Geologic Reconnaissance and Test-Well Drilling Camp Irwin, California

By FRED KUNKEL *and* F. S. RILEY

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

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By Fred Kunkel and F. S. Riley

ABSTRACT

The area of this study covers five alluvial-filled structural basins herein called the Camp Irwin, Bicycle, Langford, Coyote, and Dry Gulch basins. These basins lie northeast of the town of Barstow within or near the Camp Irwin Military Reservation.

The geologic units are grouped in two categories: consolidated rocks and unconsolidated deposits. The consolidated rocks are mostly hard and impervious; and, except for minor amounts in cracks and fractures, they are generally not water bearing. The unconsolidated deposits are porous and generally more permeable, and as a group are potentially capable of storing, transmitting, and yielding significant quantities of ground water.

The consolidated rocks, as mapped, include the crystalline basement complex of pre-Tertiary age, a series of volcanic and associated continental sedimentary rocks of Tertiary age, and two groups of volcanic rocks of late Tertiary to early Quaternary age.

The unconsolidated deposits, as mapped, comprise six units of alluvial deposits ranging in age from late Tertiary to Recent, as follows: Granitic gravel of unknown origin, older fan deposits, older valley-floor alluvium, alluvial-fan deposits, valley-floor alluvium, and wash deposits. There are also two units of lake deposits, ranging in age from late Pleistocene to Recent, as follows: Lacustrine and playa deposits, and dune sand of Recent age.

Four test wells were drilled in connection with this study. The logs of materials penetrated, the summaries of test pumping, and the chemical analyses of the waters are included; also given are similar data for seven wells drilled by the Army from 1941 to 1944.

The geologic reconnaissance and well data indicate that the valley-floor areas of Camp Irwin, Bicycle, Langford, and Coyote basins are favorable for the development of ground water. Wells in these four basins yield from 115 to 1,700 gpm. One well in Dry Gulch basin that was drilled to a depth of 335 feet bottomed in basalt above the water table.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESIGATION AND REPORT

The U. S. Geological Survey, at the request of the U. S. Army Corps of Engineers, conducted reconnaissance geologic mapping from

August to December 1954 and logged test wells from November 1954 to January 1955 at Camp Irwin and vicinity, California. The work was requested as part of a survey for an additional water supply for the camp. The engineering phases of the work, including the test-well drilling program, were carried out by C. F. Hostrup and Associates, consulting engineers, Los Angeles, Calif.

This report presents a description of the consolidated rocks and unconsolidated deposits, a reconnaissance geologic map, and the data obtained during test-well drilling and pumping. The reconnaissance geologic mapping was carried out with special reference to the distribution and character of the unconsolidated deposits, some of which are abundantly water bearing. Only minor attention was given to the consolidated rocks, which in general are poorly water bearing. The consolidated rocks were studied principally for the purpose of ascertaining major structural features that might affect the occurrence of ground water in the area of investigation. The location of the area is shown on figure 17, and the results of the mapping are shown on the geologic map (pl. 9). Because interest was primarily in areas where additional water supplies might be obtained near the present site of Camp Irwin, the geologic mapping was most critical in the valleys containing Coyote, Langford, and Bicycle Lakes and an unnamed valley, herein referred to as Dry Gulch (pl. 9).

The Geological Survey sampled and logged four test wells drilled, one each in Coyote, Langford, Bicycle, and Dry Gulch basins.

The work by the U. S. Geological Survey was under the general supervision of J. F. Poland, district geologist in charge of ground-water investigations in California, and under the immediate supervision of G. F. Worts, Jr., area geologist in charge of investigations in southern California. The geologic mapping was done by the authors, and the test-well sampling and logging was done in large part by R. S. Stulik, of the Geological Survey.

LOCATION AND GENERAL DESCRIPTION OF THE AREA

Camp Irwin Military Reservation covers an area of about 970 square miles, roughly rectangular in shape, lying entirely within the Avawatz Mountain quadrangle. By road the south boundary of the reservation is about 26 miles northeast of Barstow and about 37 miles northeast of Camp Irwin proper.

The area mapped lies between 116°33′ and 116°58′ west longitude and between 35°00′ and 35°22′ north latitude, and includes the southwestern part of the military reservation and certain adjacent lands. This area lies entirely within the Tiefort Mountains, Goldstone Lake, Alvord Mountain, and Lane Mountain quadrangles. Geographically the area comprises about 450 square miles of rugged desert mountains and intermountain basins and includes most of the drainage areas tributary to Bicycle, Langford, and Coyote Lakes, as well as small areas tributary to Red Pass and West Cronise Lakes, east of the area shown on plate 9. Within the 3 principal drainage areas, there are 5 alluvial-filled structural basins that constitute known or potential ground-water reservoirs. For the purpose of this report these are called the Camp Irwin basin, in which the Camp and the existing Camp supply wells are located; Dry Gulch basin about 4 miles northwest of Camp Irwin; and Bicycle, Langford, and Coyote basins, centered about their respective playas (pl. 9). Prior to the test-well drilling, useful quantities of ground water were known to be obtainable from wells at moderate depths in Camp Irwin and Coyote basins, but nothing was known about the yields of the deposits in Langford, Bicycle, and Dry Gulch basins.

PREVIOUS INVESTIGATIONS BY THE GEOLOGICAL SURVEY

This region was examined by the Geological Survey from 1917 to 1919 in connection with a report on desert watering places and from 1919 to 1920 with attention to the occurrence of ground water. The information obtained is available in Water-Supply Paper 578, The Mojave Desert Region, California, by D. G. Thompson, 1929. This publication is out of print, but it can be consulted in most of the larger public libraries and in offices of the Geological Survey.

ACKNOWLEDGMENTS

There are no published geologic maps of the Camp Irwin area. Geologists of the Mineral Deposits Branch of the U. S. Geological Survey have mapped the following areas, with principal attention to the consolidated rocks: Goldstone Lake and Tiefort Mountains quadrangles, reconnaissance mapping by F. M. Byers, Jr., G. I. Smith, and R. C. Ellis; Alvord Mountain quadrangle, detailed mapping by F. M. Byers, Jr.; and Lane Mountain quadrangle, detailed mapping by T. H. McCulloh.

The writers wish to acknowledge the generous cooperation of these geologists, in permitting extensive use of pertinent information from preliminary copies of their maps.

The geology of the unconsolidated deposits for the entire area and the geology of both the consolidated and unconsolidated deposits in the area north of Camp Irwin was mapped by the Ground Water Branch.

Also, the authors wish to thank Lt. Col. H. S. Long and others of the Camp Irwin personnel for assistance in securing daily range clearance and for supplying helicopter flights on special occasions.

GEOLOGIC UNITS

The geologic units mapped in the investigation are described in this section with reference to their distribution, physiography, stratigraphic and age relations, and general lithology; and with special reference to the elements of their physical character, as observed in surface outcrops, that would suggest their potential water-bearing properties. On the basis of observations in similar areas, certain reasonable conjectures about the probable subsurface occurrence and character of the units are presented.

The geologic ages of the various units given in this reconnaissance report are believed to be essentially correct in their mutual relations, but may be in error relative to the absolute geologic time scale. They are based principally on stratigraphic and physiographic relations interpreted in accordance with the general Cenozoic history of the Mojave Desert as described by numerous geologists. For the most part these men have had very few paleontological age determinations at their disposal. In and near the area mapped in this investigation, the only units that have been dated by fossil evidence are certain upper Miocene continental sediments and the Manix lake beds of Pleistocene age.

For the purposes of this report the geologic units are grouped in two general categories: consolidated rocks and unconsolidated deposits. The consolidated rocks are mostly hard and impervious; and, except for minor amounts of water in cracks and fractures, they are not considered to be generally water bearing. The unconsolidated deposits are porous and generally more permeable, and as a group are potentially capable of storing, transmitting, and yielding significant quantities of ground water.

CONSOLIDATED ROCKS

The consolidated rocks, as mapped, include the crystalline basement complex of pre-Tertiary age; a series of volcanic rocks and associated continental sediments of Tertiary age; and two groups of volcanic rocks of late Tertiary to early Quaternary age.

PRE-TERTIARY—BASEMENT COMPLEX

The basement complex comprises a heterogeneous group of igneous, metaigneous, and metasedimentary rocks, which span a long range of geologic ages. The basement complex is older than the rocks of known Tertiary and Quaternary age from which it is separated by a profound erosional unconformity. The basement complex generally crops out in rugged mountains or upland areas. It also forms the so-called bedrock that underlies at considerable depth the younger rocks and deposits of the valley floors. Although essentially impervious and therefore considered essentially not water bearing, the crystalline rocks may contain enough water in fractures and joint systems to supply springs and to contribute small quantities of recharge to ground water in the adjacent unconsolidated deposits.

TERTIARY—VOLCANIC AND ASSOCIATED CONTINENTAL SEDIMENTARY ROCKS

For the purposes of this report a variety of volcanic rocks and associated continental sedimentary rocks, which were mapped and described in detail by McCulloh (written communication, 1952) in the Calico Mountains area and by Byers [1] in the Alvord Mountain area, have been grouped into a single mapped unit. The extent and the description of this composite unit are based largely on the more detailed work by McCulloh and Byers in their respective areas.

