DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

HYDROLOGIC INVESTIGATIONS
ATLAS HA–694B (SHEET 2 OF 2)

POTENTIOMETRIC SURFACE IN CONSOLIDATED ROCKS OF THE CARBONATE–ROCK PROVINCE

INTRODUCTION

The atlas of which this sheet is a part is a product of the Great Basin Regional Aquifer-System Analysis (RASA) study. This sheet shows the potentiometric surface of ground water in consolidated rocks of the Carbonate-Rock Province as defined by Mifflin (1968, p. 15 and 16), Hess and Mifflin (1978, p. 1 and 2), and Harrill and others (1983, p. 16 and 24). The sheet also helps to delineate regional flow systems within the province (J. R. Harrill, U.S. Geological Survey, written commun., 1982). Sheet 1 of this atlas shows the general distribution of hydraulic head in basin-fill deposits throughout the RASA study area.

This atlas is Chapter B of a three-part series. Chapter A delineates and describes hydrogeologic units in the Great Basin region, and Chapter C shows inferred directions of ground-water flow and individual flow systems.

The writers express their appreciation to the U.S. Air Force for the release of data from their carbonate-rock exploration programs associated with the MX missile-siting investigation, to Richard Satkin of Gulf Oil Company for potentiometric-head data from drill-stem tests, and to Russell W. Plume and Mark Taylor of the U.S. Geological Survey for calculating potentiometric heads from drill-stem test data for oil and gas exploration wells.

GENERAL FEATURES

The Carbonate-Rock Province is in the eastern half of the Great Basin, and includes areas in eastern Nevada and western Utah, as well as the Death Valley area of California and small parts of Idaho and Arizona (fig. 1). In this report, the boundaries of the province generally correspond with geologic features—mainly faults—as described by Stewart (1980, p. 10). The province is bounded by: (1) the Willard, Charleston, Nebo, Blue Mountain, and Muddy Mountain thrust faults to the east; (2) the Death Valley shear zone to the south; (3) the Roberts Mountain thrust fault to the west; and (4) the Snake River drainage basin to the north (fig. 2). The study area includes a few valleys outside these structural boundaries in areas that contain outliers of—or are underlain by—carbonate rocks and are a part of a major flow system contained predominately in the province.

GENERALIZED HYDROGEOLOGY

The Carbonate-Rock Province of the Great Basin is named for the thick sequences of Paleozoic limestone and dolomite in the region. These carbonate rocks are underlain by Precambrian metamorphic and granitic rocks and upper Precambrian to Middle Cambrian clastic sedimentary rocks. They are overlain by upper Paleozoic to Mesozoic clastic sedimentary rocks, Cenozoic volcanic rocks, and Cenozoic basin-fill deposits. Rocks of the region are intruded by granitic rocks that range in age from late Mesozoic to Cenozoic. Several episodes of deformation have affected the study area, as indicated by regional thrust and strike-slip faults and block faulting that have created the present basin-and-range topography.

Carbonate rocks characteristically are more permeable than the adjacent noncarbonate rocks, because of secondary permeability developed by dissolution of carbonate minerals along faults, fractures, and bedding planes. Consequently, ground water generally moves more easily through the carbonate rocks than through the noncarbonate rocks. The ability of the carbonate rocks to store and transmit ground water differs from place to place; transmissivities range from less than 13 ft^2 per day in undeformed areas to more than 130,000 ft^2 per day where the rocks are intensely fractured and faulted (Eakin, 1966, p. 266; Winograd and Thordarson, 1975; and Ertec Western, Inc., 1982).

