shallow ground water and, therefore, influence the context of any monitorining program: 1) continued in-valley use of potable water for lawn irrigation, limited agriculture, evaporative cooling, etc., 2) sewage treatment and discharge in the Las Vegas Wash area, 3) limited reuse of sewage for golf course irrigation, 4) overdraft of the deeper aquifers, 5) continuation of present land and water use patterns (excepting large scale industrial waste disposal), and 6) increasing use of Colorado River water.

In addition to the above, it is expected that shallow ground-water resources will be intentionally and increasingly used for both waste disposal and as a source of water supply for such nonpotable uses as cooling water or irrigation. Use should fully reflect the nature of the local geologic framework with respect to ground-water quality and availability and any impacts on wastewater reuse.

An objective of this study has been development of a shallow ground-water monitoring program to furnish data for assessing the hydrogeologic effects of various water management plans developed for the Valley and particularly as they bear on return flows to Las Vegas Wash and Lake Mead. In part this has been achieved through definition of the principal problems and demonstrating the objectives and methodology for data collection, as well as data reduction techniques. The following items of consideration, in terms of water quality and associated fluid potential data from sampling points of known characteristics, are believed basic to a shallow ground-water monitoring program in Las Vegas Valley:

1. The three-dimensional chemical state of the system should be established through properly distributed water sampling points.

2. Individual sampling points should consist of fully cased and properly sealed wells, some of which are piezometers and open to a small or discrete portion of the system whereas others should be high capacity wells open to relatively large production intervals.

3. Wells should be sampled at set time periods and maximum effort should be made to maintain sampling points.

4. Shallow ground-water return flows should be sampled by means of natural springs/seeps and through interception of shallow zones of high permeability (buried wash channels?).

5. Known areas of recharge from lawn watering, golf course irrigation, and sewage/industrial waste disposal are particularly significant sources of contamination and should be monitored.

6. Monitoring of shallow and underlying aquifers in areas of wastewater reuse should precede, accompany and follow such reuse.

7. The monitoring programs of existing agencies should be carefully reviewed to increase efficiency and information returns. It is particularly important that information concerning well depths and sampling depths be collected as part of ground-water sampling programs.

8. The monitoring program should be amplified where and when needed to answer specific questions alternative management proposals raise with changing concepts and patterns of land and water use.

All data should be reasonably representative of a common time frame. This could be achieved by maintaining continuous water level records at a few selected representative locations plus measurements collected throughout the Valley and at least once during each period of maximum and minimum demand each year. Methods of measurement should be accurate and datum elevations should be surveyed, rather than estimated or assumed.

To obtain information about vertical hydraulic gradients, piezometer nests should be installed and maintained at selected points throughout the Valley. Obvious places are near pumping centers, in the vicinity of selected housing developments, and near selected golf courses. Piezometers should be installed so that distribution of hydraulic potentials in the vertical section can be determined during construction.

At present, such fluid potential data are essentially nonexistent in most of the Valley, and are key to relating water quality changes in underlying production aquifers to the shallow ground-water zone.

RECOMMENDATIONS

GROUND-WATER MONITORING

Recommendation I

Formulation of monitoring objectives and implementation of a monitoring program should directly stem from the broader objectives for management of ground-water resources in the Valley. Because of the close relationships between shallow ground water, land use, water use, and nonpoint return flows, state and local agencies having authority and responsibility in these areas should necessarily formulate these broad objectives. In addition, these must be in consonance with regional water quality management goals established by Federal authority; of particular importance is salinity control on the Colorado River.

There is strong justification developed in this work for adopting a monitoring program to provide useable data for evaluating the state of the shallow ground-water system with respect to 1) water quality, 2) water table (storage) fluctuations, 3) response in terms of surface discharge from the Valley, and within the Valley, and 4) responses in terms of quality change influenced by water transfer from shallow, low quality zones to deeper production zones.

Recommendation II

Findings of the present study indicate the following considerations are most relevant to formulation of management objectives for the shallow ground-water resource in Las Vegas Valley:

1. Existing state of the system as documented by this study, and the types and magnitudes of pollution and hydraulic impacts stemming from activities in the Valley;

2. Wastewater disposal requirements of the future, and the mandate of salinity control for the Colorado River Basin;

3. Continually increasing water supply demands, development, and proportional generation of return flow wastewaters;

4. Development of an adequate data base for management schemes involving the shallow system (i.e., uses for water supply or waste disposal);

5. The basic role the shallow ground-water zone takes in the generation of saline water return flow to Las Vegas Wash;

6. The time lag response of this system to external stress (lead time in planning for system responses is important); and

7. The great paucity of useable data to relate and predict probable responses to external stress.

In summary, the policy and management approach must integrate both water supply and wastewater disposal within the physical framework of the resource, as outlined herein and in relation to the objectives and constraints posed by Colorado River-Lake Mead salinity/eutrophication problems. The paucity of information on temporal responses and associated rates of change suggest that, at the very minimum, a valley-wide general monitoring program should be maintained that specifically address the shallow ground-water system as outlined above.

Recommendation III

The ground-water sampling program of the District Health Department should be continued and, if possible, repeated for areas identified in this study as having high nitrate problems. Cross-referencing of water analyses and drillers' logs, preferably using computerized storage and access, is highly recommended.

The presence of nitrate in ground water at depths of 101 to 300 feet may be related to improper well construction, particularly due to emplacement of gravel packs and(or) perforated intervals open to shallow saturation where nitrate concentrations reflect waste disposal practices.

Recommendation IV

Continued use of septic tanks and present or planned irrigation of green areas with treated sewage effluent should be accompanied by local ground-water monitoring programs to document changes in quality and storage. Use of sewage effluent in areas with near surface caliche layers or in areas with permeable gravels, both conditions commonly being present in the western part of the developed area, are not recommended.

WATER SUPPLY

Recommendation I

Feasibility studies should be conducted to determine if the area of relatively good quality ground water in the northeastern part of the Valley can be more fully developed. Secondly, the cause(s) of nitrate contamination in this area should be documented and corrective action taken.

Recommendation II

Throughout much of the Valley, investigations should be made to evaluate the shallow ground-water zone in terms of potential water supply for such purposes as irrigation or industrial supplies. Continually increasing water demands and use, coupled with problems of rising water tables and increased return flows of poor quality shallow ground water to Las Vegas Wash, indicate that one management alternative may involve concentrated development of this potential supply for selected uses. Present knowledge of quality should be supplemented by additional exploratory work, including test drilling, to develop information on well design, spacing, water quality, and potential yields.

WASTEWATER MANAGEMENT

Recommendation I

Economic and technical feasibility studies should be initiated to evaluate locations, assimilative capacity, and long-term effectiveness of salinity control through use of phreatophytes for consumptive use of saline wastewater introduced to the shallow ground-water zone.

INTRODUCTION

RESEARCH OBJECTIVES

Projections indicate Clark County population will double in about ten years (Boyle-CH_2M, 1969a). This growth is placing new demands on water supplies to sustain present use patterns. The quality of these supplies, as well as the quality of the return flows to both Lake Mead and the ground-water reservoir, need to be considered if comprehensive water quality management is to accomplished.

The overall study was designed to quantitatively determine the effects of past water use on ground-water occurrence and quality in Las Vegas Valley and provide a basis for projecting both physical and hydrochemical changes which are likely to result from increasing water utilization in the area. Of particular importance was the development of an improved understanding of the effects of water importation into a desert basin. The present report focuses on water quality aspects whereas reports by Patt (1977) and Westphal (1977) address quantitative changes in the shallow zone water budget and digital modeling thereof, respectively.

Water quality deterioration in Las Vegas Valley is attributable to natural, hydrogeologic factors and to land and water use patterns. Impact of these on basin wide water quality management is significant and will require increased consideration in the future.

Some of the more important effects recognized or suspected to date include:

1. An increase in TDS content of waters used in the area.
2. Increased return flows due to application of water to lawns, recreational areas and commercial crops.
3. Leaching of soluble salts from the soil profile to shallow ground water.
4. Alteration of ground-water potentials, thereby increasing discharge into Las Vegas Wash and downward movement of shallow, mineralized ground water into deeper aquifers heavily developed for water supply purposes.
5. Industrial waste return flows are adversely affecting the water quality in Las Vegas Wash.

The water quality section of this research effort has the following objectives:

1. Define the nature, extent, and cause of poor quality ground water in the shallow parts of the Las Vegas Valley ground-water system.

2. Demonstrate the interface between land and water use patterns and ground-water quality in relation to comprehensive basin wide water quality management.

3. Develop a water resources system response monitoring program designed to furnish appropriate hydraulic and chemical data to assist in maintaining ground-water quality in Las Vegas Valley.

METHOD OF STUDY

Field-oriented hydrogeologic techniques and development of a data bank from existing records encompassed the major thrust of the data collection and interpretation effort. In addition, more than 2,300 water samples were analyzed over a four year period for gross, trace, and nutrient constituents. Efforts in the first two years focused on the foremost industrial and sanitary sources in terms of effluent volume and quality and likely adverse impacts on surface water and ground-water resources. The Basic Management Inc. (BMI) industrial complex is adjacent to the Las Vegas Wash and wastes are primarily from metal and mineral processing plants and chemical manufacturing. Other major industrial effluent sources include cooling water from two power plants and two gravel washing operations. Municipal wastes from four separate sewage treatment plants also are tributary to the Wash.

Ground-water quality was determined by installation and sampling of approximately 55 new wells for areas or depths where data were lacking and by organizing analyses by the District Health Department. To obtain additional information such as static water levels and stratigraphic conditions, analyses were cross-referenced to driller logs from more than 6,300 wells in the Valley. This data bank of water analyses and well logs (not included herein) is probably the most comprehensive data base available for stratigraphic and hydrologic information concerning Las Vegas Valley. Tritium data were developed and extensively utilized to identify return flows resulting from urbanization and industrial water use.

To establish time-series data for ground-water quality, the sampling program included reentry to wells sampled in the mid-1940's and mid-1960's. If the original wells could not be located or had been destroyed, nearby substitute wells with similar completion characteristics were selected.

The trend surface analytical technique, in conjunction with the data bank, was implemented to reduce and portray extensive water quality and well log data. Manual retrieval of analyses and logs and cross-referencing would have been extremely inefficient considering the numbers available. Trend surfaces have the attribute of portraying broad, overall trends rather than detailed but complex variation of raw data. Statistics such as the correlation coefficient relate how well the surface fits the raw data and therefore provide a measure of how well the trends estimate spatial variability for the system and parameter considered.

HYDROGEOLOGIC FRAMEWORK AFFECTING RETURN FLOWS

INTRODUCTION

Las Vegas Valley is a major topographic depression covering 350 square miles in southern Nevada. The area of study is shown in Figure 1. The Valley trends northwest-southeast and is situated along the Las Vegas shear zone characterized by intense structural deformation, primarily consisting of right lateral movement (Longwell et al., 1965). Along this zone extensive erosion of bedrock units created a basin at least 3,000 feet deep in the central part of the Valley. Basin development by structural displacement associated with normal faulting is also probable but evidence is scarce. Faults downthrown to the east are present in the valley fill. Filling the bedrock depression are thick deposits of sand, gravel, silt, and clay which generally are coarsest toward the mountain fronts, becoming finer-grained toward the lower portions of the Valley. These were deposited by ephemeral streams originating in the highlands. Silt and clay deposits occupy the central portion of the Valley.

Mapped surficial deposits (Price, 1966; Bingler and Luza, in press; Dinger, in press) consist of alluvial sediments underlain by late Pleistocene (Wisconsinan) pond/marsh deposits that lie on top of and are interfingered with Pleistocene fan and playa sediments. Maxey and Jameson (1948) believed the foregoing were deposited in a large, ancestral valley eroded into the Muddy Creek Formation which is largely composed of fine-grained lake and alluvial sediments. The latter partly fills the large erosional basin developed in the bedrock strata affected by the shear zone. Sediments mapped as Muddy Creek Formation (Longwell et al., 1965) are exposed along the southern edge of Frenchman Mountain and the eastern edge of Whitney Mesa. They are unconformably overlain by surficial sands and gravels. The best exposure of the Muddy Creek sediment crops out in the Whitney Mesa area and consists of a sequence of red to pink clays and silts often more than twenty feet thick.

Extensive ground-water development is primarily from the Pleistocene valley fill and possibly from coarse-grained facies of the Muddy Creek Formation which may be present in the western part of the Valley. At present, essentially no use is made of ground water in the very shallow deposits and associated caliche strata, or the underlying bedrock units, because of inadequate permeability, excessive depth to water, and/or poor water quality. Extensive ground-water discharge as evapotranspiration and surface water discharge occurs in the Las Vegas Valley Wash area which encompasses about 30 square miles and is located generally between East Las Vegas and Henderson and between Las Vegas Wash and the BMI industrial complex.

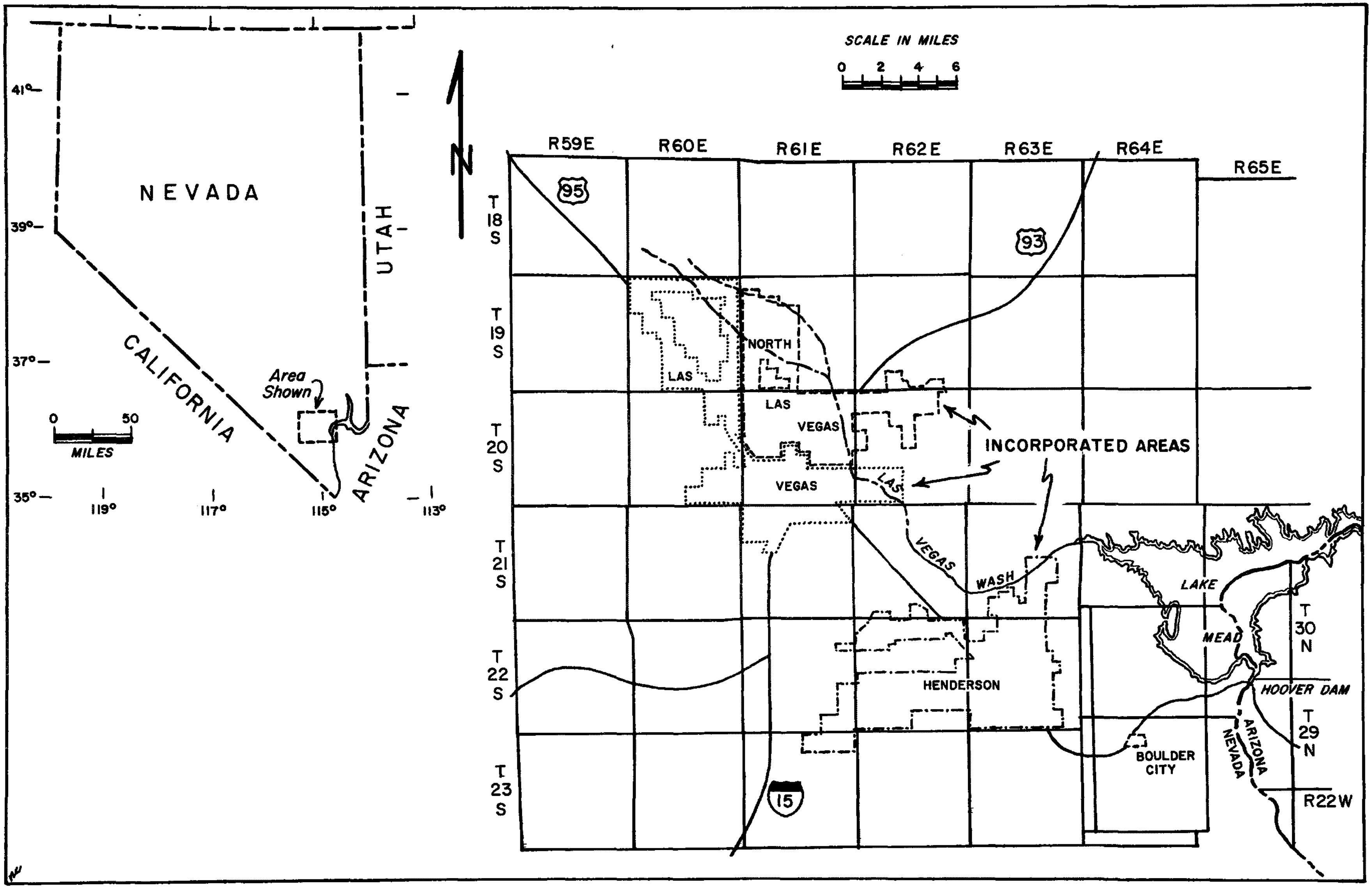


Figure 1. Location Map showing Las Vegas Valley and the study area.

PRINCIPAL FEATURES OF SHALLOW GROUND-WATER OCCURRENCE AND USE

Disposition of aquifers in Las Vegas Valley is schematically shown in Figure 2. In some parts of the Valley, the predevelopment pattern of upward movement from the confined aquifers to the near surface zone has been modified in the last thirty years by heavy withdrawal of ground water from the middle zone of aquifers. This zone occurs between depths of about 450 feet and 750 feet (Maxey and Jameson, 1948). As a result, the piezometric head in the confined aquifers has been greatly lowered. It was 60 feet above land surface in parts of the Valley and it is now generally below the level of water in the near surface zone, which in the present study is defined as the upper 300 feet of valley fill and, therefore, includes the near surface and (part of) the shallow zones as defined by Maxey and Jameson (1948). Prior to extensive ground-water development, the near surface zone was recharged by upward movement from the underlying confined zones and by infiltration of spring flows originating in the deeper aquifers (Maxey and Jameson, 1948).

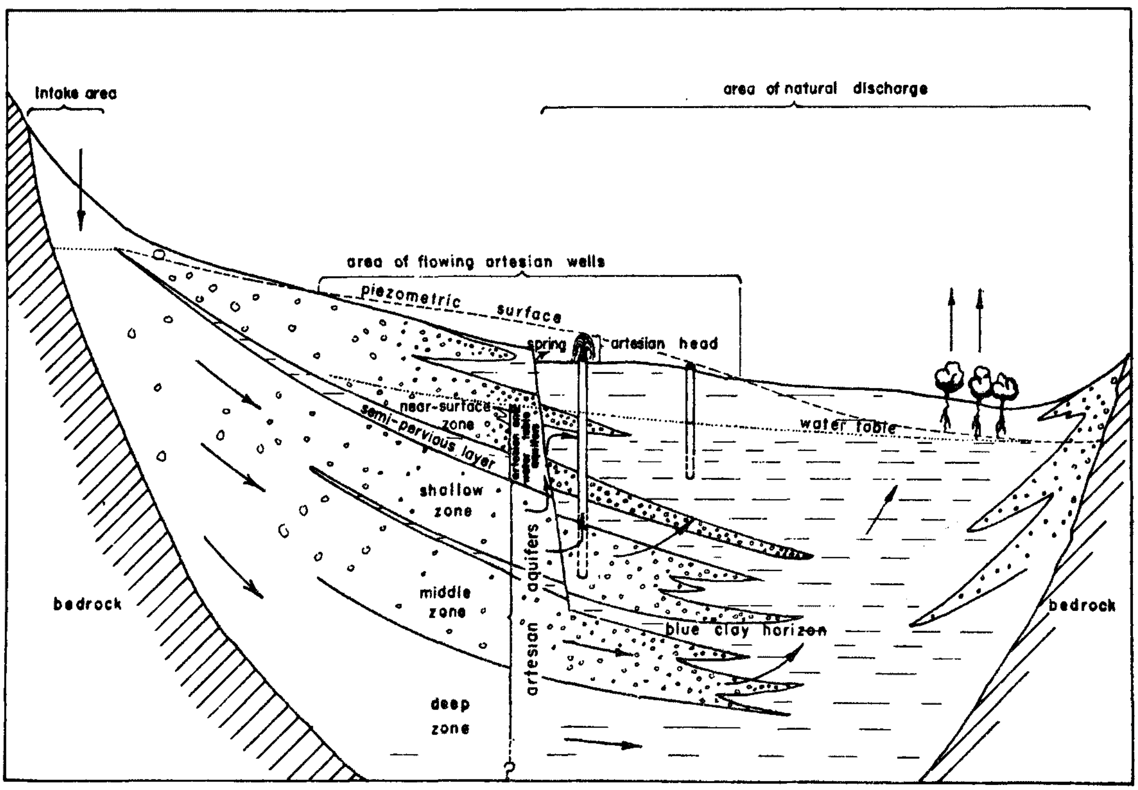


Figure 2. Generalized east-west hydrogeologic cross-section showing ground-water occurrence and flow prior to extensive development (Malmberg, 1961, based on Maxey and Jameson, 1948).

A large marshy area known as "Las Vegas" was centered about Las Vegas Creek forming an area of approximately eight square miles. A shallow water table recharged by upward movement also was present in the Duck Creek drainage, along the upper reaches of Las Vegas Wash and along the lower reaches of Flamingo and Tropicana Washes. Other discharge areas were present in the areas of Tule Springs and the Gilcrease Ranch, both in the extreme northwestern corner of the study area. In effect, discharge by evaporation and evaportranspiration equaled recharge by infiltration and upward movement and the near surface zone was in equilibrium, with no surface flow leaving the Valley. Beginning in the mid 1940's, this natural predevelopment condition underwent rapid and dramatic change. Upward movement and spring discharge was greatly reduced as a result of gradually increasing overdraft of the deeper (middle zone as defined by Maxey and Jameson, 1948) aquifers, particularly those in the western and northwestern portions of the suburban area. Whereas there has been widespread reduction in artesian head, dewatering of shallow sediments has only occurred in a north-south trending belt on the western edge of the developed area in the Valley. In the last 30 years, the near surface zone as defined herein has been, for the most part, the locus of increased recharge from surface sources and decreased discharge as a result of phreatophyte removal. Patt (1977) describes the changes in the near surface zone water budget from 1943 to 1973.

Principal natural and cultural features bearing on the occurrence and quality of shallow ground water in Las Vegas Valley are shown in Figure 3. Fault scarps oriented generally north-south are geologically young but predate man's presence in the Valley. Whitney Mesa and extensions of this lineament to the north are perhaps the best surficial expressions of this faulting (Figure 4). These delineate the transition from fine-grained sediments to the east and coarser materials to the west. Lateral, eastward ground-water movement is impeded by a decrease in transmissivity in the fault zone areas. The largest springs in the Valley, most of which ceased to flow in the late 1940's and early 1950's, are generally located in close proximity to the scarps. This is indicative of loss of transmissivity and conduit development associated with the fault zones. Under natural conditions prior to heavy pumping, these springs were characterized by very stable flow, water quality, and temperature indicative of a deep-seated source. The springs are now dry as a result of heavy pumping and reduced upward movement. Shallow ground water on the order of 100 feet or less, commonly appears to accumulate in the upthrown block and "weep" across an exposed scarp face. This is a manifestation of extremely low permeability of fine-grained surficial sediments and pronounced boundary conditions exerted by near surface caliche layers, common in the western two-thirds of the Valley (Figure 5).

The areas of principal ground-water development and amount of production for public water supply are shown in Figure 3. Principal public water supply developers include the Las Vegas Valley Water District, North Las Vegas, and Nellis Air Force Base. A second major user group, the resort industry, is centered on the Las Vegas Strip and involves extensive development to support lawn irrigation and other recreational uses.

As a result of return flows from nonpoint sources and from industrial and sanitary waste discharges, an extensive high water table has developed in the eastern part of the Valley particularly in the Las Vegas Wash area (Figure 6). Because the prevailing ground-water flow direction is eastward toward the lowest point in the Valley, saline, nutrient-laden ground water surfacing along Las Vegas Wash constitutes a significant baseflow component to surface flows and necessitates joint consideration of surface water and ground-water factors in basin wide water quality management.

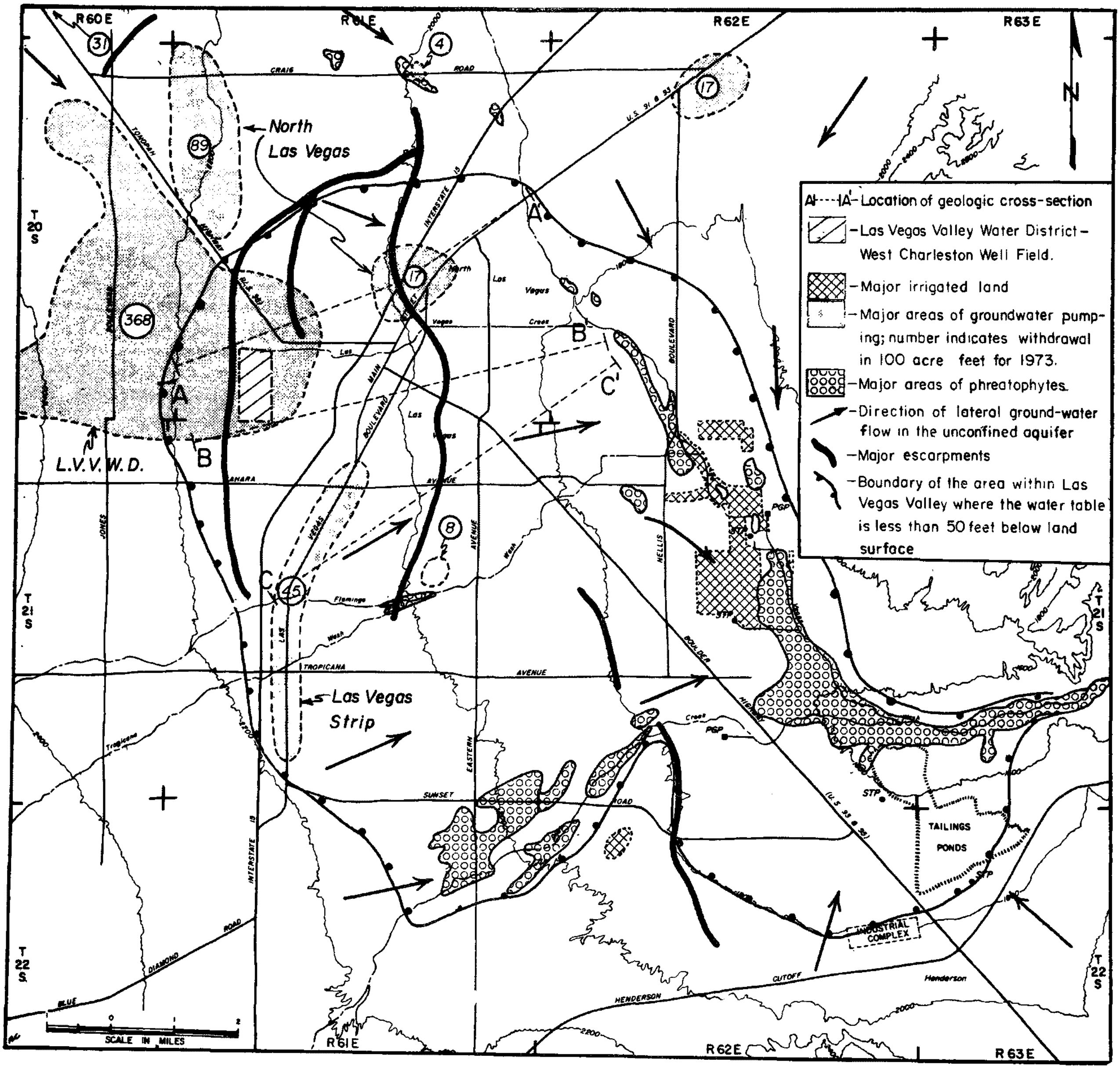


Figure 3. Principle features of ground-water occurrence and development.

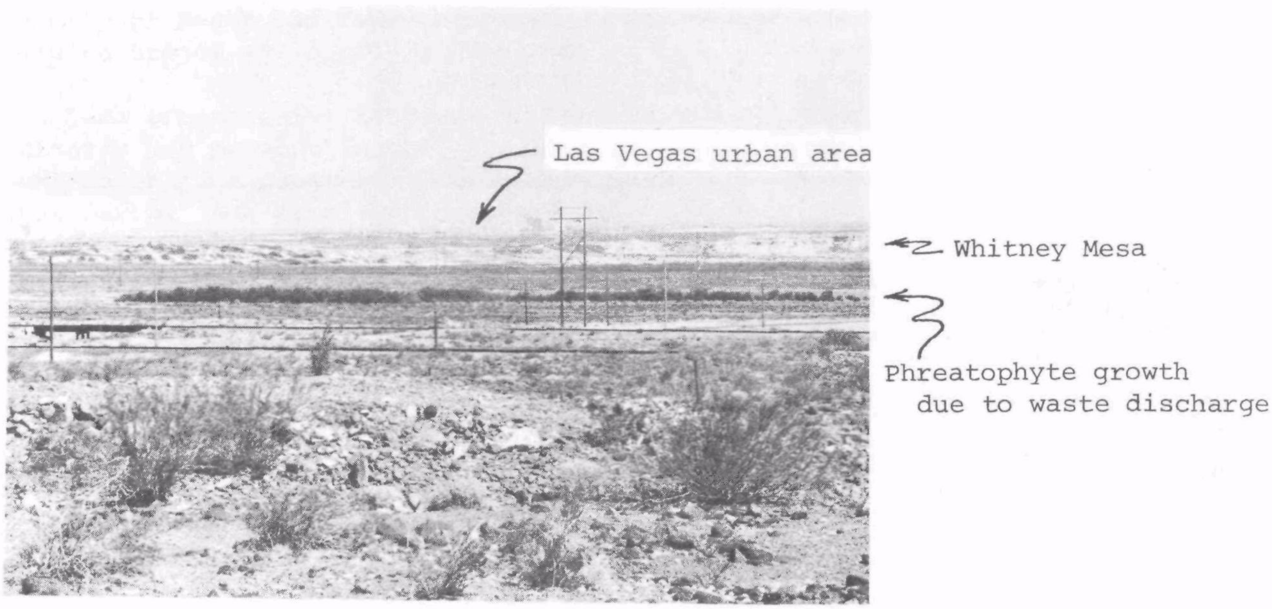


Figure 4. Photograph of Whitney Mesa as viewed looking northwest from Las Vegas Wash.

Figure 5. Photograph of caliche layers in the vicinity of Tropicana and Polaris Avenues.

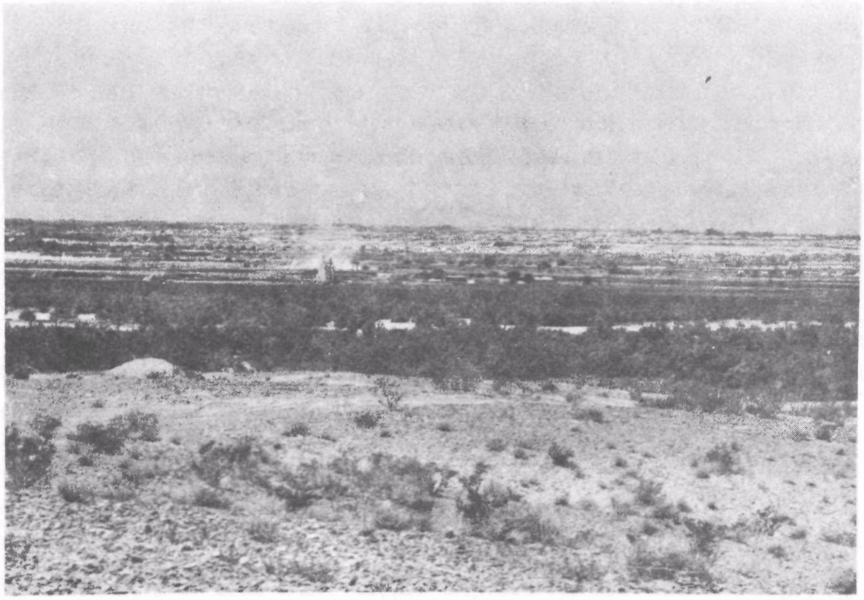


Figure 6. Photograph of the upper Las Vegas Wash area showing a principal fault scarp in the background and waterlogged areas.

PRINCIPAL AQUIFER ZONES

Four principal aquifers in Las Vegas Valley were identified by Maxey and Jameson (1948). In the northwestern quarter of the Valley, they recognized a near surface aquifer to depths of 200 feet. Below this, to depths of 450 feet, the shallow aquifer is present and consists of sand and gravel interbedded with silt and clay. At the base of the shallow aquifer in parts of the Valley they reported that a fairly persistent layer of blue clay overlies the highly productive middle aquifer, the principal source of ground water pumped in the Valley. A deep aquifer, recognized at depths below 700 feet in the western half of the Valley, has only been developed in recent years. Subsurface conditions vary laterally so the aforementioned aquifer relations do not generally persist east of the principal scarp.

Because of decreasing quantities of sand and gravel from west to east, aquifers in the eastern two-thirds of the Valley yield progressively less water and wells rarely exceed a depth of 500 feet. There is a loss of productivity accompanied with natural deterioration in quality toward the east and southeast. As a result, considerably less ground-water development occurs in these areas. Zones of highest transmissivity occur between depths of 200 to 900 feet in the area between Charleston Boulevard and Tonopah Highway and west of the East 1/2, Section 32, Township 20 South, Range 61 East (20/61-32, E 1/2)[2]. The principal pumping centers are shown in Figure 3. In an area of one-half square mile, the main well field (Charleston well field) of the Las Vegas Valley Water District produced approximately 60 percent of all the ground water extracted in the Valley until 1973. Since the late 1960's, ground water production by the Las Vegas Valley Water District and

2 The location system used in this report is described in Appendix 3.

the City of North Las Vegas has rapidly shifted to the north and west and has featured deeper wells of higher yield.

Less transmissive tongues of cemented gravel separated by clay and silt aquitards are present in the remainder of the urbanized area lying west of a north-south line passing approximately through the southern reach of the Las Vegas Strip. Relatively thin gravel lenses extend east of this line. Throughtout the developed portion of the Valley, shallow aquifers in the upper few hundred feet consist of sand and gravel lenses, or thin layers of porous caliche conglomerate or caliche sandwiched between thick silt and clay sediments. Highly permeable zones, probably representing former wash channels extend generally east-west through finer-grained sediments and are most common in township 21/61. Similar linear trending zones of high permeability are likely in those portions of Paradise Valley located in the Duck Creek subbasin.

In general, unconfined ground water is present at depths ranging from less than 10 to more than 200 feet below the land surface in the urbanized portion of the Valley. Where thick caliche units are present near the land surface, near surface ground water can be locally confined under several feet of head.

RECHARGE-DISCHARGE RELATIONS

Previous studies by Maxey and Jameson (1948) and Malmberg (1961) concluded that recharge to the Las Vegas Valley ground-water basin is a result of precipitation in surrounding mountainous catchment areas. Rainfall and snowmelt in the Spring Mountains and, to a lesser extent in the Las Vegas and Sheep ranges, probably infiltrate directly into the bedrock or flanking alluvial aprons. Minor recharge probably occurs in the McCullough Range and possibly from the Frenchman-Sunrise Mountain block east of the Valley. Studies by Winograd and Friedman (1972) and more recently by Winograd and Thordarson (1975) indicate that the recharge area may extend beyond the topographic basin but to what extent in terms of area and volume of recharge is unknown. Figure 3 illustrates the principal directions of lateral flow in the near surface zone.

Estimates of recharge and discharge prepared by Maxey and Jameson (1948) and Malmberg (1965) indicate ground-water flux of 21,000 to 35,000 acre feet per year under natural conditions. With heavy overdraft of the artesian aquifers beginning in the mid-1940's, followed by importation of water in the 1950's, the natural water balance has been severely disrupted in terms of volume, distribution, and quality because discharge formerly equaled recharge and no water (except flood flows) exited the Valley except flow from uncontrolled flowing wells in the 1920's and 1930's.

The principal sources of recharge to the near surface system include irrigation return flows, septic tank and sewage treatment plant effluents, industrial effluent ditches and disposal ponds, and upward flow from deeper, artesian aquifers. Discharge from the system occurs as direct evaporation, evapotranspiration from phreatophytes, and discharge to surface water courses. Ground-water discharge causing surface flow is significant only in the Las Vegas Wash area. In the remainder of the Valley recharge to the near surface system results in positive change in storage, downward movement to the deeper, heavily pumped aquifers, and development of small springs and seeps.

Under natural, predevelopment conditions, the only ground-water outflow from the Valley was Las Vegas Wash underflow which is estimated at about 250 acre feet per year or less. At present an additional 12,300 acre feet per year of underflow surfaces in the lower reaches of Las Vegas Wash (Kaufmann, 1971; Westphal and Nork, 1972). In the developed portions of the Valley, major springs and artesian wells have ceased to flow as a result of heavy pumping. Extensive mesquite groves and stands of saltbush that formerly discharged 25,000 acre feet per year have been removed and replaced with suburban sprawl and extensive lawns. Exclusive of Henderson and the BMI effluents, recharge to the shallow aquifer in 1973 amounted to 38,500 acre feet per year (Patt, 1977) and represented water which was 1) going into storage, 2) leaking downward to recharge the deeper aquifers, or 3) flowing laterally toward Las Vegas Wash.

HYDROGEOLOGY OF THE NEAR SURFACE ZONE

The near surface zone as used herein is defined as that portion of the total ground-water system occurring within 300 feet of land surface. It, therefore, includes the near surface zone and part of the shallow zone as defined by Maxey and Jameson (1948). Initial attempts to more rigidly characterize shallow ground water in terms of boundary conditions, permeability distribution, or water quality revealed a high degree of natural variability and a lack of precise data. Therefore, a "slice" approach was used, analogous to that of Domenico et al. (1964).

Based on their observations in the period from 1940 to 1956, Maxey and Jameson (1948) and Malmberg (1965) described the near surface zone as follows:

1. Depths to water range from a few feet to a few tens of feet below land surface.

2. Recharge is by upward movement from underlying aquifers and by downward percolation of surface water.

3. Natural discharge is solely from evapotranspiration.

4. Transmissivities are low and the amount of water moving laterally through the sediments is small.

In the present study several thousand well logs and soils/engineering reports were examined for lithologic and water level data to determine 1) if there is a geologic basis for differentiating between the near surface and deeper flow systems and 2) the areal extent of the near surface system. Except in a few cases where well locations were verified in the field, water level elevations and elevations of lithologic horizons were obtained through use of 7½ minute or 15 minute topographic maps in conjunction with reported well locations. As expected, drillers' descriptions of lithology were extremely variable with respect to units encountered in a given area.

A network of northward trending, roughly parallel fault scarps occupy the central portion of the Valley (see Figure 3) and affect ground-water movement. The most prominent scarp extends northwest from 22/62-4 in the vicinity of Whitney Mesa to downtown Las Vegas th n north through North Las Vegas and the Craig Country Club (20/61-3). Lower Las Vegas Valley is considered to be the area east of Whitney Mesa and southeast of the Las Vegas Wastewater Treatment Plant. East Las Vegas, Pittman, and Henderson are the principal communities in lower Las Vegas Valley.

The near surface zone consists primarily of clay and silt with interstratified deposits of sand, gravel, and caliche. Near the main north-south scarp, fine-grained Muddy Creek or Pleistocene sediments are widespread, particularly east of the scarp. Figure 7 shows the fine-grained sediments comprising the scarp in the vicinity of Cashman Field in North Las Vegas. Ground water flowing across the scarp face exists the excavation indicated by the arrow. The horizontal line indicates the approximate upper boundary of saturation. Farther west in the vicinity of Valley View Drive and the Las Vegas Expressway, areally extensive and highly indurated caliche is at the surface or near surface. As shown in Figure 8, the fine-grained sediments between caliche layers are saturated and require emplacement of under-drains to allow construction in this area. Subsurface conditions are nearly identical in the vicinity of Decatur Boulevard approximately three-quarters of a mile west.

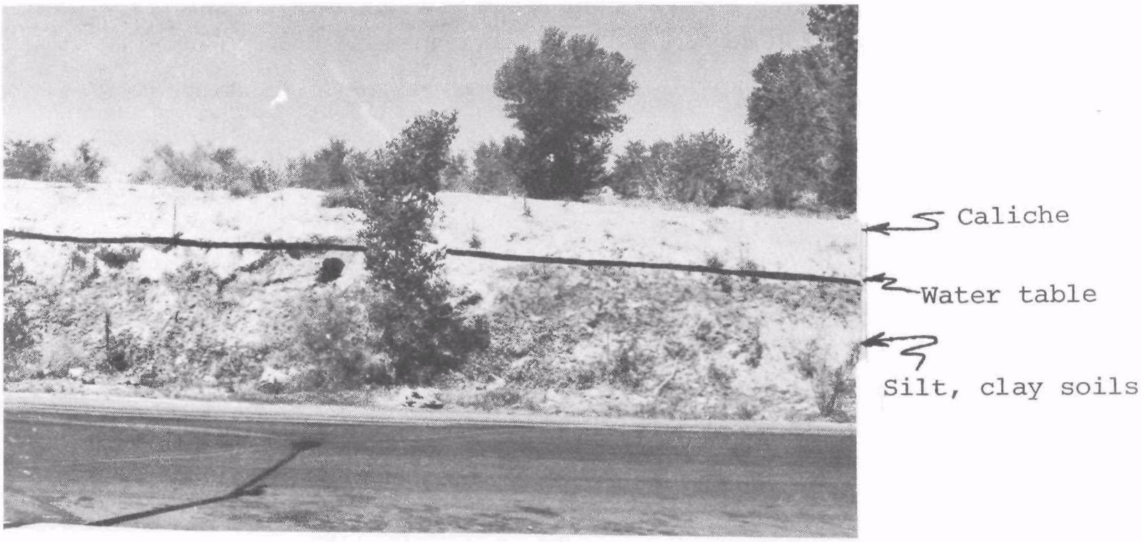


Figure 7. Closeup view of the upper part of the fault scarp shown in Figure 6. Photograph taken approximately one-quarter mile south of Cashman Field in the vicinity of 9th Street and Harris Avenue.

In the vicinity of the recently constructed West Charleston reservoir near Buffalo Drive, there is a thick section of unsaturated, moderately well cemented sands and gravels (Figure 9). The caliche is sufficiently indurated that fracturing occurs across rather than around the larger clasts (Figure 10).

Figure 8. Photograph of an excavation for the Las Vegas Expressway taken at Valley View Boulevard.

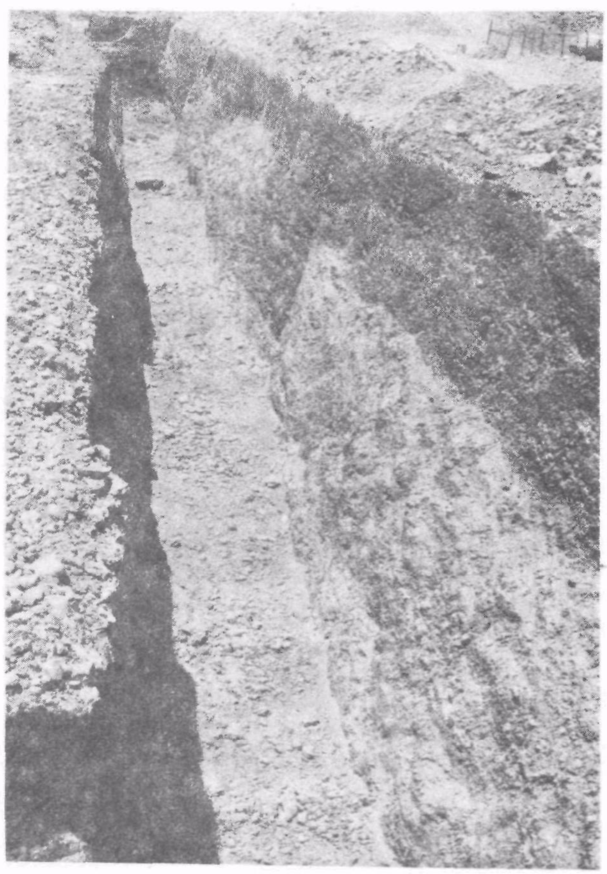


Figure 9. Photograph showing cemented gravels in surficial alluvial fan deposits in the vicinity of Charleston Boulevard and Buffalo Drive.

Nevertheless, close-up views reveal the rounded particles and give some indication of high residual porosity and permeability, despite cementation (Figure 11). Significant amounts of aquitard materials in upper zones are absent from driller reports for the areas west of Jones Boulevard. Displacement appears to decrease with each minor scarp west of the main north-south scarp. Subsurface data from water well logs show an east to west facies change from fine-grained sediments to coarser materials characteristic of alluvial fans.

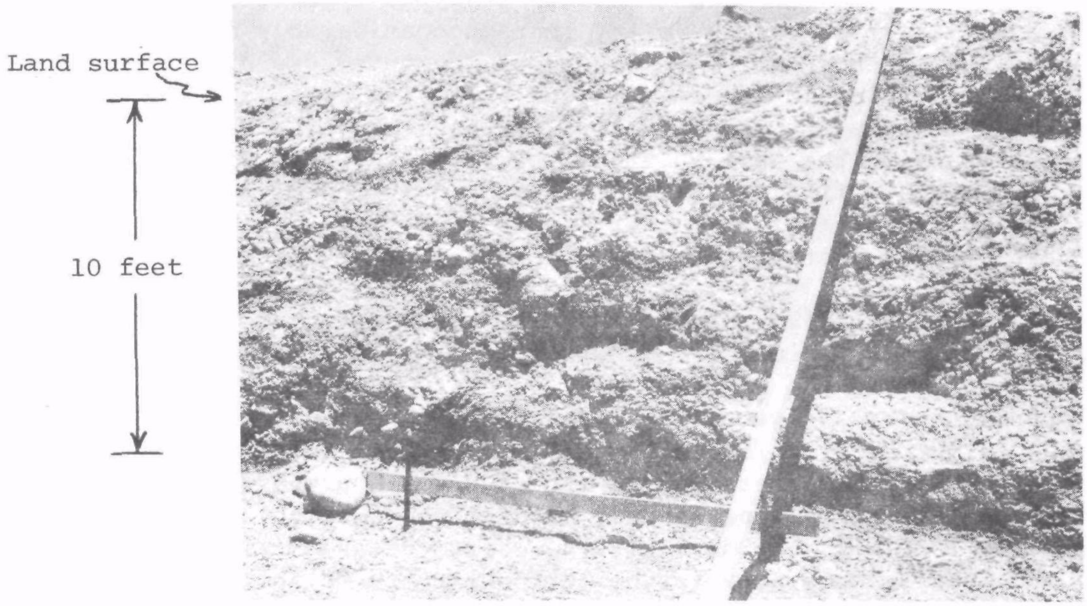


Figure 10. Photograph showing the degree of induration in the West Charleston Boulevard and Buffalo Drive area. Note the occurrence of fracturing across clasts.

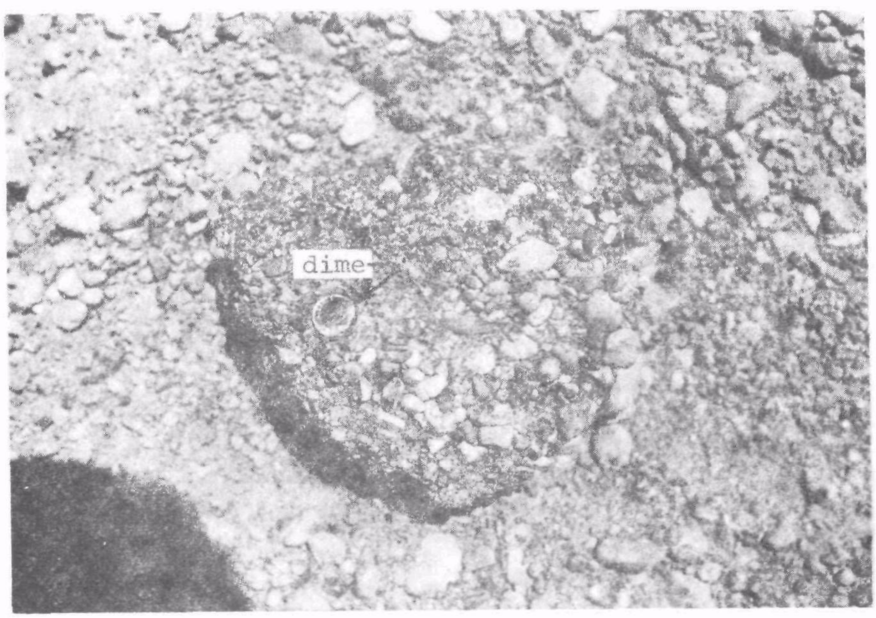


Figure 11. Closeup photograph of cemented gravel in the Charleston Boulevard and Buffalo Drive area (note dime for scale).

To clarify understanding of the facies changes generally described above, east-west stratigraphic cross-sections (Figure 12, 13, 14) were prepared from logs of wells and soil borings. Although the cross-sections portray the general changes in sediment type and distribution, there is insufficient lithologic description in the available logs to describe separate aquifer zones in detail. Attempts to use Markovian analysis of vertical variability as an estimate of lateral variability were also unproductive.

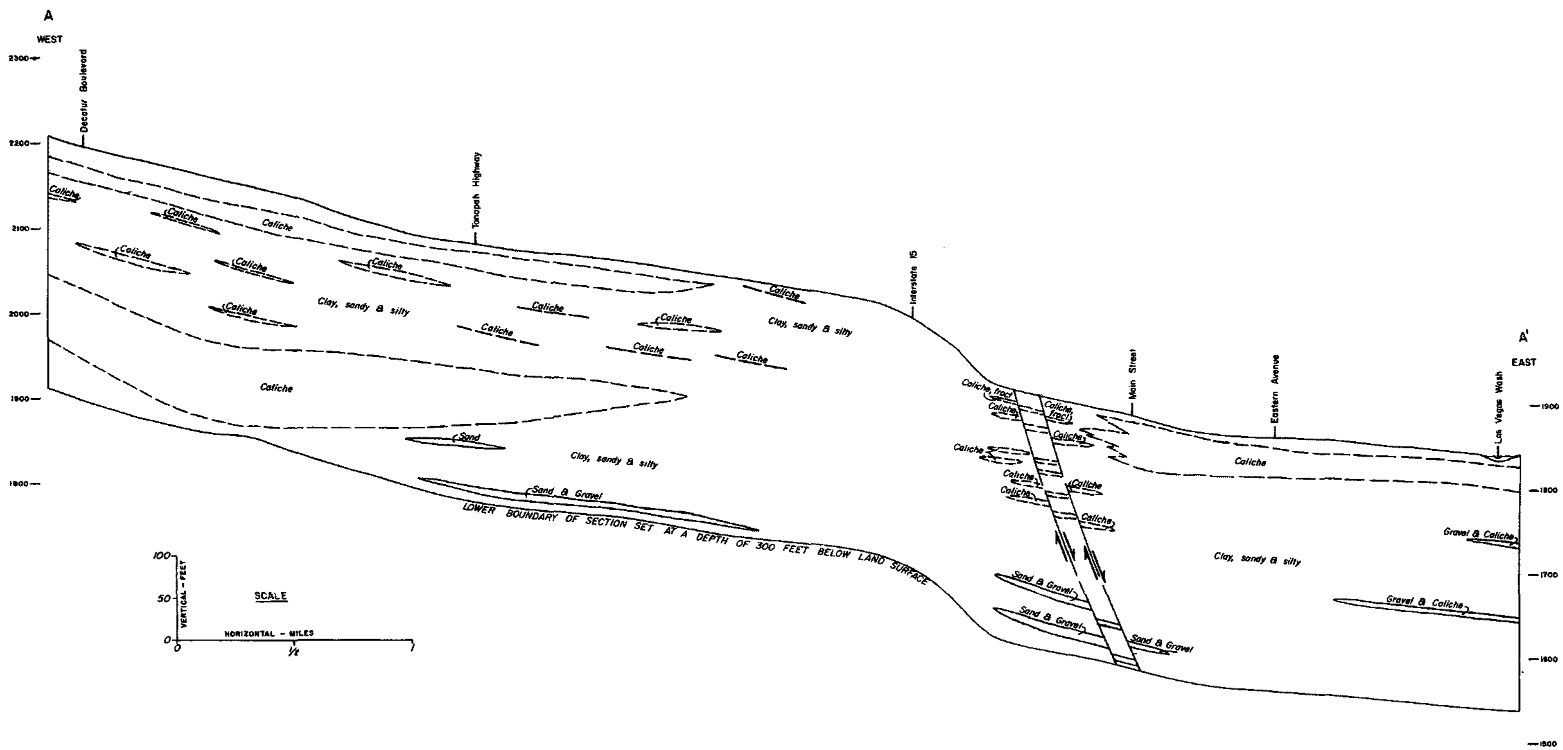
It is apparent from the cross-sections that the upper 300 feet of sediments in the western part of the Valley contain considerably more coarse-grained sediments in the form of sand, gravel, cemented gravel and caliche conglomerate. The thin but impermeable and extensive caliche units and interbedded silt and clay layers create marked permeability boundary conditions. In the eastern part of the Valley, transmissivity decreases due to the dominance of caliche, silt, and clay. Although only one or two fault planes are shown in the cross-sections, other faults with small throws are believed present, particularly west of the scarp shown.

In addition to stratigraphic or lithologic definition of the near surface zone, water level information was also utilized. Figure 15 depicts the hydraulic potentials in the near surface zone between 1970 and 1973. In the western part of the Valley water level data were obtained from soil boring records and driller reports for wells completed in the near surface zone. The exception was in the general area west of Jones Boulevard where the bottom of the near surface zone can not be distinguished. In that area, water levels in wells 300 feet deep or less were used. Because it was not possible to define the near surface zone in the northeast part of the Valley on the basis of lithologic data, a well depth criterion of 300 feet or less was also used.

Water level data were examined to determine the influence of geologic materials on hydraulic potentials in the near surface zone in an eight square mile area centered on Charleston Boulevard west of Rancho Road. The area was selected for study because of its proximity to the Las Vegas Valley Water District's Charleston well field (20/61-32), the known presence of extensive layers of caliche, and availability of well data. To minimize the effect of temporal variation in driller reported water levels, wells were divided into groups according to date drilled. Water level comparisons are shown in Table 1.

It is evident that heads were above the bottom of the near surface zone where it was distinguishable as such. This was true even in the vicinity of the well field where potentials in the deep artesian aquifer were 160 feet below land surface. The 1971 and 1972 data indicated a gradient reversal, i.e. downward, probably as a result of pumping from the middle and deep aquifers. The downward gradient provides opportunity for the migration of water from the near surface aquitard into underlying middle zone aquifers. Furthermore, the head data in Table 1 suggest this condition has existed since the mid-1950's. Thus, downward transfer of poor quality water may be occurring in this part of the Valley.

From the efforts to stratigraphically and hydraulically define the near surface zone and from careful review of previous studies, the Valley was



SEE FIGURE 3 FOR LOCATION

Figure 12. Idealized geologic cross section A-A' from the West Charleston Boulevard area and Nellis Air Force Base.

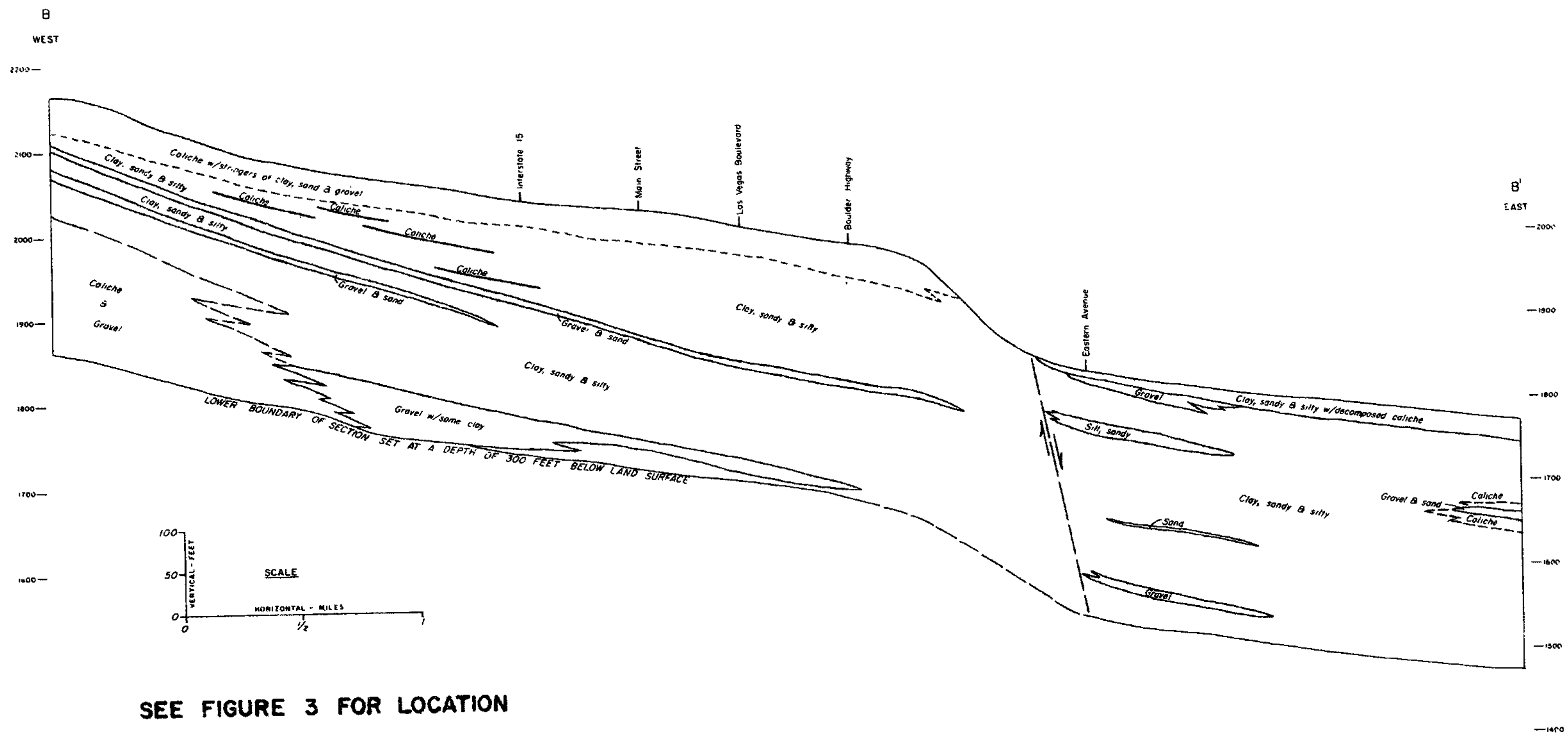
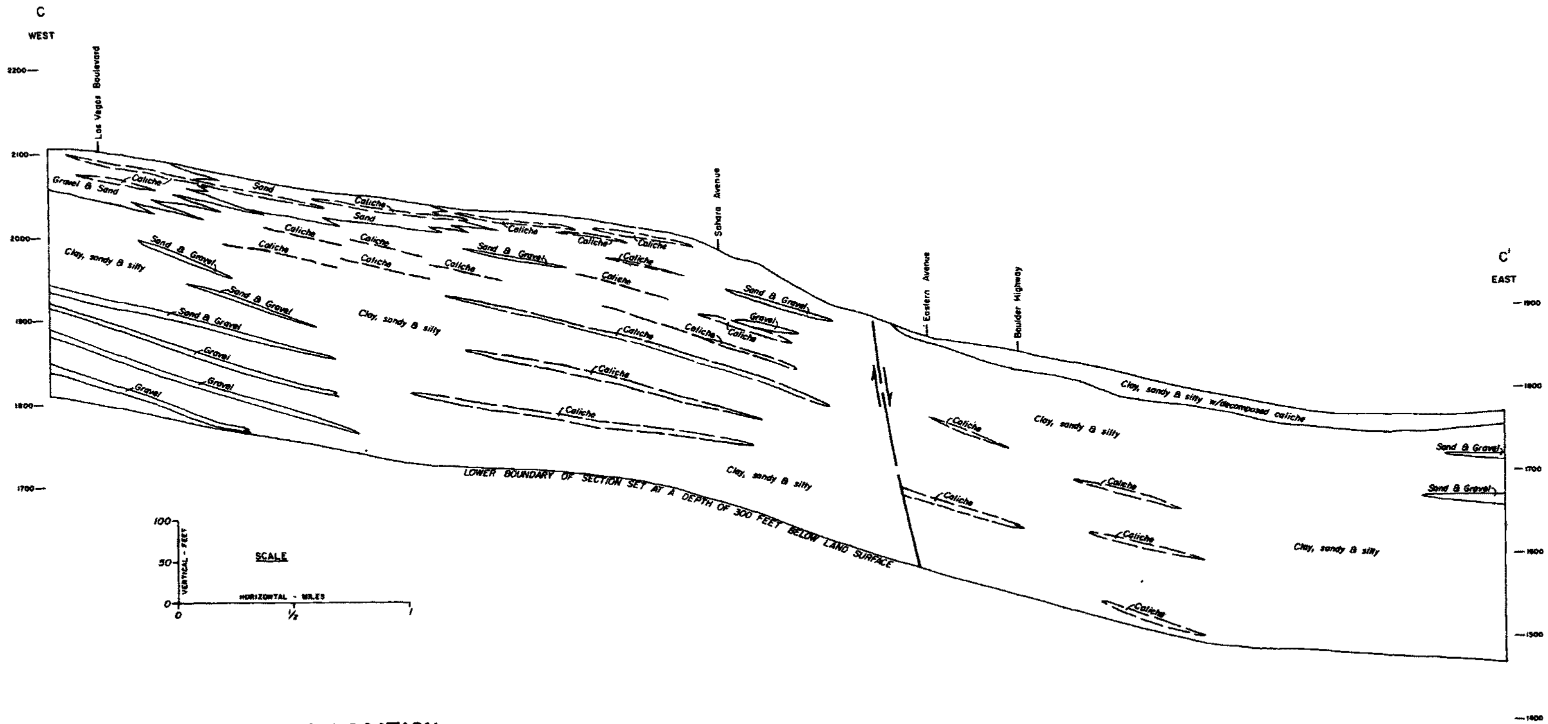


Figure 13. Idealized geologic cross section B-B' from the West Charleston Boulevard area and downtown Las Vegas.



SEE FIGURE 3 FOR LOCATION

Figure 14. Idealized geologic cross section C-C' from Las Vegas Boulevard South (the "Strip") and downtown Las Vegas.

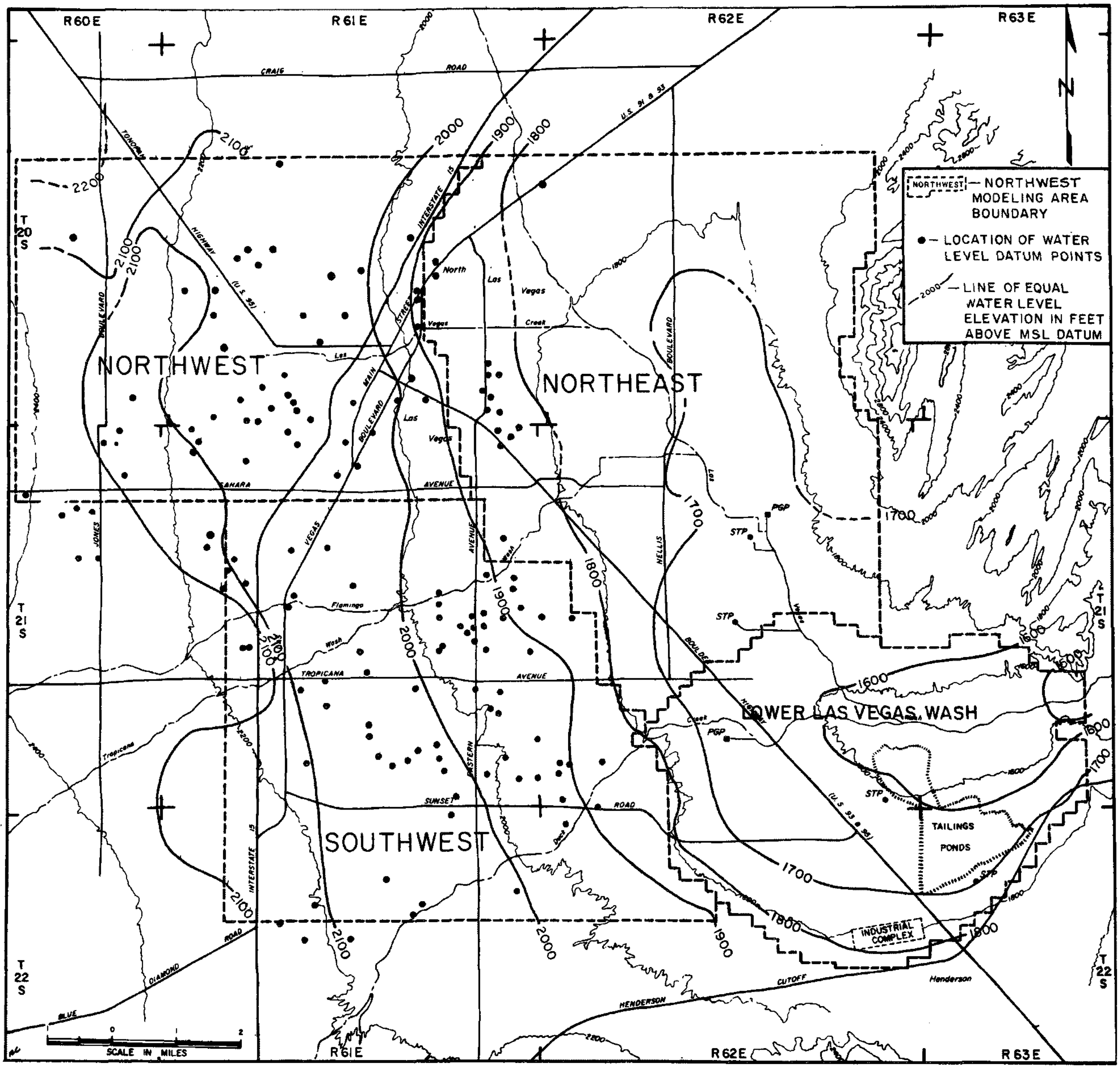


Figure 15. Water table map of the "near surface" zone, with an outline of the ground-water flow model areas.

TABLE 1. COMPARISON OF REPORTED WATER LEVELS IN WELLS OF DIFFERENT DEPTHS IN THE WEST CHARLESTON BOULEVARD AREA

Location T/R	Sec	Quarter	Year Drilled	Well Depth (feet)	Water level elevation*	Comments
20/61	32	231	1951	70	2100	Very shallow wells indicating water table position only
		422	1951	140	2075	
		321	1952	160	2100	
20/60	36	443	1955	150	2156	No boundary indicated. Wells located between Decatur Blvd. and Wilshire Street
		444	1955	160	2160	
		443	1955	206	2165	
	36	41	1959	81	2150	No boundary indicated.
		432	1960	225	2149	
		444	1960	250	2135	
21/60	01	33	1959	200	2213	Boundary estimated to be between 200 to 252 feet below surface
		434	1960	250	2130	
		31	1961	252	2135	
		34	1960	300	2130	
		42	1959	300	2125	
		42	1962	300	2120	
	01	41	1954	110	2180	Boundary estimated to be 230 to 246 feet below surface
		41	1955	150	2157	
		42	1955	162	2170	
		42	1954	170	2160	
		41	1955	175	2162	
		42	1955	220	2150	
		33	1953	230	2186	
		22	1957	246	2135	
21/60	02	22	1955	240	2190	Boundary estimated to be 243 to 265 feet below surface
		22	1955	243	2190	
		23	1954	260	2165	
		23	1954	265	2165	
		22	1955	270	2140	
		22	1955	300	2155	
21/61	04	222	1971-1972	50	2057	Boundary between shallow and deeper aquifers indicated
20/61	33	323	"	170	2038	
		233	"	395	2007	
20/60	36	334	"	149	2151	Boundary between near surface and shallow aquifers indicated
	36	244	"	830	2002	
21/60	01	342	"	170	2132	
21/60	12	124	"	154	2129	Boundary between shallow and near surface aquifers indicated
		232	"	320	2031	
21/60	11	434	"	273	2044	No boundary apparent from water levels. Located between Jones Blvd. and med line of 21/61-11
		123	"	700±	2028	

* Final static water level reported by driller at time of well completion. Static level in feet above mean sea level.

divided into four separate areas, each of which have broadly similar hydraulic and geologic conditions (see Figure 15). The lower reach of Las Vegas Wash and environs constituted one such area whereas the remainder were in the urbanized portion of the Valley.

GROUND-WATER QUALITY

INTRODUCTION

Previous documentation of ground-water quality in Las Vegas Valley, regardless of depth, is notoriously deficient. The resource, in terms of quality, has largely either been taken for granted or ignored. In-valley effluent disposal practices are cases in point. Very limited discussions of water quality are presented in Mendenhall (1909), Carpenter (1915), Hardman and Miller (1934), Maxey and Jameson (1948), and Malmberg (1965). An unpublished water quality map produced by Domenico and Maxey (1964) depicted zones or regions of TDS as indicated by specific conductance. The water sampling program of the District Health Department resulted in several thousand water analyses for the period 1968 to present but there was no previous attempt to reduce and interpret the data. The Las Vegas Valley Water District and the City of North Las Vegas have additionally monitored their wells in the western part of the Valley; however, few data prior to 1969 are available. The present study, then, represents the first attempt at description of ground-water quality in Las Vegas Valley. A subsequent effort by Dinger (in preparation) relates shallow ground-water quality to geologic conditions.

Changes in ground-water quality with time in Las Vegas Valley might be expected for a number of reasons, some of which are:

1. Extensive overdraft of deeper artesian aquifers resulting in downward leakage of poorer quality water from overlying aquitards and induced lateral inflow of poorer quality water in the central portion of the basin.

2. Terrestrial disposal of sanitary and industrial wastes.

3. Septic tank waste disposal systems.

4. Importation of increasing amounts of more saline Lake Mead water and subsequent distribution within the Valley.

5. Irrigation of lawns, golf courses, parks, and commercial crops with potable and wastewater, resulting in leaching of highly alkaline soils and salt concentration due to consumptive use.

6. Discharge from evaporative coolers.

METHOD OF STUDY

For the urban and suburban areas of the Valley, ground-water quality variations through space and time were analyzed using trend surfaces and nonparametric statistical tests, respectively. With background or ambient conditions established, attention was then directed to specific land and water use practices instrumental in affecting ground-water quality. In this regard, tritium and nitrate data were used to document return flows associated with urbanization and industrialization. Three chemical data bases were utilized: 1) historical analyses from 1909-1964 (supplemental by resampling of the same wells or substitutes, where possible), 2) chemical data on file at the District Health Department and representative of valley-wide sampling of domestic and municipal wells from 1968-1972, and 3) approximately 2,000 water analyses of shallow ground water, effluents and potable water sampled as part of the study in the period 1970-1973.

Extensive water sampling, flow measurements, and installation of 36 new wells in the first year of the study resulted in the generation of an essentially new data base for the lower reaches of Las Vegas Wash and adjacent areas in Henderson, Whitney, Pittman, and East Las Vegas. In the remainder of the Valley, principal reliance was placed on available water analyses and well records, supplemented with a limited number of shallow wells and water analyses therefrom. Well characteristics are stated in Appendices 1 and 5.

Surface and ground-water samples from stations located throughout the Valley as shown Figures 16 and 17 and described in Appendix 2, were collected from February 1970 through September 1973 to characterize quality with respect to gross chemistry, trace elements, nutrients, and tritium. This effort focused on sampling areas and depths not included in the District Health Department sampling program and(or) to supply new data for locations previously sampled by earlier researchers. In this way temporal comparisons could be made. With respect to the Las Vegas Wash area, samples for gross chemical analysis were predominantly collected on a monthly basis for ground-water and surface water points. For all samples except those collected for tritium analysis, the following determinations were made: pH (laboratory), specific conductance (field and laboratory), temperature, bicarbonate, carbonate, chloride, sulfate, phosphate, fluoride, nitrate, ammonia, and four principal cations. Analytical results for water samples collected in the course of the study are shown in Appendices 3 and 6. With the exception of the section describing historical changes in water quality, the interpretations herein are based on samples collected from February 1970 through September 1973. Subsequent data shown in Appendix 3 are for information only.

Spatial variations in ground-water quality, particularly for depths below 50 feet, were determined largely from District Health Department data. Analyses from January 1, 1968 through 1972 were selected for depth intervals 0 to 50 feet, 51 to 100 feet, and 101 to 300 feet providing the anion:cation ratio was in the range 0.9 to 1.1. From card decks of acceptable analyses plots of sampling point locations were prepared to determine density of data points in the study area for the three depth intervals selected. In areas of high density, analyses for depth intervals 51 to 100 feet and 101 to 300 feet were averaged to one value per quarter section to avoid undue weighting of the polynomial equations describing the trend surfaces. For these same depth intervals, data decks containing only actual, versus averaged, data were prepared to plot the locations where various water quality parameters exceeded a threshold value, usually the U. S. Public Health Service (1962) standard for drinking water.

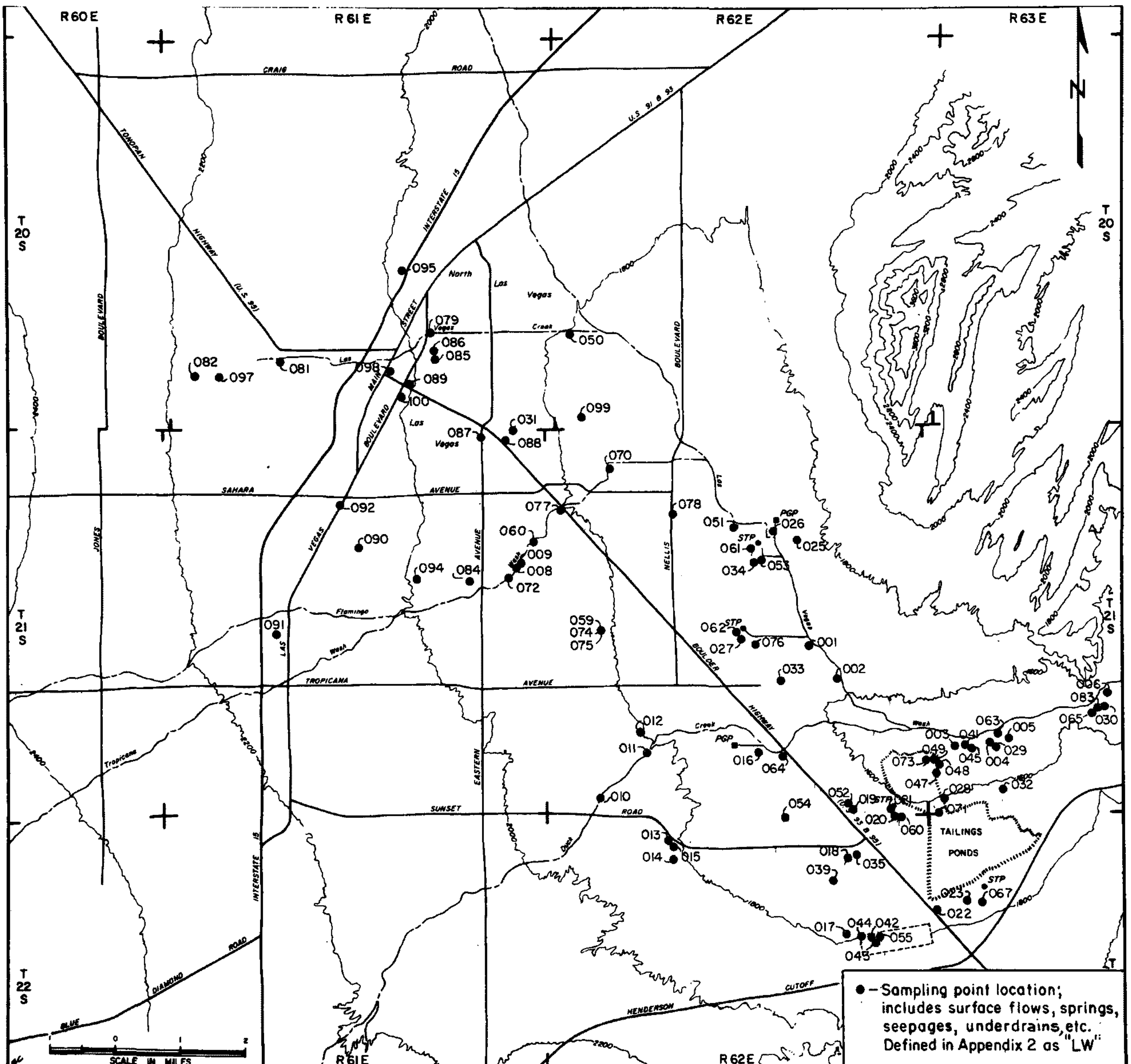


Figure 16. Locations of surface water, spring, and seep sampling stations.

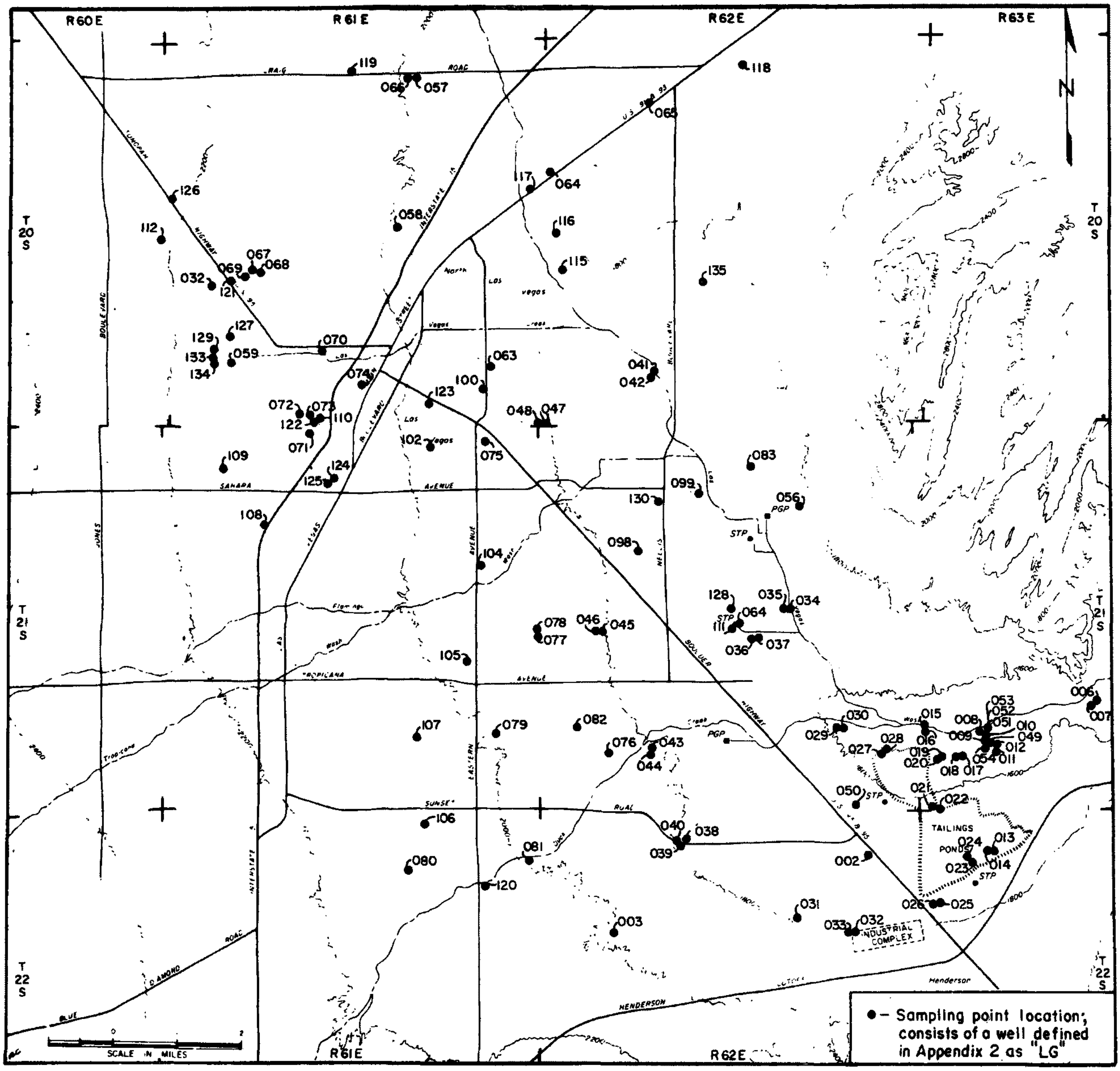


Figure 17. Locations of sampling wells.

The data base was also used to produce hydrochemical facies maps for the depth interval from 101 to 300 feet. The plotting routine was used in combination with a program which categorized each water analysis into 1 of 16 facies or classes of water quality resulting from different sediment composition and source areas, variations in residence time within the flow system, and effects of ion exchange with fine-grained sediments. Domains of dominant classes or facies were mapped to show trends throughout the area where data were available.

The data decks were also used to generate trend surfaces depicting the trend for various water quality parameters. Data availability varied with the depth interval considered. In the case of the depth interval from 0 to 50 feet, only TDS, chloride, and nitrate were considered as the water was clearly not potable and these parameters were considered most indicative of return flows from developed and agricultural areas. In addition to the trend surfaces for each parameter, CALCOMP plots of actual values by location were made to enable a visual scan of the raw data and selection of the contour interval and reference contour for the trend.

The trend surface technique involves fitting polynomial surfaces to map data by means of a general linear model incorporating a least-squares fit of a planar or curvilinear surface to the observed data. More complex surfaces involved higher order polynomials and more terms in the equation collectively relating each datum (Z) to its location (X, Y) in the area of consideration. In theory, there is no upper limit to the exponents but the most useful trends seldom exceed the fifth or sixth degree. The coefficient of correlation statistic expresses the variation accounted for, which typically is in the range of 60 to 90 percent and progressively greater for the higher order polynomials.

In the past, trend surface analysis has primarily been applied to stratigraphic, structural and sedimentation problems involving such topics as analysis of lithofacies variations, source areas for heavy mineral assemblages, and evaluation of economic deposits of oil, gas, and ore. Davis et al. (1969) applied trend surface analysis to a problem involving ground-water use, replenishment and aquifer characteristics in Indiana. A bibliography of the applications is found in Krumbein and Greybill (1965) and in Lustig (1969). For the present study, trend surfaces were relied upon to portray chemical quality of ground water for several reasons. From a research standpoint, the method had not been adequately tested and applied to ground-water quality problems. Another consideration was the need to reduce and generalize a great mass of chemical data, some of which were of questionable veracity. Retrieval of raw data for manual plotting and contouring would have been extremely time consuming and inefficient. Finally, broad overall trends are analytically more useful in describing variations in Las Vegas Valley.

