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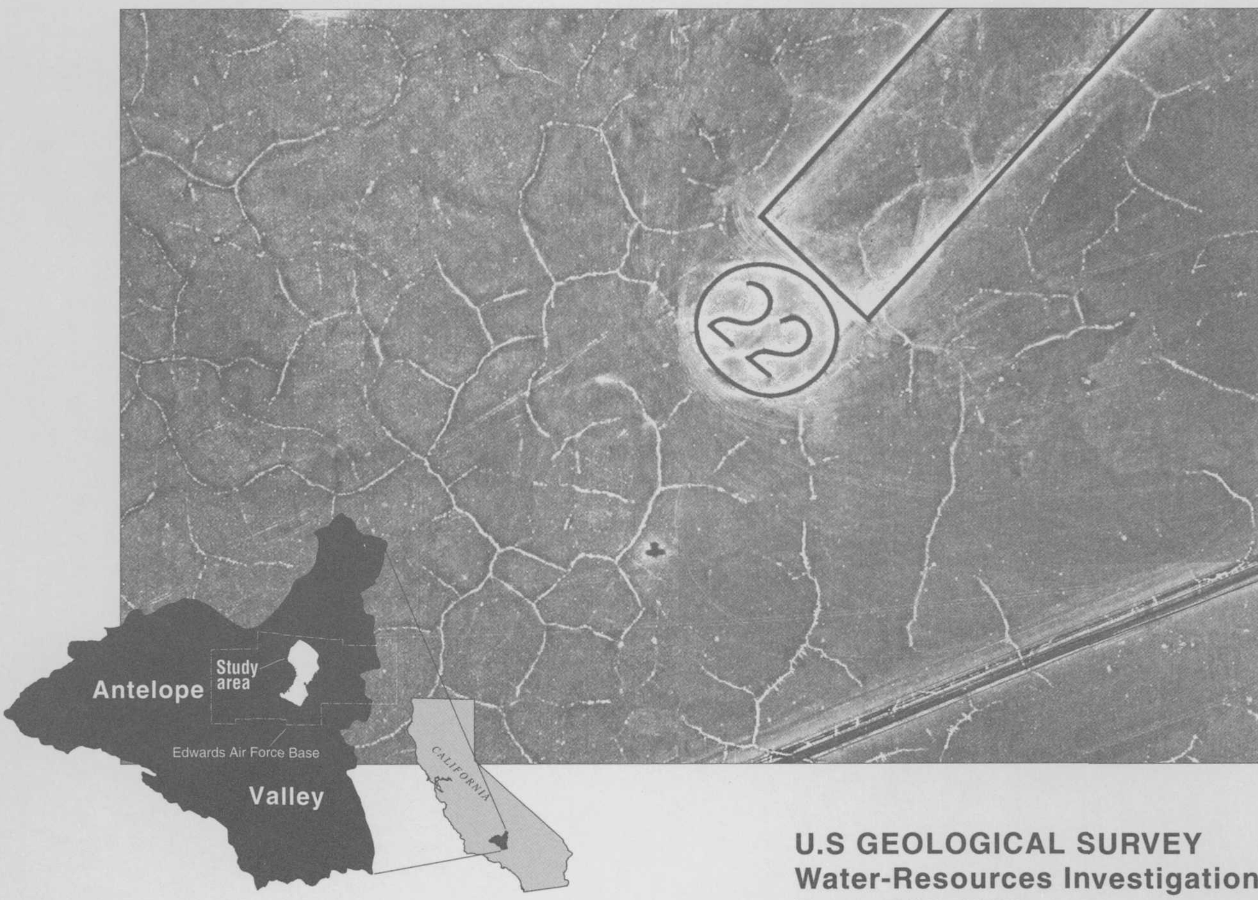
TOPOGRAPHY, SURFACE FEATURES, AND FLOODING OF ROGERS LAKE PLAYA, CALIFORNIA



U.S GEOLOGICAL SURVEY
Water-Resources Investigations
Report 98-4093

Prepared in cooperation with the
U.S.DEPARTMENT OF THE AIR FORCE

Topography, Surface Features, and Flooding of Rogers Lake Playa, California

By RANDAL L. DINEHART and KELLY R. MCPHERSON

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Sacramento, California
1998

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Multiply	By	To obtain
	Area	
square mile (mi^2)	2.590	square kilometer
	Length	
foot (ft)	0.3048	meter
inch (in.)	25.40	millimeter
mile (mi)	1.609	kilometer

Vertical Datum

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Topography, Surface Features, and Flooding of Rogers Lake Playa, California

By Randal L. Dinehart *and* Kelly R. McPherson

ABSTRACT

Rogers Lake is a desert playa used as a military airport for Edwards Air Force Base in the Antelope Valley of southern California. Previous measurements of land subsidence and ground-water levels in the study area indicated that ground-water pumping induced tensional stresses in the playa, which were sporadically relieved through the formation of long cracks. Drying of the sediments beneath the playa also may have accelerated the natural formation of giant desiccation polygons. When water flows across the playa, the cracks erode into fissures of sufficient width and depth to endanger traffic on the playa. Topographic surveys of the playa were made to derive a contour map that would allow examination of erosive flow paths. Crack networks were surveyed in selected areas during 1995 and compared with cracks visible in aerial photographs taken in 1990. Crack networks remained visible in their positions following several inundations of the playa. The density of the crack networks increased in all of the selected areas.

INTRODUCTION

The hard, smooth playa surface of Rogers Lake has long been a primary benefit to flight operations at Edwards Air Force Base (AFB), California. When an increasing incidence of fissuring and surface erosion on the playa became apparent to airfield managers, transects across the playa were surveyed by the U.S. Geological Survey (USGS). A contour map was prepared from the transects. Aerial photographs were overlaid by subsequent maps of crack networks to assess the longevity of cracks and the short-term changes in selected areas of the playa.