In both the Calico and the Alvord Mountains, the unit includes the oldest rocks overlying the basement complex, but it also includes appreciably younger rocks separated from the basal beds by erosional uncomformities and some intrusive rocks. The rocks in both areas probably range in age from middle to late Miocene, but no attempt has been made to establish a lithologic correlation or time equivalence between the formations in the two areas.

In the Calico Mountains the composite unit consists largely of volcanic rocks, comprising the Jackhammer and Pickhandle formations of McCulloh (written communication, 1952), and a younger group of unnamed volcanic rocks. The predominant rock types are andesite and dacite with some basalt and tuff interbedded and associated with the sedimentary rocks. The unit overlies the narrow band of basement complex that crops out along the northern edge of the Calico Mountains and dips generally south away from Coyote Valley. In addition to being composed largely of impervious rocks, the only known occurrences of the unit in the southern part of Coyote Valley are far above the regional water table.

In the Alvord Mountain area the rocks of Miocene age include a larger proportion of continental sedimentary rocks, principally arkosic sandstone and conglomerate with a few beds of silt, clay, and tuff. The volcanic rocks consist principally of basalt flows, which are interbedded with the continental sedimentary rocks. The upper part of the unit possibly may be an equivalent of the Barstow formation. These rocks as a group overlie the bedrock core of Alvord Mountain on its northeast flank and dip beneath younger unconsolidated deposits in Langford Valley and West Cronise Valley (east of area

[1] Byers, F. M., Jr., 1956, Geologic map of the Alvord Mountain quadrangle, California: U. S. Geol. Survey open-file report, Washington, D. C.

covered by pl. 9) to the north and northeast. They are broken by numerous small faults and are moderately to strongly folded.

In the outcrop area the continental sedimentary rocks probably are above the zone of ground-water saturation, but in the adjacent valleys they might be penetrated below the water table by deep wells. As observed in outcrops the sedimentary rocks are slightly to highly indurated and in general appear to be of low permeability. Although a few of the beds, if penetrated in the zone of ground-water saturation, might yield small quantities of water to wells, these rocks in general are not considered to be water bearing.

UPPER TERTIARY AND QUATERNARY(?)—VOLCANIC ROCKS

The volcanic rocks, consisting principally of latite and andesite, with lesser amounts of dacite, basalt, and perlitic obsidian, form the top of Lane Mountain and comprise relatively large mountain areas northwest and southwest of the camp. At Lane Mountain and in the mountains immediately west of the Camp Irwin basin these rocks rest unconformably on the basement complex. In the latter area they generally include at their base 50–100 feet of tuff, tuffaceous sand, and agglomerate. In the mountains farther to the northwest they attain an observed thickness of more than 1,000 feet, and their base is not exposed.

The rocks in the several outcrop areas included in this unit are very similar in their general lithology and stratigraphic position, but their actual equivalence has not been demonstrated. They are tentatively thought to be of Pliocene and possibly very early Pleistocene age.

Because of their dense crystalline texture and usual position in mountainous areas high above the regional water table, these volcanic rocks are not generally classified as water bearing. However, in Dry Gulch basin these volcanic rocks appear to dip beneath the younger alluvial deposits underlying the valley floor and might be tapped below the water table by moderately deep wells drilled in the bottom of the valley. They were not penetrated in test well M1 (pl. 9) in sec. 23, T. 14 N., R. 2 E. Whether these rocks would yield appreciable quantities of water to wells would depend on the extent to which they contain open fractures capable of storing and transmitting water. In certain areas of the world, like the Columbia Plateau and the Hawaiian Islands, wells drilled into fractured lava flows and scoria have exceptionally good yields. The andesitic flows just west of Camp Irwin were extensively fractured in the surface outcrops examined. However, it is not known whether the fractures are original features that formed during the solidification and cooling of the flows and therefore continuous throughout its mass, or whether they are the result of weathering processes and hence limited essentially to the exposures.

TERTIARY(?) AND QUATERNARY—BASALT

The youngest consolidated rocks mapped are basalt dikes, plugs, and small flows, occurring at scattered sites principally in the northern third of the mapped area. Locally, thin beds of pumiceous tuff and agglomerate are associated with the basalt. The basalt variously intrudes as fissure fillings or overlies not only the basement complex and the late Tertiary and Quaternary(?) volcanic rocks but also the late Tertiary to Quaternary granitic gravel and continental deposits. However, the basalt has contributed numerous fragments to the Quaternary alluvial deposits in the northern part of the area. On the basis of the reported age of basalt of similar character and stratigraphic position in nearby parts of the Mojave Desert, this basalt is believed to be generally of early Quaternary and possibly very late Tertiary age. Differences in lithology and mode of occurrence suggest that not all of the outcrops mapped in this unit are equivalent in age. A Quaternary age for many of the dikes is suggested by their location in the plane of active faults that apparently are associated with the regional Pleistocene diastrophism. On the other hand, some of the flows, notably those overlying the late Tertiary and Quaternary(?) volcanic rocks just west of Camp Irwin, may be appreciably older, possibly of late Tertiary age. More detailed studies might show that the basalt flows capping the hills in secs. 1 and 2, T. 13 N., R. 2 E., and shown on the map (pl. 9) as part of the late Tertiary and Quaternary(?) volcanic rocks, should be grouped with the younger basalt.

The water-bearing properties of the basalt are not known. The basalt flows overlying the volcanic rocks west of Camp Irwin dip beneath the alluvium of Dry Gulch basin and were found above the water table in test well M1 (pl. 9) in sec. 23, T. 14 N., R. 2 E. (See log at end of report.) However, beneath the water table they might yield water to wells in the manner previously outlined in the discussion of the late Tertiary and Quaternary(?) volcanic rocks in the same area.

UNCONSOLIDATED CONTINENTAL DEPOSITS

The unconsolidated deposits, as mapped, comprise six units of alluvial deposits ranging in age from late Tertiary to Recent, as follows: Granitic gravel of unknown origin, older alluvial-fan deposits, older valley-floor alluvium, alluvial-fan deposits, valley-floor alluvium, and wash deposits. There are also two units of lake deposits as follows: Lacustrine and playa deposits of late Pleistocene age and dune sand of Recent age.

The granitic gravel of unknown origin is the oldest of the unconsolidated deposits. This deposit rests unconformably on the rocks of Miocene age and the basement complex, and it is moderately to strongly deformed, weathered, and indurated. Because of its stratigraphic position and degree of deformation, it is believed to be late Tertiary to early Quaternary in age.

The next group of unconsolidated deposits comprises the older alluvial-fan deposits and older valley-floor alluvium, which are considered equivalent in age. They rest unconformably on the late Tertiary to Quaternary granitic gravel and on the basement complex; are mildly deformed to undeformed, except where adjacent to active faults; and are somewhat weathered and indurated. Their mild degree of deformation suggests that they probably in large part postdate the middle Pleistocene orogeny, but locally mud-flow breccia in the older alluvial-fan deposits suggests that in part they may be contemporaneous with this orogeny and hence of middle Pleistocene age. Their topographic position, lithology, and degree of weathering provide a basis for distinguishing them from the overlying younger alluvial deposits. Also included in this group are the lacustrine deposits.

The youngest group of unconsolidated deposits comprises the alluvial-fan deposits, valley-floor alluvium, and playa deposits. These deposits rest conformably or with minor unconformity on the older alluvial and lacustrine deposits, are essentially undeformed, and are not appreciably weathered. The uppermost parts of these deposits of this group are of Recent age, and the lowermost parts probably are of late Pleistocene age. The wash deposits represent the youngest of these alluvial deposits and have been mapped only in the major stream channels.

UPPER TERTIARY TO QUATERNARY—GRANITIC GRAVEL OF UNKNOWN ORIGIN

The granitic gravel of unknown origin crops out in two areas. One area is on the northern flank of Alvord Mountain and extends westward across the slope north of Coyote Lake. The other is over a considerable area northwest of Bicycle basin. East and north of Alvord Mountain, the gravel rests with slight to moderate angular unconformity on older Tertiary volcanic and continental rocks, but to the northwest it rests directly on the erosional surface of the basement complex. It is overlain with angular unconformity by Pleistocene and Recent alluvial deposits. In the area northwest of Bicycle Lake, the base of this unit is exposed resting on the basement complex at several places along the conspicuous east-trending fault zone 4 miles north of Camp Irwin.

Lithologically, the deposit in the area north of Alvord Mountain is a crudely bedded poorly sorted alluvial deposit, consisting almost exclusively of granitic debris, principally coarse sand and gravel. In surface outcrop the abundant feldspar grains are considerably weathered, resulting in the development of secondary interstitial clay. In several areas, such as in the anticline southeast of Langford Lake, the basal part of the unit, where underlain directly by the basement complex, consists of a coarse breccia or boulder conglomerate. Locally, the upper part of the unit contains andesite cobbles. The unit is traversed by several faults and is slightly to moderately deformed by folding, particularly around the flanks of Alvord Mountain. In general, the structure of the unit in that area is a somewhat subdued duplication of the structural pattern in the underlying Tertiary volcanic rocks and associated continental sedimentary rocks.