DEEP GROUND-WATER QUALITY (depth interval 101 to 300 feet)

Figure 18 shows the location of water analyses taken to describe changes in the depth interval from 101 to 300 feet. Fewer analyses available in approximately the central portion of the study area reflect gradual destruction of wells in the older urban developments which are now relying on municipal water systems. Light density in the north-central portion is largely a result of nondevelopment.

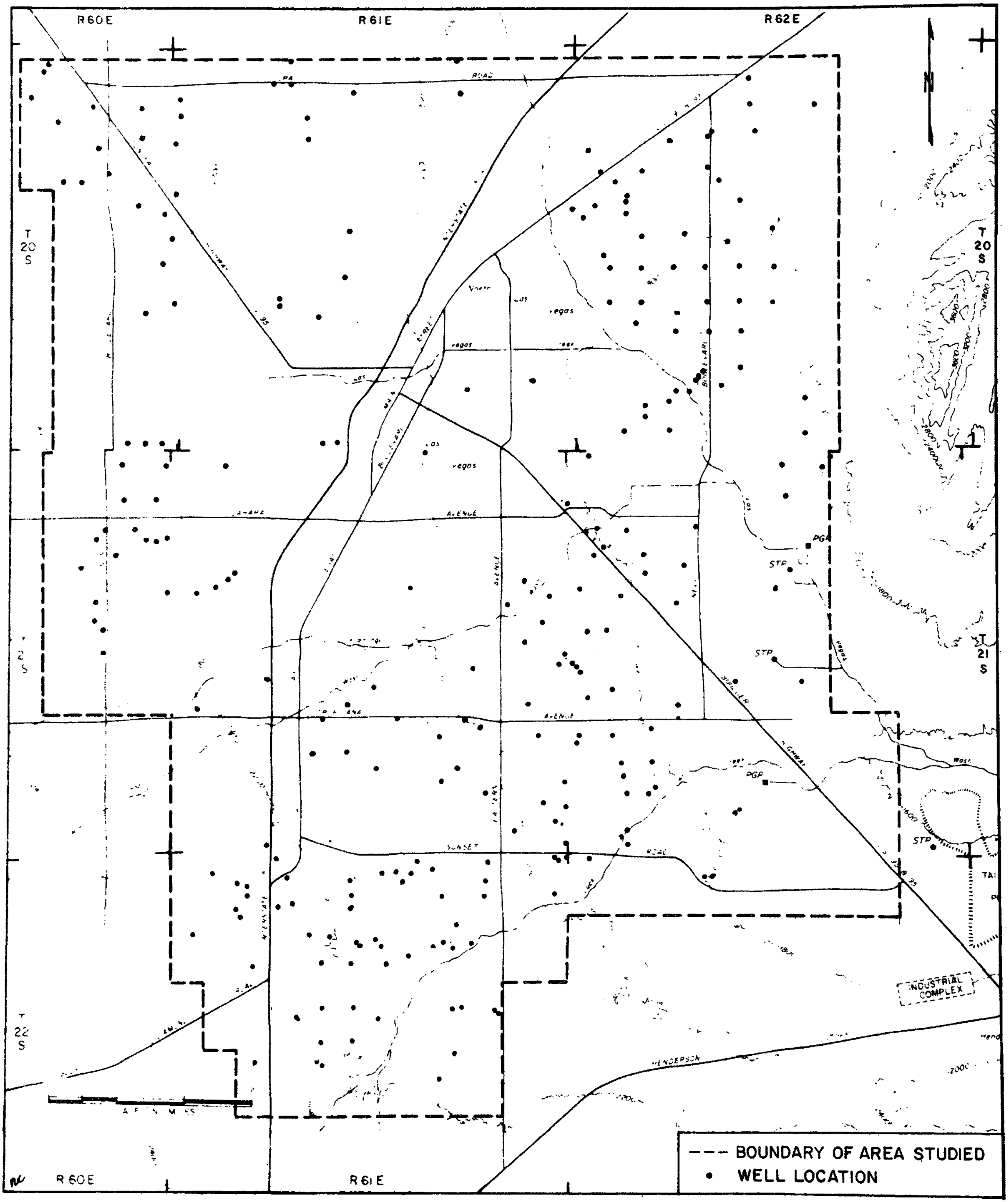


Figure 18. Locations of domestic wells and selected test wells used to characterize ground-water quality at depths of 101 to 300 feet in the period 1968-1972.

First order or regional trends in TDS for the three depth intervals considered are shown in Figure 19. At depths of 101 to 300 feet, the progressive increase in mineralization of ground water along the valley-wide flow path is primarily a function of natural hydrogeologic controls. This is shown in more detail in Figures 20 and 21, which are hand-contoured and sixth degree trends of TDS at depths of 200 to 300 feet and 101 to 300 feet, respectively. Although both maps generally agree, the hand-contoured version is less useful in depicting broad, valley-wide conditions, despite the fact that data are averaged to one value per section. The sixth order trend (Figure 21) reveals minimum concentrations of approximately 300 mg/ℓ in the northwestern sector along the principal ground-water flow path into the Valley. From this point flow is eastward across the northern half of 20/61, and southeastward toward Las Vegas Wash. Mineralized ground water present along the west central and southern portions of the study area reflects the presence of soluble, gypsiferous, Mesozoic sediments in the recharge areas and contiguous alluvial fans in the southern portion of the Spring Mountains. Other factors contributing to the mineral content of ground water in this part of the Valley include longer time in the flow system, less annual recharge o water flux, and decreased permeability associated with finer-grained shale and siltstone bedrock and resulting detritus. In contrast, the central and northern portions of the Spring Mountains are composed primarily of Paleozoic carbonate strata with high secondary permeability, essentially no evaporites, and greater annual recharge due to higher average elevation. As a result, ground water is of higher quality.

In general, the pattern for TDS for the zone from 101 to 300 feet is one of progressive increase along the flow path. This is an expected and normal pattern because the dominant sink is the lowland area centered on Las Vegas Wash, the point toward which all ground water flows. The mineral content of deep ground water in the southeasterly portion of 21/62 increases from 1,000 to 3,000 mg/ℓ in a distance of about four miles. Comparing this with the change in the distance from the prime recharge area in the Spring Mountains to the 1,000 mg/ℓ contour line, (roughly 30 miles), gives an indication of the role played by the composition and permeability of fine-grained valley-fill.

The east-west trending zone of relatively good quality water extending across the northern portion of the study area to the central portion of 20/62, and then southward toward Boulder Highway is indicative of favorable conditions for ground-water development. These might include rather permeable sediments and/or significant ground-water inflow.

Warm ground water below depths of several hundred feet in the southern and southeastern portions of the study area also contributes to the dissolved solids in the shallow aquifers. Warm ground water and a mineral spa are present in 22/62-21. Water from an artesian well (LG002) 1,000 feet deep in section 4 of the same township varied from 22.2 to 33.5°C and contained between 3,127 and 4,660 mg/ℓ TDS when sampled in 1970. Other wells 300 feet deep or greater, with water containing in excess of 2,000 mg/ℓ TDS, are reported in 22/62, by Domenico and Maxey (1964) and Hardman and Miller (1934).

Sulfate concentrations in ground water at depths of 101 to 300 feet are shown in Figure 22 which is similar in pattern to the TDS plot discussed

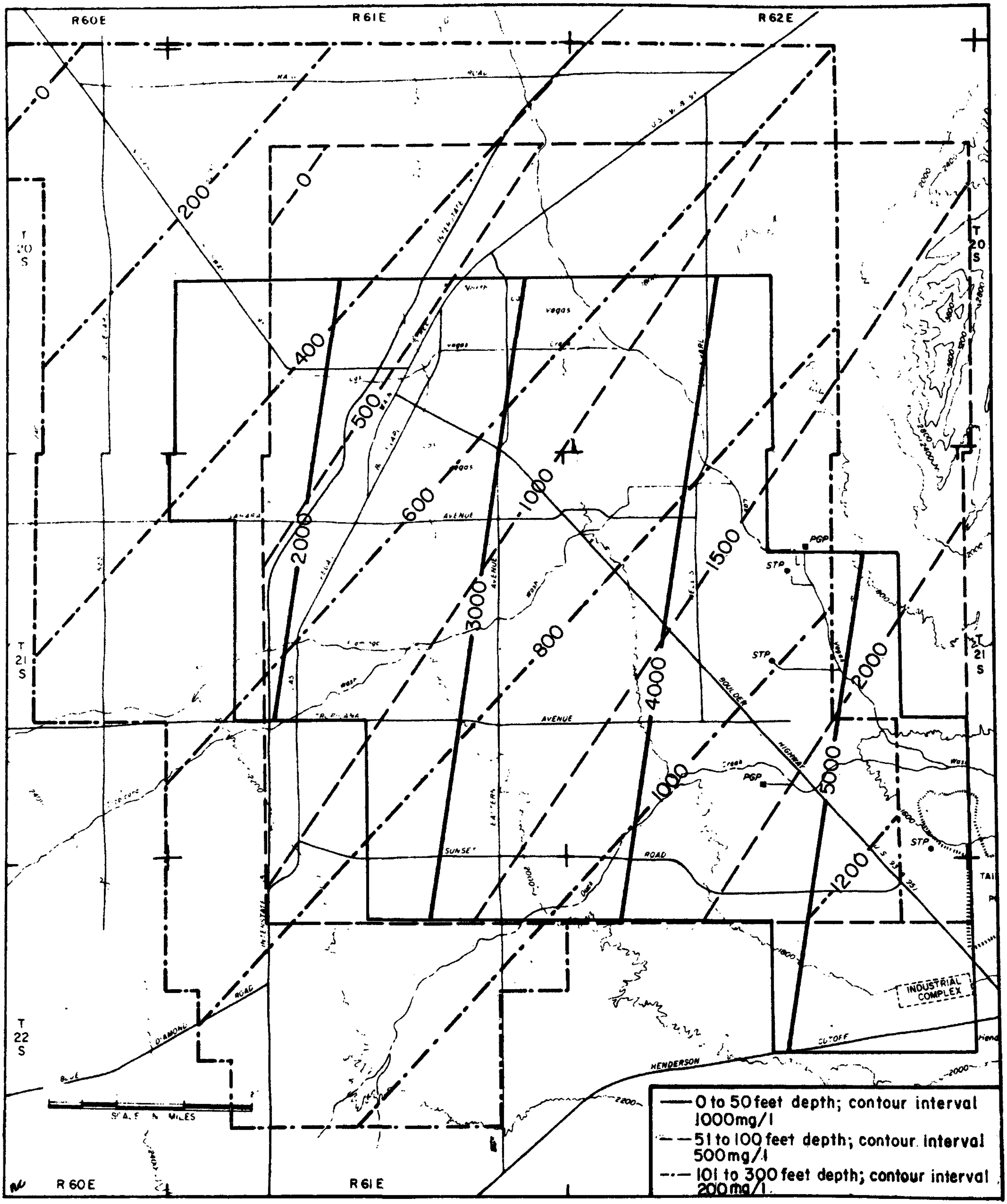


Figure 19. First degree trend surfaces for total dissolved solids in ground water at depths of 0 to 50, 51 to 100 and 101 to 300 feet deep.

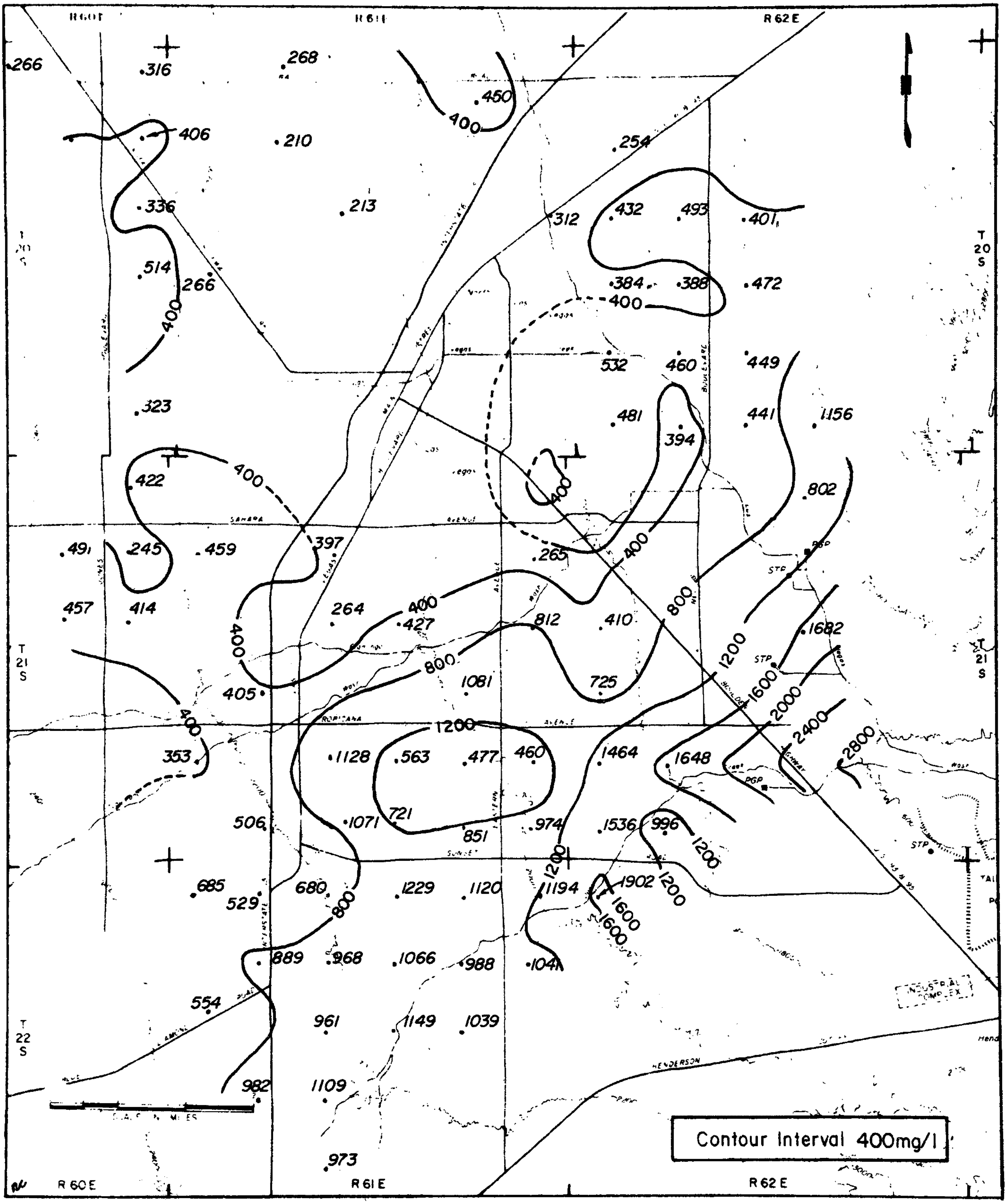


Figure 20. Distribution of total dissolved solids in ground water at depths of 200 to 300 feet (manually contoured).

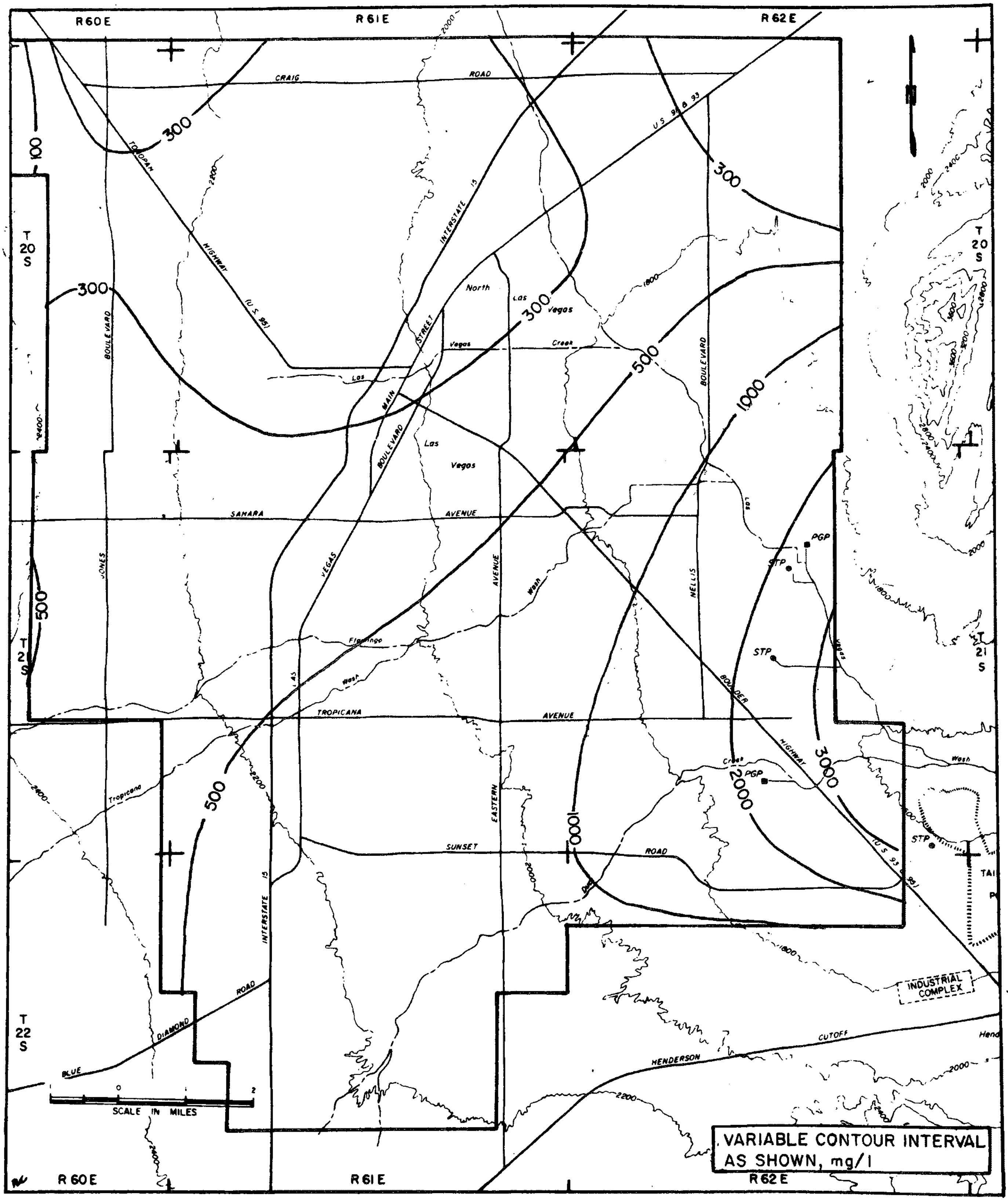


Figure 21. Sixth degree trend surface for total dissolved solids in ground water at depths of 101 to 300 feet.

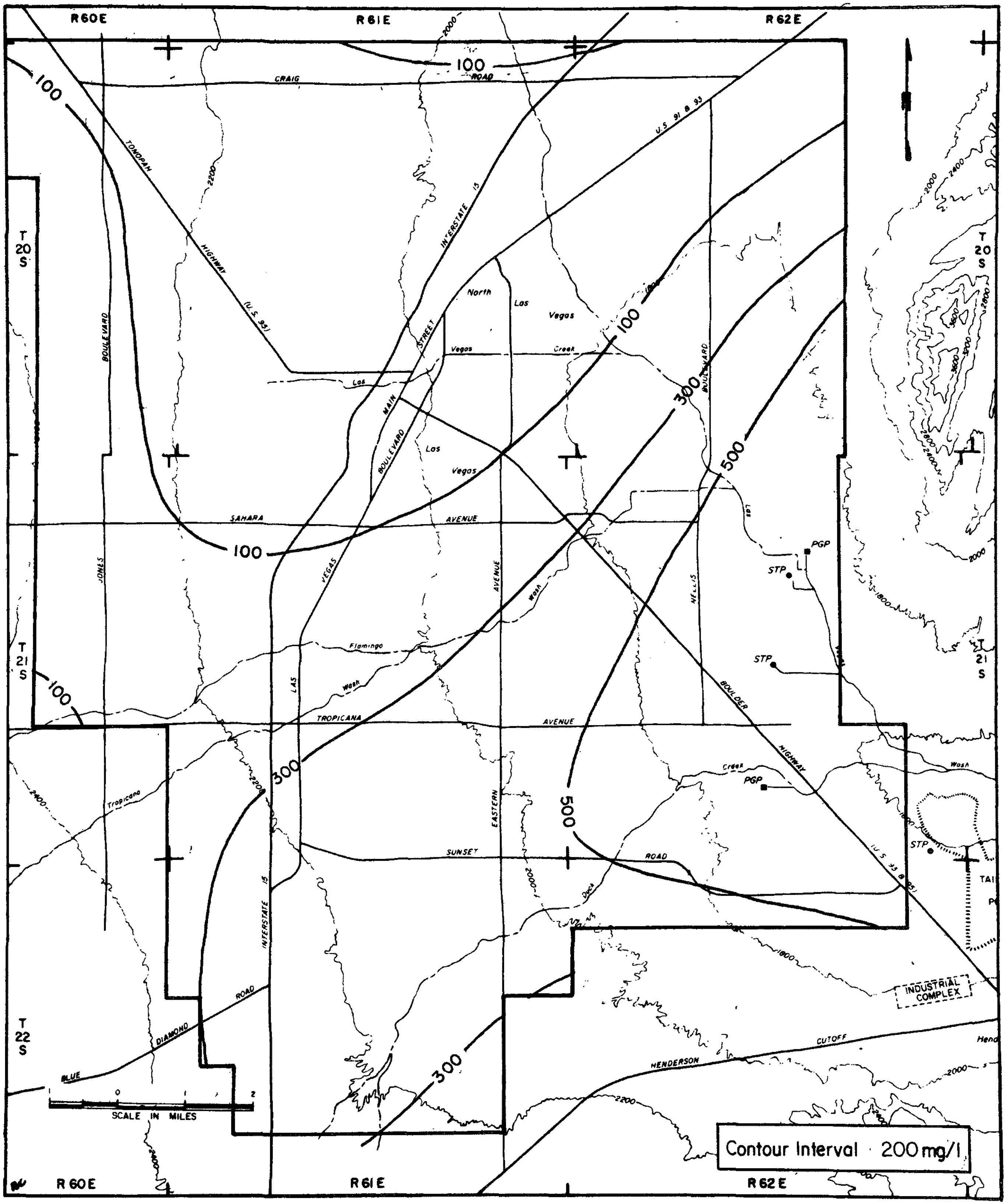


Figure 22. Fourth degree surface for sulfate in ground water at depths of 101 to 300 feet.

above. Minimum sulfate concentrations are associated with recharge entering the Valley from the north and northwest. Both the TDS and sulfate trends are indicative of minor inflow from the northwest flank of Sunrise Mountain. Inflow from the west, southwest, and south, particularly the latter, is enriched in sulfate with the result that most of the ground water in Paradise Valley does not meet the U.S. Public Health Service (1962) standard.

Nitrate and chloride trend surfaces had the lowest coefficients of correlation, indicating numerous local variations are present in comparison to broad, valley-wide trends for the parameters previously discussed. In general, the shallow aquifer, as defined by Maxey and Jameson (1948) at depths of 250 to 450 feet, contains 5 mg/ℓ or less nitrate. It is probable that wells in the depth range of 101 to 300 feet with greater than 5 mg/ℓ nitrate are either producing (in part) from the upper portion of the saturated zone and/or there is leakage along the casing. Data to check these possibilities were not available for all wells in question.

Distribution of chloride in ground water for the interval from 101 to 300 feet is also poorly described by the trend surfaces. As in the case of nitrate, numerous local variations are superimposed on the first order, regional trend (Figure 23). The latter depicts a concentration gradient of approximately 10 mg/ℓ per mile. Actual concentration in the southeast and northwest corners of the study area are 185 and 10 mg/ℓ, respectively. The low concentrations of chloride suggest prime recharge to the alluvial fill comes from source area(s) low in chloride and is characterized by short residence time, or relatively short flow paths, or both. This in turn, suggests that recharge to the valley fill may also be associated with movement in the carbonate aquifers rather than only in the alluvial aprons flanking the carbonates.

It is apparent from the first order chloride trends (Figure 23) that absolute concentrations at any point and concentration gradients across the Valley are very dissimilar for the three depth intervals considered. Markedly more saline conditions prevail in the interval from 0 to 100 feet and largely reflect natural conditions, primarily concentration by evapotranspiration and the presence of saline soils. Both influences are apparent in the interior portion of the Valley characterized by shallow depths to ground water, phreatophytes, and fine-grained playa facies sediment types. However, man-related factors such as waste disposal are also operative and are dominant influences in the eastern part of the Valley.

In terms of water quality, the depth interval from 51 to 100 feet can be considered as transitional. This, plus the scarcity of data points (as reflected in Figure 24), justifies discussion of this zone in conjunction with the overlying and underlying intervals.

SHALLOW GROUND-WATER QUALITY (depth interval 0 to 50 feet)

Effects of Soil and Runoff

Water quality in the near surface zone within the study area is generally poor. The salts present are a result of concentration by evaporation and transpiration from areas with a high water table and former marshy areas,

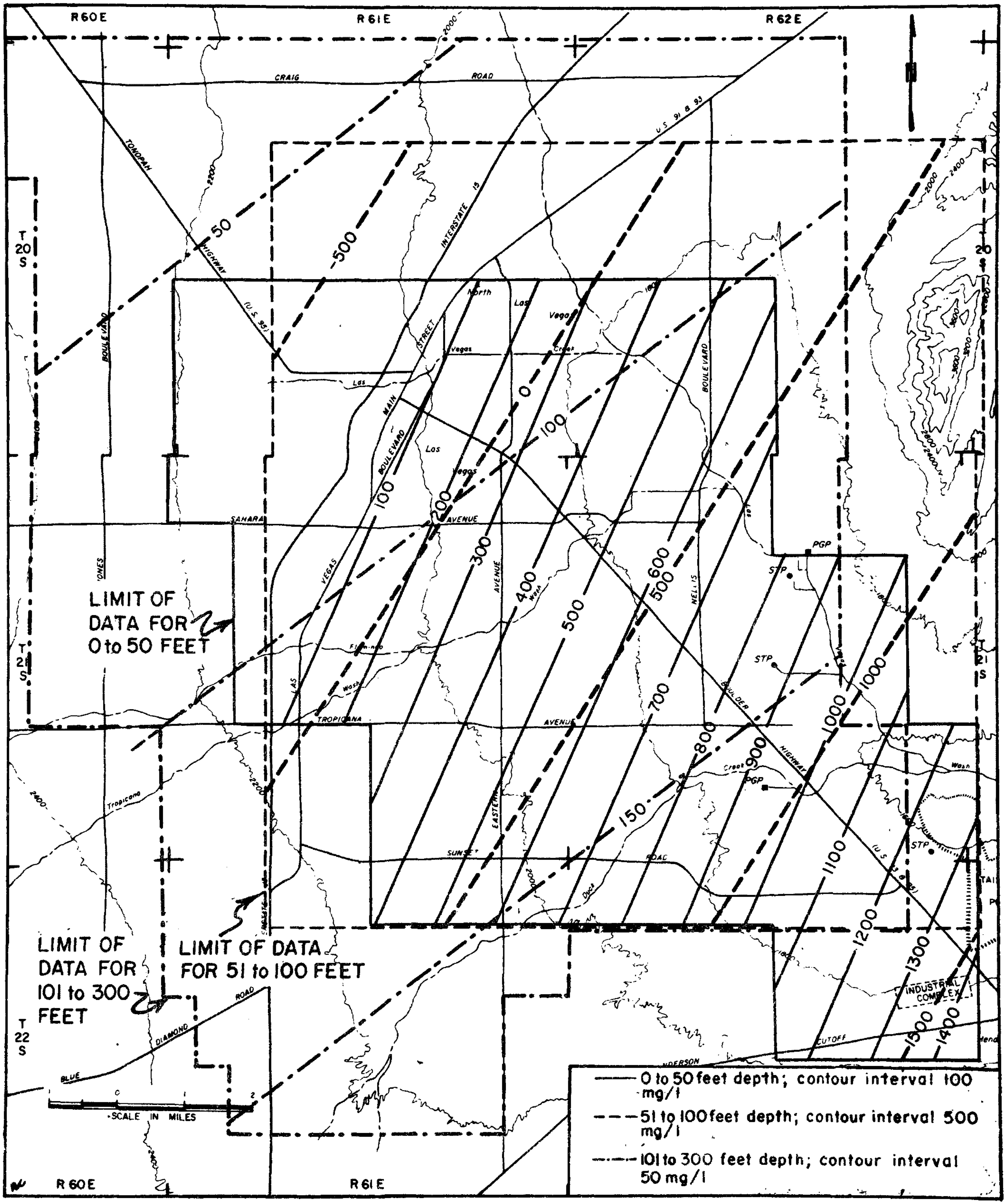


Figure 23.. First degree trend surface for chloride in ground water at depths of 0 to 50, 51 to 100, and 101 to 300 feet.

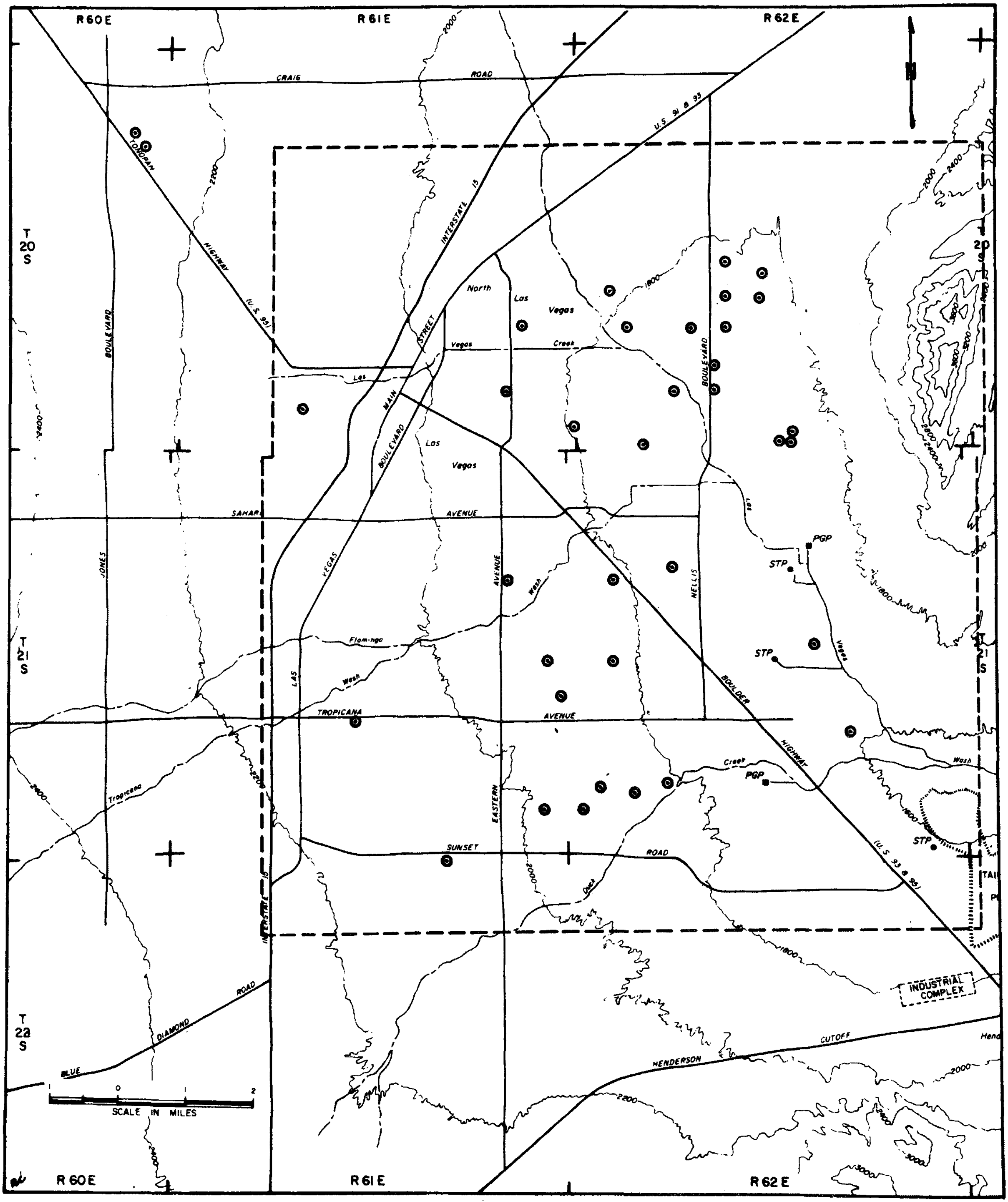


Figure 24. Locations of wells used to characterize ground-water quality at depths of 51 to 100 feet.

streams, and possibly shallow lakes or ponds. Dissolution of the valley fill, sulfate in particular, is also a contributor. Sulfate in the form of gypsum is abundant in the Mesozoic sediments in the southern end of the Spring Mountains and in the Sunrise Mountain and Rainbow Garden areas to the east. Urbanization and associated lawn watering plus limited agricultural development have leached the salts in the soil profile directly as a result of return flows or indirectly as a result of a rising water table. The latter phenomenon is most pronounced in the vicinity of Las Vegas Wash. Definition of the effects on ground-water quality due to modifications in soil profiles, greatly increased return flows from irrigation water, and altered runoff patterns associated with developed versus undeveloped areas was not possible. However, a general understanding of probable influences merits discussion.

An indication of the role soil conditions should have on surface water and shallow ground-water quality can be seen by comparing the distribution and characteristics of major soil groups (see Figure 25 and Table 2) as defined by Langan et al. (1967). The major soil associations reflect distinctive landscape forms, parent materials, and patterns of individual soil types. For example, the Glendale-Land association is restricted to the level or nearly level valley floor. It is moderately to well drained and capable of supporting irrigated crops. The parent materials are primarily recently reworked, fluvial and(or) floodplain sediments . The Badland-Bracken-McCarran soil association, on the other hand, is derived from fine-grained sediments associated with distal ends of alluvial fans or with former lakes or sluggish, through-moving drainage in late Pleistocene time. Medial portions of the fans contain very shallow, medium to coarse-grained soils underlain by well cemented gravel or caliche. These are represented by the Cave-Goodsprings-Las Vegas and the Tonopah-Pittman-Eastland-Jean associations. Soils in the Skyhaven-Spring-Gass association are somewhat intermediate in character between those developed on the fans and those on playa materials. They are fine to medium grained, relatively shallow, moderately to strongly mineralized and locally underlain by a limey hardpan.

In summary, the floodplains of the major washes contain less saline, very deep loamy soils. Between the dominant drainage courses are the highly gypsiferous, deep loamy soils. These are bounded on the north by the Skyhaven-Spring-Gass association developed on level and gently sloping terraces consisting of loamy clayey soils and underlain by a hardpan. It is likely under predevelopment conditions, that overland flow across the gypsiferous soils on the interfluves resulted in significant salt removel.

Generally, medial portions of the alluvial fans surrounding the developed areas of the Valley, and contributing significant runoff to urbanized areas during intense, but localized, precipitation events, are characterized by low infiltration rates. This is attributed to the presence of caliche and cemented gravel hardpans. From a study of caliche development and the effects on runoff and infiltration on the Red Rock Canyon fan, Cooley et al. (1973) concluded that caliches on four representative physiographic units within the fan apron as far east as 21/61-3ab have infiltration rates equivalent to stratified or unweathered clay, i.e., essentially impervious. Throughout most of the developed area in the Valley the native soils present severe limitations on the use of septic tanks (Table 2) which is also indicative of low permeability within five feet of the land surface.

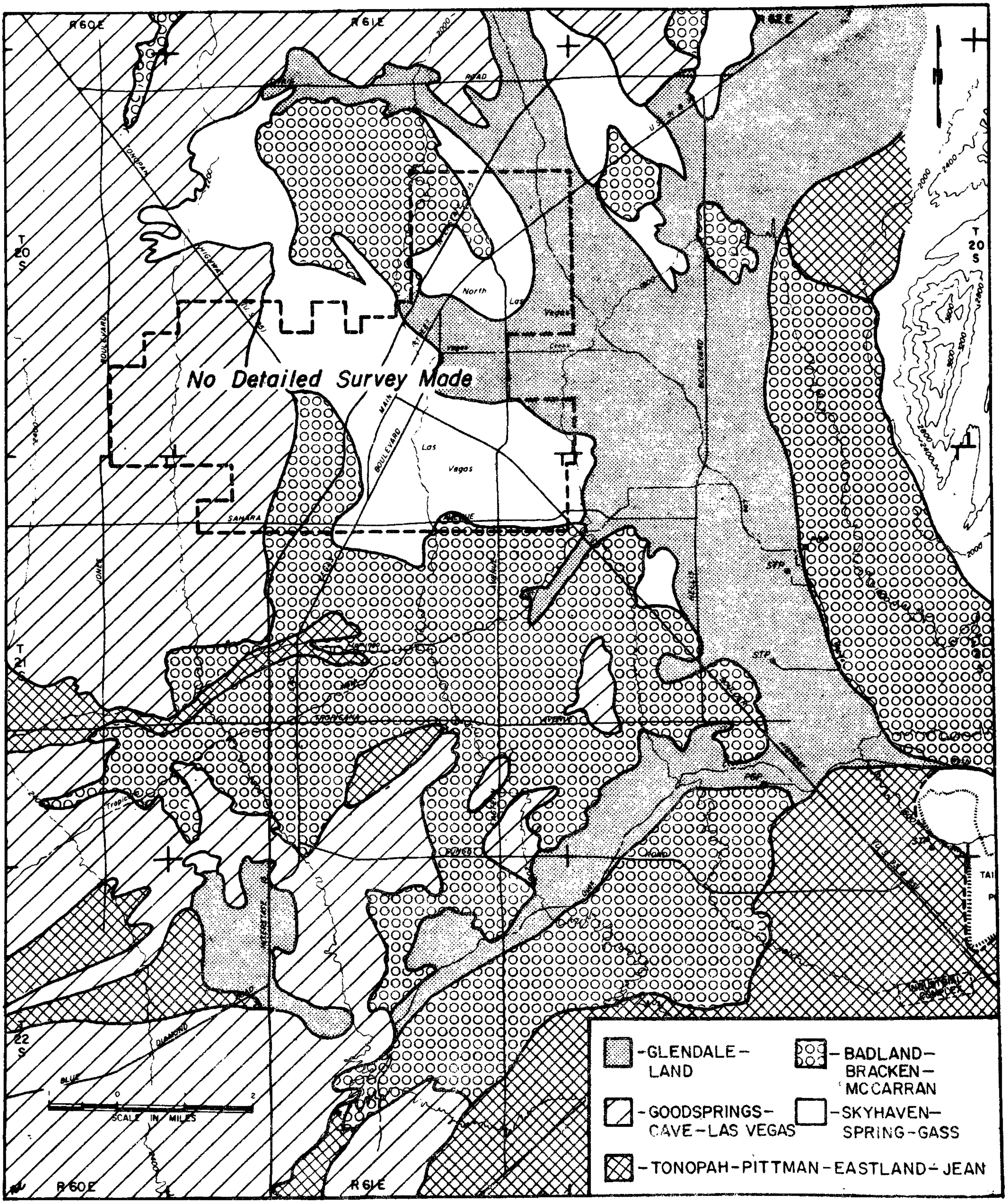


Figure 25. Map of the major soil associations in Las Vegas Valley.

TABLE 2. SUMMARY OF THE CHARACTERISTICS OF MAJOR SOILS IN LAS VEGAS VALLEY*

Soil Association	Soil Name and Characteristics	Unified Classification	Septic Tank Limitation
Glendale-Land	"Very deep loamy soils on nearly level floodplains" Glendale soils constitute 60 percent of the association and are well drained, medium textured, strongly calcareous, and moderately or slowly permeable. Land soils constitute 20 percent of the association and are well drained, moderately fine to medium textured, unusually high in crystalline salt and gypsum and moderately slowly or slowly permeable.	ML, GP, SM, CL	Moderate-Severe
Badland-Bracken-McCarran	"Deep and very deep, loamy and gravelly, highly gypsiferous soils on nearly level to moderately sloping terraces and on eroded, moderately sloping to strongly sloping terrace escarpments" Badland makes up about 35 percent of the association and consists of highly gypsiferous, calcareous, lake laid silts and clay. Bracken and McCarran soils each constitute 32 percent of the association and are well drained, gravelly, moderately coarse textured and high in gypsum.	OL/ML, CL, SC, CH	Severe
Cave-Goodsprings-Las Vegas	"Shallow and very shallow gravelly and loamy soils on nearly level and gently sloping terraces. Commonly underlain by hardpan or cemented gravel" Cave soils constitute 35 percent of the association which occupies 35 percent of the Valley. Cave soils are very shallow to shallow, moderately coarse textured, and overlie a thick calcareous hardpan. Goodsprings soils make up 30 percent of the association and are shallow to shallow, medium textured and overlie a thick, calcareous hardpan. The hardpan underlying these soils inhibits installation of offsite improvements and cannot be ripped. The soils are well drained but have very shallow root zones and low water holding capacity.	SM, SC, ML, CL	Severe
Skyhaven-Spring-Gass	"Shallow to deep loamy and clayey soils on nearly level and gently sloping terraces; shallow soils underlain by a hardpan." Skyhaven soils form 50 percent of the association. These are well drained, calcareous, moderately fine textured, and overlie a calcareous hardpan. Spring soils, forming 37 percent of the association, are imperfectly drained, moderately fine textured, high in gypsum and calcite. Gass soils are moderately well drained, fine textured, calcareous.	CL, SM, CH	Severe
Tonopah-Pittman-Eastland-Jean	"Very deep to shallow, gravelly sandy and gravelly loamy soils on nearly level to strongly sloping alluvial fans; shallow soils underlain by a hardpan". This association is most prominent as scattered spots on the alluvial fans surrounding the Valley. Tonopah soils, forming 37 percent of the association, are very gravelly, coarse textured, calcareous, and excessively drained. Pittman soils form 37 percent of the association and are very coarse textured, calcareous, and well drained. Jean and Eastland soils each constitute 13 percent and are coarse textured, well to excessively drained, and moderately deep over gravelly parent material.	GW, GP, SM, GM, GW	None

* Adapted from Langan et al., 1967.

The role of sheet runoff as a mechanism for removing surficial salts from the soils is evident from Table 3 which was developed from a U.S. Geological Survey (1972) study within the city limits of Las Vegas.

TABLE 3. AREAS SUBJECT TO FLOODING IN THE CITY OF LAS VEGAS

Zone	Description	Area (square miles)
A	Subject to inundation by the base (100-year) flood	8.58
B	Subject to inundation by the 500-year flood, but not included in Zone A	1.36
B1	Subject to inundation by sheetflow which may occur at any time	26.39

Areas under Clark County jurisdiction are excluded, hence flooded areas associated with the major washes, with the exception of Las Vegas Creek, are not reflected in the figures shown above. The total area subject to flooding and sheetflow in the Valley is unknown but can be estimated from the drainage areas and projected floods for the major washes (Table 4). In terms of geologic time, the Lesser, Intermediate Regional, and Standard Project Floods and associated sheet runoff are likely to have occurred many times, thereby removing much of the surficial accumulations of salt.

TABLE 4. PEAK DISCHARGES ASSOCIATED WITH FLOODS IN LAS VEGAS VALLEY*

Drainage Course	Drainage area square miles	Peak discharge (cfs) associated with the following floods: Lesser	Intermediate Regional	Standard Project
Lower Las Vegas Wash	1,571	27,000	39,000	100,000
Duck Creek	1,510	26,500	38,500	98,000
Flamingo Wash	1,000	23,000	34,000	83,000
Las Vegas Creek	807	22,000	31,500	77,500

* Taken from U. S. Army Corps of Engineers (1967).

Intense urban and suburban development in the Valley covers an area of roughly forty square miles. Within this area many of the tributary and distributary channels have been filled in resulting in increased overland and overstreet flood flows associated with intense, short duration storms most common as thunderstorms in July and August. Numerous channel improvements, particularly in certain reaches of Las Vegas Wash, Flamingo Wash, and most recently, Las Vegas Creek have alleviated flooding problems in local areas but a significant drainage problem remains according to Cooley et al. (1973), Jones (1972), and the U. S. Army Corps of Engineers (1967).

At numerous locations former dry wash channels have been encroached upon and even filled to make room for structures. Figures 26 through 29 illustrate a typical situation where a natural wash channel has been covered with a housing development. Overland flow from the development is at least partly returned to the Wash, as storm sewers are nonexistent. "Improvements" of the same channel in the downstream direction can be seen from comparing Figures 27 and 28, taken west and east, respectively, where the Wash crosses Eastern Avenue. Note the drastic reduction in channel capacity between the natural and "improved" state. To allow more development, land has been leveled on either side of the "improved" channel (see Figures 28 and 29). The channel has been completely filled in preparation for construction of another development still further downgradient.

With the exception of areas underlain by thick, competent caliche at very shallow depths, construction of areally extensive housing tracts, is

Figure 26. Photograph of an unimproved wash channel in the vicinity of Harmon and Eastern Avenues. Note that the subdivision in the background straddles the wash.

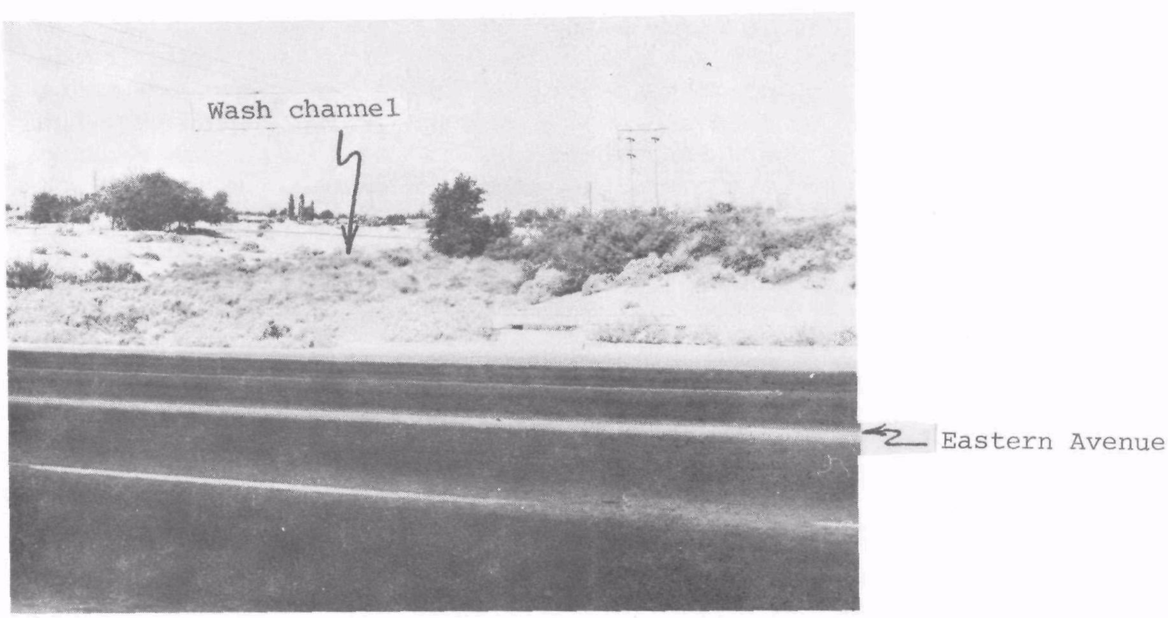


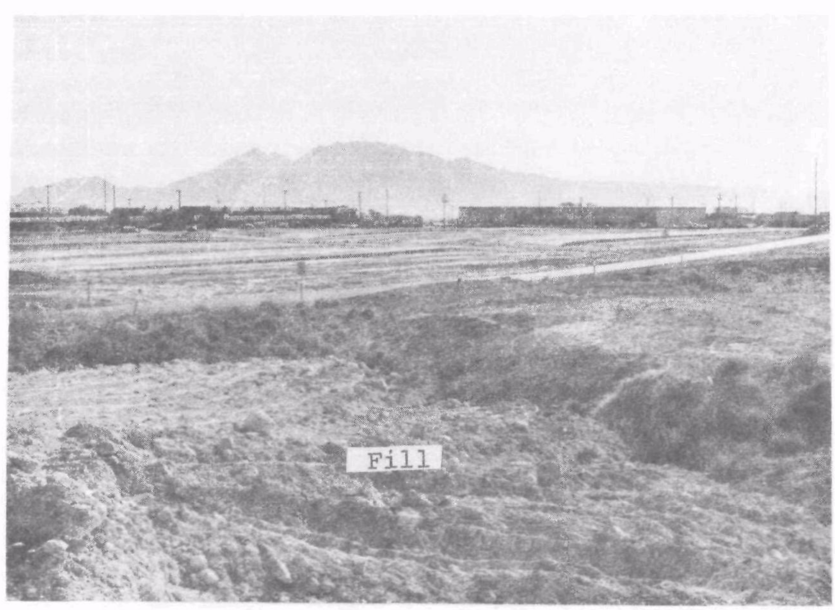
Figure 27. Photograph of an unimproved wash channel immediately west of Eastern Avenue and south of Rochelle Avenue.

Leveled for development

Fill

Figure 28. Photograph of the dry wash in Figure 27 showing channel encroachment as a result of fill operations in the area east of Eastern Avenue and south of Rochelle Avenue. Note the reduction of floodplain by earth fill.

Leveled land



Wash channel

Figure 29. Terminus of the wash shown in Figures 27 and 28 in a proposed housing development. Note the absence of stream channel in the leveled land and the lack of a culvert beneath the street.

preceded by deep leveling and grading (Figure 30) to provide proper gradients for sanitary sewers and storm runoff and to remove expansive soils laden with mirabilite and thenardite that are damaging to foundations. After construction the subsequent development becomes an area of recharge due to return flows from irrigation. Patt (1977) has shown that annual recharge from such areas is on the order of 6 to 11 acre feet per acre.

Figure 30. Photograph showing typical soil excavation and land leveling in preparation for constuction of a subdivision.

To summarize, rapid urban and suburban growth in Las Vegas Valley for about thirty years has involved consistent disruption of natural drainage paths and associated salt flux processes in the native soils. For overland and open channel flow, the net effect has been to collect and channelize flow through urban portions, totally impede and block sheet flow, and to reduce the discharge capacity of lesser tributaries. This has led to localization of runoff and increased local recharge to the near surface zone. Similarly removal of caliche layers and hardpans, together with nonpoint wastewater return flows, increases the leaching of saline soils, and increases salinity in shallow ground water. Increased infiltration of poor quality overland flow and concentration of diffuse ground water in permeable sediments of modern channels and ancestral washes is documented in this study using nitrate and tritium data.

Impacts of Return Flows on Shallow Ground-Water Quality

Nitrate, chloride and TDS concentrations are particulary diagnostic of return flows associated with urbanized portions of the Valley, areas of sewage disposal, areas irrigated with sewage, and the industrial area at Henderson. Detailed documentation of water use and return flows presented in this study and by Malmberg (1965) reveal returns from sewage effluent, industrial wastes, cooling water, and septic tank systems have infiltrated the near surface aquifer.

As early as 1912, effluent from the original Las Vegas sewage treatment plant at Ninth Street and Harris Avenue was used for irrigation on the Stewart Ranch located in the flat area now occupied by Lions Park and Fantasy Park. Treatment plants were successively established in 1931 at 15th Street and Harris Avenue, in 1942 at 25th Street and Harris Avenue, in 1948 at Harris Avenue and Manning Street, and in 1956 at Vegas Valley Drive and Monson Road. Primary effluent from the 1931 plant was used for irrigation until 1948 when the plant closed. From 1948 to the present, effluent from the plants built in 1948 and 1956 was used to irrigate acreage east of what is now the Winterwood Golf Course (L. Anton, City of Las Vegas, oral communication).

In 1955, 7,000 acre feet of effluent infiltrated in the eastern part of the Valley. Whereas recharge to the near surface aquifer over the entire Valley was estimated at 14,000 acre feet per year by Malmberg (1965) and about 18,000 acre feet by Patt (1977). From 1955 to 1969, water levels in the vicinity of the Clark County Sewage Treatment Plant rose about 14.6 feet, or 1.04 feet per year, largely as a result of the irrigation of alfalfa with sewage effluent in the surrounding area. The Soil Conservation Service noted that for 1,130 irrigated acres surrounding the City and County treatment plants, the water table was six feet or less from the land surface in 43 percent of the area (Stains, 1970). At the present time, there are over 5,000 acres in the Valley being irrigated with 43,000 acre feet per year, only a third of which is consumptively used.

Sewage effluent applied to the Paradise Valley and Winterwood golf courses since 1960 and 1965, respectively, has caused little change in TDS, but nitrate in shallow ground water increased to as much as 140 mg/ℓ at stations LW015 and LW099. In the vicinity of the City and County sewage treatment plants, TDS is on the order of 4,000 to 6,000 mg/ℓ which is not markedly different than background in this area. Nitrate, however, is much elevated and typically varies from 90 to 130 mg/ℓ in wells LG037, 060, and 128. Phosphate in the latter is 8.8 mg/ℓ or approximately 88 times normal background concentration.

Sewage effluent from individual treatment plants associated with several major hotels also contributed to nitrate concentrations in ground water. Beginning in 1944 an Imhof tank and oxidation lagoons were used at the Last Frontier Hotel on the Las Vegas Strip. The ponds proved to be under capacity and thereafter until 1954 the combined effects of evaporation and infiltration disposed of 50,000 to 100,000 gallons of effluent per day (G. B. Maxey, oral communication). During this period and particularly after 1954, the District Health Department noted contaminated wells in the area. The Flamingo Hotel, built in 1947, had onsite treatment facilities and an outfall line which allowed effluent to flow along Flamingo Raod and infiltrate and evaporate in the desert. At the Tropicana Hotel a treatment plant was built and the effluent was used on its nine-hole golf course. Any excess was held in detention ponds at the site of the present day Paradise Hotel. Effluent from a treatment plant constructed at the Desert Inn in 1950 was similarly used for irrigation and filling a lake on the golf course. Effluent from the Sands Hotel was formerly used for golf course irrigation or allowed to flow to the nearby desert. Prior to 1955, effluent from an activated sludge plant was used for irrigation of the Dunes Hotel golf course.

Septic tanks are also believed to be a significant source of nitrate contamination. By 1973 approximately 4,000 septic tank installations were known in the Valley and contributed an estimated 1,750 acre feet per year of wastes to the near surface aquifer (Patt, 1977).

Other miscellaneous nitrate sources include the LDS Church Farm and adjacent farms. Located between the City and County Sewage Treatment Plants, an area of about 1,160 acres has been irrigated with effluent since 1957. The sewage treatment plant at Nellis Air Force Base operated from 1940 to 1971. Leakage from the lagoons and return flow from the nine-hole Base golf course, which was partially irrigated with effluent until 1971, have contributed to anomalous nitrate concentrations in the area immediately south of the oxidation lagoons. This is an area that otherwise has relatively high quality water in the upper 300 feet of valley fill.

The importance of other sources of nitrate such as fertilizers, buried evaporites, and leaky sewer lines is poorly understood but believed to be minor. Another source may be the oxidation of buried organic mats associated with depostis at springs in the northwestern part of the Valley where nitrate concentrations in shallow ground water in the last few years have gone from less than 5 mg/ℓ to 450 mg/ℓ and are cause for concern. Detailed studies of this phenomenon are being conducted (Patt and Hess, 1976). The effects of livestock, horses in particular, is unknown but may be locally significant considering that 10,000 horses are estimated in the Valley.

Because numerous sources of nitrate are or have been present, concentrations in ground water were initially analyzed through use of trend surfaces to ascertain variations for depth intervals 0 to 50, 51 to 100, and 101 to 300 feet. The second approach consisted of plotting nitrate levels equal to or greater than 10 mg/ℓ and comparing the results with known distributions of septic tank and cesspool waste disposal systems and areas of sewage disposal. In a negative fashion, the trend surfaces for nitrate (Figures 31 and 32) proved to be rather revealing. Concentrations above 10 mg/ℓ in the zone from 0 to 50 feet are common, particularly in the eastern part of the Valley. In contrast, nitrate at depths of 101 to 300 feet is irregularly distributed and generally quite low in concentration. This implies that waste disposal, and primarily that in the eastern part of the Valley, dominates the shallow nitrate pattern.

The threshold value of 10 mg/ℓ was selected to distinguish between background and polluted levels of nitrate. The value is arbitrary but conservatively so because natural values average less than 5 to 7 mg/ℓ according to raw data plots and trends initially generated. By determining deviations from background and relating them to causal factors of land and water use, conclusions can be drawn concerning the impact of septic tanks and other sources of nitrate pollution on shallow ground-water quality.

In the course of calculating the return flows to the near surface aquifer, highly detailed maps of areas served by on-site disposal facilities were prepared by Patt (1977) from an examination of septic tank permits issued by the Clark County Health Department. Indirect confirmation of this approach for the period 1943-1972 was made by using aerial photographs and comparing developed areas versus areas served by the City and County Sanitation Districts.

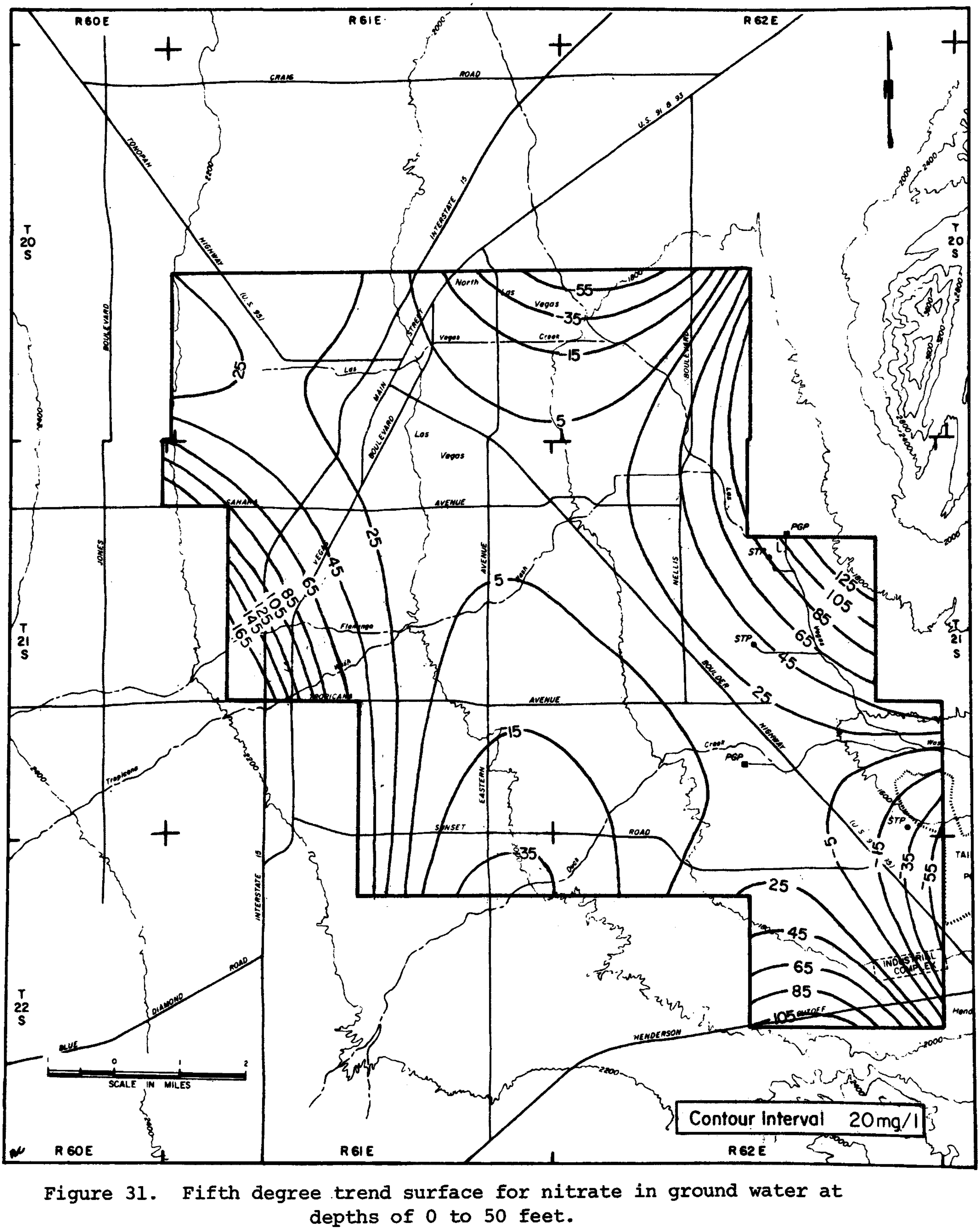


Figure 31. Fifth degree trend surface for nitrate in ground water at depths of 0 to 50 feet.

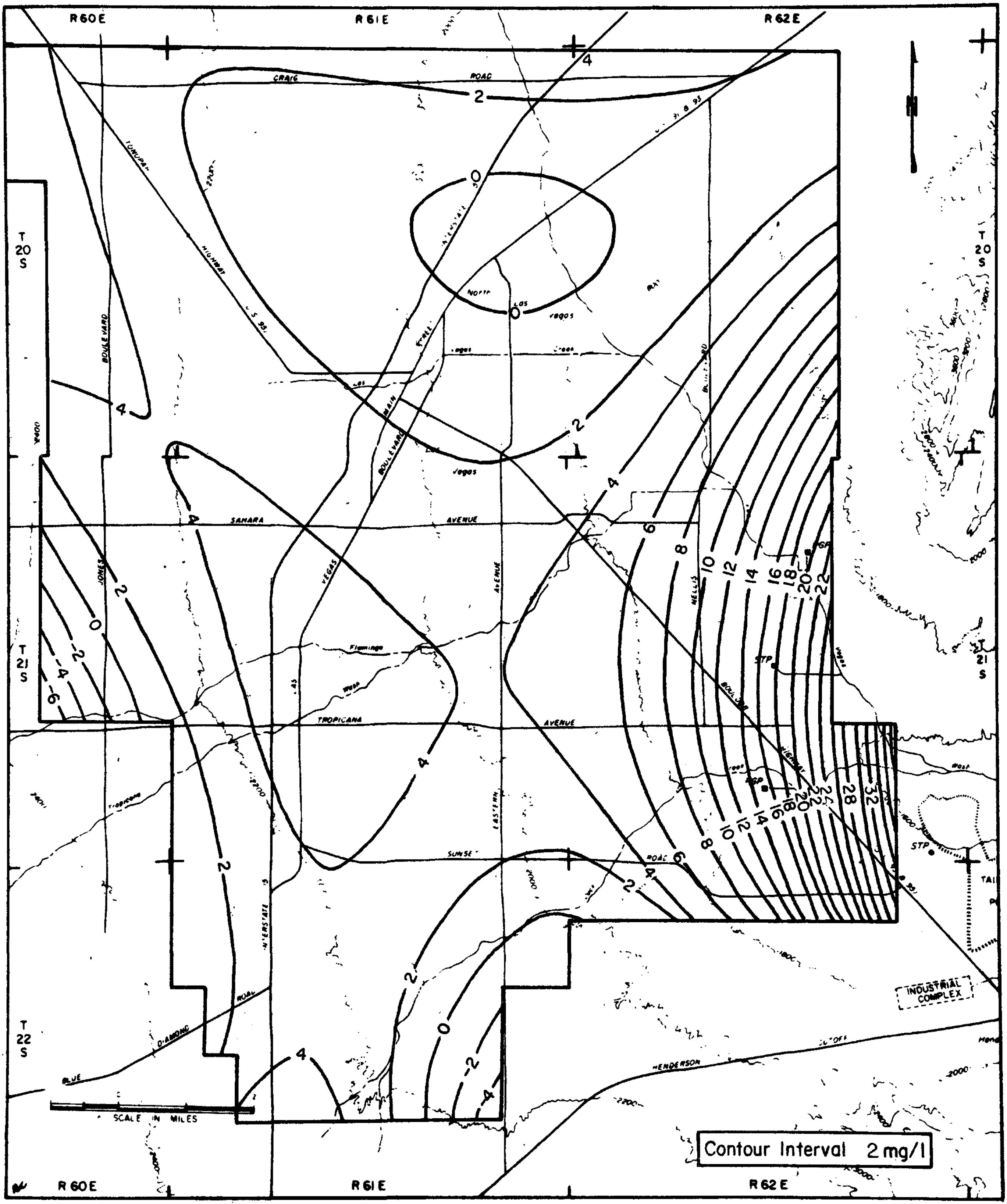


Figure 32. Fourth degree trend surface for nitrate in ground water at depths of 101 to 300 feet.

Developed areas not served by sewers were assumed to contain septic tanks. A generalized version of the detailed maps plus nitrate concentrations in ground water is shown in Figure 33. Also shown are additional areas which are or were recharged with wastewater. These areas were identified from previous reports (Maxey and Jameson, 1948; Leeds, Hill and Jewett, 1961; Malmberg, 1965; Boyle et al., 1969 a, b) and from interviews with local officials and hotel personnel (see Patt, 1977). High nitrate concentrations from industrial and sanitary waste return flows in the vicinity of the lower reach of Las Vegas Wash are discussed separately.

It is evident that distribution of septic tank disposal systems is irregular but widespread. The distribution is indicative of the suburban sprawl, or "leapfrog" form of development which typifies surburnan growth in Las Vegas. Numerous developments with on-site sewage disposal and either public water supply or individual wells have been and will continue to be common in the Valley. Although the volume of return flow from such sources is relatively small, the water quality effects in terms of higher concentrations of nitrate are readily noticeable.

In the zone from 101 to 300 feet deep, nitrate typically averages five mg/ℓ or less and rarely exceeds the arbitrary limit of 10 mg/ℓ. Slightly higher average concentrations for the same depth zone are evident in domestic wells in the area between Warm Springs Road on the north and Paradise Spa to the south. For the period from 1965 to January 1968 there are only about a dozen values greater than 10 mg/ℓ for this area. Insofar as development was minor prior to 1968, nitrate is apparently a recent addition and attributable to the rapid proliferation of septic tanks and, possibly, horses in an area of granular soils and a gradually declining water table. In general, horses in the Valley are coincidentally located in areas served by septic tank disposal systems.

Ground water in those portions of Paradise Valley east of Eastern Avenue is generally under slight artesian head, hence return flows of any type are unlikely to affect ground-water quality at depth. Comparison of the pre- and post-1968 nitrate data for the central and western portions of the Valley reveals that more recent analyses tend to be higher. The pre-1968 data are commonly associated with nitrate sources that are now inactive. These include areas with septic tank disposal systems which were converted to municipal sewer systems or areas used for sewage disposal only for a short period as in the case of certain Strip hotels. Nitrate concentrations of 10 to 158 mg/ℓ associated with recent developments in the northwestern part of the study area attest to the rapidity with which septic tank leachate appears in ground water, probably due to faulty well seals. Thin but extensive permeability barriers in the vadose zone contribute to lateral flow and surfacing.

Nitrate concentrations exceeding 10 mg/ℓ in the interval from 0 to 100 feet are not well known. Domestic wells in this depth range were drilled in the early 1950's to effect necessary land improvements and thereby gain title to acreage released under the Desert Land Entry Act. Most of these wells were never sampled or were destroyed, hence water quality data are scarce. Wells of this type were relatively shallow and many have gone dry as a result of heavy pumping on the west side of the City. Thus, for a variety of reasons, limited data exist concerning very shallow water quality at depths of 0 to 100

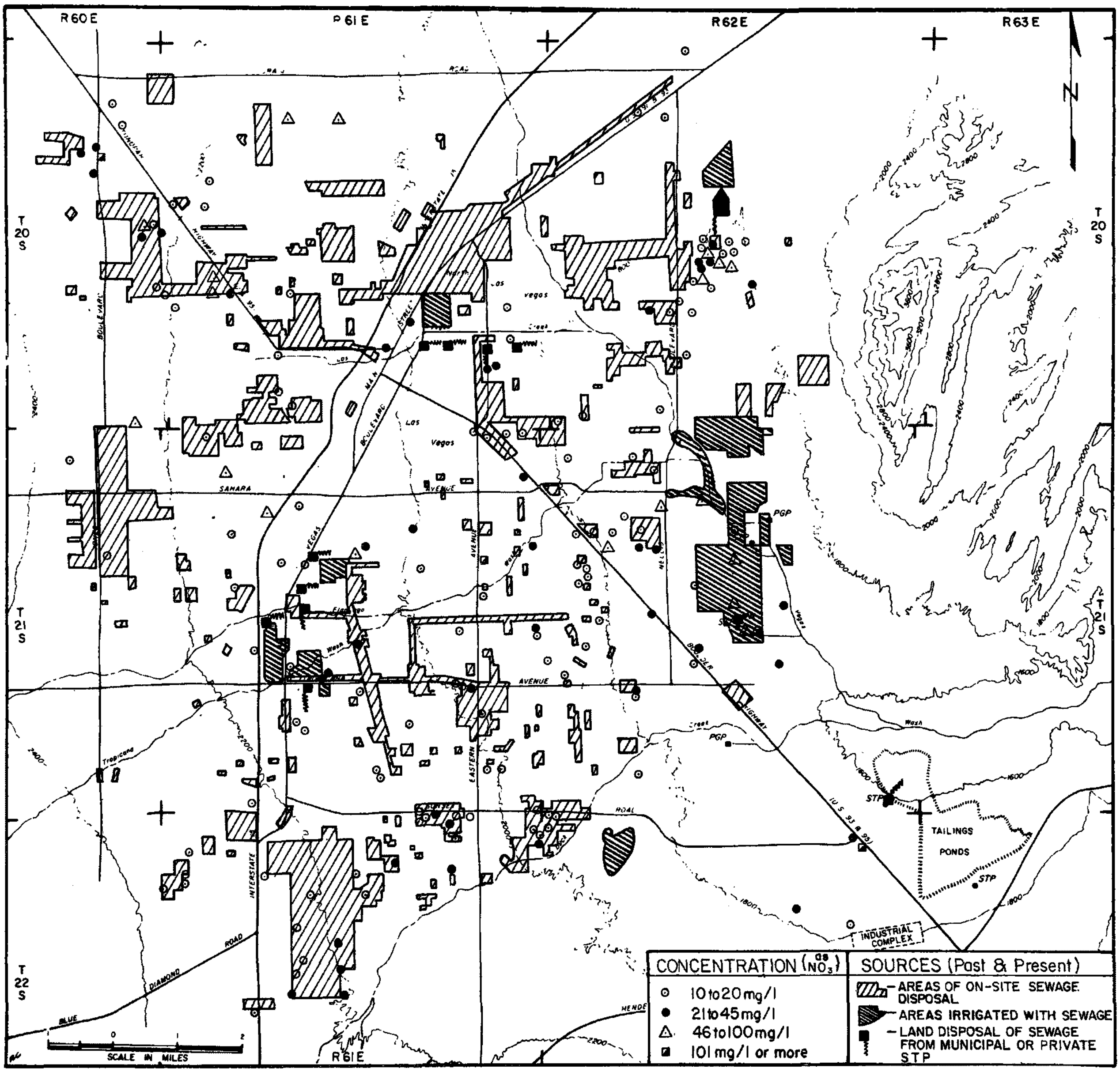


Figure 33. Generalized map showing the sources and concentrations of nitrate in ground water.

feet. As a result, emphasis was placed on sampling natural or man-induced springs and seeps and installing wells that just penetrated the water table. The locations of wells and other sampling points considered to tap shallow ground water to depths of 50 feet are shown in Figure 34.

Water quality and head data from domestic wells 100 feet or less in depth in 20/62-21 indicate shallow high quality water moves into this area from the north and west. Contamination of this water by septic tank leachate, leakage from the Nellis Air Force Base sewage treatment plant (20/62-05db), and return flows from the Base golf course which was irrigated with sewage, is evidenced by nitrate concentrations ranging from 10 to 90 mg/ℓ in 11 of the wells 100 feet or less deep and from 10 to 80 mg/ℓ in wells 101 to 300 feet deep (Figure 33). Septic tanks have been in use in this area since the early 1950's. The Nellis treatment plant was active from 1940 to mid-1971 and treated an average of 0.55 million gallons per day (MGD) from 1958 to 1971. The impact of return flows from an oxidation lagoon providing primary treatment for approximately 50,000 gallons a day (gals/day) of sewage from Lake Mead Base, about a mile northeast of Nellis Air Force Base, is unknown. Another closer source of nitrate is return flow from the leachfield of the Meikle Manor trailer court (20/62-12a) which was established in 1958.

High concentrations of nitrate are common in shallow ground water beneath areas irrigated with or receiving sewage. These include the Winterwood and Paradise Valley Golf Courses, the alfalfa fields in the vicinity of the City and County Sewage Treatment Plants, and the underflow of Las Vegas Wash beginning in the reach where sewage return flows first appear. Values of nitrate beneath such areas are variable, with averages ranging from about 40 to 80 mg/ℓ nitrate, several times greater than typical values associated with domestic wells in areas of septic tanks. For this reason, nitrate polluted ground water downgradient from Nellis Air Force Base is believed to be primarily a result of return flow from the Base sewage treatment plant rather than from septic tanks.

Nitrate data summarized in Table 5 show that, with few exceptions, concentrations of 10 mg/ℓ or more in very shallow ground water are present only at sampling points within or closely proximal to a recognizable source, usually sewage effluent. This is particularly true for the LW series of sampling points (springs and seeps). This association is not true for wells LG098, 100, 106, and 110 where low nitrate is present in areas with septic tanks. Conversely, wells LG109 and 109 are in areas without septic tanks but have nitrate well above background. Infiltration of nitrate enriched runoff from fertilized lawns may be the source. Other sources of nitrate include direct recharge by industrial waste (LG031) or sewage effluent (LG034, 037, 060) and return flows area areas irrigated with sewage effluent (LG099, 129, LW015).

Patterns of TDS distribution in ground water at depths of 51 to 100 feet (the eastern portion of which is shown in Figure 35) and 101 to 300 feet (Figure 21) reflect gradual enrichment eastward across the Valley and rapid increase in the vicinity of Las Vegas Wash. This is believed to demonstrate mainly natural influences on water quality. In contrast, both the hand-contoured (Figure 36) and trend surface maps (Figure 37) for TDS in the interval from 0 to 50 feet indicate large differences in terms of absolute

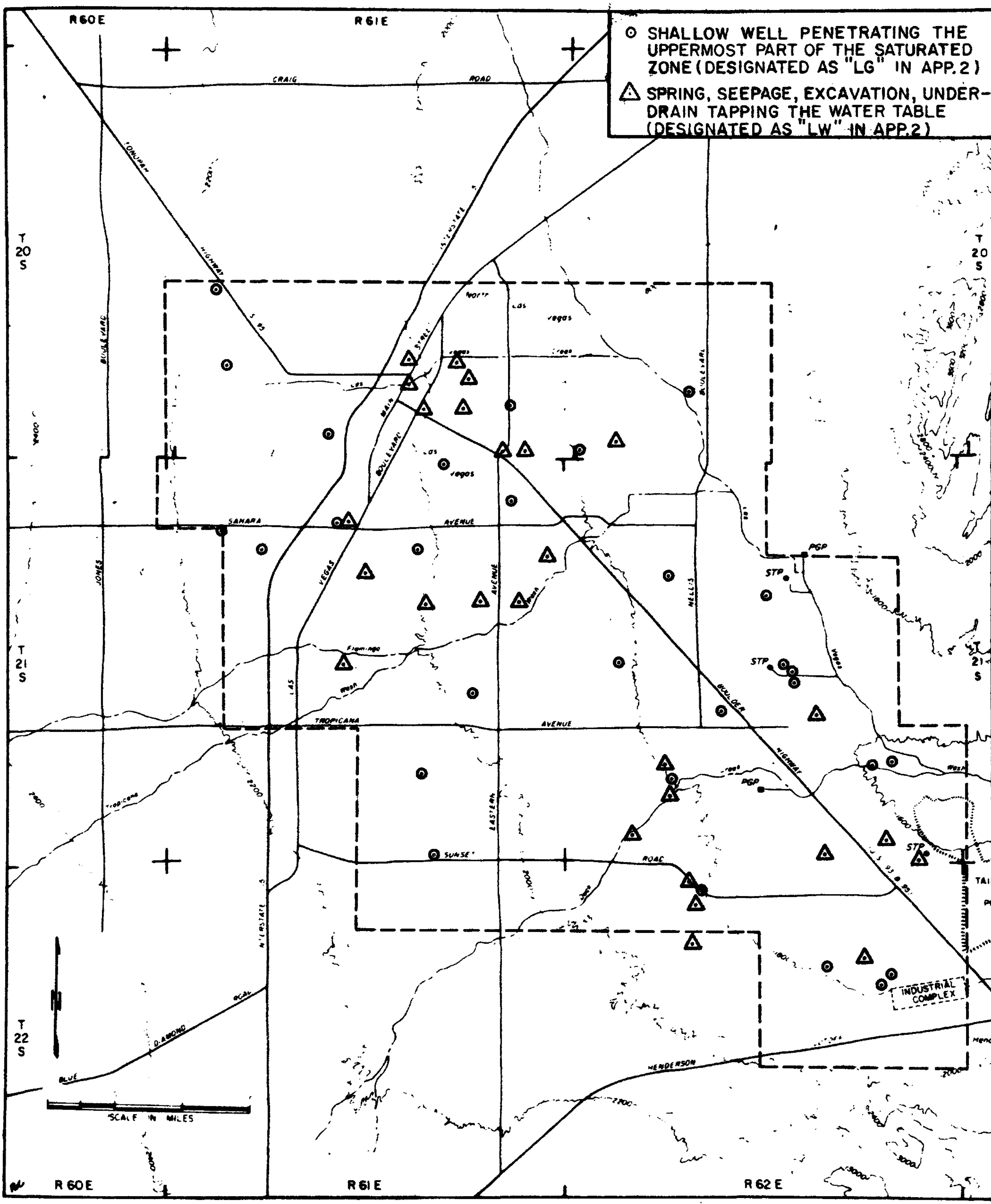


Figure 34. Locations of wells and springs used to characterize ground-water quality at depths of 0 to 50 feet.

TABLE 5. NITRATE CONCENTRATIONS IN SELECTED GROUND-WATER SAMPLES AS RELATED TO NEARBY LAND USE

Sampling Point	Nitrate mg/ℓ NO_3*	Nearby Source†	Remarks
LW 10	(<0.5)	no	
LW 11	(<0.90)	no	
LW 12	(2.1)	no	
LW 13	(<6.99)	no	
LW 14	(<1.47)	no	
LW 15	(17.8)	Paradise Valley Country Club	Golf course irrigated by sewage effluent
LW 19	(<1.17)	no	
LW 20	(<0.6)	no	
LW 31	(<5.01)	possibly	Lawn runoff and possibly some septic tanks
LW 33	(27.0)	possibly	Discharge from tile drain; area to west may have been irrigated with sewage in past
LW 39	(<0.6)	no	
LW 54	(<1.26)	no	
LW 60	<1.19)	no	
LW 72	(3.0)	no	
LW 84	3.3	no	Discharge from spring or tile underdrain
LW 85	8.9	no	
LW 86	9.1	no	
LW 87	13.3	yes	Septic tanks present in area since 1950
LW 88	12.3	yes	Underdrain discharge, inflow partially from area with septic tanks
LW 89	<0.1	no	
LW 90	29.3	yes	Underdrain discharge; inflow from golf course and grassed areas
LW 91	3.4	no	Underdrain discharge; high nitrate expected from a nearby golf course, formerly irrigated with sewage
LW 92	<0.1	no	
LW 94	18.6	yes	Underdrain discharge; nitrate source is unknown
LW 96	(13.2)	yes	Lawn runoff and septic tank leachate
LW 99	12.7	yes	Septic tanks present in the area since 1958
LW100	0.2	no	
LG 30	(1.54)	no	
LG 31	(32.9)	yes	Local recharge by industrial effluent containing nitrate
LG 32	(<1.44)	yes	"
LG 34	(38.6)	yes	Recharged by sewage effluent in Las Vegas Wash
LG 37	(65.3)	yes	Return flow from irrigation with sewage effluent
LG 39	(<0.46)	no	
LG 41	(<0.50)	no	
LG 43	(<0.54)	no	

TABLE 5 (continued)

Sampling Point	Nitrate mg/ℓ NO_3*	Nearby Source†	Remarks
LG 46	(<0.37)	no	
LG 48	(<0.19)	no	
LG 60	(87.6)	yes	Sewage effluent from Clark County STP
LG 98	(0.9)	yes	Background nitrate concentration in return flow despite nearby septic tanks and livestock; three other local wells contain from 17 to 35 mg/ℓ
LG 99	(83.2)	yes	Irrigation return flow; sewage effluent
LG100	(2.1)	yes	Background concentrations are unexpected insofar as the adjacent area contains septic tanks since the 1950's
LG101	(6.6)	possibly	Occasional high nitrate may be irrigation return flow from lawns in the nearby residential development
LG102	(0.57)	no	
LG103	(5.97)	no	
LG104	(93.5)	yes	Rapid increase between April and September may be result of nitrogen fertilizer in runoff from a nearby golf course
LG105	(0.47)	no	
LG106	(0.95)	yes	Background nitrate concentration is present in the return flow despite nearby septic tanks in use since the 1950's; 8 local wells contain 10 to 38 mg/ℓ NO_3
LG107	(1.17)	no	
LG108	(61.7)	possibly	Source of high nitrate is possibly runoff from lawns in nearby development; recent recharge is indicated by a concentration of 16.4 TU in shallow water table
LG109	(43.2)	possibly	Same comments as above; no tritium data collected
LG110	(1.52)	yes	Area contained septic tanks since the early 1940's and shallow ground water has 16.3 TU indicating some recent recharge; lack of nitrate unexplained
LG128	91.0	yes	Return flow from an area irrigated with sewage effluent
LG129	9.3	no	
LG138	40.0	possibly	Sample collected from very shallow water table downgradient from International Hotel golf course
LG139	52.0	yes	Septic tanks

* The values shown are from one-time grab samples except for averaged data shown in parentheses. All chemical data are from Appendix 3.