The pumping of ground water near the south end of Rogers Lake was correlated with decreases in land-surface elevation (subsidence) of nearly 3 ft (Blodgett and Williams, 1992). The formation of large fissures on the playa was associated with observed land subsidence. Land subsidence by compaction of local soils following ground-water withdrawal has been reviewed by Holzer (1984). Subsequent water erosion of fissures formed by land subsidence has been observed throughout the western United States (Holzer, 1984); fissures on Rogers Lake playa could have widened rapidly by the same process. To protect the integrity of the playa, remedial measures for controlling flow across Rogers Lake playa were considered at Edwards AFB. To provide information for possible remedial measures, the topography and surface features of Rogers Lake playa were studied in detail, in cooperation with the U.S. Department of the Air Force.

Purpose and Scope

The purpose of this report is to describe the topography, surface features, and flooding of Rogers Lake playa which were measured by the USGS between 1991 and 1996. Data presented include surveyed transects, elevation contours, photomosaics of Rogers Lake for dry and wetted conditions, lake stage during rainfall, and positional surveys of crack networks for selected areas of the playa. Selected aerial photographs are used in this report to illustrate erosional surface features. Records of rainfall, tributary stage, and lake stage are used to illustrate hydrologic processes at the playa.

Acknowledgments

The data-collection program for surveying of Rogers Lake playa was directed by James C. Blodgett, USGS (retired). The U.S. Department of the Air Force provided access to the playa for surveying.

GEOMORPHOLOGY OF ROGERS LAKE PLAYA

In southern California, the Tehachapi and San Gabriel Mountains meet to form a westerly pointing, V-shaped front that shields the Antelope Valley from the influx of moist Pacific Ocean air. Edwards AFB includes Rogers Lake, a desert playa in the Antelope Valley (fig. 1). In desert landscapes of the southwestern United States, playas evolve in the lowest elevations where sediment, eroded from the surrounding mountains and depleted of coarse material, is deposited from suspension by evaporating water. According to Dutcher and Worts (1963), the fine-grained sediments underlying Rogers Lake playa were originally deposited during the Pleistocene Epoch in ancient Lake Thompson, which encompassed a region including the present playas at Edwards AFB. The present playa is surfaced by sands, silts, and clays transported in flowing water from the surrounding hills. The playa boundary is defined by the distal ends of several alluvial fans.

Rainfall is rare and unevenly distributed in deserts, which limits the occurrence and duration of erosion. Consequently, desert landscapes evolve more slowly than landscapes in humid climates. Drainage channels on the alluvial deposits surrounding Rogers Lake have not formed mature, dendritic networks. Therefore, inflows at different points along the lake shore come from relatively small watersheds. The surficial deposits of Rogers Lake playa are derived from sediment in these watersheds and from redistribution of the erodible playa deposits.

The sequence of deposition and weathering of sediments on Rogers Lake playa has been discussed in detail by Neal (1963) and by Motts and Carpenter (1970). Although Rogers Lake playa is classed as a hard, clay-pan playa, the surface types range from small mud curls and cracked, puffy surfaces to a smooth, hard, and compact surface. Flooding of the playa and the subsequent movement of surface sediments cause variations in surface types as water evaporates.

The origin of giant desiccation polygons on Rogers Lake playa was investigated by Motts and Carpenter (1970). They concluded that increasing desiccation of the fine-grained deposits, accompanied by lowering of ground-water levels, contributed to formation of giant polygons (fig. 2). Motts and Carpenter (1970) noted that deep contraction induces cracking, which is dependent on the relation of the ground-water potentiometric surface to the clay and silt blanket of the playa. The area enclosed by giant polygons is a function of sediment thickness, with larger polygonal areas forming in thicker sediments (Allen, 1985, p. 157). The playa sediment cracks in response to the size and the distribution of defects within the sedimentary layer.

Although polygonal cracking is common on playas at undeveloped locations, the frequency at which cracks appear on Rogers Lake playa seems to have increased since the 1980s (Blodgett and Williams, 1992). Many of the cracks attain widths of several feet and lengths of several hundreds of feet (fig. 3). The sudden appearance of these fissures on Rogers Lake playa has been ascribed to overall land subsidence in the Antelope Valley. In the 1940s, the potentiometric surface was at or above the playa surface (Motts and Carpenter, 1970). As ground water was pumped from aquifers near Rogers Lake with the development of Edwards AFB, soil was compacted and the resulting subsidence generated tensional stresses that were relieved by accelerated cracking of the playa sediments.

A report on initial investigations of the playa was published in 1992 (Blodgett and Williams, 1992). Periodic measurements at a bench mark near Rogers Lake playa (M1155, fig. 1) indicated gradual land subsidence at the south end of Rogers Lake during the period 1961–91 (fig. 4). Subsequent measurements at bench mark M1155 showed the trend continuing from 1991 to 1995. The effects of land subsidence on Edwards AFB were investigated by the USGS using ground-water monitoring and detailed surveys of the topography of Rogers Lake playa. Results of the ground-water monitoring program are described by Rewis (1995).