In the area northwest of Bicycle Lake, the lowermost part of the unit is a massive and cemented boulder deposit composed of coarse angular unsorted metaigneous detritus derived directly from the adjacent basement complex. Where observed, this basal part of the deposit is about 100 feet thick. Overlying the basal part along the north side of the fault is 100–200 feet of moderately well-bedded sand, tuffaceous sand, and highly tuffaceous sandy silt, grading from generally coarse material near the bottom to fine material in the upper part of the unit. Northward dips of as much as 20° were observed adjacent to the east-trending fault 4 miles north of Camp Irwin, but the dips flatten rapidly northward to a regional dip of 1°–2° that prevails over a considerable area. The gentle dissected slope north of the fault zone is a series of sandy silt and silty clay beds which are locally tuffaceous. Except for the admixture of tuffaceous material, which locally is a very large percent of the total, the deposits in this area are composed principally of granitic or metaigneous detritus, although some stringers of andesite and latite pebbles were found.

On the basis of stratigraphic and structural relations, the granitic gravel is tentatively believed to be of late Tertiary to early Quaternary age. It may be in part equivalent to and in part somewhat younger than the late Tertiary and Quaternary(?) volcanic rocks. However, the gravel is older than the Tertiary(?) and Quarternary basalt, which intrudes it in several series of small dikes north of Coyote Lake and north of Bicycle Lake and in several plugs northwest of Bicycle Lake.

Although the granitic gravel probably is above the water table in most areas, it appears to dip beneath the younger alluvial deposits in Langford basin and the northern part of Coyote basin and probably underlies the alluvium at moderate depths below the water table in the lower parts of these basins. It is probable that the granitic gravel was penetrated in the lower parts of test wells A1 (pl. 9) in sec. 31, T. 12 N., R. 2 E., and B1 in sec. 35, T. 13 N., R. 3 E. (See logs, p. 257–258.) The poor sorting of the deposits and the considerable amount of interstitial clay, as observed in surface outcrops, suggest that the permeability may be very much less than might be expected of an unconsolidated sand and gravel deposit. Nevertheless, the deposits beneath the water table in the vicinity of Coyote Lake probably yield moderate quantities of water to properly constructed wells and probably yielded water to the test wells. It is also possible that the feldspars may be less decayed at depth, in which case the permeability of the deposit would be higher than where it is exposed to surface weathering.

The water-bearing potential of the granitic gravel in the area northwest of Bicycle Lake is believed to be very poor because of the fine-grained and strongly weathered materials in the upper part of the deposit and the extremely poor sorting of the coarse basal breccia. In addition, the deposit is not definitely known to occur below the water table in the vicinity of Bicycle Lake. However, it is thought to underlie the alluvial deposits in the northern part of Bicycle basin and in the valley area just to the north and probably is saturated, at least in part, in these areas. In the latter area, however, two test wells—one drilled to 585 feet in 1942, and the other drilled to 349 feet in 1944—probably penetrated these deposits and reportedly were dry. It is not clear from the records available whether these wells failed to reach the zone of saturation or simply tapped deposits which, though saturated, were so impermeable as to yield essentially no water to the bore holes.

MIDDLE TO UPPER PLEISTOCENE

OLDER ALLUVIAL-FAN DEPOSITS

Coarse alluvial-fan deposits which have been raised above the adjacent alluvial surfaces by faulting or upwarping then dissected by erosion have been mapped as older alluvial deposits. These deposits, derived from the presently existing mountain masses, generally occur in relatively small areas. For example, in the area on the northwest flank of the Tiefort Mountains and in an area 1–3 miles east of Langford Lake, the deposits have been uplifted by late(?) Pleistocene faulting and as a result have been deeply dissected by erosion. As nearly as can be determined from poor exposures, the older alluvial-fan deposits in both areas are made up of coarse, very poorly sorted, and crudely bedded detritus consisting principally of metamorphic fragments derived directly from the adjacent mountains and probably including some talus and mud-flow debris as well. Valleyward these deposits probably are equivalent in part to the older valley-floor alluvium, which is concealed beneath the upper Pleistocene to Recent valley-floor alluvium.

The older alluvial-fan deposit east of Langford Lake contains numerous basalt cobbles and boulders derived from the basalt believed to be of very late Tertiary (?) and early Pleistocene age. The coarse angular material deposited in the upper part of this deposit suggests a nearby source area of high relief. The apparent source for the detritus is the upland area of basement complex just to the north. At present this is an area of mature dissection and relatively low relief and does not appear to be supplying material as coarse, angular, and poorly sorted as the older alluvial-fan deposits. Therefore, it seems likely that a considerable period of dissection and degradation of the bedrock area has elapsed since the deposition of this material. On this basis the deposition is thought to have occurred in early to middle Pleistocene time.

The older alluvial-fan deposits on the northwest flank of Tiefort Mountain probably were derived from this rugged mountain source and apparently are somewhat similar to the material currently being deposited on the active fans fringing the mountain. However, the older alluvial-fan deposits have been deeply dissected, so deeply that the base is exposed in contact with the underlying basement complex in the bottom of two ravines. Presumably, therefore, the basal part of the deposits dates back to the time of the major uplift of Tiefort Mountain, which probably occurred during middle Pleistocene time.

The outcrop areas of the older alluvial-fan deposits are far above the regional water table, and there is little evidence to suggest that the deposit extends beneath the younger alluvial deposits into the zone of ground-water saturation. Even if saturated, they would probably yield only small quantities of water because of their muddy unsorted texture. Beneath the younger alluvial deposits, the older alluvial-fan deposits probably grade laterally away from their source areas into cleaner better sorted older valley-floor alluvium described in the next section.

OLDER VALLEY-FLOOR ALLUVIUM

Alluvial deposits, principally sand and gravel, that were derived from existing upland areas but are now dissected have been mapped as older valley-floor alluvium. The older valley-floor alluvium is exposed in several areas west and northwest of Bicycle Lake and at scattered locations elsewhere in the mapped area. Where exposed the old surface of this deposit has been degraded by sheet wash and wind erosion, with the result that a veneer of residual gravel, commonly one cobble thick, characteristically mantles the deposit. This residual or lag gravel is composed of pebbles, cobbles, and locally boulders, principally of volcanic origin, whose exposed surfaces are stained a very dark brown by desert varnish (manganese and iron oxides).

The degree of dissection of the old surface ranges from slight to great but is only moderate in most areas, probably in part as a result of the protection provided by the veneer of residual gravel. In the exposures northwest of Bicycle Lake, particularly in secs. 4, 5, and 9, T. 14 N., R. 3 E. (pl. 9), the degree of dissection increases toward the west. West of the area mapped as older valley-floor alluvium, the unit is present in the form of a gravel veneer capping the higher interfluvial ridges and overlying the moderately eroded surface of the upper Tertiary to Quaternary granitic gravel of unknown origin.

The older valley-floor alluvium is slightly tilted and warped upward along the margins of the valleys in most areas of exposure. West of Bicycle Lake it has been gently bowed upward and faulted, with a dip of 26° adjacent to the fault. In this area the original uplifted surface has been nearly planed off by erosion.

The older valley-floor alluvium, as exposed in the cutbanks of gullies and arroyos, as much as 40 feet deep, and in a few road cuts, consists principally of coarse sand with numerous stringers of subangular to rounded pebbles and cobbles. Interstitial clay is a conspicuous constituent of much of the unit but is essentially absent in some exposures. Bedding is moderately well developed; crossbedding and minor intraformational unconformities are common. Most of the detritus has been derived from areas of volcanic rocks. Fragments of andesitic volcanic rocks generally predominate, and fragments of basalt are common.

In the vicinity of Bicycle Lake, the older valley-floor alluvium rests unconformably on the basement complex, the late Tertiary and Quaternary(?) volcanic rocks, and the granitic gravel of undetermined origin. In this area the deposit thickens from a featheredge along its western margins to a maximum exposed thickness of about 50 feet. Throughout most of the exposed areas, the depth of the base of the deposit is unknown. Along its lower margins the unit is being buried by alluvial deposits of Recent age.

Because it overlies the granitic gravel of undetermined origin and the basalt and because it has been involved locally in appreciable structural deformation, the older valley-floor alluvium is tentatively thought to be of middle Pleistocene or early late Pleistocene age.

The older valley-floor alluvium underlies the alluvial deposits of late Pleistocene and Recent age in much of Bicycle and Camp Irwin basins, and probably occurs below the water table in a considerable part of these basins. If found in wells, the older alluvium probably would be logged as sand and gravel or as sand, gravel, and clay. In Camp Irwin basin, material of this kind was logged in camp supply wells 1 to 4 from depths between 280 and 500 feet. Similarly, older valley-floor alluvium probably was found in the lower parts of test wells in Coyote and Bicycle basins and possibly at intermediate depths in test wells in Langford and Dry Gulch basins. (See logs at end of report.) However, the log data are not sufficiently detailed to correlate this material with the older alluvium mapped in the surface outcrops.

The results of the test pumping on camp supply wells demonstrated that the material below 280 feet in these wells is much less permeable than the overlying deposits, which is typically the case where identifiable older alluviums have been tapped below younger alluviums in other ground-water basins. The muddy appearance of the older valley-floor alluvium in many surface outcrops indicates that much of the deposit probably is of rather low permeability. Some of the material in the exposures, however, is relatively clean and well sorted, suggesting that locally the deposits might yield moderately large quantities of water to wells. It is probable that most of the water supplied to the test well in Bicycle basin was from the older valley-floor alluvium.