† Land use patterns summarized by Patt (1977) were examined to determine if a source of nitrate could be identified in the immediate area (of the well or spring) or in the area hydraulically upgradient therefrom.

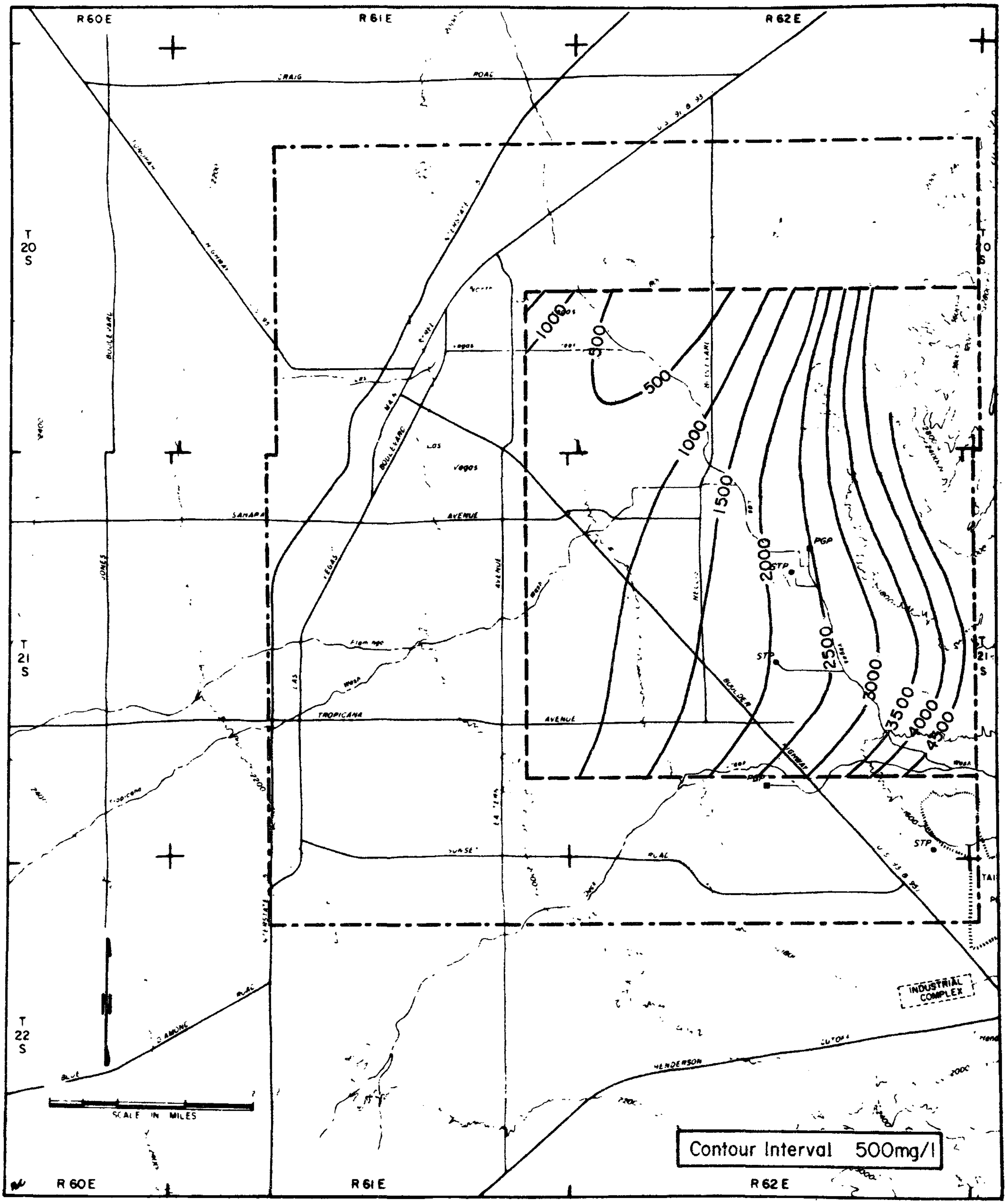


Figure 35. Fifth degree trend surface for total dissolved solids in ground water at depths of 51 to 100 feet.

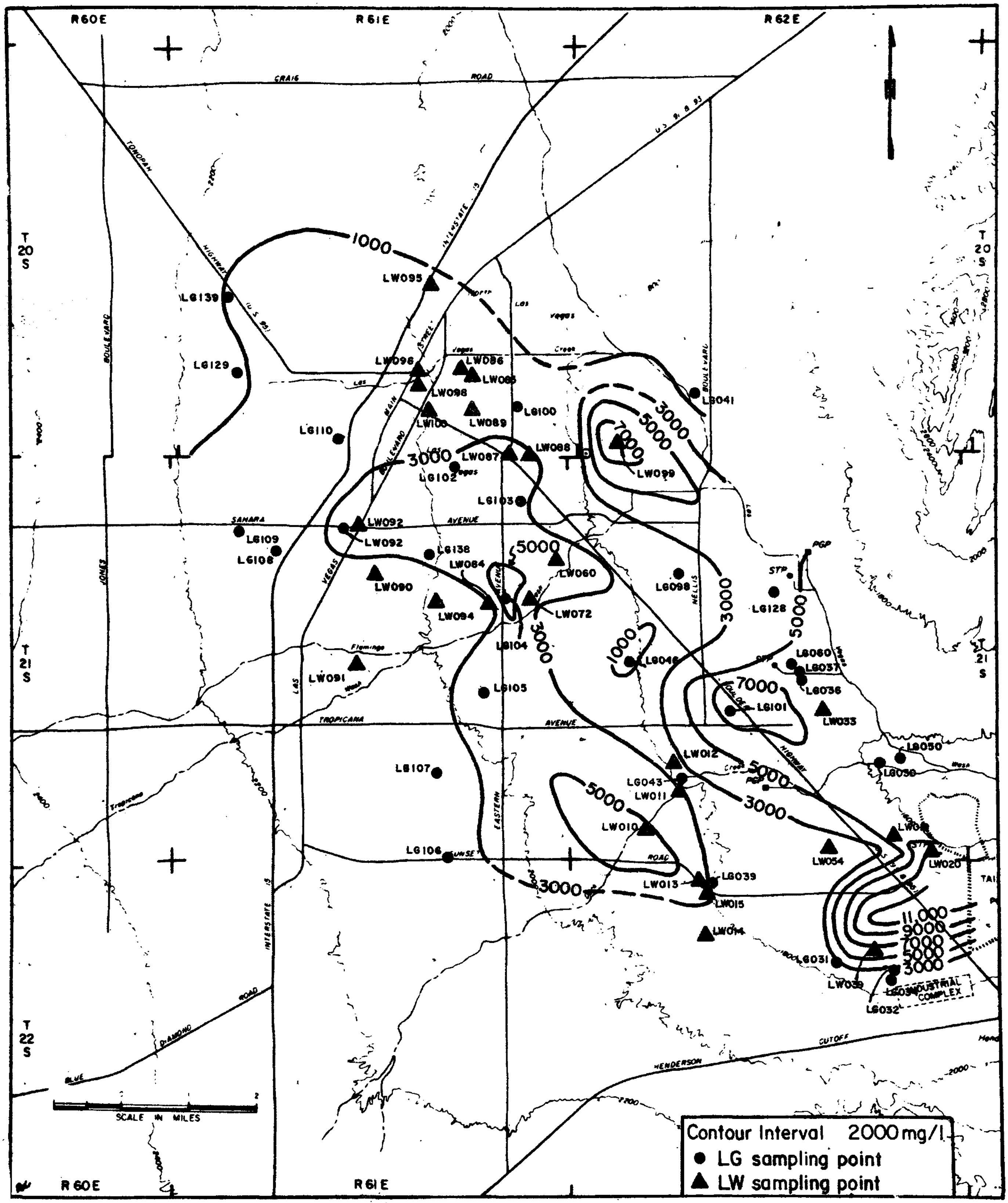


Figure 36. Distribution of total dissolved solids in ground water at depths of 0 to 50 feet (manually contoured).

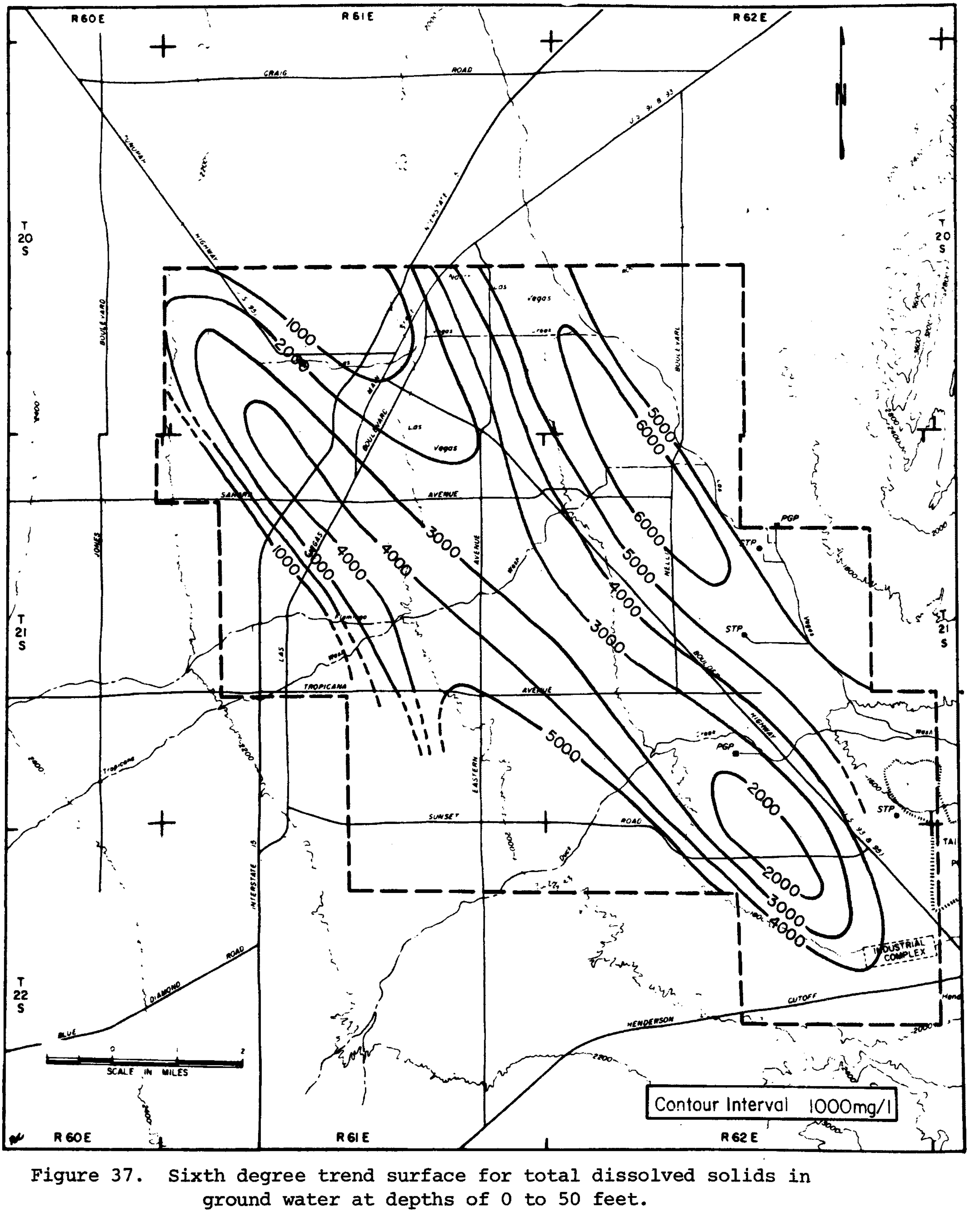


Figure 37. Sixth degree trend surface for total dissolved solids in ground water at depths of 0 to 50 feet.

concentrations and pattern or regularity. The trend surface shows that mineralized waters occur near parallel, northwest trending highs located across 1) Paradise Valley, the Las Vegas Strip and the BMI complex, and 2) the northeastern portions of the urbanized area. In the western, northern, and northeastern portions of the study area, about 1,000 mg/ℓ TDS may constitute the ambient condition. Increasing mineralization along the flow path is evident as TDS reaches 3,000 mg/ℓ within a few miles. This increase is, in part, a result of natural factors, including the presence of mineralized soils and concentrating effects of evapotranspiration. Human influence may be indicated by peak concentrations of TDS which occur in patterns roughly coincidental with previous sewage disposal in the area of the Las Vegas Strip, in part of the upper reach of Las Vegas Wash in the vicinity of old and recent sewage disposal areas or areas irrigated with sewage, and in the southeastern part of the Valley near the BMI complex. Return flows from nonpoint urban and suburban sources solubilize salts formerly deposited in the shallow soil profile by discharging ground water. The magnitude of change in water quality is poorly defined but is expected to be sizeable, particularly in the eastern third of the Valley where saline soils are highly developed and where ground-water levels are closest to the land surface. Presence of sanitary wastes in shallow ground water is already indicated by chloride and nitrate, in particular.

Chloride at depths of 0 to 50 feet (Figure 38) increases in concentration from about fifty mg/ℓ northwest of the urban area to between 500 and 1,000 mg/ℓ in the upper reaches of Las Vegas Wash. Concentrations at stations LW019, LW020, LG031, and LG050 are noticeably higher than the regional trend due to the presence of industrial wastewater return flows in the shallow aquifer. From 1971 through 1973, waste discharges from the BMI complex exhibited a wide range in chloride concentrations (178 to 168,310 mg/ℓ). An average value is difficult to define but is probably at least 5,000 mg/ℓ and, therefore, well above background. This influences the concentration gradients for chloride in the very shallow aquifer in the southeastern part of the Valley.

UTILITY OF THE TREND SURFACE TECHNIQUE

Trend surfaces and statistics for various depth intervals proved useful for evaluating and portraying lateral ground-water quality variations and the degree of variability. Judgements are made in rejecting anomalous raw data and in comparing plots of raw data to determine what order surface provides the "best fit." Effects of such judgements were apparent, as evidenced by the increased value of the correlation coefficient derived from selected versus raw data (Table 6). Nevertheless, if there was poor initial correlation (in the case of magnesium, chloride and nitrate for the interval from 101 to 300 feet) little change was effected in the coefficient following the data selection procedure.

The highest correlation coefficient was generally associated with the sixth order surface, but only in a few instances was this surface judged the best indicator of overall trends. This decision was made on the basis of visual comparison of various surfaces with plots of the actual data. Absolute values of the coefficients were indicative of the order or trend, or lack thereof, in the data.

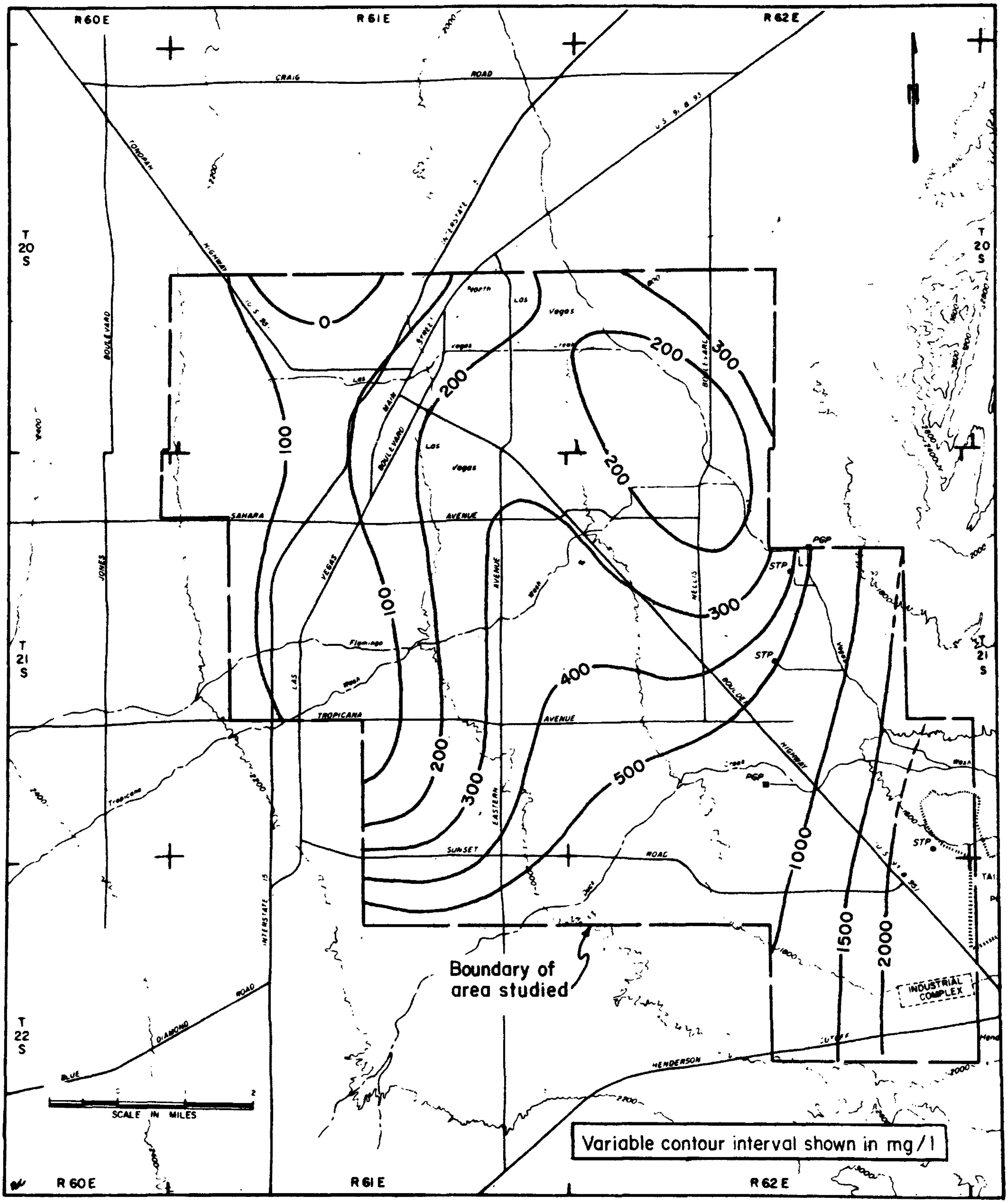


Figure 38. Fourth degree trend surface for chloride in ground water at depths of 0 to 50 feet.

TABLE 6. SUMMARY OF CORRELATION COEFFICIENTS FOR THE TREND SURFACES

Depth (feet) From	To	Surface Order	Ca	Mg	Parameter SO_4	Cl	NO_3	TDS
0	50	1			.285	.531	.049	.516
					(.302)	(.705)	(.032)	(.538)
		2			.424	.650	.158	.536
					(.510)	(.834)	(.424)	(.604)
		3			.506	.687	.468	.601
					(.525)	(.886)	(.552)	(.618)
		4			.558	.707	.684	.625
					(.500)	(.909)	(.697)	(.608)
		5			.517	.698	.686	.619
					(.510)	(.904)	(.696)	(.602)
		6			.599	.688	.683	.611
					(.581)	(.932)	(.704)	(.665)
51	100	1	.432	.306	.469	.451	.134	.486
		2	.672	.511	.687	.711	.249	.737
		3	.694	.547	.709	.829	.441	.769
		4	.741	.660	.755	.857	.500	.785
		5	.743	.668	.760	.882	.627	.798
		6	.744	.674	.763	.905	.651	.805
101	300	1	.466	.294	.427	.375	.022	.424
			(.530)	(.365)	(.513)	(.377)	(.128)	(.500)
		2	.516	.367	.498	.434	.096	.483
			(.589)	(.425)	(.587)	(.440)	(.252)	(.582)
		3	.554	.409	.530	.452	.185	.499
			(.626)	(.481)	(.635)	(.468)	(.355)	(.619)
		4	.581	.427	.548	.466	.232	.518
			(.669)	(.521)	(.673)	(.477)	(.437)	(.656)
		5	.593	.429	.553	.480	.235	.524
			(.587)	(.486)	(.583)	(.474)	(.201)	(.628)
		6	.586	.320	.465	.327	.142	.346
			(.671)	(.502)	(.657)	(.039)	(.246)	(.670)

Note: Numbers in parentheses derived after removing anomalous data and using no more than one analysis per location.

Several shortcomings in the use of trend surfaces and their statistics to display ground-water quality variations were apparent. For the present study, at least, there was an inverse relationship between the amount of data and the "goodness of fit" for a given surface and parameter. Similar results were reported by Rockaway and Johnson (1967) in their analysis of water level data. For example, the interval from 0 to 50 feet had fewer data points, generally resulting in a higher correlation coefficient compared to the intervals from 51 to 100 and 101 to 300 feet. This erroneously indicated there was greater regularity or order in the very shallow system when in fact the opposite was true.

High data values for nitrate and chloride at depths of 0 to 50 feet were consistently associated with sanitary and industrial wastes in the eastern part of the Valley. Away from areas of waste disposal and for most samples collected below a depth of 50 feet, nitrate is 5 mg/ℓ or less and this is considered background. Where well depths exceeded 50 feet or were unknown, the chemical data were not used in the trend surface portrayals for the interval 0 to 50 feet. The combination of few data points and the association of high nitrate in areas of waste disposal, therefore, partially accounted for the high (0.704) correlation coefficient for the interval from 0 to 50 feet versus only 0.246 for the interval from 101 to 300 feet. The low coefficient of correlation for nitrate at depths of 101 to 300 feet suggests very little variation, i.e., background conditions, whereas in the shallow aquifer there is obviously a high positive correlation that can be attributed to urbanization.

Another weakness clearly demonstrated by some of the trend surfaces was that the best fit to the available data frequently had unrealistic values in marginal areas where data were scarce or nonexistent. This even resulted in negative values (see examples, Figure 31 and 32), which indicated failure of the surface to "fit" the actual data. Perhaps a final problem of using the technique was the tendency for misunderstanding the difference between a trend surface and maps or surfaces manually contoured from real data. Whereas both approaches showed concentration increase or decrease, trend surfaces did not always clearly express true values and local deviations.

ANALYSIS OF TEMPORAL CHANGES IN GROUND-WATER QUALITY

Description of Study Method and Data Base

Ground-water quality data from previous studies by Carpenter (1915), Hardman and Miller (1934), Maxey and Jameson (1948), and Malmberg (1965) were supplemented with analyses collected during the study to determine if significant changes had occurred with time. The chemical data, well characteristics, and sampling locations are shown in Appendices 4 and 5, and Figure 39, respectively. An unpublished survey made by L. Reed of the Desert Research Institute to determine chemical stratification in ground water and unpublished work for the Nevada State Engineer by Domenico and Maxey (1964) were also referred to. The latter contained data and conclusions concerning changes in ground-water quality in the period from the early 1940's to 1963. Prior to the present study, this was the only attempt to document temporal change in ground-water quality in the Valley. From comparisons of chemical data from 1942-1944 and 1963, Domenico and Maxey (1964) concluded quality had not

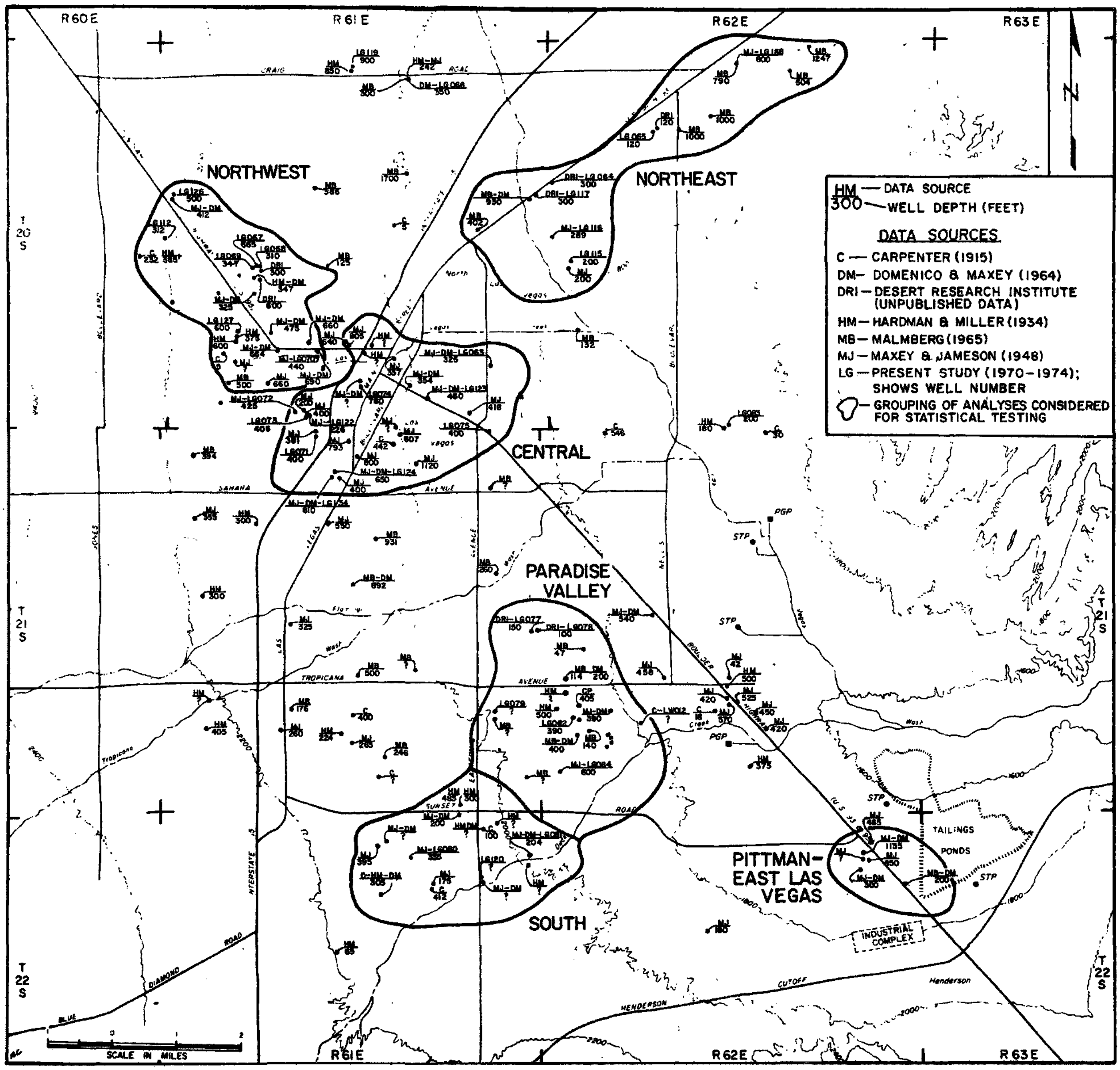


Figure 39. Locations of wells sampled between 1915 and 1972.

deteriorated in the areas of major withdrawals but there was evidence of deterioration in the southern and southwestern parts of the Valley.

Beginning in 1962, the District Health Department began an extensive ground-water sampling program to ascertain the quality of public and private potable water supplies in Clark County, with emphasis on Las Vegas Valley. Data from this program, which was most active from 1968-1972, were extremely valuable to the present study in defining spatial variations in water quality attributable to land and water use patterns and natural hydrogeologic conditions.

In contrast, there are few historical data to ascertain temporal changes. Excluding: 1) recent (1969-present) analyses from producing wells in the Las Vegas Valley Water District and North Las Vegas well fields, 2) water quality data collected by the Health Department, and 3) the present study, there are approximately 412 analyses extending over the period 1921-1967. The analyses extend over an area of 150 square miles and were collected from wells ranging from 8 to 1,700 feet deep.

Tables 7 and 8, respectively, summarize the depth intervals sampled for the various townships and periods of sampling for the same areas. Table 7 shows that 44 percent of historical water quality data prior to 1968 pertain to wells of unspecified or unknown depth. Therefore, much of their scientific value is lost. Furthermore, only 2 percent of available analyses document very shallow water quality in the 0 to 100 foot depth interval whereas 22 percent are from wells deeper than 400 feet. The remaining 32 percent of the analyses are from wells ranging in depth from 101 to 400 feet. In townships 21/62 and 22/62, deteriorating ground-water quality from return flows and solution of evaporites from a rising water table are difficult to document because there are essentially no chemical data for the unconfined aquifer. Townships 20/60, 21/60, and 22/60 similarly are devoid of baseline water quality data, hence changes in the system, from a multitude of causes, are and will continue to be extremely difficult to document.

Historical records for all depth intervals are noticeably absent in 20/60, 21/60, and 22/60. The impact of this shortcoming may be substantial considering the rapid urbanization underway in the eastern portions of 20/60 and 21/60. For 20/61, 21/61, and 22/61, data extend over a period of approximately 45 years. However, paucity of analyses makes it difficult to define the chemical state of the system at given points or certain periods. With the exception of 20/61, 21/61, 21/62, and 22/61, nothing is known about historical ground-water quality prior to the 1955 to 1962 period. Since the early 1940's sewage and industrial wastes were deliberately allowed to infiltrate in 20/62, 21/62, and 22/62 with essentially no monitoring data.

A recognized shortcoming of the approach chosen to compare historical trends in water quality was the comparison of wells of greatly varying depths that, in all likelihood, tapped different aquifers. To overcome this, analyses would have to be additionally segregated by well depth thereby further reducing each sample group and, in turn, degrees of freedom.

As stated earlier, previously sampled wells were field located or substitute wells constructed to provide recent chemical data for comparison with

TABLE 7. NUMBER AND DISTRIBUTION OF CHEMICAL ANALYSES OF GROUND WATER FOR THE PERIOD 1912-1967 INCLUSIVE

	Total number of analyses	Well Depth Range (in feet)											
		Unknown		0-100		101-200		201-300		301-400		401+	
Township	1912-1967	#	%	#	%	#	%	#	%	#	%	#	%
20/60	12	5	41	0	0	3	25	1	8	2	16	1	8
20/61	61	14	23	0	0	0	0	0	0	14	23	33	54
20/62	67	27	40	6	9	16	24	9	13	2	3	7	10
21/60	9	3	33	0	0	0	0	5	55	0		1	10
21/61	124	61	49	2	2	10	8	13	10	9	7	29	23
21/62	40	20	41	0	0	9	18	1	2	6	12	13	27
22/60	NO CHEMICAL DATA COLLECTED PRIOR TO 1968												
22/61	68	39	57	1	1	10	15	9	13	5	7	4	5
22/62	22	12	55	0	0	5	23	3	14	0	0	2	9
TOTAL	412	181	44	9	2	53	13	41	10	38	9	90	22

TABLE 8. YEAR AND LOCATION OF CHEMICAL ANALYSES OF GROUND WATER FOR THE PERIOD 1912-1967 INCLUSIVE

	Township								
Year	20/60	20/61	20/62	21/60	21/61	21/62	22/60	22/61	22/62
1912	1	2			1	2		3	
1926								1	
1927		1			2				
1929						1			
1930					3			1	
1931		3							
1932		2							
1934		2			1				
1935					1				
1938		1							
1941		3	1		2			1	
1942		1				14		2	1
1943					1				
1944		6			3			3	
1945		9	3		6	1		2	3
1946						2			
1947		3			9	4			
1951		1							
1952		1							
1953					1				
1955			1						
1956		3	4						
1957						2			
1962	2	11	5	3	18	1		9	5
1963		6	7		20	6		14	2
1964		2	7		10	1		10	1
1965	2	3	3	2	9	3		4	
1966	1	6	10	2	19	1		9	6
1967	5	4	24	1	15	9		9	3
Sub-Total	11	70	65	8	121	48		68	22
TOTAL	412								

historical analyses. Pertinent data concerning both the original and substitute wells are shown in Appendix 5. There are inconsistencies in determining and reporting TDS concentrations in previous studies. This parameter was recalculated and presented as the sum of the principal ionic constituents, with bicarbonate expressed as carbonate, following the conversion specified in Hem (1970). Table 9 summarizes how TDS was determined in previous studies and how the original data are presented in Appendix 4. For consistency all historical and recent data in this report show TDS calculated by summation, with bicarbonate converted to carbonate.

TABLE 9. METHODS USED TO DETERMINE TOTAL DISSOLVED SOLIDS IN PREVIOUS STUDIES

Reference	Original determination	Original value presented in Appendix 4 under heading:
Carpenter, 1915	Residue on evaporation	Evaporation
Hardman and Miller, 1934	Residue on evaporation	Evaporation
Maxey and Jameson, 1948	Summation of dissolved constituents without conversion of bicarbonate to carbonate	Total
Desert Research Institute, 1963 (unpublished data)	Summation of dissolved constituents without conversion of bicarbonate to carbonate	Total
Domenico and Maxey, 1964	Residue on evaporation	Evaporation
Malmberg, 1965	1. Analyses by U.S. Geological Survey reported residue upon evaporation at 180°C	Evaporation
	2. Analyses by University of Nevada, Reno calculated total dissolved solids from specific conductance and as residue upon evaporation	Total

Groupings of wells in various parts of the Valley for which historical chemical data are available are shown in Figure 39. Groups were selected using criteria of: 1) generally similar hydrogeologic and water quality conditions within each area; 2) sufficient number of wells to constitute a minimal sample size for statistical tests; and 3) different time periods in which changes in water quality could be compared.

Within each areal grouping of historical ground-water quality data, the values for TDS and chloride were analyzed for temporal change by means of two nonparametric tests, the Mann-Whitney test and, in cases where sufficient data were present, the Kruskal-Wallis test for one-way analysis of variance. Nonparametric statistical techniques were chosen because of uncertainty concerning the normality of the sample distribution, the sample size, and the fact that data were not on interval or ratio scale. Detailed explanation of the tests and their application to hydrogeological problems are found in Siegel (1956) and Siddiqui and Parizek (1972), respectively.

The Mann-Whitney test was used to evaluate whether two independent samples of chemical data from the same general area of the Valley, but from different time periods, belonged to the same population. A two-tailed test at the five percent level of significance was specified and compared to the probability associated with the test statistic, U or z. The raw chemical data are arranged in ascending order, assigned ranks and then the latter are grouped according to year to calculate the statistic U using either of the following:

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

or

$$U = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - R_2$$

where R_1 = sum of the ranks assigned to the group with sample size n_1

R_2 = sum of the ranks assigned to the group with sample size n_2

Depending on the values for n_1 and n_2, either critical values of U or probabilities associated with the observed U are used to accept or reject the null hypothesis at the preset level for α. If the larger group (n_2) exceeds 20, U is calculated as shown and then used to determine z:

$$z = \frac{U - (n_1 n_2)/2}{\sqrt{\frac{(n_1)(n_2)(n_1 + n_2 + 1)}{12}}}$$

which is almost normally distributed with zero mean and unit variance (Siegel, 1956). Tabular values of probability associated with the observed value of z are compared with the previously set level of significance ($\alpha = 0.05$) to accept or reject the null hypothesis.

The Kruskal-Wallis one-way analysis of variance by ranks, tests whether k independent samples are from the same population. As in the case of the Mann-Whitney test, the null hypothesis states the k samples are from the same population. That is, the differences among samples are either genuine population differences or they are chance variations likely to occur among random samples. In the Kruskal-Wallis test, three or more groups of data are tested, whereas the Mann-Whitney test compares two groups at a time.

The H statistic used in the Kruskal-Wallis test is defined as follows:

$$H = \frac{12}{N(N + 1)} \sum_{j=1}^{k} \frac{R_j^2}{n_j} - 3(N + 1)$$

where R = number of samples

n_j = number of cases in the jth sample

$N = \Sigma\ n_j$; the total number of observations

j = sum of ranks in jth sample (column)

$\sum_{j=1}^{k}$ = sum over the k samples (columns)

Where the k samples are from the same population or identical populations, H_o is true. H is distributed as Chi square (χ^2) with N-1 degrees of freedom (df).

Significance of Test Results

Initial results of the Mann-Whitney test are presented in Table 10 for each subarea of the Valley containing sufficient analyses for comparison purposes. Values for TDS and chloride from previous studies were compared to see if statistically significant changes occurred between each time period. For the time periods and depths considered (range 8 to 1,700 feet; mean 468 feet, standard deviation 262 feet), essentially no significant change in ground-water quality from 1912 to present is shown to have occured anywhere in the Valley. At first glance this may demonstrate the slowness with which a large, heavily developed ground-water reservoir exhibits change in water quality due to a variety of stresses. It is the author's contention that insufficient data exist to depict change and that the tests, in fact, are not diagnostic.

In a second attempt to test the data and to reduce the shortcomings inherent in statistical testing with a sparse data base, larger sample sizes were generated for the six subareas by grouping and comparing the available chemical data for the periods 1912 to 1945 and 1962 to 1972. This grouping is hydrologically justified in the northwest and central areas. Although the period prior to 1946 was characterized by gradually increasing ground-water withdrawal, overdraft did not occur (Maxey and Jameson, 1948). Recharge to the deeper, artesian aquifers was believed to be primarily by lateral inflow without significant vertical leakage from the shallow aquifer. Similarly, chemical data for the period 1962 to 1972 represents different hydrologic conditions in that overdraft conditions are believed to have prevailed since 1946 and significantly since 1962, when 55,500 acre feet of water were pumped. Peak pumpage of 70,000 acre feet occurred in 1973. Since 1971 there has been a gradual decline in ground-water withdrawal by the Las Vegas Valley Water District because Lake Mead water became more widely available with completion of Stage I of the Southern Nevada Water Project.

TABLE 10. SUMMARY OF THE MANN-WHITNEY TEST RESULTS TO EVALUATE HISTORICAL CHANGES IN GROUND-WATER QUALITY

Area: NORTHWEST

Sampling Date	1912	1934	1942	1947	1962	1968	1972
1912			NS / S		NS / S		NS / S
1934			NS / NS	NS / NS	NS / NS		NS / NS
1942				NS / NS	NS / NS		NS / NS
1947							NS / NS
1962						NS / NS	NS / NS
1968							NS / NS

Area: SOUTH

Sampling Date	1912	1934	1942	1947	1962	1968	1972
1912			NS / NS	NS / NS	NS / NS		NS / NS
1934				NS / NS			NS / NS
1942				NS / NS			NS / NS
1947						NS / NS	NS / NS
1962						NS / NS	NS / NS
1968							NS / NS

Area: CENTRAL

Sampling Date	1912	1934	1942	1947	1962	1968	1972
1912			NS / NS				
1934			NS / NS		NS / NS		S / NS
1942					NS / NS		NS / NS
1947							
1962							NS / NS
1968							

Area: NORTHEAST

Sampling Date	1912	1934	1942	1947	1962	1968	1972
1912							
1934							
1942				NS / NS	NS / NS	NS / NS	NS / NS
1947					NS / NS	NS / NS	NS / NS
1962						NS / NS	NS / NS
1968							NS / S

Area: PARADISE VALLEY

Sampling Date	1912	1934	1942	1947	1962	1968	1972
1912		NS / NS	NS / NS		NS / NS		NS / NS
1934					NS / NS		NS / NS
1942					NS / NS		NS / NS
1947							
1962							NS / NS
1968							

Area: PITTMAN-EAST LAS VEGAS

Sampling Date	1912	1934	1942	1947	1962	1968	1972
1912							
1934							
1942				NS / NS	NS / NS		
1947					NS / NS		
1962							
1968							

Notations "NS" and "S" indicate not significant or significant, respectively, and refer to observations for the paired year groups considered. Blanks indicate no data or insufficient data for test. Values in the upper left and lower right of each box refer to TDS and chloride, respectively.

Results of testing for various subareas delineated in Figure 39 are shown in Table 11. Significant change in TDS and chloride has occurred in the northwest area. Deteriorating water quality through time is indicated by increased mean values of 118 and 21.2 mg/ℓ for TDS and chloride, respectively. In the central area, significant change did not occur. Despite the absence of statistically significant change, TDS and chloride increased 83 and 11.6 mg/ℓ, respectively. The central area has not been the locus of heavy pumping because high yield wells are uncommon and water quality is less satisfactory than in the main well fields to the west and northwest. Changes in ground-water quality may be a result of induced lateral or vertical influx of poorer quality water.

TABLE 11. RESULTS OF THE MANN-WHITNEY TEST TO DETERMINE SIGNIFICANT CHANGE IN GROUND-WATER QUALITY FOR THE PERIODS 1912-1945 AND 1962-1972

Area	Parameter	1912-1945 # samples	1962-1972 # samples	Statistic values U_c	U_t	Z_c	Z_t	Result*
Northwest	TDS	17	19	77	99			S
	Cl	17	19	83	99			S
Central	TDS	24	16			1.19	1.28	NS
	Cl	24	16			0.36	1.28	NS
Paradise Valley	TDS	16	9	58	37			NS
	Cl	16	9	57	37			NS
South	TDS	8	12	47	22			NS
	Cl	8	12	42	22			NS
Northeast	TDS	3	10	12	3			NS
	Cl	3	10	2	3			S
Pittman-East Las Vegas	TDS	5	3	5	0.572			NS
	Cl	5	3	7	1			NS

* S = Significant; NS = Not Significant; α 0.05.

With the exception of chloride in the northeast area, analyses from the remaining four areas (Paradise Valley, south, northeast and Pittman-East Las Vegas) showed no significant change in water quality. Considering the small sample sizes for the northeast, the change in chloride may simply be coincidental.

The general lack of significant change compared to constituent increases in the northwest and central areas suggests only minor hydraulic response of the shallow aquifers as a result of local and valley-wide water use patterns through time. In general, the long term trend in the other four areas cited has involved reduction of artesian head due to overdraft elsewhere in the Valley. Typically, development of single family domestic ground-water supplies has been the rule, although in the past there was irrigated agriculture in Paradise Valley involving both flowing and pumped wells (Maxey and Jameson, 1948). In the vicinity of East Las Vegas, a slight increase in artesian pressure was observed in the period 1952 to 1964 (Domenico, et al., 1964). Marked changes in head and reversals of flow gradients between confined and water table aquifers, as is the case in the western part of the Valley, are not evident. Rather, the greatest hydraulic and water quality responses are due to increased irrigation return flow and infiltration of sanitary and industrial waste representing additions to shallow ground-water storage (Kaufmann, 1971; Westphal and Nork, 1972). An adequate number of shallow sampling points does not exist to monitor expected changes over time.

Table 12 summarizes Kruskal-Wallis test results for TDS and chloride concentrations in selected areas (see Figure 39). The probabilities shown in column 5 are tabular values (Siegel, 1956) associated with the observed value of H for two degrees of freedom. In all cases the observed values of H with two degrees of freedom have a probability of occurrence greater than the preset level of significance (α) of 0.05. Therefore, the result was to accept the null hypothesis that samples are from the same population, i.e., no significant change in ground-water quality has occurred.

TABLE 12. RESULTS OF THE KRUSKALL-WALLIS TEST TO DETERMINE SIGNIFICANT CHANGE IN GROUND-WATER QUALITY FOR PERIOD 1944-1972

Area	Years Considered	Parameter	H Statistic	Probability associated with H	Result*
Northwest	1944-1963-1972	TDS	5.46	~ 0.069	NS
		Cl	3.446	$.10<p<.20$	NS
Central	1944-1963-1972	TDS	3.14	$.2<p<.30$	NS
		Cl	1.79	$.3<p<.5$	NS
South	1956-1963-1972†	TDS	2.14	$.129<p$	NS
		Cl	3.00	$.129<p$	NS
Paradise Valley	1944-1963-1972†	TDS	1.01	$.105<p$	NS
		Cl	3.17	$.105<p$	NS
Pittman-E. Las Vegas	1944-1963-1972†	TDS	0.66	$.123<p$	NS
		Cl	1.06	$.123<p$	NS

* NS = Not Significant; $\alpha = 0.05$; df =2.

† Considering only wells less than 300 feet or less in depth.

UTILITY OF THE DATA STORAGE AND RETRIEVAL SYSTEM

Two examples of the versatility of the water quality data storage and retrieval system developed to meet study objectives are described below. To determine where ground-water quality in the depth interval from 101 to 300 feet does not meet the U. S. Public Health Service (1962) drinking water standards for sulfate (250 mg/ℓ) and TDS (1,000 mg/ℓ), a plot (Figure 40) was prepared which shows the location of the wells and the parameters involved. An arbitrary limit of 500 mg/ℓ for hardness was set on the basis of comments in McKee and Wolf (1973).

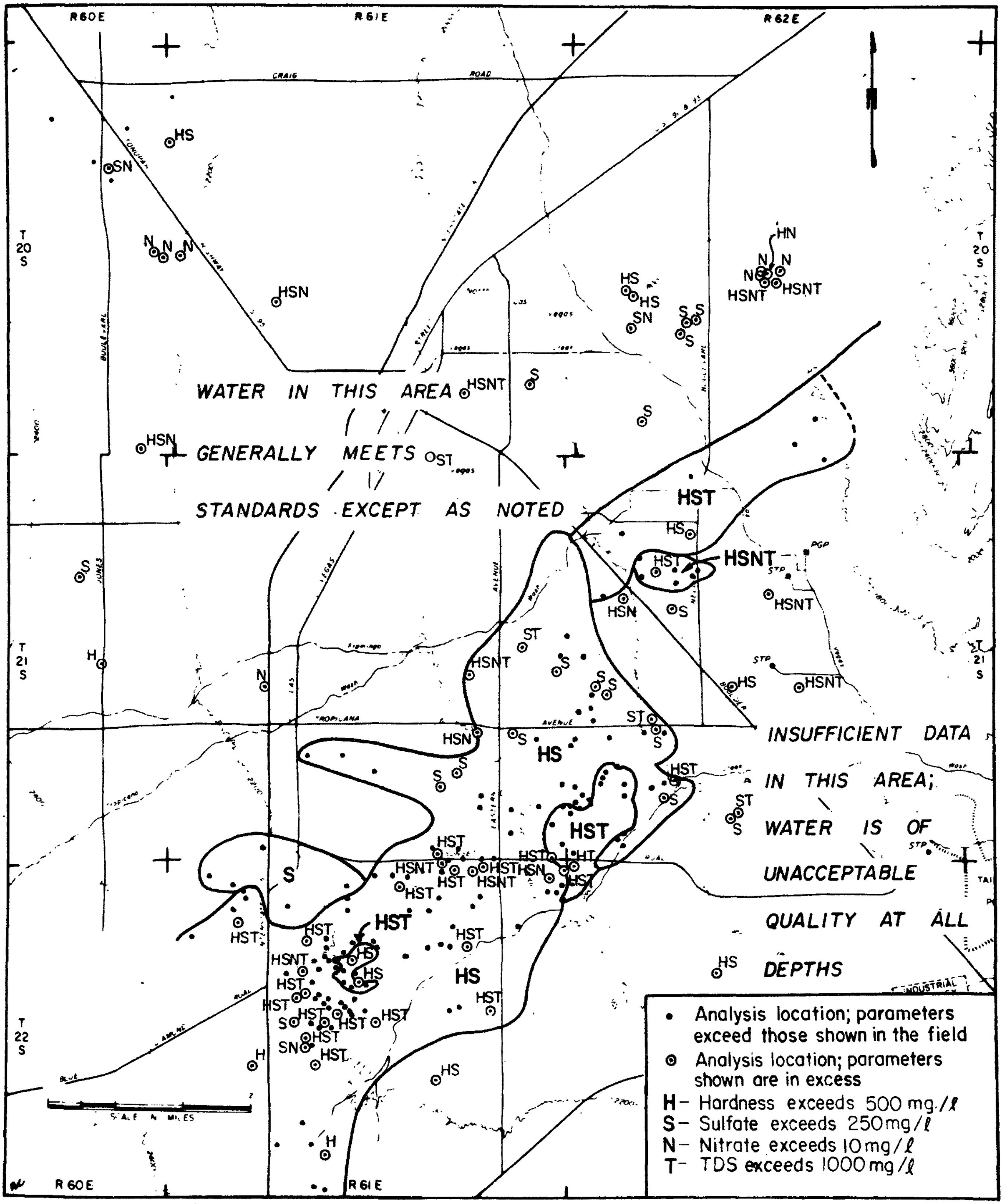


Figure 40. Locations of wells 101 to 300 feet deep with inferior water quality.

A nitrate threshold of 10 mg/ℓ was chosen because concentrations at depths of 101 to 300 feet are normally below 10 mg/ℓ. Thus, although nitrate concentrations to data rarely exceed the maximum permissible limit (45 mg/ℓ) in drinking water, nitrate trends shown in Figure 40 are believed indicative of areas where bacterial contaminants or dangerous nitrate concentrations are most likely. This is particularly true of areas served by shallow domestic wells and septic tank systems as in 20/61, 20/62, 21/62, and 22/61.

Hardness, sulfate and TDS are the most common parameters exceeding the recommended levels in the Valley and are probably the result of natural factors. For example, excessive hardness and sulfate generally coincide with the Duck Creek drainage area in Paradise Valley, an area of gypsiferous soils, high evapotranspiration and poor to moderately permeable sediments. As expected, wells with excessive TDS are located farther eastward, i.e., in the downgradient position of the flow system. In 21/62, high TDS is associated either with high nitrate or is present along the extreme eastern edge of the study area. The association with nitrate is considered indicative of infiltrated sewage effluent and(or) septic tank leachate whereas minimal recharge and highly gypsiferous sediments on the flanks of the Frenchman Mountain block could account for hardness-sulfate-TDS association.

Further utility of the data bank created in the course of the study can be seen in Figure 41 which was generalized from a computer generated plot of water analyses classified as to hydrochemical facies. The hydrochemical facies concept was developed by Chebotarev (1955 a, b, c) and utilized by Back (1961 and 1966) and Seaber (1965) in studies of ground-water quality in the Atlantic Coastal Plain. Briefly, 16 possible facies are identified on the basis of relative concentration (in milliequivalents/liter) of the principal ions expressed as a percentage of total anions and total cations (Table 13). For example, water containing 90 percent or more of sodium + potassium cations and 90 percent or more bicarbonate + carbonate anions is defined as belonging to the sodium + potassium: bicarbonate + carbonate facies. Chemical facies are a result of lithologic variations along the flow path, residence time in the flow system, and changes in mineral composition along the flow path due to solubility, ion exchange, precipitation, etc.

TABLE 13. CLASSIFICATION OF HYDROCHEMICAL FACIES
(adapted from Back, 1961 and Seaber, 1965)

Anion facies	Range in HCO_3+CO_3 content (as % of total anions)	Range in $Cl+SO_4$ content (as % of total anions)
HCO_3+CO_3	90-100	0-<10
HCO_3, $Cl+SO_4$	50-<90	10-<50
$Cl+SO_4$, HCO_3	10-<50	50-<90
$Cl+SO_4$	0-<10	90-100

TABLE 13 (continued)

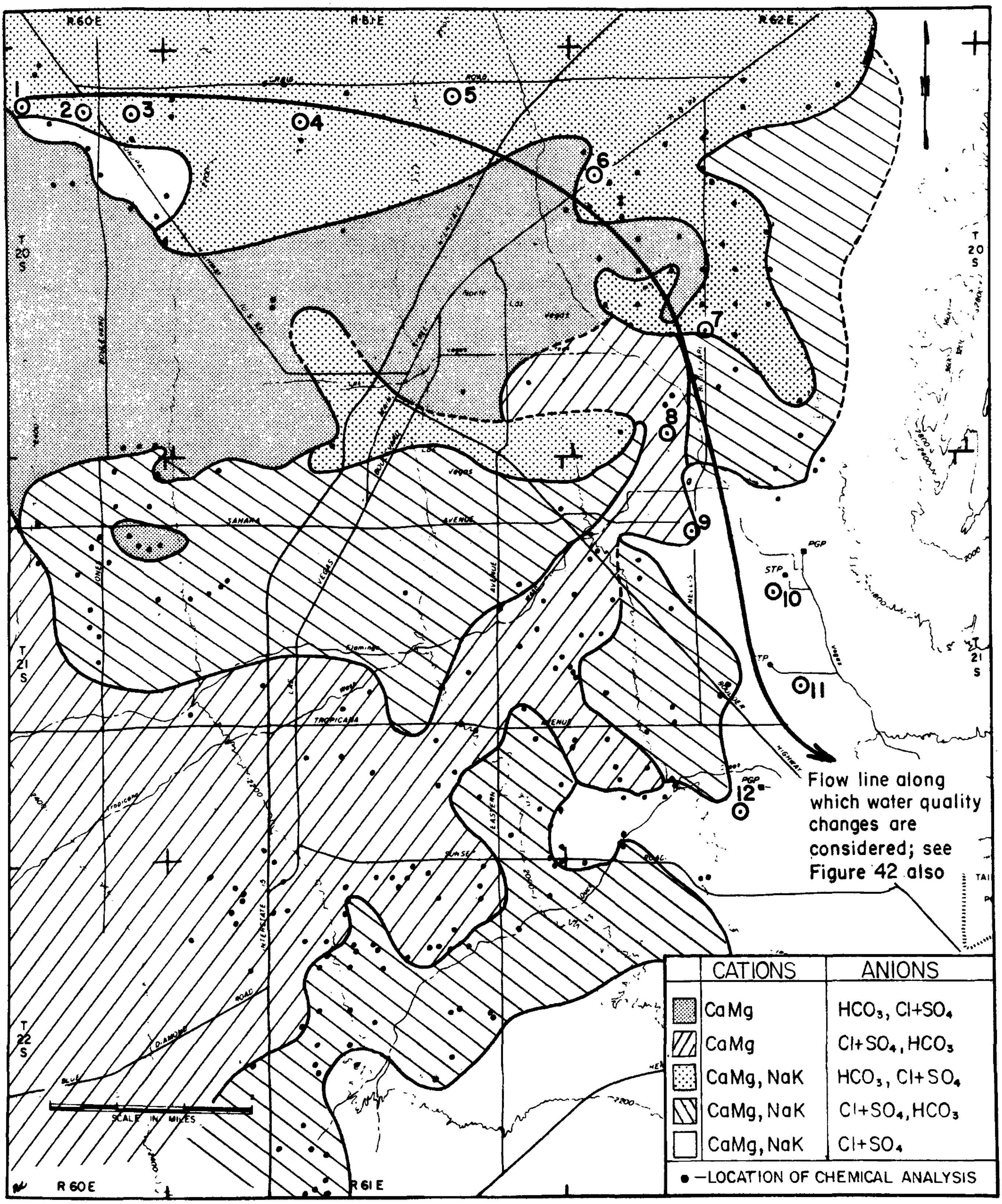


Figure 41. Hydrochemical facies in ground water at depths of 101 to 300 feet.

Cation facies	Range in Ca+Mg content (as % of total cations)	Range in Na+K content (as % of total cations)
Ca+Mg	0-<10	90-100
Ca+Mg, Na+K	10-<50	50-<90
Na+K, Ca+Mg	50-<90	10-<50
Na+K	90-<100	0-<10

Lateral variations or facies changes result from litholgic influences in the recharge areas, residence time in the aquifer(s), and changes in the mineral composition in the aquifer along the direction of flow. Variations in chemical character of water in the depth interval from 101 to 300 feet are most apparent along flow paths through the northern and central portions of the Valley. Figures 41 and 42 depict selected data points along a given flow line. The progressive change from calcium-magnesium-bicarbonate to calcium-magnesium-sulfate facies is believed a result of increased gypsiferous sediments, longer residence time, and possibly minor recharge from the Frenchman Mountain block. As expected, TDS also increases with distance along the flow path. Progressive increase in the percentage of sodium and potassium and decrease in calcium is indicative of ion exchange. In the central portion of the Valley, these comments also apply except the calcium-magnesium character is retained despite the anion shift from bicarbonate to sulfate. Along the southern limits of the urbanized area, ground water at depths of 101 to 300 feet is consistently of the calcium-magnesium-chloride-sulfate type. Chloride increases about three percent per mile of flow and, as expected, dissolved solids also increase slightly.

Periodic generation of hydrochemical facies maps and comparison of changes in patterns through time can provide an estimate of changing water quality conditions. The approach is most productive if used in conjunction with time series data for individual parameters (ions, ionic ratios, TDS, etc.) and specific wells or well fields. At present, data from the interval 0 to 50 feet partially characterize spatial variations in water quality. Temporal trends are qualitatively known, particularly where waste disposal, wastewater recycling, or other land use in characterized by distinctive return flows.

RETURN FLOWS OF INDUSTRIAL ORIGIN

In terms of both flow volume and chemical concentration, the major waste disposal operation adversely affecting ground-water quality is the Basic Management, Inc. (BMI) complex in Henderson. Operations began in the early 1940's and initially produced magnesium metal to support the war effort. The present chemical manufacturing and minerals processing industries or predecessor companies began operation in 1945, 1948, and 1950. Throughout the periods of operation, liquid effluents have been conveyed via open ditches to tailings ponds where disposal has been by evaporation and infiltration.

Initial effort in the study involved definition of the hydrogeologic framework and effects of industrial waste disposal in lower Las Vegas Wash.

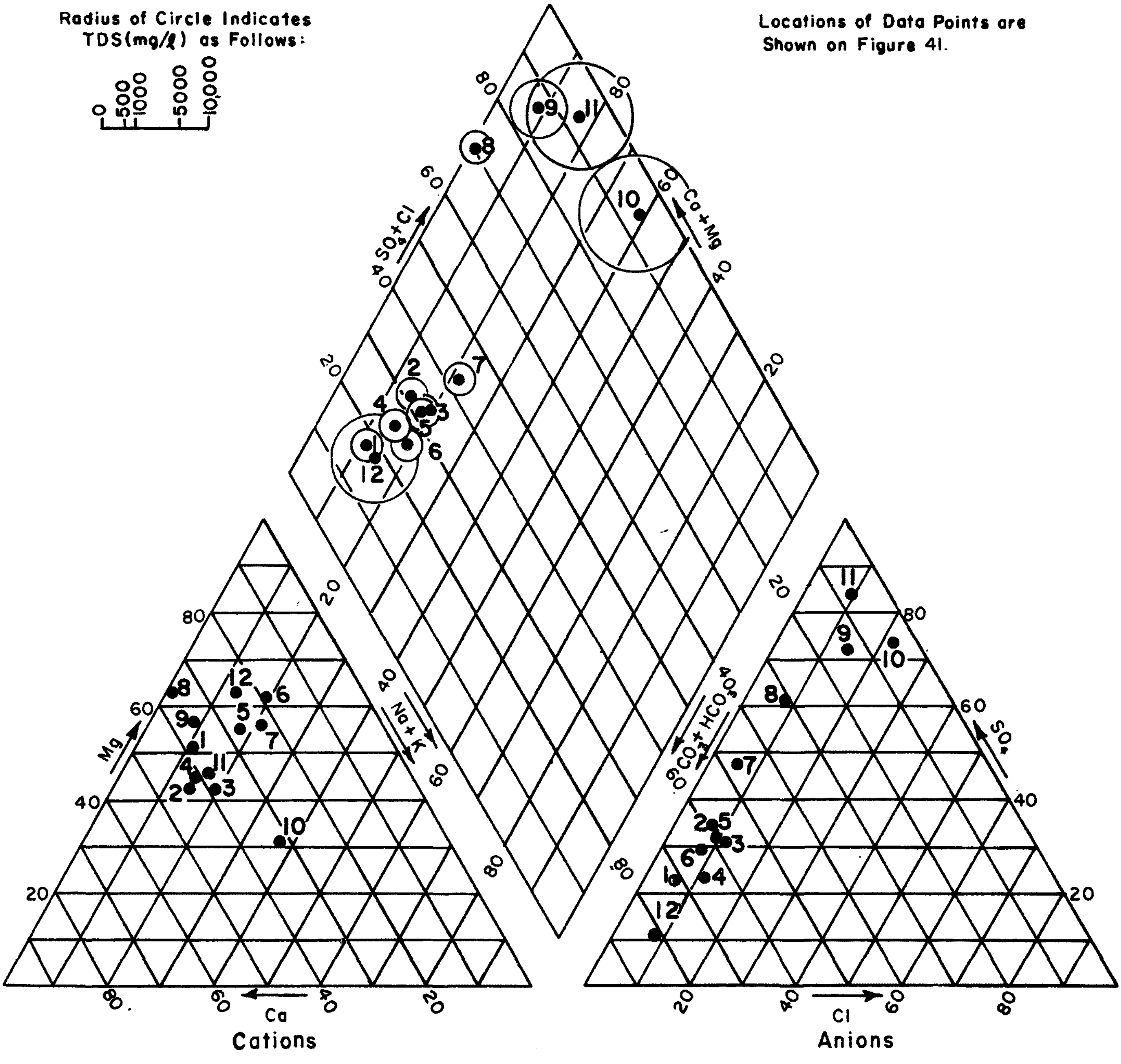


Figure 42. Piper diagram showing variations in ground-water quality along a selected flow path through Las Vegas Valley.

This involved assessment of lithologic boundary conditions and water quality (Kaufmann, 1971), waterlogging (Kaufmann, 1972), and combined paper analog and digital analysis of the flow regime (Westphal and Nork, 1972).

Ground-water inflow was first estimated by Kaufmann (1971) by taking into account the total monthly surface water flows into the Wash during 1970 as well as the Wash flow at Pabco Road and North Shore Road (located at stations LW003 and LW007, respectively). These are summarized in Figure 43. The hydrograph separations reveal ground water enters the Wash in the reaches above and below Pabco Road. Considering only the months when sewage effluent demand (for irrigation) and evapotranspiration losses are minimal and correcting total flow differences for other known surface water inputs, net flow differences are attributable to ground water. Net average ground-water return flow in the upper reach of the Wash is 3.37 MGD (10.3 acre feet per day), much of which exits the tailing ponds. Lesser amounts are from commercial irrigation with sewage, and "other" general return flow from sources such as lawn watering or golf course irrigation. Accretion in the reach below Pabco Road is approximately 5.67 MGD (17.4 acre feet per day) for a total accretion of 9.04 MGD (27.7 acre feet per day). This compares well with the value 10.68 MGD (32.8 acre feet per day) derived from a more detailed budget analysis of Westphal and Nork (1972).

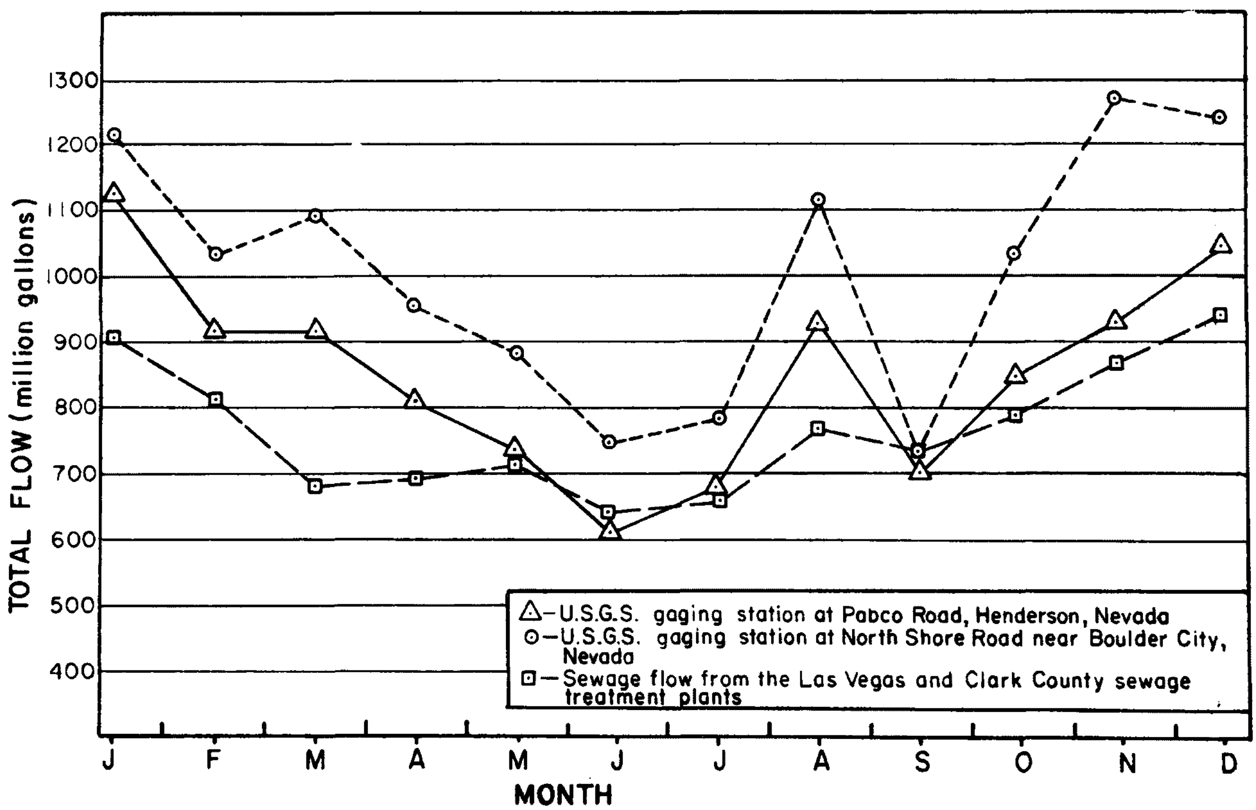


Figure 43. Hydrograph showing Las Vegas Wash discharge in 1970.

Recognizing that marked ground-water inflow occurs in the reach containing the tailings ponds, an effort was made to ascertain the flow path. The initial effort (Kaufmann, 1971) concluded that industrial return flow infiltrating via the tailings ponds and ditches entered the Wash after flowing laterally through thin (20 to 100 feet thick) and highly permeable sand and gravel deposits. Although this was true, the subsequent modeling study (Westphal and Nork, 1972) indicated that underlying, less permeable sediments also were involved and 7.3 MGD (22.4 acre feet per day) of effluent infiltrated. This latter explanation is shown in Figure 44 which depicts the shallow, saturated materials between the upper tailing ponds and Las Vegas Wash, and probable directions of ground-water flow. From the location of the trough between the southern boundary and the mound, the presence of wastewaters infiltrating from the upper ponds is indicated as far as 2,300 feet south of the ponds. It also appears that ground water in saturated materials downgradient from the mound is derived principally from percolation of effluent from the upper ponds. Significant vertical transfer of water into low-yield sediments must occur to satisfy the boundary conditions, aquifer characteristics, and system stresses.

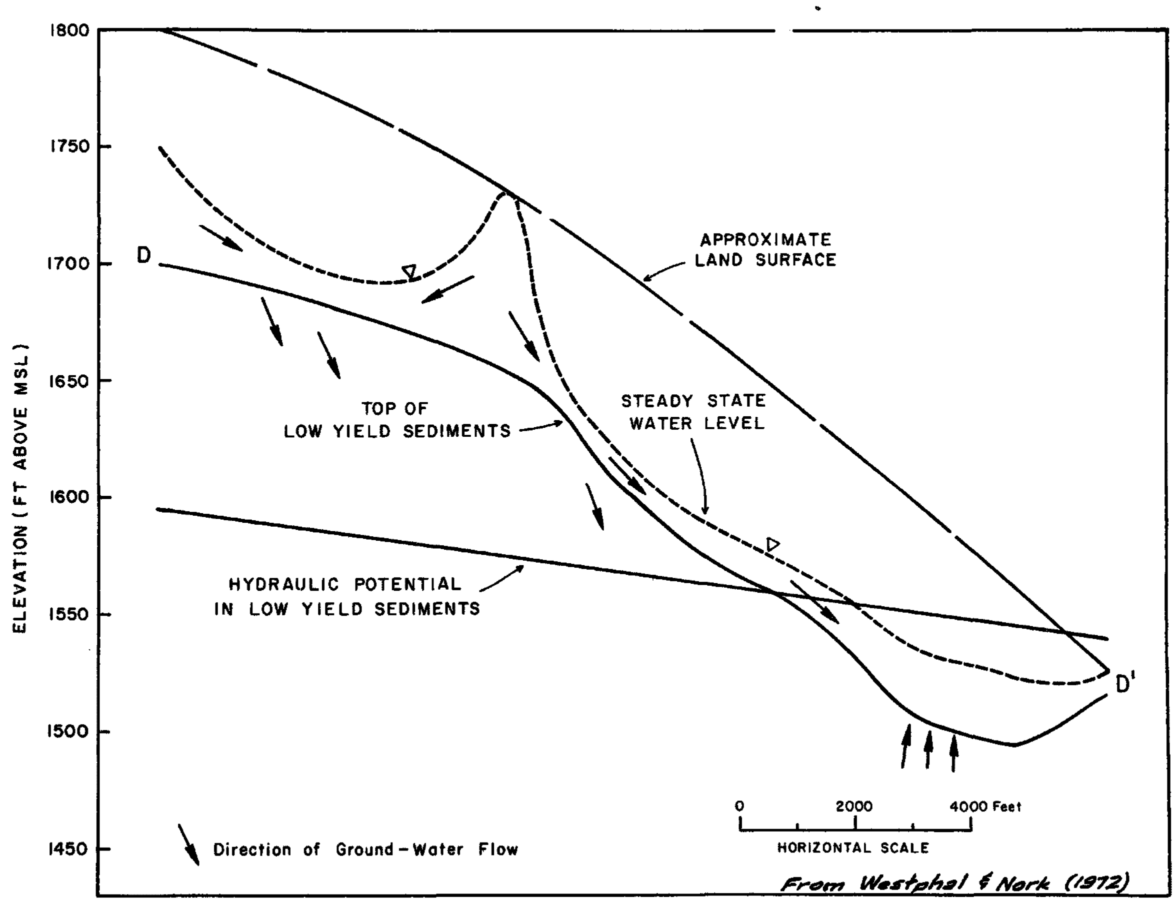


Figure 44. Ground-water flow system cross-section in the area between the BMI tailings pond and Las Vegas Wash.

Variations in ground-water quality were determined with respect to lateral and vertical position relative to Las Vegas Wash and particularly in relation to the BMI tailings ponds and lagoons. Peak concentrations of chloride, nitrate, and TDS are located in areas extending from the plant area to Las Vegas Wash as shown in Figures 45, 46, and 47. It is apparent that pollutants have migrated extensively from the northern portion of the plant area and from the tailings ponds. This is confirmed by tritium data, particularly for stations LW020, LG030, and LG050.

Effects of industrial wastes on natural ground-water quality below the lagoons and lower ponds include greatly increased sodium and chloride (wells LG027 and LG028) compared to natural shallow ground-water quality tributary to the Wash from the south (LG029, LG030, LG019, and LG020) and the north (LG015 and LG016). Total dissolved salt concentrations are also noticeably increased. Ground water below the lagoons near the plants and in the lower ponds contains 5,000 to 32,000 mg/ℓ TDS in contrast to 2,000 ± 500 mg/ℓ in ground water free of industrial wastes as at LG015, LG016, and LG031.

At the time of the study influent to the upper ponds had a mean pH of 4.08 and increased concentrations of sodium (527 mg/ℓ), chloride (948 mg/ℓ) and nitrate (102 mg/ℓ) relative to natural shallow ground water in the surrounding area. The industrial effluent contains large concentrations of TDS, chloride, and nitrate, the latter originating as nitric acid used in ore processing. As expected, ground-water quality in the area north of the upper ponds is enriched in nitrate and chloride relative to background levels. Detailed relationships between effluent quality and ground-water quality are difficult to assess because of the lack of historical information. Tremendous variability in the quality of water discharged during the course of the study is apparent from analyses for stations LW022, 042, 043, and 044. Similar variability over the last three decades can be assumed. Also unknown is the volume of effluent discharged, the locus of discharge, i.e., upper ponds or lower ponds, and duration of use.

The quality of ground-water discharge into the Wash is shown in Table 14. Wells are at the depths indicated and are situated along or immediately adjacent to the Wash. They are arranged from left to right in the downstream direction and are paired, i.e., LG029 and LG030 constitute a piezometer nest, as do LG019 and LG020, etc. Wells on the southern edge of the channel and downstream from the treatment plants contain TDS concentrations ranging from 5,000 to 7,000 mg/ℓ. Nitrate data for well LG037 near the Clark County Sewage Treatment Plant indicate effluent infiltration and an increase in nitrate in the shallow zone from background levels of 0.1 to 3 mg/ℓ to 130 mg/ℓ. However, from this point downstream toward the tailings ponds, nitrate decreases to background level (wells LG029 and LG030) and then increases again in the vicinity of Pabco Road crossing (21/63-30c) due to influx of contaminated water evident in well LG020.

Further indications of high salt and nitrate loads in ground water tributary to the Wash downstream from Pabco Road include analyses from observation wells (LG004 through LG007) and from dewatering wells installed in connection with the Southern Nevada Water Project pipeline. The pipeline crossed under the Wash near station LW004, requiring dewatering of 30 to 35 feet of sediments over a period of several weeks. At the peak of the dewatering effort, approximately 20 to 30 MGD (61.3 to 92.2 acre feet per day) were withdrawn from the well network. Well LG051 contained about 4,500 mg/ℓ TDS, primarily calcium, sodium, and sulfate. With increasing distance

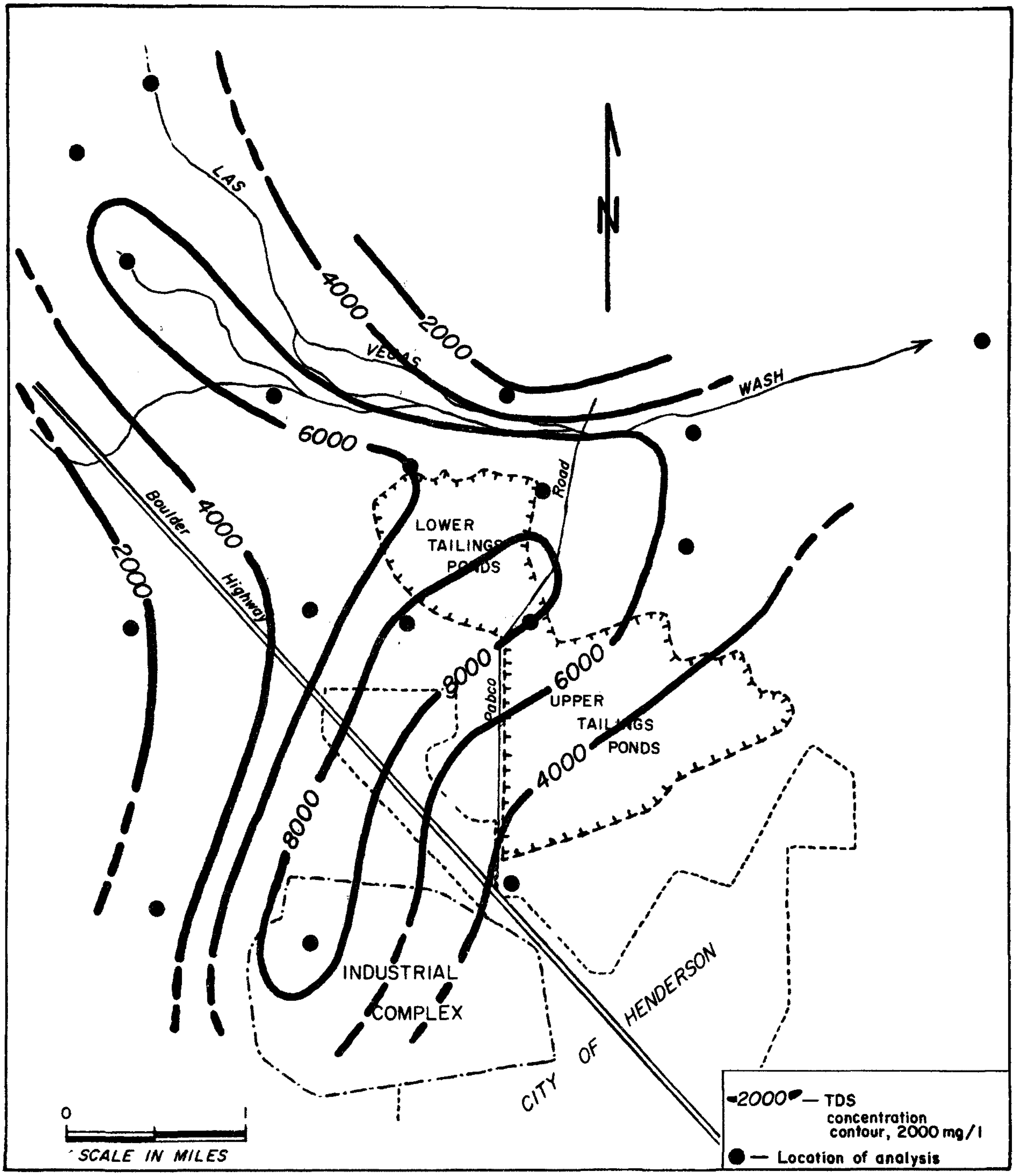


Figure 45. Distribution of total dissolved solids in shallow ground water adjacent to the lower reach of Las Vegas Wash.

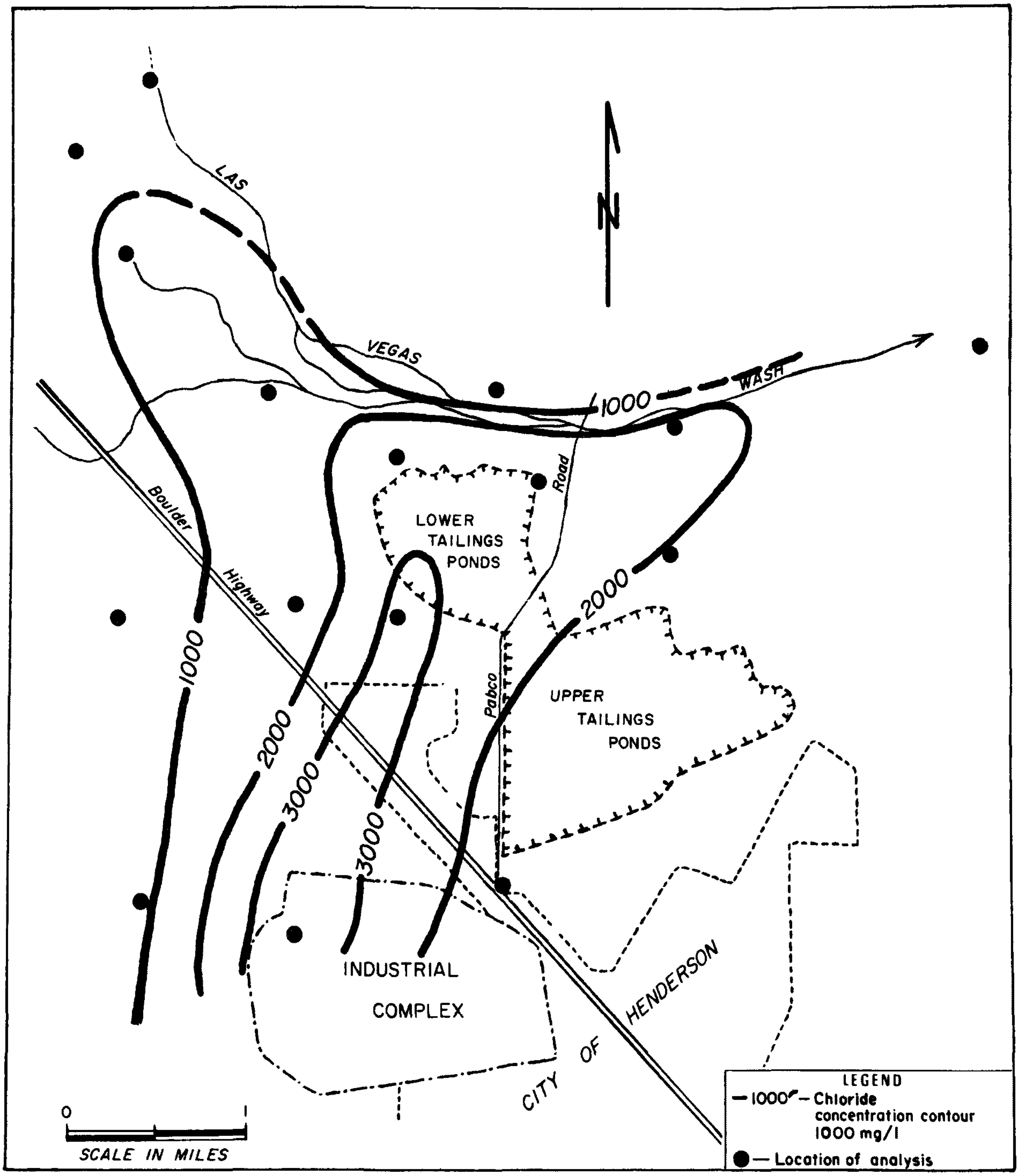


Figure 46. Distribution of chloride in shallow ground water adjacent to the lower reach of Las Vegas Wash.