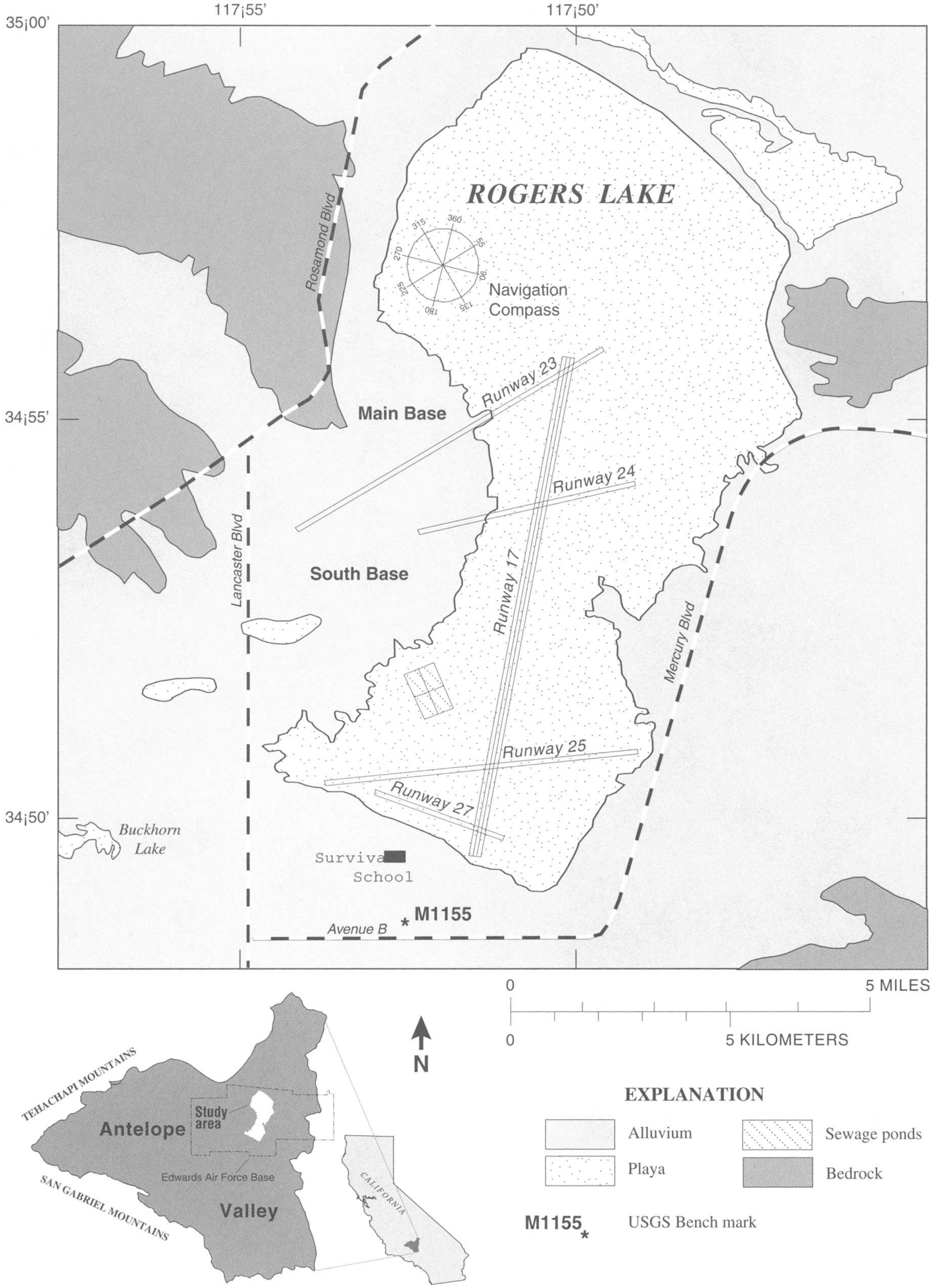

Figure 1. Location of Edwards Air Force Base and Rogers Lake.

Figure 2. Giant polygons formed by desiccation cracks that cross runways 25 and 17 near the southern end of Rogers Lake playa, Edwards Air Force Base, California. Distances across the polygons often exceed 300 feet. (Photographed in 1990)

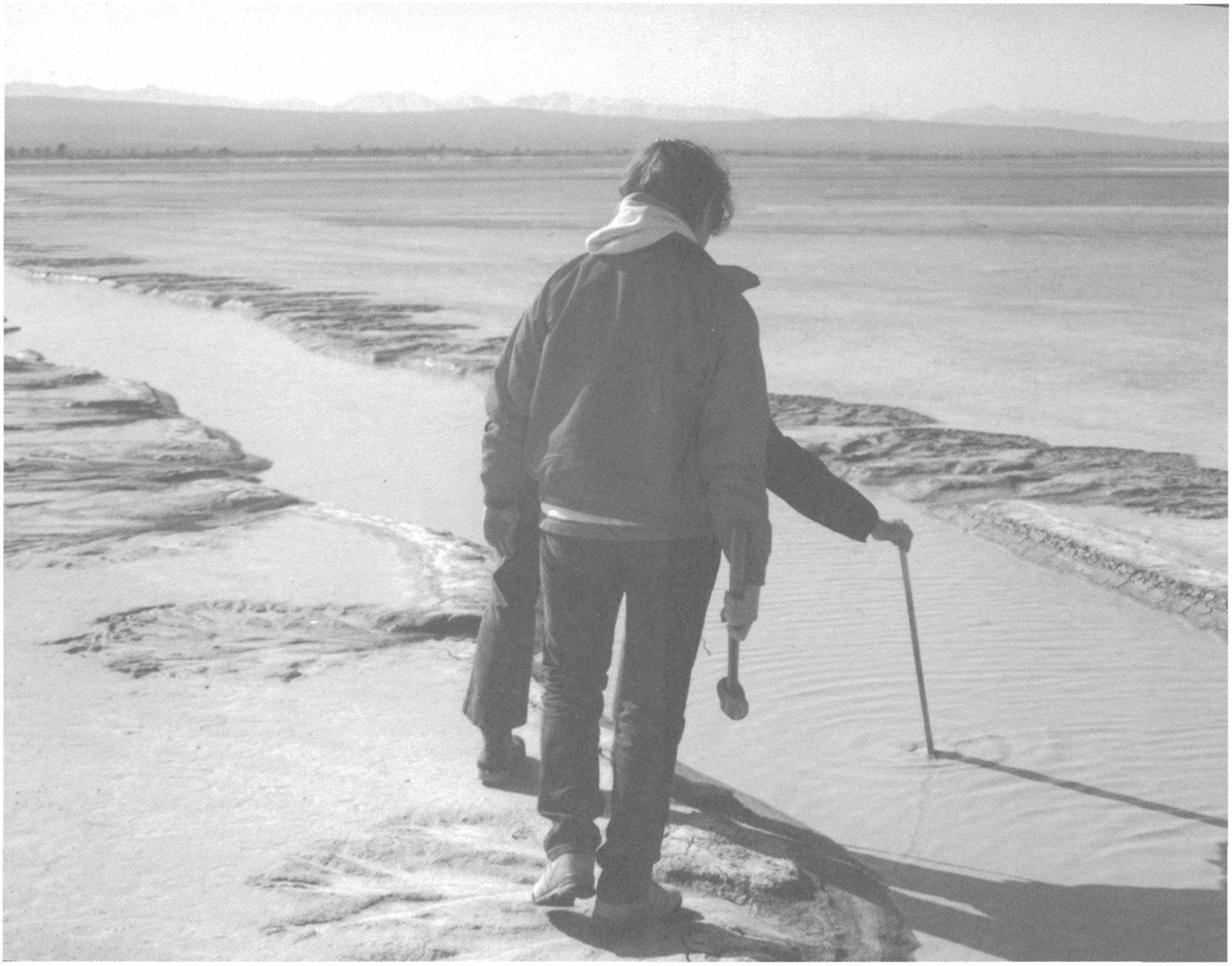

Figure 3. Erosional fissure located near runway 25 on the east side of Rogers Lake playa, Edwards Air Force Base, California. View toward the southeast. Cracks can attain widths of several feet and lengths of several hundred feet. (Photographed in 1992)