LACUSTRINE DEPOSITS

The lacustrine deposits occur in an area 0.5–6 miles east and southeast of Coyote Lake. These deposits are not well exposed; a few outcrops in the SE¼ sec. 8, T. 11 N., R. 3 E., and in secs. 15, 16, and 21, T. 11 N., R. 3 E., are composed predominantly of well-sorted clean crossbedded sand interbedded with lenses of fine silt and clay. In topographic form the surface of the deposits is characterized by an extensive flat-topped plain or terracelike surface at an elevation of about 1,780 feet, which extends about 8 miles southeast to the Mojave River (not shown on fig. 17). The surface also is characterized by numerous shallow undrained depressions (pl. 9) and a lack of an integrated drainage pattern.

The lacustrine deposits appear to overlie the granitic gravel of unknown origin and the basement complex; their thickness is unknown. They are being covered on the east and north by alluvial-fan deposits from Alvord Mountain. This encroachment of fan deposits has blocked eastward drainage from the lacustrine deposits, creating about a dozen small playas along the contact between the two deposits (pl. 9).

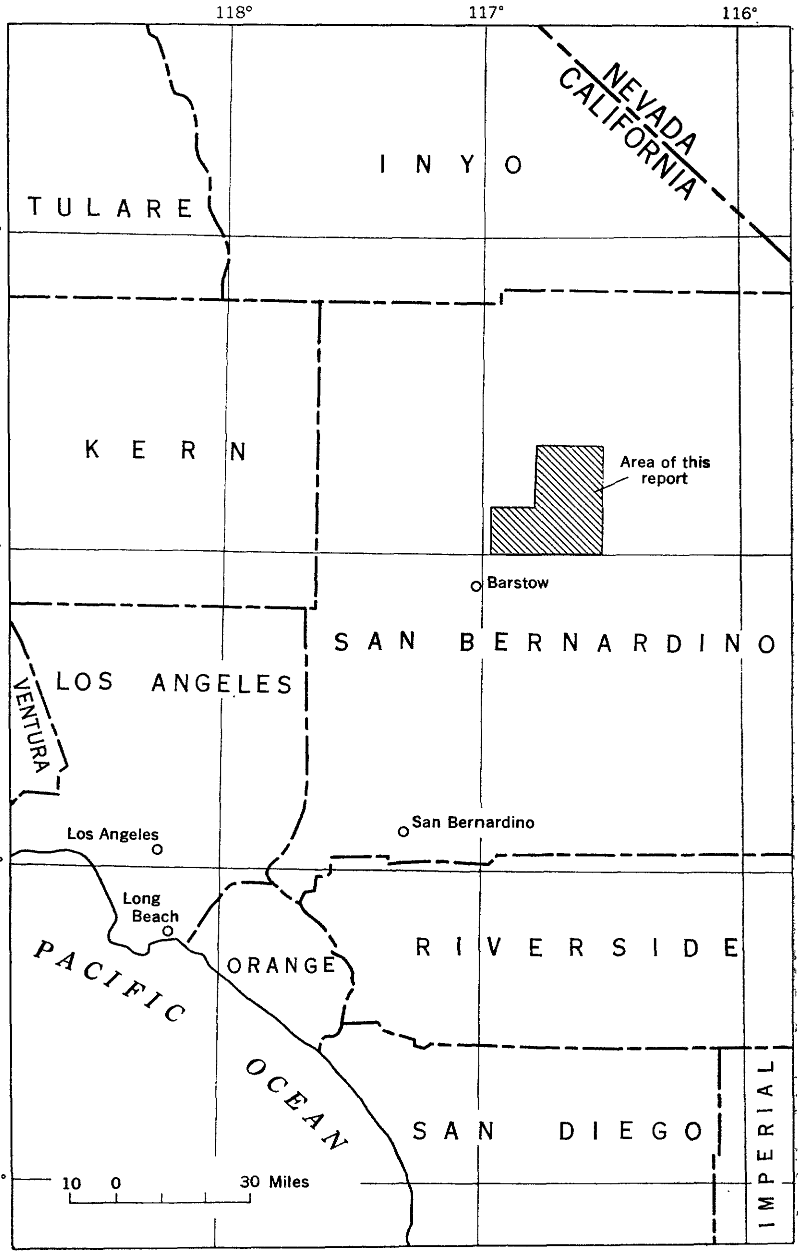

FIGURE 17.—Map of a part of southern California showing the area covered by this report.

An examination of aerial photographs of the area strongly suggests that some of the lacustrine deposits were laid down as a sand bar or sand spit in a relatively shallow lake that occupied a much larger area than the present playa of Coyote Lake. This hypothesis is further supported by the existence of a very distinct shoreline cut on dissected fan deposits southwest of Coyote Lake at an altitude of approximately 1,785 feet in secs. 8, 17, and 21, T. 11 N., R. 2 E.

Inasmuch as the lacustrine deposits are older than the playa deposits of Coyote Lake and yet appear to be a relatively young feature, they are believed to be late Pleistocene in age.

Drillers' logs are not available for wells drilled in these deposits, and it is not known whether wells draw water from them. Although the surface exposures consist largely of well-sorted clean sand associated with bars or beach features, it is likely that deposits of this nature are thin and underlain by predominantly fine-grained lacustrine deposits such as these exposed along the Mojave River near Manix (not shown on pl. 9). Such deposits presumably would not yield water freely to wells.

UPPER PLEISTOCENE TO RECENT

ALLUVIAL-FAN DEPOSITS

The alluvial deposits directly underlying the surfaces of steep alluvial fans and aprons along the major mountain fronts and the gentler slopes fringing low hills and upland areas have been mapped as alluvial-fan deposits. Also included in this unit are thin pediment veneers and limited areas of alluvial fill in small reentrant valleys. Because the areas shown on the map as alluvial-fan deposits are slopes of active deposition, the materials exposed in these areas are of Recent age. However these uppermost deposits of Recent age are believed to be underlain by a continuous and essentially conformable sequence of similar deposits, whose lowermost strata probably are of late Pleistocene age. The alluvial-fan deposits probably rest with minor unconformity on older valley-floor alluvium and older fan deposits and with marked unconformity on older rocks and deposits. Their thickness ranges from a featheredge at the contact with the source-area rocks to an unknown maximum that may be as much as several hundred feet beneath the larger fans, such as those west of Coyote Lake.

On the steeper slopes the surfaces of the fan deposits contain channels 2–8 feet deep, with the depth increasing upslope. The lithology of the deposits is revealed to a slight degree in these channels and more extensively in the deeper and more numerous gullies typical of the areas mapped as dissected fan deposits. The lithologic feature most characteristic of the fan deposits is the very poor sorting of the materials. On the steep uppermost slopes of alluvial fans in very arid regions, the deposits are thought to be built up in large part by viscous mudflows and debris-laden sheetfloods of very brief duration. Downslope from the mountain ravines these agents deposit large boulders and great quantities of cobbles in a matrix of sandy mud. The resulting deposit is essentially unsorted and very poorly stratified. As the slope angle decreases with increasing distance from the apex of the fan, the average size of the larger fragments also decreases. In addition, the high average sorting ability of runoff that reaches the lower slopes of large fans, tends to reduce the quantity of interstitial fine material in the lower slope deposits. Thus, there is a general tendency, particularly on larger fans, toward improvement of sorting downslope by a reduction in the percentages of both the very coarse and the very fine fractions of the detritus. These processes are discussed more fully in the section on valley-floor alluvium.

Cobbles and boulders may be essentially absent on steep fans derived from certain granitic rocks that disintegrate readily into nearly equigranular fragments of sand and fine gravel, but even in such deposits the interstices are typically clogged with clayey silt and sand.

The comparatively gentle slopes surrounding upland areas of mature dissection and relatively subdued relief, such as those south of Camp Irwin and west and south of Langford Lake, characteristically lack the strongly concave-upward surface and steep upper slopes of the typical alluvial fan or apron. In addition, the profile along such slopes, parallel to or concentric with the mountain front, is nearly level in contrast to the undulating profile along an alluvial apron built up by coalescing fans. These are the essential physiographic features of a type of desert slope on which there is a gradual downslope transition from a rock-floored erosional slope, or true pediment bordering the hills, to a morphologically indistinguishable slope of deposition, which merges with the alluvial plain of the valley floor. This characteristically is underlain by a mantle of Quaternary slope wash. Typically this alluvial mantle is merely a very thin pediment veneer along its upper margins and locally for some distance downslope, but in general the deposit is thought to increase gradually in thickness downslope, possibly attaining a thickness of 100 feet or more along its lower margins.

Slope-wash deposits and gently sloping fans derived from areas of low relief lack the high percentage of cobbles and boulders usually found in the steep fan deposits. However, the runoff over these surfaces, because of its infrequent occurrence, small volume, and brief duration, is always overloaded with rock debris and has very little sorting power. Thus, the resulting deposits, though lacking in the very large fragments typical of most steep fan deposits, still possess the characteristic silty and clayey matrix.