The Carbonate-Rock Province can be divided into three major hydrostratigraphic units: (1) carbonate rocks; (2) noncarbonate rocks; and (3) basin-fill deposits. Carbonate-rock units can form extensive aquifers that store and transmit large quantities of water along fault and fracture systems that extend through several basins and ranges. Discharge from these regional aquifers is manifested by large springs and, in some areas, extensive wetlands. Noncarbonate-rock units are generally less permeable than the carbonate rocks or basin-fill deposits, so they act as flow barriers to, or impermeable caps on, the regional aquifers. Basin-fill deposits are generally more permeable than the carbonate rocks and are capable of storing and transmitting vast quantities of water. In many places these deposits are hydraulically connected with adjacent and underlying carbonate rocks, resulting in one continuous ground-water flow system bounded by noncarbonate rocks or structural features (Ertec Western, Inc., 1981).

Recharge to regional aquifers within the Carbonate-Rock Province presumably occurs primarily in the mountains, with most of the recharge originating as precipitation or melting snow in the higher altitudes. Water entering carbonate rocks in the mountains may travel through or beneath several basins and ranges before being discharged. Some of the ground water may be discharged in a topographically low area along the flow path of the regional aquifer. Figure 3 shows a conceptual drawing of ground-water flow in a regional aquifer. Thus, a regional aquifer may contain several discharge areas along its flow path upgradient from the lowest discharge area in the flow system. The White River flow system (fig. 4), within the larger Colorado River system, is a good example of a regional aquifer with several ground-water discharge areas along its flow path (Eakin, 1966).

WATER-LEVEL CONTOURS

Water-level contours in figure 1 representing the regional potentiometric surface of ground water in consolidated rocks of the Carbonate-Rock Province were constructed using data from: (1) wells that penetrate mostly carbonate rocks, including those drilled for the MX missile project, for the Nevada Test Site, for oil and gas exploration, and for water supplies; (2) springs for which the discharge exceeds 100 gallons per minute and the water chemistry indicates a mostly carbonate rock source and a long ground-water flow time; and (3) flooded mine shafts in carbonate rocks.

Water-level contours shown on the map indicate the general direction of ground-water flow in the carbonate rocks. However, potentiometric-head data for volcanic rocks that overlie carbonate rocks are included on the map for Pahute Mesa, Yucca Mountain, and the Groom Lake area on the Nevada Test Site (Winograd and Thordarson, 1975), the Hot Creek Valley area in central Nevada (Dinwiddie and Schroder, 1971), and for some oil and gas exploration wells (the Pahute Mesa, Yucca Mountain, Groom Lake, and Hot Creek Valley areas are indicated by stipple pattern in fig. 1). Contours are shown as long dashed lines where their location is imprecise owing to insufficient water-level data. Water-level contours shown by short dashed lines can be used to infer the probable direction of ground-water flow in areas of carbonate rocks or in basins underlain by carbonate rocks where suitable water-level data are scarce or lacking. Locally, the configuration of dashed contours may be based on water levels in the overlying basin-fill deposits in areas that are assumed to have a good hydraulic connection between the carbonate rocks and basin fill.

SOURCES OF DATA

The data for this map were compiled from: (1) Ertec Western, Inc., reports (1981, and 1982); (2) Technical Publications 14, 18, 23, 25, 33, 42, 43, 45, 47, 51, 56, 59, 64, 69, and 71 of the Utah Department of Natural Resources; (3) U.S. Geological Survey reports by Bjorklund and Robinson (1968), Dinwiddie and Schroder (1971), Eakin (1966), Hewett (1956), Sass and Munroe (1974), Westgate and Knopf (1932), and Winograd and Thordarson (1975); (4) Desert Research Institute (University of Nevada) reports by Fiero and Illian (1969) and Mifflin (1968); (5) a mining engineer's report by Stuart (1955); (6) drill-stem tests of oil and gas wells (data from Nevada Division of Mineral Resources and Gulf Oil Company); (7) U.S. Geological Survey topographic maps (scales, 1:24,000, 1:62,500, and 1:250,000); (8) data for wells currently being drilled on the Nevada Test Site (D. H. Schaefer, U.S. Geological Survey, oral commun., 1982); (9) data for wells previously drilled on the Nevada Test Site (R. P. Snyder, U.S. Geological Survey, written, commun., 1967); and (10) water levels reported in well logs on file with the Nevada State Engineer.