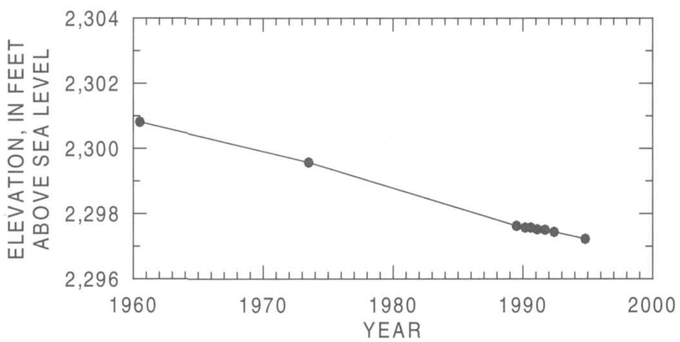

Figure 4. Changes in elevation at bench mark M1155 south of Rogers Lake, Edwards Air Force Base, California, 1961–95.

TOPOGRAPHIC MAP

Elevation across Rogers Lake playa varies less than 10 ft from north to south. Playa elevation generally ranges between 2,268 and 2,273 ft above sea level. Existing USGS topographic maps of Rogers Lake were compiled using 10-foot contour intervals, which do not indicate slope of the playa topography. Surveys of transects across the playa were used to refine the contours to 0.5-foot intervals, from which figure 5 (at back of report) was prepared.

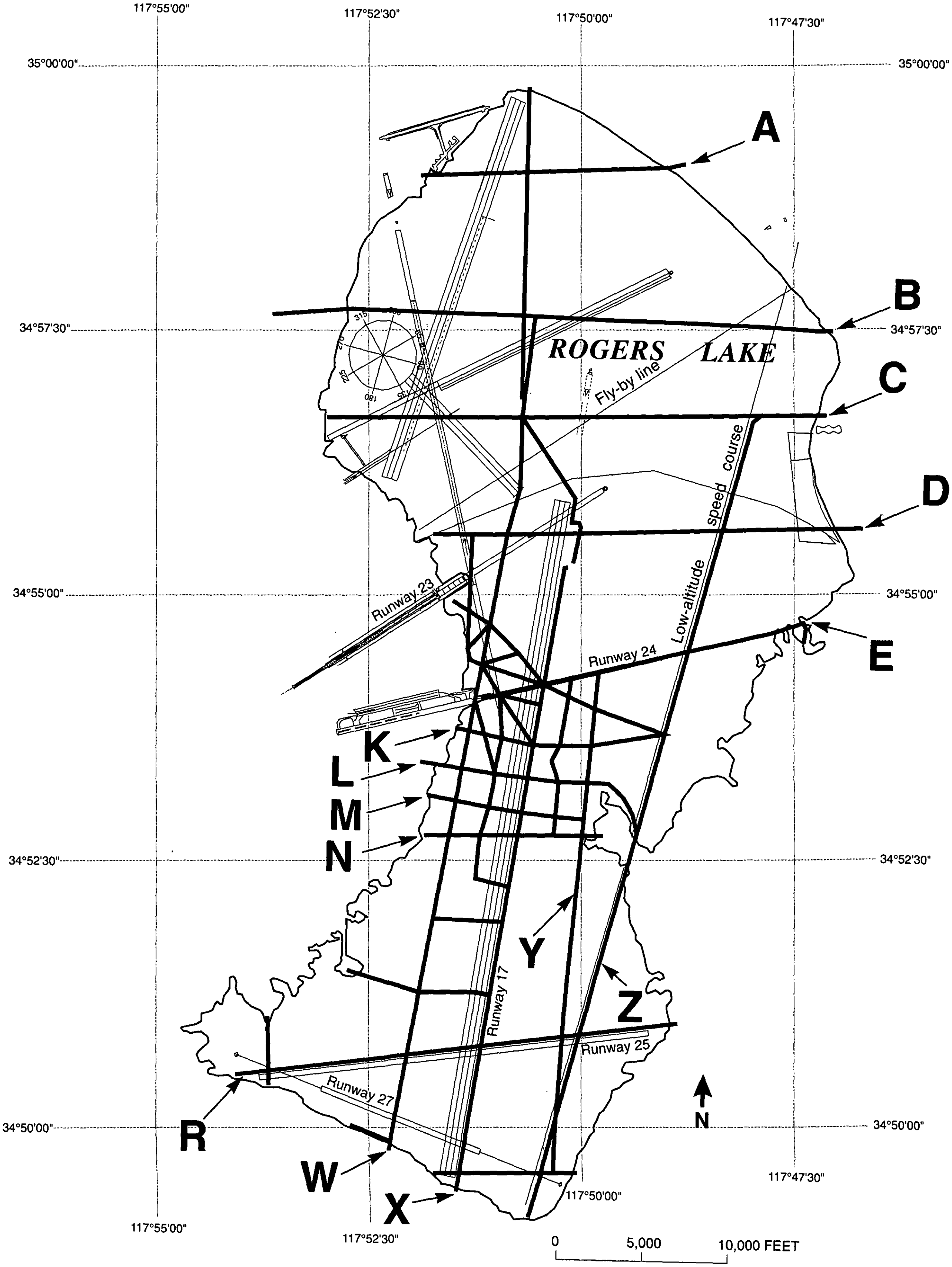

Figure 6. Location of transects surveyed on Rogers Lake playa between 1989 and 1995, Edwards Air Force Base, California. Fine lines indicate location of runways on playa. (See figures 7–9 for elevations of selected transects.)