The alluvial-fan and related deposits grade into contemporaneous valley-floor alluvium along their lower margins. Although there are usually well-defined distinctions in lithology between typical fan deposits and typical valley alluvium, the lateral facies change is apt to be gradational through a zone of appreciable width. In the absence of surface and subsurface lithologic data, the somewhat arbitrary contact between the alluvial-fan deposits and valley-floor alluvium has been drawn on the basis of changes in the character of detritus on the soil surface and the poorly distinct to pronounced flattening of the alluvial slope that usually marks the change from conditions of fan deposition to those of valley-floor deposition. In vertical section the contact zone between the two units below land surface probably shifts back and forth laterally for appreciable distances, producing a relatively wide zone of interfingering valley and fan alluvial deposits.

Because of their very poor sorting and muddy matrix, the materials mapped as alluvial-fan deposits commonly are of low permeability and porosity and, consequently, are not regarded as good aquifers. Furthermore, wells drilled on the middle and upper parts of the pediment slopes and probably many of the upper fan slopes as well would enter consolidated rock or poorly permeable late Tertiary to Quaternary continental deposits or granitic gravel before reaching the water table. The tendency for downslope improvement of sorting probably produces a moderate increase in the permeability and porosity of the fan deposits underlying the lower slopes, and in these areas, too, the deposits usually are thicker. Thus, the alluvial deposits underlying the lower fan and pediment slopes, though believed to be generally too impermeable to yield water copiously to wells, probably contain significant quantities of ground water in storage in the interstices below the water table. This stored water probably moves into the adjacent valley alluvium very slowly under natural conditions but would drain at an accelerated rate if water levels in the alluvium were lowered by heavy pumping.

VALLEY-FLOOR ALLUVIUM

GENERAL CHARACTER

The alluvial deposits underlying the undissected alluvial surfaces of the lower valley areas, between the lower margins of the fan deposits and the edges of the playas, have been mapped as valley-floor alluvium. Because the areal extent of the alluvium, as shown on the map, is limited to surfaces of active deposition, the deposits exposed at the surface are of Recent age. These surficial deposits are believed to be underlain by a continuous and conformable sequence of valley-floor alluvium that probably spans an age range of late Pleistocene to Recent. Significant deposits of valley-floor alluvium occur in the valley areas centered about Bicycle, Langford, and Coyote Lakes and in Dry Gulch basin. In most of these structural basins the alluvium probably rests with minor local unconformity on older alluvial deposits.

The approximate thickness of the upper Pleistocene to Recent valley-floor alluvium has been estimated from the logs of the test wells. In Coyote basin the thickness is at least 105 feet (well A1, pl. 9, in sec. 31, T. 12 N., R. 2 E.); in Langford basin, about 120 feet (well B1 in sec. 35, T. 13 N., R. 3 E.); in Bicycle basin, possibly 100 feet (well K1, sec. 13, T. 14 N., R. 3 E.); and in Dry Gulch basin, possibly 85 feet (well M1, sec. 23, T. 14 N., R. 2 E.). The maximum total thickness of unconsolidated or semiconsolidated Tertiary and Quaternary deposits is not known in any of the basins because no wells have been drilled to the basement rock in the centers of the basins.

The lithology of the valley-floor alluvium is known principally from observations in other similar areas, because there are no extensive exposures and only very meager log data from the few wells in the area mapped. In general, the alluvium presumably consists of interstratified, interfingered, discontinuous beds, lenses, and stringers of poorly to fairly well-sorted sand, gravel, silt, and clay. The valley-floor alluvium differs from alluvial-fan deposits by being less angular, better sorted, finer grained, and better bedded. Like the fan deposits the alluvium tends to become finer grained and better sorted toward the playas. The logs of the test wells show that in the larger basins the valley-floor alluvium is composed largely of loose coarse sand and gravel with minor amounts of clay.

MODE OF DEPOSITION

Small floods of brief duration are rapidly dissipated by distributary channels and infiltration losses on the upper fan slopes, and consequently their suspended sediment, both coarse and fine, is deposited in those areas, which tend to become oversteepened as a result of the accumulation of these deposits. Larger flows spread their deposits farther down the slope, sorting and distributing their load, which ranges from gravel to clay, over a broader band of the fan slope. The very rare maximum flood of large flow and sustained duration distributes its suspended sediment over the entire alluvial slope, from fan head to playa, sorting out and depositing the coarse, medium, and fine fractions on the steep, intermediate, and flat parts, respectively, of the alluvial profile. This produces a significantly thick, moderately well-graded and well-sorted stratum of material along the entire profile. Thus, the material deposited by the maximum floods tends to be better sorted, better bedded, and, at any given point along the profile, coarser grained than the deposits laid down by small or average-sized flows.

Gravels deposited on the slopes by major floods are well sorted and grade from boulders, cobbles, and coarse gravel on the upper slopes to fine gravel and sand on the valley floor. Finer grained material carried by minor floods subsequently fills the large interstices of the boulders, cobbles, and coarse gravel on the upper slopes; but, as the gravel size decreases toward the valley, more and more of this finer grained material is filtered out until at the valley floor the gravels contain little of the sediments of the minor floods. Because of this filtering action and the fact that small flows ordinarily do not carry large quantities of sediment very far, it is thought that the valley-floor alluvium is composed of a much higher proportion of major-flood deposits than alluvial-fan material. This is believed to account in large measure for the better sorting and resulting higher permeability that characterize the valley-floor alluvium of most desert basins.

From the foregoing discussion it appears that mountain drainage systems capable of producing large and long-sustained streamflows are most conducive to the deposition of coarse-grained, well-sorted, and relatively permeable alluvial fill in the adjacent major valleys. In order to yield large flows the mountainous part of a drainage basin must have a large capacity to collect and concentrate runoff, and in order to yield sustained flows it must have a large capacity to store temporarily part of the available water and subsequently to release it to sustain the declining stages of runoff. The aridity of the desert climate is, of course, the dominant factor in controlling the runoff from the mountain watersheds; but assuming this condition to be essentially constant in a given area, there are physical characteristics of watersheds that will influence the nature, magnitude, and duration of runoff. Among the most important of these are the size of the mountain watershed area, its mean elevation above sea level, the texture, shape, and degree of integration of the drainage pattern in the watershed area, the absorptive and retentive properties of the mantle rock, and certain characteristics of the channels, principally their slope, cross-sectional area, and roughness.

Other conditions being equal, a large watershed area will contribute more runoff to an adjacent valley area than a small watershed, and a high mountain area will induce more orographic precipitation than a low one. Similarly, a well-integrated coarse-textured drainage pattern in the mountains will divide the total mountain watershed into a small number of large drainage basins, thus collecting the available runoff and delivering it to the valley areas in a few large streams, rather than in numerous small streams such as descend from a mountain area in which the drainage pattern is fine textured and poorly integrated. An elongate drainage system tends to deliver its runoff over a relatively long period, owing to the storage capacity of its axial channel and the nonsynchronization of peak flows from its tributary streams. A fan-shaped drainage system tends to have a very flashy runoff comprising the superimposed synchronous peak discharges from all of its tributaries. An extensive mantle of broken rock and rubble on the watershed slopes tends to diminish the peak flow and extend the duration of runoff derived from such slopes. Gently sloping rough channels of large cross-sectional area tend to produce slower, more sustained runoff than the converse conditions.

Consideration of the drainage-system characteristics just outlined may be of assistance in comparing the possible lithologic character and water-bearing properties of the alluvial fills in a group of valleys whose ground-water resources are essentially unknown. However, because of the complex interaction of these and other factors and because of the difficulty in evaluating the relative influence of the various factors, such theoretical comparisons probably are justifiable only where there are rather large differences in the size or altitude of the watershed areas or very pronounced differences in the stream patterns.

In the Camp Irwin area the mountain watershed contributing runoff and alluvial detritus to the west side of Coyote basin is very much larger than the watersheds surrounding the other basins, and the stream pattern is comparatively well integrated. Therefore, it is believed that the valley-floor alluvium west of Coyote Lake is, on the whole, the best sorted and generally the most permeable of the alluvial deposits mapped. The differences between the drainage-system characteristics of the other basins are not sufficiently outstanding to warrant an attempt at further comparisons in this report.

WATER-BEARING PROPERTIES

The saturated part of upper Pleistocene to Recent valley-floor alluvium is believed to be the best water-bearing material in the area. In general, it probably has the highest permeability and specific yield of any of the geologic units. However, much of it lies above the zone of ground-water saturation. The lower part of the valley-floor alluvium is known to be saturated in much of Langford and Coyote basins and is thought to be saturated in parts of Camp Irwin basin. In these basins the valley-floor alluvium is believed to contain relatively large quantities of recoverable ground water in storage, and capable of yielding the water freely to properly located and constructed wells. However, in Dry Gulch and Bicycle basin the deposit is above the zone of ground-water saturation.

PLAYA DEPOSITS

The playa deposits (pl. 9), underlying the surfaces of Bicycle, Langford, and Coyote Lakes and unnamed smaller playas, consist largely of well-sorted clay, silt, and fine sand, deposited from shallow bodies of standing water that have covered the bottoms of the basins during periods of large runoff. The thickness of the deposits is not known but may extend 50–100 feet beneath the major playas. The lower strata probably were deposited during the latter part of the Pleistocene in perennial lakes that were formed after movements of the earth's crust disrupted the preexisting drainage systems. With increasing aridity during the Recent epoch, the perennial lakes gave way to intermittent or ephemeral lakes in which were laid down the true playa deposits, comprising the uppermost strata in the sequence. In general, the playa or intermittent lake deposits differ from perennial lake deposits by being less well sorted, slightly coarser, and buff or brown, indicating a neutral or oxidized state, rather than blue or green, indicating a reduced state.