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CONVERSION FACTORS

"Inch-pound" units of measure used in this report may be converted to International System (metric) units by using the following factors:

Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)
gallons per minute (gal/min)	0.06309	liter per second (L/s)

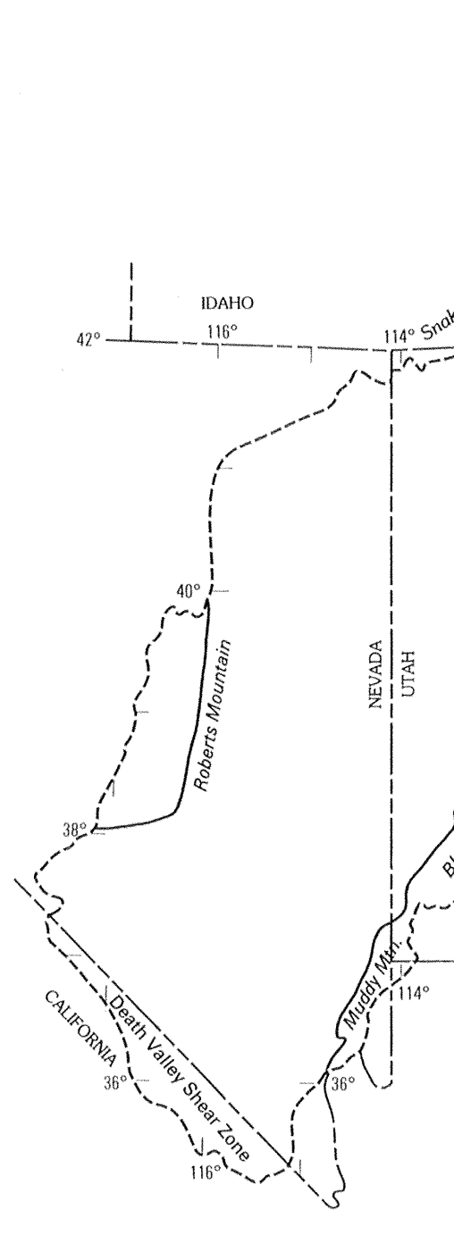


Figure 2.—**Location of geologic features, mainly faults, used in constructing the Carbonate-Rock Province boundary (Stewart, 1980, p. 10). In some areas the boundary does not coincide with the geologic feature because valleys that contain outliers of—or are underlain by—carbonate rocks and are part of a major flow system in the province, are included in the study area.**

TABLE 1.—*Springs for which (1) discharge exceeds 100 gal/min and (2) water chemistry indicates long flow time, mostly through carbonate rocks*

Reference no. (fig. 1)	Name	Reference no. (fig. 1)	Name
1	Klobe Spring	36	Mormon Hot Spring
2	Waterworks Spring	37	Moon River Spring
3	North Spring	38	Hot Creek Spring
4	Thomas Spring	39	Cold Spring
5	Middle Spring	40	Nicholas Spring
6	Lost Spring	41	Arnoldson Spring
7	South Spring	42	Preston Big Spring
8	Percy Spring	43	Campbell Ranch Spring
9	Shoshone Spring	44	Blue Eagle Spring
10	Old Dugan Place Hot Spring	45	Tom Spring
11	Upper Hot Creek Ranch Spring	46	Indian Springs
12	Hot Creek Ranch Spring	47	Corn Creek Springs
13	Nelson Spring	48	Fairbanks Spring
14	Warm Spring	49	Rogers Spring (Ash Meadows area)
15	Odger Ranch Spring	50	Long Street Spring
16	Fish Creek Spring		
17	Big Muddy Spring	51	Devils Hole
18	Iverson (Warm) Spring	52	Crystal Pool
19	Ash Spring	53	Point-of-Rock (King) Spring
20	Crystal Spring	54	Big Spring
21	Hiko Spring	55	Manse Springs
22	Duckwater Big Warm Spring		
23	Duckwater Little Warm Spring	56	Panaca Warm Spring
24	Lockes Big Spring	57	Rogers Spring (Muddy Mountain area)
25	Hay Corral Spring	58	Blue Point Spring
26	Reynolds Spring	59	Warm Springs
27	Little Salt Spring	60	Shipley Hot Spring
28	Blue Lake Spring		
29	Holbrook Springs	61	Bailey Spring
30	Diana's Punch Bowl	62	Thompson Ranch Spring
		63	Travertine Spring
31	Twin Spring	64	Texas Spring
32	Monte Neva Hot Spring	65	Nevares Spring
33	Coyote Spring		
34	North Tule Spring	66	Grapevine Spring
		67	Stainigers Spring
		68	Tecopa Hot Spring