To measure land subsidence at Edwards AFB, a vertical-control network was established using bench marks at locations known to be unaffected by subsidence (Ikehara and Phillips, 1994). Reference marks were established along straight segments across the playa at intervals of about 0.4 mi. The reference marks were established at the top of 3-foot long sections of reinforcing bar driven into the playa.

Beginning in 1989, transects were surveyed across the playa to third-order accuracy. A selected set of transects is shown in figure 6. About 22 separate transects were surveyed. Elevations and point locations were determined by differential leveling, with points spaced about 200 ft apart. Ten long transects cross the playa in the east-west direction and four long transects trend in the north-south direction (fig. 6). The most recent transects were surveyed in 1995 near South Base, where flow from north to south is constricted. In 1995, short transects were added near South Base and other transects were lengthened. Bench marks and reference marks used to establish elevation for the transects are listed in table 1 (at back of report).

The surveyed points of the transects were plotted on 7.5-minute quadrangle maps and digitized into data sets in ARC/INFO, a proprietary software program. Points in individual transects were digitized sequentially to preserve each transect as a separate profile within the ARC/INFO data files. Contours originally were interpolated to 0.5 ft using ARC/ INFO with a bilinear method for the transect points. Program-generated contours were smoothed manually by comparison with aerial photomosaics. To smooth the map boundary, contours near the playa shoreline on the 1970 quadrangle were digitized and added to the transects used for the 1995 contour map (fig. 5).

TOPOGRAPHIC FEATURES

The contour map (fig. 5) and profiles drawn from the surveyed transects (figs. 7–9) show the main topographic features of Rogers Lake playa. The surface area of the playa is 45 mi^2. Water on the playa may cover large areas, but the water surface is not the same elevation from north to south. Instead, water flows slowly downslope until it ponds. The southward movement of water was observed repeatedly in the 1980s by Edwards AFB personnel during lake flooding.

Although the playa is virtually flat, exaggeration of the vertical scale on the profiles shows distinct high and low points that control the flow of water. The downward slope of the playa from north to south is shown in transects W and X (fig. 7). The average slope along transect W is about 0.0002. Transects X and Y show a break in slope near runway 24. Playa elevation decreases almost 3 ft between runway 24 and the lowest elevations at the southern end of the playa.

Floodwater migrates southward on the wetted playa in a channel that is a few hundred feet wide. Many of the transects cross the main north-south flow channel; some transects show a dip at the channel (fig. 8). The east-west transects also show the influence of older alluvial deposition at the playa margins, where elevations rise 1 to 3 ft between the flow channel and the playa margins. In particular, transect D is concave toward the playa margin where elevation increases, which is a typical feature of alluvial-fan deposition.

Transects E and R (fig. 9) follow runways 24 and 25, respectively. Along transect R, playa elevation decreases from the playa margin by more than 5 ft along a distance of 2,000 ft. The upper end of transect R is occupied by a silt-clay alluvial fan that is replenished from local inflow.

Latitudinal transects K–N (fig. 8) downstream from runway 24 show a topographic ridge that begins near the peninsula at the east side of the playa (see fig. 6) and continues northward for nearly 3 mi. Another topographic high, which is not confined to the playa margins, is documented in transects B and C at the east side of the playa (fig. 8). Inflow of sediment and water near the east end of transect B may be responsible for the apparent alluvial fan form. A fan-related rise of the playa toward the east also is evident in north-south trending transects W-Z (fig. 7).

Wide, low areas are shown in both the north and south ends of the topographic map (fig. 5). The western ends of transects B and C (near the navigation compass; see fig. 6) show regions with only a few tenths of a foot deviation along a distance of 3,000 ft, with both western segments at an elevation of about 2,270 ft above sea level. Transect R shows a low area at the south end of the playa that ranges between 2,268 and