These perennial and intermittent lake deposits generally overlie unconformably the deposits of Tertiary and Quaternary age; laterally they interfinger with contemporaneous valley-floor alluvium of late Pleistocene and Recent age and possibly the older alluvium. Inasmuch as the surfaces of these dry lakes may be covered with water during times of sheetflooding or stream runoff, the deposits left on the surfaces of the playas are Recent in age.

There is no evidence to suggest that the lakes in which these deposits were formed have radically shifted position since they first came into being. However, substantial variations in size have doubtless occurred many times during the accumulation of the deposits. For this reason, wells drilled near the present-day margins of the playas probably would encounter alternating beds of lake clays and coarser alluvial deposits.

The playa deposits, being composed of very fine-grained materials, are undoubtedly of very low permeability. Where saturated they yield essentially no water to wells, and where unsaturated they permit no significant downward percolation of the water that occasionally ponds on the lakebeds, except through cracks or the peculiar "drain" holes found in some playas, such as Coyote Lake. The playa deposits underlying Bicycle and Langford Lakes probably are largely or entirely above the water table, but those underlying Coyote Lake are generally below the water levels in wells in the alluvium near the playa margins. Under these conditions the playa deposits act as confining beds, producing artesian pressure in the underlying aquifers.

RECENT

WASH DEPOSITS

The deposits in the large well-defined channels of ephemeral streams, commonly known as dry washes, have been mapped as wash deposits. They consist of very loose clean coarse sand and gravel underlying the dry washes, probably to depths of several feet or locally several tens of feet. The deposits are active whenever there is runoff and are among the youngest materials in the area; accordingly, they are of Recent age.

Although the wash deposits are all above the water table, they are significant to the ground-water resources of the area because they are the sites of major recharge to ground water. Concentration in these channels of runoff from occasional storms provides maximum opportunity for infiltration of surface water into the permeable wash deposits and thence downward to ground water.

DUNE SAND

Dune sand has accumulated locally in a few areas, mostly north and east of Coyote Lake, and is of very limited extent. This sand, deposited by wind, locally attains a maximum thickness of 20–30 feet. In large part the sand is drifting, but locally it is anchored by mesquite and sagebrush. It is probably of Recent age.

At the north edge of Coyote Lake, several springs issue from the sand. The largest of these is Jack Rabbit Spring (pl. 9), whose discharge in March 1955 was about 5 gpm (gallons per minute). An unnamed spring stands as a pool in a craterlike depression on the top of a low dune about 5 feet above the surrounding land. A brief study of the springs together with a hydrologic reconnaissance of the valley have led to the conclusion that the springs result from ground-water discharge from the underlying alluvial deposits and that the source of the water is not from the dune sand. The sand has accumulated in and around these springs and has formed spring mounds, which are relatively common features around spring zones in desert areas. Except in this local area, the dune sand is not saturated and therefore is not considered a source of ground water.

TEST-WELL DRILLING

On the basis of the geologic reconnaissance, test-well sites were selected. These sites, one each in Coyote, Langford, Bicycle, and Dry Gulch basins, were test drilled and test pumped by the Roscoe Moss Co. The Geological Survey supervised the logging of the wells in Coyote, Langford, and Bicycle basins and measured the drawdown and recovery during and following the test pumping. The test well in Dry Gulch basin was logged by the Roscoe Moss Co.

The test wells in Coyote, Langford, and Bicycle basins, which are 584, 500, and 444 feet deep, respectively, show that the unconsolidated deposits in these basins contain relatively large quantities of water in storage and are capable of yielding the stored water at rates of 500–1,700 gpm without excessive drawdown. However, the test well in Dry Gulch basin encountered basalt and was abandoned at a depth of 335 feet without reaching water. The test-well logs, water-level measurements, yields at various pumping rates, and chemical analyses of the waters are presented on the following pages.

To make the record more complete, drillers' logs, water-level measurements at various pumping rates, and chemical analyses of water for 6 wells drilled in Camp Irwin basin between 1941 and 1943 and 1 well drilled north of Bicycle Lake in 1944 also are given. The logs and pumping data indicate that the unconsolidated deposits in Camp Irwin basin contain relatively large quantities of water in storage and are capable of yielding the stored water at rates of 115–550 gpm without excessive drawdown.

The log of the 349-foot well north of Bicycle Lake, in the NE¼NE¼ sec. 3, T. 14, N., R. 3 E., SBB and M, indicates that the well penetrated consolidated rock from 300 to 349 feet. The record is not clear as to whether this well failed to reach the zone of saturation or simply penetrated water-bearing deposits of low yield.

The chemical analyses indicate that the waters in the four areas tested are potable so far as dissolved solids are concerned. However, the fluoride concentrations of 1.6 ppm in Bicycle basin, 1.8 ppm in Langford basin, 3.2 ppm in Coyote basin, and 10 ppm in Camp Irwin basin are above the limit of 1.5 ppm specified by the U. S. Public Health Service for water used on interstate carriers.[2]

[2] U. S. Public Health Service, 1946, Drinking water standards: Public Health Repts., v. 61, no. 11, p. 12.

12N/2E-31A1, Coyote Lake well 1

[U. S. Army, Camp Irwin, Calif., NE¼NE¼ sec. 31, T. 12 N., R. 2 E., SBB and M. Drilled by Roscoe Moss Co., November 1954. Cable-tool drilled. Casing diameter 14 inches from 0 to 570 feet, perforated from 150 to 552 feet. Land-surface altitude 1,789.5 feet]

Well log

[Logged by Fred Kunkel and Ronald Stulik, U. S. Geol. Survey]

Material [1]	Thickness (feet)	Depth (feet)
Sand, granitic, and fine gravel	2	2
Caliche	.5	2.5
Sand, granitic, and gravel as much as one-fourth inch	37.5	40
Sand, granitic, and gravel as much as one-fourth inch; occasional metamorphic fragments; some clay	40	80
Sand, very coarse, and gravel as much as three-fourths inch; some clay	14	94
Sand and pebble gravel; mostly granitic but with some epidote and metasediments	4	98
Sand and gravel as much as one-fourth inch	7	105
Sand, very coarse, and gravel as much as 1 in.; some clay	110	215
Sand and gravel as much as one-half inch	45	260
Sand and gravel as much as 1½ in	2	262
Sand and gravel; one 4-in. cobble; some clay	8	270
Sand and pebble gravel	2	272
Sand, tight, with clay; some gravel as much as one-fourth inch	8	280
Sand, fine, with some pebble gravel and clay, tight	10	290
Sand, fine, and gravel as much as one-half inch; some clay, tight	10	300
Sand, fine, tight, with some silt	20	320
Sand, fine, tight; some gravel as much as one-fourth inch	3	323
Gravel as much as 1½ in.; no clay; very little sand	1	324
Sand, coarse, and pebble gravel; some clay	6	330
Sand, fine, some coarse sand, and gravel as much as three-fourths inch; no clay	5	335
Sand, fine to coarse; some gravel as much as one-half inch	12	347
Sand, fine, brown, silty, tight	105	452
Clay, sandy, with gravel as much as one-half inch	100	552
Clay and sand with gravel as much as 1½ in	3	555
Clay and sand with gravel as much as one-half inch	29	584

[1] An outstanding characteristic of the materials penetrated is the very slight variation in the lithology from the surface to 584 ft.

12N/2E-31A1, Coyote Lake well 1—Continued

Summary of test pumping

Date	Pumping rate (gpm)	Depth to water below land surface (feet)
1955		
Jan. 4	0	56. 24
Jan. 5	0	56. 08
Jan. 6	0	56. 36
Do	770	[1] 97
Do	1, 000	[1] 101
Do	1, 425	[1] 124
Do	1, 575	[1] 244
Do	1, 740	[1] 151
Jan. 7	0	56. 57
Jan. 11	0	56. 33
Mar. 1	0	55. 88
Mar. 6	0	55. 94

[1] Pumping measurements were by air line and have been adjusted to agree with measurements by wetted steel tape.

Chemical analysis

[Collected from pump discharge Jan. 6, 1955, by Geological Survey. Analysis 396618 by Smith-Emery Co., Los Angeles, Calif.]