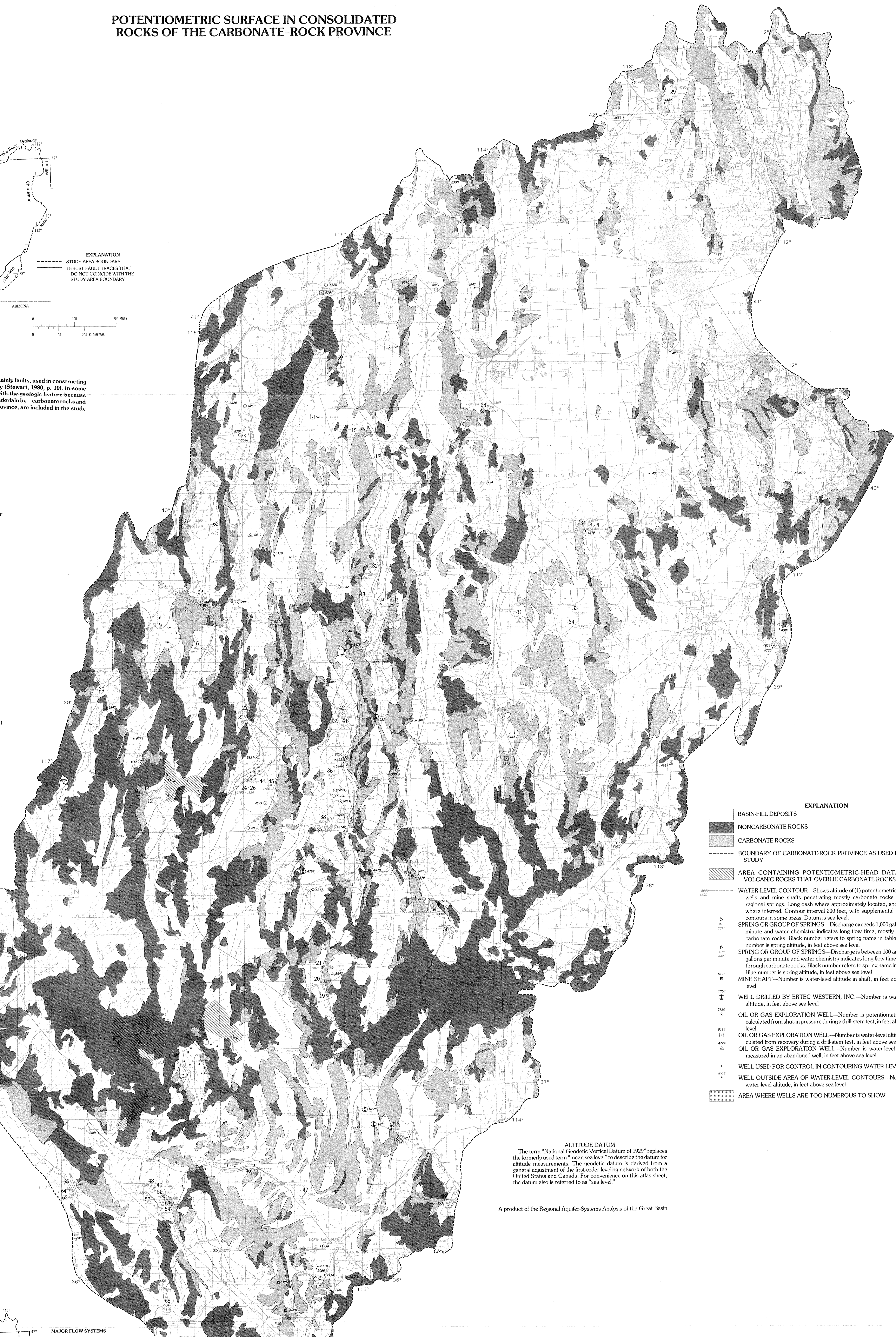


Figure 1.—**Potentiometric surface in consolidated rocks of the Carbonate-Rock Province.**