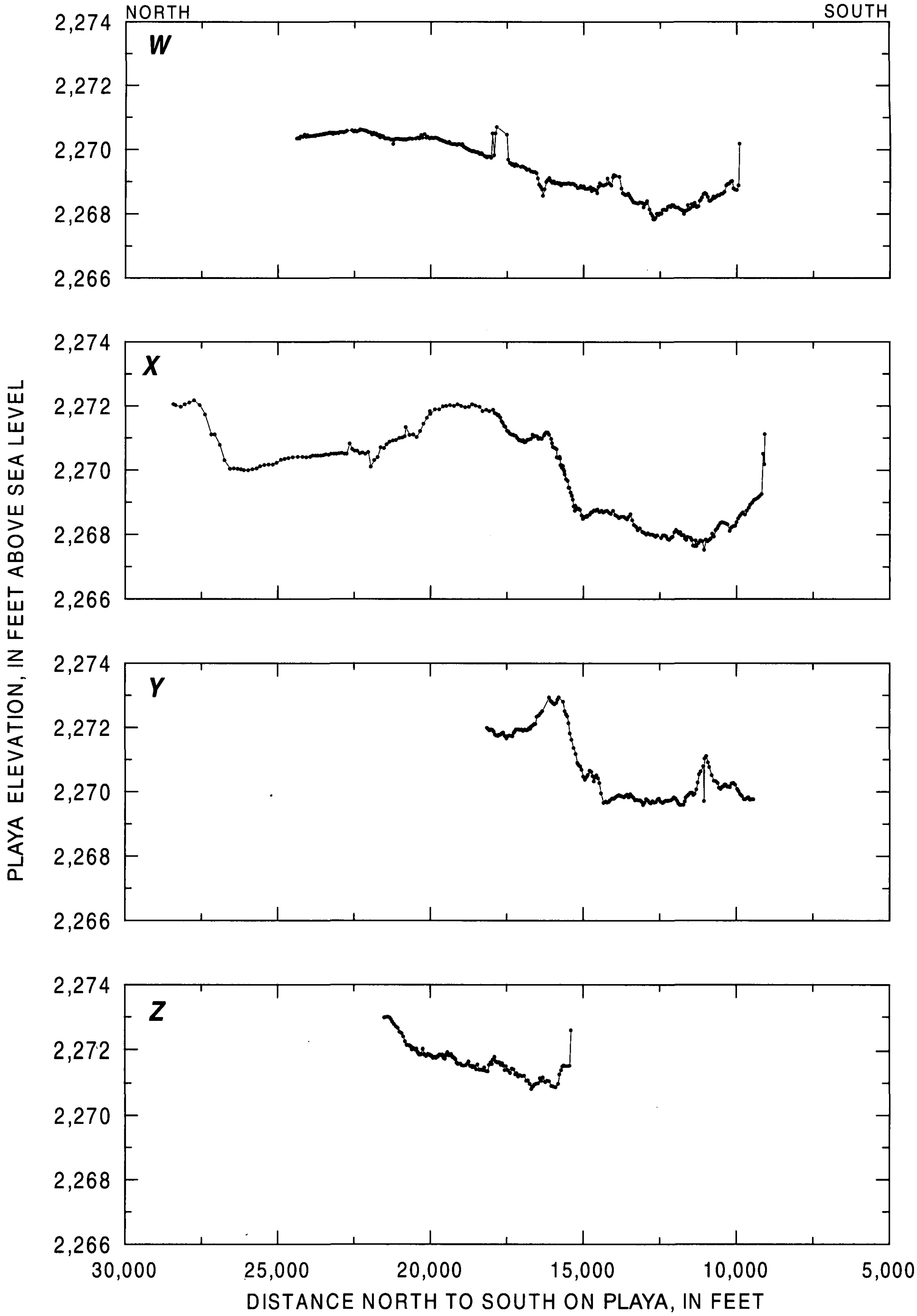

Figure 7. Elevations of Rogers Lake playa along north-south transects, Edwards Air Force Base, California. (See figure 6 for location of transects.)

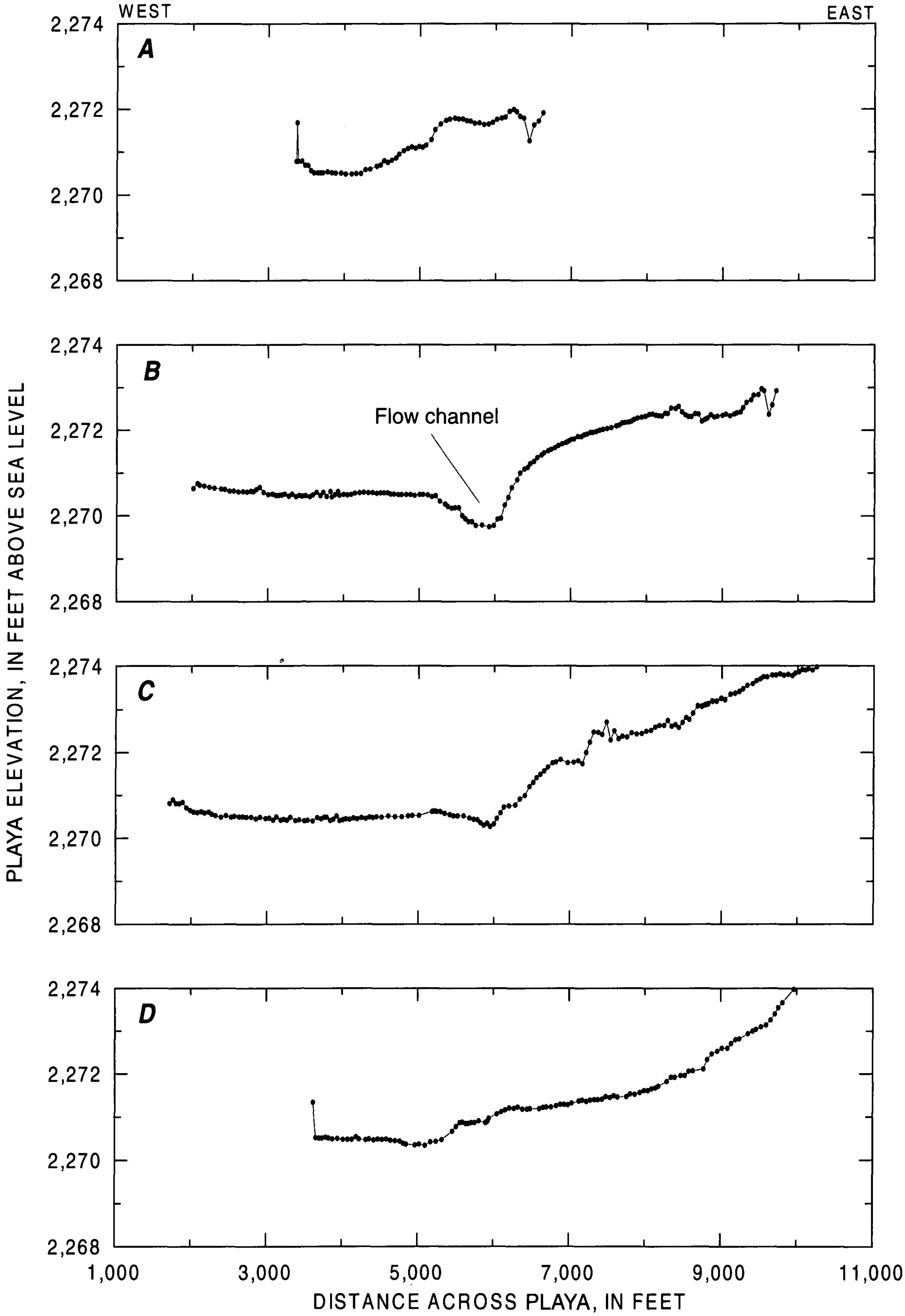

Figure 8. Elevations of Rogers Lake playa along east-west transects, Edwards Air Force Base, California. (See figure 6 for location of transects.)