Constituent	Concentration (parts per million)
Silica (SiO_2)	14. 0
Aluminum oxide (Al_2O_3)	Tr.
Iron oxide (Fe_2O_3)	Tr.
Calcium (Ca)	32. 0
Magnesium (Mg)	12. 6
Sodium (Na)	176. 6
Potassium (K)	----------
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	91. 5
Sulfate (SO_4)	296. 4
Chloride (Cl)	94. 0
Nitrate (NO_3)	0
Boron (B)	1. 5
Fluoride (F)	3. 2
Hydrogen sulfide (H_2S)	0
Carbon dioxide, uncombined (CO_2)	13. 0
Sum of determined nonvolatile constituents	672. 9
Specific conductance micromhos at 25°C	1, 112
Hydrogen ion concentration pH	7. 1
Water temperature ° F	75

13N/3E-35B1, Langford Lake well 1

[U. S. Army, Camp Irwin, Calif., NW¼NE¼ sec. 35, T. 13 N., R. 3 E., SBB and M. Drilled by Roscoe Moss Co., December 1954. Cable-tool drilled. Casing diameter 14 inches from 0 to 500 feet, perforated from 100 to 482 feet. Land-surface altitude 2,196.3 feet]

Well log

[Logged by Ronald Stulik, U. S. Geol. Survey]

Material	Thickness (feet)	Depth (feet)
Sand and gravel as much as three-fourths inch; some sandy clay	120	120
Sand and gravel as much as 1½ in.; some clay	5	125
Sand and gravel as much as 1 in	5	130
Clay, sandy, with some pebble gravel interbedded	25	155
Sand and gravel as much as 2 in	2	157
Sand and pebble gravel, cemented (noncarbonate)	28	185
Sand, tight, and gravel as much as 1 in	40	225
Sand and gravel as much as 2½ in.; some clay	85	310
Sand, graded gravel as much as 2½ in., and some clay; unit loose	28	338
Clay, sandy, with some gravel as much as 2 in	19	357
Clay and boulders as much as 10 in	8	365
Clay, sandy, tight, with some coarse sand	20	385
Sand and gravel as much as 1 in	5	390
Sand and gravel as much as 1 in.; some clay	10	400
Clay, sandy, tight, with some pea gravel	18	418
Sand and gravel as much as one-half inch; some clay	4	422
Clay, sandy, tight; some pea gravel	21	443
Sand and gravel as much as 1½ in	19	462
Clay, sandy, tight, with gravel from ¼ to 1 in	30	492
Clay, sandy, tight; no gravel	8	500

13N/3E-35B1, Langford Lake well 1—Continued

Summary of test pumping

Date	Pumping rate (gpm)	Depth to water below land surface (feet)
1954		
Dec. 27	0	[1] 83.97
Dec. 28	0	[2] 84
Do	0	[3] 93
Do	280	[3] 108
Do	400	[3] 134
Do	515	[3] 179
Do	635	[3] 224
Do	695	[3] 242
1955		
Mar. 6	0	[1] 83.86

[1] Measurement by wetted tape.
[2] Measurement by air line adjusted from 86 to 84 ft (2 ft) to agree with measurement by wetted tape.
[3] Well pumped Dec. 27, 1954. Measurement adjusted 2 ft to compensate for error in air-line measurement.

Chemical analysis

[Collected Dec. 28, 1954, by Geological Survey. Analysis 396,467 by Smith-Emery Co., Los Angeles, Calif.]

Constituent	Concentration (parts per million)
Silica (SiO_2)	18.0
Aluminum oxide (Al_2O_3)	Tr.
Iron oxide (Fe_2O_3)	Tr.
Calcium (Ca)	8.4
Magnesium (Mg)	1.5
Sodium (Na)	166.5
Potassium (K)	------
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	201.4
Sulfate (SO_4)	113.4
Chloride (Cl)	75.0
Nitrate (NO_3)	11.0
Boron (B)	2.0
Fluoride (F)	1.8
Hydrogen sulfide (H_2S)	0
Carbon dioxide, uncombined (CO_2)	8.1
Sum of determined nonvolatile constituents	496.8
Specific conductance (micromhos at 25° C)	749
Hydrogen ion concentration (pH)	7.6
Water temperature (° F)	74

14N/3E–13K1, Bicycle Lake Well 1

[U. S. Army, Camp Irwin, Calif., NW¼SE¼ sec. 13, T. 14 N., R. 3 E., SBB and M. Drilled by Roscoe Moss Co., January 1955. Cable-tool drilled. Casing diameter 14 inches from 0 to 430 feet, perforated from 174 to 410 feet. Land-surface altitude 2,394.0 feet]

Well log

[Logged by Ronald Stulik, U. S. Geol. Survey]

Material [1]	Thickness (feet)	Depth (feet)
Sand and gravel as much as 3 in	10	10
Sand and gravel as much as 3 in.; clay increases with depth	90	100
Clay, sandy, and gravel as much as one-half inch	35	135
Clay, sandy, with very little gravel	43	178
Clay, sandy, and gravel as much as one-half inch	59	237
Sand and gravel as much as one-half inch; very little clay	8	245
Clay, sandy, and gravel as much as three-fourths inch	10	255
Sand, coarse, volcanic, and some 2-in. gravel; very little clay	39	294
Clay, sandy; some gravel as much as one-half inch	11	305
Sand, fine, and some clay	15	320
Clay, sandy, tight, and gravel as much as one-fourth inch	26	[1] 346
Clay, sandy	74	420
Clay	24	444

[1] From 346 to 444 ft the amount of sand gradually decreased, leaving almost a gumbolike clay from 420 to 444 ft.

Summary of test pumping

Date	Pumping rate (gpm)	Depth to water below land surface (feet)
1955		
Jan. 28	0	[1] 172
Jan 31	355	[1] 197
Do	415	[1] 208
Do	605	[1] 250
Do	670	[1] 257
Do	710	[1] 262
Feb. 1	0	170.89
Mar. 6	0	170.49

[1] Measurement by air line, no correction applied because there were no wetted tape measurements for comparison prior to pumping.

14N/3E–13K1, Bicycle Lake Well 1—Continued

Chemical analysis

[Collected Jan. 31, 1955, by C. F. Hostrup, consulting engineer. Analysis 396,673 by Smith-Emery Co., Los Angeles, Calif.]

Constituent	Concentration (parts per million)
Silica (SiO_2)	18.0
Aluminum oxide (Al_2O_3)	Tr.
Iron oxide (Fe_2O_3)	Tr.
Calcium (Ca)	29.6
Magnesium (Mg)	8.7
Sodium (Na)	140.3
Potassium (K)	----
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	213.6
Sulfate (SO_4)	103.3
Chloride (Cl)	94.0
Nitrate (NO_3)	17.6
Boron (B)	0
Fluoride (F)	1.6
Hydrogen sulfide (H_2S)	0
Carbon dioxide, uncombined (CO_2)	8.0
Sum of determined nonvolatile constituents	518.3
Specific conductance micromhos at 25° C	950
Hydrogen ion concentration pH	7.7
Water temperature °F	76

14N/2E–23M1, Dry Gulch well 1—well log

[U. S. Army, Camp Irwin, Calif., NW¼SW¼ sec. 14, T. 14 N., R. 2 E., SBB and M. Drilled by Roscoe Moss Co., January 1955. Cable-tool drilled. Casing diameter 14 inches from 0 to 320 feet, not perforated. Land-surface altitude 2,829.9 feet. Logged by Clyde Nelson, Roscoe Moss Co.]

Material [1]	Thickness (feet)	Depth (feet)
Clay and gravel as much as 1 in	85	85
Clay and boulders	55	140
Clay and gravel as much as 1 in	20	160
Clay, sandy, and gravel as much as one-fourth in	135	295
Clay, sandy	17	312
Lava rock, (basalt) hard	23	335

[1] No water found; bottom of well above water table.

13N/3E-5D1, Camp Irwin well 1

[U. S. Army, Camp Irwin, Calif., NW¼NW¼ sec. 5, T. 13 N., R. 3 E., SBB and M. Drilled by E. W. Brockman, February 1941. Cable-tool drilled, gravel pack. Casing diameter 14 inches from 0 to 524 feet, perforated from 235 to 500 feet. Altitude of land surface about 2,525 feet, of concrete floor 2,527.04 feet]

Well log

[Logged by driller]

Material	Thickness (feet)	Depth (feet)
Sand	3	3
Clay, hard, decomposed, granitic, and conglomerate	57	60
Granite, soft, decomposed	20	80
Granite, hard, decomposed	150	230
Sand and small gravel	6	236
Granite, hard, decomposed, and clay	9	245
Gravel	21	266
Clay	4	270
Gravel	12	282
Clay	3	285
Gravel, dirty, and considerable clay	146	431
Clay, hard, sandy	6	437
Clay, soft, and gravel	63	500
Clay, hard	24	524

Summary of test pumping

Date	Pumping rate (gpm)	Depth to water below undescribed reference points (feet)
1940		
February	0	219
Do	110	245
Do	148	258
Do	191	275
Do	225	290
Do	270	305
Do	272	310
1943		
September	0	213
1945		
June	0	226
Do	280	258
1951		
February 9	0	[1] 223.7

[1] Reference point is concrete floor at an altitude of 2,527.04 ft.

13N/3E-5D1, Camp Irwin well 1—Continued

Chemical analysis

[Collected and analyzed November 1953 by U. S. Engineers, Los Angeles, Calif.]