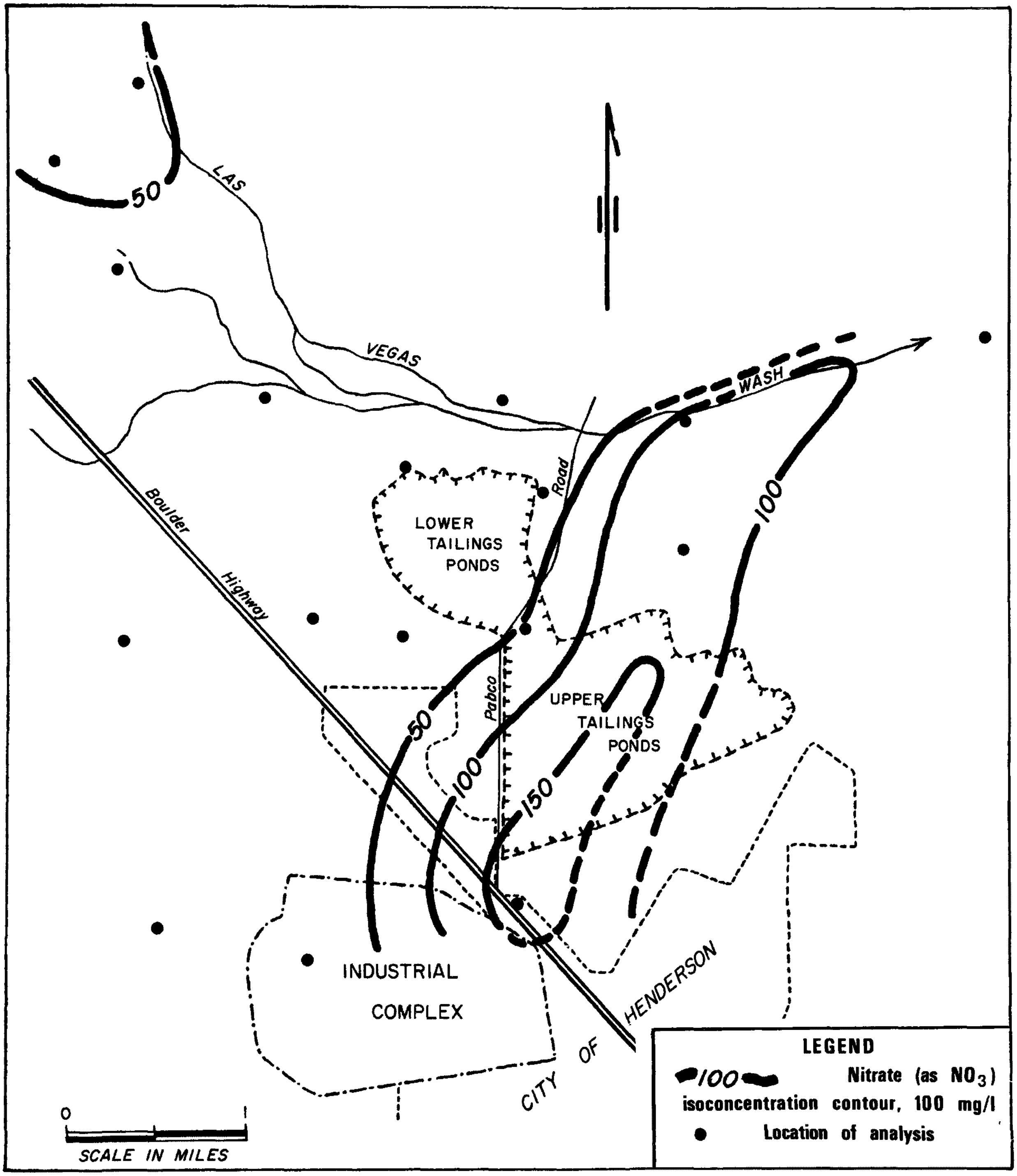


Figure 47. Distribution of nitrate in shallow ground water adjacent to the lower reach of Las Vegas Wash.

TABLE 14. GROUND-WATER QUALITY IN THE UNDERFLOW OF LAS VEGAS WASH*

		UPSTREAM													DOWNSTREAM
	Well	LG035	LG034	LG036	LG037	LG029	LG030	LG016	LG015	LG019	LG020	LG007	LG006	LG005	LG004
	Depth	102'	35'	45'	25'	97'	30'	47'	25'	60'	21'	134'	41'	95'	47'
Concentrations, mg/ℓ	Cl	46	427	856	980	507	1168	150	239	1180	2339	1178	1489	1476	1775
	SO_4	704	3087	2754	3602	2678	3228	1837	1010	3208	2670	1950	2103	2373	2383
	PO_4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	NO_3	0.12	53	58	130	<0.1	1.59	<0.1	0.11	<0.1	16.7	73	89	36	<0.1
	Na	87	674	751	1165	480	885	247	252	764	1560	689	782	1023	875
	K	11	41	26	30	70	111	25	26	177	46	82	83	72	88
	Ca	146	446	488	552	562	632	330	255	523	588	585	619	516	724
	Mg	96	354	318	353	306	456	215	103	420	269	270	302	341	436
	TDS	1193	5352	5317	6911	4811	6753	2993	2213	6320	7734	5069	5658	6130	6615

* Values shown from June 1971 samples. Well locations are shown in Figure 17.

southward from the Wash, nitrate, chloride, potassium, and sodium increase whereas calcium, magnesium, and sulfate decrease.

Considering these ground-water quality data, the ionic shifts in Wash water quality in the vicinity of the tailing ponds are understandable. As shown in Table 15, the most significant quality change by percentage is nitrate, which is low in concentration in the channel substrate at a depth of 42 feet or more (wells LG015, LG016, and LG017) but very high in shallow wells adjacent to the pond area (wells LG052, LG053, LG054, and LG055). These contained 152, 134, 168, and 116 mg/ℓ nitrate, respectively. A similar comparison can be made for chloride.

TABLE 15. LAS VEGAS WASH WATER QUALITY IN THE VICINITY OF HENDERSON

	Station			Percentage change
	LW003* (mg/ℓ)	LW004† (mg/ℓ)	LW005‡ (mg/ℓ)	$\frac{\text{LW005-LW003}}{\text{LW003}} \times 100$
Cl	654	860	1000	+53
SO_4	988	1178	1366	+38
PO_4	20	16	12	-40
NO_3	25	30	63	+152
Na	495	591	594	+20
K	30	40	51	+70
Ca	260	324	408	+57
Mg	107	139	179	+67
TDS	2833	3439	3909	+38

* Mean of 17 analyses for samples collected between February 1970 and July 1971.

† Mean of 11 analyses for samples collected between June 1970 and July 1971.

‡ Mean of 10 analyses for samples collected between April 1970 and July 1971.

High nitrate concentrations are characteristic of return flows from the upper ponds and part of the lower ponds. In addition, well LG055, which is flowing and only 35 feet deep, contains 407 TU, indicating the influx of very young ground water in this reach of the Wash (hydrologic significance of tritium is discussed in detail in the following section). Further downstream, head and tritium data from wells LG006 and LG007 indicate the spring pond adjacent to the Wash is also fed with tritiated, nitrate rich ground water indicative of industrial return flows.

The chemical load in Las Vegas Wash attributable to industrial waste seepage was determined as follows: 1) direct measurement of chemical concentration and discharge, and 2) indirectly as the mass flux difference between two adjacent stations on the Wash (Kaufmann, 1971). Stations LW029, LW048, and LW049 were established as sampling and gaging sites to monitor surface water flow of industrial effluent to the Wash. The remaining stations on the Wash are, in downstream order, LW003, LW041 and LW045, and LW004 and LW063. Calculated salt loads are shown in Table 16.

Table 17 shows effects of waste loading by comparing chemical concentration and mass already in the Wash to that from other sources at three points in the Wash (in consecutive downstream order: LW003, LW041-LW045, and LW004-LW063). Each station is alternately considered as a "basepoint" where mass flux is compared to mass flux at points upstream or downstream. The differential (between points in the Wash or between the Wash and the tributaries) divided by the mass flux at the basepoint indicates the contribution from ground-water or surface water sources tributary to the Wash in the reach considered (see also footnotes, Table 17). Using TDS for example, stations LW048 and LW049 contributed 107,306 and 126,281 pounds per day on March 11 and 30, 1971, respectively. This represents 24 and 31 percent additions of TDS to the Wash relative to the load present upstream from the influence area of the tailings ponds.

Mass flux calculations show significant contributions of salts and nutrient in the form of nitrate originating in the tailing ponds seepage. Considering mass flux in the Wash reach hydraulically above the ponds equal to 100 percent, additional contributions calculated for three segments (above Pabco Road, between Pabco Road and the gravel pit, from the gravel pit) of the reach influenced by the ponds are shown in Tables 16 and 17. In general terms, the salt flux or loading attributable to ground water contaminated by wastewater discharge approximately equaled that from all other sources. This underscores the need to consider ground water in any basin water quality management program to control pollutant discharge from Las Vegas Wash.

TABLE 16. EFFECTS OF GROUND-WATER RETURN FLOWS ON WATER QUALITY AND CHEMICAL MASS IN LAS VEGAS WASH

Date	Station	Discharge cfs	Discharge MGD‡	Concentration, mg/ℓ Na	Cl	SO_4	TDS	Chemical mass, lbs/day Na	Cl	SO_4	TDS
March 11, 1971*	LW048	1.231	0.796	1860	2378	2404	7794 }	26337	33921	31892	107306
	049	1.38	0.892	1880	2437	2141	7467 }				
	003	34.149	22.07	483	643	1131	3020	88872	118312	208104	555680
	041	11.903	7.693	495	646	1071	3227 }	103074	135540	216633	628595
	045	25.154	16.256	526	694	1091	3108 }				
March 30, 1971*	048	1.399	0.904	1880	2355	2409	7735 }	31506	39389	38237	126281
	049	1.703	1.1	1890	2359	2189	7411 }				
	003	35.95	23.22	464	585	985	2720	90016	113490	191090	527680
	041	15.02	9.70	460	596	1009	2753 }	99264	127268	213670	586827
	045	23.03	14.88	500	637	1064	2934 }				
July 7, 1971†	048	0.68	0.439	1824	2392	2482	7835 }	14032	18796	17733	66464
	049	0.773	0.500	1764	2408	2074	7183 }				
	003	14.33	9.26	618	860	1432	3749	47728	66418	110593	289535
	004	15.508	10.02	704	1170	1681	4571 }	62522	103836	148362	403152
	063	0.972	0.628	704	933	1504	4037 }				
	029	6.17	3.99	526	1907	1588	5535	17505	63465	52849	184205

* Based on one set/station of discharge measurements and water samples, collected from 0900-1040H.

† Based on mean values for water quality and discharge. Two water samples and two discharge measurements collected at stations LW029, LW048, LW049 whereas stations LW003, LW004, LW063 were each gaged and sampled three times. All data were collected in the period 0930-1700H.

‡ One MGD = 3.069 acre feet per day.

TABLE 17. PERCENTAGE OF SODIUM, CHLORIDE, SULFATE, AND TOTAL DISSOLVED SOLIDS ADDED TO LAS VEGAS WASH BY GROUND-WATER RETURN FLOWS

Date	Na	Cl	SO_4	TDS	Remarks
March 11, 1971	42	40	18	24	*
	16	14	4	13	†
March 30, 1971	54	53	25	31	*
	10	12	12	11	†
July 7, 1971	42	39	19	30	*
	28	61	36	46	‡
Mean % *	46	44	21	28	
†	13	13	8	12	
‡	28	61	36	46	
Total %	87	118	65	86	

* Represents mass contributions (by percentage) to the Wash by the ponds in the reach above Pabco Road (LW003). Calculated from chemical mass loading (Table 16) as follows:

$$\frac{\text{LW048} + \text{LW049}}{\text{LW003} - (\text{LW048} + \text{LW049})} \times 100$$

† Represents mass contributions (by percentage) to the Wash in the reach between Pabco Road (LW003) and Gravel Pit Road (LW041, LW045). Calculated from chemical mass loading as follows:

$$\frac{(\text{LW041} + \text{LW045}) - \text{LW003}}{\text{LW003}} \times 100 .$$

‡ Represents mass contributions (by percentage) to the Wash attributable to water exiting the Stewart Brothers gravel pit. The mass added is calculated as the percentage addition to that already present in the Wash at stations LW004 and LW063 as follows:

$$\frac{\text{LW029}}{\text{LW004} + \text{LW063}} \times 100$$

TRITIUM AS AN INDICATOR OF RETURN FLOWS

Introduction

The foregoing sections describing ground-water quality variations through space and time are largely developed from analysis of gross chemical data. In the lower Las Vegas Wash area, tritium data proved particularly diagnostic of the presence of return flows. Subsequent phases of the study also utilized this technique in the remainder of the Valley, portions of which have received tritiated Colorado River water since 1955.

Under certain conditions, tritium, a radioisotope of hydrogen, can be a useful tool in determining age and source of ground water. Use is made of environmental tritium rather than artificial introduction as a tracer. Atmospheric detonation of the first hydrogen bomb in March 1954, and other hydrogen bomb tests between 1954 and 1961, in particular, introduced large quantities of tritium to the atmosphere and subsequently to precipitation. For Las Vegas Valley, recharge occurs primarily from precipitation in the Spring Mountains, the Sheep and Las Vegas Ranges, and, to lesser extent, from rainfall and runoff incident to the Valley floor. Because of relatively long travel times, tritium in Las Vegas Valley ground water derived from recharge in mountainous areas is absent or at background levels of less than five tritium units (TU; one TU is equivalent to one atom of tritium in 10^{18} atoms of hydrogen). Tritium of higher concentrations could be found in areas of the Valley where recharge has been from infiltrated runoff, or return flow from imported Colorado River water. Because Colorado River water has been distributed in roughly the eastern half of the Valley since 1955, tritium is expected in return flows from such water usage. The concentration of tritium in the Colorado River has been significant but highly variable ($<$ 100 to 750 TU) in the period 1955 to 1973. Colorado River water was used as the only source of water in the Henderson area beginning in 1942. For the remainder of the Valley, but excluding North Las Vegas as well as western and northwestern Las Vegas, River water was used from 1955 through the summer of 1971 for summer peaking purposes only and at a maximum flow rate of about 57 acre feet per day. After September 1971, the Southern Nevada Water Project (Phase I) was completed and river water was used on a year-round basis in the eastern part of the Valley, i.e., roughly east of Las Vegas Boulevard.

Of interest to the present study is use of Colorado River water in the period 1955 through the summer of 1971. During this period there was rapid growth in population and widespread introduction of tritiated river water for use in lawn watering. Although use of such water increased greatly in 1972, effects of this usage were not recognizable within the time frame of the study.

Because of the complex distribution system in the service area of the Las Vegas Valley Water District and because River water was used only intermittently for peaking purposes from 1955 to 1971, quantitative estimations of the concentrations of tritium entering shallow ground-water resources is impossible. Only Henderson and the BMI industrial complex used Colorado River water exclusively.

Certain areas of low density residential development are served by individual domestic wells generally 300 feet or less in depth and tapping the unconfined aquifer. Tritium is therefore not particularly diagnostic of return flows under these conditions. Instead, nitrate was used as an indicator insofar as these same areas are also served by septic tank disposal systems. For the remaining areas of the Valley and for the bulk of the population and water uses dependent on public water supplies, comparisons of tritium content in ground water were made considering the probable source of local recharge and the age of nearby developed areas which range from the early 1940's to the early 1970's. In this manner, tritium was used to qualitatively assess the occurrence of recharge by irrigation return flows.

Despite the foregoing complications and limitations, tritium is diagnostic of return flows under the following circumstances:

1. Tritium in ground water beneath areas served partly by Colorado River water is indicative of return flows from irrigation and other urban-related sources.

2. Shallow ground water in areas not served by Colorado River water but containing higher concentrations (i.e., >5 TU) is probably recharged by in-valley precipitation and runoff.

3. Areas served wholly by Colorado River water are expected to have maximum levels of tritium in ground water; this assumes that dilution is comparable to other areas in the Valley.

Water Sampling Network

Locations and descriptions of all the stations sampled for tritium are provided in Figure 48 and Appendix 6. If all of the tritium data are considered, the sampling points fall into six categories (Figure 49): 1) Colorado River (Lake Mead), 2) deep ground water from artesian aquifers, 3) Las Vegas Wash surface flow, 4) shallow ground water adjacent to irrigated areas in the Valley, 5) return flow from point sources tributary to Las Vegas Wash, and 6) influents and effluents from the City and County sewage treatment plants (LW027, LW034, LW061, and LW062) and localized, high volume return flows from the BMI tailings ponds (LW032, LW048, and LW049) or influent to the upper ponds (LW022).

Some points in categories 3, 4, and 5 fit into more than one group, by virtue of their location. For the most part, samples in category 4 are from a variety of drains, seeps, springs, wells, and excavations throughout the Valley. The data in category 5 are from very shallow wells penetrating the uppermost few feet of the water table and are immediately adjacent to established residential areas irrigated, for the most part, with River water.

Tritium in Las Vegas Valley Water

When considering source and distribution of tritiated water, it is necessary to consider precipitation and runoff within the Valley, sources of recharge to the deeper ground-water reservoirs, and general relations of the Colorado River system water. Tritium rainout in the United States through

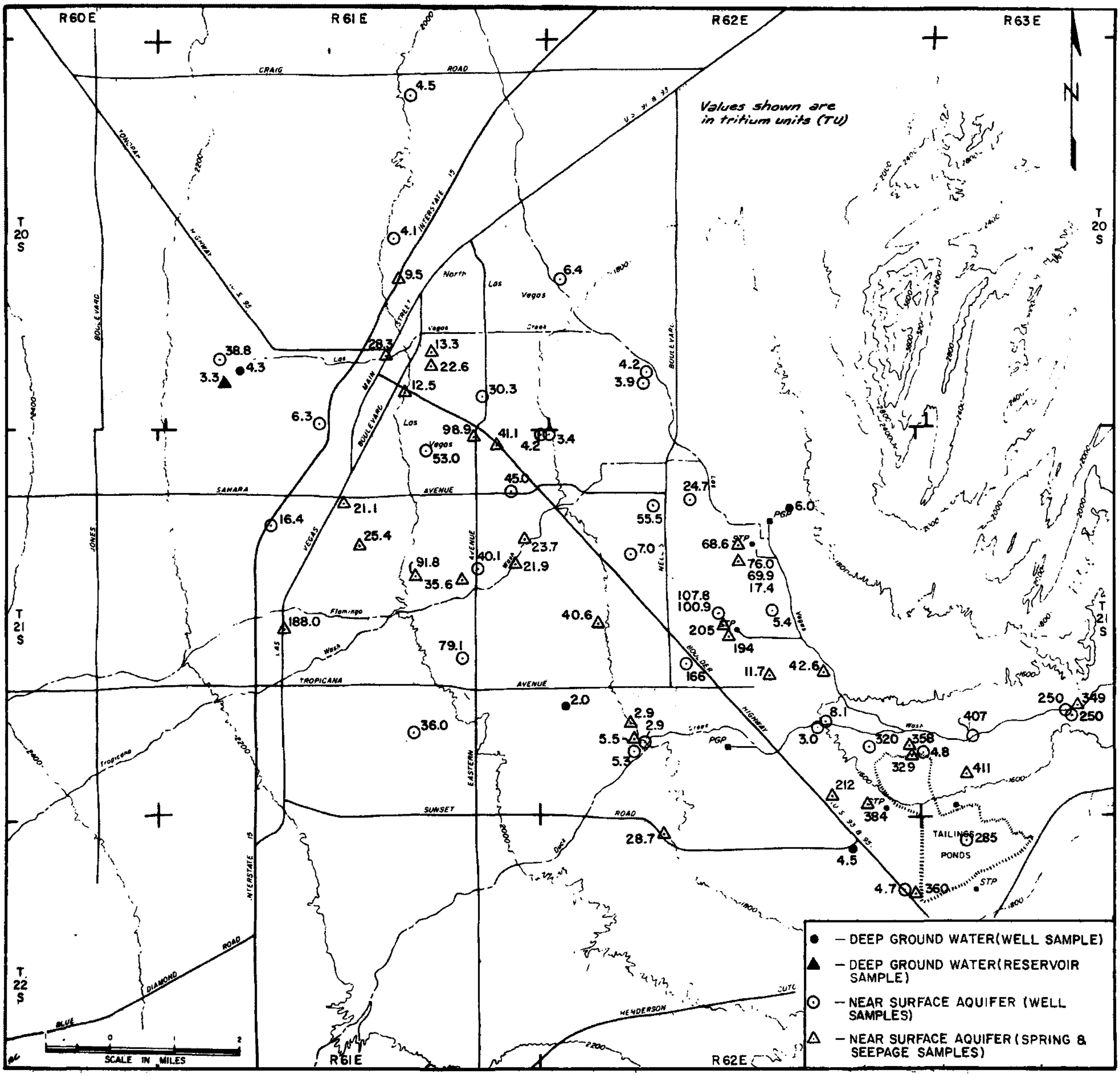


Figure 48. Locations of surface water and ground-water stations sampled for tritium.

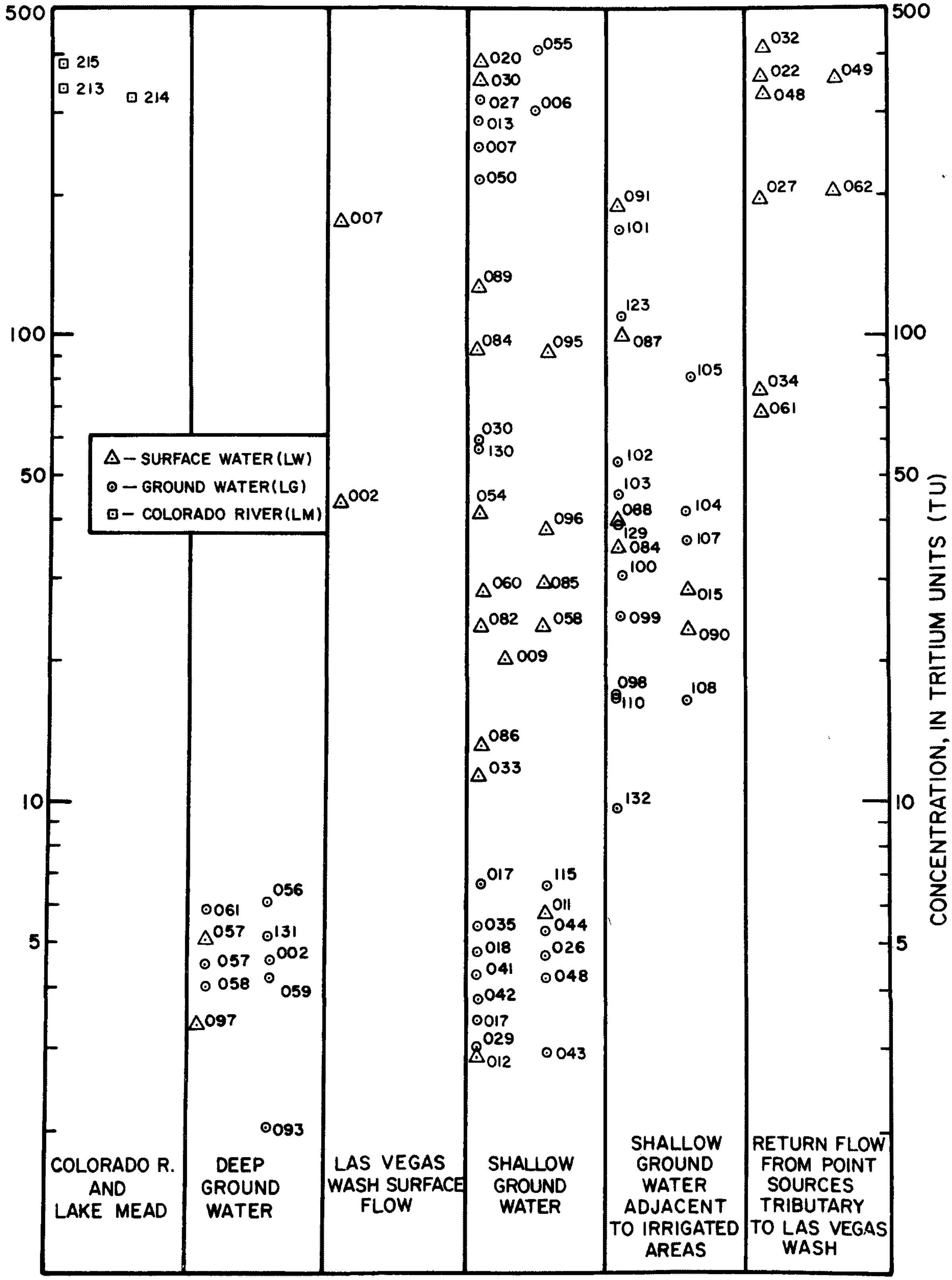


Figure 49. Tritium concentrations versus water type.

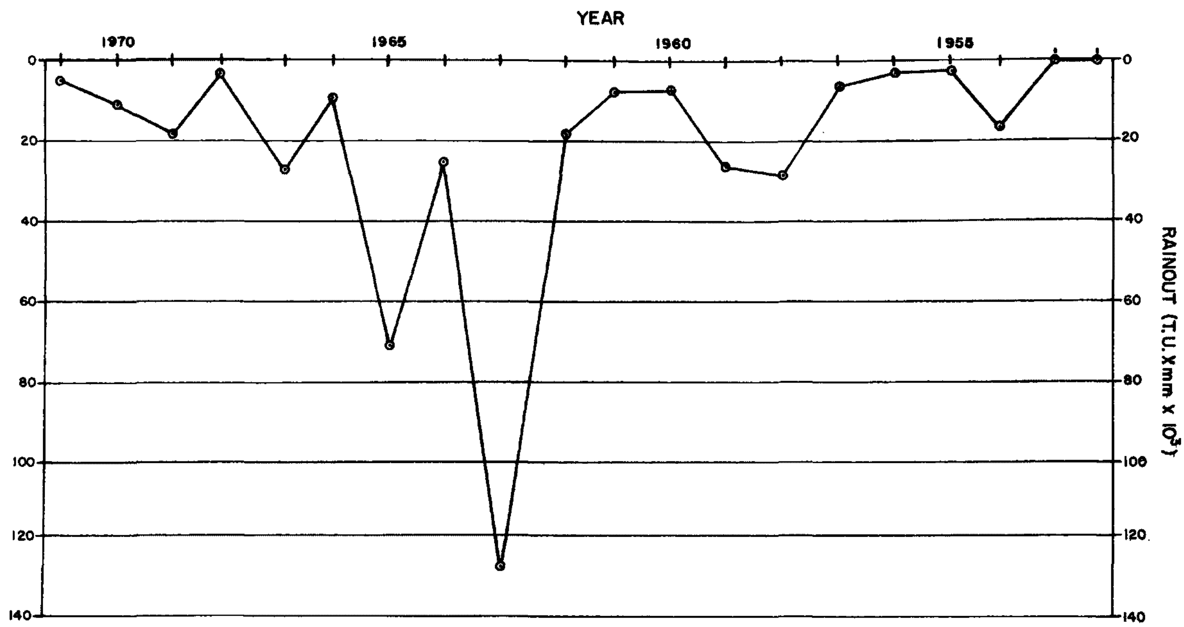
1968 has been summarized by Kaufman and Libby (1954), Libby (1962), Thatcher (1962), Thatcher and Hoffman (1963), Stewart and Hoffman (1966) and Stewart and Farnsworth (1968). Unpublished data since 1968 were supplied by T. Wyerman (written communication). Concentrations in precipitation over southern Nevada for the last decade are only approximately known. Atmospheric tritium was first monitored at the Nevada Test Site in early 1969. In 1971 and 1972 spring peaks were about 150 TU and 90 TU, respectively, compared to 75 TU and less than 50 TU, respectively, for 1969 and 1970 (H. Classen, U. S. Geological Survey, oral communication).

Long-term precipitation records for Las Vegas Valley indicate above average rainfall from 1912-1923 and from 1930-1941. In the intervening years, and particularly from 1942-1971, there has been a long-term deficit in rainfall with noticeable positive departures from the average occurring only in 1949, 1952, 1955, and 1965. Long-term average precipitation is 4.4 inches per year, whereas pan evaporation is about 90 inches.

Estimated local tritium rainout from 1952-1971 is shown in Figure 50. Due to weapons testing, the largest pulse over most of the northern hemisphere was in 1963. A second peak in 1965 was a result of above average rainfall over much of the country, despite the reduced concentrations of tritium relative to 1963. Although large rainout pulses occurred in 1963 and 1965, they followed over two decades of below normal precipitation in the Valley. From 1959-1963, cumulative precipitation was 5 inches below average. This deficit increased to 8.4 inches by 1965. Therefore, except along wash channels and in areas of ponded water, it is unlikely that rainfall of 7.96 inches in 1965 resulted in widespread, in-valley recharge.

Prior to September 1971, deep aquifers supplied the majority of water distributed in the Valley. This is particularly true for the area west of Main Street and in North Las Vegas. Average tritium content in the deeper, artesian aquifers is 4.6 TU. The range for 5 samples is 4.1 to 5.1 TU and comparable to values for Corn Creek Springs (4.8 TU) in an area of the Valley 20 miles northwest of Las Vegas, and to a composite sample of the West Charleston well field of the Las Vegas Valley Water District (3.3 TU). The discharge from Corn Creek Springs most likely is via conduits originating in deep-seated carbonate strata subcropping beneath the valley fill. Therefore, this water is regarded as "dead", i.e., not recently recharged. This is also true for deep, artesian aquifers underlying Paradise Valley (LG093) and Pittman (LG002) which contained 2.0 and 4.5 TU, respectively.

Relatively shallow observation wells were installed in the course of the study along the upper reach of Las Vegas Wash (LG041, 042) and along the main scarp through the Valley (LG043, 044, 047, 048). Tritium in these ranged from 2.9 to 5.3 TU, indicating that recent recharge of tritiated water to the water table at depths of 48 to 168 feet did not occur. Stations LG041 and LG042 are within 100 feet of the Wash axis which is expected to be a locus of recharge insofar as this reach has a depressed water table and carried flow for practically every runoff event in the Valley. However, at another location (LG055), bed infiltration of stormwater runoff apparently was related to improvement of the Flamingo Wash channel upstream from Nellis Boulevard. Before the drainage ditch was constructed, no through-flowing streams or stream channels traversed the area. After construction of the east-west



Year	TU*	Precipi-tation† (mm)	Year	TU*	Precipi-tation† (mm)
1952	2.5	177	1962	500	37
1953	12	15	1963	1300	98
1954	140	121	1964	900	28
1955	20	152	1965	350	202
1956	60	52	1966	200	49
1957	50	126	1967	190	141
1958	250	115	1968	130	28
1959	250	106	1969	140	129
1960	70	112	1970	100	109
1961	100	81	1971	80	65

* Precipitation before 1952 is estimated to contain 2 to 10 TU depending on location and local weather patterns (Kaufman and Libby, 1954; Libby, 1961). Values from 1953 through 1971 are based on contour maps of the U. S. including correlation with Ottawa, Canada (T. A. Wyerman, written communication; Stewart and Farnsworth, 1968; Stewart and Hoffman, 1966; Stewart and Wyerman, 1970; Wyerman et al., 1970). Unpublished U. S. Geological Survey data for the Nevada Test Site (H. Claassen, oral communication) and U. S. Environmental Protection Agency data (D. Wruble, written communication) for Las Vegas Valley were also utilized.

† U. S. Department of Commerce, Environmental Data Service Records for Las Vegas, Nevada.

Figure 50. Approximate Tritium Rainout at Las Vegas, for the period of 1952-1971.

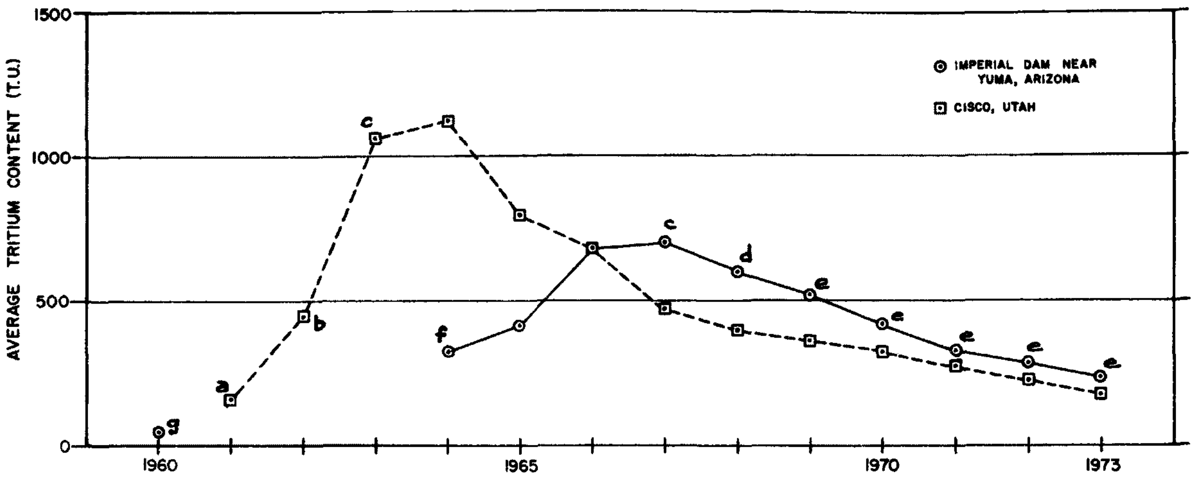
trending channel across the north quarter of 21/61-8, perennial spring discharge originating in the vicinity of stations LW084, 072, 008, 009, 060, and 077 (in downstream order) and occasional flash floods flowed in the ditch. As a result, TDS in a well 90 feet deep and located just south of the ditch and west of Nellis Boulevard tripled in a six month period causing the well to be abandoned in 1971 after many years use. Subsequent sampling yielded 55.5 TU, clearly indicative of recent recharge to the water table. Samples from three of the stations cited above and located upstream from the well in question contained from 21.9 to 35.6 TU, again indicative of the addition of recent, tritiated return flows to the near surface aquifer and subsequent discharge in small springs. As discussed below, some of these stations may reflect recharge from overland flow as a result of precipitation, whereas others with significant tritium are more likley due to irrigation return flows.

In summary, the foregoing comments concerning rainfall and runoff indicate the probability of local, in-valley recharge. Attention is now directed to what is believed to be the more significant recharge source, namely return flows from urban irrigation and from industrial waste disposal, both of which are closely related to the Colorado River water supply source.

Beginning in 1965, the concentration of tritium in the Colorado River was monitored monthly at Cisco, Utah and at Imperial Dam, California. Random samples were collected as early as 1961 and 1964 at the Cisco station and Imperial Dam, respectively. The 1961 to 1968 data presented by Wyerman et al. (1970) and unpublished data for 1969 to 1973 (T.A. Wyerman, written communication) are summarized in Figure 51 to show average annual tritium concentrations in the Colorado River. Annual average tritium content at Imperial Dam near Yuma in the last 13 years ranged from 52 to 710 TU, whereas concentrations in the upper basin at Cisco, Utah ranged from 141 to 1,126 TU. The variation between the Cisco and Imperial Dam stations on the Colorado River reflect difference in latitude, continental effects, and more importantly, transit time in the river system, which is increased because of the major impoundments. The highest level at Cisco was in 1963 and 1964, whereas at Imperial Dam the peak occurred in 1966-1967. Tritium in Colorado River water distributed within the Valley since 1961 can be roughly estimated as the straight line average of the Cisco and Imperial Dam values (T.A. Wyerman, written communication).

From Figure 51, it is estimated that tritium in the Colorado River water imported into Las Vegas Valley peaked at about 750 TU in 1963 and 1964, with a uniform decline to approximately 200 TU in 1973. Concentrations in the period 1953-1963 are little known but probably are on the order of 10 TU or less in 1953 and early 1954. Peaks of several hundred TU may have occurred in 1958 and 1959 followed by a second period of decline before levels reached a maximum in 1963.

The service areas of the City of Las Vegas and Clark County Sanitation Districts and the Las Vegas Valley Water District distribution (pressure) zones are shown in Figures 52 and 53. Tritium in the influent to the City and County sewage treatment plants as of June 29, 1971 was about 70 TU and 200 TU, respectively, which is indicative of the tritium concentration in return flows at that time. This difference (70 versus 200 TU) is expected because about one-half of the service area for the City plant was supplied almost solely with deep well water, whereas the County plant services an area



a) Samples collected only in September and October
b) Samples collected only in August
c) Average of 9 monthly samples
d) Average of 10 monthly samples
e) Average of 11 monthly samples
f) Sample collected only in November
g) Concentration in water delivered to Southern California in February 1960 (Libby, 1961)

Figure 51. Average annual tritium content of the Colorado River water.

largely dependent on River water or a mixture of River water and ground water. Insofar as the Colorado River contained about 350 TU in 1971, the concentration of 70 TU in influent to the City Sewage Treatment Plant indicates that about two-thirds of the water delivered was ground water with the balance from the Colorado River. For the County Treatment Plant, there are about equal proportions of river water and ground water. Prior to 1971, the approximate areas receiving river water and the volumes delivered are shown in Figures 53 and 54, respectively. Although much more widespread use of River water began in September 1971 as a result of the Southern Nevada Water Project, the author believes that 1973 tritium data accurately document ground-water conditions prior to any significant influences from Project water. This assumption is believed justified considering the time necessary for infiltration and migration of return flows from areas of application to sampling points.

There is abundant evidence of tritiated Colorado River water recharging shallow ground water in the area of the BMI complex in Henderson. Here, tritium concentrations range from 212 to 411 TU in shallow ground water. At least locally the shallow ground-water reservoir contains the probable upper limit for tritium concentrations, considering original concentrations in the Colorado River and decay of 5.5 percent per year. In other words, dilution of return flows has been essentially nil in this area. Recharge from the tailings ponds was estimated to be 9.3 MGD (28.5 acre feet per day) in December 1971, and at least 230,000 acre feet over the operating lifetime of the complex, hence extremely high concentrations of tritium in return flows are expected.

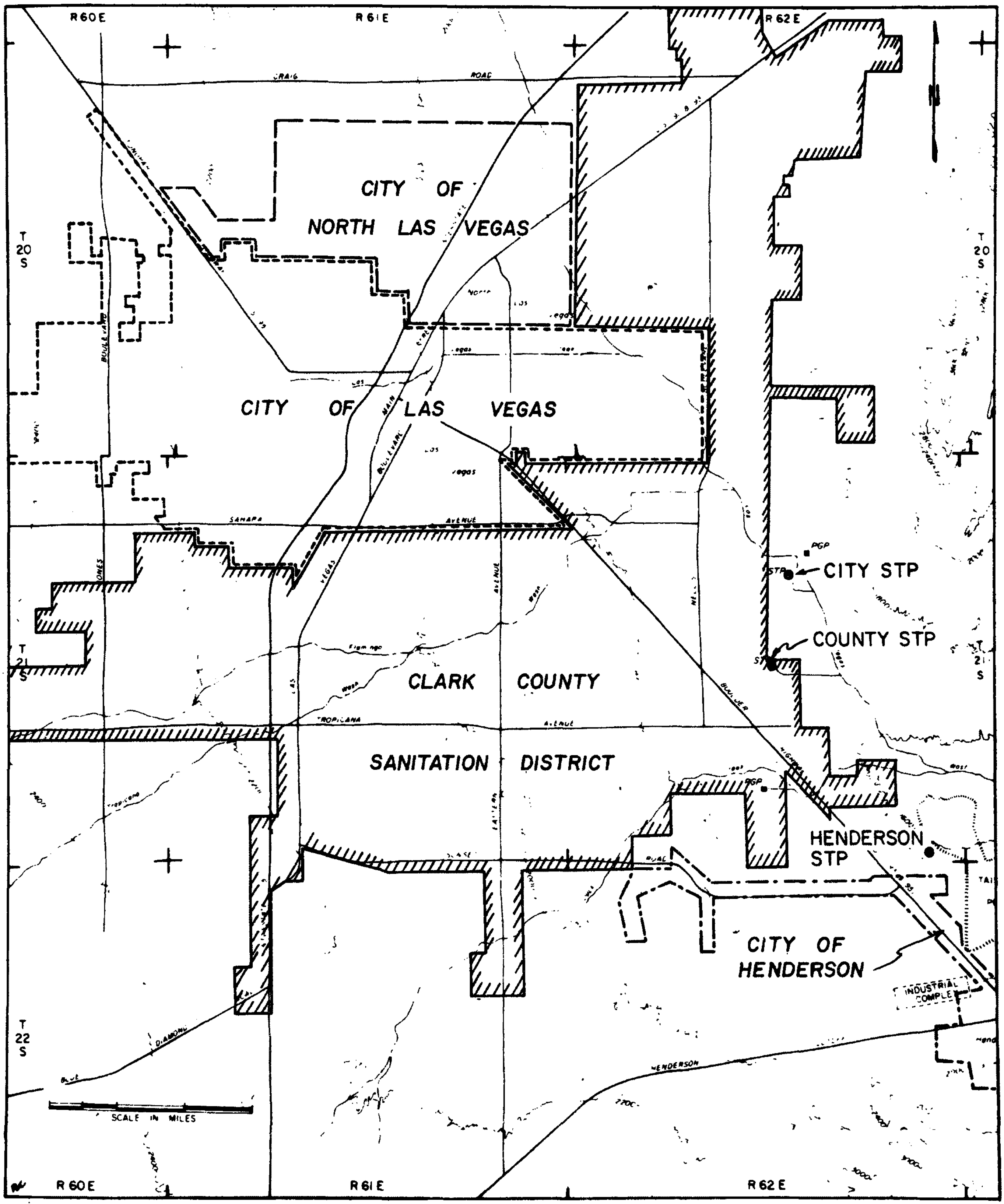


Figure 52. Map of the sanitation district service areas in Las Vegas Valley.

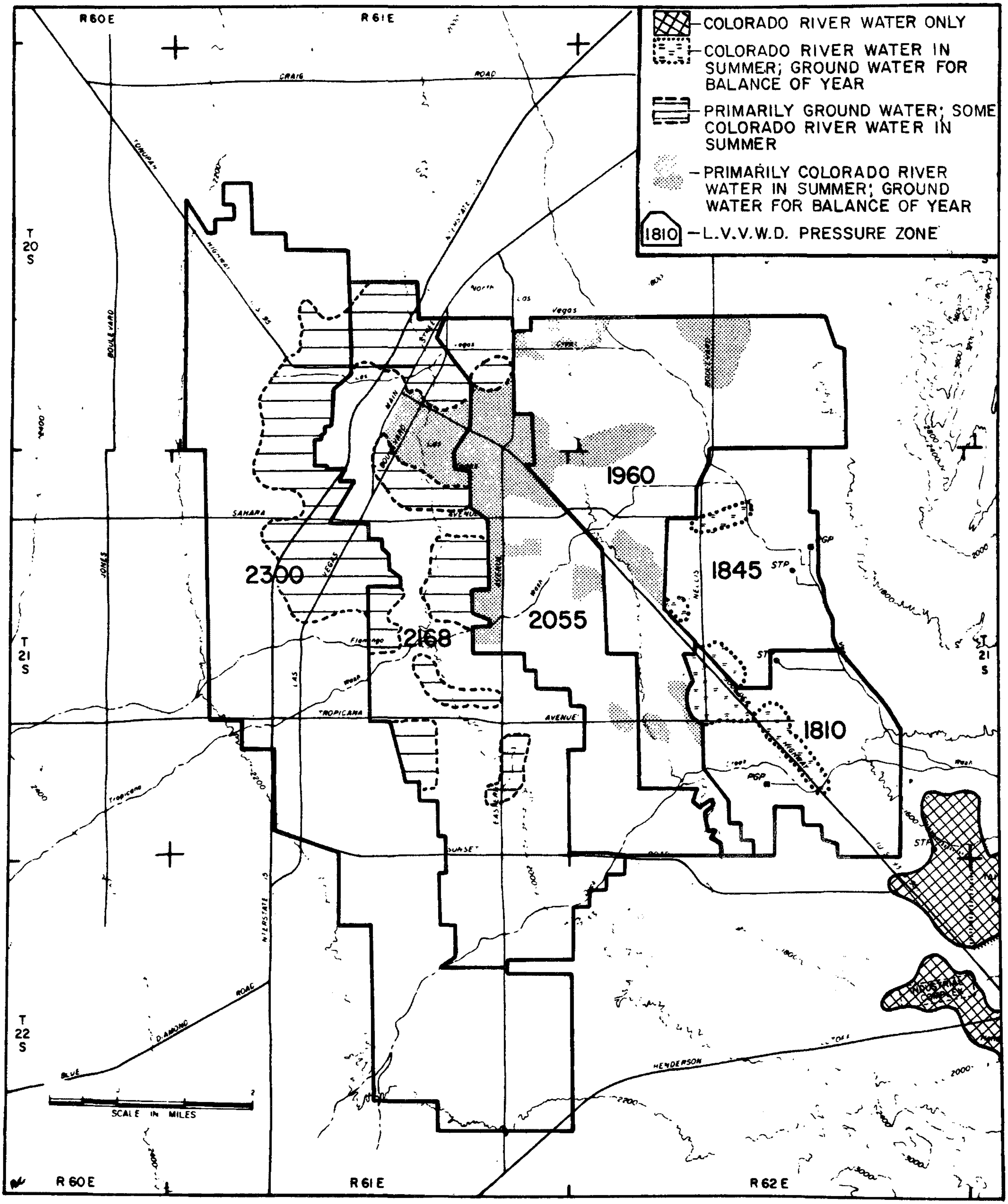


Figure 53. Approximate distribution of Colorado River water in Las Vegas Valley Water District pressure zones from 1955-1971.

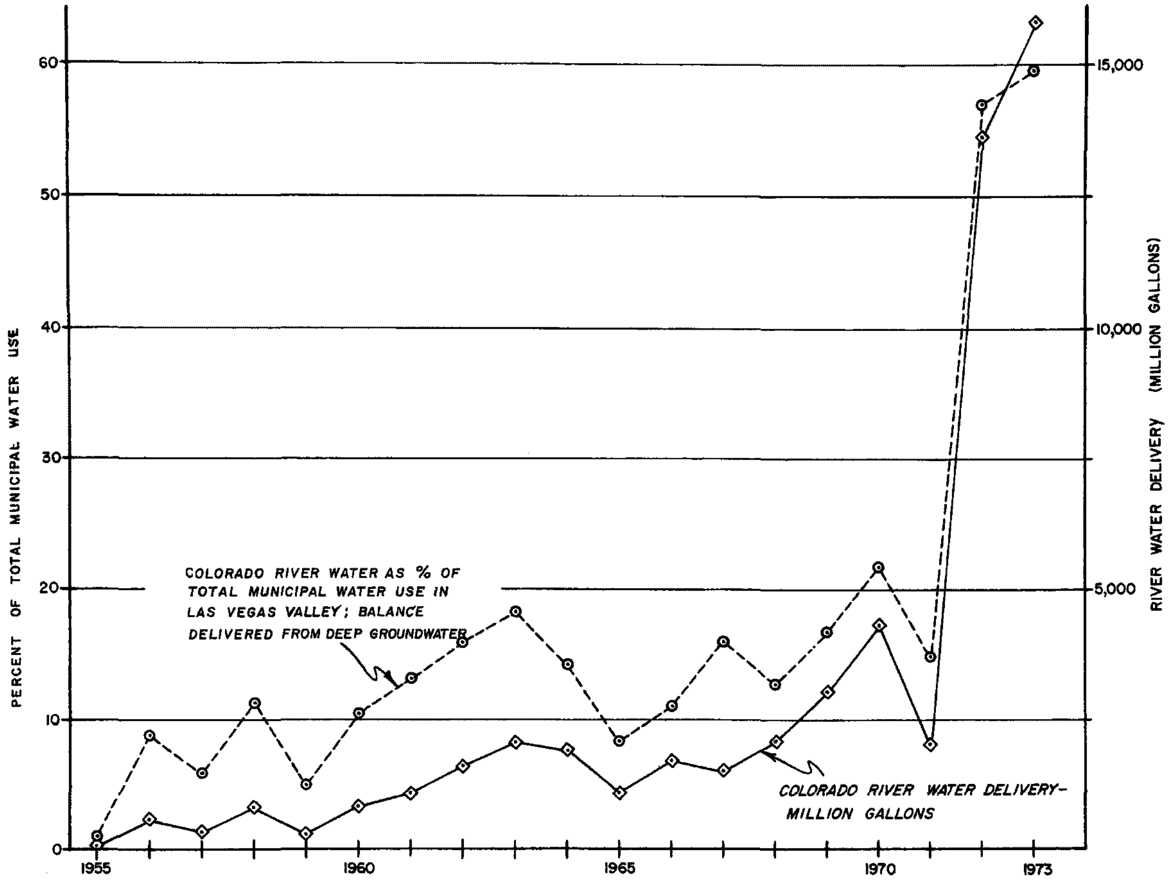


Figure 54. Colorado River water deliveries to Las Vegas Valley from 1955 through 1973 (exclusive of deliveries to BMI and Henderson).

Many indications of recharge from the ponds and ditches are described by Kaufmann (1971). For example, well LG050, which is 30 feet deep and located essentially downgradient from the plant area, was recharged by the effluent ditch leading from the plant area and then past station LW018 to the lower ponds. When the effluent was rerouted to the upper ponds in early 1971, well yield decreased sharply. The concentration of 212 TU probably reflects slight mixing of low-level, natural ground water with infiltrated industrial effluent. Station LW020, which contains 384 TU, is located at the terminal end of a french tile drain field extending generally southward toward Boulder Highway. Installed to allow farming in an area with a high water table, the tiles now collect shallow ground water heavily contaminated with wastewater originating in the plant area.

Tritium concentrations in ground water below and adjacent to both upper and lower tailings ponds indicate widespread contamination. Prominent springs (LW032, LW048, and LW049) created as a result of waste disposal contain tritium concentrations of 411, 329, and 358 TU, respectively. Below the upper pond area, which has most consistently received effluent since the early 1940's, piezometer LG013 (247 feet deep) contained 285 TU. This substantiates one of the early modeling results of this study, i.e., contamination has entered the less permeable sediments beneath the shallow sand and gravel. Contamination of the shallow, permeable sediments extends from the plant area northward 1.8 miles and from the upper ponds northeastward 1.5 miles. The overall area affected is about 16 square miles and consists of a swath 2 to 3 miles wide in an east-west direction and extending northward from the plant area to Las Vegas Wash.

Springs adjacent to the ponds discharge contaminated water isotopically similar to that from the Colorado River. Water from deeper zones along the Wash in the reach above the ponds contains 3.9 to 5.4 TU. To the west, the first wells showing increased tritium are in the vicinity of Duck Creek. Well LG030, at a depth of 30 feet, has 47.1 TU whereas an adjacent flowing well (LG029) completed in the low yield sediments at a depth of 97 feet contains 3.9 TU. Thus, water discharging from depth and upgradient of the ponds, contains essentially background tritium concentration and is unaffected by industrial wastes. In the vicinity of the lower ponds, two deep wells (LG017, 019) contain background levels of tritium, which may signify that contamination in the less permeable, deeper sediments has not yet reached the Wash.

Industrial effluents entering the Wash transform the underflow of the Wash from older, largely natural water discharging from the Valley, to one which is predominantly young and from the Colorado River. Water from wells LG006, LG007, and LG055, in or near the Wash channel and downgradient from the ponds, contains 250 to 407 TU.

Tritium concentrations in 23 shallow ground-water sampling points just tapping the water table beneath urban and suburban portions of the Valley also indicate that return flows are present. As expected, concentrations are higher in the eastern half of the developed area where Colorado River water, in various degrees of dilution with ground water, has been delivered since 1955 (see Table 18 and Figure 53). Heaviest use of Lake Mead water has been along Boulder Highway and surrounding areas and in the downtown area (in order, pressure zones 1810, 1845, 1960, 2055, and 2168). Shallow wells purposely located within or adjacent to irrigated areas average 54.7 TU whereas springs, seeps and underdrains sampled regardless of location contain 45.4 TU.

It is apparent from the tritium data (Table 18) that recent recharge has occurred in the urban and suburban areas. Markedly elevated values of 125 and 166 TU characterize return flows in the downtown area and a residential development adjacent to Boulder Highway. Both areas received Lake Mead water in the summer months from 1955-1971. Very shallow ground water beneath Winterwood Golf Course, which is irrigated with treated sewage effluent from the County Plant, contains 24.7 TU and is therefore low but of similar magnitude to other locations known to be irrigated with the same effleunt (e.g., LW015) or receiving Colorado River water (e.g., LW059, 087, 088; LG098, 100, 102, 105, 107). Station LW015 (a spring) contains 38.7 TU and 17.7 mg/ℓ nitrate. The probable source for the discharge of 18.8 gallons per minute (0.083 acre feet per day) is irrigation return flow from Paradise Valley Country Club. For the last 14 years, the course has mainly been watered with effluent from the Clark County Sewage Treatment Plant. Spring flow in Flamingo Wash (LW009, 060) may be recharged in part by return flows of

TABLE 18. TRITIUM CONTENT OF SHALLOW GROUND-WATER RECHARGED BY IRRIGATION RETURN FLOWS FROM URBAN AND SUBURBAN DEVELOPMENTS

Sampling Point	Tritium Content (TU)	Nearby source of recharge	Year(s) developed
LW 009	21.9	Suburban developments and golf courses*	-
015	28.7	Paradise Valley Country Club	1960
059	40.6	Flamingo Reservoir (contains Colorado River water); Paradise Crest Housing tract (served by Colorado River water)	
060	23.7	Flamingo Wash underflow*	
084	35.6	Stardust Country Club Golf Course	
085	22.6	Downtown Las Vegas	Pre-1943
086	13.3	"	Pre-1943
087	98.9	Housing tract	
088	41.1	None†	
089	125	Downtown Las Vegas	Pre-1943
090	25.4	Desert Inn Country Club Golf Course; Convention Center	
092	21.1	Sahara Hotel; nearby homes and businesses	
094	91.8	None†	
LG 098	17	Housing tract	1965-1969
099	24.7	Winterwood Golf Course	1965
100	30.9	Housing tract	1947
101	166	Housing tract	1965
102	53	Huntridge Park homes	Pre-1943
103	45	Housing tract	
104	40.1	Desert Inn Country Club Golf Course	
105	79.1	Royal Crest Rancheros homes	1965
107	36	Southgate homes	1963
130	55.5	Flamingo Wash drain ditch	

* Stations LW084, 009 and 060 (in downstream order) are situated on Flamingo Wash which is the locus of springs and flowing wells and irrigation return flow from nearby golf courses and housing tracts.

† Ground-water discharge from an underdrain in the basement of a department store. Nearby recharge sources include return flow from housing tracts, apartment houses and on-site landscaping.

Colorado River water in that upgradient service areas are pressure zones 2168 and 2055.

Four samples of shallow ground water from observation wells just tapping the water table in areas west of Interstate Highway-15 and adjacent to residential development contain between 9.7 and 38.8 TU. The lowest concentration occurs in perched water at a depth of five feet beneath the Eastland Heights residential area. This development is served by private water supply wells and septic tank systems. Well LG108 with 16.4 TU is adjacent to a development served almost solely with deep ground water. Therefore, local recharge of runoff is believed to be the source of tritium. The maximum value of 38.8 TU is from a well immediately downgradient from the Charleston Estates development which was on ground water until 1972. The elevated tritium is indicative of either very rapid introduction of Colorado River water to return flows or it is a result of precipitation and infiltration of overland flow.

Ground-water seepage at the intersection of the Union Pacific Railroad and Bonanza Road (LW096) contains 38.3 TU compared to 9.5 TU in another seep (LW095) at the junction of Lake Mead Boulevard and Interstate Highway-15. Both sampling points are in or immediately adjacent to the 2168 pressure zone of the Las Vegas Valley Water District; therefore, Lake Mead water mixed with ground water has been present since 1955. There is very light residential development in the surrounding area and minimal lawn watering.

In summary, the tritium data are indicators of in-valley recharge to the shallow ground-water zone. Usefulness as a quantitative tool to determine volume of recharge is generally not possible due to uncertainties with respect to dilution, initial tritium concentrations, and timing of infiltration. Qualitatively, the tritium results corroborate conclusions reached using gross chemical analyses and water budget methods. More intensive tritium sampling would be necessary to define tritium content of shallow ground water completely removed from return flow sources or natural runoff infiltration, and to establish the importance of in-valley recharge from precipitation, concentrated runoff, and localized flooding. Data developed indicate that concentrations of greater than 20 TU are likely a result of irrigation return flows. The utility of using environmental tritium for detailed studies of recharge will decrease with time because environmental tritium concentrations continue to decrease due to termination of the atmospheric thermonuclear testing. Also, radioactive decay is gradually lowering concentrations in shallow ground water to marginally significant concentrations.

BIBLIOGRAPHY

Back, W. 1966. Hydrochemical Facies and Ground-Water Flow Patterns in the Northern Part of the Atlantic Coastal Plain. U. S. Geological Survey, Professional Paper 498-A. p. A1-A42.

Back, W. 1961. Techniques for Mapping of Hydrochemical Facies. U. S. Geological Survey, Professional Paper 424-D. p. D380-D382.

Bingler, E. C. and K. Luza. (in preparation). Geology of the Las Vegas, Nevada Southeast 7½' Quadrangle. Nevada Bureau of Mines.

Boyle-CH_2M (Boyle Engineering and Cornell, Howland, Hayes and Merryfield). 1969a. A Comprehensive Water Quality Control Program for the Las Vegas Drainage Basin - Phase I. Report submitted to the Inter-Agency Water Pollution Control Task Force. 180 pp.

Boyle-CH_2M. 1969b. A Comprehensive Water Quality Control Program for the Las Vegas Drainage Basin - Phase II. Report submitted to the Inter-Agency Water Pollution Control Task Force. 125 pp.

Carpenter, E. 1915. Ground Water in Southeastern Nevada. U. S. Geological Survey, Water Supply Paper 365. p. 31-41.

Chebotarev, I. I. 1955a. Metamorphism of Natural Waters in the Crust of Weathering. Geochimica et Cosmochimica Acta 8:22-48.

Chebotarev, I. I. 1955b. Metamorphism of Natural Waters in the Crust of Weathering. Geochimica et Cosmochimica Acta 8:137-170.

Chebotarev, I. I. 1955c. Metamorphism of Natural Waters in the Crust of Weathering. Geochimica et Cosmochimica Acta 8:198-212.

Cochran, G. F. and W. C. Wilson. 1971. Arid Urban Water Management: Some Economic, Institutional and Physical Aspects. Technical Report Series H-W, Hydrology and Water Resources Publication No. 11, Center for Water Resources Research, Desert Research Institute. 62 pp.

Cooley, R. L., G. W. Fiero, Jr., L. H. Lattman, and A. L. Mindling. 1973. Influence of Surface and Near-Surface Caliche Distribution on Infiltration Characteristics and Flooding, Las Vegas Area, Nevada. Center for Water Resources Research, Desert Research Institute, Project Report 21. 41 pp.

Davis, L. G., A. K. Turner, and W. N. Melhorn. 1969. Analysis of Ground-Water Use, Replenishment, and Aquifer Characteristics in Bartholomew

County, Indiana. Water Resources Research Center, Purdue University, Technical Report 3. 83 pp.

Dinger, J. S. (in preparation). Geologic Reconnaissance of the Las Vegas, Nevada Northeast, Northwest and Southwest 7½ Quadrangle. Nevada Bureau of Mines.

Dinger, J. S. (in preparation). Relation Between Surficial Geology and Near Surface Ground-Water Chemistry, Las Vegas Valley, Nevada. Ph.D. Thesis, University of Nevada-Reno.

Domenico, P. A. and G. B. Maxey. 1964. Data Collection Program: Las Vegas Valley. Desert Research Institute, prepared in cooperation with Nevada Department of Conservation and Natural Resources, mimeo. report.

Domenico, P. A., D. A. Stephenson, and G. B. Maxey. 1964. Ground Water in Las Vegas Valley. Desert Research Institute, Technical Report No. 7. 53 pp.

Fitzsimmons, D. 1973. Water Price Elasticity of Household Water Consumption in Las Vegas Valley, Nevada. Unpublished Masters Thesis in Agricultural and Resource Economics, University of Nevada, Reno.

Hardman, G. and M. R. Miller. 1934. The Quality of the Waters of Southeastern Nevada. University of Nevada, Agricultural Experiment Station, Bulletin 136. 62 pp.

Harrill, J. R. 1976. Water-Level Changes Associated with Ground-Water Development in Las Vegas Valley, Nevada, 1971-75. Nevada Department of Conservation and Natural Resources in cooperation with U. S. Geological Survey, Water Resources-Information Series, Report 22. 46 pp.

Hem, J. D. 1970. Study and Interpretation of the Chemical Characteristics of Natural Water. U. S. Geological Survey, Water Supply Paper 1473. 363 pp.

Jones, G. 1972 (May 29 to August 2). Newspaper articles on Flooding in Las Vegas Valley, Nevada. Las Vegas Review Journal.

Kaufman, S. and W. F. Libby. 1954. The Natural Distribution of Tritium. Physical Review 93:1337-1344.

Kaufmann, R. F. 1971. Effects of Basic Management, Inc. Effluent Disposal on the Hydrogeology and Water Quality of the Lower Las Vegas Wash Area, Nevada. Center for Water Resources Research, Desert Research Institute, Interim Progress Report to U. S. Environmental Protection Agency on Project No. 13030 EOB. 176 pp.

Kaufmann, R. F. 1972. Changes in Water Table Position and Ground Water Quality Adjacent to the Upper Portions of Las Vegas Wash. Center for Water Resources Research, Desert Research Institute, letter report to V. H. Uechert, Clark County Health Dept. 9 pp.

Krumbein, W. C. and F. A. Greybill. 1965. An Introduction to Statistical Models in Geology. New York, McGraw-Hill, Inc. 475 pp.

Langan, L. N., L. I. Larsen, and C. J. George. 1967. Soil Survey of Las Vegas and Eldorado Valleys Area, Nevada. U. S. Department of Agriculture, Soil Conservation Service in cooperation with University of Nevada Agricultural Experiment Station and U. S. Department of Interior, Bureau of Reclamation, Region 3. U. S. Department of Agriculture, Soil Conservation Service, Series 1957, No. 23. 87 pp.

Leeds, Hill, and Jewett, Inc. 1961. Water Supply for Las Vegas Valley: Report to the Director, Nevada Department of Conservation and Natural Resources. 154 pp.

Libby, W. F. 1962. Tritium Geophysics: Recent Data and Results - A Symposium in Vienna, Austria, May 3-10, 1961, in Tritium in the Physical and Biological Sciences, 1, International Atómic Energy Agency, 1961: published in Vienna by Paul Ferin.

Livingston, P. 1938. Underground Leakage from Artesian Wells in Las Vegas Area, Nevada, U. S. Geological Survey, Water Supply Paper 849 D. p. 147-173.

Longwell, C. R., E. H. Pampeyan, B. Bowyer, and R. J. Roberts. 1965. Geology and Mineral Deposits in Clark County, Nevada. Nevada Bureau of Mines, Bulletin 62. 218 pp.

Lustig, L. K. 1969. Trend Surface Analysis of the Basin and Range Province, and Some Geomorphic Implications. U. S. Geological Survey, Professional Paper 500-D. 70 pp.

Malmberg, G. T. 1961. A Summary of the Hydrology of the Las Vegas Ground Water Basin with Special Reference to Available Supply. Nevada Department of Conservation and Natural Resources, Water Resources Bulletin No. 18.

Malmberg, G. T. 1965. Available Water Supply of the Las Vegas Ground Water Basin, Nevada. U. S. Geological Survey, Water Supply Paper 1780. 116 pp.

Maxey, G. B. and C. H. Jameson. 1948. Geology and Water Resources of Las Vegas, Pahrump and Indian Spring Valleys, Clark and Nye Counties, Nevada. Nevada Department of Conservation and Natural Resources, Water Resources Bulletin No. 5. 121 pp.

McKee, J. E. and H. W. Wolf. 1973. Water Quality Criteria - Second Edition. California State Water Resources Control Board. 548 pp.

Mendenhall, W. C. 1909. Some Desert Watering Places in Southeastern California and Southwestern Nevada. U. S. Geological Survey, Water Supply Paper 224.

Patt, R. O. 1977. Las Vegas Valley Water Budget: Relationship of Distribution, Consumptive Use, and Recharge to Shallow Ground Water. Water Resources Center, Desert Research Institute. In final preparation for EPA under grant No. R800946.

Patt, R. O. and J. W. Hess. 1976. Characterization of Nitrogen Sources Contaminating Shallow Ground Water in an Arid Basin, Las Vegas Area, Nevada. Water Resources Center, Desert Research Institute, Hydrology and Water Resources Publication No. 26. 44 pp.

Price, C. E., Jr. 1966. Surficial Geology of the Las Vegas Quadrangle, Nevada. Masters Thesis, Department of Geology, University of Utah. 60 pp.

Reichert, L. and J. Leland. 1971. User Attitudes Toward Water Quality and Price, Las Vegas Valley and Reno-Sparks, Nevada. Water Resources Center, Desert Research Institute. 121 pp.

Rockaway, J. D. and R. B. Johnson. 1967. Statistical Analysis of Ground Water Use and Replenishment. Purdue University, Water Resources Research Center, Technical Report 7. 142 pp.

Seaber, P. R. 1965. Variations in Chemical Character of Water in the Englishtown Formation, New Jersey. U. S. Geological Survey, Professional Paper 498-B. 35 pp.

Siddiqui, S. H. and R. R. Parizek. 1972. Application of Nonparametric Statistical Tests in Hydrogeology. Ground Water, 10(2): 27-31.

Siegel, S. 1956. Nonparametric Statistics for the Behavioral Sciences. McGraw-Hill Book Company, Inc., New York. 312 pp.

Stains, E. 1970. Las Vegas Wash Drainage Group-Drainage Investigation Report. U. S. Department of Agriculture, Soil Conservation Service. 5 pp.

Stauffer Chemical Company and Montrose Chemical Company of California. Written testimony for the record of the EPA Region IX Office of Enforcement hearings at Las Vegas on January 25, 1972. 19 pp.

Stewart, G. L. and R. K. Farnsworth. 1968. United States Tritium Rainout and Its Hydrologic Implications. Water Resources Research 4:273-289.

Stewart, G. L. and C. M. Hoffman. 1966. Tritium Rainout over the United States in 1962 and 1963. U. S. Geological Survey Circular 620. 11 pp.

Stewart, G. L. and T. A. Wyerman. 1970. Tritium Rainout in the United States during 1966, 1967, 1968. Water Resources Research 6:77-87.

Thatcher, L. L. 1962. The Distribution of Tritium Fallout in Precipitation Over North America. Bulletin of the International Association of Scientific Hydrology 7(2):48.

That er, L. L. and C. M. Hoffman. 1963. Tritium Fallout over North America from Soviet Tests in 1961. Journal of Geophysical Research 68(20): 5899-5901.

U. S. Army Corps of Engineers. 1967. Flood Plain Information - Lower Las Vegas Wash, Clark County, Nevada. U. S. Army Corps of Engineers, Los Angeles District. 23 pp.

U. S. Geological Survey. 1972. Flood Insurance Study. Report submitted to the Department of Housing and Urban Development. 60 pp.

U. S. Public Health Service. 1962. Drinking Water Standards. Publication 956. 61 pp.

Westphal, J. A. 1977. Simulation Modeling of the Shallow Ground-Water System in Las Vegas Valley. Water Resources Center, Desert Research Institute. In final preparation for EPA for grant No. R800946.

Westphal, J. A. and W. E. Nork. 1972. Reconnaissance Analysis of Effects of Waste-Water Discharge on the Shallow Ground-Water Flow System Lower Las Vegas Valley, Nevada. Cneter for Water Resources Research, Desert Research Institute, Project Report 19. 36 pp.

Winograd, I. J. and I. Friedman. 1972. Deuterium as a Tracer of Regional Ground-Water Flow, South Great Basin, Nevada and California. Geological Society of America Bulletin 83:3691-3708.

Winograd, I. J. and W. Thordarson. 1975. Hydrogeologic and Hydrochemical Framework, South-Central, Great Basin, Nevada-California, with special reference to the Nevada Test Site. U. S. Geological Survey, Professional Paper 712-C. p. C1-C126.

Wyerman, T. A., R. K. Farnsworth, and G. L. Stewart. 1970. Tritium in Streams in the United States, 1961-1968. Radiological Health Data and Reports 11:421-439.

Appendix 1. Characteristics of Selected Observation Wells

SYSTEM FOR LOCATING DATA POINTS AND AREAS

Data points referred to in this report are identified or located by township, range, and section according to the rectangular subdivision of the public lands. Locations are south of the Mount Diablo base line and east of the Mount Diablo meridian. The three-part system used to locate a data point consists of 1) the township (T) south (S) of the base line, 2) the range (R) east (E) of the meridian, and 3) the section number. The section number is followed by letters that indicate the quarter section, quarter-quarter section, and so on. The letters a, b, c, d or the numbers 1, 2, 3, 4 are used to designate the northeast, northwest, southwest, and southeast quarters, respectively. The form incorporating letter characters is more familiar to the general user, whereas the form employing only digits is more readily adaptable to computerized data handling techniques. The systems are interchangeable and both are used herein, as appropriate.

A data point can be located to an area as small as 10 acres insofar as a quarter section is 160 acres, a quarter-quarter section is 40 acres, and a quarter-quarter-quarter section is 10 acres. For example, a well in the SW¼ NW¼NE¼ section 7, T.20S., R.60E. is designated 20/60-07abc or 20/60-07123. If the data point location were only known to within 40 acres, it would be identified as 20/60-0712. A fourth digit may be used to sequentially identify up to nine sampling points in a given 10-acre area but this digit has no location significance. To eliminate confusion, two digits are always used to indicate the section involved. Thus, section seven is indicated as 07.

In addition to the system described, sampling points were also located according to latitude and longitude down to degree, minutes and seconds (Appendix 2).

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)/ Total Depth (feet)/ Shut Down (hours)/ Casing String (feet)
LG001	23/61-04dad1				not logged	
002	22/62-01cba1				"	
003	22/62-08cbd1				"	
004	21/63-14dbdJ	48/48		0-48	peak and muck; with sand and gravel, coarse	3.35/27/17/10
						7.06/48/17/48
005	21/63-14dbd2	100/100		0-100	silt, reddish-brown; with sand and gravel (40)* coarse-medium grain, quartz, sandstone, feldspars, volcanics and limestone	
006	21/63-28aca1	44/44	41-43	0-36	sand and gravel, fine grain, volcanic	2.43/42/16/32
				36-44	gravel, cemented; with igneous fragments; 2' - 3' weathered zone	
007	21/63-28aca2	135/125	90-95	0-20	sand and gravel, fine, volcanic	
				20-37	sand, fine and pea gravel	
				37-40	sand, coarse, volcanic	
				40-48	sand, medium-fine, volcanic	
				48-55	sand, fine, volcanic	
				55-65	sand and gravel, fine, volcanic	
				65-78	gravel, pea, and very coarse; volcanics with conglomerate of volcanic fragments	
				78-120	silt, very clayey, dark reddish-brown	
				120-135	siltstone(?), brown and green, well indurated	
008	21/63-30dad1	34/34	0-34		not logged	
009	21/63-29ccb1	91/91	85-90	0-35	gravel, medium-fine, volcanic, with sand (15) coarse, volcanic, gypsum	
				35-45	sand, coarse, volcanic; with gravel (10) medium, volcanic	
				45-50	silt, with sand (20) fine	
				50-54	gravel, medium, volcanic	
				54-63	sand, coarse, volcanic	
				63-69	sand, coarse, volcanic; with clay (40) reddish-brown	

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum) Total Depth (feet) Shut Down (hours) Casing String (feet)
				69-73	clay, cream	
				73-91	clay, blue; with gypsum	5.46/80/17/75
LG010	21/63-29ccb2	42/42		0-35	sand and gravel, medium-fine; volcanic; with gypsum	
				35-42	sand, coarse, volcanic	
011†	21/63-29ccd1	39/39	0-39		not logged	
012†	21/63-29ccd2	38/38			"	
013	22/63-05cbb1	250/244	241-243	0-35	gravel, volcanic; with sand, coarse-medium, volcanic	
				35-50	sand, fine-medium; with gravel (20) medium, volcanic	35.6/45/36/43
				50-53	sand, fine-medium; with silt (25)	
				53-55	clay, beige, silty	
				55-57	sand, coarse, volcanic; with clay, brown, with manganese stain	
				57-60	clay, brown, silty	
				60-65	clay, brown, silty; with clay, white	
				65-80	clay, reddish-brown, silty	
				80-84	clay, light brown, silty	
				84-102	clay, beige, silty; with clay, light green with manganese stain	36.8/90/17/69
				102-126	clay, cream	37.8/105/17/95
				126-130	clay, beige and light green, gpysiferous	
				130-165	clay, beige, gypsiferous	
				165-172	clay, bluish-green	36.8/165/17/115
				172-190	clay, brown, gypsiferous	
				190-220	clay, dark brown, gypsiferous	48.5/220/19/170
				220-250	clay, blue, gypsiferous	38.9/250/16/234
014	22/63-05cbb2	45/45	44-45	0-35	sand and gravel, volcanic	
				35-45	sand, fine-medium, volcanic; with gravel (20) medium volcanic	35.6/45/36/43

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum) / Total Depth (feet) / Shut Down (hours) / Casing String (feet)
015	21/63-30cbcl	25/25	23-25	0-22	sand and gravel with fragments of limestone, chert and dolomite	
				22-25	gravel, medium, beige; with fine sand (20); both composed of limestone, chert and dolomite	
016	21/63-30cbc2	47/47	43-46	0-24	sand, fine, beige; with gravel coarse, composed of chert, gray limestone and dolomite	
				24-29	sand, fine, beige, composed of limestone, chert and dolomite	
				29-43	clay, greenish-gray; with (10) sand, fine	
				43-47	clay, cream and blue-gray	
017	21/63-31abbl	90/83	80-82	0-11	gravel, coarse; with sand and pebbles of rhyolite, scoria, basalt and some chalcedony quartz	5.8/11/17/10
				11-18	gravel and sand, coarse, composed of scoria, basalt, rhyolite	
				18-22	sand, fine	
				22-45	sand, fine-medium	5.6/82/ 2/43
				45-87	not logged	
				87-90	clay, green	69.43/83/21/82
018‡	21/63-31abb2	20/20	1-20	0-0.5	sand, gray-light brown, gravelly	
				0.5-1	sand, brown	
				1-3	sand, light brown	
				3-7.5	sand, light brown, silty	
				7.5-16.5	sand, brown, gravelly	
				16.5-20	gravel, gray-brown, sandy	
019	21/63-31babl	70/68		0-20	sand and clay, fine, brown; with gravel (5) volcanic	
				20-30	sand and clay, fine, gray	
				30-34	sand, fine, gray, volcanic	4.40/34/1.5/20
				34-38	clay, gray, sandy; with gravel medium, volcanic	
				38-45	gravel, medium-coarse; with sand, coarse, volcanic	

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum) / Total Depth (feet) / Shut Down (hours) / Casing String (feet)
				45-57	clay, cream	
				57-62	clay, buff green, very adhesive	
				62-70	clay, blue	flowing
020	21/63-31bab2	20/18		0-20	sand, fine; with some clay	4.11/20/2/17.5
						4.07/20/17.5/17.5
021	21/63-31cca1	40/40	37-39	0-10	alluvium, disturbed	
				10-17	not logged	
				17-20	gravel, coarse, brown, composed of scoria, basalt, and chalcedony quartz; with medium sand (15)	
				20-27	sand, coarse-fine, brown; with clay (15)	
				27-30	clay, brown, sandy; with gravel, fine, (15) composed of scoria, basalt, etc.	
				30-40	clay, hard, pinkish-brown with some manganese stain; with clay, plastic, green	
022‡	21/63-31cca2	22	1-22	0-20	sand, brown, silty	
				20-22	sand, red-brown, silty	
023	22/63-06dba1	45/45	43-44	0-35	sand and gravel, volcanic	
				35-45	silt and gravel	
024†	22/63-06dba2	30/30	1-30	0-0.5	salts, evaporative	
				0.5-1	transitional	
				1-2	sand, brown	
				2-6	sand, red-brown, gravelly	
				6-9	sand, light red-brown, silty	
				9-10	sand, red-brown, gravelly	
				10-11.5	sand, light red-brown	
				11.5-30	sand, red-brown, gravelly	
025	21/63-07bcb2	24/24		0-24	sand and gravel, fine-medium, reddish, volcanic	11.4/21/41/10
026	21/63-07bcb1	100/91	87-90	0-37	sand and gravel, fine-medium, reddish	
				37-42	sand and clay, fine, maroon; with gravel (10) medium, volcanic	

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)/ Total Depth (feet)/ Shut Down (hours)/ Casing String (feet)
				42-25	gravel, coarse, volcanic; with sand, medium grain	
				45-58	sand, fine, volcanic; with gravel, (5) coarse	
				58-90	clay, brown silty	19.5/83/17/67
				90-93	sand and gravel, fine	
				93-100	clay, brown; with sand (10) coarse grain	
027	21/62-36baa1	62/62	57-62	0-13	not logged	7.95/13/ -/0
				13-25	sand and gravel, coarse, volcanic, intermixed with cobbles	6.98/26/41/16
				25-55	sand, medium, volcanic	6.16/45/17/32
				55-62	siltstone, reddish-brown, sandy	5.6 /62/17/62
028‡	21/63-36baa2	20/20	1-20	0-1	sand, light brown, silty	
				1-5	sand, brown, gravelly	
				5-14	sand, light brown, gravelly	
				14-20	sand, brown, gravelly	
029	21/62-26dba1	100/100	95-100	0-23	sand and gravel, medium-coarse, light gray, volcanic	7.17/15/20/11 5.79/23/0.5/11
				23-30	sand, very fine, tan; with clay	
				30-34	sand, very fine, volcanic	
				34-42	gravel, medium, volcanic	4.83/34/17/34
				42-100	siltstone, reddish-brown, sandy; with gravel (10) fine, volcanic	1.17/100/17/38
030	21/62-26dba2	30/30	27-29	0-23	gravel and sand, coarse, volcanic	
				23-30	sand and gravel, volcanic	5.28/30/17/30
031	22/62-11cbb1	63/63	47-62	0-30	gravel, medium, volcanic; with sand (10) medium-fine, volcanic	
				30-38	gravel, medium-fine, volcanic; with sand and silt (20)	
				38-63	silt; with sand (25), coarse	36.7/63/17/35
032	22/62-11dac1	155/147		0-68	sand and gravel, volcanic	38.1/41.6/17/40

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)/Total Depth (feet)/Shut Down (hours)/Casing String (feet)
						40.04/47/18/45
						36.75/62.5/0.5/54
				68-105	sand, coarse, volcanic; with pea gravel (5)	38.2/10/19/80
				105-120	silt, beige, sandy	
				120-150	gravel and sand, calcified	36.5/150/5.5/143
						35.0/150/17/143
033	22/62-11dac2	45/40	36-39	0-45	sand and gravel, volcanic	36.0/45/17/40
034†	21/62-15dda1	35/35	0-35		not logged	
035	21/62-15dda2	105/105	100-104	0-10	sand, fine-coarse, volcanic, construction fill dirt	
				10-50	clay, tan-beige, sandy; with gravel (20) coarse, composed of limestone, chert and dolomite	
				50-70	clay, light tan	
				70-80	clay, greenish-gray with manganese stain	
				80-85	clay, cream, light green, with some manganese stain	
				85-105	clay, reddish-brown; with fine sand (15), Muddy Creek Formation?	
036	21/62-22bda1	50/50	44-49	0-45	siltstone, beige, sandy; with gravel (10) medium, limestone	
				45-50	clay, cream	7.94/50/3/15
037+	21/62-22bda2	31/31	29-31	0-31	siltstone, beige, sandy	
038	22/62-04bdb1	112/93	90-92	0-2	sand, coarse, loose	
				2-3	caliche	
				3-7	gravel, light gray, composed of fragments of basalt, scoria, and trachyte	
				7-18	siltstone, reddish-brown, sandy; with gravel (10) fine, volcanic	

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum) / Total Depth (feet) / Shut Down (hours) / Casing String (feet)
				18-20	conglomerate, tan to gray, composed of clasts of basalt, scoria, chert and dacite	4.04/20/39/5
				20-30	siltstone, tan, sandy; with fragments of basalt, scoria and trachyte	
				30-35	conglomerate and siltstone, grayish-tan	
				35-45	siltstone, reddish-brown, sandy	
				45-50	siltstone, reddish-tan, sandy	
				50-56	siltstone, light chocolate-brown	
				56-63	siltstone, brown, sandy	
				63-74	siltstone, beige, sandy	
				74-80	siltstone and conglomerate, gray-brown, sandy	
				80-86	siltstone, tan, sandy	
				86-97	siltstone and conglomerate, grayish-tan, sandy	
				97-112	siltstone, tan, sandy	4.21/112/17/90
039	22/62-04bab2	40/40		0-20	siltstone, beige, sandy; with conglomerate, gray, intraformational	
				20-28	siltstone, brownish-gray, sandy; with conglomerate, gray, intraformational	
				28-33	siltstone, beige, sandy	
				33-40	siltstone, brown, sandy; with conglomerate, intraformational	
040	22/62-04bcb3	110/101	98-100	1-16	siltstone, tan, sandy; with gravel (15) composed of pebbles of limestone, basalt and scoria	
				16-17.5	sandstone, brown, cemented by calcite	
				17.5-22	siltstone, tan, sandy, same as 0-16 interval	
				22-28	sandstone and oonglomerate, light gray; with gravel (15) volcanic	
				28-37	siltstone, brown, sandy	

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)/ Total Depth (feet)/ Shut Down (hours)/ Casing String (feet)
				37-43	sandstone and conglomerate, light gray	
				43-59	siltstone, brown, sandy	
				59-70	siltstone, gray, sandy; with silt (50), sandy (50)	
				70-110	siltstone, brown-tan	6.50/85/20/40
041	20/62-32aba1	67/67	61-64	0-35	silt and gravel, light gray, sandy	
				35-37	caliche	
				37-42	silt and gravel, light gray, sandy	
				42-57	silt, light beige, sandy	
				57-60	silt, light green, sandy	
				60-67	clay or silt, cream and beige, sandy	
042	20/62-32aba2	170/170	159-169	0-41	silt, light gray, sandy; with gravel, coarse	
				41-63	silt, light beige, sandy	
				63-80	clay, cream; with clay, beige	
				80-108	silt, beige, sandy	
				108-126	silt, cream, sandy	
				126-137	silt, light beige, sandy	
				137-148	silt, white, sandy	
				148-157	silt, tan, sandy	
				157-170	silt, beige, sandy	
043	21/62-29dcd1	56/56	46-56	0-25	siltstone, tan, sandy; with pea gravel (10)	
				25-28	siltstone, beige, sandy	
				28-29	sandstone, reddish-brown, intraformational, cemented	
				29-35	siltstone, beige, sandy	
				35-42	siltstone, light pinkish-brown, sandy; with sand, (35) coarse grain	
				42-56	siltstone, beige, sandy; with gravel (10), medium	

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)/ Total Depth (feet)/ Shut Down (hours)/ Casing String (feet)
044	21/62-29dcd2	129/129	122-125	0-37	silt, beige, sandy	
				37-40	silt, beige, sandy; with sand, coarse, volcanic	
				40-42	sand and gravel, pinkish-beige, well cemented	
				42-55	silt, pinkish-brown, sandy; with sand (30), coarse, volcanic	
				55-60	silt, beige, sandy	
				60-67	silt, light chocolate brown, sandy	
				67-75	silt, tan, sandy; with sand and gravel (10) coarse	
				75-90	silt, grayish brown	
				90-129	silt, pinkish-tan	
045	21/62-19aaa	125/125	122-125	0-15	silt, beige, sandy; with caliche	
				15-37	silt, light chocolate brown, sandy	
				37-48	silt, pinkish-brown, sandy; with gravel (15)	
				48-55	silt, chocolate brown, sandy	
				55-70	silt, pinkish-brown, sandy	
				70-125	silt, chocolate brown, sandy	28.45/125/41/125
046	21/62-19aaa2	40/40	36-39	0-15	silt, beige, sandy; with caliche	
				15-37	silt, light chocolate brown, sandy	
				37-40	silt, pinkish-brown, sandy; with sand and gravel (15)	
047	20/61-36ddd1	100/100	96-99	0-19	silt, beige, sandy; with pebbles limestone	
				19-63	silt, pinkish-tan	14.06/45/17/40
				63-65	anhydrite(?), light gray, sugary	
				65-70	silt, pinkish-tan	
				70-81	anhydrite(?), light gray, sugary	
				81-93	silt, pinkish-tan	
				93-100	silt, beige, sandy	
048	20/61-36ddd2	40/40	36-39	0-19	silt, beige, sandy	
				19-40	silt, pinkish-tan	

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)	Total Depth (feet)	Shut Down (hours)	Casing String (feet)
049	21/63-29ccb3	35/35	0-35		not logged				
050	21/62-35ddal	20/20	0-20		"				
055†	21/63-29ccb4	30/30	0-30		"				
056	21/62-11bcbl				"				
057	20/61-03dabl				log available from Division of Water Resources (DWR)				
058	20/61-15dccl				"				
059	20/61-29cccl				not logged				
060	21/62-22bbd2	20/20§			log available from DWR				
061	19/60-04cdal	706/631	531-631		"				
062	19/60-09cdal	612/			"				
063	20/61-36bbbl	300/	none		"				
064	20/62-18bbcl	300/	55-120		"				
065	20/62-08abal	120/	70-115		"				
066	20/61-03dabl	350/			"				
067	20/61-20caal	570/	394-570		"				
068	20/61-20caal	75/	none		"				
069	20/61-20cab	400/			"				
070	20/61-28cdal	440/			"				
071	21/61-04baal	400/			"				
072	20/61-33ccbl	425/			not logged				
073	20/61-33ccal	400/400	270-400		log available from DWR				
074	20/61-34bcbl	780/757	280-290		"				
075	21/61-01bbal	400/200			"				
076	21/62-29cccl	404/			"				
077	21/61-24aadl	160/160	60-160		"				
078	21/61-24aadl	100/100			"				
079	21/61-25cacl				not logged				
080	22/61-03ddal	335/	none		log available from DWR				
081	22/61-01dacl	209/			"				
082	21/62-30dbbl	390/			"				

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)	Total Depth (feet)	Shut Down (hours)	Casing String (feet)
083	21/62-03cabl	200/			log available from DWR				
084					"				
093					not logged				
098	21/62-08dcal	25/24	23-24	0-2	silt, sandy				
				2-3	soil, organic				
				3-4.5	caliche				
				4.5-8	clay, sandy				
				8-11	silt, clayey				
				11-12	sand				
				12-14	clay				
				14-14.5	sandϕ				
				14.5-17	clay				
				17-17.5	sandϕ				
				17.5-21	clay				
				21-25	sandϕ				
099	21/62-09abal	26/25	24-25	0-1	clay, silty				
				1-3.5	sand, silty				
				3.5-5	clay				
				5-18	sand, silty				
				18-20.5	gravel, sandy, calcareous				
				20.5-26	sandϕ				
100	20/61-35adal	12/11	10-11	0-2.5	fill				
				2.5-7	clay, silty				
				7-8	sand, medium				
				8-8.5	clay, silty				
				8.5-11	sandϕ				
				11-12	clay, sandy				
101	21/62-21cdal	31/30	29-30	0-5	sand, silty, grading downward to sandy silt with calcareous gravel				
				5-11.5	clay, gypsiferous in upper portion				
				11.5-14	clay, sandy with caliche gravel				

Appendix 1 (continued).