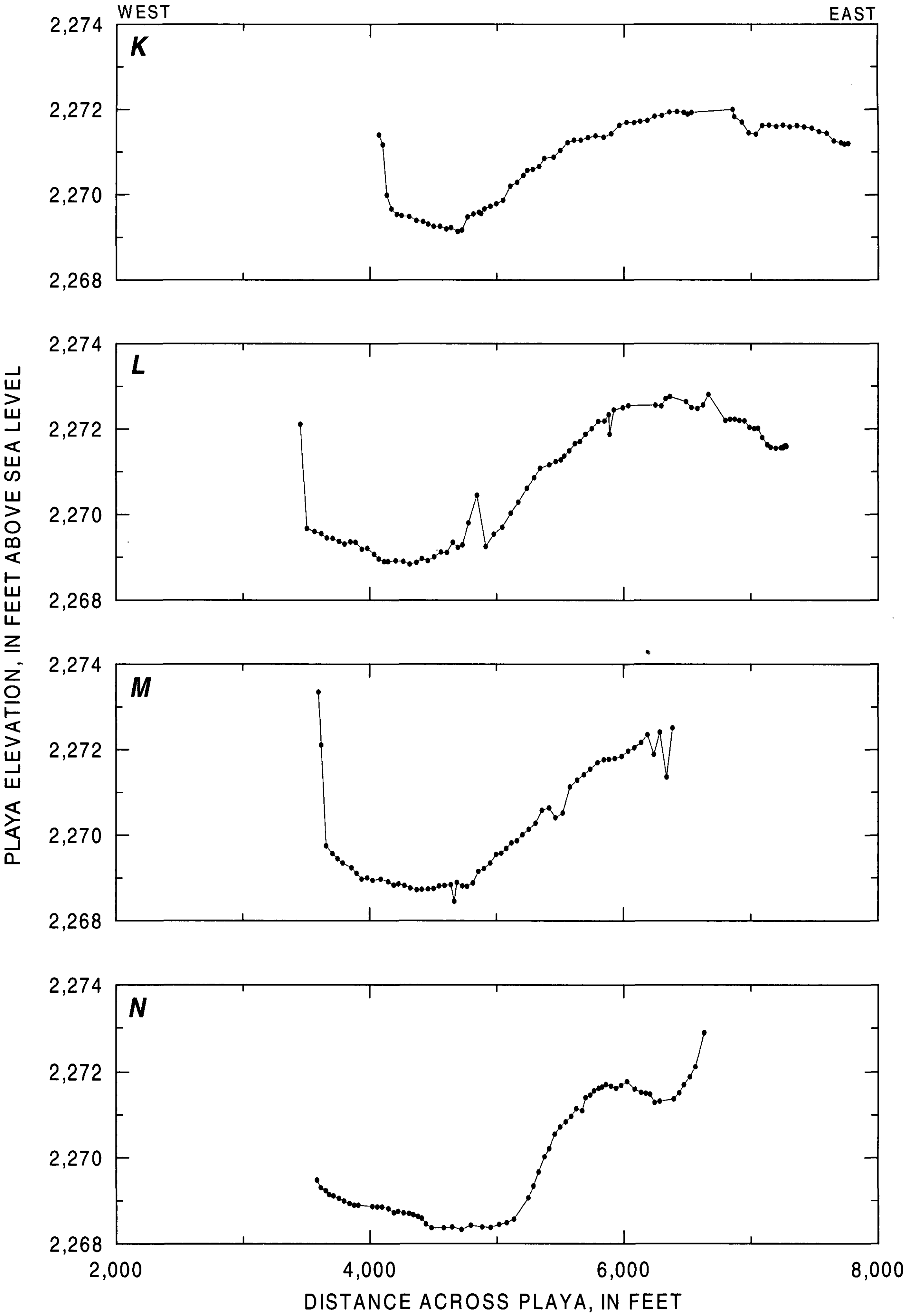

Figure 8—Continued.

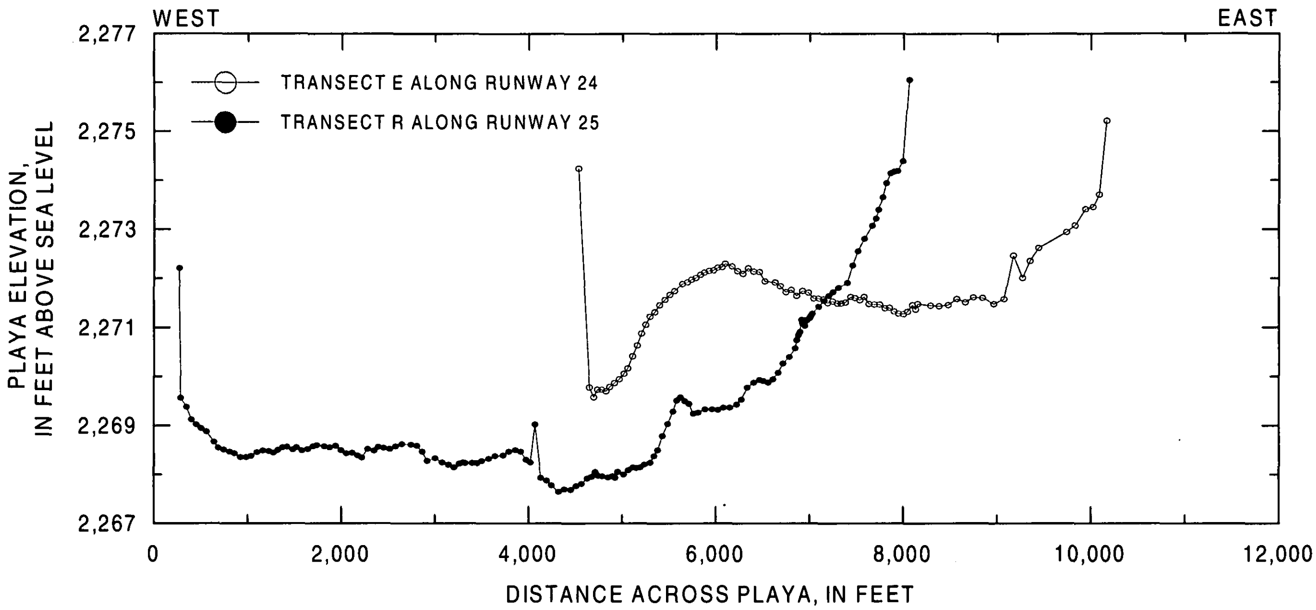

Figure 9. Elevations of Rogers Lake playa at transects along runways 24 and 25, Edwards Air Force Base, California. (See figure 6 for location of transects.)

2,269 ft above sea level. This low area consistently accumulates floodwater after marginal areas of the playa have drained.

DOCUMENTATION OF LAKE FLOODING

Nearly all water on Rogers Lake playa originates as rainfall on the playa and as streamflow from the adjacent watersheds. Daily rainfall at the airfield operations center has been recorded since 1942 (Phillip Harvey, Edwards Air Force Base, written commun., 1996). Average annual rainfall for 1942–95 is 5.04 in. Figure 10 shows monthly rainfall totals greater than 1 in. at Edwards AFB for calendar years 1991 through 1995.