Constituents	Concentration (parts per million)
Iron (Fe)	0. 1
Calcium (Ca)	11
Magnesium (Mg)	11
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	82
Sulfate (SO_4)	137
Chloride (Cl	62
Alkalinity (as $CaCO_3$)	82
Hardness (as $CaCO_3$)	74
Hydrogen ion concentration pH	7. 1

14N/3E-32P1, Camp Irwin well 2

[U. S. Army, Camp Irwin, Calif., SE¼SW¼ sec. 32, T. 14 N., R. 3 E., SBB and M. Drilled by E. W. Brockman, May 1941. Cable-tool drilled, gravel pack. Casing diameter 14 inches from 0 to 521 feet, perforated from 215 to 413 feet. Altitude of concrete floor 2,512.98 feet]

Well log

[Logged by driller]

Material	Thickness (feet)	Depth (feet)
Granite, decomposed	206	206
Conglomerate, clay, and gravel	24	230
Sand, gravel, and soft clay	5	235
Gravel, sandy, small	12	247
Clay, hard, sandy	11	258
Sand and coarse gravel	22	280
Gravel, coarse, and broken rock	4	284
Clay, sandy	10	294
Sand, coarse, and gravel	106	400
Clay	13	413
Conglomerate, dry, and lava formation	108	521

14N/3E-32P1, Camp Irwin well 2—Continued

Summary of test pumping

Date	Pumping rate (gpm)	Depth to water below undescribed reference points (feet)
1941		
May	0	210
Do	240	233
Do	340	247
Do	425	256
Do	465	258
Do	505	264
Do	518	266
Do	545	274
Do	555	325
1943		
September	0	213
1945		
June	0	212
Do	325	252
1951		
February 9	0	[1] 210.3

[1] Reference point is concrete floor at an altitude of 2,512.98 ft.

Chemical analysis

[Collected and analyzed November 1953 by U. S. Engineers, Los Angeles, Calif.]

Constituent	Concentration (parts per million)
Iron (Fe)	0.1
Calcium (Ca)	15
Magnesium (Mg)	12
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	81
Sulfate (SO_4)	146
Chloride (Cl)	62
Alkalinity (as $CaCO_3$)	81
Hardness (as $CaCO_3$)	86
Hydrogen ion concentration ... pH	7.6

14N/3E-32L1, Camp Irwin well 3

[U. S. Army, Camp Irwin, Calif., NE¼SW¼ sec. 32, T. 14 N., R. 3 E., SBB and M. Drilled by Roscoe Moss Co., November 1942. Cable-tool drilled. Casing diameter 14 inches from 0 to 500 feet, perforated from 234 to 460 feet. Altitude of land surface 2,507 feet, of concrete floor 2,502.7 feet]

Well log

[Logged by Bromwell and Glover, Roscoe Moss Co.]

Material	Thickness (feet)	Depth (feet)
Gravel and clay	3	3
Conglomerate	17	20
Sand and gravel	18	38
Sand, coarse, and clay	30	68
Conglomerate	45	113
Clay, sandy	17	130
Gravel	129	259
Clay, coarse, sandy	11	270
Gravel and clay	50	320
Sand, hard, and clay	35	355
Clay, sandy, and some sharp gravel	80	435
Clay and lava boulders	65	500

Summary of test pumping

Date	Pumping rate (gpm)	Depth to water below undescribed reference points (feet)
1942		
November	0	208
Do	135	272
Do	205	303
1943		
September	0	208
1945		
June	0	205
Do	190	300
1951		
February 9	0	204
Do	0	[1] 199.5

[1] Reference point is concrete floor at an altitude of 2,502.7 ft.

14N/3E-32L1, Camp Irwin well 3—Continued

Chemical analysis

[Collected and analyzed November 1953 by U. S. Engineers, Los Angeles, Calif.]

Constituents	Concentration (parts per million)
Iron (Fe)	0.1
Calcium (Ca)	18
Magnesium (Mg)	14
Carbonate (CO_3)	5.0
Bicarbonate (HCO_3)	104
Sulfate (SO_4)	165
Chloride (Cl)	64
Alkalinity (as $CaCO_3$)	109
Hardness (as $CaCO_3$)	103
Hydrogen ion concentration pH	8.5

14N/3E-32Q1, Camp Irwin well 4

[U. S. Army, Camp Irwin, Calif., SW¼SE¼ sec. 32, T. 14 N., R. 3 E., SBB and M. Drilled by Roscoe Moss Co., December 1942. Cable-tool drilled. Casing diameter 14 inches from 0 to 430 feet, perforated from 185 to 392 feet. Altitude of land surface about 2,475 feet, of concrete floor 2,477.19 feet]

Well log

[Logged by Bromwell and Glover, Roscoe Moss Co.]

Material	Thickness (feet)	Depth (feet)
Sand and gravel	3	3
Clay and gravel	52	55
Clay, sandy	11	66
Gravel with clay	24	90
Clay, sandy	95	185
Sand and clay with streaks of gravel	5	190
Clay, sandy	10	200
Sand and gravel (water)	6	206
Clay and gravel	66	272
Streaks of gravel and clay	8	280
Clay, sandy; some gravel	95	375
Clay and some gravel	20	395
Clay, sandy; some gravel	15	410
Clay, sandy, and lava boulders	20	430

14N/3E-32Q1, Camp Irwin well 4—Continued

Summary of test pumping

Date	Pumping rate (gpm)	Depth to water below undescribed reference points (feet)
1942		
December	0	173
Do	240	197
Do	267	200
Do	310	206
Do	335	213
Do	362	223
1943		
September	0	173
1945		
June	0	178
Do	330	218
1951		
February 9	0	[1] 174. 15

[1] Reference point is concrete floor at an altitude of 2,477.19 ft.

Chemical analysis

[Collected and analyzed November 1953 by U. S. Engineers, Los Angeles, Calif.]

Constituents	Concentration (parts per million)
Iron (Fe)	0. 1
Calcium (Ca)	15
Magnesium (Mg)	15
Carbonate (CO_3)	2. 0
Bicarbonate (HCO_3)	85
Sulfate (SO_4)	145
Chloride (Cl)	61
Alkalinity (as $CaCO_3$)	87
Hardness (as $CaCO_3$)	97
Hydrogen ion concentration pH	8. 2

14N/3E-32Q2, Camp Irwin well 5

[U. S. Army, Camp Irwin, Calif., SW¼ SE¼ sec. 32, T. 14 N., R. 3 E., SBB and M. Drilled by Roscoe Moss Co , December 1942. Cable-tool drilled. Casing diameter 14 inches from 0 to 350 feet, perforated from 220 to 312 feet. Altitude of concrete floor about 2,490 feet]

Well log

[Logged by driller]

Material	Thickness (feet)	Depth (feet)
Sand and gravel	3	3
Sand and gravel, cemented	19	22
Sand and gravel with some clay	46	68
Clay, sandy	74	142
Sand and gravel, cemented	14	156
Sand and gravel, small	26	182
Sand and gravel, streaks of clay (first water at 208 feet)	30	212
Sand and gravel	24	236
Sand and clay	8	244
Gravel with some clay	37	281
Rock and gravel	31	312
Gravel and clay	7	319
Clay and lava boulders	31	350

Summary of test pumping

Date	Pumping rate (gpm)	Depth to water below undescribed reference points (feet)
1943		
July	0	188
Do	85	215
Do	115	234
Do	160	301
1945		
June	0	195
Do	170	292
1951		
February 9	0	[1] 186. 3

[1] Reference point is concrete floor at an altitude of about 2,490 ft.

14N/3E-32O2, Camp Irwin well 5—Continued

Chemical analysis

[Collected and analyzed January 1944 by U. S. Engineers, Los Angeles, Calif.]

Constituents	Concentration (parts per million)
Silica (SiO_2)	56
Aluminum (Al)	0
Iron (Fe)	.25
Calcium (Ca)	10
Magnesium (Mg)	2.7
Sodium (Na) and Potassium (K) as Na	127
Carbonate (CO_3)	0
Bicarbonate (HCO_3)	114
Sulfate (SO_4)	112
Chloride (Cl)	55
Nitrate (NO_3)	8.0
Boron (B)	.8
Fluoride (F)	10
Hydrogen ion concentration pH	8.2

14N/3E-32J1, Camp Irwin well 6

[U. S. Army, Camp Irwin, Calif., NE¼SW¼ sec. 32, T. 14 N., R. 3 E., SBB and M. Drilled by Roscoe Moss Co., December 1943. Cable-tool drilled. Casing diameter 14 inches from 0 to 334 feet, perforated from 200 to 310 feet. Open hole cemented off from 334 to 340 feet. Altitude of land surface about 2,475 feet]

Well log

[Logged by driller]

Material	Thickness (feet)	Depth (feet)
Sand, gravel, and clay, cemented	46	46
Sand, brown clay	14	60
Clay, sandy	10	70
Sand and gravel; slightly cemented	106	176
Sand and gravel with small stratas of clay; some gravel to 2 inches; first water at 196 feet	44	220
Sand and gravel; some stratas of clay; slightly cemented	64	284
Clay, hard, sandy	12	296
Clay, hard	44	340

14N/3E-32J1, Camp Irwin well 6—Continued

Summary of test pumping

Date	Pumping rate (gpm)	Depth to water below undescribed reference points (feet)
1943		
December 29	0	172
Do	80	240
Do	90	267
Do	115	304

14N/3E-3A1, North of Bicycle Lake, well L3—well log

[U. S. Army, Camp Irwin, Calif., NE¼NE¼ sec. 3, T. 14 N., R. 3 E., SBB and M. Drilled by Roscoe Moss Co., in 1944. No water was found. No evidence of well in 1954 at reported site, presumed destroyed. Logged by driller]

Material	Thickness (feet)	Depth (feet)
Sand and clay, cemented	15	15
Clay, sandy	125	140
Conglomerate, cemented	160	300
Lava rock	44	344
Granite	5	349

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