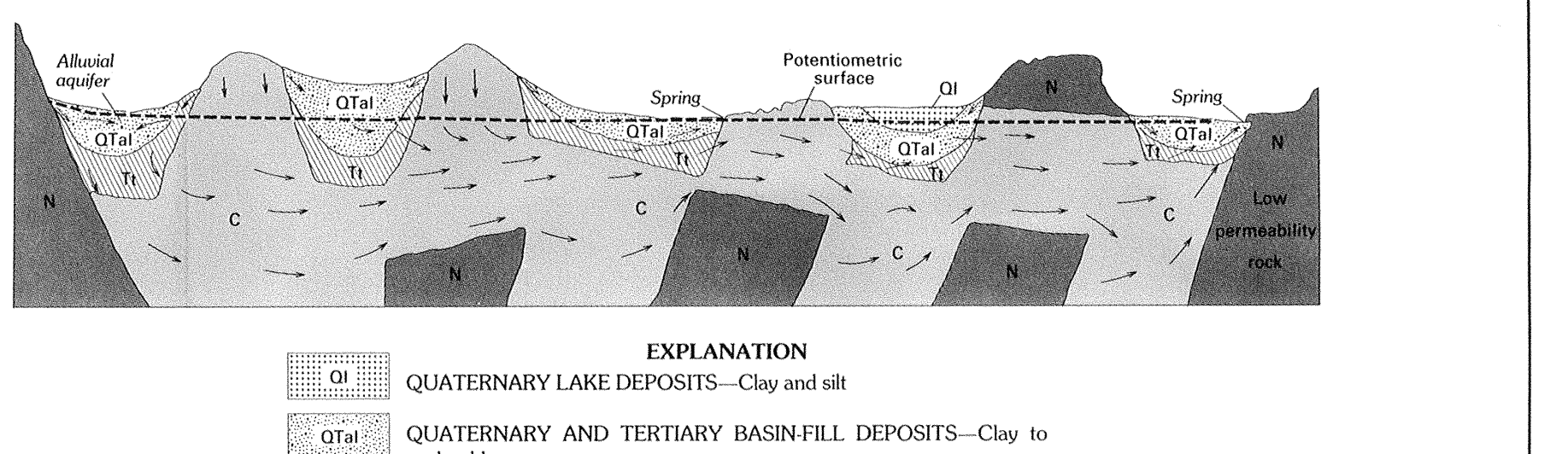
EXPLANATION

- ☐ BASIN-FILL DEPOSITS
- ■ NONCARBONATE ROCKS
- ▒ CARBONATE ROCKS
- ------- BOUNDARY OF CARBONATE-ROCK PROVINCE AS USED IN THIS STUDY
- ▨ AREA CONTAINING POTENTIOMETRIC-HEAD DATA FOR VOLCANIC ROCKS THAT OVERLIE CARBONATE ROCKS
- 5000 / 4300 WATER-LEVEL CONTOUR—Shows altitude of (1) potentiometric head in wells and mine shafts penetrating mostly carbonate rocks and (2) regional springs. Long dash where approximately located, short dash where inferred. Contour interval 200 feet, with supplemental 100-foot contours in some areas. Datum is sea level.
- 5 ● 3810 SPRING OR GROUP OF SPRINGS—Discharge exceeds 1,000 gallons per minute and water chemistry indicates long flow time, mostly through carbonate rocks. Black number refers to spring name in table 1. Blue number is spring altitude, in feet above sea level
- 6 ○ 4421 SPRING OR GROUP OF SPRINGS—Discharge is between 100 and 1,000 gallons per minute and water chemistry indicates long flow time, mostly through carbonate rocks. Black number refers to spring name in table 1. Blue number is spring altitude, in feet above sea level
- 6125 ◩ MINE SHAFT—Number is water-level altitude in shaft, in feet above sea level