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)	Total Depth (feet)	Shut Down (hours)	Casing String (feet)
				14-15.5	clay, gypsiferous				
				15.5-26.5	clay, sandy				
				26.5-27	caliche				
				27-28	clay, silty				
				28-30.5	sand, siltyϕ				
				30.5-31	clay, silty, with caliche gravel				
102	21/61-02bacl	20/17	16-17	0-4	clay				
				4-9	clay with interbedded caliche gravel				
				9-11.5	clay, sandy				
				11.5-14.5	sand with calcareous gravel				
				14.5-15	clay and calcareous gravel				
				15-16	sandϕ				
				16-20	clay, sandy				
103	21/61-01cacl	10/9	8-9	0-4.5	silt				
				4.5-7.5	clay, silty, with coarse calcareous gravel				
				7.5-10	clay, silty, with gravelϕ				
104	21/61-13bbcl	8/7	6-7	0-3	sand, silty				
				3-3.5	clay, silty, with gravel, calcareous				
				3.5-6	clay, silty				
				6-8	clay, with calcareous gravelϕ				
105	21/61-23dabl	36/35	34-35	0-5.5	sand, silty				
				5.5-11.5	silt, sandy				
				11.5-20	clay, with calcareous gravel				
				20-23	clay				
				23-25.5	sandϕ				
				25.5-26	clay				
				26-27	sandϕ				
				27-28	clay				
				28-28.5	sandϕ				
				28.5-33	clay				
				33-34	sandϕ				
				34-36	clay				

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)	Total Depth (feet)	Shut Down (hours)	Casing String (feet)
106	22/61-02bbal	46/45	44-45	0-1	sand				
				1-4	silt, sandy				
				4-7.5	caliche				
				7.5-10	silt, sandy				
				10-13	caliche				
				13-17	caliche, friable				
				17-19.5	caliche				
				19.5-33	clay				
				33-34	caliche				
				34-38	clay				
				38-43	clay, silty, with calcareous gravelϕ				
				43-46	clay, sandy				
107	21/61-26ccbl	31/30	29-30	0-2	silt, sandy				
				2-7.5	caliche conglomerate				
				7.5-9.5	silt, sandy				
				9.5-10	caliche				
				10-27	clay				
				27-31	clay, silty with 6 to 8 inch thick sand and gravel lensesϕ				
108	21/61-09acdl	36/35	34-35	0-1.5	fill				
				1.5-4	silt, sandy, gypsiferous				
				4-6	gravel, calcareous				
				6-11	caliche conglomerate				
				11-19.5	silt, sandy, with calcareous gravel				
				19.5-22.5	clay				
				22.5-26	limestone conglomerate				
				26-30	silt, sandy, with calcareous gravelϕ				
109	21/61-05cbcl	39/37	36-37	0-8.5	silt, sandy, with caliche gravel				
				8.5-10	caliche				
				10-14.5	sand, silty, with calcareous gravel				
				14.5-17	clay, silty				

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)	Total Depth (feet)	Shut Down (hours)	Casing String (feet)
				17-21	sand, silty with caliche and gravel				
				21-24.5	clay, silty				
				24.5-26	sand, silty, with calcareous gravel				
				26-29.5	clay, silty, with calcareous gravel				
				29.5-34	calcareous gravel				
				34-35	clay, sandy				
				35-36.5	caliche				
				36.5-39	gravel, calcareousϕ				
				39-	caliche				
110	20/61-33cdbl	35/21	20-21	0-9	silt, sandy				
				9-14.5	silt with calcareous gravel				
				14.5-17	caliche conglomerate				
				17-21.5	gravel, calcareousϕ				
				21.5-28	clay, gravelly				
				28-34	clay, silty, with calcareous gravel				
				34-35	silt, gravelly				
111	21/62-22bba				not logged				
112	20/60-24aaa	312/312	213-312		log available from DWR				
113	19/60-23bbc	560/			"				
114	19/60-27aab	605/			not logged				
115	20/62-19cab	200/200	none		log available from DWR				
116	20/62-19bbb	289/289			not logged				
117	20/61-13adb	300/300	60-300		log available from DWR				
118	20/62-04add	800/800	70-784		"				
119	20/61-04add	900/900			"				
120	22/61-12bbb				"				
121	20/61-19bba	295/295	275-290		"				
122	20/61-33cca	226/			"				
123	20/61-35cbb	460/			"				
124	21/61-04dacl	650/			"				

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)	Total Depth (feet)	Shut Down (hours)	Casing String (feet)
125	21/61-04dac2	810/			log available from DWR				
126	20/61-18bcc	500/500	300-500		"				
127	20/61-29cbc	600/			"				
128	21/62-15ccb	30/30	0-30		not logged				
129	20/61-30ddb	10/10	8-10		"				
130	21/62-08aad	90/			log available from DWR				
131	19/60-23add	90/			"				
132	20/60-19dca	5/5			not logged				
133	20/61-31aba1	91/90	86-90	0-6	caliche, hard, dense				
				6-37.5	not logged				
				37.5-46.5	caliche, medium-hard, slightly cemented				
				46.5-49.5	clay, silty, calcareous, interbedded thin caliche gravel				
				49.5-52	caliche, hard, dense				
				52-58	clay				
				58-59	caliche				
				59-87	clay, interbedded with thin lenses of caliche				
				87-88.5	caliche				
				88.5-91	clay				
134	21/61-31aba2	20/19	17-19	0-20	same as log for LG133				
135	20/62-21cda1	215/			log available from DWR				
136	21/62-08dca1	100/			"				
137	21/61-12cdb	375/			"				
138	21/61-10add1	6/			not logged				
139	20/60-19dbb1	17/			"				
140	19/60-23aab1	208/			log available from DWR				

* Percent present in cuttings sample.

† Dewatering well installed by the A & K Construction Co. in conjunction with installation of the Southern Nevada Water Project pipeline. Cased to full depth of drilled hole with continuously slotted 20-inch diameter pipe.

Appendix 1 (continued)

Well	Location	Depth drilled/ depth cased (feet)	Perforated Interval (feet)	Depth (feet)	Description	S.W.L. (feet below datum)	Total Depth (feet)	Shut Down (hours)	Casing String (feet)

‡ Observation well installed by Montgomery Engineers of Nevada, Inc. for BMI. Cased to full depth with continuously slotted 2-inch diameter pipe.

ϕ Water bearing.

§ Estimated.

Appendix 2. Location and Description of Water Sampling Stations

ABBREVIATIONS USED IN APPENDIX 2

ADJ - adjacent
AK - A & K Construction Company
AP - airport
ARTES - artesian
B - Boulder
BC - Boulder City
BLDR - Boulder
BMI - Basic Management, Inc.
BTN - between
CC - country club
CCSTP - Clark County Sewage Treatment Plant
CEN - central
CHRAL - Charleston
COMP - complete
CONV CNTR - Convention Center
COR - corner
CORTZ - Cortez
CROSS - crossing
CRS - course
CURT MAN - Curtis Manor
CUT - cutthroat (flume)
CYP - Cypress
DEPT - department
DISC - discountinued
DRI - Desert Research Institute
E - east
EFFL - effluent
EMRSN - Emerson
ESTERN - Eastern
EXPWY - expressway
FLAM - Flamingo
FRWY - freeway
GC - golf course
HARRS - Harris
HEND - Henderson
HO - hotel
HWY - highway
INFL - influent
L - lake
LC - lower crossing of Las Vegas Wash and SNWP
LIQ - liquid
LM - Lake Mead
LN - Lane
LOW - lower
LT - lot
LV - Las Vegas
LVBM - Las Vegas Building Materials
LVBN - Las Vegas Blvd. North
LVVWD - Las Vegas Valley Water District
LVW - Las Vegas Wash
MAT - material
MONT WARD - Montgomery Ward
MRLND - Maryland
N - north
ND - and
NLV - North Las Vegas
NO - number
OGD - Ogden
OKY - Oakey
OUTFL - outfall
P HOL ADAIR - Pot Holiday Authority (Carlton Adair)
PRKNG - parking
PRWY - Parkway
RES - resvoir
RS - rock/sand
S - south
SAND - Sandhill
SHRA - Sahara
SNWP - Southern Nevada Water Project
SP - spring
STA - station
STP - sewage treatment plant
SUP - supper
SW - southwest
TERM - terminal
TIMET - Titanium Metals Corporation
TL and PRDS - Telephone Line (Hollywood Blvd.) and Pabco Roads
TR PK - trailer park
TRIB - tributary
UP - upper
UPRR - Union Pacific Railroad
V - valley
VEHCLS - vehicles
VV - Valley View
W - West
WINTRWD, WW - Winterwood
WY - way

EXPLANATION OF SAMPLING LOCATIONS

DESIGNATION OF SAMPLING LOCATIONS (S. P. Designation)

The following conventions were employed in numbering sample location and containers:

Type Sampling Point	Designation
Surface water in Las Vegas Valley	LW & 3 digit number commencing with 001
Ground water	LG & 3 digit number commencing with 001

Surface water is defined in the present study to include all samples collected from other than wells. The designation of LG (ground water) points is therefore restricted to locations where the sample is removed directly from the subsurface. Springs, seeps, ground-water fed streams and various wastewater discharge points are classified as surface water (LW) and further subdivided according to type.

SAMPLE POINT INDEX (S. P. Index)

Code	Sample Point
1	Stream, river, creek
2	Lake, pond, reservoir
3	Well
4	Precipitation
5	Spring
6	Mine
7	Cave
8	Composite
9	Ditch
0	Other or unknown
A	Sanitary waste (occurs as surface water)
B	Industrial waste (occurs as surface water)
C	Industrial wastes mixed with ground water (occurs as ground water)
D	Industrial wastes mixed with ground water (occurs as surface water)
E	Power plant cooling and blowdown water discharge
F	Liquid fraction of sewage sludge

Location	S.P. Index	S.P. Designation	Description	Lat.	Long.
21/62-232311	1	LW001	LAS VEGAS WASH 1	360638	1150131
21/62-234241	1	002	LAS VEGAS WASH 2	360614	1150059
21/63-303411	1	003	LAS VEGAS WASH 3	360518	1145901
21/63-293241	1	004	LAS VEGAS WASH 4	360521	1145825
21/63-293311	1	005	LAS VEGAS WASH 5	360524	1145810
21/63-281121	1	006	LAS VEGAS WASH 6	360556	1145629
21/63-144111	1	007	LAS VEGAS WASH 7	360720	1145416
21/61-131221	1	008	FLAMINGO WASH 1	360745	1150626
21/61-131211	1	009	FLAMINGO WASH 2	360747	1150624
21/62-314111	5	010	STEVENS SPRING	360437	1150445
21/62-294343	5	011	UNNAMED SPRING	360513	1150412
21/62-294221	5	012	GRAPEVINE SPRING	360530	1150418
22/62-051411	5	013	WHIT. MESA SP. 1	360358	1150353
22/62-043221	5	014	WHIT. MESA SP. 2	360314	1150348
22/62-042331	5	015	WHITNEY MESA SEEP	360353	1150346
21/62-273421	A	016	CLARK STA OUTFALL	360518	1150226
22/62-114131	B	017	STAUFFER DITCH A	360244	1150051
22/62-021431	B	018	STAUFFER DITCH B	360351	1150056
21/62-354141	C	019	LV BLDG MAT POND	360431	1150046
21/62-363441	C	020	HEND STP GW DRAIN	360421	1150010
21/62-363411	A	021	HEND STP OUTFALL	360427	1150010
22/63-072311	B	022	TITANIUM DITCH	360308	1145926
22/63-071221	A	023	BMI STP OUTFALL	360316	1145854
21/62-113231	B	025	NEV RS DISCHARGE	360810	1150141
21/62-104221	E	026	SUNRISE STA OUTFALL	360813	1150206
21/62-222241	A	027	CLARK COUNTY STP EFFL	360646	1150236
21/63-313131	C	028	BMI SEEP PABCO RD	360440	1145916
21/63-293325	D	029	GRAVEL PIT DRAIN	360519	1145824
21/63-281421	2	LW030	POND ADJ LV WASH	360546	1145632

Appendix 2 (continued)

Location	S.P. Index	S.P. Desig-nation	Description	Lat.	Long.
20/61-363431	1	LW031	CHARLESTON DITCH	360934	1150630
21/63-322341	C	032	GRAVEL PIT SEEP	360453	1145825
21/62-224421	1	033	TRIB TO DUCK CREEK	360610	1150154
21/62-103441	A	034	LV STP OUTFALL	360748	1150218
22/62-021441	B	035	BMI NO. 1 (disc.)	360352	1150046
22/62-024321	D	039	GRAVEL PIT	360303	1150106
21/63-304311	1	041	LAS VEGAS WASH 9	360518	1145850
22/62-123231	B	042	STAUFFER EFFL 3	360247	1150032
22/62-123321	B	043	STAUFFER EFFL 6	360243	1150031
22/62-123232	B	044	STAUFFER EFFL 2	360246	1150039
21/63-304312	1	045	LAS VEGAS WASH 9A	360516	1145856
21/63-312241	D	047	BMI POND SEEP 1	360459	1145922
21/63-312211	D	048	BMI POND SEEP 2	360507	1145924
21/63-312221	D	049	BMI POND SEEP 3	360511	1145928
20/62-302431	1	050	E. WASH AVE DITCH	361052	1150532
21/62-102331	1	051	WINTRWD GC STREAM	360757	1150245
21/62-354131	D	052	LVBM USED WATER	360427	1150043
21/62-103442	F	053	LVSTP SLUDGE LIQ	360748	1150114
21/62-344431	2	054	LVBM NEW POND	360422	1150149
22/62-123241	B	055	STAUFFER CUT FLUME	360245	1150028
17/59-341121	5	057	CORN CREEK SPRING	362620	1152120
22/58-023321	5	058	BONNIE SPRINGS	360312	1152712
21/62-191113	5	059	FLAM RES COMP GW	360653	1150457
21/61-124131	5	060	FLAM WASH 3	360810	1150611
21/62-103421	A	061	LVSTP INFL	360840	1150225
21/62-222221	A	062	CLARK CO STP INFL	360718	1150243
21/63-293242	1	063	LVW 4 NORTH	360531	1145825
21/62-274341	E	064	DUCK CR AT US 93	360506	1150200
21/63-281313	1	LW065	LVW ABOVE LW030	360545	1145636

Appendix 2 (continued)

Location	S.P. Index	S.P. Desig-nation	Description	Lat.	Long.
21/62-363442	A	LW066	HEND STP INFL	360421	1150009
22/63-071111	A	067	BMI STP INFL	360316	1145839
23/64-094311	A	068	BC STP INFL	355803	1144942
23/64-094312	A	069	BC STP EFFL	355758	1144942
21/62-053221	1	070	FLAM WASH AT LAMB	360906	1150451
21/63-313313	D	071	UPPER POND SEEP	360424	1145922
21/61-131231	1	072	FLAM WASH AT EMRSN	360737	1150636
21/63-312222	D	073	NE COR LOW POND	360507	1145926
21/62-191114	5	074	FLAM RES DRAIN 1	360653	1150458
21/62-191115	5	075	FLAM RES DRAIN 2	360652	1150458
21/62-222421	4	076	CCSTP OUTFL FLUME	360643	1150225
21/62-072411	9	077	FLAM WASH AT B HWY	360083	1150543
21/62-092231	9	078	FLAM WASH AT NELLIS	360802	1150322
20/61-263221	9	079	LV CR AT FNSY PARK	361052	1150705
20/61-273431	9	080	LV CR AT MAIN ST	361030	1150621
20/61-294431	9	081	LV CR AT RANCHO	361030	1151029
20/61-312141	9	082	LV CR AT BEDFORD	361015	1151147
21/63-281313	1	083	LVW BELOW LW065	360550	1145641
21/61-14142	5	084	SAHARA-NEV. C. C.	367150	1150717
20/61-263311	5	085	LEROY APTS.	361036	1150749
20/61-263312	5	086	MARYLAND PKWY HARRS	361038	1150750
21/61-02111	5	087	BALLARD ND ESTRN	360930	1150705
21/61-01211	5	088	MONT WARDS	360930	1150647
20/61-34131	5	089	CORTZ PARKING LOT	361005	1150741
21/61-10331	5	090	CONVENTION CENTER	360758	1150904
21/61-20114	5	091	DUNES HOTEL	360647	1150922
21/61-09111	5	092	SAHARA HOTEL	360835	1150922
21/61-14223	5	094	SEARS	360735	1150805
20/61-22421	5	LW095	LM ND FRWY NO 1	361144	1150820

Appendix 2 (continued)

Location	S.P. Index	S.P. Designation	Description	Lat.	Long.
20/61-27341	5	LW096	BONANZA ND UPRR	361037	1150833
20/61-31113	2	097	LVVWD 50 MG RES	361019	1151123
20/61-34211	9	098	CASINO CENTER ND OGD 30	361020	1151833
20/62-31341	9	099	DEL AMO ND SAND 9	360941	1150519
20/61-34133	9	100	CEN TELEPHONE BLDG	361005	1150822
23/61-044141	3	LG001	NEW HEND AP WELL	355830	1150922
22/62-013211	3	002	PITTMAN ARTES WELL	360339	1150022
22/62-083241	3	003	PARADISE V CC	360246	1150444
21/63-144241	3	004	P HOL ADAIR 48	360714	1145425
21/63-144242	3	005	P HOL ADAIR 100	360713	1145425
21/63-281311	3	006	OLD USGS GAGE 44	360545	1145634
21/63-281312	3	007	OLD USGS GAGE 135	360644	1145638
21/63-304141	3	008	AK NO 5 LC 35	360526	1145827
21/63-293321	3	009	SNWP LC 91	360520	1145824
21/63-293322	3	010	SNWP LC 42	360519	1145824
21/63-293341	3	011	AK NO 36 LC 39	360517	1145819
21/63-293342	3	012	AK NO 37 LC 38	360517	1145817
22/63-053221	3	013	BMI E UP POND 250	360344	1145825
22/63-053222	3	014	BMI E UP POND 45	360344	1145826
21/63-303231	3	015	TL AND P RDS 25	360527	1145933
21/63-303232	3	016	TL AND P RDS 47	360526	1145933
21/63-311221	3	017	PABCO RD E 90	360506	1145900
21/63-311222	3	018	PABCO RD E 19.5	360506	1145901
21/63-312121	3	019	BMI L POND E 70	360506	1145921
21/63-312122	3	020	BMI L PONDS E 20	360459	1145922
21/63-313311	3	021	L UPPER PONDS 40	360424	1145922
21/63-313312	3	022	L UPPER PONDS 22	360424	1145922
22/62-064211	3	023	BMI W UP POND 45	360345	1145854
22/63-064212	3	LG024	BMI W UP POND 30	360346	1145856

Appendix 2 (continued)

Location	S.P. Index	S.P. Desig-nation	Description	Lat.	Long.
21/63-072322	3	LG025	TIMET DITCH 24	360308	1145926
21/63-072321	3	026	TIMET DITCH 100	360307	1145927
21/62-362111	3	027	BMI L PONDS W 62	360506	1150011
21/63-362112	3	028	BMI L PONDS W 19.5	360507	1150011
21/62-264211	3	029	DUCK CK AT LVW 100	360529	1150101
21/62-264212	3	030	DUCK CK AT LVW 30	360529	1150100
22/62-113221	3	031	GIBSON RD 63	360253	1150141
22/62-114131	3	032	STAUFFER DITCH 150	360243	1150050
22/62-114132	3	033	STAUFFER DITCH 45	360245	1150048
21/62-154411	3	034	AK UP CROSS 35	360245	1150047
21/62-154412	3	035	DRI UP CROSS 105	360703	1150149
21/62-222411	3	036	COUNTY STP 50	360640	1150215
21/62-222412	3	037	COUNTY STP 31	360640	1150216
22/62-042321	3	038	WHITNEY MESA 112	360356	1150337
22/62-042322	3	039	WHITNEY MESA 40	360354	1150342
22/62-042323	3	040	WHITNEY MESA 110	360355	1150344
20/62-321211	3	041	UPPER LVW 67	361019	1150407
20/62-321212	3	042	UPPER LVW 170	361020	1150407
21/62-294341	3	043	NO NAME SP 56	360514	1150410
21/62-294342	3	044	NO NAME SP 129	360514	1150411
21/62-191111	3	045	CAMPBELL RES 125	360649	1150500
21/62-191112	3	046	CAMPBELL RES 40	360648	1150500
20/61-364441	3	047	CHARLESTON BLVD 100	360933	1150551
20/61-364442	3	048	CHARLESTON BLVD 40	360933	1150552
21/63-293323	3	049	AK NO 20 LC 35	360520	1150130
21/62-354411	3	050	LVBM WELL WATER 20	360532	1150041
21/63-293231	3	051	AK LC COMP 30	360525	1145826
21/63-293232	3	052	AK LC COMP 30	360524	1145826
21/63-293233	3	LG053	AK LC COMP 30	360522	1145826

Appendix 2 (continued)

Location	S.P. Index	S.P. Desig-nation	Description	Lat.	Long.
21/63-293331	3	LG054	AK LC COMP 30	360517	1145824
21/63-293324	3	055	AK NO 16 LC 30	360521	1145825
21/62-112321	3	056	NEV RS WASH WATER	360912	1150206
20/61-034121	3	057	NO 2 NELLIS AFB	361420	1150815
20/61-154331	3	058	NLV LOSEE WELL	361215	1150827
20/61-29333	3	059	NO 34 LVVWD	360946	1151124
21/62-222242	3	060	CCSTP DEWATER	360646	1150231
19/60-04341	3	061	CITY LV, TULE 706	361923	1151607
19/60-09341	3	062	CITY LV, TULE 612	361835	1151613
20/61-36222	3	063	T. H. GEE 325	361025	1150806
20/62-18222	3	064	3115 LVBN 300	361227	1150412
20/62-08121	3	065	4229 LVBN 120	360605	1150551
20/61-03412	3	066	NELLIS AFB 350	361342	1150812
20/61-20311	3	067	3086 W L MEAD 665	361144	1151054
20/61-20311	3	068	3001 W L MEAD 300	361144	1151046
20/61-20312	3	069	226 ANDERSON 400	361141	1151105
20/61-28341	3	070	1531 W BONANZA 440	361036	1150937
21/61-04211	3	071	1823 W CHARL 400	360928	1150957
20/61-33332	3	072	2040 GOLDRING 425	360947	1150900
20/61-33331	3	073	1824 GOLDRING 400	360947	1150957
20/61-34232	3	074	UPRR NO 157, 780	361012	1150905
21/61-01221	3	075	2500 BLDR HWY 400	360926	1150654
21/62-29333	3	076	4200 E RUSSEL 404	360511	1150451
21/61-24114	3	077	3340 ROCHELLE 160	360643	1150606
21/61-24114	3	078	3360 ROCHELLE 100	360643	1150603
21/61-25313	3	079	5326 TOPAZ (was coded as 5360)	360526	1150648
22/61-03441	3	080	7117 PARADISE 335	360338	1150814
22/61-01413	3	LG081	7044 TOMIYASU 101	360345	1150613

Appendix 2 (continued)

Location	S.P. Index	S.P. Designation	Description	Lat.	Long.
21/62-30422	3	LG082	5372 SANDHILL 390	360513	1150525
21/62-03312	3	083	6000 E CHARLESTON 200	360857	1150227
21/62-31133	3	084	6100 S PEARL 600	360443	1150524
21/62-30241	3	093	CASEY ND SANDHILL	360536	1150529
21/62-08433	3	098	DILLINGHAM 25	360757	1150412
21/62-09122	3	099	W W GOLF CRS 26	360835	1150935
20/61-35144	3	100	SW 25TH ND ELM 12	361008	1150657
21/62-21314	3	101	BILLMAN 31	360610	1150323
21/61-02213	3	102	STIBOREK 20	360922	1150749
21/61-01434	3	103	MOTOR VEHICLE 10	360855	1150645
21/61-13223	3	104	PETERSON 8	360738	1150700
21/61-23412	3	105	JARRETT 36	360625	1150720
22/61-02221	3	106	ENGELSTAD 46	360416	1150756
21/61-26332	3	107	MCSTRAVIK 31	360522	1150805
21/61-08134	3	108	I15 MILO WY 36	360817	1151040
21/61-05323	3	109	VV AND OKY 39	360830	1151119
20/61-33342	3	110	JOSEPHS 35	360943	1150950
20/60-24111	3	112	CURT MAN #2, 312	361208	1151222
19/60-23223	3	113	7000 GILCREASE 560	361750	1151422
19/60-27112	3	114	RANCH SUP CLUB 605	361313	1151243
20/62-19312	3	115	LA PAZ TR PK 200	361142	1150532
20/62-19222	3	116	2343 N PECOS 289	361209	1150549
20/61-13142	3	117	2934 LVBN 300	361248	1150602
20/62-04144	3	118	NELLIS AFB #1, 800	361430	1150240
20/61-04144	3	119	628 W CRAIG RD 900	361945	1151535
22/61-12222	3	120	DAY DREAM RANCH 600	360353	1150657
20/61-19441	3	121	CLUB 95, 295	361133	1151117
20/61-33331	3	LG122	716 SHADOW LN, 226	360940	1150953

Appendix 2 (continued)

Location	S.P. Index	S.P. Desig-nation	Description	Lat.	Long.
20/61-35322	3	LG123	1201 FREMONT 460	360957	1150756
21/61-044131	3	124	MICHELAS 1, 650	360857	1150926
21/61-044132	3	125	MICHELAS 2, 810	360857	1150926
20/61-18233	3	126	NLV AIR TERM 500	361239	1151214
20/61-29323	3	127	LORENZI PARK 600	361042	1151107
21/62-15332	3	128	AK LDS FARM 300	360743	1150241
20/61-30442	3	129	LV EXPWY ND VV 10	361034	1151127
21/62-08114	3	130	2633 SO NELLIS 90	360832	1150357
19/60-23144	3	131	HALVERSON 400	361706	1151331
20/60-19431	3	132	MELODY ND CYP 5	361127	1151126
20/61-304421	3	133	W OF WELL 15A 91	361033	1151129
20/61-304422	3	134	W OF WELL 15A 20	361031	1151129
20/62-21341	3	135	2100 BLEDSOE 215	361127	1150312
21/62-08431	3	136	2102 ALOHA 100	360753	1150408
21/61-12342	3	137	3208 S TOPAZ 375	360753	1150647
21/61-10144	3	138	2832 MARYLAND PKWY 6	360812	1150813
20/61-19422	3	139	1850 SYCAMORE 17	361134	1151136
19/60-23112	3	140	6261 WITTIG 208	361722	1151342
21/62-28412	3	LG141	RANCH HOUSE 140	360535	1150251

Appendix 3. Chemical Analyses of Las Vegas Valley Water Samples from February 1970 to April 1976

EXPLANATION OF WATER QUALITY CODES

CODING CONVENTIONS

Analytical data preceded by a minus sign (-), other than the categories immediately below, indicate the presence of this constituent in amounts "less than" the number shown. For example, -0.10 indicates a concentration less than one-tenth of a milligram per liter. The following codes are also used:

000000	analysis not regularly run for this constituent at this sampling point
-666660	constituent in solution not fully ionized. Milli-equivalents were not calculable.
-77777	analysis or theory indicated none of this constituent to be present, e.g., it is chemically impossible for bicarbonate (HCO_3^-) to exist in aqueous solution at pH = 12
-88888	analysis revealed "trace" amounts of this constituent and was reported as "trace" by the lab
-99999	analysis usually run for this constituent at this sampling point, but not run for this sample

SAMPLE PRESERVATION

Samples taken for nitrogen compound analysis and preserved with mercuric chloride were coded M in the water analysis data system. All other analyses were done on unpreserved samples unless otherwise indicated. Code C indicates a seperate sample taken for phosphorus compound analyses and preserved with chloroform. All other analyses were done on unpreserved samples unless otherwise indicated. In general, only surface water samples expected to contain unstable nitrogen and phosphorus compounds were preserved.

ADDITIONAL INFORMATION

The Water Analysis Data System (WADS) of the Water Resources Center, Desert Research Institute, is well documented. Readers are encouraged to check the appropriate references for retrieving additional data concerning sampling and analyses that could not be put into this appendix because of space limitation. Information concerning sample preservation, trace element analyses, and elemental form (soluble, organic, suspended, colloidal) is available.

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LG 1 NEW HEND AP WELL 23S 61E 04 414 1																
3-25-70	13	-99.0	1144	7.78	150	180	180	-.10	7.8	135	9	60	31	.0	.8	678
LG 2 PITMAN ARTES WELL 22S 62E 01 321 1																
3-31-70	24	33.5	4108	7.86	92	403	1353	.20	-.5	615	37	222	450	.0	1.4	3126
10-17-70	292	22.2	5196	7.67	159	766	2407	-.10	116.0	424	20	414	433	.0	2.0	4660
LG 3 PARADISE V CC 22S 62E 08 324 1																
5-18-70	68	28.4	1070	8.00	153	101	332	-.10	2.0	100	12	90	43	.0	.5	755
LG 4 P HOL ADAIR 47 21S 63E 14 424 2																
6- 7-71	472	22.2	8745	7.50	332	1775	2383	-.10	-.1	875	88	724	436	.0	1.6	6446
9-16-71	775	19.0	8622	6.58	23	1722	2519	-.10	-.0	885	83	564	424	.0	1.0	6210
12- 2-71	964	16.7	8387	6.51	84	1726	2542	-.10	.6	910	85	586	426	.8	1.4	6319
5- 2-72	1420	20.0	7857	6.18	23	1887	2530	-.04	3.3	881	89	569	412	.8	.8	6384
8- 2-72	1594	23.3	8698	5.37	2	1801	2568	-.08	1.0	871	84	530	414	.8	.7	6272
LG 5 P HOL ADAIR 100 21S 63E 14 424 2																
6- 7-71	473	22.2	8315	7.55	291	1476	2373	-.10	36.0	1023	72	516	341	.0	1.8	5982
9-16-71	774	19.4	8064	7.38	243	1470	2397	-.10	24.0	1032	70	464	340	.0	1.7	5919
12- 2-71	945	18.9	7763	7.32	194	1496	2408	-.10	16.0	1032	74	443	340	2.0	1.7	5908
5- 2-72	1421	21.7	7295	7.38	222	1427	2358	-.04	19.2	1001	78	470	322	2.0	1.7	5788
8- 2-72	1593	25.6	8247	7.66	207	1456	2460	-.04	14.3	1024	74	450	334	2.0	1.7	5917
LG 6 OLD USGS GAGE 44 21S 63E 28 131 1																
6- 7-71	474	22.2	7931	7.39	190	1489	2103	-.10	89.0	782	83	619	302	.0	1.1	5561
9-16-71	773	20.6	7436	7.37	188	1454	2061	-.10	78.0	787	80	594	303	.0	1.0	5451
12- 2-71	845	20.0	7117	7.39	213	1439	2063	-.10	67.0	777	84	583	300	1.0	1.1	5420
5- 2-72	1422	21.1	6867	7.10	227	1400	2022	-.04	81.0	745	89	618	282	1.0	1.1	5350
8- 2-72	1592	27.2	7525	7.29	68	1447	2084	-.04	10.0	774	85	494	281	1.0	.7	5210
11- 1-72	1738	20.0	6706	7.15	128	1444	1960	-.04	27.0	750	88	566	284	1.0	.8	5183
2- 8-73	1927	18.9	6401	7.49	176	1482	2174	-.04	40.0	753	86	622	299	.9	1.0	5545
5- 7-73	2043	21.1	7495	7.35	189	1509	2148	-.04	19.0	749	86	602	304	5.1	-99.0	5515
8- 2-73	2188	22.2	7951	7.13	173	1502	2081	-9.99	22.0	732	104	596	306	.2	-10.0	5428
LG 7 OLD USGS GAGE 135 21S 63E 28 131 2																
6- 7-71	475	22.2	6966	7.35	241	1178	1950	-.10	73.0	689	82	585	270	.0	1.1	4947
9-16-71	772	20.0	6553	7.56	228	1158	2033	-.10	54.0	685	80	549	269	.0	1.1	4942
12- 2-71	946	19.4	7429	7.28	201	1103	2011	-.10	36.0	678	83	520	269	2.5	1.0	4802
5- 2-72	1424	22.8	6148	6.79	170	1204	2015	.04	31.0	661	87	541	263	.4	1.0	4887
8- 2-72	1591	24.4	7023	7.67	168	1245	2063	-.04	24.0	657	83	535	274	.4	1.0	4965
11- 1-72	1739	20.0	6108	6.96	202	1243	2004	-.04	24.0	638	83	554	267	.4	.1	4913
2- 8-73	1926	17.8	6543	7.80	114	1223	2084	-.04	4.9	655	85	537	273	.6	1.0	4919
5- 7-73	2054	21.1	6659	7.08	112	1290	2049	-.04	.7	640	83	507	275	.5	-99.0	4900
8- 2-73	2189	21.7	7194	7.17	182	1269	2019	-9.99	33.0	627	100	567	376	.3	-10.0	5081

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LG 9 SNWP LC 91			21S 63E 29 332 1													
9-16-71	765	21.9	7456	8.75	-77	1579	1871	-.10	6.0	831	164	488	260	.0	.3	5199
12- 2-71	882	22.2	7418	8.53	-77	1766	1630	-.10	5.2	767	153	531	276	15.0	.4	5144
2- 2-72	1130	-21.7	7307	6.51	7	1742	1464	-.04	1.6	690	173	523	206	21.6	-.1	4825
5- 6-72	2056	24.5	8144	9.06	-77	2031	1685	-.04	2.3	845	118	506	283	25.0	-99.0	5495
7-31-72	1554	23.3	10414	8.87	45	2487	1887	-.04	17.3	1163	184	471	328	25.0	.3	6585
10-31-72	1743	22.2	12486	4.03	-77	3290	2016	-.10	121.0	1751	241	519	309	31.7	-99.0	8279
2- 8-73	1930	-99.0	9505	7.77	95	2193	2292	-.10	26.0	960	175	680	391	20.0	-99.0	6784
LG 10 SNWP LC 42			21S 63E 29 332 2													
9-15-71	764	23.9	8075	8.35	45	1808	1945	-.10	.5	832	85	612	325	.0	.8	5630
12- 2-71	948	21.1	9044	8.20	10	2072	2320	-.10	51.0	1076	88	640	376	26.0	1.2	6655
2- 2-72	1126	21.0	8136	7.15	51	1720	2015	-.04	143.0	875	79	537	304	4.3	1.2	5703
3- 2-72	1303	22.2	7580	7.47	63	1633	1921	-.04	170.0	855	77	541	295	4.8	1.2	5529
7-31-72	1555	31.7	8177	5.57	4	1715	2031	-.04	62.0	880	74	520	301	4.8	1.1	5590
5- 7-73	2055	24.5	7535	7.71	39	1656	1925	-.04	77.0	841	70	473	294	14.0	-99.0	5369
LG 11 AK NO 36 LC 39			21S 63E 29 334 1													
9-16-71	766	21.6	6594	7.72	147	1282	1600	-.10	149.0	529	93	621	249	.0	.4	4596
12- 2-71	947	20.6	6363	7.61	152	1381	1456	-.10	179.0	520	93	588	246	.2	.4	4538
2- 2-72	1111	18.1	6944	7.41	178	1648	1208	-.04	115.0	530	78	556	274	1.0	.7	4499
5- 2-72	1426	22.2	6763	7.65	156	1713	1413	-.04	107.0	558	86	665	292	1.0	.7	4912
7-31-72	1552	24.4	8387	7.67	149	2003	1439	-.04	78.0	639	89	700	322	1.0	.7	5344
10-31-72	1741	22.2	8264	7.87	121	2078	1516	-.10	110.0	615	112	764	338	.2	-99.0	5593
1-29-73	1928	-99.0	7844	7.85	111	1847	1632	-.10	120.0	567	105	778	296	.2	-99.0	5400
5- 7-73	2058	21.1	7269	7.49	177	1795	1251	-.04	152.0	748	75	515	244	.2	-99.0	4867
LG 12 AK NO 37 LC 38			21S 63E 29 334 2													
9-23-71	778	21.1	6098	7.31	208	1722	896	-.10	120.0	506	53	518	321	.0	1.1	4239
12- 2-71	965	19.4	6546	7.31	173	1630	1110	-.10	136.0	535	53	503	313	.0	1.3	4366
2- 2-72	1110	17.0	7255	7.31	153	1796	1301	-.04	85.0	617	63	607	247	.0	1.2	4792
5- 2-72	1425	21.7	7545	7.30	155	2019	1468	-.04	57.0	657	65	689	332	.0	1.2	5365
7-31-72	1553	22.2	8969	7.63	150	2242	1252	-.04	95.0	793	67	667	305	.0	1.2	5496
5- 7-73	2059	22.2	7259	7.45	177	1795	1224	-.04	162.0	802	57	490	229	.2	-99.0	4847
LG 13 BMI E UPPOND 250			22S 63E 05 322 1													
6- 8-71	484	-99.9	7160	7.40	121	1532	1533	-.10	152.0	485	51	700	299	.0	.8	4812
9-16-71	767	26.0	7152	7.68	192	1483	1868	-.10	66.0	568	82	689	321	.0	.7	5172
12-22-71	984	23.3	7031	7.26	94	1517	1807	-.10	128.0	553	69	686	306	2.0	.7	5115
2- 3-72	1142	26.0	6944	7.56	60	1464	1918	-.04	79.0	520	93	665	291	8.6	.6	5068
3- 2-72	1298	26.1	6738	7.61	104	1478	1909	-.04	89.0	502	88	684	300	8.6	.6	5110
5- 2-72	1431	27.8	6576	7.46	150	1447	1859	-.04	118.0	511	65	742	303	3.5	.8	5123
8- 1-72	1559	27.8	7073	8.22	24	1472	1878	-.04	-.1	509	64	560	303	25.0	.4	4823
11- 2-72	1765	25.6	6201	7.25	108	1343	1962	-.04	155.0	484	69	671	313	5.7	.6	5057
2- 8-73	1939	23.9	6694	7.50	20	1442	1845	-.04	14.0	524	67	589	294	24.0	.1	4808
5- 7-73	2069	26.7	6708	8.38	25	1453	1795	-.04	5.4	515	73	562	300	27.0	-99.0	4742
8- 2-73	2200	29.4	8082	7.37	156	1599	1939	-9.99	64.0	662	86	596	287	3.5	-10.0	5313

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMP	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LG 14 BMI E UP POND 45 22S 63E 05 321 2																
9-21-70	302	28.9	4015	7.66	283	1050	610	-.10	72.0	288	9	213	297	.0	1.5	2680
8- 1-72	1560	25.6	6973	7.62	147	1568	832	.16	134.0	516	11	363	267	.0	1.0	3764
2- 8-73	1940	22.2	5833	7.90	142	1462	741	.16	117.0	574	13	273	268	2.2	-99.0	3520
5- 7-73	2070	21.7	6521	7.38	86	1795	651	-.04	134.0	620	12	304	304	6.5	-99.0	3869
LG 15 TL AND P RDS 25 21S 63E 30 323 1																
6- 8-71	483	-99.9	2904	7.50	327	239	1010	-.10	.1	252	26	255	103	.0	.9	2047
9-15-71	762	20.0	2739	7.35	319	233	964	-.10	-.1	244	27	244	103	.0	.9	1973
12- 2-71	884	16.7	2605	7.47	255	246	927	-.10	.2	237	28	215	107	4.2	.8	1890
2- 2-72	1125	13.1	2902	7.54	280	257	1067	-.04	1.5	230	26	259	110	4.4	.6	2093
7-31-72	1550	24.4	2749	7.77	143	252	995	.10	13.4	236	27	175	111	4.4	.6	1885
11- 1-72	1749	19.4	2517	7.29	190	277	990	-.04	-.1	241	28	216	106	4.2	.7	1956
2- 8-73	1933	16.7	2847	7.47	157	296	1040	-.04	-.1	289	30	201	114	3.8	.7	2052
5- 7-73	2060	16.7	2832	7.29	167	282	1035	-.04	.3	271	28	197	112	6.1	-99.0	2014
8- 2-73	2195	20.0	2946	7.41	161	279	949	-9.99	.2	260	26	183	102	4.1	-10.0	1882
LG 16 TL AND P RDS 47 21S 63E 30 323 2																
10- 2-70	289	18.9	1985	7.26	139	304	1592	.14	17.0	335	44	377	119	.0	.5	2857
6- 8-71	482	-99.0	3531	7.65	187	150	1837	-.10	-.1	247	25	330	215	.0	2.2	2898
9-15-71	761	18.9	3398	7.47	164	146	1803	-.10	-.1	243	26	309	214	.0	2.2	2824
12- 2-71	883	16.7	3338	7.38	164	150	1728	-.10	.4	240	24	305	207	-.2	2.1	2737
2- 2-72	1124	16.0	3389	7.44	179	150	1793	-.04	2.6	236	26	309	209	.1	2.0	2816
7-31-72	1551	24.4	3511	7.86	154	144	1859	-.04	.3	240	25	317	217	.1	2.2	2880
11- 1-72	1750	16.7	3095	6.90	156	141	1898	-.04	-.1	232	24	312	208	.1	2.2	2805
2- 8-73	1932	13.3	3372	7.42	166	141	1846	-.04	-.1	243	26	323	208	.2	2.2	2871
5- 7-73	2061	20.0	3354	7.41	141	134	1781	-.04	.3	225	25	287	210	.2	-99.0	2732
8- 2-73	2194	20.6	3663	7.14	126	147	1799	-9.99	.3	221	21	311	210	.2	-10.0	2771
LG 17 BMI L PONDS E 90 21S 63E 31 122 1																
10- 3-70	284	27.5	6386	7.47	79	1349	2112	-.10	3.7	751	19	643	245	.0	.6	5162
10- 3-70	286	29.4	6543	7.62	77	1406	2169	-.10	3.4	765	95	695	247	.0	.6	5419
10- 6-70	287	25.6	7413	7.16	115	1539	2455	-.10	-100.0	830	222	696	327	.0	.2	6126
6- 8-71	479	-99.0	30776	7.40	131	4265	17796	-.10	-.1	3010	3700	520	2915	.0	.3	32271
9-15-71	757	25.0	35504	4.78	9	4950	19490	-.10	1.6	3252	4480	525	3490	.0	.3	36193
12- 2-71	885	21.1	31850	6.76	65	4162	16300	-.10	.6	3220	3214	529	2843	2.4	.4	30303
2- 2-72	1132	23.0	30574	7.18	83	4095	16639	-.04	2.5	3065	3074	514	2764	2.6	.3	30197
3- 2-72	-0	23.3	29794	6.88	99	4180	16847	-.04	3.6	2980	3180	520	2842	4.1	.3	30606
5- 4-72	1400	23.9	29022	6.77	61	3981	16655	-.04	2.8	3122	3280	527	2820	2.8	.3	30421
9- 1-72	1618	26.7	32406	7.25	44	4247	17100	-.04	.6	3145	4130	524	2719	2.8	.3	31891
11- 1-72	1747	22.2	30641	5.66	14	4478	18431	-.04	.6	3216	4325	542	3050	2.8	.4	34053
2- 8-73	1934	22.2	30996	5.61	2	4177	17291	-.04	-.1	3061	4112	556	2812	2.5	.5	32013
5- 7-73	2062	22.2	30788	8.13	57	4244	16855	-.04	.7	2928	3770	552	2525	4.1	-99.0	30907
8- 2-73	2198	25.6	37131	4.90	11	4844	19199	-9.99	.8	3252	4305	552	3140	2.6	-10.0	35301
LG 18 BMI L PONDS E19.5 21S 63E 31 122 2																
6- 8-71	478	-99.9	7581	7.45	87	1424	2212	-.10	136.0	790	7	712	266	.0	.8	5588
9-15-71	758	26.7	7446	7.25	91	1638	2282	-.10	148.0	843	11	725	270	.0	.8	5962
12- 2-71	886	22.8	6891	7.47	89	1323	2324	-.10	148.0	802	8	672	260	1.5	.8	5583

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
2- 2-72	1131	18.0	7068	7.42	79	1266	2265	-.04	145.0	699	5	673	248	-.1	.6	5341
3- 2-72	-0	20.0	6727	7.43	94	1283	2279	-.04	150.0	703	4	671	249	-.1	.6	5386
5- 4-72	1401	21.1	6669	7.20	88	1247	2240	.28	154.0	750	4	700	246	-.1	.8	5386
8- 1-72	1619	34.4	7424	7.68	81	1233	2426	-.08	138.0	745	4	649	248	.1	.8	5484
11- 1-72	1748	24.4	7281	7.26	85	1242	2292	-.04	132.0	737	5	664	245	.1	.8	5360
2- 8-73	1935	18.9	6906	7.20	82	1203	2309	-.04	126.0	708	7	639	244	.1	.6	5277
5- 7-73	2063	21.1	6964	5.52	77	1256	2232	-.04	142.0	692	6	664	252	.1	-99.0	5282
8- 2-73	2207	27.8	7436	7.18	81	1259	2203	-9.99	123.0	696	48	710	242	.1	-10.0	5321
LG 19 RMI L POND E 70 21S 63E 31 212 1																
10- 8-70	296	23.6	10861	7.70	198	2817	2757	-.10	14.0	1942	48	658	326	.0	.9	8660
10- 9-70	297	23.3	7191	7.67	113	1843	1827	-.10	3.8	837	62	570	360	.0	.8	5559
4-23-71	460	20.0	7605	7.39	77	1115	3160	-.10	.1	708	170	593	422	.0	.4	6206
6- 8-71	480	-99.9	7992	7.50	69	1108	3208	-.10	-.1	764	177	573	420	.0	.4	6284
9-15-71	759	21.1	7679	7.04	76	1110	3194	-.10	.3	743	168	558	415	.0	.4	6226
12- 2-71	950	18.9	7267	7.74	81	1122	3078	-.10	.3	767	159	557	418	1.6	.4	6143
2- 2-72	1127	23.1	7586	7.49	71	1092	3217	-.04	1.7	741	202	555	409	1.6	.4	6255
8- 1-72	1616	32.2	8026	7.88	57	1126	3377	-.08	1.0	744	190	549	421	1.6	.4	6438
10-31-72	1746	20.6	7734	7.88	74	1087	3348	-.10	.3	728	176	567	419	.3	-99.0	6362
2- 8-73	1936	20.0	7704	7.95	75	1097	3335	.12	.3	773	168	554	413	.2	-99.0	6378
5- 7-73	2065	23.3	7662	7.42	69	1094	3241	-.04	.3	753	201	549	420	.4	-99.0	6293
LG 20 RMI L PONDS E 20 21S 63E 31 212 2																
6- 8-71	481	-99.9	11584	7.65	244	2339	2670	-.10	16.7	1560	46	588	269	.0	.9	7610
9-15-71	760	22.3	11160	7.65	254	2422	2670	-.10	11.4	1810	49	592	284	.0	.9	7965
12- 2-71	949	20.0	10282	7.44	256	2359	2612	-.10	11.0	1830	52	585	259	1.7	.9	7836
2- 2-72	1125	20.0	11089	7.41	252	2457	2729	-.04	6.2	1787	52	610	264	.1	.9	8030
3- 2-72	1299	20.6	10833	7.66	252	2489	2775	-.04	4.9	1837	57	580	281	.1	.9	8149
5- 4-72	1402	21.1	10629	7.12	249	2489	2736	-.04	5.6	1643	55	636	276	.1	.9	7964
8- 1-72	1617	25.6	11588	7.51	192	2427	2773	-.04	.7	1832	51	577	267	.1	.8	8023
10-31-72	1745	-99.0	11166	7.93	143	2463	2772	-.10	12.0	1792	84	515	278	.3	-99.0	7987
2- 8-73	1937	18.9	11446	8.00	137	2597	2829	-.10	3.3	1890	108	590	280	.2	-99.0	8364
5- 7-73	2064	20.0	12413	7.44	222	2899	2702	-.04	2.6	1935	60	666	299	.2	-99.0	8673
LG 21 L UPPER PONDS 40 21S 63E 31 331 1																
9-30-70	290	25.6	8006	7.65	72	1644	2817	-.10	2.1	1062	136	674	370	.0	.5	6741
6- 8-71	476	-99.9	11715	8.45	45	2192	3391	-.10	50.0	1440	342	594	460	.0	.5	8492
9-15-71	756	26.7	8500	8.85	56	2307	3366	-.10	79.0	1275	297	619	493	.0	.5	8464
12- 2-71	983	21.1	10530	8.20	30	2256	3260	-.10	83.0	1440	208	596	490	9.9	.5	8358
2- 2-72	1133	23.0	10779	8.80	60	2184	3302	-.04	72.0	1358	293	606	461	7.3	.5	8313
5- 2-72	1437	23.3	10046	8.76	53	2144	3165	-.04	56.0	1390	278	605	423	7.3	.3	8095
8- 1-72	-0	24.4	11397	9.27	52	2182	3385	-.04	47.0	1360	237	587	474	9.5	.3	8308
11- 2-72	1766	22.8	11227	8.96	-77	2606	3103	-.04	39.0	1330	251	598	481	10.6	.3	8419
2- 8-73	1939	22.2	10733	9.20	-77	2168	3386	-.04	56.0	1314	246	557	494	10.2	.4	8232
5- 7-73	2071	23.3	10583	9.17	-77	2149	3228	-.04	44.0	1291	221	576	462	11.0	-99.0	7982
8- 1-73	2199	24.4	11260	8.72	173	2178	3280	-9.99	31.0	1250	307	564	452	15.0	-10.0	8082
LG 22 L UPPER PONDS 22 22S 63E 31 331 2																
6- 8-71	477	-99.0	9459	7.35	83	1636	2778	-.10	170.0	1090	32	659	357	.0	.7	6764

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LG 23 BMI H UPPOND 45			22S 63E 06 421 1													
6- 8-71	485	-99.0	7261	7.60	281	1746	872	-.10	138.0	530	25	501	326	.0	1.4	4278
9-16-71	768	22.5	5579	7.75	264	1550	629	-.10	48.0	510	22	357	283	.0	1.5	3530
12- 2-71	985	20.6	5889	7.42	227	1578	946	-.10	76.0	548	22	382	338	1.2	1.6	4004
11- 2-72	1764	22.8	7675	7.01	155	2049	757	-.04	122.0	787	30	475	244	1.2	.8	4542
LG 25 TIMET DITCH 24			21S 63E 07 232 2													
9-16-71	770	25.0	7425	7.67	129	1444	599	-.10	186.0	364	44	328	305	.0	.5	3334
12- 2-71	951	21.7	3467	7.73	52	863	543	-.10	44.0	340	28	145	176	4.2	.6	2169
2- 3-72	1136	20.0	4664	7.88	108	1151	607	-.04	110.0	386	24	240	237	.1	1.0	2809
3- 2-72	1291	20.6	3874	7.66	127	877	681	-.04	72.0	345	20	194	193	.1	1.1	2446
8- 1-72	-0	30.0	3381	7.87	92	636	685	-.04	9.2	343	18	119	139	.1	1.1	1996
11- 1-72	1763	25.6	2991	7.47	140	538	648	-.10	15.6	328	13	129	110	.1	-99.0	1851
2- 8-73	1941	18.9	3142	8.00	132	587	645	.10	17.0	393	10	123	94	.2	-99.0	1934
5- 7-73	2066	21.1	2528	8.07	105	270	826	-.04	1.9	349	8	87	78	.5	-99.0	1671
LG 26 TIMET DITCH 100			21S 63E 07 232 1													
6- 8-71	486	-99.9	7526	7.00	14	2387	213	-.10	.6	539	26	520	280	.0	.3	3893
9-16-71	769	23.1	7324	7.47	40	2419	240	-.10	-.1	537	29	515	295	.0	.3	4055
12- 2-71	952	22.8	6891	7.15	54	2378	237	-.10	1.1	529	26	507	294	1.2	.3	4001
2- 3-72	1137	19.0	7514	7.54	51	2438	250	-.04	2.0	530	26	529	294	1.2	.4	4096
3- 2-72	1292	23.9	7159	7.44	52	2415	256	-.04	4.4	521	27	522	296	1.2	.3	4068
5- 2-72	1434	24.4	7065	7.60	50	2407	260	-.04	.5	510	26	546	292	1.2	.3	4067
8- 1-72	1557	24.4	7806	7.74	52	2431	270	-.04	.2	521	26	516	298	1.2	.3	4089
11- 1-72	1762	25.0	7414	7.98	58	2367	3	-.10	.2	506	27	526	290	1.2	-99.0	3749
2- 8-73	1942	23.9	7334	8.00	23	2367	3	-.10	.2	542	36	462	264	1.2	-99.0	3687
5- 7-73	2067	26.7	7328	7.36	50	2347	252	-.04	-.1	505	24	494	265	1.2	-99.0	3913
LG 27 BMI L PONDS W 62			21S 62E 36 211 1													
10-16-70	293	24.4	8154	10.78	-77	2062	1333	.28	6.7	2017	35	83	-1000	.0	1.4	5538
6- 9-71	496	-99.9	8888	7.90	150	2159	1238	-.10	6.1	1814	20	221	42	.0	2.0	5576
9-14-71	753	-99.9	9282	7.94	142	2384	1330	-.10	2.3	1665	24	321	73	.0	2.0	5872
12- 3-71	959	18.9	8613	7.52	156	2302	1379	-.10	8.0	1683	26	384	94	1.7	1.9	5956
2- 2-72	1134	20.0	8084	7.66	167	1911	1329	-.04	34.0	1435	24	305	81	1.7	2.1	5205
3- 2-72	1296	21.7	7685	7.70	165	1915	1334	-.04	.2	1465	29	280	80	1.7	2.0	5189
5- 4-72	1403	21.1	7086	7.43	179	1713	1292	-.04	2.4	1353	23	289	73	1.7	2.2	4838
8- 1-72	1613	22.8	7695	7.81	183	1623	1442	-.04	.9	1325	23	277	81	1.7	2.3	4867
11- 1-72	1767	22.2	7014	7.54	135	1443	1516	-.10	.2	1275	29	284	80	.0	-99.0	4694
2- 8-73	1945	21.7	6923	8.12	161	1424	1495	-.10	.3	1271	30	253	83	.4	-99.0	4636
5- 8-73	2075	26.7	6285	7.62	186	1223	1365	-.04	-.1	1107	19	242	67	.4	-99.0	4116
LG 28 BMI L PONDS W19.5			21S 63E 36 211 2													
6- 9-71	495	-99.9	10740	11.15	-77	2501	931	.62	34.0	2355	8	11	1	.0	.7	5841
9-14-71	754	21.7	10448	11.22	-77	2413	1314	.56	8.4	2525	8	14	-0	.0	.8	6284
12- 3-71	958	20.0	9475	11.09	-77	2407	1277	.40	2.3	2410	9	24	-0	2.2	.9	6133
2- 2-72	1135	17.8	9224	11.25	-77	2106	1298	.58	10.8	2145	10	-0	-0	.2	1.0	5572
3- 2-72	1295	18.3	7791	11.07	-77	1944	1275	.72	10.3	2083	13	20	1	.2	1.0	5349
5- 4-72	1404	18.9	7816	11.35	-77	1849	1253	1.72	4.4	2023	7	4	0	.2	1.0	5143
8- 1-72	1614	23.3	8628	11.10	-77	1664	1416	.66	2.3	1915	8	22	2	.2	1.0	5031

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
POINT IDENTIFIER AND LOCATION																
11- 1-72	1768	23.3	8164	10.98	-77	1520	1486	.96	1.5	1905	2	25	-0	.2	-99.0	4941
LG 29 DUCK CK AT LVW100 21S 62E 26 421 1																
4-22-71	451	-99.9	5444	7.86	147	624	2658	-.10	.8	411	68	548	298	.0	1.2	4681
6-10-71	499	-99.9	5728	7.65	137	587	2678	-.10	-.1	480	70	562	306	.0	1.1	4751
9-14-71	752	20.6	5569	7.66	141	591	2621	-.10	-.1	454	69	570	303	.0	1.2	4679
12- 3-71	961	17.8	6406	7.58	144	588	2598	-.10	.9	484	63	559	306	2.0	1.1	4673
2- 2-72	1099	10.8	5493	7.50	141	575	2621	-.04	2.1	442	72	543	301	2.0	1.2	4629
7-31-72	1549	21.1	5789	7.50	142	574	2801	-.04	.4	446	70	547	303	2.0	1.2	4814
11- 2-72	1770	18.9	5533	8.37	135	568	2740	.20	.5	450	75	550	303	.1	-99.0	4753
5- 8-73	2077	21.7	5489	7.26	122	557	2630	-.04	.7	428	68	519	298	.2	-99.0	4561
LG 30 DUCK CK AT LVW 30 21S 62E 26 421 2																
6- 9-71	497	-99.0	8737	7.70	270	1168	3228	-.10	1.6	885	111	632	456	.0	1.8	6616
9-14-71	755	19.4	8369	7.70	260	1346	3249	-.10	.2	897	100	616	433	.0	1.7	6771
12- 3-71	960	17.8	8000	7.18	229	1337	3268	-.10	1.0	958	105	597	482	2.6	1.5	6865
2- 2-72	1098	17.0	8395	7.28	259	1326	3338	-.04	2.3	925	126	588	469	2.6	1.6	6906
7-31-72	1548	23.3	8608	7.55	148	1330	3285	-.04	.3	922	109	558	438	2.6	1.6	6719
11- 3-72	1769	18.9	8379	7.26	263	1283	3082	-.04	3.8	903	111	581	424	2.6	1.7	6521
2- 8-73	1946	17.8	8057	7.30	190	1243	3184	-.04	4.2	921	109	512	414	.1	1.7	6482
5- 8-73	2076	25.6	7908	7.10	198	1272	2958	-.04	.3	862	104	526	397	.4	-99.0	6217
8- 1-73	2203	22.2	8486	7.30	213	1337	2903	-9.99	.2	875	113	545	397	.4	-10.0	6275
LG 31 GIBSON RD 62 22S 62E 11 322 1																
6- 8-71	487	-99.0	4157	7.70	86	975	372	-.10	18.0	240	23	291	159	.0	.6	2121
9-14-71	751	24.4	4356	7.56	76	1008	377	-.10	22.0	286	23	297	169	.0	.6	2220
12- 3-71	986	22.2	3984	7.64	94	1014	367	-.10	36.0	282	23	294	169	1.5	.6	2233
2- 3-72	1139	24.0	4249	7.44	94	1035	379	-.04	28.0	271	21	300	171	1.5	.7	2253
5- 4-72	1407	24.4	4158	7.50	93	1058	389	-.04	37.0	284	22	325	178	1.5	.6	2341
8- 2-72	1581	27.8	4605	7.72	87	1078	448	-.04	28.0	296	23	321	185	1.5	.7	2424
11- 2-72	1760	23.3	4775	7.56	100	1134	413	-.04	32.0	306	25	344	189	1.5	.6	2494
2- 8-73	1944	23.3	4826	7.53	97	1144	440	-.04	46.0	325	25	322	194	1.5	.8	2546
5- 8-73	2047	24.4	4820	7.54	99	1193	412	-.04	50.0	296	22	345	201	.1	-99.0	2568
8- 1-73	2202	26.7	5176	7.55	102	1182	443	-9.99	32.0	333	21	357	203	.1	-10.0	2621
LG 32 STAUFF DITCH 150 22S 62E 11 413 1																
8-26-70	224	28.9	7681	7.48	153	1606	2553	-.10	13.0	1507	41	567	94	.0	3.8	6460
8-27-70	226	35.0	4569	7.65	97	935	1432	-.10	-.1	746	33	300	108	.0	2.3	3604
8-28-70	229	32.2	7361	7.50	165	1371	2796	.26	.8	1332	41	616	135	.0	3.4	6377
8-28-70	230	32.2	17097	7.60	137	3810	2901	-.10	.5	2217	59	788	376	.0	3.9	10223
8-29-70	228	28.9	12619	7.67	264	3820	2493	.48	-.1	2221	50	825	357	.0	3.8	9900
8-29-70	231	29.4	12927	7.31	155	4087	2352	-.10	.7	2205	48	842	465	.0	2.8	10079
8-29-70	232	27.8	12917	7.39	154	4182	2182	-.10	-.1	2207	37	717	460	.0	2.3	9863
8-31-70	233	26.7	12911	7.30	142	4202	2052	-.10	-.1	2182	33	713	475	.0	1.9	9729
8-31-70	239	29.2	5579	7.77	165	1556	909	-.10	1.8	838	21	296	180	.0	1.1	3894
9- 1-70	235	27.8	913	7.93	103	172	172	-.10	5.4	152	7	33	14	.0	.6	607
6-10-71	498	-99.0	14729	7.42	330	3930	1976	.12	-.1	2164	29	700	426	.0	2.3	9390
9-16-71	771	25.9	11598	7.48	285	3115	1610	-.10	-.1	1607	26	548	336	.0	2.1	7384
12- 2-71	953	25.0	6671	7.45	214	1807	1029	-.10	.4	1060	19	315	196	2.0	1.5	4535
2- 3-72	1141	25.6	6115	7.37	201	1525	932	-.04	1.9	858	14	255	156	.1	2.0	3843
3- 2-72	1297	25.6	5453	7.51	185	1371	867	-.09	2.9	835	18	232	151	.1	1.4	3569

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
8- 2-72	1590	30.0	2328	8.08	100	470	314	-.04	-.1	308	8	71	49	.1	.8	1270
11- 2-72	1761	25.0	9352	7.04	238	2327	1380	-.04	-.1	1310	21	423	264	.1	2.0	5844
2- 8-73	1943	24.4	2514	7.51	120	529	384	-.04	-.1	344	10	91	57	.1	.9	1475
5- 7-73	2068	28.3	2184	7.39	112	437	318	-.04	.3	276	8	77	45	.1	-99.0	1218
8- 1-73	2201	28.3	7124	7.34	184	1674	1041	-9.99	-.1	905	15	283	184	.1	-10.0	4193
LG 34 AK UP CROSS 35			21S 62E 15 441 1													
6-10-71	503	-99.9	6287	7.70	268	427	3087	-.10	53.0	674	41	446	354	.0	1.6	5215
9-14-71	744	18.0	5804	7.64	268	388	3050	.14	51.0	638	37	432	341	.0	1.6	5070
12- 3-71	991	17.8	5383	7.46	265	378	2830	-.10	41.0	625	37	399	340	2.0	1.6	4784
2- 3-72	1140	17.0	5514	7.45	265	367	2874	-.04	32.0	575	30	388	353	2.0	1.8	4753
3- 2-72	1304	16.1	5896	7.80	272	436	3094	-.04	42.0	649	39	417	359	2.0	1.6	5174
5- 4-72	1418	20.0	6044	7.40	294	489	3329	-.04	35.0	659	39	471	420	2.0	1.6	5590
7-31-72	1544	24.4	6341	7.79	301	456	3236	-.06	28.0	671	42	443	389	2.0	1.8	5417
11- 3-72	1773	18.9	5665	7.53	270	372	2835	-.04	22.0	555	42	464	325	2.0	1.9	4752
2- 9-73	1957	18.3	5785	7.54	271	408	3075	-.04	36.0	605	30	419	391	2.0	1.8	5101
5- 8-73	2072	20.0	6482	7.58	310	481	3378	-.04	35.0	667	40	445	429	.2	-99.0	5627
8- 2-73	2219	20.0	6831	7.52	333	481	3327	-9.99	50.0	705	43	424	405	.1	-10.0	5599
LG 35 DRI UP CROSS 105			21S 62E 15 441 2													
10-12-70	283	18.1	1761	7.43	125	267	2741	-.10	18.0	429	28	475	289	.0	1.5	4310
6-10-71	502	-99.0	1663	7.65	202	46	704	-.10	.1	87	11	146	96	.0	1.7	1191
9-14-71	743	21.1	1525	7.84	170	45	657	.10	-.1	81	12	126	91	.0	1.7	1096
12- 3-71	990	18.9	1475	6.80	193	44	599	-.10	-.1	79	10	117	88	1.8	1.7	1035
2- 3-72	1138	20.0	1575	7.53	203	45	677	-.04	-.1	75	11	137	93	1.8	1.8	1141
3- 2-72	1305	19.9	1569	7.77	214	49	698	-.09	1.9	77	11	142	95	1.8	1.8	1182
7-31-72	1545	22.2	1605	7.98	130	50	694	-.04	-.1	79	11	119	95	1.8	1.6	1116
11- 3-72	1772	20.6	1564	7.57	132	46	680	-.04	-.1	81	10	119	94	1.8	1.6	1098
2- 9-73	1956	20.0	1514	7.75	152	46	671	-.04	-.1	78	11	126	91	.1	1.7	1100
5- 8-73	2073	22.2	1574	7.65	123	51	696	-.04	-.1	77	13	120	98	.2	-99.0	1115
8- 2-73	2220	21.1	1867	7.57	107	62	815	-9.99	.3	93	10	139	107	.2	-10.0	1280
LG 36 COUNTY STP 50			21S 62E 22 241 1													
6- 9-71	493	-99.0	6828	7.50	65	856	2754	-.10	58.0	751	26	488	318	.0	1.0	5284
9-14-71	745	20.6	5554	7.28	84	708	2278	-.10	1.3	527	24	471	270	.0	1.0	4322
9-14-71	745	20.6	8080	8.11	40	981	3455	-.10	.9	1117	33	455	326	.0	.9	6388
12- 3-71	966	18.3	4845	7.65	54	688	1999	-.10	.4	447	18	420	256	10.0	1.0	3866
2- 3-72	1170	18.9	3959	7.52	91	614	1338	-.04	2.7	265	15	317	206	1.0	.9	2805
3- 2-72	1306	18.3	3800	7.45	125	603	1327	.34	3.1	264	18	336	203	5.2	1.1	2822
5- 3-72	1406	22.2	3647	7.47	36	597	1274	-.04	5.6	271	15	288	206	6.4	.9	2681
7-31-72	1546	23.3	4013	7.82	49	592	1292	-.04	-.1	268	17	267	205	6.4	.9	2673
11- 3-72	1771	20.0	3894	7.71	30	612	1213	-.04	-.1	259	16	265	207	6.4	.9	2594
2- 9-73	1955	19.4	4039	7.56	39	623	1453	-.04	-.1	313	17	281	223	6.4	1.0	2936
5- 8-73	2074	22.2	4318	7.52	46	656	1500	-.04	-.1	326	17	292	234	11.0	-99.0	3059
8- 2-73	2221	21.1	4833	7.50	48	683	1613	-9.99	-.1	364	18	318	244	10.8	-10.0	3274
LG 37 COUNTY STP 31			21S 62E 22 241 1													
6- 9-71	494	-99.0	8451	7.55	98	980	3602	-.10	130.0	1165	30	552	353	.0	1.0	6861
9-14-71	746	23.3	707	7.98	157	8	270	-.04	.6	12	4	72	39	.0	.4	434

POINT IDENTIFIER AND LOCATION

LG 38 WHITNEY MESA 112 22S 62E 04 232 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
6-11-71	508	-99.0	1213	7.63	136	120	310	-.10	1.3	103	12	75	43	.0	.5	732
9-14-71	750	21.1	1241	7.92	134	135	303	-.10	.6	108	11	73	45	.0	.6	742
12- 3-71	954	20.6	1141	7.55	137	124	302	-.10	2.3	100	11	74	45	1.7	.5	728
2- 2-72	1044	20.0	1181	7.75	133	129	306	-.04	1.2	100	11	73	43	1.7	.5	730
8- 2-72	1589	28.3	1264	7.88	113	134	314	-.04	1.1	101	10	74	44	1.7	.6	735
11- 1-72	1759	21.7	1211	8.33	132	131	316	.12	1.2	103	6	82	43	1.7	-99.0	748
2- 9-73	1950	15.6	1191	8.25	134	131	317	.18	.3	103	6	83	43	1.7	-99.0	751
5- 4-73	2046	22.2	1200	7.67	133	128	303	-.04	3.2	93	9	72	43	1.7	-99.0	718

LG 39 WHITNEY MESA 40 22S 62E 04 232 2

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
6-11-71	507	-99.0	4075	7.30	206	709	1083	-.10	-.1	286	39	378	179	.0	1.2	2776
9-14-71	749	20.6	4029	7.57	137	713	1069	-.10	-.1	271	39	364	181	.0	1.3	2706
12- 3-71	987	19.4	3768	7.15	166	726	1005	-.10	.5	265	38	332	182	2.0	1.3	2633
2- 1-72	1045	20.0	3990	7.33	175	736	1023	-.04	1.3	269	41	338	186	2.0	1.1	2684
8- 2-72	1538	25.0	4113	7.58	88	746	1022	-.06	1.3	266	37	298	181	2.0	1.1	2598
11- 1-72	1758	20.0	4052	8.13	102	763	1098	-.10	-.1	266	41	330	196	2.0	-99.0	2746
2- 9-73	1949	19.4	4142	8.15	103	770	1108	-.10	.2	285	45	300	202	2.0	-99.0	2763
5- 4-73	2045	20.6	4033	7.45	103	766	1036	-.04	-.1	271	40	295	197	2.0	-99.0	2658

LG 40 WHITNEY MESA 110 22S 62E 04 232 3

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
6-11-71	506	-99.0	1322	7.70	127	138	346	-.10	.1	90	12	94	52	.0	.4	795
9-14-71	742	21.7	1307	7.81	117	144	337	-.10	-.1	94	13	83	58	.0	.4	787
12- 3-71	955	20.6	1324	7.47	124	149	332	-.10	.6	93	13	93	54	1.3	.5	798
2- 1-72	1097	21.0	1254	7.62	117	142	335	-.04	-.1	86	11	84	54	1.3	.4	771
8- 2-72	1608	22.2	1324	7.94	128	148	336	-.04	-.1	85	12	86	55	1.3	.4	786
11- 1-72	1757	-99.0	1251	8.42	118	146	348	.16	.1	83	12	94	52	1.3	-99.0	794
2- 9-73	1948	18.3	1215	8.37	117	142	342	.16	.2	85	30	94	53	1.3	-99.0	805
5- 4-73	2044	22.2	1255	7.62	119	144	328	-.04	-.1	84	12	83	52	.2	-99.0	761

LG 41 UPPER LVW 67 20S 62E 32 121 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
6- 9-71	490	-99.0	988	7.85	194	37	322	-.10	-.1	40	10	55	72	.0	1.0	632
9-27-71	788	-99.0	784	7.96	235	29	165	-.10	.4	33	8	40	55	.0	1.3	449
12- 3-71	989	18.9	708	8.27	247	42	149	-.10	-.1	35	9	40	55	1.5	1.2	454
2- 1-72	1148	18.9	697	8.16	269	27	124	-.04	-.1	29	8	34	53	1.5	1.1	409
7-31-72	1541	21.1	663	7.97	250	23	98	-.08	2.0	29	8	29	53	1.5	1.2	368
11- 1-72	1754	20.0	683	8.09	262	15	118	-.04	.8	29	7	33	50	1.5	1.1	384
2-12-73	1961	20.0	608	7.96	250	18	107	-.04	-.1	27	7	26	48	.1	1.2	358
5- 4-73	2049	21.1	534	8.51	188	14	79	-.04	.4	20	7	18	44	.1	-99.0	274

LG 42 UP LVW 170 20S 62E 32 121 2

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
6- 9-71	489	-99.0	955	7.85	253	31	258	-.10	2.9	29	8	48	79	.0	1.0	581
9-13-71	737	21.1	915	7.97	251	32	276	-.10	1.8	33	10	46	73	.0	1.1	547
12- 3-71	988	18.9	840	7.64	256	35	222	-.10	1.2	27	8	46	75	1.7	1.1	542
2- 1-72	1096	20.0	860	7.88	252	29	234	-.04	2.7	24	7	39	77	1.7	1.0	539
7-31-72	1540	21.1	883	8.25	236	39	208	-.04	-.1	28	7	38	73	1.7	1.2	513
11- 1-72	1753	20.0	921	7.59	249	30	242	-.04	3.0	21	7	44	81	1.7	1.0	554
2-12-73	1960	20.0	876	7.69	241	37	248	-.04	1.7	28	8	41	78	1.7	1.2	563
5- 4-73	2048	25.6	911	8.11	230	41	246	-.04	-.1	32	8	41	74	.6	-99.0	556

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
8- 2-73	2216	22.2	1080	7.42	228	60	253	-9.99	1.1	43	8	46	81	.6	-10.0	615
LG 43 NO NAME SP 56			21S 62E 29 434 1													
6-11-71	505	-99.0	3749	7.22	246	364	1460	-.10	.2	245	39	420	169	.0	1.6	2820
9-14-71	748	20.6	3703	7.52	172	373	1435	-.10	-.1	233	41	383	161	.0	1.7	2712
12- 3-71	956	14.4	3219	6.85	165	355	1265	-.10	.6	230	38	303	158	1.5	1.6	2434
2- 1-72	1151	20.0	3316	7.19	226	362	1262	-.04	1.6	235	37	315	159	1.5	1.6	2486
8- 1-72	2214	22.2	3320	6.93	190	366	1172	-9.99	-.1	235	36	236	162	1.5	-10.0	2302
8- 2-72	1610	22.2	3511	7.73	190	365	1263	-.04	1.9	231	38	287	165	1.5	1.6	2447
11- 2-72	1755	19.4	3407	6.95	200	372	1229	-.04	.2	222	36	290	166	1.5	1.7	2417
2- 9-73	1952	20.0	3221	6.93	149	365	1254	-.04	-.1	229	38	275	161	.2	1.7	2397
5- 4-73	2043	21.1	3236	6.73	98	373	1205	-.04	-.1	217	36	256	160	.0	-99.0	2295
LG 44 NO NAME SP 129			21S 62E 29 434 2													
6-11-71	504	-99.0	3643	7.25	206	381	1352	-.10	.4	272	35	347	175	.0	1.2	2665
9-14-71	747	21.7	3594	7.54	165	392	1295	-.10	-.1	239	35	319	175	.0	1.1	2537
12- 3-71	957	19.4	3338	7.70	178	382	1275	-.10	.4	228	24	306	174	1.5	1.2	2479
2- 1-72	1152	20.0	3389	7.18	219	378	1307	-.04	1.7	231	36	318	176	1.5	1.2	2558
8- 2-72	1609	21.7	3471	7.72	146	386	1311	-.08	.4	227	33	286	182	1.5	1.1	2500
11- 2-72	1756	19.4	3449	7.14	138	388	1283	-.04	-.1	222	33	268	180	1.5	1.0	2444
2- 8-73	1951	19.4	3302	7.30	135	384	1325	-.04	-.1	229	34	271	179	1.5	1.1	2491
8- 2-73	2213	26.1	3501	7.22	107	376	1290	-9.99	.2	235	32	246	182	1.5	-10.0	2415
LG 45 CAMPBELL RES 125			21S 62E 19 111 1													
6-10-71	500	-99.0	1074	7.20	66	12	504	-.10	-.1	20	5	139	50	.0	.4	763
9-14-71	740	22.2	833	6.93	60	13	358	-.10	-.1	20	6	81	46	.0	.3	554
12- 3-71	992	20.6	797	7.00	101	31	292	-.10	-.1	25	5	75	45	1.8	.4	526
2- 1-72	1153	22.0	653	7.57	136	16	219	-.04	-.1	17	3	64	37	1.8	.4	425
8- 2-72	1611	23.3	587	8.11	122	15	157	-.04	.2	16	4	39	34	1.8	.4	329
11- 3-72	1774	22.2	547	7.72	126	9	153	-.04	-.1	15	3	37	35	1.8	.4	315
2- 9-73	1953	19.4	526	7.72	133	11	150	-.04	-.1	17	4	34	35	.1	.6	317
5- 4-73	2052	25.0	544	7.91	128	10	156	-.04	-.1	19	3	36	36	.1	-99.0	323
8- 3-73	2223	22.2	594	7.86	140	16	161	-9.99	-.1	17	2	40	43	.1	-10.0	348
LG 46 CAMPBELL RES 40			21S 62E 19 111 2													
6-10-71	501	-99.0	874	7.60	186	23	275	-.10	.6	18	3	96	44	.0	.3	551
9-14-71	741	22.2	839	7.64	166	21	266	-.10	.5	22	3	73	46	.0	.3	514
12- 3-71	993	20.0	807	7.46	180	28	286	-.10	-.1	23	3	90	49	1.2	.3	570
2- 1-72	1154	21.0	886	7.54	171	26	314	-.04	.7	24	2	90	49	1.2	.3	592
8- 2-72	1612	22.8	1074	7.85	165	38	373	-.04	.5	34	3	109	61	1.2	.5	701
11- 3-72	1775	21.7	959	7.34	129	36	344	-.04	-.1	33	3	78	58	1.2	.2	616
2- 9-73	1954	21.1	1030	7.55	162	42	383	-.04	-.1	37	4	97	59	.1	.4	701
5- 4-73	2053	22.8	1196	7.76	177	69	419	-.04	-.1	40	3	117	64	.1	-99.0	799
8- 3-73	2222	23.3	1332	7.20	193	68	459	-9.99	.6	44	2	131	69	.1	-10.0	868
LG 47 CHARLES BLVD 100			20S 61E 36 444 1													
6- 8-71	492	-99.0	469	8.00	190	9	88	-.10	.8	12	4	37	34	.0	.4	278
9-13-71	738	21.7	436	8.00	166	10	72	-.10	.8	10	5	25	32	.0	.4	236
12- 3-71	963	20.6	484	7.71	181	11	121	-.10	-.1	10	5	42	36	1.4	.4	316
2- 1-72	1150	21.0	466	7.92	188	7	87	-.04	.6	8	3	34	33	1.4	.5	268