- 1858 ⧗ WELL DRILLED BY ERTEC WESTERN, INC.—Number is water-level altitude, in feet above sea level
- 5320 ⊙ OIL OR GAS EXPLORATION WELL—Number is potentiometric head calculated from shut-in pressure during a drill-stem test, in feet above sea level
- 6118 ⊡ OIL OR GAS EXPLORATION WELL—Number is water-level altitude calculated from recovery during a drill-stem test, in feet above sea level
- 4724 △ OIL OR GAS EXPLORATION WELL—Number is water-level altitude measured in an abandoned well, in feet above sea level
- • WELL USED FOR CONTROL IN CONTOURING WATER LEVELS
- 4327 • WELL OUTSIDE AREA OF WATER-LEVEL CONTOURS—Number is water-level altitude, in feet above sea level
- ⁙ AREA WHERE WELLS ARE TOO NUMEROUS TO SHOW

ALTITUDE DATUM

The term "National Geodetic Vertical Datum of 1929" replaces the formerly used term "mean sea level" to describe the datum for altitude measurements. The geodetic datum is derived from a general adjustment of the first-order leveling network of both the United States and Canada. For convenience on this atlas sheet, the datum also is referred to as "sea level."

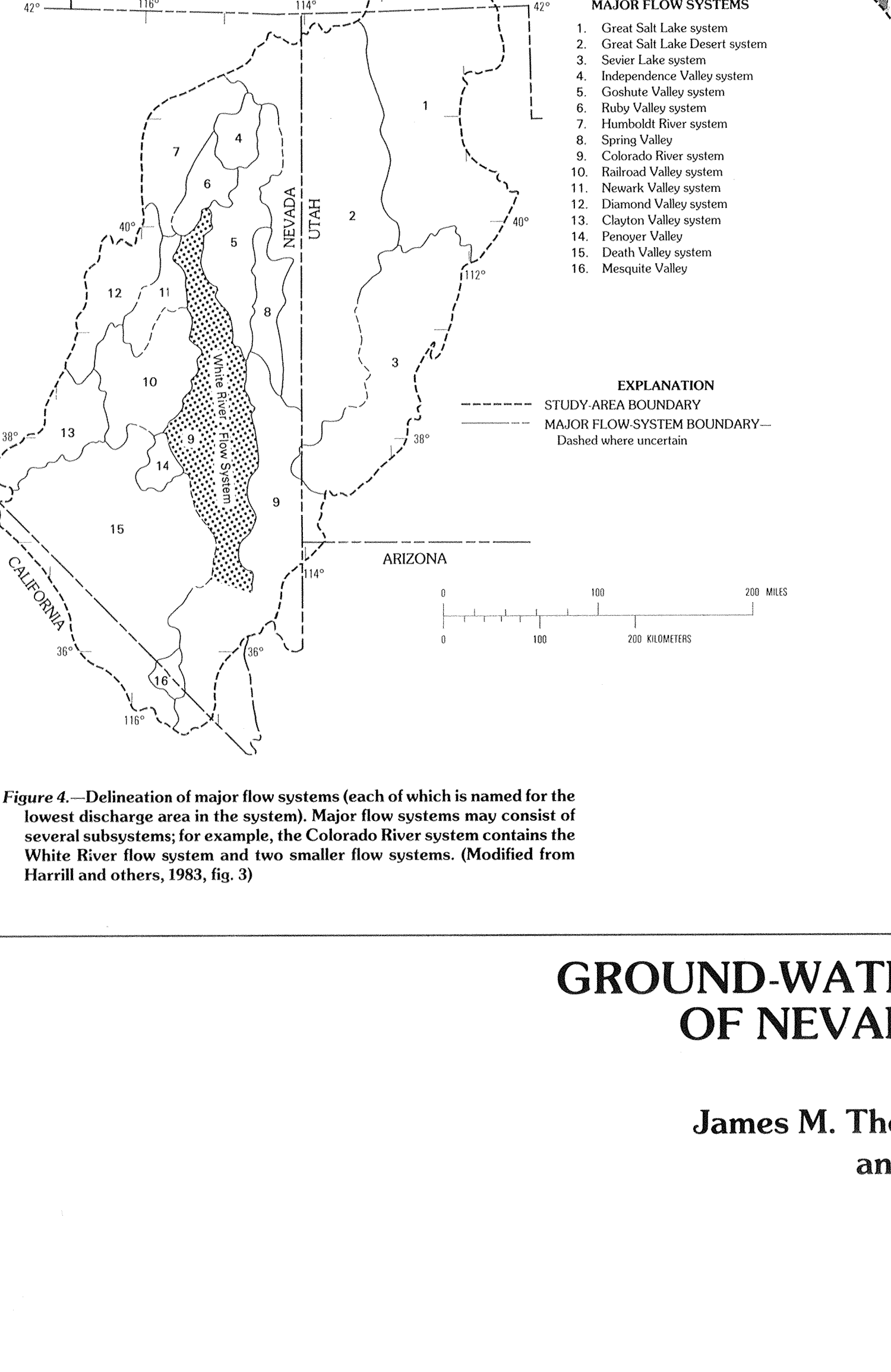
A product of the Regional Aquifer-Systems Analysis of the Great Basin