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
7-31-72	1543	23.3	707	7.98	157	8	220	-.04	.6	12	4	72	39	1.4	.4	435
11- 1-72	1751	20.6	622	7.56	179	6	180	-.04	.4	8	4	66	34	1.4	.4	389
2-12-73	1958	20.6	532	7.80	179	1	128	-.04	-.1	16	4	42	34	1.4	.5	315
5- 4-73	2050	24.4	490	7.84	180	4	101	-.04	.7	8	4	36	33	.2	-99.0	275
8- 2-73	2217	23.9	458	8.12	169	12	83	-9.99	.1	14	2	25	33	.2	-10.0	252
LG 48 CHARLSTON BLVD 40			20S 61E 36 444 2													
6- 9-71	491	-99.0	2765	7.50	225	117	1309	-.10	-.1	148	26	202	208	.0	.4	2121
9-13-71	739	22.2	2723	7.55	175	129	1258	-.10	-.1	168	28	196	200	.0	.3	2065
12- 3-71	962	18.9	2272	7.07	216	126	1110	-.10	-.1	135	23	192	173	1.2	.3	1866
2- 1-72	1149	21.0	2487	7.29	196	125	1181	-.04	.3	134	68	171	192	1.2	.3	1969
7-31-72	1542	23.3	2578	7.80	120	124	1185	-.04	.6	135	26	150	190	1.2	.2	1871
11- 1-72	1752	20.6	2838	6.86	92	126	1168	-.04	-.1	125	24	136	184	1.2	.2	1810
2-12-73	1959	20.6	2302	7.40	157	113	1090	-.04	-.1	127	23	155	171	.1	.3	1757
5- 4-73	2051	22.2	2305	7.55	127	120	1083	-.04	-.1	137	20	136	180	.1	-99.0	1739
8- 2-73	2218	23.3	2482	7.37	134	124	1140	-9.99	.1	129	22	143	184	.1	-10.0	1808
LG 49 AK NO 20LC 35			21S 63E 29 332 3													
6-11-71	509	-99.0	7578	7.62	206	1602	1680	-.10	132.0	527	142	705	327	.0	.5	5217
9-15-71	763	22.8	8385	7.39	208	1903	1541	-.10	118.0	542	148	743	357	.0	.7	5455
2- 2-72	1128	20.0	7773	7.27	180	1868	1592	-.09	72.0	536	151	692	336	.1	.6	5336
5- 2-72	1427	21.7	8024	7.40	163	2049	1665	-.04	62.0	652	196	786	349	.1	.6	5840
7-31-72	1556	28.9	9280	7.71	157	2080	1771	-.04	55.0	719	168	762	347	.1	.7	5980
10-31-72	1742	21.1	9415	7.91	124	2309	1874	.12	103.0	860	160	675	331	.1	-99.0	6373
2- 8-73	1931	20.0	8484	7.80	161	1924	1813	.16	109.0	940	140	677	255	.1	-99.0	5937
5- 7-73	2057	23.3	8620	7.21	168	1996	1687	-.04	139.0	1042	153	622	235	.5	-99.0	5957
LG 50 LVBM WELL WATR 20			21S 62E 35 441 1													
5-17-71	471	-99.0	5196	7.85	196	1067	1071	-.10	2.4	608	30	300	146	.0	1.2	3322
6-11-71	528	21.0	6730	7.62	193	1486	1269	-.10	1.7	932	35	397	178	.0	1.1	4395
LG 51 AK LC COMP 30			21S 63E 29 323 1													
3-10-71	371	-99.9	5109	7.24	305	415	2485	-.10	.8	403	40	606	272	.0	1.3	4373
3-10-71	372	-99.9	5160	7.28	320	490	2282	-.10	2.2	438	37	635	251	.0	1.3	4294
LG 52 AK LC COMP 30			21S 63E 29 323 2													
3-10-71	370	-99.9	6701	7.34	206	1247	1677	-.10	152.0	588	134	629	241	.0	.6	4770
LG 53 AK LC COMP 30			21S 63E 29 323 3													
3-10-71	369	-99.9	6973	7.40	195	1228	1858	-.10	134.0	570	130	662	247	.0	.6	4925
4-22-71	440	18.9	6465	7.95	210	1096	1897	-.10	81.5	521	116	557	340	.0	.6	4712
LG 54 AK LC COMP 30			21S 63E 29 333 1													
3-10-71	373	-99.9	6293	7.13	231	1228	1525	-.10	168.0	473	102	523	256	.0	.9	4389
4-22-71	438	20.0	6896	7.95	192	1427	1624	-.10	136.0	417	96	652	299	.0	1.0	4746

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LG 55 AK NO 16LC 33			21S 63E 29 332 4													
9-23-71	776	21.9	8494	7.27	182	2019	1529	-.10	116.0	622	147	710	339	.0	.5	5572
2- 1-72	1167	22.0	7825	7.48	165	1849	1684	-.04	83.0	635	161	688	338	-.1	.6	5520
5- 2-72	1428	22.2	8045	7.29	152	2019	1750	-.04	85.0	753	165	740	322	-.1	.6	5909
LG 56 NEV RS WASH WATER			21S 62E 11 232 1													
3-31-70	25	-99.9	2381	7.67	207	107	1202	-.10	7.5	172	13	208	161	.0	1.5	1975
5- 4-70	35	23.0	2216	7.70	203	83	1252	-.10	18.4	172	14	205	168	.0	1.5	2014
6- 4-70	79	28.6	2261	7.80	210	76	1175	-.10	7.5	187	15	193	166	.0	1.5	1925
7- 7-70	107	23.3	2284	7.90	207	77	1151	-.10	9.2	172	14	196	162	.0	1.5	1885
8- 6-70	143	24.4	2222	8.09	208	83	1156	-.10	16.8	172	16	195	160	.0	1.5	1902
9-11-70	206	25.6	2332	8.00	212	83	1188	.13	17.4	167	16	200	150	.0	1.5	1928
9-11-70	207	25.6	2488	8.12	212	77	1238	-.10	8.3	185	16	204	158	.0	1.7	1992
3- 2-72	1294	21.1	2537	7.95	218	90	1280	-.04	8.4	184	16	209	160	.0	1.6	2056
LG 57 NO 2 NELLIS AFB			20S 61E 03 412 1													
6-15-71	547	23.6	411	8.00	225	8	33	-.10	1.2	9	1	47	23	.0	.2	234
LG 58 NLV LOSEE WELL			20S 61E 15 433 1													
6-15-71	546	23.3	605	7.99	232	25	107	-.10	2.5	13	2	75	35	.0	.1	373
LG 60 CCSTP DEWATER SH			21S 62E 22 224 2													
1- 0--0	1414	-99.0	6982	7.54	202	748	3423	.12	101.0	1015	59	524	310	.0	1.4	6281
2- 1-72	1207	19.0	7255	7.51	207	696	3510	-.04	84.0	966	79	534	333	.0	1.6	6306
3- 2-72	1307	-99.0	7306	7.73	204	748	3584	.10	98.0	1049	69	502	319	.2	1.4	6471
6- 1-72	1458	21.1	7284	7.58	198	716	3558	.28	92.0	1067	62	496	332	.2	1.3	6422
7-31-72	1547	22.2	7976	7.70	209	808	3548	.20	84.0	1047	43	548	329	.2	1.4	6512
9- 6-72	1655	21.1	7975	7.55	199	794	3886	.16	87.0	1207	73	507	335	.2	1.3	6989
11- 5-72	1791	18.9	8074	8.20	199	750	3953	.28	86.0	1183	53	440	342	.2	-99.0	6905
1-16-73	1880	18.9	8088	7.98	195	743	3756	-99.00	83.0	1196	67	502	341	.2	1.4	6786
2- 1-73	1915	18.9	6633	8.23	186	526	3390	.16	73.0	781	56	450	350	.2	-99.0	5718
LG 61 CITY LV TULE 706			19S 60E 04 341 1													
6-14-71	542	22.2	439	8.00	246	8	20	.12	1.8	8	2	41	26	.0	.2	228
10- 4-72	1693	22.2	424	7.79	247	6	21	-.00	2.2	9	1	43	25	.0	.2	230
LG 62 CITY LV TULE 612			19S 60E 09 341 0													
10- 4-72	1699	22.2	430	7.76	243	3	31	-.00	1.5	7	1	46	25	.0	.2	234
LG 63 T H GEE 325			20S 61E 36 222 0													
10- 5-72	1703	21.7	438	7.87	235	5	39	-.00	2.2	8	2	43	25	.0	.2	240
LG 64 3115 LVBN 300			20S 62E 18 222 0													
10- 5-72	1707	21.1	491	7.81	286	5	34	-.00	.9	12	2	24	44	.0	1.0	264

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
POINT IDENTIFIER AND LOCATION																
LG 66 NELLIS AFB 350 20S 61E 03 412 0																
10- 5-72	1710	20.0	412	7.76	231	5	33	-.00	1.3	9	1	44	23	.0	.2	229
LG 67 3087 W L MEAD 665 20S 61E 20 311																
10- 5-72	1712	19.4	519	7.79	234	13	72	-.00	3.0	10	1	55	32	.0	.2	301
LG 68 3001 W L MEAD 300 20S 61F 20 311 0																
10- 5-72	1713	20.0	652	7.72	-0	18	134	-.00	6.3	16	2	58	43	.0	.2	277
LG 69 226 ANDERSON 400 20S 61E 20 312 0																
10-11-72	1715	21.7	664	7.64	258	14	134	-.00	5.1	16	2	63	42	.0	.2	404
LG 70 1531 W BONANZA440 20S 61E 28 341 0																
10-11-72	1717	24.4	9570	7.54	3380	60	1	-.00	6.3	21	3	89	63	.0	.2	1907
LG 71 1823 W CHARLES400 21S 61E 04 211 0																
10-11-72	1718	21.1	1380	7.35	12	62	671	-.00	1.1	62	8	71	112	.0	.1	993
LG 72 2040 GOLDRING 425 20S 61E 33 332 0																
10-11-72	1720	21.1	1415	7.50	292	73	457	-.00	4.9	80	11	92	95	.0	.2	956
LG 73 1824 GOLDRING 400 20S 61E 33 331 0																
10-11-72	1721	21.1	1074	7.70	271	62	316	-.00	3.3	35	5	93	73	.0	.2	720
LG 74 UPRR NO 157 780 20S 61E 34 232 0																
10-12-72	1722	24.4	397	7.67	209	7	37	-.00	1.9	8	2	42	21	.0	.2	221
LG 75 2500 BLDR HWY 400 21S 61E 01 221 0																
10-12-72	1724	20.6	335	8.04	165	4	35	-.00	1.6	12	4	23	20	.0	.5	182
LG 76 4200 E RUSSEL 404 21S 62E 29 333 0																
10-12-72	1725	23.3	744	7.69	199	11	229	-.00	2.0	29	6	66	39	.0	.4	480
LG 77 3340 ROGHELLE 160 21S 61E 24 114 0																
10-13-72	1726	21.7	1039	7.49	242	56	302	-.00	6.0	42	3	98	56	.0	.3	682
LG 78 3360 POCHELLE 100 21S 61E 24 114 0																
10-13-72	1727	21.1	2006	7.40	261	157	741	-.00	11.2	115	5	178	108	.0	.4	1444

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LG 79 5326 TOPAZ 21S 61E 25 312 0																
10-13-72	1728	20.0	1120	7.71	161	96	307	-.00	2.7	106	4	86	30	.0	.3	712
LG 80 7117 PARADISE 335 22S 61E 03 441 0																
10-13-72	1729	28.9	1269	7.39	196	73	455	-.00	2.7	43	10	148	54	.0	.7	884
LG 81 7044 TOMIYASU 201 22S 61E 01 413 0																
10-13-72	1730	25.6	1346	7.41	207	104	437	-.00	2.7	57	15	171	61	.0	.8	950
LG 82 5324 SANDHILL 390 21S 62E 30 422 0																
10-17-72	1731	23.3	891	7.45	212	18	358	-.00	2.4	24	6	106	53	.0	.3	672
LG 83 6000 E CHARL 200 21S 62E 03 312																
10-20-72	1736	16.7	395	7.48	192	4	47	-.00	1.6	19	4	32	18	.0	.3	222
LG 84 6100 S PEARL 600 21S 62E 31 133																
10-20-72	1737	16.7	867	7.83	116	19	377	-.00	.8	23	6	90	49	.0	.3	621
LG 93 CASEY ND SANDHILL 21S 62E 30 241																
1-10-73	1887	22.2	10056	7.75	202	22	368	-.04	2.5	26	6	118	51	.0	.4	693
LG 98 DILLINGHAM 25 21S 62E 08 433																
4-18-73	2026	20.0	2121	7.85	279	137	785	-99.00	1.5	112	6	177	126	.1	.3	1482
5- 9-73	2080	23.3	2030	7.43	284	133	767	-.04	.4	114	7	179	122	.1	-99.0	1462
9- 6-73	2255	23.3	1822	8.00	257	120	689	-99.00	.8	98	2	187	110	5.3	-99.0	1339
LG 99 W W GOLF CRS 26 21S 62E 09 122																
4-18-73	2025	21.1	5302	7.57	489	442	2345	-99.00	14.5	422	59	395	356	.3	.9	4275
5- 9-73	2081	25.6	5001	7.59	198	416	2235	-.04	95.0	403	56	365	352	.3	-99.0	4019
9- 6-73	2254	21.1	4716	8.09	371	403	2154	-99.00	140.0	358	67	335	339	.5	-99.0	3979
LG100 SW 25TH ND ELM 12 20S 61E 35 144																
4-18-73	2023	20.0	3281	7.66	266	121	1646	-99.00	2.5	181	20	292	215	.3	.2	2608
5- 9-73	2079	23.3	2157	7.75	148	116	1525	-.04	1.7	167	18	262	208	.3	-99.0	2371
LG101 BILLMAN 31 21S 62E 21 314																
4-18-73	2027	21.1	9941	7.60	278	807	4975	-99.00	.7	1548	93	522	475	.4	1.4	8559
5- 9-73	2082	26.7	9610	7.46	127	799	5100	-.04	12.4	1571	27	511	467	.4	-99.0	8550
LG102 STIBOREK 20 21S 61E 02 213																
4-18-73	2022	20.0	5412	7.67	427	280	2808	-99.00	.8	447	45	440	372	.2	.4	4603
5- 9-73	2087	24.4	4492	7.58	208	212	2270	.16	.5	363	26	333	317	.2	-99.0	3624

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
9- 7-73	2264	26.7	4261	7.99	409	216	2238	-99.00	.4	382	35	300	311	.2	-99.0	3684
LG103 MOTOR VEHCLS 10 21S 62E 01 434																
4-18-73	2021	-99.0	3469	7.64	173	238	1625	-99.00	4.4	141	23	433	171	.2	.4	2721
5- 9-73	2078	23.3	3521	7.74	179	239	1733	.04	8.0	122	23	478	172	.2	-99.0	2863
9- 6-73	2256	28.9	3704	8.11	215	348	1694	-99.00	5.5	237	49	489	150	.5	-99.0	3079
LG104 PETERSON 8 21S 61E 13 223																
4-18-73	2029	16.7	7533	7.67	300	427	3973	-99.00	.3	942	169	498	360	.2	.5	6518
5- 9-73	2086	21.7	6678	7.46	306	408	3645	.04	.8	778	123	517	370	.2	-99.0	5993
9- 6-73	2260	27.8	59410	7.78	492	12890	31384	-99.00	175.0	13975	4560	750	2602	2.1	-99.0	66580
9- 7-73	2263	26.1	53640	7.85	476	9494	27516	-99.00	198.0	11950	3865	717	2416	2.1	-99.0	56392
LG105 JARRETT 36 21S 61E 23 412																
4-18-73	2030	19.4	4877	7.69	240	292	2617	-99.00	.0	329	22	534	303	.1	.0	4216
5- 9-73	2085	22.2	4560	7.37	242	282	2662	.04	.6	299	14	519	308	.1	-99.0	4203
9- 6-73	2261	21.1	4716	7.83	235	294	2690	-99.00	.8	347	32	515	313	.1	-99.0	4307
LG106 ENGELSTAD 46 22S 61E 23 412																
5- 9-73	2083	24.4	3177	7.18	173	203	1620	.04	-.1	111	12	416	194	.0	-99.0	2641
9- 6-73	2253	22.8	2700	7.94	99	175	1640	-99.00	1.8	109	9	362	192	.0	-99.0	2538
LG107 MCSTRAVIK 31 21S 61E 26 332																
4-18-73	2031	21.1	2349	7.65	195	106	1022	-99.00	.2	167	9	200	117	.1	.4	1717
5- 9-73	2084	23.9	2246	7.41	222	100	1004	.04	.3	152	10	217	119	.1	-99.0	1711
9- 6-73	2252	24.4	2200	8.12	235	107	1012	-99.00	3.0	173	9	203	114	.1	-99.0	1737
LG108 W OF I15MILO WY36 21S 61E 08 134																
4-18-73	2028	21.7	3251	7.62	193	129	1733	-99.00	[illegible]	87	9	444	187	.4	.3	2718
5- 9-73	2090	22.2	2658	7.49	190	112	1349	-.04	77.0	58	8	361	163	.4	-99.0	2221
9- 6-73	2259	21.1	2307	7.95	209	113	1102	-99.00	74.0	76	8	336	140	.4	-99.0	1952
LG109 VV AND OKY 39 21S 61E 05 323																
4-17-73	2033	21.7	2845	7.77	263	189	1192	-99.00	1.7	191	12	191	189	.8	.3	2096
5- 9-73	1520	24.4	2903	7.54	263	187	1237	-.04	66.0	187	12	219	197	.8	-99.0	2235
9- 6-73	2257	21.1	2864	8.03	258	190	1270	-99.00	62.0	203	8	210	203	.8	-99.0	2273
LG110 JOSEPHS 35 20S 61E 33 342																
3- 2-73	1966	25.6	2706	7.67	246	158	1110	-99.00	3.3	161	20	117	216	.0	.4	1907
4-18-73	2032	21.1	2974	7.66	298	181	1275	-99.00	2.0	178	24	171	235	.4	.4	2213
5- 9-73	2088	25.6	2922	7.53	434	172	1210	-.04	2.0	171	22	196	239	.4	-99.0	2226
9- 6-73	2258	23.9	2763	7.93	378	173	1212	-99.00	.3	182	30	204	236	.3	-99.0	2223
10- 4-72	-0	.0	0	.00	378	0	0	.00	.0	0	0	0	0	.0	.0	0

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LG112 CURT MANNO2 312 20S 62E 24 111 1																
6- 8-73	2147	24.4	613	8.03	262	20	74	-99.00	11.5	17	2	51	36	.2	.2	342
10- 4-72	1701	.0	0	.00	262	0	0	.00	.0	0	0	0	0	.0	.0	0
LG113 7000 GILCREAS 560 19S 60E 23 223																
6- 8-73	2135	25.6	416	7.74	239	6	20	-99.00	2.9	10	1	39	24	.0	.2	221
10- 4-72	1702	.0	0	.00	239	0	0	.00	.0	0	0	0	0	.0	.0	0
LG114 RNCH SUP CLUB 605 19S 60E 27 112																
6- 8-73	2134	26.7	433	8.04	239	4	26	-99.00	2.4	8	1	41	24	.0	.2	224
10- 5-72	1704	.0	0	.00	239	0	0	.00	.0	0	0	0	0	.0	.0	0
LG115 LA PAZ TR PK 200 20S 62E 19 312																
6- 8-73	2138	25.6	398	7.83	200	7	37	-99.00	1.8	15	2	24	29	.0	.6	214
10- 5-72	1705	.0	0	.00	200	0	0	.00	.0	0	0	0	0	.0	.0	0
LG116 2342 N PECOS 289 20S 62E 19 222																
6- 8-73	2137	25.9	398	7.82	249	8	48	-99.00	1.1	27	4	25	34	.0	.9	271
10- 5-72	-0	.0	0	.00	249	0	0	.00	.0	0	0	0	0	.0	.0	0
LG117 2934 LVBN 300 20S 61E 13 142																
6- 8-73	2139	26.7	549	7.90	251	18	69	-99.00	1.9	22	2	36	3	.0	.7	275
10- 5-72	1709	.0	0	.00	251	0	0	.00	.0	0	0	0	0	.0	.0	0
LG118 NELLIS AFB 1 800 20S 61E 19 441																
6- 8-73	500	26.7	519	7.89	243	8	29	-99.00	3.3	18	3	35	25	.0	.6	241
10- 5-72	1711	.0	0	.00	243	0	0	.00	.0	0	0	0	0	.0	.0	0
LG119 4434 CRAIG RD 900 20S 61E 04 144																
6-12-73	2145	25.0	384	7.68	193	4	38	-99.00	.6	18	3	32	19	.0	.6	210
10- 6-72	1714	.0	0	.00	193	0	0	.00	.0	0	0	0	0	.0	.0	0
LG120 DAY DREAM RANCH 22S 61E 12 222																
6-12-73	2146	99.0	1016	7.46	205	26	365	-99.00	3.2	23	6	120	51	.0	.5	696
10-11-72	1716	.0	0	.00	205	0	0	.00	.0	0	0	0	0	.0	.0	0
LG121 CLUB 95 295 20S 61E 19 442																
6- 8-73	2133	28.9	434	7.80	235	4	36	-99.00	-.0	7	2	48	22	.0	.2	234
10-11-72	1719	.0	0	.00	235	0	0	.00	.0	0	0	0	0	.0	.0	0
LG122 716 SHADOW L 226 20S 61E 33 331																
6- 8-73	2132	26.7	438	7.83	225	4	46	-99.00	2.0	7	2	44	26	.1	.3	243
10-12-72	1723	.0	0	.00	225	0	0	.00	.0	0	0	0	0	.0	.0	0

POINT IDENTIFIEP AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	OS-SUM
LG123 1201 FREMONT 460	20S 61E 35 322															
6- 8-73	2144	25.6	413	7.60	204	5	46	-99.00	1.9	9	3	42	23	.0	.3	230
10-19-72	1732	.0	0	.00	204	0	0	.00	.0	0	0	0	0	.0	.0	0
LG124 MICHELAS 1 650	21S 61E 04 413															
6-11-73	2143	26.1	529	7.71	220	8	90	-99.00	2.4	10	3	54	29	.0	.3	304
10-19-72	1733	.0	0	.00	220	0	0	.00	.0	0	0	0	0	.0	.0	0
LG125 MICHELAS 2 810	21S 61E 04 413															
5-11-73	2142	25.6	469	7.91	222	6	61	-99.00	2.1	9	2	49	25	.0	.2	264
10-20-72	1734	.0	0	.00	222	0	0	.00	.0	0	0	0	0	.0	.0	0
LG126 NLV AIR TERM 500	20S 61E 18 233															
6-18-73	2140	26.7	420	7.86	234	4	29	-99.00	2.0	7	1	47	22	.0	.2	227
10-20-72	1735	.0	0	.00	234	0	0	.00	.0	0	0	0	0	.0	.0	0
LG127 LORNZI PK 600	20S 61E 18 233															
6-18-73	2141	26.7	443	7.82	233	5	40	-99.00	2.5	7	2	49	23	.0	.2	243
LG128 AK LDS FARM 30	21S 62E 15 332															
4-11-73	2026	17.8	5551	8.05	336	558	1999	8.83	91.0	716	104	326	159	.0	.9	4128
LG129 LV EXPWY ND VV 10	20S 61E 30 442															
2- 5-73	1924	19.4	1170	7.87	239	67	314	-99.00	9.3	79	6	88	53	.0	.3	733
LG132 MELODY ND CYP 5	20S 60E 19 431															
7-18-73	2149	-99.0	4569	7.27	582	226	2228	-99.00	1.4	297	60	344	356	.1	.8	3799
LG135 2100 BLEDSOE 215	20S 62E 21 341															
11-22-72	1823	-99.0	555	8.42	307	12	52	-99.00	-.0	26	12	29	49	.0	.8	332
LG136 3102 ALOHA 100	21S 62E 08 431															
11-22-72	1821	-99.0	2904	8.22	187	281	1184	-99.00	.3	95	12	248	215	.0	.6	2128
LG137 3208 S. TOPAZ 375	21S 61E 12 342															
11-22-72	1821	-99.0	510	8.52	216	17	74	-99.00	2.4	11	2	49	30	.0	.3	292
LG138 2832 MD. PKWY 6	21S 61E 10 144															
2- 6-73	1925	13.3	3806	7.85	162	182	1976	-99.00	40.0	225	55	316	276	.0	.3	3150

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
POINT IDENTIFIER AND LOCATION																
LG139 1850 SYCAMORE 17 20S 61E 19 422																
7-18-73	2150	-99.0	1982	7.65	383	138	519	-99.00	52.0	154	25	92	107	.2	.3	1276
LG140 6261 WITTIG 208 19S 60E 23 112																
7-18-73	2148	-99.0	1556	7.77	268	69	230	-99.00	370.0	26	7	159	85	.0	.2	1078
LG150 1 MI E LK MEAD DR 22S 63E 04 341 1																
8-15-75	-0	-.0	1177	7.90	256	119	288	.10	5.5	169	12	39	16	.0	.0	774
LG151 BESIDE LG007 21S 63E 28 131 3																
8-15-75	-0	-.0	6610	7.43	234	1135	1995	.67	-.5	671	91	553	232	.0	-.0	4793
LG152 1/2 MI W HEND STP 21S 62E 35 411 1																
8-15-75	-0	-.0	3201	8.01	226	535	710	5.68	.3	408	20	193	69	.0	-.0	2053
LG153 .5 MI S SUNSET RD 22S 62E 03 333 1																
8-15-75	-0	-.0	1198	8.32	242	58	296	.61	.3	22	12	22	9	.0	-.0	538
LW 1 LAS VEGAS WASH 1 21S 62E 23 231 1																
6- 6-70	84	27.5	1136	6.90	240	116	177	31.80	41.2	120	13	70	40	.0	.9	728
7- 7-70	112	27.5	2010	7.75	451	230	316	33.75	1.1	202	21	110	58	.0	1.0	1194
8- 6-70	148	30.6	1041	7.86	180	114	160	17.75	46.1	98	14	70	37	.0	.8	646
9-11-70	202	28.6	1530	7.12	191	188	279	22.38	54.5	150	16	97	49	.0	.9	952
9-11-70	203	28.6	1646	7.07	181	194	327	27.50	70.4	169	17	92	50	.0	.9	1037
12-15-70	304	99.9	2146	7.51	208	284	601	20.10	87.5	300	17	117	82	.0	1.0	1612
1-19-71	333	20.0	2070	7.54	163	280	396	19.10	10.1	187	18	112	61	21.0	.9	1185
2-18-71	366	21.1	1707	7.34	287	243	283	19.40	11.5	178	18	103	52	25.1	1.0	1075
4-22-71	445	24.4	1753	7.20	296	232	262	20.80	5.6	208	16	77	55	17.8	.9	1041
6-11-71	522	28.0	1764	7.35	293	305	317	22.80	7.3	199	16	99	57	18.0	.8	1186
7-26-71	649	30.0	2025	7.45	275	276	384	23.20	8.4	217	16	102	56	14.4	.5	1233
8-30-71	724	30.0	2086	7.30	276	275	331	19.50	7.4	208	16	95	51	21.0	.7	1160
10- 1-71	802	25.0	1813	7.23	291	261	248	19.50	5.4	202	14	85	41	25.9	.7	1046
11-10-71	840	22.8	1891	7.29	298	260	250	19.70	3.2	197	13	84	42	32.0	1.1	1049
12- 1-71	897	20.5	1764	7.13	265	245	331	20.00	2.8	195	15	93	50	21.0	.9	1105
1- 3-72	1035	16.9	1898	7.72	261	256	360	19.70	2.3	200	20	100	53	20.0	.3	1160
4- 5-72	1344	25.6	1791	7.15	282	293	277	17.20	10.0	198	15	97	54	19.0	1.2	1120
5- 4-72	1378	23.5	2230	7.28	265	262	567	21.00	8.7	246	17	119	70	18.0	1.0	1460
6- 1-72	1450	26.7	2074	7.18	225	256	500	22.00	7.8	232	15	122	62	14.0	1.3	1342
7-10-72	1532	-99.9	2198	6.80	305	268	473	20.00	9.0	267	15	100	57	24.0	1.5	1385
8- 6-72	1623	30.0	1876	7.07	131	264	318	12.20	6.6	175	12	99	50	.1	.5	1002
10- 1-72	1695	27.8	1810	7.25	296	252	300	23.00	2.3	209	14	84	41	28.0	1.7	1101
12- 4-72	1829	18.9	1635	7.29	254	188	337	23.00	1.8	165	14	82	45	17.0	.4	999
1- 5-73	1865	-99.0	1625	7.32	241	169	312	28.00	2.3	163	15	79	39	23.0	1.4	950

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LW 2 LAS VEGAS WASH 2 21S 62E 23 424 1																
6- 6-70	85	26.9	1425	6.85	220	149	307	30.70	46.5	156	15	84	52	.0	.9	949
7- 7-70	113	28.6	1718	6.85	192	197	456	25.60	54.9	180	16	124	64	.0	.8	1213
8- 6-70	149	30.3	1302	7.83	183	151	304	13.50	43.4	126	16	75	51	.0	.8	870
9-11-70	204	28.3	1648	7.22	190	193	349	22.80	54.3	192	17	100	63	.0	.9	1085
9-11-70	205	28.3	1672	7.35	180	164	388	25.80	67.9	183	18	97	51	.0	1.0	1084
12-15-70	305	-99.9	2154	7.55	196	264	603	21.00	81.5	244	36	120	79	.0	1.0	1546
1-19-71	334	20.6	2120	7.45	159	279	473	18.30	11.6	204	17	127	81	15.7	.8	1306
3-11-71	374	19.0	1737	7.50	321	164	414	24.80	3.0	173	21	123	63	15.7	1.0	1160
4-22-71	446	23.9	1768	7.27	289	242	269	20.80	4.5	222	17	78	53	18.0	.9	1067
6-11-71	521	28.0	2243	7.32	291	326	322	23.20	6.5	228	16	101	57	17.5	.8	1241
7-26-71	650	30.0	1985	7.20	281	266	390	23.00	6.9	210	16	103	56	14.7	.4	1224
8-30-71	725	30.0	2597	7.45	270	281	346	19.50	6.2	213	16	99	53	19.8	.6	1187
10- 1-71	801	24.4	2003	7.42	269	278	354	18.70	2.3	225	16	102	51	25.1	.6	1205
11-10-71	841	22.2	2143	7.26	291	284	341	19.30	1.8	222	17	99	51	30.0	.8	1209
12- 1-71	896	20.5	1784	7.13	269	218	329	20.50	2.0	185	15	92	43	19.0	1.0	1057
1- 3-72	1034	16.9	1755	7.33	275	218	368	22.80	1.4	181	16	93	53	21.0	.4	1110
2- 1-72	1169	18.0	2213	7.19	265	292	514	18.40	2.3	251	17	120	69	21.0	1.1	1436
3- 2-72	1257	18.3	2358	7.19	294	276	664	24.00	7.8	264	20	153	82	27.0	1.1	1663
5- 4-72	1377	22.5	2657	7.37	298	299	760	21.00	11.5	302	21	157	85	21.0	.9	1825
6- 1-72	1449	25.0	2054	7.20	238	241	529	23.00	7.2	235	15	118	64	16.0	1.4	1366
7-10-72	2326	-99.9	2326	6.78	288	303	509	18.20	7.8	254	17	112	62	21.0	1.3	1446
8- 6-72	1622	30.0	2247	7.06	144	264	525	14.50	6.3	222	15	123	66	15.0	.4	1323
10- 1-72	1694	26.7	2134	7.25	296	283	446	22.00	2.5	11	0	110	55	25.5	1.3	1102
10- 2-73	2272	26.7	2050	8.11	151	279	395	18.00	14.0	216	14	117	54	25.5	-.0	1207
11- 1-73	2282	-99.0	2599	8.26	113	249	348	21.00	2.6	203	13	93	47	25.5	-.0	1058
12- 4-73	2298	-99.0	1819	7.72	108	312	412	19.00	4.1	236	15	100	57	25.5	-.0	1234
1- 2-74	2213	13.3	1684	7.68	112	297	462	16.00	2.8	229	14	111	58	25.5	-.0	1270
3- 2-74	2326	20.0	2387	7.27	119	349	515	18.50	3.0	274	17	134	68	.1	-.0	1437
4- 4-74	2332	19.4	1949	7.01	176	224	475	37.00	2.2	222	17	109	58	18.7	-.0	1250
5- 8-74	2339	26.1	2275	7.01	260	307	464	20.30	2.3	248	18	132	65	22.8	-.0	1407
6- 5-74	2352	28.3	1871	7.27	162	243	421	21.00	5.0	233	14	95	51	22.8	-.0	1185
7- 2-74	2357	26.1	1815	7.87	180	202	411	26.00	2.5	209	18	99	50	22.8	-.0	1130
8- 2-74	2365	30.0	2139	7.06	164	302	396	17.40	6.0	233	16	110	55	22.8	-.0	1239
9- 4-74	2372	29.4	1949	6.99	262	277	413	18.90	.6	217	15	114	57	22.8	-.0	1265
10- 3-74	2375	26.7	1921	6.86	156	256	392	16.40	8.0	200	16	113	50	22.8	-.0	1152
11- 6-74	2383	23.3	1972	6.64	217	261	365	17.50	12.0	216	15	102	54	22.8	-.0	1173
12- 4-74	2387	18.9	1583	7.41	307	174	335	25.00	7.0	223	16	93	48	22.8	-.0	1094
2- 6-75	2397	17.8	2168	7.39	214	302	442	18.36	4.0	241	15	106	59	22.8	-.0	1315
3- 7-75	2403	21.1	2215	6.76	207	281	470	22.00	2.0	228	17	119	60	22.8	-.0	1324
4- 3-75	2413	21.1	2458	6.80	235	345	570	17.50	8.0	257	19	144	74	22.8	-.0	1573
6- 3-75	2425	26.7	2442	5.80	150	322	536	21.20	10.3	264	23	115	71	22.8	-.0	1460
7- 1-75	2431	27.8	2086	6.30	142	302	392	20.10	10.0	223	16	106	51	22.8	-.0	1212
8- 5-75	2437	-99.0	2026	6.15	149	290	393	-99.00	10.5	221	14	108	53	22.8	-.0	1186
9- 4-75	2438	27.8	1742	6.72	176	206	382	-99.00	60.0	182	13	99	50	22.8	-.0	1102
10- 7-75	2447	23.9	1935	6.43	143	264	366	-99.00	13.0	227	15	99	48	22.8	-.0	1125
11- 6-75	2448	20.5	2109	6.90	107	302	427	21.50	6.2	233	15	108	53	22.8	-.0	1242
12- 3-75	2455	21.1	2100	6.40	100	301	416	21.10	4.5	238	14	104	52	22.8	-.0	1223
12-30-75	2461	20.0	2109	6.60	155	309	393	19.00	3.0	230	15	108	54	22.8	-.0	1230
2- 3-76	2464	21.0	1931	7.34	95	275	388	20.60	2.5	239	13	89	52	22.8	-.0	1149
3- 4-76	2467	17.0	1992	7.60	137	254	464	18.50	2.8	192	15	106	65	22.8	-.0	1208
4- 1-76	2472	25.0	2144	6.89	111	293	452	17.98	4.5	245	14	110	51	22.8	-.0	1266

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LW 3 LAS VEGAS WASH 3			21S 63E 30 341 1													
2-28-70	5	-99.9	3190	7.56	117	773	882	27.50	40.8	563	30	229	101	.0	1.1	2705
3-31-70	22	15.5	4764	7.61	237	800	1102	16.79	31.2	595	28	290	121	.0	1.4	3102
5- 5-70	51	15.8	4622	7.48	270	823	1152	19.10	12.9	590	29	300	140	.0	1.4	3200
6- 5-70	87	21.4	4282	7.75	289	910	1175	19.90	11.1	688	34	340	135	.0	1.5	3457
7- 7-70	114	22.2	3375	7.75	332	665	923	26.00	17.3	466	28	232	112	.0	1.3	2634
8- 6-70	151	24.4	3198	8.00	258	632	868	12.75	29.2	442	37	240	100	.0	1.2	2490
9-10-70	174	20.6	3645	7.63	277	748	958	16.75	22.1	556	30	280	105	.0	1.3	2854
9-10-70	175	20.6	4454	7.87	250	866	1007	18.30	19.5	601	33	280	115	.0	1.4	3064
12-15-70	306	-99.9	3533	7.58	224	555	1085	18.90	37.2	464	28	230	120	.0	1.3	2649
1-19-71	335	9.4	3212	7.48	236	448	900	21.80	37.2	366	28	232	103	.0	1.1	2253
2-17-71	367	12.2	3379	7.57	228	563	879	21.80	33.4	434	32	253	100	2.5	1.5	2433
3-11-71	375	9.5	3969	7.58	254	643	1131	20.00	36.6	483	32	300	119	2.5	1.5	2893
3-30-71	407	13.3	3878	7.80	250	585	985	20.20	23.5	464	29	255	107	.1	1.4	2593
3-30-71	413	14.4	3920	7.79	259	600	1017	14.00	23.5	470	29	257	112	.1	1.4	2651
4-22-71	444	-99.9	3436	7.70	248	520	894	20.10	26.7	441	25	227	102	.1	1.4	2379
6-11-71	519	18.0	4031	7.85	303	577	943	21.70	9.2	430	25	250	103	8.0	1.4	2517
7- 7-71	623	-99.9	5516	8.00	296	894	1511	13.90	2.7	645	34	381	142	.4	1.6	3771
7- 7-71	626	-99.9	5350	8.05	287	871	1427	14.70	4.2	620	32	355	137	.4	1.6	3604
7- 7-71	629	-99.9	5126	8.00	285	816	1358	15.00	4.7	588	32	337	133	.5	1.5	3426
7-26-71	640	22.2	3148	7.54	281	411	888	22.60	16.6	360	24	226	96	.8	1.2	2184
8-30-71	708	21.7	4225	7.62	268	556	997	17.20	15.3	449	35	246	107	.4	1.3	2556
10- 1-71	800	13.9	3248	7.60	254	456	836	18.70	25.0	384	28	228	92	1.2	1.3	2195
11-10-71	826	9.4	3572	7.51	215	483	907	18.80	40.0	392	28	236	101	1.6	1.1	2314
12- 1-71	930	11.5	3091	7.08	206	420	794	21.20	33.0	344	26	206	93	3.3	1.0	2048
1- 3-72	1033	8.1	3284	7.26	220	465	876	19.60	40.0	365	28	209	93	4.3	1.1	2210
2- 1-72	1166	39.2	3447	7.55	202	448	979	19.10	45.0	382	30	218	106	4.0	1.1	2331
3- 2-72	1255	9.3	3864	7.73	231	584	1193	18.30	23.0	493	31	257	125	.4	1.3	2840
4- 5-72	1343	18.3	3174	7.42	248	442	951	21.00	16.2	394	24	218	102	.8	1.3	2292
5- 4-72	1375	15.5	3429	7.68	263	468	1014	23.00	10.5	428	22	237	107	.1	1.3	2440
6- 1-72	1445	22.2	3259	7.30	245	433	964	27.00	11.4	399	32	215	108	5.3	1.3	2316
7-10-72	1539	23.0	3564	7.78	261	461	993	19.80	16.7	404	25	222	99	.2	1.3	2370
8- 6-72	1621	23.3	3481	7.67	263	437	895	21.00	16.3	388	26	216	100	1.3	1.2	2232
9- 6-72	1658	22.2	3309	7.36	230	485	899	20.00	13.8	406	44	205	92	5.0	1.3	2284
10- 1-72	1692	20.0	2862	7.60	257	352	857	22.00	24.0	320	26	207	90	.1	1.2	2026
11- 6-72	1787	12.8	3095	7.49	216	402	823	22.00	32.0	350	26	202	89	1.9	1.0	2055
12- 4-72	1830	10.0	2601	7.23	189	302	737	23.00	34.0	278	23	175	82	3.2	1.1	1751
1- 4-73	1849	-99.0	2535	7.10	175	284	675	23.00	42.0	258	23	167	73	3.2	1.2	1635
1-31-73	1896	7.8	3108	7.09	182	439	933	21.00	39.0	391	24	198	95	3.0	-99.0	2232
3- 4-73	1985	11.7	3035	7.50	227	315	816	19.70	24.0	320	22	198	89	1.3	-99.0	1916
4- 1-73	1962	10.0	3486	7.28	238	474	949	19.00	39.0	415	25	217	102	.2	-99.0	2357
5- 2-73	1970	16.1	2548	7.03	183	296	744	21.00	12.0	256	22	180	79	3.3	-99.0	1703
5-31-73	2104	21.1	2820	7.21	233	395	698	25.60	15.5	322	20	179	77	10.0	1.2	1858
7- 2-73	2126	24.4	3187	7.30	266	427	824	20.80	4.9	375	43	201	89	18.0	-99.0	2134
8- 1-73	2165	23.3	2753	8.20	260	407	785	21.00	6.7	360	25	191	93	12.0	-99.0	2029
9- 5-73	2244	21.1	2282	8.20	258	330	681	22.00	16.0	285	23	188	74	2.6	-99.0	1748
10- 2-73	2270	18.9	2801	8.28	133	338	743	12.00	28.0	297	21	172	80	2.6	-.0	1759
11- 1-73	2284	-99.0	2287	8.38	206	342	659	12.80	24.0	298	20	167	68	2.6	-.0	1695
12- 4-73	2296	-99.0	2703	8.17	202	335	701	16.30	29.0	304	22	183	80	2.6	-.0	1773
1- 2-74	2315	5.6	2703	7.97	181	342	656	25.00	20.0	277	41	152	80	2.6	-.0	1685
3- 2-74	2328	14.4	2795	7.77	214	356	738	25.00	16.8	308	21	183	81	12.4	-.0	1846
4- 4-74	2334	-99.0	2897	7.64	232	379	770	22.20	15.7	323	20	176	88	9.5	-.0	1918
5- 8-74	2340	17.8	2530	7.04	244	296	659	24.60	11.7	270	19	163	79	7.4	-.0	1648

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
6- 5-74	2353	20.0	2578	7.66	252	312	697	21.00	8.7	298	19	161	74	7.4	-.0	1722
7- 2-74	2359	20.0	3013	8.13	252	384	814	16.80	9.4	345	23	204	86	7.4	-.0	2014
8- 2-74	2363	25.0	2954	6.98	257	390	748	20.20	3.0	342	26	183	84	7.4	-.0	1930
9- 4-74	2370	23.3	2513	7.65	266	325	658	21.50	5.3	272	18	162	73	7.4	-.0	1673
10- 3-74	2376	20.0	2922	7.55	252	420	688	29.80	8.0	339	40	174	81	7.4	-.0	1911
11- 6-74	2382	13.3	2679	7.35	230	355	656	18.30	17.0	316	23	153	75	7.4	-.0	1734
12- 4-74	2388	11.1	2384	7.38	281	329	580	22.00	26.0	268	29	187	76	7.4	-.0	1662
2- 6-75	2398	10.0	2938	7.13	178	382	764	21.35	24.3	328	27	174	80	7.4	-.0	1895
3- 7-75	2404	12.8	2839	6.90	215	378	762	22.00	22.0	320	24	167	84	7.4	-.0	1892
4- 3-75	2411	13.3	2788	7.03	177	285	964	13.50	21.0	282	29	201	95	7.4	-.0	1985
6- 3-75	2426	19.7	2543	6.60	229	314	596	26.10	2.9	267	19	153	69	7.4	-.0	1568
7- 1-75	2432	20.6	2645	6.50	229	331	626	26.10	2.5	281	19	161	72	7.4	-.0	1639
8- 5-75	2435	-99.0	2532	6.87	263	312	627	-99.00	53.0	270	19	167	72	7.4	-.0	1657
9- 4-75	2440	22.2	2684	6.81	231	350	677	-99.00	52.8	297	19	178	77	7.4	-.0	1772
10- 7-75	2445	-99.0	2927	7.00	221	375	734	-99.00	6.0	331	22	185	75	7.4	-.0	1844
11- 6-75	2449	15.5	2876	7.70	189	385	739	20.00	8.3	322	21	183	79	7.4	-.0	1858
12- 3-75	2453	15.0	2588	7.30	168	344	668	25.60	10.5	280	19	168	73	7.4	-.0	1678
12-30-75	2459	14.4	2396	6.70	159	329	624	24.00	4.5	275	19	162	69	7.4	-.0	1592
2- 3-76	2463	14.0	2541	7.48	160	362	668	20.50	3.5	319	21	161	75	7.4	-.0	1716
3- 4-76	2468	15.0	2866	7.58	172	385	808	14.38	14.4	300	21	183	84	7.4	-.0	1902
4- 1-76	2473	22.0	2866	7.05	183	389	798	17.45	13.1	334	20	181	80	7.4	-.0	1930

LW 4 LAS VEGAS WASH 4 21S 63E 29 324 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
6- 6-70	88	21.0	4925	7.80	275	1250	1482	15.60	28.8	854	44	450	172	.0	1.5	4433
7- 8-70	121	23.3	4577	7.75	302	1025	1135	19.00	21.0	690	44	310	156	.0	1.4	3550
8- 7-70	152	26.4	3575	8.10	272	762	1049	8.50	16.6	500	42	226	121	.0	1.2	2860
9-10-70	166	21.7	4612	7.70	266	1090	1085	12.62	28.4	750	43	380	140	.0	1.3	3661
9-10-70	167	21.7	5698	7.83	262	1015	1326	13.30	26.1	700	44	350	142	.0	1.5	3747
12-15-70	307	-99.9	4046	7.65	217	663	1226	16.80	47.6	508	37	292	129	.0	1.2	3027
1-19-71	336	9.4	4344	7.56	228	700	1149	19.10	44.4	514	36	324	124	.4	1.2	3024
2-18-71	381	13.3	3500	7.50	229	572	946	21.50	34.2	468	33	256	106	2.3	1.4	2553
4-22-71	441	15.0	3471	7.91	257	520	914	19.50	29.6	423	25	237	105	.1	1.3	2401
6-11-71	514	20.0	5160	7.75	280	816	1264	17.40	25.2	497	38	345	146	5.7	1.3	3293
7- 7-71	621	-99.9	6688	7.85	253	1234	1701	10.50	39.0	700	59	495	200	.5	1.3	4565
7- 7-71	624	-99.9	6463	7.90	260	1152	1670	11.20	25.0	720	49	463	177	.6	1.4	4397
7- 7-71	627	-99.9	6297	8.00	254	1123	1673	11.10	28.6	691	49	479	179	.5	1.4	4360
7-23-71	634	23.9	5514	7.30	271	1042	1379	15.40	36.4	598	57	399	184	.5	1.1	3846
8-30-71	706	23.3	6467	7.75	250	1079	1469	11.10	36.4	618	60	438	188	.3	1.1	4024
10- 1-71	797	15.0	4184	7.78	255	684	1076	15.30	32.0	496	38	288	126	1.4	1.2	2883
11-10-71	824	10.0	4676	7.66	214	730	1141	16.00	53.0	501	43	316	139	1.3	1.1	3046
12- 1-71	928	11.0	4054	7.45	203	639	989	17.20	49.0	431	39	284	126	3.0	1.0	2678
1- 3-72	1011	8.1	3745	7.93	225	582	975	18.50	46.0	415	33	256	112	3.2	1.1	2553
2- 1-72	1125	4.0	4003	7.45	206	574	1088	18.60	50.0	428	35	272	123	2.6	1.1	2693
3- 3-72	1252	10.0	4180	7.78	233	655	1270	17.20	29.0	516	37	305	143	.2	1.2	3089
5- 4-72	1374	16.5	4460	7.74	242	757	1262	18.00	20.0	510	38	328	143	.1	1.2	3197
6- 1-72	1442	22.2	4066	7.47	243	621	1124	24.00	17.3	464	45	272	136	3.6	1.1	2827
7-10-72	1528	25.5	4375	7.78	256	670	1185	16.70	19.0	485	36	295	130	.1	1.3	2964
8- 6-72	1620	25.0	4184	7.73	265	640	1112	16.50	22.0	464	36	289	125	.3	1.2	2837
10- 1-72	1691	21.7	3752	7.65	253	571	1058	17.20	34.0	430	36	272	117	.1	1.2	2660

LW 5 LAS VEGAS WASH 5 21S 63E 29 331 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
5-21-70	95	17.8	5196	7.75	241	1237	1635	13.90	70.9	720	34	516	202	.0	1.1	4548
6- 6-70	90	22.2	5373	7.75	235	1300	1584	11.10	62.5	790	33	412	200	.0	1.2	4510

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
POINT IDENTIFIER AND LOCATION																
7- 8-70	122	23.4	4879	7.80	220	1175	1260	11.50	44.3	700	63	376	182	.0	1.3	3921
8- 7-70	154	27.8	3953	8.00	256	884	1078	7.40	73.5	495	60	340	156	.0	1.1	3220
12-15-70	308	-99.9	4609	7.63	215	800	1367	10.70	70.8	576	54	276	155	.0	1.1	3416
1-19-71	337	10.0	4862	7.60	224	822	1315	14.50	64.0	566	47	389	153	.4	1.1	3482
2-18-71	382	16.7	4495	7.56	224	802	1242	14.40	66.5	504	55	389	150	1.5	1.2	3336
4-22-71	437	17.8	4701	7.85	238	822	1292	11.30	61.0	500	59	390	169	1.5	1.0	3424
6-11-71	513	21.0	6370	7.75	245	1150	1430	12.40	54.2	499	50	501	207	4.1	1.1	4029
7-23-71	633	25.6	5964	7.60	235	1004	1460	11.70	54.5	591	55	491	214	.4	1.1	3998
8-30-71	705	24.4	7093	7.92	214	1237	1542	7.00	56.8	617	61	515	219	.1	1.0	4362
10- 1-71	796	17.8	5181	7.87	223	985	1266	11.80	50.0	545	53	416	174	1.6	1.1	3613
11-10-71	821	11.1	5148	7.65	200	911	1281	14.60	53.0	538	49	372	170	1.2	1.0	3489
12- 1-71	926	12.0	4561	7.45	196	764	1078	14.80	53.0	435	45	332	141	2.5	.9	2962
1- 3-72	1009	8.1	4310	7.49	198	728	1105	14.90	50.0	448	48	309	141	2.2	1.1	2945
2- 1-72	1159	5.0	4477	7.55	198	691	1166	15.10	55.0	455	43	320	144	1.7	1.0	2990
3- 3-72	1249	11.1	4780	7.81	218	876	1382	14.00	34.0	537	50	365	168	.2	1.1	3534
4- 5-72	1338	20.0	4197	7.62	230	739	1179	15.80	28.0	449	44	326	148	.2	1.1	3043
5- 4-72	1373	17.0	4898	7.75	237	885	1335	15.40	31.0	545	46	357	162	.1	1.1	3494
6- 1-72	1441	23.3	4526	7.50	234	781	1226	19.70	25.0	517	53	331	156	3.0	1.1	3228
7-10-72	1525	27.5	5088	7.87	241	870	1311	11.80	30.5	539	48	368	150	.1	1.2	3448
8- 6-72	1598	26.1	5227	7.78	242	919	1290	12.50	36.0	555	52	386	157	.2	1.1	3528
10- 1-72	1690	21.7	4702	7.54	238	839	1194	14.10	41.5	528	51	362	147	.1	1.1	3295
LW 6 LAS VEGAS WASH 6 21S 63E 28 112 1																
4- 3-70	30	15.0	5743	7.69	234	1485	1052	13.20	54.5	610	51	475	185	.0	1.3	4043
5- 5-70	53	18.9	6074	7.90	235	1380	1453	9.95	26.8	696	60	510	220	.0	1.2	4473
6- 6-70	92	21.6	5196	7.85	262	1130	1686	11.70	48.7	720	34	516	210	.0	1.2	4487
7- 8-70	124	23.3	5152	7.95	272	1250	1388	11.80	46.5	700	74	426	218	.0	1.2	4249
8- 7-70	156	26.4	4398	8.20	262	1038	1148	8.23	57.6	515	76	405	174	.0	1.1	3552
9-10-70	160	20.3	4567	7.84	264	1101	1273	7.12	57.6	643	59	430	176	.0	1.1	3878
9-10-70	161	20.3	5843	7.98	261	964	1488	11.10	54.5	632	61	433	179	.0	1.3	3952
12-15-70	309	-99.9	4953	7.88	224	885	1512	10.90	72.2	557	56	397	175	.0	1.2	3776
1-19-71	338	9.4	5146	7.81	236	853	1385	13.50	64.0	578	47	438	167	.1	1.1	3663
4-22-71	448	15.6	5473	8.02	249	954	1548	8.90	58.0	564	67	473	200	.0	1.1	3996
6-11-71	511	20.0	6071	7.90	262	1000	1491	10.80	47.8	496	52	494	203	2.3	1.1	3927
7-23-71	631	22.8	6025	7.82	265	1214	1615	10.20	44.0	619	59	503	217	.3	1.1	4413
8-30-71	703	22.2	7301	8.05	247	1210	1693	6.60	51.4	647	72	523	233	.8	1.1	4559
10- 1-71	795	16.7	6297	7.74	244	1186	1794	3.80	63.0	655	81	543	241	1.4	1.1	4689
12- 1-71	927	12.0	4764	7.73	214	802	1239	12.80	63.0	467	52	370	161	2.2	.9	3275
1- 3-72	1006	6.9	4525	7.80	205	708	1213	14.20	54.0	468	51	341	150	1.0	1.0	3102
2- 1-72	1156	5.0	4754	7.82	208	759	1329	14.40	61.0	490	48	369	157	.2	1.1	3331
7-10-72	1522	23.0	5791	7.90	265	994	1614	9.00	27.0	612	58	450	183	.1	1.2	4078
12- 4-72	1836	10.6	4411	7.70	209	783	1234	13.60	52.0	504	43	338	145	.1	1.2	3216
1- 4-73	1846	-99.0	4480	7.46	199	749	1178	16.20	62.0	479	43	323	133	2.0	1.1	3084
LW 7 LAS VEGAS WASH 7 21S 63E 14 411 1																
2-28-70	6	-99.9	3903	7.84	117	995	1363	13.87	41.0	650	48	372	172	.0	1.1	3714
3-31-70	29	16.0	5476	7.90	237	1415	1202	13.20	53.6	616	50	465	175	.0	1.3	4108
5- 5-70	52	17.8	6033	7.95	250	1198	1253	9.70	45.2	526	58	490	196	.0	1.2	3900
6- 6-70	93	22.2	5078	8.00	271	1120	1792	7.50	37.7	696	31	516	205	.0	1.2	4539
7- 8-70	125	23.9	5111	8.00	294	1160	1520	10.50	44.3	700	67	414	214	.0	1.3	4276
8- 7-70	157	25.6	4190	8.19	279	1001	1377	5.10	66.4	575	66	455	190	.0	1.1	3874
9-10-70	158	21.1	4255	7.80	264	1038	1214	9.89	57.6	540	55	440	173	.0	1.2	3659
9-10-70	159	21.1	5699	7.86	265	1103	1510	10.30	46.7	608	61	440	176	.0	1.3	4086

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
12-15-70	310	-99.9	4907	8.02	231	863	1485	11.70	64.6	548	57	384	181	.0	1.2	3709
1-19-71	339	9.4	4953	7.92	233	830	1404	15.50	56.0	570	46	429	166	.1	1.1	3632
2-18-71	358	13.3	4851	7.94	244	876	1485	12.20	56.0	646	56	400	172	.6	1.3	3826
4-22-71	434	15.6	5444	8.11	246	907	1555	8.80	54.5	566	64	458	202	.6	1.1	3948
6-11-71	510	20.0	5670	7.90	271	946	1460	13.20	36.8	490	49	462	193	2.3	1.2	3787
7-23-71	630	22.8	5875	7.93	269	1013	1598	10.90	39.6	608	56	495	207	.3	1.1	4161
8-30-71	702	22.2	6937	8.05	260	1133	1621	8.70	42.8	635	64	500	212	.3	1.1	4345
10- 1-71	794	14.4	5380	7.95	257	987	1473	10.70	43.0	588	60	442	193	.7	1.1	3925
11-10-71	819	16.1	5254	7.98	228	865	1379	12.30	52.0	530	51	390	174	2.6	1.0	3569
12- 1-71	964	11.0	4561	7.76	215	764	1208	14.10	53.0	458	46	356	152	2.2	1.0	3160
1- 3-72	1005	8.1	4484	7.75	208	721	1194	14.70	52.0	456	48	349	148	.8	1.1	3086
1-31-72	1214	2.5	4587	7.79	230	744	1256	14.70	52.0	472	47	342	151	.8	1.0	3194
2- 1-72	1155	4.0	4734	7.89	208	744	1337	13.80	52.0	489	48	366	156	.3	1.2	3309
3- 3-72	1247	10.0	5053	7.81	246	866	1556	12.40	31.0	553	52	432	177	.1	1.1	3802
4- 5-72	1336	18.0	4525	7.83	244	786	1373	14.10	30.0	501	47	367	161	.2	1.2	3401
5- 5-72	1365	16.0	4919	7.99	263	836	1421	15.00	27.0	540	46	403	168	.1	1.2	3587
6- 1-72	1438	22.2	4822	7.71	268	806	1422	16.20	22.0	553	54	370	164	1.1	1.1	3542
7-10-72	1521	24.0	5890	7.90	265	999	1665	7.80	27.7	618	59	466	188	.1	1.2	4162
9- 5-72	1595	24.4	5919	7.89	278	970	1540	10.10	31.0	587	57	467	174	.1	1.2	3974
9- 6-72	1660	21.1	4851	7.90	252	864	1377	11.70	31.0	533	59	392	158	.1	1.1	3551
10- 1-72	1684	20.0	5056	7.88	262	871	1433	12.50	32.0	562	55	428	165	.1	1.2	3689
11- 6-72	1776	12.2	4952	7.78	232	825	1328	14.00	43.0	504	47	380	152	.1	1.1	3408
12- 4-72	1834	10.6	4503	7.71	215	831	1289	12.30	55.0	520	46	363	154	.1	1.3	3377
1- 4-73	1845	-99.0	4677	7.50	191	764	1243	14.20	66.0	504	45	336	139	2.0	1.1	3208
1-31-73	1894	7.2	4651	7.68	196	789	1318	14.20	66.0	525	44	358	148	.2	-.0	3359
3- 4-73	1983	12.2	4558	7.76	229	837	1311	13.00	46.0	523	44	380	148	.2	-.0	3415
4- 1-73	2020	12.2	4648	7.84	238	767	1279	13.90	42.0	496	41	370	147	.2	-.0	3273
5- 2-73	1968	15.6	4151	7.38	183	670	1147	16.90	40.8	450	40	323	131	1.7	-99.0	2910
5-31-73	2107	24.4	4982	7.21	240	902	1289	14.20	55.0	540	42	388	146	.1	1.1	3496
7- 2-73	2124	25.0	6124	7.93	255	1144	1700	5.20	56.8	694	89	489	195	.1	-99.0	4498
8- 1-73	2163	23.3	4695	8.10	272	844	1356	11.80	42.0	543	51	391	178	.1	-99.0	3551
9- 5-73	2242	21.1	4405	8.40	258	855	1316	10.80	40.0	538	49	386	149	.1	-99.0	3471
10- 3-73	2265	20.0	5085	8.22	236	828	1365	8.00	54.0	545	47	374	154	.1	-.0	3491
11- 1-73	2291	-99.0	4595	8.27	226	708	1181	4.40	23.0	481	40	331	129	.1	-.0	3009
12- 4-73	2290	-99.0	4158	8.15	224	723	1222	10.00	49.0	509	42	352	139	.1	-.0	3156
1- 2-74	2320	8.9	3742	8.04	207	748	1113	15.20	58.0	468	57	299	136	.1	-.0	2996
3- 2-74	2330	15.6	4468	7.97	217	720	1241	14.20	56.0	477	40	342	132	.1	-.0	3129
4- 4-74	2336	-99.0	4448	7.85	243	676	1241	14.70	45.0	462	38	319	140	.1	-.0	3056
5- 8-74	2345	16.6	4428	7.85	255	695	1246	15.40	36.0	483	39	330	140	.1	-.0	3110
6- 5-74	2350	21.6	3618	8.16	262	723	1286	8.20	35.0	514	43	344	137	.1	-.0	3220
7- 1-74	2356	20.6	4808	8.11	275	767	1322	10.30	27.0	522	46	370	149	.1	-.0	3349
8- 2-74	2361	24.4	4421	7.79	251	649	1281	12.20	34.0	436	46	358	130	.1	-.0	3070
9- 4-74	2369	23.3	4564	7.92	267	739	1275	10.30	35.0	477	41	362	140	.1	-.0	3211
10- 3-74	2373	18.9	5055	7.66	263	917	1283	14.00	38.0	552	78	339	166	.1	-.0	3517
11- 6-74	2379	12.2	4044	7.72	239	637	1120	13.30	51.0	450	42	300	129	.1	-.0	2860
12- 2-74	2385	8.9	3867	7.56	230	611	1043	15.80	66.0	400	37	289	117	.1	-.0	2692
2- 6-75	2399	7.8	4104	7.73	207	624	1148	14.40	60.8	436	40	310	120	.1	-.0	2855
3- 7-75	2405	12.2	4279	7.53	229	655	1192	13.00	49.0	445	5	327	140	.1	-.0	2938
4- 3-75	2409	11.1	4283	7.11	192	585	1466	9.00	25.0	475	45	302	143	.1	-.0	3145
6- 3-75	2424	18.9	4476	6.90	266	690	1168	14.50	41.0	461	37	328	125	.1	-.0	2996
7- 1-75	2430	18.9	4273	6.70	279	623	1110	15.50	30.0	429	36	315	121	.1	-.0	2817
8- 5-75	2433	-99.0	4710	6.87	263	681	1413	-99.00	32.5	469	42	403	138	.1	-.0	3308
9- 4-75	2442	24.4	4608	7.10	208	671	1385	-99.00	38.8	466	39	400	134	.1	-.0	3236
10- 7-75	2443	22.2	4564	7.26	260	647	1240	-99.00	76.0	456	42	342	126	.1	-.0	3058
11- 5-75	24470	17.8	4026	7.82	212	603	1179	14.20	53.0	414	37	325	122	.1	-.0	2851

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
12- 3-75	2452	17.8	3834	7.62	179	569	1096	14.00	55.0	395	34	300	112	.1	-.0	2663
12-30-75	2457	11.1	3600	7.40	177	569	1058	15.70	55.0	393	33	300	113	.1	-.0	2625
2- 3-76	2462	16.0	3557	7.95	173	548	1012	10.50	53.5	460	30	267	98	.1	-.0	2564
3- 4-76	2471	13.0	4136	7.75	209	616	1307	10.62	43.5	442	37	350	133	.1	-.0	3043
4- 1-75	2476	21.0	4086	7.50	202	616	1229	11.31	31.5	430	34	350	126	.1	-.0	2927
LW 8 FLAMINGO WASH 1			21S 61E 13 122 1													
4-15-70	33	15.6	3765	7.90	362	650	1603	-.10	-.5	245	28	475	297	.0	1.2	3478
5- 4-70	42	15.6	3546	7.87	356	341	2004	-.10	.7	304	27	454	280	.0	.9	3586
6- 4-70	63	19.7	2634	7.90	364	239	1456	-.10	1.2	196	25	262	242	.0	.7	2601
7- 7-70	97	23.6	2446	7.85	334	270	1243	.28	1.1	170	21	237	266	.0	.8	2373
8- 6-70	126	25.6	1862	7.80	89	28	1188	-.10	-.5	37	10	470	33	.0	.3	1810
9-11-70	212	25.6	2684	7.82	303	176	1387	-.10	2.1	135	23	348	171	.0	.7	2392
9-11-70	213	25.6	3028	7.80	290	204	1386	-.10	-.9	148	23	350	175	.0	.6	2429
12-16-70	312	-99.9	3557	7.61	382	224	2099	-.10	.7	296	36	445	250	.0	.8	3539
LW 9 FLAMINGO WASH 2			21S 61E 13 121 1													
4-15-70	31	16.9	3273	7.62	317	445	1703	-.10	1.8	245	17	395	250	.0	.7	3214
5- 4-70	37	20.0	2819	7.45	298	235	1603	-.10	3.3	206	17	368	252	.0	.6	2831
6- 4-70	64	23.3	2741	7.75	274	234	1584	-.10	3.0	201	17	272	238	.0	.5	2683
7- 7-70	98	20.8	2661	7.75	285	247	1368	-.10	4.0	187	15	250	243	.0	.6	2455
8- 6-70	127	22.2	2626	7.88	279	255	1627	.13	2.0	188	17	310	245	.0	.6	2782
9-11-70	214	22.2	2947	7.81	278	247	1497	-.10	7.4	188	17	338	220	.0	.6	2651
9-11-70	215	22.2	3312	7.85	283	238	1544	-.10	7.2	199	18	326	239	.0	.6	2711
12-16-70	313	-99.9	3510	7.36	340	241	1923	-.10	3.4	250	23	376	266	.0	1.7	3251
1-19-71	340	12.8	3813	7.51	338	233	1954	-.10	3.7	301	25	356	264	.0	.7	3304
4-23-71	466	19.4	3579	7.55	317	219	1776	.20	2.8	232	22	373	249	.0	.7	3031
7-26-71	652	20.6	3629	7.55	285	253	1700	.14	2.8	218	17	348	246	.0	.6	2926
8-31-71	734	21.0	3882	7.40	303	265	1757	.20	3.1	213	19	365	252	.0	.6	3024
6- 1-72	1460	18.3	3535	7.39	299	229	1747	.16	3.6	206	20	357	236	.0	.9	2947
7-10-72	1582	21.1	3940	7.59	303	252	1898	-.04	3.6	215	19	372	251	.1	.6	3161
LW 10 STEVENS SPRING			21S 62E 31 411 1													
4-15-70	32	16.0	7065	7.70	576	1190	2605	.31	-.5	615	45	579	540	.0	3.5	5861
5- 4-70	41	15.6	6074	7.55	563	735	2655	.25	-.4	660	79	612	540	.0	3.4	5561
8- 5-70	128	23.3	997	7.68	112	26	449	.28	-.5	25	10	195	20	.0	.3	781
LW 11 UNNAMED SPRING			21S 62E 29 434 3													
3-30-70	17	-99.9	4762	7.50	359	755	2164	.10	-.5	456	55	505	332	.0	2.5	4447
5- 4-70	45	18.6	5807	7.40	341	981	1954	.18	-.4	466	54	518	336	.0	2.4	4400
6- 5-70	66	24.2	4190	7.75	365	734	2471	-.10	-.5	520	75	610	366	.0	2.6	4958
7- 6-70	99	22.3	4216	7.25	378	731	2111	.40	2.9	408	49	562	300	.0	2.5	4353
8- 5-70	129	23.9	1555	7.80	107	45	988	.18	-.5	33	13	38	25	.0	.3	1195
9-11-70	186	20.0	4846	7.80	341	790	1906	.30	3.1	438	53	525	300	.0	1.6	4184
9-11-70	187	20.0	5608	7.84	433	833	2076	.18	-.9	449	56	460	301	.0	1.8	4390
12-16-70	314	-99.9	5300	7.25	352	846	2285	.16	1.1	519	53	498	318	.0	.7	4699
1-19-71	343	-99.9	6023	7.61	391	797	2419	-.10	.2	578	61	596	348	.0	1.8	4993
4-23-71	453	17.2	5746	7.34	445	699	2344	1.20	.2	487	62	568	308	.0	2.3	4690
7-26-71	653	22.8	5634	7.27	421	726	2270	.18	.1	471	52	530	302	.0	1.9	4560
8-31-71	730	24.0	6072	7.37	452	787	2178	.36	1.3	483	55	553	311	.0	1.7	4593
5- 4-72	1413	18.3	4221	7.59	374	466	1732	.16	.8	301	39	435	214	.0	1.8	3374

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
7-10-72	1577	23.3	4356	7.71	384	441	1704	.18	-.1	293	35	420	207	.1	1.8	3291

LW 12 GRAPEVINE SPRING 21S 62E 29 422 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
4-15-70	34	20.3	2331	7.29	219	334	1002	.12	2.2	120	41	304	150	.0	1.0	2062
5- 4-70	40	21.1	2208	7.52	217	166	1202	-.10	2.7	126	21	291	158	.0	1.0	2075
6- 5-70	67	22.2	2116	7.75	222	151	1124	-.10	1.9	136	21	287	147	.0	.9	1978
7- 6-70	100	20.6	2155	7.75	221	158	997	.25	2.2	121	22	223	150	.0	1.0	1783
8- 5-70	130	20.8	2173	8.10	220	159	1178	-.10	1.8	128	24	267	152	.0	1.1	2018
9-11-70	188	20.8	2400	7.84	227	160	1108	-.10	2.4	129	22	275	136	.0	.9	1945
9-11-70	189	20.8	2585	7.93	225	148	1092	.25	2.2	132	24	272	145	.0	1.0	1927
4-23-71	454	20.6	2579	7.31	220	159	1145	.16	2.0	164	22	285	144	.0	1.0	2030
7-26-71	654	22.2	2576	7.41	228	162	1205	-.10	1.7	131	22	277	148	.0	1.0	2060
8-31-71	731	24.5	2524	7.65	222	162	1147	-.10	1.9	121	24	275	147	.0	1.0	1988
12- 2-71	921	15.0	2656	7.46	225	168	1137	.20	2.1	132	24	286	143	.0	1.0	2004
1- 4-72	1074	16.9	2555	7.71	221	163	1144	-.10	2.9	127	23	278	141	.0	1.0	1989
2- 1-72	1180	19.0	2614	7.42	225	163	1139	-.10	2.5	124	21	275	143	.0	1.0	1980
7-10-72	1576	23.3	2653	7.48	225	161	1171	.12	1.1	123	21	271	144	.1	1.0	2004

LW 13 WHIT. MESA SP. 1 22S 62E 05 141 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
3-30-70	14	-99.9	5178	7.81	229	1245	1403	-.10	5.1	470	42	548	250	.0	1.2	4077
5- 4-70	43	24.2	5013	7.03	219	1390	1353	-.10	1.3	514	46	560	246	.0	1.3	4219
6- 3-70	69	34.4	4427	7.30	231	1270	1734	.11	2.8	588	47	580	292	.0	1.3	4629
7- 6-70	101	21.8	4138	7.55	214	1100	1214	.15	-100.0	488	43	426	230	.0	1.2	3608
8- 5-70	131	24.4	4763	7.90	183	1364	1617	.21	-.5	500	62	610	290	.0	1.3	4535
9-11-70	196	25.6	5419	7.39	236	1274	1667	.20	.9	525	53	590	250	.0	1.3	4477
9-11-70	197	25.6	6503	7.75	239	1243	1834	.16	1.5	588	59	590	246	.0	1.5	4681
1-19-71	347	13.9	5889	7.80	216	1121	1829	-.10	6.5	632	54	598	243	.0	1.3	4591
7-26-71	637	23.3	6867	7.75	284	1187	2038	-.10	3.4	678	62	583	291	.0	1.3	4983
8-31-71	729	24.0	7168	8.05	290	1286	2058	-.10	1.4	664	68	626	294	.0	1.5	5141
11-11-71	810	16.1	6409	7.65	267	1112	1822	-.10	4.3	592	57	518	258	.0	1.2	4496
12- 2-71	920	13.0	5828	7.57	240	917	1841	-.10	17.0	606	59	476	227	.0	1.0	4263
1- 3-72	1070	15.0	6054	7.76	249	1068	1775	-.10	6.6	544	56	546	245	.0	1.3	4364
2- 1-72	1181	13.0	6175	7.78	250	993	1757	-.10	6.6	536	53	519	238	.0	1.4	4227
3- 3-72	1274	-99.0	5632	7.81	243	1069	1753	-.10	6.3	536	57	511	239	.0	1.3	4292
5- 4-72	1397	20.0	6148	7.68	279	1126	1880	-.04	3.9	586	60	559	255	.0	1.4	4609
6- 1-72	1468	24.4	6436	7.63	291	1242	1986	-.04	2.4	655	65	569	280	.0	1.4	4944
7-10-72	1562	21.7	7009	7.78	291	1252	2104	-.04	1.9	630	65	591	282	.0	1.4	5070
8- 7-72	1637	22.2	6953	7.63	291	1223	1992	-.08	2.6	631	63	589	283	.0	1.4	4928
9- 7-72	1662	20.0	6566	7.66	307	1249	2100	.08	1.2	647	68	592	283	.0	1.4	5093
10- 1-72	1676	21.1	6674	7.41	307	1258	1955	-.04	.6	670	74	590	283	.0	1.3	4983
11- 7-72	1811	16.1	6458	7.54	294	1146	1888	-.04	1.5	601	61	555	263	.0	1.4	4661
12- 4-72	1843	15.6	6344	7.63	286	1130	1843	.06	3.8	592	59	542	256	.0	1.4	4568
1- 4-73	1858	-99.0	6177	7.62	270	1081	1827	-.04	6.5	580	57	514	243	.0	1.4	4443
2- 1-73	1923	14.4	10023	7.29	259	1055	1822	-.04	7.4	564	57	519	240	.0	-99.0	4391
3- 5-73	2003	14.4	6028	7.84	265	1066	1798	-.04	6.3	557	53	534	238	.0	-99.0	4382
4- 1-73	1964	14.4	6013	7.81	264	1066	1783	.16	5.1	549	51	527	237	.0	-99.0	4349
5- 3-73	2036	17.8	6020	7.60	268	1098	1834	-.04	4.3	574	56	538	253	.1	-99.0	4490
5-31-73	2111	20.0	6676	7.87	298	1244	1986	-.04	3.1	628	58	589	285	.2	1.3	4941
7- 3-73	2132	25.6	6992	7.76	236	1307	2180	-.04	.0	699	98	589	296	.1	-99.0	5285
8- 1-73	2183	23.3	6837	7.78	188	1287	2212	-.04	1.8	696	6	606	294	.1	-99.0	5195

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LW 14 WHIT. MESA SP. 2 22S 62E 04 322 1																
5-19-70	70	17.7	1548	7.40	257	206	409	.13	3.3	120	19	132	72	.0	1.2	1089
6- 5-70	71	25.6	1548	7.25	265	215	396	.11	2.0	132	21	150	75	.0	1.1	1122
7- 6-70	102	23.3	1610	7.55	269	228	418	.38	-.5	126	21	156	70	.0	1.2	1153
8- 5-70	132	25.8	2145	7.39	297	393	439	.33	-.5	166	28	205	101	.0	1.4	1480
9-12-70	198	23.3	1664	8.00	239	230	329	.15	.4	129	23	140	66	.0	1.1	1036
9-12-70	199	23.3	1738	8.02	240	223	402	.10	-.9	137	24	138	75	.0	1.3	1118
1-19-71	341	13.9	4818	7.74	247	895	1246	-.10	2.7	347	66	491	198	.0	1.0	3368
LW 15 WHITNEY MESA SEEP 22S 62E 04 233 1																
3-30-70	15	-99.9	5004	7.60	232	1000	1603	-.10	13.3	553	50	438	227	.0	1.1	4000
5- 4-70	55	20.0	5500	7.71	225	975	1623	-.10	5.9	586	54	407	214	.0	1.0	3978
6- 5-70	72	26.5	4157	7.65	232	930	1712	-.10	13.4	656	66	300	236	.0	1.0	4029
7- 6-70	103	21.7	4237	7.75	232	966	1468	-.10	14.2	602	52	368	234	.0	1.1	3820
8- 5-70	133	22.5	4318	7.82	203	972	1547	-.10	22.1	625	60	410	220	.0	1.0	3957
9-11-70	200	23.1	5234	7.81	236	975	1627	-.10	18.6	550	56	440	205	.0	1.1	3988
9-11-70	201	23.1	5699	7.96	238	1022	1750	.10	13.9	600	64	444	236	.0	1.1	4248
1-19-71	342	18.3	5699	7.50	214	951	1843	-.10	13.9	603	55	492	222	.0	1.0	4286
4-22-71	433	20.0	5746	7.27	240	931	1831	-.10	17.4	595	57	429	221	.0	1.1	4201
6-14-71	541	21.5	5931	7.45	241	946	1796	-.10	14.2	520	57	474	232	.0	1.1	4159
7-26-71	636	23.9	5714	7.75	246	965	1863	-.10	20.0	585	56	448	229	.0	1.1	4288
8-31-71	728	24.0	6172	7.95	244	997	1956	-.10	16.0	632	63	471	250	.0	1.2	4506
11-11-71	809	21.1	5831	7.69	239	916	1841	-.10	17.0	596	62	445	232	.0	1.0	4227
12- 2-71	919	13.0	6132	7.62	261	1089	1754	-.10	5.5	594	63	535	250	.0	1.1	4420
1- 3-72	1069	20.0	5726	7.78	238	915	1828	-.10	20.0	594	59	448	222	.0	1.0	4204
2- 1-72	1182	13.0	5917	7.63	243	905	1818	-.10	19.0	574	55	449	221	.0	1.1	4162
3- 3-72	1273	-99.0	5411	7.80	239	917	1812	-.10	19.0	583	57	449	222	.0	1.0	4178
5- 4-72	1398	21.0	5513	7.66	249	898	1874	-.04	18.0	585	59	459	218	.0	1.0	4235
6- 1-72	1467	21.1	5466	7.74	247	893	1843	.08	17.9	602	61	444	231	.0	1.1	4214
7-10-72	5840	23.3	5840	7.79	254	898	1887	-.04	17.0	587	57	452	225	.0	1.1	4249
8- 7-72	1636	25.6	5899	7.81	253	902	1805	-.04	18.2	569	58	453	225	.0	1.1	4155
9- 7-72	1661	24.4	5412	7.85	249	893	1903	-.04	16.0	565	58	453	216	.0	1.1	4227
10- 1-72	1678	23.9	5511	7.66	252	894	1830	-.04	18.8	587	60	463	225	.0	1.1	4202
11- 7-72	1812	20.0	5829	7.55	255	889	1719	-.04	19.0	583	58	451	220	.0	1.1	4065
12- 4-72	1844	18.9	5634	7.71	253	889	1791	.08	22.0	587	56	443	222	.0	1.1	4136
1- 4-73	1859	-99.0	5712	7.62	251	883	1818	-.04	26.0	580	57	440	213	.1	1.2	4141
2- 1-73	1922	18.3	5537	7.49	251	868	1820	-.04	20.2	565	57	441	213	.1	-99.0	4107
3- 5-73	2002	18.9	5821	7.84	252	883	1797	-.04	22.0	567	55	456	220	.1	-99.0	4125
4- 1-73	1963	15.6	5508	7.71	254	870	1802	-.04	22.0	573	54	464	221	.1	-99.0	4131
5- 3-73	2035	-99.0	5420	7.61	243	874	1799	-.04	21.7	564	56	450	221	.8	-99.0	4106
5-31-73	2110	21.1	5570	7.88	252	902	1791	-.04	21.0	570	53	454	227	.1	1.1	4143
7- 2-73	2133	25.6	5544	7.84	236	886	1846	-.04	22.0	575	81	429	225	.1	-99.0	4181
8- 1-73	2181	-99.0	5406	7.87	188	1157	1864	-.04	21.0	611	53	445	236	.1	-99.0	4479
LW 16 CLARK STP OUTFALL 21S 62E 27 342 1																
3-30-70	16	-99.9	4887	6.80	107	1200	1303	1.53	36.3	675	46	338	142	.0	1.3	3795
5- 4-70	57	15.5	4805	5.75	25	952	1353	1.14	53.2	634	50	344	130	.0	1.2	3531
6- 6-70	73	21.1	4241	6.50	73	980	1431	3.38	34.1	798	63	270	126	.0	1.2	3742
7- 6-70	104	24.4	3418	6.85	114	825	1115	3.30	13.7	520	44	290	86	.0	.8	2954
8- 5-70	134	25.8	1624	7.99	120	40	968	.38	1.5	52	16	390	27	.0	.2	1554
9-11-70	190	22.2	4507	7.00	82	831	1337	.70	43.9	575	50	380	95	.0	.9	3354