EXPLANATION

- QI QUATERNARY LAKE DEPOSITS—Clay and silt
- QTal QUATERNARY AND TERTIARY BASIN-FILL DEPOSITS—Clay to boulders
- Tt TERTIARY TUFF, ASH-FLOW DEPOSITS, AND SOME INTERBEDDED SEDIMENTARY DEPOSITS
- C CARBONATE ROCKS
- N NONCARBONATE ROCKS
- → ARROWS INDICATE GENERAL DIRECTION OF GROUND-WATER FLOW

Figure 3.—**Conceptualization of ground-water flow in a regional aquifer. (Modified from Harrill and others, 1983, fig. 9)**



MAJOR FLOW SYSTEMS

1. Great Salt Lake system
2. Great Salt Lake Desert system
3. Sevier Lake system
4. Independence Valley system
5. Goshute Valley system
6. Ruby Valley system
7. Humboldt River system
8. Spring Valley
9. Colorado River system
10. Railroad Valley system
11. Newark Valley system
12. Diamond Valley system
13. Clayton Valley system
14. Penoyer Valley
15. Death Valley system
16. Mesquite Valley

EXPLANATION

- ------- STUDY-AREA BOUNDARY
- ——— MAJOR FLOW-SYSTEM BOUNDARY—Dashed where uncertain

Figure 4.—**Delineation of major flow systems (each of which is named for the lowest discharge area in the system). Major flow systems may consist of several subsystems; for example, the Colorado River system contains the White River flow system and two smaller flow systems. (Modified from Harrill and others, 1983, fig. 3)**

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Base from U.S. Geological Survey
State maps 1:1,000,000

Geology modified from C. W. Jennings (1977), G.W. Walker (1977), J. G. Bond (1978), J. H. Stewart and J. E. Carlson (1978), and L. F. Hintze (1980)

GROUND-WATER LEVELS IN THE GREAT BASIN REGION OF NEVADA, UTAH, AND ADJACENT STATES

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