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
9-11-70	191	22.2	4953	7.18	88	882	1420	.92	40.9	542	57	378	103	.0	1.0	3468
12-15-70	315	-99.9	5955	7.29	17	1181	1723	.69	85.0	765	67	374	178	.0	1.2	4383
1-19-71	344	34.4	5579	7.22	8	1149	1770	1.44	27.5	786	54	430	159	10.7	1.3	4393
3-30-71	416	-99.9	5183	6.98	107	916	1379	2.24	3.0	600	57	323	147	10.7	1.5	3492
3-30-71	410	24.4	4687	7.06	106	888	1335	3.66	23.0	587	57	310	139	10.7	1.5	3407
4-22-71	452	30.0	4056	7.27	47	775	978	1.76	16.8	476	47	260	97	10.7	1.1	2686
6-11-71	527	38.0	4336	6.85	71	721	1066	1.90	13.2	456	42	271	81	11.3	.9	2699
7- 7-71	620	-99.9	6102	6.40	30	1096	1535	1.90	47.8	721	58	409	124	11.3	1.1	4020
7-26-71	646	39.4	4962	5.74	23	746	1611	4.50	29.3	671	44	334	102	13.6	1.0	3568
8-30-71	719	42.2	6467	6.79	43	917	1534	2.12	123.0	743	58	374	116	4.4	1.1	3894
9-28-71	790	33.3	4912	6.28	26	805	1350	2.40	88.0	673	51	308	101	4.4	1.0	3397
11-10-71	835	34.4	5705	6.98	94	939	1550	4.10	22.0	743	55	321	142	21.0	1.2	3845
12- 2-71	910	29.0	4713	6.99	54	783	1195	3.20	116.0	582	44	248	113	21.0	.9	3132
1- 3-72	1059	30.0	5438	6.83	51	1022	1367	3.40	69.0	683	49	368	135	21.0	1.0	3743
2- 1-72	1184	32.0	5046	7.20	66	876	1273	3.80	114.0	628	48	292	128	21.0	1.1	3417
3- 2-72	1263	-99.0	5390	6.70	54	1300	955	4.00	95.0	875	34	246	99	21.0	.8	3656
4- 6-72	1358	31.7	5395	7.51	116	1050	1461	2.70	39.0	738	56	358	130	8.1	1.2	3902
5- 3-72	1405	32.2	3126	8.65	32	524	807	3.40	6.4	375	26	205	59	8.4	.5	2030
6- 1-72	1461	40.0	4802	7.57	163	868	1264	2.20	37.0	673	47	326	87	3.2	.9	3389
7-10-72	1574	37.8	5444	6.89	183	922	1384	.86	20.5	705	51	318	123	3.0	1.1	3619
8- 6-72	1629	38.9	6090	6.63	64	1096	1453	4.30	102.0	786	53	392	115	4.0	1.0	4038
9- 6-72	1659	28.9	6525	7.46	115	1669	913	1.80	13.0	1060	42	275	102	6.6	.6	4139
10- 1-72	1689	37.8	6370	8.04	236	1133	1816	4.20	25.0	931	71	418	157	3.1	1.1	4676
11- 8-72	1813	30.0	7067	8.42	220	1225	1871	3.60	65.0	975	72	474	168	4.8	1.2	4968
12- 4-72	1839	31.7	6662	8.06	296	1160	1836	4.20	17.2	910	70	442	166	3.5	1.3	4755
1- 4-73	1856	-99.0	3415	9.32	24	565	798	1.10	4.9	412	28	196	74	13.0	.6	2105
1-31-73	1892	31.1	5027	8.60	112	907	1320	2.40	9.1	695	47	340	97	1.8	-99.0	3474
3- 4-73	1991	32.8	4920	6.51	126	732	1417	7.30	3.9	610	43	292	131	13.0	-99.0	3312
4- 1-73	2009	31.1	5649	7.12	240	1122	1181	3.30	4.8	797	41	331	114	.4	-99.0	3712
5- 2-73	1973	34.4	4721	7.29	214	799	1300	5.50	18.1	624	44	297	126	3.5	-99.0	3322
6- 1-73	2112	33.3	6168	8.86	260	1007	1991	5.20	14.2	785	52	445	189	14.0	1.5	4631
7- 2-73	2131	40.6	5065	6.67	63	817	1608	2.40	37.0	641	61	388	124	3.4	-99.0	3713
8- 1-73	2171	-99.0	5025	4.86	4	944	1668	2.50	13.3	744	51	413	109	14.0	-99.0	3961
10- 2-73	2276	31.1	5003	7.41	74	802	1445	.63	4.5	594	40	386	98	14.0	-.0	3421
11- 1-73	2287	-99.0	6237	7.14	24	970	1633	3.60	30.0	745	49	409	119	14.0	-.0	3984
12- 4-73	2302	-99.0	5198	7.11	86	1160	1732	3.60	97.0	866	59	449	158	14.0	-.0	4581
1- 2-74	2309	29.4	4179	7.12	86	1027	1369	4.10	41.0	682	44	338	114	14.0	-.0	3676
LW 17 STAUFFER DITCH A 22S 62E 11 413 1																
8- 5-70	135	27.5	3680	11.55	53	722	319	.11	7.8	725	6	18	11	.0	.3	1835
9-10-70	185	29.4	24651	13.57	-77	681	351	-.10	24.6	3150	7	2	0	.0	.4	4216
9-30-70	184	29.4	27499	13.12	-77	805	354	-.10	26.4	3224	6	24	10	.0	.3	4450
12-15-70	317	-99.9	2775	11.45	-77	499	406	.13	3.2	585	4	3	1	.0	.3	1501
LW 18 STAUFFER DITCH B 22S 62E 02 143 1																
2-28-70	11	-99.9	10429	12.10	-77	846	401	22.70	12.9	1190	6	66	17	.0	.1	2563
3-31-70	20	24.0	8316	11.00	-77	1037	501	2.30	20.8	1175	7	33	15	.0	.4	2792
5- 4-70	44	27.0	20651	12.50	-77	1506	409	.30	10.6	2470	6	20	6	.0	.4	4429
6- 5-70	75	33.7	12372	12.10	-77	1670	460	.54	1.3	90	11	1	0	.0	.3	2234
7- 6-70	105	26.2	4530	11.10	50	852	385	-.10	15.7	770	56	50	22	.0	.2	2176
8- 5-70	136	31.1	9246	12.53	-77	1055	359	.35	19.0	1325	6	105	30	.0	.4	2900
9-10-70	183	31.7	4344	12.63	-77	523	392	-.10	9.9	830	6	1	0	.0	.3	1762
9-30-70	182	31.7	3898	12.10	-77	565	396	-.10	15.1	725	1	55	-0	.0	.3	1757

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
12-15-70	316	-99.9	11065	7.36	119	1054	5029	.32	11.6	2382	14	345	172	.0	.2	9066
LW 19 LV BLDG MAT POND 21S 62E 35 414 1																
3-31-70	21	16.5	10140	7.56	207	2600	1002	-.10	-.5	1425	36	475	226	.0	1.6	5868
5- 4-70	56	19.8	9525	7.67	216	2870	1102	.12	-.4	1510	38	476	220	.0	1.7	6324
6- 5-70	78	24.6	8631	7.70	208	3040	1373	.11	-.5	1650	40	518	240	.0	1.9	6966
7- 6-70	106	26.7	6023	7.75	187	1890	1113	-.10	-.5	940	39	489	214	.0	1.3	4778
8- 5-70	137	26.9	5851	7.94	170	2112	1102	-.10	-.5	900	49	475	226	.0	1.3	4949
9-10-70	180	28.3	9356	7.63	188	2960	1457	-.10	.4	1700	51	525	210	.0	1.6	6998
9-10-70	181	28.3	10970	7.77	189	3200	1592	.13	-.9	1612	55	520	237	.0	1.9	7311
12-15-70	318	-99.9	9550	7.78	215	2390	1335	.06	1.0	1451	36	432	187	.0	1.7	5940
4-23-71	461	21.7	8275	7.48	199	1928	1457	.20	.2	1200	47	460	206	.0	1.4	5398
5-17-71	469	21.7	9622	7.85	145	2225	1928	-.10	.3	1281	64	575	217	.0	1.3	6363
7-26-71	645	26.1	8120	7.46	147	1891	1725	.58	.1	1136	49	487	216	.0	1.2	5578
8-30-71	718	30.0	6770	8.55	141	1283	1296	2.16	.3	799	39	366	157	.0	.6	4013
11-10-71	833	13.3	4938	7.92	281	901	978	13.70	9.6	630	27	262	109	1.7	.6	3071
LW 20 HEND STP GW DRAIN 21S 62E 36 344 1																
7- 8-70	116	24.2	8556	7.50	709	3210	1509	1.03	-.5	1420	44	700	437	.0	1.7	7671
8- 7-70	138	26.1	16371	7.76	578	3233	1876	.90	-.5	1675	48	700	475	.0	1.5	8294
9-10-70	176	25.0	12189	7.62	707	3259	1926	.83	-.5	1738	47	750	450	.0	1.5	8520
9-10-70	177	25.0	12740	7.73	709	3382	2127	.80	-.9	1760	50	720	475	.0	1.6	8865
12-15-70	319	-99.9	13086	6.70	716	3210	2276	.25	.8	1685	49	756	444	.0	1.6	8725
1-19-71	348	23.9	13250	6.80	668	3327	2176	.97	.6	1720	50	756	467	.0	1.6	8828
4-23-71	467	23.0	12692	6.85	723	3251	2097	.94	.1	1527	49	810	468	.0	1.8	8560
6-11-71	530	22.0	13316	6.90	730	3189	2185	1.70	.1	1410	49	803	474	.0	1.8	8473
7-26-71	643	24.4	12632	6.90	752	3015	2340	1.16	.5	1664	47	796	472	.0	1.7	8707
8-30-71	716	25.0	13863	7.29	718	3133	2214	.60	.0	1586	49	776	482	.0	1.8	8596
9-23-71	782	24.0	12630	7.60	703	3171	2183	1.70	.2	1632	51	821	471	.5	1.8	8679
11-10-71	831	24.4	12924	6.86	765	3195	2257	1.20	.2	1630	63	771	482	2.1	1.5	8779
12- 2-71	912	24.0	12467	6.87	714	3220	2251	1.10	.4	1573	48	800	472	1.3	1.7	8720
1- 3-72	1060	24.0	12303	7.33	710	3151	2297	.24	1.5	1572	41	820	461	.4	1.7	8695
2- 2-72	1187	24.0	12510	7.15	713	3153	2285	1.10	1.3	1629	56	795	476	.1	1.9	8749
3- 2-72	11665	-99.0	11665	7.23	686	3115	2311	2.10	1.0	1600	48	761	477	.2	1.8	8655
5- 4-72	1387	23.0	12088	6.87	711	3164	2257	1.80	2.6	1606	53	835	462	.2	1.8	8733
7-10-72	1568	23.9	13067	7.32	691	3163	2314	1.02	.8	1607	51	871	471	.1	1.9	8821
11- 8-72	1780	23.3	12793	6.75	656	3274	2320	1.50	.3	1650	55	905	490	.1	1.9	9021
12- 4-72	1833	22.2	12852	7.05	656	3256	2401	.82	.1	1667	54	905	473	.1	2.1	9082
1- 4-73	1854	-99.0	13141	6.91	658	3309	2330	.70	.5	1575	51	846	487	1.0	2.1	8926
3- 4-73	1988	23.3	13466	7.09	642	3406	2314	1.10	.8	1672	53	942	489	.1	-99.0	9193
4- 1-73	2007	22.2	12885	6.92	639	3586	2258	.80	.7	1660	52	940	484	.1	-99.0	9296
5- 2-73	1972	25.6	13003	6.86	600	3483	2220	1.40	.2	1622	49	925	487	.3	-99.0	9083
5-31-73	2102	33.3	13152	7.34	619	3668	2212	4.00	.9	1630	51	895	502	.2	1.9	9269
7- 2-73	2129	26.1	13286	7.51	626	3499	2283	.48	.8	1664	83	846	483	.4	-99.0	9167
8- 1-73	2169	26.7	12550	7.95	604	3472	2421	2.90	.3	1692	78	910	524	.4	-99.0	9398
9- 5-73	1140	25.6	12210	8.00	525	3529	2385	1.40	.3	1704	68	891	590	.9	-99.0	9428
LW 21 HEND STP OUTFALL 21S 62E 36 341 1																
7- 8-70	117	25.0	3455	7.20	327	620	803	-99.99	-.5	460	22	226	106	.0	.6	2398
8- 7-70	139	31.1	3387	7.29	177	659	709	33.10	-.5	446	21	234	98	.0	.6	2287
9-10-70	178	33.3	3310	7.10	188	644	702	12.80	.9	450	20	212	86	.0	.6	2221
9-10-70	179	33.3	3581	7.13	185	667	785	13.40	52.1	412	21	217	94	.0	.7	2353

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
12-15-70	320	-99.9	3786	7.44	160	632	804	30.50	18.3	436	19	224	90	.0	.7	2333
1-19-71	349	21.1	3681	6.96	917	637	201	9.98	.1	410	21	195	85	13.3	.6	2024
4-23-71	468	14.0	4137	7.46	411	765	786	29.40	3.1	496	24	248	111	17.3	.8	2683
6-11-71	531	27.0	4000	7.40	399	656	725	25.60	.3	414	22	220	95	15.2	.8	2370
7-26-71	644	26.1	3489	7.37	436	587	676	22.40	.8	430	19	211	86	11.3	.6	2259
8-30-71	717	25.0	3661	7.62	403	553	619	9.50	.7	409	18	201	81	16.1	.6	2106
11-10-71	832	13.3	3425	7.47	350	535	611	22.00	.2	394	21	190	75	26.0	.5	2047
12- 2-71	913	9.0	3375	7.70	345	556	638	23.80	.7	412	20	201	81	23.0	.6	2126
1- 3-72	1061	10.0	3078	7.64	344	500	597	24.50	.1	354	16	172	70	31.0	.4	1934
2- 2-72	1188	9.0	3148	7.62	387	496	570	28.00	.4	359	16	180	73	22.0	.6	1935
3- 2-72	1265	-99.0	2927	7.38	360	505	580	28.00	.2	358	17	179	73	29.0	.6	1946
4- 6-72	1357	18.9	3102	7.40	416	544	585	30.00	1.1	382	18	184	76	26.0	.7	2051
5- 4-72	1388	22.5	3345	7.54	380	578	645	29.00	.2	411	19	202	83	21.0	.6	2175
6- 1-72	1462	28.3	3341	7.55	392	563	651	28.00	.2	418	19	207	85	16.0	.6	2181
7-10-72	1569	25.0	3425	7.15	348	534	667	24.00	.2	383	16	198	78	13.0	.6	2086
8- 6-72	1630	31.1	3140	7.17	364	475	605	25.00	.2	350	15	179	72	19.0	.6	1920
10- 1-72	1677	20.0	2993	7.46	339	492	585	27.00	.2	356	15	178	72	9.6	.5	1903
11- 8-72	1851	14.4	3033	7.47	382	480	584	30.00	1.1	356	16	179	67	9.6	.5	1910
12- 4-72	1832	13.3	3413	7.37	349	575	625	27.00	.2	395	16	190	78	28.0	.6	2106
1- 4-73	1853	-99.0	3187	7.30	354	491	587	34.00	.5	357	15	182	71	29.0	.6	1941
3- 4-73	1989	14.4	3728	7.14	372	597	661	29.00	.5	410	15	221	81	5.7	-99.0	2203
4- 1-73	2008	13.9	3527	7.04	399	604	671	31.00	.3	412	16	223	81	28.0	-99.0	2263
5- 2-73	1971	22.2	3285	7.18	361	556	611	33.00	.2	371	11	204	80	27.0	-99.0	2071
5-31-73	2103	26.1	3338	7.16	352	535	605	29.30	.4	366	15	185	74	22.0	.5	2006
7- 2-73	2130	29.5	3197	7.31	394	508	573	31.00	.4	372	30	199	72	30.0	-99.0	2010
8- 1-73	2171	28.9	2643	7.63	194	463	583	32.00	.1	358	16	188	63	23.0	-99.0	1822
9- 5-73	2249	25.6	2551	8.20	303	451	597	29.00	.2	343	14	189	58	15.0	-99.0	1845
10- 2-73	2267	24.4	2761	7.91	115	406	568	13.00	-.5	320	14	175	62	15.0	-.0	1630
11- 1-73	2290	-99.0	2599	8.22	166	395	515	13.00	100.0	313	14	167	60	15.0	-.0	1674
12- 4-73	2292	-99.0	2703	7.72	157	398	510	32.00	101.0	316	15	178	56	15.0	-.0	1690
1- 2-74	2318	8.3	2599	7.63	134	450	538	31.00	.3	303	13	168	56	15.0	-.0	1640

LW 22 TITANIUM DITCH 22S 63E 07 231 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
7- 8-70	118	26.4	6422	2.15	-77	940	494	-.10	155.0	127	7	108	239	.0	.2	2071
8- 5-70	140	27.8	7005	2.11	-77	1171	372	1.46	119.6	170	8	110	212	.0	.3	2164
9-10-70	168	28.9	5588	2.40	-77	297	774	.10	6.6	132	10	105	48	.0	.4	1373
9-10-70	169	28.9	4309	2.24	-77	308	827	.17	3.9	125	10	108	47	.0	.5	1430
12-15-70	321	-99.9	8548	12.23	-77	1152	490	-.10	256.0	1425	9	19	3	.0	.5	3355
1-19-71	350	20.6	4862	2.87	-77	1068	524	-.10	119.2	408	16	110	234	.0	.6	2480
2-18-71	368	24.4	8033	1.98	-77	830	1394	2.92	105.0	276	12	119	168	8.3	.3	2915
4-23-71	458	25.6	7836	2.12	-77	1173	1677	.32	83.0	647	8	160	222	8.3	.6	3979
6-11-71	536	29.0	7878	10.45	-77	1896	578	-.10	156.0	1445	8	41	27	8.3	.2	4159
7-26-71	639	26.1	5293	2.30	-77	645	1005	.14	12.2	517	9	127	43	8.3	.3	2367
8-30-71	709	26.7	2722	8.62	97	450	386	-.10	7.1	411	6	38	34	8.3	.3	1398
9-23-71	780	27.0	61571	13.50	-77	6741	647	2.50	39.0	10200	17	24	7	8.3	5.3	17691
11-10-71	829	22.2	7617	11.85	-77	1211	822	-.10	42.0	1510	17	4	-0	1.6	.3	3608
12- 1-71	905	25.0	7747	11.35	-77	1713	754	-.10	19.0	1570	8	89	0	1.8	.3	4155
1- 3-72	1065	18.1	27705	11.44	-77	8770	1203	-.10	21.0	6560	8	26	1	.7	.3	16590
1-19-72	-0	-99.0	7979	11.50	-77	2083	669	-.10	11.2	1750	7	51	1	.7	.2	4572
1-25-72	-0	-99.0	14897	12.37	-77	3370	851	.40	8.6	3128	7	14	-0	.7	.3	7380
1-27-72	-0	-99.0	9845	11.72	-77	2638	737	2.40	9.6	2218	7	30	1	.7	.3	5644
1-30-72	-0	-99.0	12577	12.06	-77	3110	794	.30	19.6	2630	23	33	2	.7	.3	6612
2- 2-72	1194	20.0	4618	10.38	-77	1139	424	-.10	98.0	918	14	40	11	.1	.2	2645
2- 4-72	-0	-99.0	7649	5.45	5	2096	791	1.00	131.0	1116	41	141	249	.1	.3	4569

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
3- 2-72	1268	-99.0	2232	8.84	60	413	439	-.10	11.8	324	12	86	39	.2	.3	1354
3- 9-72	-0	-99.0	13848	11.30	-77	3925	783	-.10	118.0	3153	26	19	1	.2	.1	8025
3-11-72	-0	-99.9	8904	7.76	71	2393	998	-.10	56.0	1605	27	164	112	.2	.4	5390
3-15-72	-0	-99.9	9268	9.15	39	2523	834	-.10	169.0	1667	27	89	208	.2	.4	5537
3-19-72	-0	-99.9	6869	2.44	-77	1563	872	-.10	148.0	931	10	120	157	.2	.2	3802
3-23-72	-0	-99.9	8927	2.38	-77	2343	847	.84	155.0	1022	13	196	310	.2	.3	4888
4- 6-72	1353	21.7	20884	1.32	-77	2945	2349	10.00	113.0	1476	29	193	200	.2	.3	7316
5- 2-72	1436	26.7	10317	2.27	-77	2873	1048	-.04	279.0	1180	7	145	492	.2	.3	6024
6- 1-72	1463	26.7	5711	2.48	-77	1434	405	.14	127.0	332	8	143	291	9.4	.4	2749
7-10-72	1564	25.6	6632	2.30	-77	979	946	.42	162.0	286	5	107	266	9.4	.3	2762
8- 6-72	1633	27.8	5488	2.40	-77	1080	482	1.40	133.0	191	5	102	278	9.4	.4	2283
9- 7-72	1664	26.7	9344	11.21	-77	2047	1678	-.04	6.0	2151	9	25	-0	9.4	2.3	5928
10- 2-77	1680	27.8	5238	9.75	172	1278	414	30.00	.9	634	20	70	262	9.4	.5	2803
11- 8-72	1819	23.9	9471	2.30	-77	2146	895	-.04	191.0	1117	12	93	279	9.4	.6	4743
12- 4-72	1835	20.0	12440	2.58	-77	3036	549	.52	157.0	1545	7	110	280	9.4	.6	5694
1- 4-73	1855	-99.0	5246	8.50	68	1290	412	.10	188.0	592	6	150	6	5.7	.5	2684
3- 4-73	1990	25.0	9529	13.15	-77	14040	1620	2.00	212.0	16875	23	28	16	5.7	-99.0	32822
4- 1-73	2004	19.4	9550	1.97	-77	1755	629	1.50	84.0	620	6	104	173	4.4	-99.0	3377
5-31-73	2109	25.0	5480	2.78	-77	1379	604	.66	117.0	467	39	101	247	12.0	.5	2967
7- 2-73	2123	29.4	8891	1.76	-77	394	2212	3.30	8.4	379	26	126	48	1.4	-99.0	3198
8- 1-73	2168	25.6	7628	1.94	-77	902	1225	.60	96.0	194	6	112	250	9.9	-99.0	2796
9- 5-73	2247	27.8	7968	2.70	0	1208	1324	-.04	142.0	485	13	143	254	54.0	-99.0	3623
10- 2-73	2266	25.6	6455	1.99	-77	764	911	.69	.4	370	8	108	53	54.0	-.0	2270
11- 1-73	2289	-99.0	13514	1.75	-77	1463	1988	.26	198.0	339	9	116	273	54.0	-.0	4440
12- 4-73	2291	-99.0	7692	1.99	-77	1550	757	130.00	213.0	359	10	150	330	54.0	-.0	3553
1- 2-74	2319	16.6	20790	1.28	-77	2963	364	14.00	13.3	323	6	127	53	54.0	-.0	3917
3- 2-74	2329	23.3	14344	1.82	-77	2875	1138	.06	199.0	1296	11	126	281	15.8	-.0	5942
4- 4-74	2335	-99.0	6223	3.82	-77	1700	710	.04	147.0	662	8	91	312	19.3	-.0	3649
5- 8-74	2343	-99.0	4774	2.68	-77	1063	561	.06	128.0	287	7	98	265	13.1	-.0	2422
6- 5-74	2354	28.9	769	3.36	-77	500	629	.14	7.2	422	5	75	25	13.1	-.0	1677
7- 2-74	2360	20.0	3974	11.62	197	513	625	.14	30.0	757	7	19	5	13.1	-.0	2065
8- 2-74	2362	29.4	5735	3.91	-77	1500	509	.06	3.0	545	10	112	286	13.1	-.0	2978
9- 4-74	2368	29.4	15899	12.55	2757	1547	950	-.02	3.0	2618	15	5	-0	13.1	-.0	6506
10- 3-74	2374	27.8	4448	9.05	112	936	363	.03	250.0	890	9	23	15	13.1	-.0	2555
11- 6-74	2380	25.6	38418	1.12	-77	4909	1117	2.10	290.0	1215	12	211	356	13.1	-.0	8125
12- 2-74	2389	23.3	9149	2.19	-77	1929	1121	.38	277.0	887	8	96	346	13.1	-.0	4678
2- 6-75	2400	19.4	9119	2.24	-77	2375	303	.41	273.0	515	8	80	502	13.1	-.0	4069
3- 7-75	2406	20.0	13088	7.05	74	3582	1488	.16	305.0	2440	1	84	384	13.1	-.0	8334
4- 3-75	2410	20.0	8313	2.20	-77	1488	821	.12	80.0	444	7	98	247	13.1	-.0	3198
6- 3-75	2423	26.1	47813	1.20	-77	3725	7082	4.00	290.0	913	10	102	406	13.1	-.0	12545
7- 1-75	2429	25.6	11190	1.90	-77	1200	2113	2.81	59.0	572	9	163	209	13.1	-.0	4341
8- 5-75	2434	-99.0	7718	2.00	-77	1400	688	-99.00	170.0	241	23	99	305	13.1	-.0	2939
9- 4-75	2441	26.7	7880	2.14	-77	1955	540	-99.00	174.0	563	23	100	300	13.1	-.0	3668
10- 7-75	2444	24.4	9922	2.23	-77	2525	439	-99.00	322.0	925	7	89	358	13.1	-.0	4678
12- 3-75	2456	22.2	7285	2.30	-77	1760	335	.05	147.0	490	6	93	204	13.1	-.0	3048
12-30-75	2458	24.4	7668	2.51	-77	2175	308	-.02	227.0	428	6	82	409	13.1	-.0	3648
2- 5-76	2466	19.0	37095	9.00	400	14300	539	-.02	390.0	8420	7	24	333	13.1	-.0	24223
3- 4-76	2470	18.0	18903	8.30	168	6750	356	.02	305.0	3200	5	68	646	13.1	-.0	11426
4- 1-76	2475	25.0	3842	2.30	-77	535	281	-.02	19.2	180	4	74	31	13.1	-.0	1137
LW 23 BMI STP OUTFALL			22S 63E 07 122 1													
7- 8-70	119	27.5	2071	7.25	342	265	390	-99.99	-100.0	292	12	84	35	.0	.3	1246
8- 7-70	141	29.7	1440	7.59	106	146	329	36.80	51.0	168	11	93	35	.0	.4	923
9-10-70	170	28.3	1463	6.72	102	146	384	19.23	54.0	176	11	92	32	.0	.4	965

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
9-10-70	171	28.3	1472	6.79	93	134	386	20.90	64.9	178	12	94	35	.0	.4	971
12-15-70	322	-99.9	1721	7.38	81	193	424	29.70	62.8	193	17	96	35	.0	.4	1091
1-19-71	351	18.3	1683	7.30	66	156	392	26.20	4.8	179	16	104	38	15.8	.5	965
6-14-71	540	25.0	1918	7.55	314	160	363	30.10	.6	208	12	87	32	22.3	.6	1070
9-30-71	710	28.3	1951	7.10	216	197	332	29.20	.9	193	12	83	32	26.4	.5	1012
10- 1-71	781	24.4	1644	7.31	272	163	346	32.80	.3	188	12	99	33	26.0	.6	1034
11-10-71	828	22.8	1744	7.36	249	167	327	34.20	.2	191	13	82	33	28.0	.5	999
12- 2-71	914	18.0	1751	7.53	270	201	329	40.00	.4	197	14	88	34	31.0	.6	1067
1- 3-72	1064	7.2	1570	7.44	232	163	349	37.00	2.0	186	12	86	32	26.5	.4	1008
3- 2-72	1267	-99.9	1527	7.33	276	160	335	32.00	.9	170	11	84	32	29.0	.7	990
4- 6-72	1355	18.9	1505	7.27	270	159	338	19.40	2.1	168	11	89	34	27.0	.7	980
5- 2-72	1433	24.4	1521	7.21	248	171	338	33.00	.6	175	11	93	32	26.0	.9	1003
6- 1-72	1463	26.1	1471	7.38	508	161	188	32.00	1.0	199	12	94	37	18.0	1.3	994
7-10-72	1563	26.1	1643	7.06	299	168	345	21.00	.2	167	11	97	32	18.0	.9	1008
8- 6-72	1634	29.4	1615	7.08	272	144	357	38.00	.4	174	11	88	32	18.0	.7	997

LW 25 NEV RS DISCHARGE 21S 62E 11 323 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
3-31-70	27	19.0	3218	7.75	175	432	1453	-.10	41.6	225	22	391	180	.0	1.3	2832
5- 4-70	36	23.4	2251	7.35	185	124	1303	.10	22.3	180	14	252	153	.0	1.2	2140
6- 4-70	80	27.4	3077	7.65	138	344	1431	.11	29.9	269	14	233	182	.0	1.1	2572
7- 7-70	108	31.1	2684	7.75	178	213	1352	.32	23.0	218	17	237	167	.0	1.4	2317
8- 6-70	144	31.1	2455	7.98	166	172	1297	-.10	20.4	183	16	270	135	.0	1.3	2176
12-15-70	323	-99.9	3313	7.84	177	188	1675	-.10	46.4	216	16	403	165	.0	1.2	2798
1-19-71	352	17.2	3533	7.25	144	319	1562	-.10	41.0	280	17	366	171	.0	1.1	2828
3-30-71	403	23.0	3004	7.71	186	189	1397	-.10	30.0	225	19	298	161	.0	1.3	2412
7- 7-71	616	23.1	3027	7.90	178	138	1399	-.10	13.3	203	14	299	163	.0	1.5	2318
8-30-71	723	28.9	3431	8.01	152	185	1471	-.10	14.0	221	17	292	166	.0	.9	2442
12- 1-71	898	23.0	2990	7.46	175	191	1417	-.10	27.0	214	19	322	156	.0	1.3	2434
1- 3-72	1036	14.0	2904	7.67	203	159	1386	.14	19.0	203	12	286	158	.0	1.3	2325
2- 1-72	1170	15.0	2929	8.04	200	156	1372	-.10	17.0	213	12	272	159	.0	1.4	2301
5- 4-72	1379	27.0	3074	7.84	182	216	1466	.90	21.0	235	16	309	154	.0	1.4	2509
7-11-72	1586	32.8	3326	7.59	155	229	1515	.10	23.3	239	17	304	162	.0	1.4	2567

LW 26 SUNRISE STA OUTFL 21S 62E 10 422 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
3-31-70	28	25.0	3380	6.02	27	680	802	3.10	80.2	382	35	240	86	.0	2.0	2323
5- 4-70	46	27.8	3943	6.05	21	847	501	3.84	125.8	482	12	234	75	.0	2.1	2293
6- 4-70	81	33.6	3412	6.45	40	706	664	2.64	153.3	448	43	230	63	.0	1.7	2331
7- 7-70	109	36.4	3377	6.95	70	692	809	3.16	8.9	456	43	228	78	.0	1.1	2353
8- 6-70	145	37.8	3217	7.48	66	631	679	4.76	155.1	364	45	250	68	.0	1.2	2230
9-11-70	208	36.7	3925	6.91	62	753	1059	3.20	82.0	500	47	305	85	.0	1.2	2866
9-11-70	209	36.7	4240	6.98	60	795	1061	2.37	109.6	544	54	320	94	.0	1.3	3011
12-15-70	324	-99.0	4862	7.11	24	952	932	4.60	187.5	570	52	296	118	.0	2.9	3127
1-19-71	353	31.1	3419	7.25	3	656	651	6.12	116.2	403	38	208	84	6.4	2.3	2172
3-30-71	401	20.5	4813	7.03	77	916	1020	7.30	145.0	538	59	296	128	6.4	2.1	3156
4-22-71	447	10.6	1695	7.61	108	284	295	1.65	21.7	153	20	103	34	6.4	.9	973
6-11-71	523	26.0	2586	10.00	9	376	538	.20	5.3	308	23	134	23	4.8	.4	1417
7- 7-71	615	31.9	6444	9.25	53	1230	1415	.88	44.0	904	77	379	79	4.8	2.3	4162
8-30-71	722	37.8	5685	8.90	34	1042	1035	1.80	113.0	669	59	362	53	.8	1.9	3354
9-28-71	793	-99.0	3298	7.98	75	636	607	.76	95.0	453	37	204	39	.8	.5	2109
11-10-71	839	31.1	4308	6.92	50	814	860	3.30	94.0	541	48	256	82	8.0	1.7	2733
12- 1-71	899	28.0	5169	6.77	46	1094	1079	4.50	255.0	695	66	360	121	8.0	2.1	3707
1- 3-72	1037	24.0	5192	6.69	40	1049	1091	4.00	197.0	664	55	340	121	2.0	2.1	3545
2- 1-72	1171	26.0	4796	7.58	53	934	974	6.70	202.0	583	52	296	110	2.1	2.7	3189

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
4- 5-72	1345	35.6	5119	9.74	-77	893	1540	2.00	33.0	911	54	246	74	8.4	2.0	3763
5- 4-72	1381	28.5	5877	7.93	82	1244	1236	3.60	192.0	830	76	388	119	1.9	3.4	4135
6- 1-72	1451	34.4	6017	6.85	88	990	1071	4.20	138.0	682	60	312	96	2.2	3.0	3401
7-10-72	1534	-99.0	4504	7.11	75	836	912	3.80	114.0	578	47	281	59	1.3	2.2	2871
8- 6-72	1624	37.8	7023	6.97	164	1420	1299	5.20	156.0	920	78	463	109	1.4	2.8	4535
9- 6-72	1657	31.1	5831	7.01	109	1185	1298	4.80	180.0	806	74	391	116	.9	2.7	4112
10- 1-72	1683	32.2	5208	7.24	101	1047	1134	4.50	171.0	737	63	370	91	3.8	2.4	3673
11- 6-72	1789	22.2	9471	10.10	-77	1561	2726	1.04	197.0	1920	93	378	50	1.8	1.2	6929
12- 4-72	1828	26.7	5480	7.71	264	1034	1349	4.30	124.0	708	6	378	165	.7	3.0	3902
1- 5-73	1866	-99.0	6332	10.77	-77	1079	1430	-.04	115.0	1210	57	235	6	.7	.7	4133
1-31-73	1901	25.6	5600	8.27	248	1088	1422	5.00	103.0	771	61	396	164	.7	-.0	4132
1-31-73	1901	25.6	5600	8.27	248	1088	1422	5.00	103.0	771	61	396	164	1.7	-.0	8392
3- 4-73	1994	18.3	2403	7.67	95	244	761	-.04	3.9	221	12	134	98	4.5	-99.0	1525
4- 1-73	2012	13.9	3204	7.30	192	325	1278	.40	2.3	239	15	269	185	4.5	-.0	2413
5- 2-73	1977	28.9	4456	7.92	64	506	1854	.28	3.4	574	25	229	201	.4	-99.0	3424
5-30-73	2094	31.1	5928	7.14	425	1217	1188	1.50	15.8	802	73	342	127	2.1	3.7	3981
7- 2-73	2117	34.4	7992	11.90	0	1172	1493	-.04	12.7	1355	94	260	-0	3.6	-99.0	4390
8- 1-73	2175	32.2	6997	9.70	40	1534	1701	-.04	64.0	1142	110	443	101	2.6	-99.0	5117
9- 4-73	2236	31.1	6767	11.11	-77	1276	1921	-.04	92.0	1433	59	297	4	4.8	-99.0	5088
9- 4-73	2239	36.7	4385	7.60	39	767	1633	3.30	56.0	627	40	404	114	4.8	-99.0	3668
10- 2-73	2273	33.3	6089	7.36	65	1146	1484	3.02	559.0	796	63	446	105	4.8	-.0	4639
11- 1-73	2281	-99.0	5198	7.44	39	1018	1167	6.60	60.0	690	54	397	72	4.8	-.0	3489
12- 4-73	2299	-99.0	5509	7.62	96	938	1345	4.60	95.0	654	59	403	127	4.8	-.0	3678
1- 2-74	2312	2.2	1362	7.93	160	95	620	.74	6.4	98	18	167	68	4.8	-.0	1157
LW 27 CLARK CO STP EFFL 21S 62E 22 224 1																
3-31-70	18	23.0	2024	7.23	369	190	401	30.00	-100.0	215	14	113	63	.0	1.2	1207
5- 4-70	58	23.4	2461	6.98	273	378	451	18.50	1.6	291	16	125	73	.0	.4	1489
6- 6-70	83	25.6	1968	6.85	168	336	409	23.80	12.1	245	14	124	68	.0	.9	1315
7- 7-70	111	27.8	1612	6.90	200	184	391	25.50	.2	160	15	105	58	.0	.8	1037
8- 6-70	147	28.9	1866	7.88	175	312	420	12.40	52.0	220	17	127	71	.0	.6	1319
9-11-70	218	28.9	2126	6.90	165	323	413	20.08	14.2	242	18	125	65	.0	.6	1302
9-11-70	219	28.9	2154	6.69	148	340	437	22.40	53.3	250	20	125	70	.0	.7	1391
12-15-70	330	-99.9	2120	7.56	163	295	377	28.90	71.4	228	16	101	58	.0	.7	1256
1-19-71	359	22.8	1985	7.39	167	244	404	24.40	2.4	193	17	112	60	17.7	.7	1157
3-30-71	404	22.0	2200	7.37	312	313	371	18.60	9.8	220	17	112	63	17.3	.6	1296
4-22-71	450	22.8	1768	7.29	311	208	319	29.70	.7	204	15	89	58	17.1	.8	1094
6-11-71	525	29.0	2517	7.30	308	343	366	21.50	4.2	236	15	115	59	23.4	.5	1335
7- 7-71	611	23.8	2597	7.22	247	360	542	15.50	13.6	267	19	145	72	16.1	.6	1572
7- 7-71	612	-99.9	2441	7.40	280	355	435	17.50	9.3	247	17	131	65	22.3	.7	1437
8-30-71	720	28.9	2921	7.49	261	357	560	22.40	6.6	292	18	136	70	22.8	.8	1614
10- 1-71	806	26.1	2311	7.52	286	266	544	26.20	4.2	257	19	108	66	23.2	.7	1455
11-10-71	837	25.0	2290	7.33	285	276	483	23.00	3.8	250	14	108	60	28.0	.7	1386
12- 1-71	901	22.0	2331	7.23	310	321	506	19.70	2.5	271	18	130	68	26.0	.6	1515
1- 3-72	1056	18.0	2432	7.32	274	334	477	17.80	1.9	256	15	127	65	24.5	.5	1454
2- 1-72	1174	20.0	2252	7.51	288	321	412	18.70	.8	245	15	110	58	33.0	.6	1356
3- 2-72	1260	-99.0	2442	7.37	286	374	523	18.20	3.0	282	17	127	69	29.0	.5	1584
4- 5-72	1349	23.9	1884	7.52	316	249	348	26.00	2.1	209	16	95	53	28.0	.8	1182
5- 2-72	1383	24.0	2449	7.38	297	406	457	11.20	2.5	285	16	131	63	25.0	.5	1543
6- 1-72	1457	26.1	2340	7.14	299	330	504	19.30	3.5	270	16	130	64	27.0	.6	1512
7-10-72	1535	-99.0	2178	7.21	281	257	453	27.00	1.3	231	16	108	51	20.0	.9	1304
8- 6-72	1627	31.1	2468	7.22	311	341	472	18.00	2.0	260	15	119	62	29.0	.7	1472
9- 6-72	1654	26.7	2155	7.11	127	307	496	16.00	2.8	242	16	119	58	26.0	.6	1345
10- 1-72	1697	28.3	2184	7.32	272	264	475	29.00	3.2	240	16	109	58	22.1	.8	1351

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
POINT IDENTIFIER AND LOCATION																
11- 6-72	1792	23.3	2208	7.34	275	263	485	36.00	2.0	246	17	116	55	28.0	.8	1385
12- 4-72	1840	20.6	2858	7.45	305	348	695	24.00	5.6	325	19	147	81	29.0	.8	1825
1- 5-73	1864	-99.0	1583	7.43	219	177	315	23.00	2.0	161	12	78	42	14.0	1.2	933
3- 4-73	1992	21.1	2382	6.90	329	269	412	29.00	.4	224	15	119	58	31.0	-99.0	1319
4- 1-73	2010	17.8	2708	7.06	303	388	604	20.00	.6	304	18	153	78	23.0	-99.0	1738
5- 2-73	1975	24.4	2200	7.05	289	282	489	27.00	.0	238	13	124	58	29.0	-99.0	1402
5-31-73	2095	26.7	2740	6.74	199	446	546	19.00	1.2	312	17	134	75	33.0	.5	1682
7- 2-73	2119	28.9	2617	7.17	311	391	513	22.00	.4	298	32	136	65	30.0	-99.0	1640
8- 1-73	2173	29.4	2082	8.10	136	370	527	17.00	2.6	276	19	150	58	25.0	-99.0	1512
9- 4-73	2238	28.3	1862	8.60	143	280	516	31.00	1.7	261	18	131	54	24.0	-99.0	1387
10- 3-73	2275	27.8	2426	7.85	122	344	511	27.50	.9	287	17	138	61	24.0	-.0	1471
11- 1-73	2288	-99.0	2100	7.91	140	251	483	29.00	1.5	236	16	109	58	24.0	-.0	1277
12- 4-73	2301	-99.0	2037	7.67	127	285	480	31.00	2.4	241	17	118	61	24.0	-.0	1322
1- 2-74	2310	18.3	1946	7.50	112	379	569	23.00	99.0	294	17	150	71	24.0	-.0	1681
LW 28 BMI SEEP PARCO RD 21S 63E 31 313 1																
2-28-70	12	-99.9	11000	7.83	39	2760	2725	-.10	123.6	1262	35	815	489	.0	.4	8230
3-31-70	23	22.0	8772	8.42	67	2506	1503	-.10	265.8	850	40	750	340	.0	.5	6289
5- 5-70	54	22.2	8092	7.35	75	1903	2504	-.10	194.9	944	47	766	356	.0	.5	6752
6- 5-70	86	28.1	6565	7.30	66	1810	2248	.10	203.8	950	56	694	360	.0	.5	6355
7- 8-70	120	23.9	6371	7.50	87	1740	2172	.45	161.7	860	56	562	344	.0	.4	5939
8- 7-70	150	28.3	6329	7.62	89	1750	2136	-.10	186.1	905	58	775	320	.0	.5	6175
9-10-70	172	30.0	6353	7.42	84	1581	2169	-.10	150.6	815	58	740	315	.0	.5	5870
9-10-70	173	30.0	8154	7.38	83	1720	1720	-.10	146.1	852	64	723	305	.0	.5	5571
12-15-70	326	-99.9	8154	8.36	71	1460	2441	-.10	150.0	809	59	704	298	.0	.4	5956
1-19-71	355	17.8	7806	8.39	77	1438	2431	-.10	144.0	790	58	751	305	.1	.5	5955
4-23-71	459	19.4	8409	7.28	90	1567	2405	.70	150.0	834	61	733	320	.1	.5	6116
LW 29 GRAVEL PIT DRAIN 21S 63E 29 332 5																
5-21-70	96	21.9	5603	7.75	115	1570	1737	.12	179.4	566	39	725	300	.0	.4	5173
6- 6-70	89	23.3	5473	7.70	118	1430	1788	-.10	181.6	538	41	736	296	.0	.4	5069
7- 7-70	115	24.8	5451	7.75	104	1485	1924	-.10	172.8	540	89	650	316	.0	.4	5228
8- 7-70	153	25.6	5339	7.94	119	1565	1607	-.10	201.6	480	96	700	300	.0	.5	5008
9-12-70	220	22.5	6063	7.83	165	1590	1374	-.10	221.5	495	112	724	300	.0	.5	4898
9-12-70	221	22.5	7331	7.80	155	1650	1855	-.10	199.2	621	111	735	295	.0	.5	5543
12-15-70	327	-99.9	7361	7.39	182	1474	1879	-.10	157.0	512	121	695	285	.0	.5	5213
1-19-71	356	18.9	6709	7.42	190	1319	1875	-.10	146.5	544	117	624	292	.2	.6	5012
6-11-71	516	22.0	9382	7.75	162	1762	1744	-.10	134.0	520	66	837	351	.2	.8	5495
7- 7-71	617	-99.9	8299	7.85	154	1907	1588	-.10	129.0	526	82	812	336	.2	.7	5457
9-23-71	777	20.0	7572	7.75	137	1689	1707	-.10	97.0	623	87	707	307	.2	.8	5285
12- 1-71	929	17.5	7419	7.40	129	1748	1785	-.10	126.0	600	116	792	322	.2	.6	5553
1- 3-72	1010	11.9	7932	7.58	131	1855	1830	-.10	92.0	614	111	796	328	1.4	.6	5692
2- 1-72	1160	11.7	8173	7.52	133	1878	1864	-.10	86.0	624	117	790	333	1.4	.7	5759
3- 2-72	1251	15.0	7896	7.69	125	1925	1882	-.10	76.0	662	129	779	332	.2	.6	5847
4- 5-72	1339	22.0	8190	7.35	122	1981	1901	.04	78.0	692	129	771	326	.1	.7	5939
5- 2-72	1429	22.2	8326	7.55	116	1999	1934	-.04	80.0	725	133	793	317	.1	.7	6039
6- 1-72	1443	23.9	8745	7.16	122	2144	1918	-.04	96.0	836	125	813	317	.2	.7	6310
7-10-72	7454	29.5	9454	7.77	122	1999	1971	-.04	110.0	895	119	811	299	.2	.8	6265
8- 6-72	1600	28.3	9130	7.72	143	2114	1895	-.04	93.0	952	111	740	283	.1	.9	6259
9- 7-72	1666	23.3	8384	7.61	166	1983	1851	-.04	92.0	933	103	736	251	.1	.9	6032
10- 1-72	1682	22.2	8140	7.45	164	1936	1765	-.04	96.0	925	96	702	253	.2	.9	5855
11- 6-72	1783	20.0	8532	7.54	157	1949	1845	-.04	104.0	946	89	742	255	.3	.9	6009
12- 4-72	1839	15.6	8605	7.71	144	1914	1830	-.04	60.0	921	91	742	259	.3	.9	5889

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
1- 4-73	1848	-99.0	8609	7.58	140	1924	1909	-.04	116.0	894	94	717	258	2.8	.9	5985
1-31-73	1898	15.6	8124	7.61	139	1913	1853	-.04	127.0	908	91	708	258	2.8	-99.0	5930
3- 4-73	1984	16.7	9136	7.60	143	1972	1817	-.04	144.0	898	89	742	258	.1	-99.0	5991
4- 1-73	1965	13.3	8236	7.56	142	1932	1911	-.04	130.0	896	95	752	260	.1	-99.0	6046
5- 2-73	1969	20.0	8026	7.50	164	1853	1738	-.04	142.0	895	66	717	236	.2	-99.0	5728
5-31-73	2108	24.4	8320	7.69	152	1875	1979	-.04	157.0	891	93	691	257	.3	.9	6019
7- 2-73	2125	28.9	7592	7.89	188	1692	1619	-.04	131.0	812	79	636	217	.4	-99.0	5279
8- 1-73	2164	23.3	7077	7.77	156	1650	1784	-.04	106.0	847	76	604	277	.4	-99.0	5421
9- 5-73	2243	25.6	6427	8.50	167	1534	1795	-.04	99.0	853	81	636	206	.4	-99.0	5287
10- 2-73	2271	22.2	7500	7.97	109	1490	1876	.17	126.0	812	55	614	221	.4	-.0	5248
12- 4-73	2297	-99.0	8264	8.05	154	1693	1828	-.04	104.0	852	58	581	233	.4	-.0	5525
1- 2-74	2314	11.1	6231	8.05	151	1693	1920	-.04	102.0	878	60	675	249	.4	-.0	5651
3- 2-74	2327	-99.0	8100	7.91	158	1724	1814	.06	129.0	831	65	699	247	.4	-.0	5587
4- 4-74	2333	15.0	8284	7.85	165	1799	1892	.06	136.0	878	68	670	254	.4	-.0	5778
5- 8-74	2341	23.3	8162	7.61	188	1791	1863	.06	129.0	888	63	643	243	.4	-.0	5713
6- 5-74	2351	25.0	7277	7.95	201	1750	1789	-.04	114.0	908	68	657	234	.4	-.0	5620
7- 2-74	2358	21.7	7723	7.91	106	1655	1735	-.04	139.0	865	65	574	221	.4	-.0	5326
8- 2-74	2364	28.9	7956	7.74	180	1699	1909	.10	1.3	850	65	665	239	.4	-.0	5518
9- 4-74	2371	26.1	7385	8.05	198	1585	1887	-.02	144.0	830	58	651	231	.4	-.0	5484
10- 3-74	2377	23.9	7582	8.05	193	1643	1835	.10	140.0	888	55	637	233	.4	-.0	5527
11- 6-74	2381	18.9	8897	7.48	175	1604	1849	.10	153.0	915	55	653	243	.4	-.0	5559
12- 4-74	2386	15.6	7517	7.39	167	1643	1783	.10	161.0	794	53	592	237	.4	-.0	5345
2- 6-75	2401	14.4	7994	7.80	160	1683	1843	.10	141.0	835	47	679	237	.4	-.0	5544
3- 7-75	2407	16.1	8054	7.20	150	1757	1788	.06	163.0	850	6	627	249	.4	-.0	5514
4- 3-75	2412	19.4	8161	7.52	145	1925	1775	.11	175.0	904	61	634	260	.4	-.0	5805
6- 3-75	2422	20.6	8749	5.90	187	1917	1835	.14	165.0	284	64	796	520	.4	-.0	5673
7- 1-75	2428	20.6	8698	5.70	193	1897	1875	.17	135.0	922	62	737	275	.4	-.0	5999
8- 5-75	2436	-99.0	8508	6.13	188	2109	1711	-99.00	175.0	868	178	670	266	.4	-.0	6070
9- 4-75	2439	21.7	8629	7.25	210	1764	1537	-99.00	173.0	815	170	595	250	.4	-.0	5408
10- 7-75	2446	20.6	8354	6.26	181	1841	1755	-99.00	244.0	859	64	657	266	.4	-.0	5776
11- 5-75	2450	20.0	7400	7.29	190	1737	1471	.06	148.0	674	46	453	218	.4	-.0	4841
12- 3-75	2454	19.4	7668	7.49	192	1891	1419	.07	151.0	680	44	475	298	.4	-.0	5053
12-30-75	2460	16.1	8051	7.61	192	2038	1434	.04	151.0	670	43	463	268	.4	-.0	5162
2- 3-76	2465	18.0	8029	7.25	162	2085	1379	.08	147.0	656	40	662	334	.4	-.0	5383
3- 4-76	2469	16.0	8588	7.85	158	2312	1474	.01	123.0	750	41	740	381	.4	-.0	5899
4- 1-76	2474	23.0	10011	6.60	140	2846	1510	.12	143.0	820	45	900	474	.4	-.0	6808

LW 30 POND ADJ LV WASH   21S 63E 28 142 1

6- 5-70	91	22.5	5846	7.70	230	1383	1990	-.10	59.8	750	38	558	315	.0	1.0	5207
7- 8-70	123	25.3	5579	7.65	234	1470	1873	.20	64.2	720	85	524	318	.0	1.1	5170
8- 7-70	155	23.6	5432	7.92	211	1436	1677	.12	119.6	585	90	602	288	.0	1.1	4901
9-10-70	162	22.8	5573	7.73	239	1445	1736	.15	75.3	615	73	630	288	.0	1.1	4982
9-10-70	163	22.8	7361	7.75	244	1550	2165	.12	57.3	740	89	635	304	.0	1.1	5662
12-15-70	328	-99.9	7571	7.53	243	1470	2185	-.10	57.0	747	85	640	288	.0	1.1	5593
1-19-71	357	13.3	7211	7.47	253	1380	2176	-.10	63.6	768	81	594	295	.0	1.1	5483
4-22-71	436	19.4	7388	7.60	242	1361	2181	.12	64.6	720	77	638	279	.0	1.0	5441
6-11-71	512	22.0	8063	7.65	251	1367	2129	.14	62.4	747	76	632	292	.0	1.1	5430
7-23-71	632	25.0	7439	7.23	260	1399	2215	-.10	59.6	779	81	635	292	.0	1.1	5590
8-30-71	704	23.3	8240	7.15	257	1370	2106	.20	61.0	737	83	652	287	.0	1.1	5424
11-10-71	820	16.1	7250	7.32	253	1300	2110	-.10	55.0	753	80	626	290	.0	1.0	5340
12- 1-71	924	14.0	6720	7.34	260	1261	2092	-.10	73.0	741	85	630	271	.0	1.0	5282
1- 3-72	1007	11.9	6824	7.57	256	1252	2072	-.10	59.0	675	78	647	260	.0	1.0	5170
2- 1-72	1157	9.0	5891	7.56	256	1236	2067	-.10	59.0	682	77	602	258	.0	.8	5107
5- 2-72	1423	23.3	6701	7.56	256	1262	2067	.12	54.0	715	79	600	265	.0	1.0	5169

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMR	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
6- 1-72	1440	23.3	6988	7.23	260	1300	2120	.44	50.0	733	86	620	274	.4	1.1	5313
7-10-72	1523	27.5	7513	7.62	248	1349	2210	.20	51.3	733	82	653	275	.1	1.1	5477
9- 7-72	1596	25.6	7434	7.61	274	1398	2088	-.08	44.0	708	89	636	283	.1	1.1	5382
1- 4-73	1847	-99.0	7150	7.47	261	1329	2117	.10	38.0	691	82	624	275	.2	30.0	5315
LW 31 CHARLESTON DITCH 20S 61E 36 343 1																
8- 6-70	142	26.8	2245	8.45	319	103	1198	-.10	3.2	128	28	180	202	.0	.4	2000
9-11-70	216	28.9	2077	8.09	311	90	940	.93	5.3	114	25	175	173	.0	.3	1677
9-11-70	217	28.9	2208	7.97	317	75	1006	.83	4.5	123	27	182	163	.0	.3	1738
12-16-70	329	-99.9	2650	8.21	336	105	1271	-.10	6.0	136	36	214	194	.0	.3	2128
4-23-71	465	21.7	2729	7.78	174	119	1277	.26	5.1	114	35	212	218	.0	.4	2066
6-14-71	537	25.0	2851	7.90	337	115	1245	.44	5.4	148	32	207	215	.0	.3	2134
7-26-71	648	27.2	2707	7.65	332	116	1275	.46	4.4	148	32	205	216	.0	.4	2160
8-31-71	735	27.0	2618	8.15	321	83	1152	.58	7.1	120	33	191	199	.0	.3	1944
12- 2-71	918	6.0	2733	8.03	329	106	1251	.90	8.2	141	33	217	210	.0	.3	2130
1- 3-72	1058	16.7	2688	8.02	317	110	1255	-.10	6.8	138	27	210	210	.0	.3	2113
2- 1-72	1175	19.0	2658	8.01	299	117	1212	.24	5.2	137	28	218	195	.0	.3	2059
6- 1-72	1454	24.4	2472	7.78	322	113	1165	.22	4.3	129	25	202	195	.0	.3	1992
7-10-72	1584	30.0	2653	7.89	319	116	1195	.40	3.8	132	28	196	189	.1	.3	2008
11- 7-72	1806	24.4	2621	8.90	356	184	718	.54	.1	437	20	75	71	.2	-100.0	1680
12- 4-72	1824	21.1	2622	7.54	419	253	828	.08	.2	339	20	96	121	.2	-100.0	1864
1- 5-73	1871	-99.0	2711	7.70	350	115	1203	.20	-.1	133	28	200	205	.2	2.0	2058
3- 4-73	1997	18.9	2911	7.71	339	125	1287	.36	7.9	147	29	212	217	.2	-99.0	2192
4- 1-73	2015	17.8	2900	8.12	336	133	1380	.10	8.1	166	32	223	230	.2	-99.0	2337
5- 2-73	1980	22.8	2832	7.81	321	136	1352	.32	6.8	150	30	210	225	.3	-99.0	2268
5-30-73	2092	25.6	2840	7.93	333	92	1338	.04	7.2	145	33	201	228	.1	.3	2208
7- 2-73	2115	27.8	2747	7.79	259	121	1262	-.04	5.5	147	43	208	206	.1	-99.0	2120
8- 1-73	2177	27.8	2262	8.10	304	111	1088	-.04	5.0	154	30	198	193	.1	-99.0	1929
LW 32 GRAVEL PIT SEEP 21S 63E 32 234 1																
9-10-70	164	22.8	5430	7.62	95	1553	1591	-.10	181.6	514	74	790	275	.0	.5	5026
9-10-70	165	22.8	7182	7.63	98	1630	2032	-.10	174.9	649	81	796	286	.0	.5	5697
12-15-70	325	-99.9	6955	7.20	172	1263	1944	-.10	160.0	480	56	752	268	.0	.5	5008
1-19-71	354	20.6	6625	7.32	164	1268	1938	-.10	154.0	510	57	673	297	.1	.6	4978
4-22-71	439	19.4	7495	7.22	219	1729	1555	-.10	130.5	446	34	795	338	.1	.9	5136
6-11-71	515	21.0	8600	7.25	213	1982	1468	-.10	108.5	547	36	817	351	.1	.9	5415
7-23-71	635	22.2	8220	7.37	173	2007	1539	-.10	106.0	666	38	783	328	.1	.8	5553
8-30-71	707	21.7	7562	7.42	157	1563	1423	-.10	82.0	691	37	589	237	.1	1.0	4700
10- 1-71	787	21.1	7781	7.78	117	1775	1801	-.10	124.0	538	52	868	331	.9	.5	5548
11-10-71	827	22.2	7849	7.31	151	1685	1851	-.10	86.0	694	34	760	294	.9	.9	5480
12- 1-71	904	17.0	7764	7.43	109	1758	1865	.20	157.0	506	43	875	320	.9	.5	5580
1- 3-72	1013	19.0	7583	7.49	110	1709	1935	-.10	98.0	593	38	832	299	.4	.6	5559
2- 1-72	1161	17.0	7913	7.53	113	1751	1866	-.10	101.0	522	43	836	317	.4	.5	5492
3- 2-72	1250	21.7	7854	7.61	134	1811	1922	-.10	56.0	716	38	821	294	.1	.8	5725
4- 5-72	1340	22.0	8087	7.13	127	1971	1971	-.04	63.0	862	46	777	274	.1	.9	6028
5- 2-72	1430	22.2	8702	9.40	136	2058	1959	-.04	84.0	950	37	819	263	.1	.8	6238
6- 1-72	1444	23.9	9501	7.74	142	2398	1723	-.04	122.0	1245	53	762	235	.2	1.0	6609
7-10-72	1526	22.0	9206	7.56	181	2096	1823	-.04	108.5	1160	34	704	203	.2	1.2	6219
8- 6-72	1599	23.3	8909	7.62	175	1943	1870	.10	101.0	1155	32	669	196	.1	1.1	6053
9- 7-72	1665	20.0	7761	7.55	210	1695	1805	-.04	102.0	1065	31	610	170	.1	1.3	5583
10- 1-72	1681	23.3	-0	7.28	212	1685	1671	-.04	116.0	1025	28	590	1	.1	1.3	5221

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LW 33 TRIB TO DUCK CK 21S 62E 22 442 1																
9-11-70	192	18.3	5598	7.34	257	1014	2335	.38	3.1	538	61	640	350	.0	1.8	5070
9-11-70	193	18.3	6650	7.40	241	1090	2655	.44	3.4	596	73	656	356	.0	1.9	5550
4-23-71	462	14.4	6896	7.32	232	1002	2828	.20	25.6	650	46	593	368	.0	1.6	5629
7-26-71	647	23.3	7870	7.30	284	1123	3210	.12	19.6	833	42	654	418	.0	1.7	6441
8-30-71	714	21.0	7765	7.50	266	1000	3000	-.10	19.1	768	58	613	406	.0	1.4	5996
11-10-71	836	12.2	7040	7.50	229	959	2644	.14	33.0	695	47	586	362	.0	1.4	5441
12- 2-71	915	8.0	6944	7.49	232	991	2765	-.10	30.0	695	51	575	371	.0	1.5	5594
3- 2-72	1262	-99.0	6843	7.66	233	1012	2886	-.10	32.0	709	55	573	373	.0	1.6	5756
4- 5-72	-0	19.0	6644	7.20	229	981	2837	2.30	34.0	706	50	583	363	.1	1.7	5671
5- 4-72	1386	16.5	7097	7.44	250	1019	2947	.10	30.0	742	50	620	384	.1	1.6	5917
7-10-72	1575	23.3	8216	7.63	264	1126	3405	.18	36.5	844	46	691	426	.1	1.7	6706
8- 6-72	1628	25.6	8107	7.56	267	1096	3341	.12	34.0	869	43	645	421	.1	1.7	6582
1- 4-73	1857	-99.0	7160	7.52	231	962	2959	.20	40.0	709	53	625	365	.1	1.7	5828
1-16-73	1881	9.4	7097	7.56	228	976	2963	.10	37.5	730	54	581	373	.1	1.8	5829
LW 34 LV STP OUTFALL 21S 62E 10 344 1																
3-31-70	26	20.5	1513	7.30	312	180	240	25.20	-100.0	145	12	80	53	.0	1.1	889
5- 4-70	38	22.4	1028	6.98	263	116	255	35.70	27.5	108	13	62	42	.0	.4	789
6- 4-70	82	28.9	1403	6.80	224	205	153	24.50	6.6	163	13	57	44	.0	1.0	777
7- 7-70	110	27.8	1126	7.00	194	129	160	41.50	1.1	121	12	57	37	.0	1.1	655
8- 6-70	146	30.0	1023	7.29	117	114	158	13.90	48.5	83	13	64	42	.0	.7	586
9-11-70	210	29.4	1449	7.02	180	235	157	17.95	35.4	163	14	72	42	.0	.7	825
9-11-70	211	29.4	1417	7.29	173	239	198	20.40	63.1	165	13	76	45	.0	.8	905
12-15-70	331	-99.9	1476	7.46	305	188	176	29.70	5.0	183	13	61	38	.0	1.3	845
1-19-71	360	20.6	1510	7.31	106	214	187	51.60	4.4	157	16	72	40	20.7	1.0	816
3-30-71	402	22.0	1450	7.26	258	177	222	28.00	16.8	146	16	76	44	17.2	1.1	871
4-22-71	449	23.3	1521	7.23	301	197	171	31.00	5.0	199	15	65	40	17.2	1.2	889
6-11-71	524	28.0	1615	7.25	264	232	177	21.10	11.9	164	13	75	43	14.8	.9	882
7- 7-71	613	-99.0	1406	7.35	245	169	195	28.00	9.6	138	14	70	39	10.4	1.0	795
7- 7-71	614	-99.9	1635	7.55	240	202	203	24.00	14.5	157	14	77	42	11.1	1.1	864
8-30-71	721	31.1	1825	7.42	254	235	228	21.40	10.4	178	13	72	42	18.9	1.0	945
10- 1-71	804	25.6	1644	7.15	289	228	227	26.20	4.5	188	14	75	39	21.9	1.0	966
11-10-71	838	23.3	1681	7.26	277	229	226	21.00	2.7	185	12	70	41	29.0	1.0	952
12- 1-71	900	21.0	1792	7.42	270	260	252	16.20	3.3	197	14	85	44	23.0	.8	1028
1- 3-72	1038	7.2	1724	7.51	240	259	281	15.70	3.4	187	12	89	45	18.4	.4	1028
2- 1-72	1172	19.0	1845	7.41	293	265	247	16.70	5.2	185	14	83	46	22.0	1.1	1029
3- 2-72	1258	19.4	1484	7.40	244	206	253	23.00	8.4	156	13	76	44	14.0	1.6	915
4- 5-72	1346	24.4	1607	7.16	308	254	200	18.80	8.4	182	14	72	45	26.0	1.3	974
5- 4-72	1380	24.5	1521	7.44	247	210	237	21.00	6.0	165	11	74	44	14.0	1.1	905
6- 1-72	1452	27.2	1798	7.36	229	276	309	15.30	7.0	208	12	97	48	12.0	1.1	1098
7-10-72	1533	-99.0	1604	7.23	276	194	250	26.00	6.9	169	13	72	36	17.0	2.1	922
8- 6-72	1625	30.6	1886	7.26	164	281	303	33.00	9.6	203	13	92	47	17.0	1.5	1081
9- 6-72	1644	27.2	1522	7.42	260	191	287	18.00	-.0	169	13	87	45	17.0	.7	956
10- 1-72	1696	28.3	1628	7.21	270	213	281	32.00	2.6	191	13	80	37	19.8	1.7	1004
12- 4-72	1827	18.9	1830	7.32	253	236	330	20.00	2.2	196	13	88	47	25.0	.5	1082
1- 5-73	1863	-99.0	2618	7.35	243	383	526	16.20	.9	277	16	132	70	19.0	.6	1560
3- 4-73	1993	21.1	2019	7.22	305	254	289	24.00	2.2	207	13	81	41	31.0	-99.0	1093
4- 1-73	2013	17.8	2021	7.25	259	301	367	14.50	3.6	218	13	99	55	17.0	-99.0	1216
5- 2-73	1976	25.6	1889	7.22	288	239	298	25.00	2.4	197	10	90	44	27.0	-99.0	1074
5-30-73	2073	28.3	1564	6.96	197	227	249	19.00	5.2	157	13	73	48	18.0	1.2	907
7- 2-73	2116	30.6	1888	7.53	330	290	279	15.30	.1	199	28	91	49	22.0	-99.0	1136

POINT IDENTIFIER AND LOCATION MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
8- 1-73	2174	31.1	1682	7.85	154	290	287	17.00	7.2	208	14	109	46	17.0	-99.0	1071
9- 4-73	2235	30.0	1431	7.28	163	228	267	71.00	3.0	187	13	94	39	20.0	-99.0	1003
10- 3-73	2274	26.7	1776	7.87	130	302	274	19.00	8.0	204	14	101	44	20.0	-.0	1050
11- 1-73	2280	-99.0	1299	8.09	118	211	277	23.00	3.7	182	13	76	39	20.0	-.0	903
12- 4-73	2300	-99.0	1455	7.66	121	234	311	28.00	3.9	211	13	80	41	20.0	-.0	1001
1- 2-74	2311	15.0	1861	7.63	103	289	376	14.30	5.0	202	12	104	49	20.0	-.0	1122
LW 35 BMI NO. 1 (DISC.) 22S 62E 02 144 1																
2-28-70	10	-99.9	14300	3.05	-77	3160	761	-.00	79.7	1375	266	426	375	.0	.6	6444
3-31-70	19	24.0	24821	8.21	42	7550	2355	-.10	443.0	3600	33	1115	415	.0	1.4	15533
5- 4-70	39	29.7	8271	3.39	-77	2305	852	-.10	252.5	980	15	320	340	.0	.7	5065
6- 5-70	74	35.8	28105	6.90	43	7680	1515	-.10	528.9	4050	39	1010	440	.0	1.4	15286
LW 36 OSW GULF RO 21S 63E 14 412 1																
2-28-70	7	-99.9	337	6.33	9	77	2	.01	12.4	51	5	2	0	.0	.1	153
LW 37 OSW HAVERS RO 21S 63E 14 412 2																
2-28-70	8	-99.9	805	6.61	7	222	1	.64	13.7	125	12	21	8	.0	.1	408
LW 38 OSW AEROJECT RO 21S 63E 14 412 3																
2-28-70	9	-99.9	680	6.88	7	205	3	.01	14.5	126	12	4	1	.0	.1	370
LW 39 GRAVEL PIT 22S 62E 02 432 1																
6- 3-70	76	23.6	21982	6.80	110	5780	1380	.32	-.4	3520	52	478	210	.0	4.2	11399
6- 5-70	77	29.3	26195	7.15	111	6800	2000	.19	-.4	4540	59	532	261	.0	4.6	14251
9-11-70	194	26.4	17171	7.33	95	5499	1667	.23	-.5	3612	60	500	150	.0	3.0	11538
9-11-70	195	26.4	17966	7.41	94	5761	1975	.21	-.9	4060	66	485	154	.0	3.2	12551
LW 41 LAS VEGAS WASH 9 21S 63E 30 431 1																
1-19-71	361	13.9	4015	7.54	227	651	1088	19.60	39.2	508	32	298	119	.1	1.3	2868
3-11-71	376	9.5	3969	7.59	258	646	1071	19.60	39.2	495	32	297	119	.1	1.5	2847
3-30-71	406	14.4	3920	7.76	249	596	1009	19.00	23.8	460	29	254	105	.1	1.4	2620
3-30-71	412	14.4	3850	7.81	250	581	993	18.20	24.2	460	29	257	113	.7	1.4	2600
4-22-71	443	14.4	3391	7.75	245	487	867	20.90	32.3	387	25	222	99	.1	1.3	2262
6-11-71	518	18.5	3939	7.80	300	550	920	23.20	6.0	427	24	241	105	7.1	1.4	2452
10- 1-71	799	13.9	3856	7.75	253	476	878	18.90	22.0	413	26	210	92	1.4	1.3	2263
11-10-71	825	10.0	4098	7.61	214	622	1079	16.00	30.0	496	33	273	116	2.3	1.0	2774
1- 3-72	1031	6.9	3130	7.31	215	448	851	19.60	40.0	347	27	217	95	4.0	1.0	2155
2- 1-72	1164	2.8	3472	7.66	191	438	974	17.80	46.0	374	28	217	107	4.1	1.1	2301
3- 2-72	3664	9.4	3664	7.88	234	526	1128	19.30	23.0	453	29	245	118	.2	1.2	2657
4- 5-72	1341	19.0	3378	7.48	246	483	1021	21.00	17.4	418	28	233	110	.5	1.2	2446
LW 42 STAUFFER EFFL 3 22S 62E 12 323 1																
1-19-71	362	21.1	2760	8.29	113	506	554	.36	3.2	513	5	68	74	.0	.3	1729
4-23-71	456	47.2	68503	8.23	5863	28194	1161	-.10	3.1	20580	8	6	5	.0	.3	52760
6-11-71	533	37.0	45867	4.30	-77	15646	990	-.10	6.1	10560	5	34	10	.0	.1	27251
8-30-71	712	-99.9	62794	4.55	-77	19150	798	-.10	13.0	13635	8	51	19	.0	1.7	33676
12- 1-71	908	22.5	81980	4.29	-77	30186	2269	-.10	2.1	22240	9	43	11	.0	.1	54760

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
POINT IDENTIFIER AND LOCATION																
1- 3-72	1067	21.9	47200	4.59	-77	16706	1064	-.10	-.1	12100	11	83	25	.0	.2	29990
2- 2-72	1195	26.0	25437	4.37	-77	8228	556	-.10	1.3	5855	3	24	5	.0	-.1	14672
3- 2-72	1270	-99.0	38742	7.82	4284	12282	520	-.10	2.6	10119	9	37	18	.1	.2	25094
5- 4-72	1395	30.0	42737	6.24	628	15670	768	-.04	1.5	11450	6	48	13	.1	.2	28265
7-10-72	1572	30.0	33657	4.54	-77	11033	961	-.04	1.8	7781	5	48	16	.1	.3	19846
8- 7-72	1638	29.4	39429	4.98	-77	13350	839	-.04	4.2	9957	7	82	25	.1	.2	24265
1- 5-73	1860	-99.0	125	12.92	3068	34558	4779	-99.99	-.1	37365	8	2	-0	.1	2.2	78223
LW 43 STAUFFER EFFL 6	22S 62E 12 332 1															
1-19-71	364	41.7	43089	8.89	13790	15584	460	-.10	4.0	15500	8	0	12	.0	.3	38349
4-23-71	455	22.2	19892	1.39	-77	1252	1977	5.50	3.1	125	5	90	31	.0	.4	3489
6-11-71	534	37.0	278900	.20	-77	28821	1216	-.10	10.4	366	6	102	32	.0	-.1	30553
8-30-71	715	25.6	3859	3.50	-77	540	831	-.10	12.0	569	5	82	31	.0	.3	2070
9-23-71	784	11.1	1843	8.84	102	178	535	4.40	4.9	282	8	47	46	.0	.4	1156
11-11-71	814	31.1	13239	1.71	-77	1131	1874	6.20	5.1	643	8	86	36	3.5	.3	3793
12- 1-71	907	26.0	609760	-.00	-77	8220	182584	-.10	481.0	8240	14	122	48	1.2	-.1	199711
2- 2-72	1196	22.0	636711	.06	-77	8367	189334	-.10	52.0	2190	7	103	31	1.2	-.1	200085
3- 2-72	1271	18.9	7654	2.00	-77	700	1396	9.20	10.0	595	5	87	32	.2	.3	2835
5- 4-72	1396	23.0	5700	1.11	-77	4912	3343	6.60	3.0	1250	4	113	33	.2	.3	9664
6- 1-72	1466	30.0	61707	.83	-77	3273	8278	68.00	8.0	763	5	94	34	.2	.3	12524
8- 7-72	1639	33.3	173567	.07	-77	1469	43301	4.00	4.0	2395	10	132	37	.2	-.2	47353
1- 5-73	1861	-99.0	2359	2.55	0	321	341	-.04	3.4	143	5	81	29	.2	.3	924
LW 44 STAUFFER EFFL 2	22S 62E 12 323 2															
4-23-71	457	23.9	17803	12.37	-77	1009	364	5.04	60.2	2820	6	1	0	.0	.7	4266
6-11-71	535	35.0	573308	-.00	-77	168310	-78	1.80	4.8	334	5	89	29	.0	-.1	168774
8-30-71	713	32.2	4788	2.78	-77	480	328	8.50	4.6	567	6	103	23	.0	.2	1521
9-23-71	783	31.0	1323	3.44	-77	202	275	9.80	1.5	115	4	79	28	.0	.3	715
11-11-71	813	42.2	154453	.77	-77	15836	59	127.00	2.3	96	4	62	19	1.0	.1	16206
12- 1-71	909	37.0	2767	2.95	-77	374	356	132.00	-.1	291	5	78	29	3.7	.3	1269
1- 3-72	1068	19.1	2011	2.56	-77	310	314	18.60	-.1	101	4	77	28	1.9	.3	855
LW 45 LAS VEGAS WASH 9A	21S 63E 30 431 2															
3-11-71	377	11.0	4230	7.65	248	694	1091	19.00	46.1	526	31	321	130	.0	1.4	2981
3-30-71	405	13.3	4278	7.76	245	637	1064	17.80	27.3	500	32	275	120	.1	1.4	2795
3-30-71	411	15.0	4114	7.92	252	624	1064	17.00	29.0	491	32	278	117	.1	1.4	2777
4-22-71	442	15.0	3506	7.78	245	519	927	20.30	20.0	415	26	232	105	.1	1.3	2386
6-11-71	517	21.0	4391	7.80	285	679	1105	20.50	15.2	513	28	299	129	.1	.5	2929
10- 1-71	798	15.0	3806	7.79	251	574	1022	17.50	24.0	480	30	243	109	1.2	1.3	2626
11-10-71	822	8.9	3572	6.52	222	506	930	17.70	36.0	420	31	226	102	3.0	1.1	2382
1- 3-72	1030	6.9	3591	7.12	208	544	959	18.60	44.0	411	29	232	106	2.9	1.1	2450
2- 1-72	1163	3.0	3742	7.86	200	506	1026	18.30	47.0	385	30	262	125	2.8	1.0	2502
3- 2-72	1253	10.0	4201	7.84	230	652	1265	17.20	32.0	518	35	296	137	.2	1.1	3067
4- 5-72	1342	18.9	3163	7.31	250	432	940	21.00	16.0	378	24	231	103	.8	1.3	2270
LW 47 BMI POND SEEP 1	21S 63E 31 224 1															
3-11-71	380	14.5	10750	7.86	236	2425	2707	-.10	71.3	2020	36	720	198	.0	1.5	8295

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LW 48 BMI POND SEEP 2 21S 63E 31 221 1																
3-11-71	378	14.5	10750	7.49	280	2378	2404	-.10	4.4	1860	37	662	166	.0	2.4	7651
3-30-71	408	15.0	10889	7.53	277	2355	2409	.14	5.0	1880	50	592	164	.0	2.4	7594
3-30-71	414	15.0	10889	7.51	273	2342	2419	.18	5.0	1820	49	586	163	.0	2.4	7521
6-11-71	520	-99.0	11714	7.60	275	2388	2524	.18	6.4	1891	52	570	169	.0	2.5	7738
7- 7-71	618	-99.9	11520	7.80	283	2392	2482	-.10	9.0	1824	59	616	167	.0	2.6	7691
7-26-71	641	22.2	11178	7.43	301	2395	2607	.24	9.0	1930	55	590	174	.0	2.5	7911
8-31-71	726	22.0	11647	7.60	302	2447	2555	.22	10.8	1920	58	610	173	.0	2.5	7925
9-28-71	791	18.3	10959	7.68	292	2392	2509	.26	10.4	1865	65	596	170	.0	2.6	7754
11-11-71	812	15.0	11206	7.56	288	2454	2414	.22	13.8	1858	61	599	177	.0	2.3	7721
12- 1-71	902	16.0	11792	7.65	293	2505	2421	.40	15.0	1862	52	594	189	.0	2.2	7784
1- 3-72	1075	11.9	11595	7.66	292	2718	2523	.28	15.0	1970	46	635	196	.0	2.2	8249
2- 2-72	1190	11.0	11514	7.79	279	2607	2544	.30	21.0	1962	58	645	196	.0	2.2	8172
3-10-72	1275	-99.0	10707	7.48	286	2524	2588	-.10	18.9	1906	54	571	192	.8	2.1	7997
5- 4-72	1389	19.5	11463	7.49	288	2403	2551	.16	29.0	1913	55	615	201	.2	2.1	7911
6- 1-72	1446	21.7	10778	7.73	287	2367	2608	.60	32.0	1830	57	615	201	.3	2.2	7854
7-10-72	1565	26.1	11483	7.78	301	2387	2703	.60	35.3	1807	58	638	204	.1	2.3	7984
8- 6-72	1631	27.2	11538	7.64	295	2370	2581	.26	48.0	1865	58	634	196	.2	2.3	7900
10- 1-72	1700	21.1	10819	7.39	318	2443	2556	.24	18.7	1895	60	640	205	.2	2.3	7977
11- 8-72	1822	16.7	11555	7.53	332	2407	2583	.20	12.9	1921	58	637	205	.3	2.5	7990
12- 4-72	1831	15.0	12543	7.55	339	2852	2740	.22	11.7	2167	61	731	222	.3	2.4	8954
1- 5-73	1850	-99.0	11796	7.35	330	2520	2647	.30	13.6	1988	54	599	195	.3	2.2	8182
2- 1-73	1918	12.8	10617	7.58	307	2827	2624	.22	15.4	1897	49	581	201	.3	-99.0	8346
3- 4-73	1986	15.6	12223	7.69	299	2339	2649	.22	16.6	1947	51	569	201	.2	-99.0	7920
4- 1-73	2006	15.6	11005	7.61	298	2259	2641	.18	19.5	1935	52	567	199	.2	-99.0	7820
5- 3-73	2041	25.0	10583	7.72	286	2311	2637	.34	13.2	1880	51	574	204	.6	-99.0	7812
5-31-73	2106	22.8	10562	7.68	295	2329	2684	.24	23.0	1770	54	579	216	.4	2.2	7803
7- 2-73	2127	28.9	10389	7.84	304	2192	2691	.12	24.3	1755	93	596	217	.2	-99.0	7718
8- 1-73	2166	24.4	9530	7.94	238	2118	2757	-.04	22.0	1667	65	596	230	.2	-99.0	7572
9- 5-73	2245	25.0	9350	8.15	303	2225	2707	.30	24.0	1631	59	663	250	.2	-99.0	7709
10- 2-73	2269	22.2	10636	7.80	177	2177	2308	.17	23.0	1671	53	615	232	.2	-.0	7167
11- 1-73	2286	-99.0	10395	7.97	229	2149	2670	.72	24.0	1656	49	607	229	.2	-.0	7498
12- 4-73	2294	-99.0	8961	7.84	216	2073	2606	-.04	24.0	1619	48	605	234	.2	-.0	7315
1- 2-74	2317	12.2	8940	8.06	145	2206	2565	.12	17.1	1624	117	586	233	.2	-.0	7420
LW 49 BMI POND SEEP 3 21S 63E 31 222 1																
3-11-71	379	15.0	10530	7.32	242	2437	2141	.10	-.1	1880	36	600	127	.0	3.5	7344
3-30-71	409	17.2	10780	7.49	269	2359	2189	.24	.2	1890	50	520	131	.0	3.1	7275
3-30-71	415	16.1	11000	7.51	259	2376	2087	.26	.1	1900	47	510	125	.0	3.3	7176
6-14-71	539	21.5	11217	7.45	264	2434	2079	.26	-.1	1815	52	507	134	.0	3.3	7154
7- 7-71	619	-99.9	10983	7.60	226	2408	2074	.26	.1	1764	55	515	138	.0	3.0	7069
7-26-71	642	23.3	10627	7.33	280	2384	2146	.24	-.1	1945	53	476	142	.0	3.0	7287
8-31-71	727	21.0	11050	7.55	262	2470	2136	.30	-.1	1931	52	496	135	.0	3.2	7352
9-28-71	792	18.3	10252	7.66	247	2454	2085	.31	-.1	1951	51	491	126	.0	3.5	7284
11-11-71	811	15.6	11032	7.49	243	2416	1965	.26	.2	1855	56	476	118	.0	3.2	7009
12- 1-71	903	16.0	10527	7.35	235	2486	1999	.30	.2	1890	58	454	127	.0	3.0	7133
1- 4-72	1076	14.0	10589	7.56	240	2524	2018	.24	1.1	1910	43	465	127	.0	3.0	7210
2- 2-72	1191	13.0	10684	7.45	246	2452	2043	.10	1.6	1936	57	469	134	.0	3.2	7216
3-10-72	1276	-99.0	10265	7.46	250	2485	2136	.25	3.7	1945	56	472	124	.5	3.4	7349
5- 4-72	1390	19.0	10213	7.56	265	2427	2105	.32	2.8	1915	54	480	129	.2	3.3	7247
6- 1-72	1447	21.1	10216	7.27	261	2406	2167	.32	-.1	1910	54	477	129	.2	3.5	7275
7-10-72	1566	21.7	10938	7.46	269	2406	2219	.36	-.1	1861	54	495	134	.1	3.4	7295

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
9- 6-72	1632	24.4	10645	7.64	263	2404	2221	.38	.1	1985	53	480	134	.2	3.3	7411
10- 1-72	1698	21.1	10314	7.25	266	2439	2145	.26	-.1	2010	56	482	134	.3	3.5	7401
11- 8-72	1823	16.7	10709	7.27	268	2447	2164	.26	.2	1899	53	475	139	.4	3.6	7313
1- 4-73	1851	-99.0	10544	7.29	270	2341	2208	.30	-.1	1904	50	483	136	.2	3.7	7259
2- 1-73	1918	-99.0	9971	7.32	271	2236	2214	.22	.4	1857	48	454	135	.3	-99.0	7078
3- 4-73	1987	16.1	10358	7.61	270	2271	2167	.28	-.1	1930	50	446	128	.2	-99.0	7125
4- 1-73	2005	16.7	10100	7.46	276	2211	2186	.28	-.1	1935	51	441	130	.2	-99.0	7090
5- 3-73	2037	21.7	9954	7.46	285	2236	2175	.44	.2	1813	49	436	141	.6	-99.0	6991
5-31-73	2105	26.1	9814	7.32	325	2191	2380	2.60	2.1	1575	55	538	232	3.2	1.8	7141
7- 2-73	2128	28.3	10589	7.25	408	2307	2521	2.60	.7	1715	99	587	247	.7	-99.0	7680
8- 1-73	2167	23.3	9169	8.15	313	2167	2110	1.00	-.1	1700	63	455	150	.7	-99.0	6801
9- 5-73	2246	22.8	8729	8.19	303	2206	2094	.30	-.1	1695	57	462	169	.7	-99.0	6833
10- 2-73	2268	22.2	9956	8.13	229	2483	2101	.62	-.5	1707	48	444	150	.7	-.0	7047
11- 1-73	2285	-99.0	9979	8.34	277	2111	2102	.73	.2	1687	45	443	143	.7	-.0	6669
12- 4-73	2295	-99.0	9771	7.95	261	2149	2077	1.07	.1	1666	44	444	153	.7	-.0	6663
1- 2-74	2316	11.6	6185	8.22	130	2138	2133	-.07	-.1	1692	45	430	147	.7	-.0	6649

LW 50 E. WASH AVE DITCH 20S 62E 30 243 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
4-23-71	464	27.2	1518	7.49	208	89	538	7.00	.3	104	31	122	84	.0	.5	1078
6-14-71	538	36.0	990	9.60	-77	96	265	.12	.2	64	13	67	31	.0	.4	537
8-31-71	736	26.0	1493	7.77	158	127	442	1.96	.2	137	15	126	38	.0	.5	966
9-27-71	789	26.0	1993	7.75	149	144	775	.99	.4	173	44	154	90	.0	.5	1454
11-11-71	808	13.3	1433	8.95	317	71	418	2.30	.3	73	13	117	88	.0	.4	938
12- 2-71	917	10.0	1670	7.98	382	92	464	1.70	.3	103	20	120	97	.0	.4	1086
1- 3-72	1057	10.0	1416	8.30	214	77	409	.96	.2	91	10	104	74	.0	.4	872
4- 6-72	1359	27.8	1894	8.53	202	186	616	2.50	.7	178	26	160	65	.0	.6	1333
6- 1-72	1455	35.0	1450	7.41	252	109	466	2.00	7.4	112	16	149	53	.0	.5	1039
7-10-72	1585	33.3	1673	7.16	90	196	469	.50	.4	158	25	115	41	.2	.8	1050
9- 6-72	1645	23.9	524	7.40	200	15	117	2.10	3.6	14	6	85	19	.5	.3	362
11- 7-72	1793	-99.9	2032	7.38	261	193	582	4.90	.5	199	29	147	67	.5	.5	1352
12- 4-72	1825	10.0	1768	7.37	222	168	474	8.10	.4	169	16	133	50	2.3	.6	1131
1- 5-73	1867	-99.0	4656	7.90	273	412	2182	-.04	2.3	310	23	386	321	.2	.7	3772

LW 51 WINTRWD GC STREAM 21S 62E 10 233 1

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
4-23-71	463	27.2	4222	7.86	194	380	2008	.46	.1	288	21	384	305	.0	.6	3483
12- 2-71	916	5.0	4029	7.99	259	372	1929	-.10	.5	267	19	380	292	.0	.5	3388
1- 3-72	1040	8.0	4002	7.85	252	350	1809	-.10	3.1	254	18	348	271	.0	.5	3177
2- 1-72	1173	5.0	3650	8.14	239	307	1645	-.10	4.0	217	18	331	247	.0	.6	2887
3- 2-72	-0	-99.0	3832	8.03	213	347	1858	-.10	1.5	235	19	337	272	.0	.6	3174
4- 5-72	1348	23.3	4156	7.38	164	371	1904	.38	-.1	265	20	347	283	.0	.5	3271
5- 4-72	1419	27.8	4168	7.97	123	431	1951	.22	4.7	304	22	331	287	.0	.6	3392
6- 1-72	1453	31.1	4168	7.59	304	365	2040	.90	.4	276	26	424	286	.4	.6	3569
11- 6-72	1793	13.3	4457	7.98	-0	426	2074	-.04	.1	302	21	357	314	.2	.6	3495
1-31-73	1903	11.1	4046	8.25	187	390	2014	-.04	1.8	283	22	378	299	.3	-99.0	3480
3- 4-73	1995	18.9	4558	8.01	154	386	1950	-.04	-.1	273	21	345	295	.2	-.0	3346
4- 1-73	2011	14.4	4093	7.87	236	351	1908	-.04	.7	264	19	372	279	.2	-.0	3310
5- 3-73	1978	30.0	4072	7.98	144	375	1860	-.04	.2	245	17	333	265	.1	-99.0	3166
3- 2-74	2325	22.2	3958	7.96	173	345	1840	.04	.7	261	18	334	254	.1	-.0	3138
4- 4-74	2331	10.0	3958	7.96	268	326	1776	.06	.7	262	17	336	252	.1	-.0	3102
5- 9-74	2338	23.9	3700	8.45	229	345	1627	1.18	.2	286	16	316	233	.1	-.0	2937
6- 5-74	2355	32.2	2911	7.62	184	434	964	12.00	12.2	412	37	180	98	.1	-.0	2239
8- 2-74	2366	35.6	3759	8.29	195	348	1640	.38	-.5	265	21	300	233	.1	-.0	2903
10- 3-74	2378	26.7	2224	7.55	141	97	1070	-.02	7.0	116	35	302	71	.1	-.0	1768

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
11- 6-74	2384	11.1	3862	7.99	283	307	1548	.02	4.0	256	19	305	236	.1	-.0	2814
12- 4-74	2390	10.6	2582	7.26	212	214	1079	-.03	8.0	167	22	229	152	.1	-.0	1975
2- 6-75	2402	11.1	3698	8.24	224	298	1669	.04	3.5	257	19	304	223	.1	-.0	2884
3- 7-75	2408	20.0	3523	7.84	231	285	1599	.18	.1	273	20	268	223	.1	-.0	2782
4- 3-75	2414	19.4	3558	7.51	230	303	1669	.27	3.1	231	18	423	216	.1	-.0	2977
6- 3-75	2421	24.4	3561	6.70	204	303	1436	1.78	-.1	256	18	271	206	.1	-.0	2592
7- 1-75	2427	26.7	3917	6.20	176	350	1675	.43	-.5	311	21	294	225	.1	-.0	2963
LW 52 LVBM USED WATER			21S 62E 35 413 1													
5-17-71	470	-99.0	10289	7.51	129	2318	2142	-.10	1.0	1330	69	602	229	.0	1.2	6756
LW 54 LVBM NEW POND			21S 62E 34 443 1													
6-11-71	529	26.0	3026	8.00	169	503	660	.14	-.1	279	24	149	133	.0	1.3	1828
12- 2-71	911	6.0	2520	8.02	150	426	600	-.10	1.0	245	18	139	114	.0	1.0	1618
1- 4-72	1051	15.6	2576	8.04	148	442	588	-.10	2.2	240	17	140	113	.0	1.0	1616
2- 1-72	1183	6.0	2502	8.01	154	418	568	-.10	2.9	233	17	129	111	.0	1.0	1556
5- 3-72	1408	24.4	2918	8.13	157	517	700	-.04	-.1	303	25	144	130	.0	1.3	1897
LW 55 STAUFF CUT FLUME			22S 62E 12 324 1													
6-11-71	532	30.0	18936	12.55	-77	2393	798	.24	7.2	2932	7	6	-0	.0	.3	6143
7-26-71	638	23.9	4311	8.74	174	961	512	.24	3.7	849	49	52	28	.0	.3	2541
8-30-71	711	26.7	12621	1.85	-77	849	3228	.58	6.6	1312	11	205	61	.0	.3	5673
9-23-71	785	29.0	9154	3.90	-77	1235	3280	.39	8.3	2003	8	280	80	.0	.4	6896
11-11-71	815	30.0	9428	2.27	-77	1664	1114	3.00	39.0	1307	7	66	23	2.3	.2	4225
12- 1-71	906	29.0	20394	7.28	255	6663	846	.20	1.2	4430	9	202	75	.9	.4	12353
1- 3-72	1066	22.0	5767	11.25	-77	1365	434	-.10	16.0	1220	6	33	3	2.6	.2	3079
2- 2-72	1193	23.0	8407	10.75	49	2533	362	-.10	4.3	1823	6	53	25	2.6	.3	4834
3- 2-72	-0	-99.0	8843	2.20	-77	702	2732	2.10	12.9	1099	12	158	52	.3	.5	4770
4- 6-72	1352	24.4	60911	1.36	-77	20960	2127	17.50	10.7	14365	14	128	35	.3	.3	37658
5- 4-72	1391	29.0	18153	2.31	-77	4774	2254	1.40	4.6	3670	8	155	50	.2	1.0	10919
6- 1-72	1465	28.3	20842	1.32	-77	947	3509	28.00	11.2	402	5	170	37	.2	.3	5110
7-10-72	1571	26.1	3069	2.90	-77	468	629	-.04	9.5	302	6	102	40	.2	.4	1557
8- 7-72	1640	28.9	5187	3.67	-77	1400	431	.30	3.5	944	4	84	31	.2	.3	2898
9- 7-72	1663	30.0	14501	12.51	0	2237	508	.08	5.2	2595	6	19	1	.2	.3	5372
10- 1-72	1679	28.3	3872	11.80	0	588	320	-.04	4.7	699	5	17	6	.2	.3	1641
1- 5-73	1862	-99.0	12416	13.35	0	15815	2267	-.04	27.5	22100	17	70	-1	.2	-100.0	40297
LW 57 CORN CREEK SPRING			17S 59E 34 112 1													
6-14-71	543	22.2	524	7.65	289	11	22	-.10	3.8	7	2	51	33	.0	.2	271
LW 58 BONNIE SPRINGS			22S 58E 02 332 1													
6-15-71	544	19.2	782	7.50	356	17	92	-.10	.5	11	2	91	41	.0	.2	430
LW 59 FLAM RES COMP GW			21S 62E 19 111 3													
1- 5-72	1087	-99.0	913	7.80	224	22	278	-.10	3.8	20	3	105	44	.0	.3	587
2- 2-72	1185	17.0	923	7.76	226	24	282	-.10	3.8	23	3	97	49	.0	.4	594
7-10-72	1578	19.4	1059	7.75	225	39	342	-.04	2.4	26	3	114	54	.0	.4	691
10- 1-72	1687	20.6	1577	7.92	204	135	532	.28	3.7	113	6	146	64	.2	.5	1101
11- 7-72	1798	13.9	1568	7.76	160	151	497	3.70	1.9	141	10	141	39	1.3	.6	1065

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
POINT IDENTIFIER AND LOCATION																
5- 2-73	2030	25.6	1800	6.85	91	375	590	14.70	2.0	140	34	163	39	14.0	-99.0	1417
5-30-73	2099	30.6	1664	7.23	148	151	538	.98	.6	166	14	145	30	.3	.6	1120
7- 2-73	2113	31.1	1768	7.13	148	158	564	.72	.4	193	32	150	36	.5	-99.0	1208
8- 1-73	2182	33.3	1552	7.88	151	138	504	.80	.2	189	9	150	32	.5	-99.0	1097
LW 60 FLAM WASH 3			21S 61E 12 413 1													
7-26-71	651	23.3	4962	7.59	332	383	2550	-.10	-.1	340	20	429	378	.0	.6	4264
8-31-71	733	24.0	4679	7.65	315	331	2222	-.10	.3	285	19	437	333	.0	.6	3783
9-27-71	786	19.0	4892	7.77	327	399	2542	-.10	.1	351	23	466	380	.0	.7	4322
11-11-71	807	15.6	5280	7.74	324	395	2389	-.10	.5	344	23	445	375	.0	.6	4132
12- 2-71	922	14.0	4555	7.68	332	533	2307	-.10	.8	312	25	455	390	.0	.6	4186
1- 4-72	1072	8.1	4299	7.78	321	298	2115	-.10	2.4	265	21	434	300	.0	.6	3594
2- 1-72	1177	8.0	3783	8.19	311	226	1904	-.10	3.6	223	23	391	260	.0	.7	3185
3- 3-72	1272	-99.0	4085	8.02	304	278	2109	-.10	1.8	256	20	385	293	.0	.7	3493
4- 5-72	1334	18.2	4504	7.37	327	348	2418	-.04	.5	313	20	426	349	.0	.7	4036
5- 4-72	1385	21.0	4387	7.84	347	330	2319	-.04	2.4	302	20	434	332	.0	.7	3911
6- 1-72	1459	23.9	2912	6.87	303	175	1396	-.04	.8	156	24	311	184	.0	.6	2396
7-10-72	1580	25.0	4712	7.64	323	326	2410	-.04	.8	299	19	439	332	.1	.7	3985
8- 7-72	1635	24.4	4826	7.63	332	327	2315	-.04	-.1	295	19	434	332	.1	.7	3886
9- 5-72	1641	20.6	4330	7.54	296	328	2148	.14	1.0	285	26	378	310	.1	.6	3622
10- 1-72	1686	20.6	4510	7.35	329	341	2352	-.04	.4	307	20	427	339	.2	.7	3949
11- 7-72	1808	16.1	4539	7.51	335	312	2274	-.04	.8	292	21	408	319	.2	.7	3792
12- 4-72	1841	13.3	-99999	7.64	336	284	2186	-.04	1.7	290	24	406	307	.1	.8	3665
1- 5-73	1869	-99.0	4325	7.82	341	271	2203	-.04	2.2	280	24	396	306	.2	.6	3651
1-31-73	1905	11.1	3650	7.94	325	221	1954	-.04	3.4	223	26	379	261	.2	-99.0	3227
3- 5-73	2001	13.3	4350	7.92	335	253	2066	-.04	1.7	255	23	407	284	.1	-99.0	3454
4- 1-73	2016	17.8	4042	7.72	322	241	2049	-.04	2.6	250	23	402	277	.1	-99.0	3407
5- 2-73	1981	24.4	3836	7.37	281	243	1993	.28	.4	236	15	378	263	.6	-99.0	3268
5-30-73	2100	30.6	4434	7.72	330	310	2353	-.04	.4	294	20	424	325	.2	.5	3890
7- 2-73	2113	22.2	5000	7.87	338	335	2550	-.04	.7	355	42	438	355	.1	-99.0	4242
8- 1-73	2178	25.6	4765	7.70	262	326	2548	-.04	.3	346	22	442	349	.1	-99.0	4162
LW 61 LVSTP INFL			21S 62E 10 342 1													
1- 3-72	1039	21.9	1878	7.10	320	268	235	41.00	-.1	206	12	80	39	32.7	1.5	1072
4- 5-72	1347	25.6	1188	6.97	440	91	74	33.00	.2	120	13	61	34	21.0	1.4	666
LW 62 CLARK CO STP INFL			21S 62E 22 222 1													
1- 3-72	1055	21.9	1661	7.03	338	125	353	36.00	-.1	177	14	96	44	22.8	.7	1035
4- 5-72	-0	23.9	1474	6.91	448	134	216	2.80	.2	155	18	85	48	20.0	1.1	900
LW 63 LVW 4 NORTH			21S 63E 29 324 2													
7- 7-71	622	-99.9	5360	7.95	296	862	1432	13.50	3.3	699	34	390	137	.7	1.5	3719
7- 7-71	625	-99.9	5643	8.00	290	940	1489	14.10	2.9	678	34	404	143	.6	1.5	3850
7- 7-71	628	-99.9	6043	8.00	290	998	1592	13.80	2.1	735	35	427	150	.6	1.6	4098
11-10-71	823	8.9	3933	7.77	226	565	995	17.80	43.0	450	31	248	108	1.0	1.2	2571
12- 1-71	895	10.8	3118	7.43	211	457	862	20.80	40.0	362	27	215	99	1.4	1.0	2189
1- 3-72	1032	6.9	3252	7.84	197	462	899	19.60	46.0	378	27	210	98	1.1	1.1	2238
2- 1-72	1165	2.0	3383	7.57	195	457	970	18.70	52.0	392	33	227	109	1.4	1.0	2357
3- 2-72	1256	9.4	3843	7.74	243	501	1163	19.30	22.0	454	34	263	123	.3	1.2	2701
5- 4-72	1376	15.5	3668	7.94	269	517	1096	21.00	8.9	462	24	255	111	.3	1.3	2629
7-10-72	1530	23.5	3762	7.81	269	485	1050	21.00	15.1	442	25	245	105	.1	1.4	2522

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LW 64 DUCK CK AT US 93			21S 62E 27 434 1													
7-10-72	1573	31.1	3732	6.78	118	623	933	1.70	2.8	467	33	219	79	10.0	.8	2428
LW 65 LVW ABOVE LW030			21S 63E 28 131 3													
11-11-71	816	13.3	5678	8.00	211	997	1380	11.00	58.0	567	63	434	187	.0	1.0	3802
12- 1-71	925	15.0	5061	7.45	223	895	1386	10.50	66.0	496	62	423	182	2.1	1.0	3634
1- 3-72	1008	9.0	5034	7.60	212	883	1394	10.30	58.0	534	53	402	176	.8	1.0	3616
2- 1-72	1159	5.0	5108	7.84	205	851	1378	12.60	63.0	512	56	387	177	.2	1.0	3538
3- 2-72	1245	13.9	5896	7.66	241	1110	1732	6.00	61.0	612	74	486	220	.2	1.0	4421
4- 5-72	1337	19.0	5119	7.48	239	936	1506	10.50	47.0	551	59	416	186	.2	1.1	3831
5- 4-72	1366	17.0	5732	7.74	250	1052	1642	8.40	49.0	595	67	504	207	.2	1.1	4249
6- 1-72	1439	21.7	5425	7.23	255	999	1529	10.70	42.0	588	66	441	197	.8	1.1	4000
7-10-72	1524	21.8	6657	7.57	249	1279	1889	3.00	58.8	663	81	581	244	.1	-.0	4921
8- 6-72	1597	25.0	7183	7.56	254	1299	1884	1.70	53.0	653	84	594	254	.1	1.0	4948
10- 1-72	1685	20.0	6805	7.32	245	1365	1856	.65	56.0	678	94	611	269	.2	1.0	5051
10- 5-72	1708	20.0	454	7.10	267	7	26	-.00	1.7	16	3	29	34	.2	.7	248
LW 66 HEND STP INFL			21S 62E 36 344 2													
1- 3-72	1062	19.1	2919	7.01	254	458	607	35.00	4.6	360	18	173	65	19.1	.7	1869
4- 6-72	1356	22.2	2733	6.93	371	419	558	31.00	3.9	334	19	167	67	29.0	.9	1811
LW 67 BMI STP INFL			22D 63E 07 111 1													
1- 3-72	1063	20.0	1500	7.03	186	135	328	53.00	.6	157	11	88	29	14.4	.2	908
4- 6-72	1354	21.7	1495	7.31	345	136	280	29.00	.3	168	12	84	32	28.0	.7	940
LW 68 BC STP INFL			23S 64E 09 431 1													
1- 6-72	1042	17.8	1540	7.00	250	132	305	51.00	.5	175	15	75	28	31.2	.4	936
4- 6-72	1363	22.2	1515	6.95	248	163	298	45.00	.4	183	14	85	31	20.0	.3	963
LW 69 BC STP EFFL			23S 64E 09 431 2													
1- 6-72	1043	5.0	1762	7.63	271	214	367	34.00	.3	224	15	104	35	20.5	.3	1148
4- 6-72	1364	20.6	1894	7.55	277	243	412	22.00	.3	250	19	96	39	13.0	.2	1231
LW 70 FLAM WASH AT LAMB			21S 62E 05 322 1													
1- 4-72	1073	6.0	3285	7.89	265	326	1735	-.10	3.6	245	18	365	248	.0	.4	3071
2- 2-72	1186	10.0	4170	8.27	239	369	1912	-.10	2.1	262	19	368	295	.0	.6	3345
3- 2-72	-0	-99.0	3958	8.09	219	359	1922	-.10	.9	259	17	341	290	.0	.6	3298
4- 6-72	1362	25.6	4279	8.00	188	408	2080	.08	.3	280	18	372	309	.0	.5	3561
5- 4-72	1384	31.0	4168	8.20	180	417	1989	-.04	-.1	282	16	362	296	.0	.6	3451
6- 1-72	1456	33.3	4291	7.69	298	422	2073	.10	.1	304	19	409	313	.0	.6	3687
7-10-72	1583	31.7	4100	7.78	129	419	1898	-.04	.2	291	18	326	273	.1	-99.0	3289
11- 7-72	1809	14.4	4663	8.15	229	444	2155	-.04	.9	319	20	383	326	3.7	.6	3765
12- 4-72	1826	13.3	4678	8.10	278	414	2131	-.04	1.8	309	23	396	313	.1	.6	3725
1- 5-73	1868	-99.0	4491	8.12	283	399	2101	-.04	4.6	299	21	382	314	.1	.5	3661
1-31-73	1904	12.2	4234	8.40	136	416	2157	-.04	2.5	303	23	371	316	.3	-99.0	3656
3- 4-73	1996	15.6	4536	7.98	167	402	2100	-.04	1.2	294	20	369	307	.1	-99.0	3575
4- 1-73	2014	13.9	4295	8.12	186	430	2085	-.04	.6	284	19	379	299	.1	-99.0	3588

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
POINT IDENTIFIER AND LOCATION																
5- 2-73	1979	25.6	4180	7.87	217	398	2050	-.04	.4	277	15	376	295	.6	-99.0	3519
5-30-73	2091	25.0	4374	7.78	267	432	2039	-.04	-.1	292	19	376	310	.2	.6	3600
7- 3-73	2114	28.3	4296	7.89	209	425	1872	-.04	.2	300	27	346	274	.1	-99.0	3347
8- 1-73	2176	33.3	4244	8.00	236	460	1870	.10	.2	321	23	384	295	.1	-99.0	3469
LW 71 UPPER POND SEEP 21S 63E 31 331 3																
1- 4-72	1071	6.0	9413	7.65	94	1944	2751	-.10	172.0	1170	38	705	387	.0	.4	7213
2- 2-72	1189	10.0	9070	8.01	85	1800	2583	-.10	179.0	1072	39	684	371	.0	.5	6770
3- 2-72	1266	-99.0	8928	7.85	88	1830	2787	-.10	165.0	1080	34	686	386	.0	.6	7012
7-10-72	1570	28.9	14578	7.67	144	3264	4063	-.04	194.0	1955	100	917	629	.0	-.0	11192
LW 72 FLAM WSH AT EMRSN 21S 61E 13 123 1																
1- 4-72	1041	8.1	3473	8.00	370	174	1774	-.10	2.2	190	29	380	238	.0	.8	2969
2- 1-72	1178	8.0	3440	7.94	354	162	1684	-.10	5.0	176	30	359	236	.0	.7	2827
7-11-72	1587	27.2	4966	7.40	363	264	2673	.40	2.6	366	36	474	325	.0	-.0	4320
11- 7-72	1794	-99.9	3580	7.77	380	170	1750	-.04	2.3	193	32	380	236	.1	.8	2951
12- 4-72	1842	11.1	-99999	7.72	380	176	1789	-.04	3.8	202	33	367	237	.1	.9	2995
1- 5-73	1870	-99.0	3601	7.70	381	172	1791	.08	6.0	196	33	366	247	.3	.8	2999
3- 5-73	2000	11.1	3625	7.92	368	172	1771	-.04	3.3	185	28	374	236	.1	-.0	2950
4- 1-73	2017	13.3	3406	7.85	355	159	1692	-.04	3.3	172	25	369	225	.1	-.0	2820
5- 2-73	1982	17.8	2538	7.76	265	120	1402	-.04	.6	129	15	317	167	.2	-99.0	2281
5-30-73	2101	22.2	3208	7.85	361	156	1645	-.04	.5	166	28	338	221	.2	.8	2733
LW 73 NE COR LOW POND 21S 63E 31 222 2																
1- 4-72	1077	6.0	11245	7.75	334	2568	2648	-.10	13.0	1994	63	575	239	.0	1.6	8266
2- 2-72	1192	8.0	11572	7.84	309	2568	2676	-.10	21.0	2018	57	561	258	.0	1.6	8313
3-10-72	1278	-99.0	11159	7.94	294	2670	2724	-.10	17.7	2040	76	530	249	.0	163.0	8614
6- 1-72	1448	28.9	13792	7.63	197	3224	3618	.08	26.0	2430	88	672	356	.2	2.0	10514
7-10-72	1567	23.9	16021	7.61	272	3579	3887	.10	8.5	2706	108	732	380	.4	-.0	11527
1- 4-73	1852	-99.0	9633	7.77	347	1877	2457	.08	4.0	1597	58	339	216	.2	1.8	6721
LW 74 FLAM RES DRAIN 1 21S 62E 19 111 4																
1- 6-72	1078	16.1	1842	8.01	253	157	645	-.10	8.7	95	5	187	99	.0	.4	1322
2- 1-72	1179	16.0	1877	7.99	123	156	631	-.10	7.7	84	4	174	100	.0	.4	1218
7-11-72	1588	34.4	1891	7.41	177	155	645	1.08	3.4	169	13	182	38	.0	-99.0	1293
11- 7-72	1795	18.3	1135	7.37	225	46	375	-.04	2.3	30	3	127	59	.0	.4	753
1- 5-73	1872	-99.0	1193	7.52	223	52	405	-.04	3.4	36	3	135	62	.2	.4	806
3- 5-73	1998	17.8	1347	7.78	222	70	433	-.04	.5	39	3	150	66	.2	-99.0	872
4- 1-73	2018	17.8	1465	7.66	217	78	451	-.04	4.0	41	3	152	68	.2	-99.0	904
5- 2-73	1967	18.9	1400	7.75	211	89	465	-.04	4.2	40	-1	149	72	-.1	-99.0	923
5-30-73	2097	23.3	1445	7.81	221	99	487	-.04	4.9	42	3	152	80	-.1	.4	977
7- 2-73	2120	22.8	1498	7.93	215	112	511	-.04	4.1	44	21	160	77	.1	-99.0	1035
8- 1-73	2179	18.9	1482	8.00	176	123	549	-.04	4.9	43	4	166	80	.1	-99.0	1057
LW 75 FLAM RES DRAIN 2 21S 62E 19 111 5																
6-14-71	545	21.7	1083	7.85	227	46	319	-.10	3.0	38	4	114	48	.0	.4	684
8-31-71	732	20.6	876	7.48	224	26	257	-.10	2.7	24	3	102	45	.0	.4	571
7-10-72	1579	20.0	1353	7.99	179	116	404	-.04	3.4	110	5	107	46	.0	-99.0	879
11- 7-72	1796	17.8	2249	7.46	232	217	749	-.04	10.4	137	5	199	114	.0	.4	1545
1- 5-73	1873	-99.0	2401	7.76	247	236	829	-.04	15.4	137	5	204	134	.1	.5	1682

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
POINT IDENTIFIER AND LOCATION																
3- 5-73	1999	17.8	2434	7.74	240	225	787	-.04	10.0	126	4	200	125	.1	-99.0	1595
4- 1-73	2019	16.7	2213	7.79	233	213	761	-.04	13.1	128	5	199	119	.1	-99.0	1552
5- 2-73	2038	18.9	1544	7.69	208	128	532	-.04	6.0	75	-1	151	78	.1	-99.0	1072
5-30-73	2098	20.0	1584	7.85	214	134	532	-.04	5.8	81	5	150	81	.2	.4	1094
7- 2-73	2121	22.2	1638	7.98	208	138	534	-.04	4.8	97	23	156	78	.2	-99.0	1132
8- 1-73	2180	-99.0	1682	8.00	184	153	561	-.04	6.2	131	6	170	80	.2	-99.0	1197
LW 76 CCSTP OUTFL FLUME 21S 62E 22 242 1																
5- 2-73	1974	24.4	2400	7.11	284	310	563	19.50	2.8	268	13	135	64	36.0	-99.0	1551
5-30-73	2096	26.7	2760	6.63	133	454	606	18.50	2.5	323	16	146	76	28.0	.5	1737
7- 2-73	2118	28.9	2817	7.15	303	408	603	18.70	1.6	326	33	151	73	30.0	-99.0	1794
8- 1-73	2172	28.9	2192	7.80	143	380	588	17.00	4.3	321	22	157	57	22.0	-99.0	1639
LW 79 LV CK AT FNSY PRK 20S 61E 26 322 1																
9- 6-72	1650	23.3	630	7.17	245	33	112	1.30	.8	25	9	95	20	.0	.3	416
LW 80 LV CRK AT MAIN ST 20S 61E 27 343 1																
9- 6-72	1651	22.8	497	7.03	171	20	92	1.60	.8	19	9	58	13	.0	.2	299
LW 81 LV CRK AT RANCHO 20S 61E 29 443 1																
9- 6-72	1652	22.8	319	319.00	128	12	40	2.20	.3	7	4	47	9	.0	.2	183
LW 82 LV CRK AT BEDFORD 20S 61E 31 214 1																
9- 6-72	1653	23.9	2470	6.98	1090	7	30	1.50	3.4	7	4	34	6	.5	.1	630
LW 83 LVW BELOW LW065 21S 63E 28 131 3																
12- 4-72	1837	15.6	7187	7.43	257	1382	1946	.48	52.0	677	90	638	273	.0	1.1	5186
LW 84 SAHARA-NEV. C.C. 21S 61E 14 142																
1-31-73	1908	12.2	2716	7.52	355	135	1280	-.04	3.3	142	18	290	172	.0	.8	2215
LW 85 LEROY APTS. 20S 61E 26 331 1																
1-15-73	1874	14.4	2433	7.84	395	88	1080	-.04	8.9	108	18	165	210	.0	.3	1871
LW 86 MRLND PKWY HARRS 20S 61E 26 331 2																
1-15-73	1875	17.2	1878	7.72	316	66	748	-.04	9.1	82	9	137	146	.0	.3	1353
LW 87 BALLARD ND ESTRN 21S 61E 02 111																
1-15-73	1876	19.4	4119	7.67	365	213	2076	.20	13.3	276	88	257	317	.0	.5	3421
LW 88 MONT WARDS 21S 61E 01 211																
1-15-73	1877	23.3	4503	7.61	321	312	2184	-.04	12.3	397	41	258	320	.0	.3	3683

POINT IDENTIFIER AND LOCATION

MO DA YR	NUMB	TEMP	COND	PH	HCO3	CL	SO4	PO4	NO3	NA	K	CA	MG	NH4	F	DS-SUM
LW 89 CORTZ PRKING LT 20S 61E 34 131																
1-16-73	1879	20.6	1827	7.51	356	105	557	.20	-.1	174	18	120	70	.0	.4	1220
LW 90 CONV CNTR 21S 61E 10 331																
1-19-73	1883	20.0	3009	7.61	270	98	1551	-.04	29.3	153	11	291	214	.0	.3	2480
LW 91 DUNES HO 21S 61E 20 114																
1-19-73	1884	27.8	2151	7.58	154	74	1083	-.04	3.4	42	10	356	85	.0	.6	1730
LW 92 SAHARA HO 20S 61E 09 111																
1-21-73	1885	17.8	4644	7.49	71	267	2463	-.04	-.1	449	109	507	99	.0	.4	3929
LW 94 SEARS 21S 61E 14 223																
1-24-73	1888	20.0	3039	7.62	242	171	1514	-.04	18.6	170	23	268	214	.0	.6	2498
LW 96 BONANZA ND UPRR 20S 61E 27 341																
1-28-73	1890	12.2	1606	7.87	545	83	350	-99.00	.3	57	10	139	102	.0	.4	1010
1-28-73	1891	11.7	1545	7.95	360	111	416	-.04	26.0	80	15	126	93	.0	.4	1044
LW 98 CAS CTR ND OGD 30 20S 61E 34 211																
1-16-73	1878	17.8	665	8.14	221	38	116	-99.00	1.5	21	10	40	51	.0	.3	387
LW 99 DEL AMO ND SAND 9 20S 62E 31 341																
1-18-73	1882	17.2	8722	7.88	194	534	5433	-99.00	12.7	924	824	403	758	.0	.4	8985
LW100 CEN TEL BLDG 20S 61E 34 133																
1-19-73	1886	-99.0	1576	7.92	416	85	477	-99.00	.2	87	24	84	116	.0	.3	1078

Appendix 4. Chemical Analyses Used to Determine Historical Changes in Ground-Water Quality

Location	Source	Depth (feet)	Date Collected	Flow (cfs)	Remarks	Calcium	Magnesium	Sodium	Sodium & Potassium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Nitrate	Alkalinity	Dissolved solids mg/ℓ Total	Evaporation	Summation	Specific cond (micromhos/cm)	Hardness (as $CaCO_3$)
						Concentration of principal ions, mg/ℓ															
19/60- 9cdal	MJ	612	10-23-44			46	26		4		250		19	5			350		223		221
9cdal	DM	612	03-15-63			43	30		8		246		31	5		202		274	238		220
9cda	LG062	612	10-04-72			46	25	6.9	7.8	0.92	243		31	3.4	1.5				234	430	
9abbl	MJ	706	09-13-45		ζ	38	28		5		240		22	3.9			338		215		211
9abbl	DM	706	1962-3		ζ	38	28		30		244		21	4.0		200		258	253		216
9abb	LG061	716	10-04-72			43	26	9.4	10.7	1.3	247	12	21	5.9	2.2				229	424	
21cccl	MJ	8	09-13-45			55	29		3		274		31	2.8			394		256	467	256
23bbcl	MJ	560	10-25-44			46	26		4		250		19	5			350		223	442	222
23bbcl	DM	560	03-15-63			40	24		8		232		17	6		190		237	209		200
23bbc	LG113	920	06-08-73			39	24	10.3	11.6	1.3	239		20	6.2	2.9				221	417	
27aabl	MJ	605	10-23-44			44	27		8.9		247		23	8.8			358		233	420	219
27aabl	DM	605	1963			48	15		0		300		12	32		246		206	255		472
27aab	LG114	605	06-08-73			41	24	7.9	9	1.1	239		26	4.3	2.4				224	433	
20/60-24b	C	232	09-14-12	1.37	Δ	52	3		43		235		34	4	1.3			251	253		141
24adbl	HM	385	10-16-30	0.05	Δ	57	32				249		41	9.3				208	263		
24aaa	LG112	312	06-08-73			52	36	17.4	18.9	1.5	262		75	20	11.5				341	613	
20/61- 3dabl	MJ	242	05-01-41			54	15		24		237	tr	45	7		194	245		262		196
3dabl	M	300	10-16-56			48	23	6		1.1	232		34	4.9	1.5			249	233	421	
3dabl	DM	350	11-09-62			51	25		24		246		2	15		202		276	238		232
3dab	LG066	350	10-05-72			44	23	8.6	9.5	0.93	231		33	4.94	1.3				229	412	
4addl	HM	850	10-12-31	1.6		12	19		71		220		72	7.1				200	289		
4add	LG119	900	06-12-73			32	19	18.4	21	2.6	193		38	3.9	0.6				209	384	
13adcl	M	930	01-24-47			54	32		20		205		129	3.2	1			341	340	551	266
13adcl	DM	930	04-11-63			32	44		10		266		50	8		218		358	275		260
13adb	DRI	300	01-31-68			34	26		27		218		24	4.5			334		240	487	
13adb	LG117	300	06-08-73			36	37	221	24	2.4	251		69	17.8	1.9				309	549	
14dddl	M	402	01-24-47			46	27		0.9		226		35	3.5	0.8			225	224	424	226
15abl	M	1700	04-20-56			14	11	139	182	43	284		114	8	0.3			484	469	721	80
15bl	C		09-16-12	0.9	A	53	27		26		251		33	55				258	317		243
16bdbl	M	386	01-21-47			44	23		2.8		212		27	4.8	1.4			208	207	382	204
18bccl	MJ	412	02-16-45			46	26		12		212	21	30	5.3			352		245	434	222
18bccl	DM	412	11-26-62			56	76		23		288		5	5.8		236		243	307		176
18bcc	LG126	500	06-08-73			47	22	7.2	7.8	0.6	234		59	3.8	2				227	429	
19abdl	MJ	260	10-23-44			49	26		4.8		238		32	7.1			357		236	428	
19ddcl	MJ	280				48	26		8.7		242		34	6			364		242	432	224
19dda	LG121	295	06-08-73			48	22	7.0	8.6	1.6	235		36	3.9	2.2				236	434	

Appendix 4 (continued)

Location	Source	Depth (feet)	Date Collected	Flow (cfs)	Remarks	Calcium	Magnesium	Sodium	Sodium & Potassium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Nitrate	Alkalinity	Dissolved solids mg/ℓ Total	Evaporation	Summation	Specific cond (µmhos/cm)	Hardness (as $CaCO_3$)
						Concentration of principal ions, mg/ℓ															
20/61-20caa	DRI	300	01-31-68			104	82	68.3	76	8.1	335		457	30			1084		914	1180	
20caa	LG068	300	10-05-72			58	43	16.4	18.2	1.8	242		134	17.8	6.4				396	652	
20caa	LG067	665	10-05-72			55	32	9.7	11	1.3	234		72	13.3	3				301	519	
20caa	DRI	665	01-31-68		**	64	42	16.5	19.6	3.1	250		117	15.8			507		381	678	
20cac1	HM	347	09-15-44			44	14		33		237		30	10		194		240	248		167
20cac1	DM	347	11-26-62			80	0.97		0		305		5	63		250		237	299		204
20cab	LG069	400	10-11-72			63	42	16.2	18.1	1.9	258		134	14.5	5.1				403	664	
20cbc1	MJ	278	10-18-44			49	26		5.9		242		33	6.2			361		239	427	227
20cdc1	MJ	325	10-18-44			49	26		4.6		238		36	5.3			359		238		230
20cdc1	DM	325	11-26-62			37	19		16		298		20	31		244		263	270		172
21	M	125	07-21-52			164			190		243		417	136			1190		1026	1700	
22b1	C		09-16-12	0.5	Λ	53	27		26		251		33	55	2		258		319		243
27	C	28	09-23-12			60	47		23		273		141	18	tr.			455	423		343
27c1	HM		08-31-25		γ	187	607		738		203		3839	288				6332	5760		
27c1	HM		08-31-25		γ	147	147		66	57	444		695	19.4				1462	1349		
27adb1	MJ				γ	78	21		9		249		61	22		204	323		313		281
27cdd1	MJ	357	06-14-35			57	9		33		232		22	28		190	335		263		179
28cbd1	MJ	660	01-19-45			43	23		10		221		31	6			334		222	402	200
28cbd1	DM	660	12-14-62			54	27		34		216		11	5		218		260	237		248
28cda1	MJ	440	10-25-44		θ	38	22		10		210		27	5			312		205	375	185
28cda	LG070	440	10-11-72			89	63	21	25	3.5	338		183	61	6.3				593	957	
28cda1	MJ	690	10-25-44		T	38	24		11		192	6	33	6			310		212		193
28cda1	DM	690	12-19-62		T	40	29		27		224		5	12		192		607	223		220
28dac1	MJ	640	01-19-45			46	22		6.7		171		24	11			280		194	335	203
28dac1	MJ	805	01-19-45			40	22		9.2		210		30	5.3			317		210	408	192
29cbc2	HM	600	02-05-32	1.1		64	20		7.9		233		58	5.5				235	270	557	
29cbc	LG127	600	06-08-73			49	23	7	8.9	1.9	233		40	5.3	2.5				243	443	
29cbb1	HM	375	02-05-32	0.7		36	22		5.1		181		32	7.1				190	191	404	
29ccc1	MJ		10-02-42			60	19		11		220		45	13		180	265		256		228
29dbb1	MJ	475	10-18-44			48	25		5.7		236		33	5.3			354		233	429	224
29dbb1	DM	475	1962-3		δ	120	0		3.7		254		257	150		208		606	656		
29dca1	MJ	664	10-24-44			46	25		6.2		227		32	7.1			343		228	423	216
29dca1	DM	664	11-26-62			54	33		0		293		5	6.3		240		254	242		222
30dd	C		09-23-12	5.74	λ	56	23		17		239		43	2	6			267	265		234
30bbb1	HM	350	03-27-31	1.1		51	24		7.6		249		38	tr.				247	243		227
30bbb1	DM	350	11-26-62			56	48		0		228		12	57		236		218	285		336

Appendix 4 (continued)

Location	Source	Depth (feet)	Date Collected	Flow (cfs)	Remarks	Calcium	Magnesium	Sodium	Sodium & Potassium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Nitrate	Alkalinity	Dissolved solids mg/ℓ Total	Evaporation	Summation	Specific cond (µmhos/cm)	Hardness (as $CaCO_3$)
						Concentration of principal ions, mg/ℓ															
20/61-31aad2	M	500	11-02-51			50	26				238		43	3.5	2.1				242	430	232
31dac1	M	940	05-16-52			48	25	8	11.6	3.6	222		51	6.5	1.			267	265	447	222
32acb2	MJ	660	02-16-45			46	25		11		235		40	7.1			365		245	441	220
33cca1	MJ	200			θ	46	28		9.2		233		44	8.8			369		251	447	229
33cca1	MJ	400			T	47	26		12		233		46	8.8			373		254	446	225
20/61-33cca	LG073	400	10-11-72			93	73	35	40	4.6	271		316	62	3.3				720	1074	
33cca2	MJ	226	02-21-38			84	tr.		32		270		47	7.0		221	280		303		210
33cca	LG122	226	06-08-73			44	26	7.3	10.7	2.4	225		46	4	2				242	438	
33ccb2	MJ	425				49	13		26		231	3.6	25	7.8			357		238	423	177
33ccb	LG072	425	10-11-72			92	95	80	91	11.1	292		457	73	4.9				956	1415	
34adc1	MJ	354	01-19-45			28	19		11		162		26	8.8			255		172	326	148
34adc1	DM	354	1962-3			53	4.9		33		300		24	46		246		301	308		152
34bcb1	MJ		06-14-41			84	25		50		305		144	16		250	460		469		312
34bcb1	DM		04-11-63			35	24		9		203		31	5		166		256	204		188
34bcb	LG074	780	10-12-72			42	21	7.6	9.9	2.3	209		37	6.7	1.9				221	397	
35cbb2	MJ	460	09-14-45			31	22		4		162	tr.	32	6			256		175	339	166
35cbb2	DM	460	12-19-62			40	29		18		224		6	14		184		148	217		220
35ccb	LG123	460	06-08-73			42	23	9	11.7	2.7	204		46	5.3	1.9				230	414	
35ddc2	MJ	418	09-14-45			39	26		5		206	tr.	40	3.2			319		214	377	205
36bbb1	MJ	325	01-19-45			44	26		10		233		36	7.1			356		238	424	216
36bbb1	DM	325	10-29-62			20	30		86		188	0.3	6	13		154		168	248		176
36bbb	LG063	325	10-05-72			43	25	7.9	9.6	1.7	235		39	5.9	2.2				239	438	
20/62- 1bbc1	M	1247	03-02-55			47	43	46	51	4.5	198		171	39	2			522	450	748	294
3dab1	M	504	10-16-56			46	23	7	8.8	1.8	232		32	4.5	1			248	229	413	230
4add1	MJ	800	05-05-41			60	17		15		244		34	12		200	255		258		220
4add1	M	790	10-17-56			43	23	18	22	3.8	252		25	5.8	2.4			272	245	440	201
4add	LG118	800	06-08-73			35	25	18.3	21	2.8	243		29	7.5	3.3				240	519	
8acd	DRI	120	12-31-67			32	35	15.1	19.3	4.2	258		26	4.9			374		243	483	
8acd	LG065	120	10-05-72			29	34	15.9	18.8	2.9	267		26	6.7	1.7				247	454	
9abc1	M	1000	10-17-56			39	19	91	98	7.1	228		162	18	0.7			486	449	728	176
9bcc1	M	1000	10-17-56			38	25	49	55	5.8	256		88	8.6	0.9			399	341	575	199
18bbc	DRI	300	12-31-67			26	46	11	14.1	3.1	278		34	3.8			402		261	520	
18bbc	LG064	300	10-05-72			24	44	12	14.2	2.2	286		34	4.9	0.93				278	491	
19bbb1	MJ		12-17-45			25	10		56		204		35	15		28	294		241		102
19bbb	LG116	289	06-08-73			26	34	27	31	4	249		48	8.3	1.1				270	486	
19cab1	MJ		12-17-45			39	15		84		221		110	32		181	408		389		159
19cab	LG115	200	06-08-73			24	29	15	16.8	1.8	200		37	7.3	1.8				214	399	
30	M	132	10-27-52			162			175		218		451	75			1050		970	1500	

Appendix 4 (continued)

Location	Source	Depth (feet)	Date Collected	Flow (cfs)	Remarks	Concentration of principal ions, mg/ℓ: Calcium	Magnesium	Sodium	Sodium & Potassium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Nitrate	Alkalinity	Dissolved solids mg/ℓ: Total	Evaporation	Summation	Specific cond (μmhos/cm)	Hardness (as $CaCO_3$)
21/61- 1bba	LG075	400	10-12-72			23	20.2	11.6	15.5	3.9	165		35	4.4	1.6				181	335	
1cdcl	M		01-21-47			49	26		3.9		223		47	3.5	1.3			241	240	428	230
2cbbl	MJ	1120	01-19-45			32	18		50		152		124	6.2			382		305	508	154
3a	C	442	09-23-12			54	25		10		251		39	10				318	261		237
3abb2	MJ		09-14-45		θ	45	26		4.1		218	tr.	41	2.8			337		226	423	219
3abb2	MJ	807	09-14-45		T	40	23		5.5		199		39	3.2			310		209	398	196
21/61- 3bcc2	MJ	800	10-10-35			51	13		26		210		50	10		172	225		253		181
4aadl	MJ	793	01-19-45			41	23		17		223		37	9.6			351		237	418	197
4baal	MJ	381	01-19-45			31	27		29		236		46	7.1			376		256	448	188
4baa	LG071	400	10-11-72			71	112	62	70	8.3	11.9		671	62	1.06				993	1380	
4dacl	MJ	810	05-19-41			60	18		2		220		32	10			228		230		
4dacl	DM	810	04-16-63			62	38		11		232		125	10		190		388	360		312
4dac	LG125	810	06-11-73			49	25	8.9	11.3	2.4	222		61	5.8	2.1				264	469	
4dac2	MJ	650	10-25-44			36	26		10		174	16	42	5.0			309		221	404	197
4dac2	DM	650	04-16-63			61	37		8		229		115	8		188		370	342		304
4dac	LG124	650	06-11-73			54	29	10.6	13.5	2.9	220		90	7.8	2.4				304	529	
4ddbl	MJ	400	10-09-45			60	17		2		195		44	10		160	265		229		220
6accl	M	394	07-06-47			54	29		11		231		74	5.0	3.5			290	290	501	254
7accl	MJ		03-15-45		θ	49	28		7.1		232		51	5.3			372		254	458	236
7accl	MJ	355	03-15-45		T	48	27		10		232		52	7.1			376		258	458	232
9acdl	MJ	550	10-17-44			45	24		11		223		39	8.8			350		237	424	212
10cdal	M	931	04-13-53			143			521		95		1050	210			2100		1971	3000	
13bdbl	M	260	01-21-47			60	29		10		227		71	2.5	2.9			278	287	485	268
15bccl	M	892	01-23-47			47	25		4.1		211		47	3.8	1.4			233	232	420	220
15bccl	DM	892	1962-3			46	22		12		203		56	5		166		266	241		208
18dbdl	HM	300	09-10-30	0.3	}	68	32		12		243		109	10				329	350		
21bbbl	MJ	325	10-17-44			40	24		9.2		204		40	5.3			322		219	399	197
22cccl	M	500	01-06-47			65	32		7.8		227		106	7.0	4.3			334	334	560	294
23ccbl	M		01-23-47			72	37		15		216		165	8.8	1.4			406	405	657	332
24aad	DRI	100	01-29-68			70	32	10	13	3	221		109	7.5			452		339	594	
24aad	LG078	100	10-13-72			178	108	115	120	5.1	261		741	157	11.2				1444	2006	
24aad	DRI	150	01-29-68			74	36	19.4	23	3.3	216		115	17.3			480		370	667	
24aad	LG077	160	10-13-72			98	56	42	45	2.6	242		302	57	6				682	1039	
25cabl	M		01-20-47			139	51		7.4		218		357	14	2.3			678	678	1000	556
25cabl	DM		02-23-63			128	50		8		207		280	17		170		753	585		524
25cab	LG079		10-13-72			86	31	106	110	4.3	161		307	96	2.7				712	1120	
27cbbl	C	400	09-18-12			85	31		10		210		165	10	4			430	408		340
27cccl	MJ	263	10-17-44			61	31		20		253		101	11			478		348	544	282
28d	HM	224	10-27-30	0.6	α	81	25		31		245		148	12.2				410	418		
28bccl	M	176	03-06-43			72	21		18		220		116	3			400		338		266

Appendix 4 (continued)

Location	Source	Depth (feet)	Date Collected	Flow (cfs)	Remarks	Calcium	Magnesium	Sodium	Sodium & Potassium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Nitrate	Alkalinity	Dissolved solids mg/ℓ Total	Evaporation	Summation	Specific cond (μmhos/cm)	Hardness (as $CaCO_3$)
						Concentration of principal ions, mg/ℓ															
21/61-29ddal	MJ	260	10-17-44			67	34		7.3		227		118	8.8			462		347	574	306
30a	HM		08-05-27	0.25		517	197		353		263		1735	601				3667	3535		
30d	HM	405	09-21-12	0.07		102	49		10		204		1278	15				617	554		
34	C		09-18-12	0.09		134	47		18		207		358	17	1.5			713	677		528
34abcl	M	246	01-06-47		θ	64	30		11		223		107	6	3.9			332	328	564	283
35dccl	HM	300	08-05-27	0.05	T	151	52		35		219		418	38				912	802		
21/61-35dccl	HM	485	08-05-27	0.05		116	39		42		168		358	22				745	660		
36adcl	M		01-20-47			137	56		22		205		392	29	2.4			740	739	1520	572
21/62- 3al	C		12-24-12		σ	58	38		34		254		110	11				545	376		300
3bbb	LG083	200	10-20-72			32	18.5	19.2	23	3.9	192		47	5.49	1.6				223	395	
4aaa2	HM	180	04-19-29			142	94		120		254		681	60				1306	1222		
5bb	C	546	12-24-12		Φ	500	150		1509		51	tr.	4008	658				7355	6850		1865
17ddcl	MJ	540	03-18-42			228	68		678		154		1599	378		126	3113		3027		849
17ddcl	DM	540	11-09-62			254	82		136		793		2060	390		650		3717	3312		972
19acdl	M		01-23-47			42	22		14		194		55	5.2	1.3			841	235	419	196
19acdl	M	114	05-20-57		λ	123	37		53		217		357	16			744		693	1025	
19acdl	DM	200	06-04-63			122	33		27		207		360	21		170		756	665		520
20dddl	MJ	458	12-21-42			66	20		25		144		134	15		118	371		331	1180	247
21dddl	MJ		07-13-42			246	98		765		78		2252	192		64	3705		3591		1017
27bcbl	MJ	525	07-13-42			148	46		511		81		1356	136		66	2360		2237		559
27bcdl	MJ	450	07-13-42			240	119		544		107		1678	308		88	3050		2942		1088
27cbal	MJ	420	07-13-42			158	45		504		81		1372	128		66	2388		2247		580
27cccl	HM	375	09-27-26			610	358		805		204		2855	1140				6378	5868		
27 ?	HM	500	03-21-33		σ	162	71		651		80		1735	169				2734	2828		
28aadl	MJ	420	07-13-42		Π	162	63		573		81		1600	161		66	2820		2599		663
28acdl	C		09-20-12		aγ	295	164		297		197	12	1233	417	0.5			2827	2515		1410
28adal	MJ	570	07-13-42			282	188		474		181		1641	460		148	3250		3134		1476
29bccl	MJ		08-04-42			64	34		11		181		147	16		148	420		361		299
29ccbl	MJ	700	07-13-42			79	39		33		195		232	20		160	580		499		357
29ccbl	M	1165	03-08-45			80	46		21		206		240	11			603		499	783	357
29cccl	MJ	404	07-13-42			110	50		29		215		327	20		176	715		642		480
29ccc	LG076	404	10-12-72			66	39	29	34.7	5.7	199		229	10.8	2				479	744	
29dbb	C		12-24-12		ξ	275	130		99		239		959	172	0.3			2102	1753		1220
29dbb	LW012		12-02-71		ξ	286	143	132	156	24	225		1137	168	2.1				2004		
30ac	C	405	09-21-12	0.08		102	49		10		204		278	15	0.75			617	555		456
30-	HM	500	03-04-25	0.2		282	172		500		165		1273	737				3303	3045		
30dbbl	MJ	390	08-04-42			110	42		18		160		315	20		131	602		584		447
30dbbl	DM	390	06-04-63			91	48		9		198		245	17		162		582	507		424
30dbb	LG082	390	10-17-72			106	53	24	30	6.5	212		358	17.7	2.4				672	891	
30dcbl	M	400	01-20-47			106	47		29		232		295	13		-		606	604	890	458
30dcbl	DM	400	05-22-63			120	56		26		207		360	26		170		810	690		528
30d	M	140	10-21-57			460			19		202		820	121			1670		1520		

Appendix 4 (continued)

Location	Source	Depth (feet)	Date Collected	Flow (cfs)	Remarks	Concentration of principal ions, mg/ℓ										Alkalinity	Dissolved solids mg/ℓ			Specific cond (µmhos/cm)	Hardness (as $CaCO_3$)
						Calcium	Magnesium	Sodium	Sodium & Potassium	Potassium	Bicarbonate	Carbonate	Sulfate	Chloride	Nitrate		Total	Evaporation	Summation		
21/62- 31bdc2	MJ	600	07-13-42			147	50		8		158		392	37		130	805		712		572
31bdc	LG084	600	10-20-72			90	49	23	29	5.9	116		377	19	0.75				621	867	
34b	HM	375	09-27-26			610	358		805		204		2855	1140				6378	5868		
22/61- 1bcb4	DM		06-20-63		ə	178	99		38		203		563	124		166		1490	1102		852
1bcb4	HM		09-25-30	0.25		161	56		65		226		473	69				924	936		
1bdb1	HM		09-25-30	0.25		229	94		128		182		901	107				1546	1548		
1b	HM		09-25-30	0.25		294	118		156		202		1148	142				1925	1957		
1d	HM	209	09-08-30	1.0		165	58		67		220		474	86				960	958		
1dac1	MJ	209	07-13-42			177	56		44		207		448	94		170	1018		921		672
1dac1	DM	209	1962-3			131	56		36		203		385	49		166		910	757		560
1dac1	LG081	209	10-13-72			171	61	57		14.6	207		437	104	2.7				949	1346	
2aba1	MJ	200	10-17-44			134	57		2.3		198		353	30			755		674	1090	568
2aba2	DM	200	06-20-63			134	70		2.2		190		400	33		156		855	733		576
3acc1	MJ		07-03-41			148	40		55		207		452	10		170	882		808		534
3acc1	DM		06-20-63			158	59		11		195		388	67		160		1007	779		640
3caa1	MJ	395	07-03-41			150	44		40		171		453	22		140	863		793		555
3dda1	MJ	335	06-15-45			158	53		0.7		176	9	441	0.5			838		749	1138	613
3dda	LG080	335	10-13-72			148	54	44	54	10.3	196		455	73	2.7				883	1269	
10bda1	C	305	09-18-12	1.18		155	60		15		205		405	35				857	761		592
10bda1	HM	305	10-13-30			166	55		57		220		479	64				1003	929		
10bda1	DM	305	06-20-63	1.15		178	57		45		198		450	100		162		1193	927		680
11bac2	MJ	175	03-28-45			140	52		25		202	tr.	404	24			848		744	1069	566
11bac3	C	412	09-17-12	0.71		177	56		47		215		483	67	1			1044	1151		672
11bcb4	C	100	09-17-12	0.67	∞	193	73		104		191		587	168	4	-		1380	1219		782
12bbb1	MJ		10-17-44			120	51		58		157		414	52			851		772	1001	508
12bbb1	DM		06-20-63			126	53		0		203		255	20		166		786	554		536
12bbb	LG120		06-12-73			120	51	23	29	6.2	205		365	26	3.2				695	1016	
16a1	HM	65	09-07-26			188	51		102		329		326	205				1103	1036		
22/62- 1cba1	MJ	465	07-13-42			210	50		253		117		753	284		96	1800		1608		730
1cbc1	MJ	1135	03-15-45			106	20		436		84		1027	112			1785		1742	2480	347
1cbc1	DM	1135	03-14-63			240	24		64		110		1150	67		90		2065	1599		696
1cbc2	MJ		03-15-45		Y	120	31		536		323		932	254			2196		2032	2770	427
1cbc2	MJ	850	07-13-42			76	9		743		160		1296	256		131	2555		2459		227
1ccc1	MJ	300	09-24-45			174	85		378		102	tr.	513	700			1953		1900	3160	782
1ccc1	DM	300	12-19-62			203	30		269		234		145	540		98		2939	1302		684
9dcc1	MJ	180	11-09-42			98	56		124		176	tr.	279	218		144	943		862		475
12aac1	M	200	05-23-45			81	29		189		134		390	154			1010		909		321
12aac1	DM	200	1962-3			192	40		647		90		1400	394		74		2909	2717		644

EXPLANATION

A. Location

The locations and sequence numbers shown are generally identical to those in the source documents with exceptions noted in the remarks column.

B.

C	Carpenter (1915)
DM	Domenico and Maxey (1964)
DRI	Center for Water Resources Research, Desert Research Institute (unpublished)
HM	Hardman and Miller (1934)
LG075	Present study; Appendix 2 for description of sampling points
M	Malmberg (1965)
MJ	Maxey and Jameson (1948)

C. Measured or estimated discharge of flowing wells on the date of sampling.

D. Concentrations shown are mg/ℓ. Specific conductance is expressed as micromhos/cm. Values shown are rounded off as follows:

Reported concentration	rounded to
$n \leq 1$ mg/ℓ	nearest hundredth
$1 < n < 21$	nearest tenth
$n \geq 21$	nearest whole number

Total dissolved solids are expressed as "total", "evaporation" and "summation", with the latter calculated as the sum of the ionic constituents, after converting bicarbonate to carbonate. Concentrations expressed as "total" or "evaporation" are taken, as they appear, from previous reports.

Remarks

γ Shallow well
Δ Located in 20/60-24adb by Maxey and Jameson (1948).
δ Incomplete analysis indicated by poor ion balance.
θ Shallow flow (Maxey and Jameson, 1948).
Τ Deep flow (Maxey and Jameson, 1948).
ξ Grapevine Spring; located about 9 miles southeast of Las Vegas in 21/62-28 according to Hardman and Miller (1934), actual location 21/62-29dbb.
Π Located in 21/62-28 by Carpenter (1915).
α Located in 21/61-33bac by Maxey and Jameson (1948).
σ Shallow well, 30 feet to water; located in 21/62-3b and 21/62-3a by Carpenter (1915) and Hardman and Miller (1934), respectively; latter location agrees with map presented by Carpenter.
Φ Located in 21/62-5bb and 21/62-3bacl by Carpenter (1915) and Maxey and Jameson (1948), respectively.
Λ E.M. Taylor ranch (Kyle or Park); located in 20/61-22b by Carpenter (1915).

λ Las Vegas Spring

Ω Low yield artesian well approximately 500 feet deep located "near Whitney, 8 miles southeast of Las Vegas" (Hardman and Miller, 1934).

** Stated to be 665' TD and located in 20/61-20da in 1968 (DRI) report.

ζ Originally reported 631' TD. Driller's log indicates 706' TD with 631' cased.

Ψ Located in 21/62-10cdd, by Malmberg (1965).

∞ Located in 22/61-1b by Carpenter (1915).

∂ Located in 22/61-1bd4 by Domenico and Maxey (1964).

ƒ Located in 21/61-8 and 21/61-18dbd, by Hardman and Miller (1934) and Maxey and Jameson (1948), respectively.

Appendix 5. Characteristics of Wells Used to Determine Historical Changes in Ground-Water Quality

Well #	Location T R S	Address	Depth (feet)	Cased (feet)	Perforated from - to	Date sampled	Remarks*
LG061	19/60- 4cda	Tule Springs Park	706	631	531 - 631	10-04-72	Original; sampled 09-13-45 (MJ), 1962-3 (DM); irrigation and domestic supply well; listed incorrectly in earlier reports as 631' TD
LG062	19/60- 9cda	Gilcrease Ranch	612			10-04-72	Original; sampled 10-23-44 (MJ), 03-15-63 (DM); irrigation well
LG063	20/61-36bbb	480 N. 25th St.	325	300	None	10-05-72	Original; sampled 01-19-45 (MJ), 10-29-62 (DM); artesian; domestic well
LG064	20/62-18bbc	3115 L.V. Blvd. No.	300	300	55 - 120	10-05-72	Original; sampled 12-31-67 (DRI)
LG065	20/62- 8aba	4229 L.V. Blvd. No.	120	120	70 - 115	10-05-72	Original; sampled 12-31-67 (DRI); reported as 200' TD in 1968 (DRI)
LG066	20/61- 3dab	Nellis AFB Well #2	350			10-05-72	Original; sampled 05-01-41 (MJ), 10-16-56 (MB), 11-09-62 (DM); public water supply
LG067	20/61-20caa	3087 W. Lake Mead Blvd.	665	570	394 - 570	10-05-72	Original; sampled 01-31-68 (DRI); deepened from 300' in 1947, flow increased to 0.2 cfs @ 665' TD
LG068	20/61-20caa	3001 W. Lake Mead Blvd.	300	75	None	10-05-72	Original; sampled 01-31-68 (DRI)
LG069	20/61-20cab	226 Anderson La.	400	400		10-11-72	Substitute for 20/61/20cac 1(MJ), 347' TD, sampled 09-15-44 (MJ), 11-26-62 (DM)
LG070	20/61-28cda	1531 W. Bonanza Rd.	440			10-11-72	Substitute for 20/61/28 cdal, (MJ) (shallow flow), sampled 10-25-44
LG071	21/61- 4baa	1823 E. Charleston Blvd.	400			10-11-72	Substitute for 21/61/4baa (MJ), 381' TD, sampled 01-19-45

Appendix 5 (continued)

Well #	Location T R S	Address	Depth (feet)	Cased (feet)	Perforated from - to	Date sampled	Remarks*
LG072	20/61-33ccb	2040 Goldring Ave.	425			10-11-72	Original; previously sampled in mid 1940's (MJ)
LG073	20/61-33cca	1824 Goldring Ave.	400	400	270 - 400	10-11-72	Substitute for 21/61/33cca1 (MJ), 400' TD, sampled in mid 1940's, original well unperforated
LG074	20/61-34bcb	Union Pacific R.R. - Well #157	780	757	280 - 290 590 - 594	10-12-72	Original; sampled 06-14-41 (MJ), 04-11-63 (DM)
LG075	21/61- 1bba	2500 Boulder Hwy.	400	200		10-12-72	Substitute for 20/61/35ddc2 (MJ), 418' TD sampled 09-14-45
LG076	21/62-29ccc	4200 E. Russell Rd.	404			10-12-72	Original; sampled 07-13-42 (MJ), flows 0.005 cfs
LG077	21/61-24aad	3340 Rochelle Ave.	160	160	60 - 160	10-13-72	Original; sampled 01-29-68 (DRI)
LG078	21/61-24aad	3360 Rochelle Ave.	100	100		10-13-72	Original; sampled 01-29-68 (DRI)
LG079	21/61-25cac	5326 Topaz St.				10-13-72	Substitute for 21/61/25cab1 (DM), sampled 01-20-47 (MB), 02-23-63 (DM)
LG080	22/61- 3dda	7117 Paradise Rd.	335		None	10-13-72	Original; sampled 06-15-45 (MJ)
LG081	22/61- 1dac	7044 Tomiyasu La.	209			10-13-72	Original; sampled 09-08-30 (HM), 07-13-42 (MJ), 1962-3 (DM), artesian
LG082	21/62-30dbb	5374 Sandhill Rd.	390			10-17-72	Original; sampled 08-04-42 (MJ) and 06-04-63 (DM)
LG083	21/62- 3cab	6000 E. Charleston Blvd.	200			10-20-72	Sampled to determine shallow water quality in an area reported to contain very high TDS

Appendix 5 (continued)

Well #	Location T R S	Address	Depth (feet)	Cased (feet)	Perforated from - to	Date sampled	Remarks*
LG084	21/62-31acc	6100 S. Pearl St.	600			10-20-72	Original; sampled 07-13-42 (MJ)
LG112	20/60-24aaa	4200 Smoke Ranch Rd. - Well #2	312	312	212 - 312	06-08-73	Substitute for 20/60/24adb (MJ), 385' TD, sampled 09-14-12 (C), 10-16-30 (HM)
LG113	19/60-23bbc	7000 Gilcrease Rd.	560			06-08-73	Original; sampled 10-25-44 (MJ), 03-15-63 (DM)
LG114	19/60-27aab	Ranch House Rd. & Tonopah Hwy.	605			06-08-73	Original; sampled 10-23-44 (MJ), 1963 (DM)
LG115	20/62-19cab	3725 E. Lake Mead Blvd.	200	200	None	06-08-73	Substitute for 20/62/19cabl (MJ), sampled 12-17-45 (MJ)
LG116	20/62-19bbb	2342 N. Pecos Blvd.	289	289		06-08-73	Original; sampled 12-17-45 (MJ)
LG117	20/61-13adb	2934 L.V. Blvd. No.	300	300	60 - 300	06-08-73	Original; sampled 01-31-68 (DRI); 500' TD and 300'-500' perforated interval reported in 1968; driller's log indicates 300' TD and perforated 60'-300'
LG118	20/62- 4add	Nellis AFB - Well #1	800	800	90 - 784	06-08-73	Original; sampled 05-05-41 (MJ), 10-17-56 (DM)
LG119	20/61- 4add	4434 Craig Rd.	900	900		06-12-73	Substitute for 20/61/4addl (HM), 850' TD
LG120	22/61-12bbb	2465 Warm Springs Rd.				06-12-73	Possible original; believed equivalent to 20/61/12bbl (MJ), sampled 10-17-44 (MJ) 06-20-63 (DM)
LG121	20/61-19dda	800 Tonopah Hwy.	295	295	275 - 290	06-08-73	Substitute for 20/61/19ddcl(MJ), 280' TD

Appendix 5 (continued)

Well #	Location T R S	Address	Depth (feet)	Cased (feet)	Perforated from - to	Date sampled	Remarks*
LG122	20/61-33cca	716 Shadow Ln.	226			06-08-73	Possible original; believed equivalent to 20/61/33cca2 (MJ), 226' TD, sampled 02-21-38 (MJ)
LG123	20/61-35cbb	1201 Fremont St.	460			06-08-73	Original; sampled 09-14-45 (MJ), 12-19-62 (DM)
LG124	21/61- 4dac	Michelas Water Co. 244 St. Louis Well #1	650			06-11-73	Original; sampled 10-25-44 (MJ), 04-16-63 (DM)
LG125	21/61- 4dac	Michelas Water Co. 244 W. St. Louis Ave. Well #2	810			06-11-73	Original; sampled 05-19-41 (MJ), 04-16-63 (DM)
LG126	20/61-18bcc	2772 Tonopah Hwy.	500	500	300 - 500	06-08-73	Substitute for 20/61/18bcc (MJ), 412' TD, sampled 02-16-45 (MJ), 11-26-62 (DM)
LG127	20/61-29cbc	3333 W. Washington Ave.	600			06-08-73	Original; sampled 02-05-32 (HM)

*"Original" signifies a resampling in 1972 or 1973 or the same well sampled previously. "Substitute" indicates that the original well could not be located or was destroyed and that another well having the location and characteristics shown was used as a replacement. Previous sampling dates are shown, followed by initials to indicate the following data sources:

DM Domenico and Maxey (1964)
DRI Desert Research Institute
HM Hardman and Miller (1934)
MJ Maxey and Jameson (1948)

Appendix 6. Tritium Sampling Points and Analytical Results

Station*	Location	DRI Sample No.	Sample Date	Assay Date	Tritium Concentration (TU)†	Method of Analysis‡	Remarks
LW002	21/62-23bdb	574	May-June 1971	09-30-71	42.6 ± 2.2	ES	Las Vegas Wash flow, primarily sewage
					42.1 ± 1.7	EG	
007	21/63-14daa	550	06-03-71	09-30-71	173 ±10	GC	Las Vegas Wash, total flow from all sources
009	21/61-13aba	601	06-21-71	09-30-71	21.9 ± 1.5	ES	Flamingo Wash, spring flow
					21.7 ± 1.4	EG	
011	21/62-29dcd	554	06-11-71	09-30-71	5.5 ± 0.4	EG	Seepage north of Whitney Mesa
012	21/62-29dbb	556	05-31-71	09-30-71	2.9 ± 0.3	EG	Grapevine Spring
015	22/62-04bcc	555	05-31-71	09-30-71	28.7 ± 3.3	ES	Seepage from underdrain beneath Sunset Rd.
					29.2 ± 1.2	EG	
015	22/62-04bcc	608	05-31-71	11-15-71	29.9 ± 1.2	1	Check sample
020	21/62-36cdd	576	May-June 1971	09-30-71	385 ±14	GC	Ground water return flow from BMI complex
022	22/63-07bca	573	May-June 1971	09-30-71	360 ±14	GC	BMI waste discharge to upper tailings ponds
027	21/62-22bbd	553	05-27-71	09-30-71	194 ±10	GC	Clark County STP outflow
030	21/63-28adb	583	05-31-71	09-30-71	349 ±18	ES	Pond adjacent to Las Vegas Wash near bedrock constriction
032	21/63-32bcd	557	05-31-71	09-30-71	411 ±14	GC	Ground water return flow from BMI tailings ponds
033	21/62-22ddb	1881	01-16-73	04-23-73	11.7 ± 0.5	EG	Shallow ground water at extreme east end of Tropicana Avenue
034	21/62-10cdd	605	06-29-71	09-30-71	76.0 ± 3.8	ES	Las Vegas STP outflow
					75.2 ± 3.0	EG	
034	21/62-10cdd	607	06-29-71		69.9 ± 4.2	ES	Las Vegas STP outflow; check sample
					66.8 ± 2.8	EG	
034	21/62-10cdd	552	05-27-71	09-30-71	17.4 ± 0.8	EG	Las Vegas STP outflow
048	21/63-31bba	572	May-June 1971	09-30-71	329 ±13	GC	Ground-water return flow from lower (BMI) tailings ponds
049	21/63-31bbb	575	May-June 1971	09-30-71	358 ±14	GC	
057	17/59-34aab	578	06-14-71	09-30-71	4.8 ± 0.3	EG	Corn Creek Spring
058	22/58-02ccb	581	06-15-71	09-30-71	20.5 ± 0.9	EG	Bonnie Springs
059	21/62-19aaa	582	06-15-71	09-30-71	40.6 ± 2.1	ES	Ground-water seepage from beneath Flamingo Reservoir
					40.6 ± 1.8	EG	

Appendix 6 (continued)

Station*	Location	DRI Sample No.	Sample Date	Assay Date	Tritium Concentration (TU)†	Method of Analysis‡	Remarks
LW060	21/61-12dac	602	06-29-71	09-30-71	23.7 ± 1.7	ES	Spring discharge into Flamingo Wash
					23.8 ± 1.0	EG	"
060	21/61-12dac	603	06-29-71	11-15-71	26.0 ± 1	1	
061	21/62-10cdb	604	06-29-71	09-30-71	68.6 ± 3.3	ES	Las Vegas STP inflow
061	21/62-10cdb	606	06-29-71	11-15-71	73 ± 3	1	"
062	21/62-22bbb	609	06-29-71	09-30-71	205 ±12	GC	Clark Co. STP inflow
084	21/61-14adb	1908	01-28-73	04-23-73	35.6 ± 1.6	EG	Shallow ground-water discharge from a tile field beneath golf course
085	20/61-26cdc	1874	01-15-73	04-23-73	22.6 ± 0.9	EG	Shallow ground-water discharge from an underdrain beneath 15th St.
086	20/61-26cbd	1875	01-15-73	04-23-73	13.3 ± 0.6	EG	Shallow ground-water discharge from an underdrain beneath Maryland Pkwy. at Harris St.
087	21/61-02aaa	1876	01-15-73	04-23-73	98.9 ± 4.0	EG	Shallow ground-water discharge from an underdrain beneath Eastern Ave. at Ballard Dr.
088	21/61-01baa	1877	01-15-73	04-23-73	41.1 ± 1.6	EG	Shallow ground-water being pumped from underdrain below Montgomery Wards Dept. store
089	20/61-34aca	1879	01-16-73	04-23-73	125 ± 5	EG	Shallow ground water beneath El Cortez parking lot
090	21/61-10cca	1883	01-18-73	04-23-73	25.4 ± 1.0	EG	Shallow ground-water discharge from underdrain beneath Convention Center
091	21/61-20aad	1884	01-18-73	04-23-73	188 ± 7	EG	Shallow ground water pumped from elevator shaft pit of Dunes Hotel
092	21/61-09aaa	1885	01-18-73	04-23-73	21.1 ± 1.0	EG	Shallow ground water beneath Sahara Hotel
094	21/61-14bbc	1888	01-24-73	04-23-73	91.8 ± 3.6	EG	Shallow ground water pumped from basement of Sears Roebuck Dept. store
095	20/61-22dba	1889	01-28-73	04-23-73	9.5 ± 0.5	EG	Shallow ground-water discharge from an underdrain at Lake Mead Blvd. and I-15
096	20/61-27cac	1891	01-28-73	04-23-73	38.3 ± 1.7	EG	Shallow ground-water seepage from underdrains beneath UPRR trestle at Bonanza Rd.
097	20/61-31aac	551	05-28-71	09-30-71	3.3 ± 0.3	EG	Composite sample from LVVWD deep wells in main well field
LG002	22/62-01cba	580	05-31-71	09-30-71	4.5 ± 0.3	EG	Deep artesian well
006	21/63-28aca	565	06-07-71	09-30-71	301 ±15	ES	Piezometer (41 feet TD) adjacent to L.V. Wash
007	21/63-28aca	570	06-08-71	09-30-71	250 ±10	EG	Piezometer (134 feet TD) adjacent to L.V. Wash
					246 ±13	ES	

Appendix 6 (continued)

Station*	Location	DRI Sample No.	Sample Date	Assay Date	Tritium Concentration (TU)†	Method of Analysis‡	Remarks
LG013	22/63-05cbb	558	06-08-71	09-30-71	285 ±12	EG	Piezometer (241 feet TD) in BMI (upper) tailings ponds
					287 ±15	ES	
017	21/63-31abb	1747	11-01-72	04-23-73	6.5 ± 0.3	EG	Piezometer (84 feet TD) adjacent to L. V. Wash
019	21/63-31bab	568	06-10-71	09-30-71	4.8 ± 0.4	EG	Artesian well (70 feet TD) (piezometer) between lower tailings ponds and L.V. Wash; discharge from Muddy Ck. Fm
026	21/63-07bcb	566	06-08-71	09-30-71	4.7 ± 0.3	EG	Piezometer (101 feet TD) below effluent ditch leading to upper tailings ponds
027	21/62-36baa	571	06-09-71	09-30-71	320 ±13	EG	Piezometer (62 feet TD) on western side of lower tailings ponds
					320 ±16	ES	
029	21/62-26dba	563	06-10-71	09-30-71	3.0 ± 0.3	EG	Artesian well (97 feet TD); discharge from Muddy Ck. Fm.
033	21/62-26dba	559	06-09-71	09-30-71	58.1 ± 2.9	ES	Piezometer (30 feet TD) completed in shallow sand and gravel deposits overlying the Muddy Ck. Fm.
					57.2 ± 2.3	EG	
035	21/62-15dda	546	06-10-71	09-30-71	5.4 ± 0.3	EG	Piezometer (102 feet TD) in flood plain of L.V. Wash below treatment plants and irrigated area
041	20/62-32aba	549	06-09-71	09-30-71	4.2 ± 0.3	EG	Piezometer (67 feet TD) in flood plain of L.V. Wash and above treatment plants
042	20/62-32aba	564	06-09-71	09-30-71	3.9 ± 0.3	EG	Piezometer (168 feet TD) in flood plain of L.V. Wash and above treatment plant
043	21/62-29dcd	569	06-11-71	09-30-71	2.9 ± 0.3	EG	Piezometer (56 feet TD) at north end of Whitney Mesa
044	21/62-29dcd	548	06-11-71	09-30-71	5.3 ± 0.3	EG	Piezometer (129 feet TD) at north end of Whitney Mesa
047	20/61-36ddd	567	06-09-71	09-30-71	3.4 ± 0.3	EG	Piezometer (97 feet TD) on west side of scarp crossing E. Charleston Blvd.
048	20/61-36ddd	561	06-09-71	09-30-71	4.2 ± 0.3	EG	Piezometer (48 feet TD) at same location as LG047
050	21/62-35dda	579	May-June 1971	09-30-71	212 ± 9	EG	Shallow ground water 2.3 miles north of BMI complex
					215 ±11	ES	

Appendix 6 (continued)

Station*	Location	DRI Sample No.	Sample Date	Assay Date	Tritium Concentration (TU)†	Method of Analysis‡	Remarks
LG055	21/63-29ccb	547	06-11-71	09-30-71	407 ±13	GC	Shallow ground-water tributary to L.V. Wash in the vicinity of the BMI tailings ponds
056	21/62-11bcb	562	06-14-71	09-30-71	6.0 ± 0.4	EG	Deep ground water adjacent to L.V. Wash
057	20/61-03dab	585	06-15-71	09-30-71	4.5 ± 0.4	EG	Nellis AFB Well #2
058	20/61-15dcc	584	06-15-71	09-30-71	4.1 ± 0.3	EG	City of No. Las Vegas Losee Well
059	20/61-29ccc	560	05-28-71	09-30-71	4.3 ± 0.3	EG	LVVWD Well #34
061	19/60-04cda	577	06-14-71	09-30-71	5.1 ± 0.3	EG	Well at Tule Springs
093	21/62-30bda	1887	01-10-73	04-23-73	2.0 ± 0.3	EG	Artesian well in Paradise Valley
098	21/62-08dcc	2024	04-11-73	06-14-73	17.0 ± 0.8	EG	Shallow ground water adjacent to residential development using Colorado River water
099	21/62-09abb	2025	04-11-73	06-14-73	24.7 ± 1.1	EG	Shallow ground water below Winterwood Golf Course
100	20/61-35add	2023	04-11-73	06-14-73	30.9 ± 1.3	EG	Shallow ground water adjacent to an older residential development
101	21/62-21cad	2027	04-11-73	06-14-73	166 ± 7	EG	Shallow ground water adjacent to residential area served by Colorado River water
102	21/61-02bac	2022	04-11-73	06-14-73	53.0 ± 2.1	EG	Shallow ground water
103	21/61-01dcd	2021	04-11-73	06-14-73	45.0 ± 1.8	EG	Shallow ground water occurring in a zone of high permeability; possibly a buried wash
104	21/61-13bbc	2029	04-11-73	06-14-73	40.1 ± 1.6	EG	
105	21/61-23dab	2030	04-11-73	06-14-73	79.1 ± 3.2	EG	Shallow ground water adjacent to a residential area served by Colorado River water
107	21/61-26ccb	2031	04-11-73	06-14-73	36.0 ± 1.4	EG	"
108	21/61-08acd	2028	04-11-73	06-14-73	16.4 ± 0.8	EG	"
110	20/61-33cdb	2230	08-20-73	10-21-73	16.3 ± 0.7	EG	Shallow ground water beneath an old residential development served by local ground water
115	20/62-19cab	1704	10-05-72	06-14-73	6.4 ± 0.4	EG	Domestic well (200 feet TD)
128	21/62-15ccb	2026	04-11-73	06-14-73	107.8 ± 4.3	EG	Dewatering well (35 feet TD) in LDS Church farm area; fields irrigated with sewage
128	21/62-15ccb	2026	04-11-73	06-14-73	100.9 ± 4.1	EG	"; check sample
129	20/61-30ddb	1924	01-28-73	06-14-73	38.8 ± 1.6	EG	Shallow ground water adjacent to a residential area served by deep ground water from LVVWD
130	21/62-08aad	2224	08-02-73	10-21-73	55.5 ± 2.2	EG	Domestic well (90 feet TD) adjacent to Flamingo Wash
131	19/60-23add	2161	07-31-73	10-21-73	5.1 ± 0.3	EG	Well (400 feet TD) adjacent to Gilcrease Ranch

Appendix 6 (continued)

Station*	Location	DRI Sample No.	Sample Date	Assay Date	Tritium Concentration (TU)†	Method of Analysis‡	Remarks
LG132	20/60-19dca	2149	07-18-73	10-21-73	9.7 ± 0.5	EG	Very shallow ground water in an old residential area served by local ground water and septic tank disposal systems
LM213	21/64-19ada	586	06-17-71	09-30-71	333 ±13	GC	Lake Mead
LM214	21/64-19ada	587	06-17-71	09-30-71	321 ±12	GC	Lake Mead
LM215	22/64-03acd	588	06-17-71	09-30-71	372 ±13	GC	Lake Mead

* More complete sampling point descriptions are presented in Appendix 2.

† Tritium concentrations are expressed in tritium units (TU). One TU equals 1 H_3 atom in 1×10^{18} H_2 atoms.

‡ The following analytical methods were utilized by Teledyne Isotopes, Inc., Westwood, New Jersey:

ES Enrichment + liquid scintillation

EG Enrichment + gas counting

GC Direct gas counting without enrichment

1 Unspecified method of analysis made on certain check samples submitted to Dr. Gote Ostlund, School of Marine and Atmospheric Science, University of Miami, Miami, Florida

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-78-179	2.
	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Land and Water Use Effects on Ground-Water Quality In Las Vegas Valley	5. REPORT DATE August 1978 issuing date
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Robert F. Kaufmann	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Desert Research Institute Las Vegas, Nevada 89109	10. PROGRAM ELEMENT NO. 1CC614
	11. CONTRACT/GRANT NO. R-800946
12. SPONSORING AGENCY NAME AND ADDRESS Robert S. Kerr Environmental Research Laboratoty Office of Research and Development U.S. Environmental Protection Agency Ada, Oklahoma 74820	13. TYPE OF REPORT AND PERIOD COVERED Final; 11/1/69 - 1/31/74
	14. SPONSORING AGENCY CODE EPA/600/15

15. SUPPLEMENTARY NOTES

Project Officer: Fredric Hoffman, Region IX, San Francisco, CA 94111

16. ABSTRACT

The hydrogeologic study of the shallow ground-water zone in Las Vegas Valley, Nevada determined the sources and extent of ground-water contamination to develop management alternatives and minimize adverse effects. An extensive, computerized data base utilizing water analyses, well logs, head measurements, and surface flows was developed. Flow system analysis, gross chemical data and tritium analyses were used in combination with trend surface techniques to ascertain natural and contaminated ground-water quality to depths of 0 to 50, 51 to 100, and 101 to 300 feet. At depths below 100 feet, the distribution of all constituents reflects natural controls. Nitrate and chloride in the zone from 0 to 50 feet are closely related to waste disposal activities, chief of which are industrial effluent, treated sewage, and septic tanks. In addition, tritium is highly indicative of return flows associated with distribution of Colorado River water in the Valley. Localized contamination of shallow unconfined ground water and rapid appearance of return flows is accentuated by pronounced vertical hydraulic and stratigraphic boundary conditions present in the eastern and western parts of the Valley. Nonparametric testing of extremely limited historical water quality data to ascertain temporal changes, particularly for the very shallow aquifers, yielded generally insignificant results.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Ground water Water pollution	Water use Las Vegas Valley	13/B

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS *(This Report)* unclassified	21. NO. OF PAGES 332
	20. SECURITY CLASS *(This page)* unclassified	22. PRICE

EPA Form 2220-1 (9-73)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978— 757-140/1452