When rain falls on the playa, the water does not infiltrate very far into the hard silt-clay surface (Motts and Carpenter, 1970). Small storms are sufficient to inundate sizable areas of the lake to depths of a few inches. When rain continues intermittently for days during winter, much of the playa becomes covered with water. Runoff also flows to the playa from more than 10 main tributaries (fig. 11). Tributary inflow is abundant following storms, as observed at road culverts and inflow channels around the lake perimeter. Aerial photographs of the playa show that the wetted areas extend upslope to the tributary inflows.

Oblique aerial photographs document the extent of playa inundation following storms. Figure 12 shows examples of playa inundation from March 1992 and January 1995 storms. Water flows toward the center of the playa and from north to south on the playa, as is indicated with arrows on the photographs.

Vertical Aerial Photographs

Vertical aerial photographs of Rogers Lake playa are useful for comparing the contours of the topographic map with observed ponded areas and flow channels. The entire playa was photographed for the USGS by contractor during 1990 with views printed at 1:2,400 and 1:24,000 scale. More than 1,000 aerial photographs were taken and printed at 1:2,400 scale in continuous rows to show the playa. The wetted playa was photographed for the USGS on March 8, 1991, and printed at 1:24,000 scale.

Photomosaics of the playa were prepared digitally with reference to Geographic Information System (GIS) coverages. Aerial photos were scanned at 150 dots-per-inch and placed individually over a topographic outline of the playa that included roads and runways. All photomosaics are considered illustrations and are not meant for use as maps. The aerial photographs show more surface detail than is apparent in the orthophoto quadrangle maps for the same areas. Therefore, erosional features and flooding patterns on the playa can be assessed with reference to the photomosaics. Photomosaics of the dry and the wetted playa, prepared from the 1:2,400-scale photographs, were overlaid with a map of runways and flight lines (figs. 13 and 14).

A photomosaic of the wetted playa for March 1991 (fig. 14) shows ponded floodwaters that correspond to low areas shown in contour the map (fig. 5). At the north end of the playa, floodwaters converge with the flow constriction near the north end of runway 17 (fig. 14). The primary flow channel from the northwest side of the playa connects with another flow channel from the east side that diverts around the topographic high. The photomosaic shows a mottled area of small channels and ponds that eventually drain across the north end of runway 17 to the main flow channel. Oblique aerial photographs show that the area north of the topographic high collects floodwaters that flow to the west (fig. 12).

Floodwaters flow southward past runway 24 where playa elevation ranges from 2,270 ft above sea level at the intersection of runway 24 to 2,268 ft above sea level in the low area at the south end of the playa. The northern margin of the low area is bounded by a relatively steep slope (0.002) near the South Base and runway 17. This value is an order of magnitude greater than the slope for the north-south distance of the lake.

Stage Records at Lake Gages for February-March 1996

Two gaging stations were installed on Rogers Lake playa in 1995 to record lake stage. The sites were chosen to provide continuous records of gage height (water-surface elevation for lake stage) near low points in the north and south areas of the playa (fig. 11). Gage

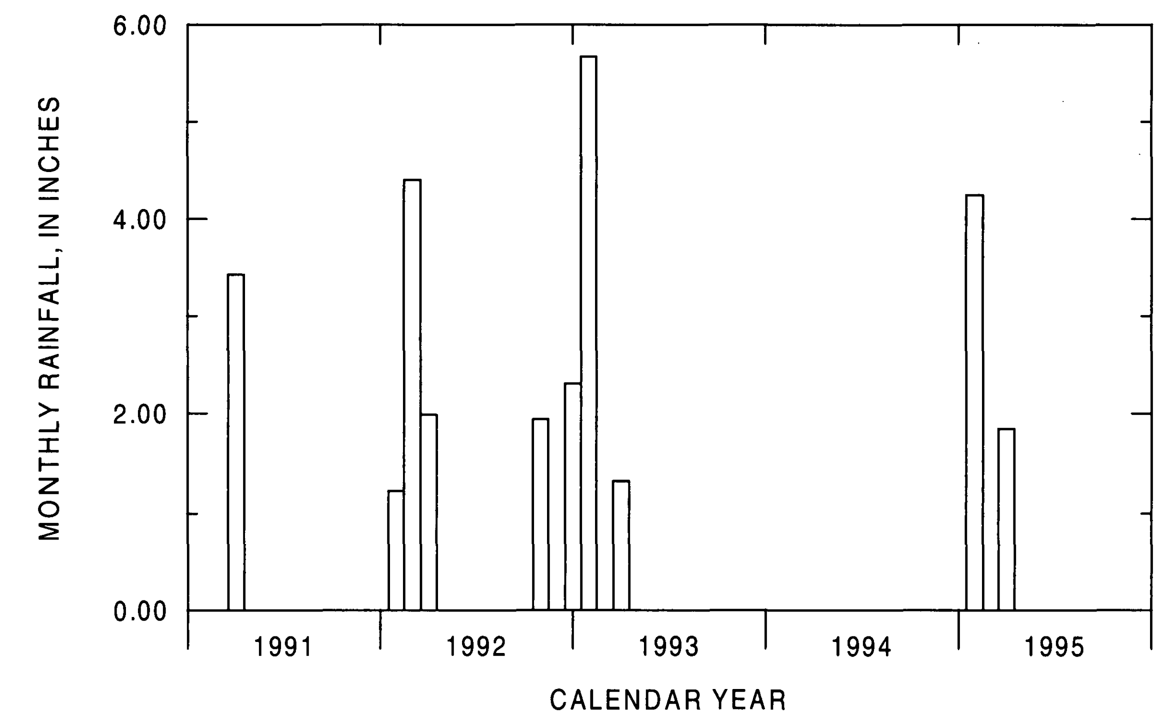

Figure 10. Monthly rainfall totals greater than 1 inch at Edwards Air Force Base, California, 1991–95. Rainfall totals are recorded at the airfield operations center (Phillip Harvey, Edwards Air Force Base, written commun., 1996).

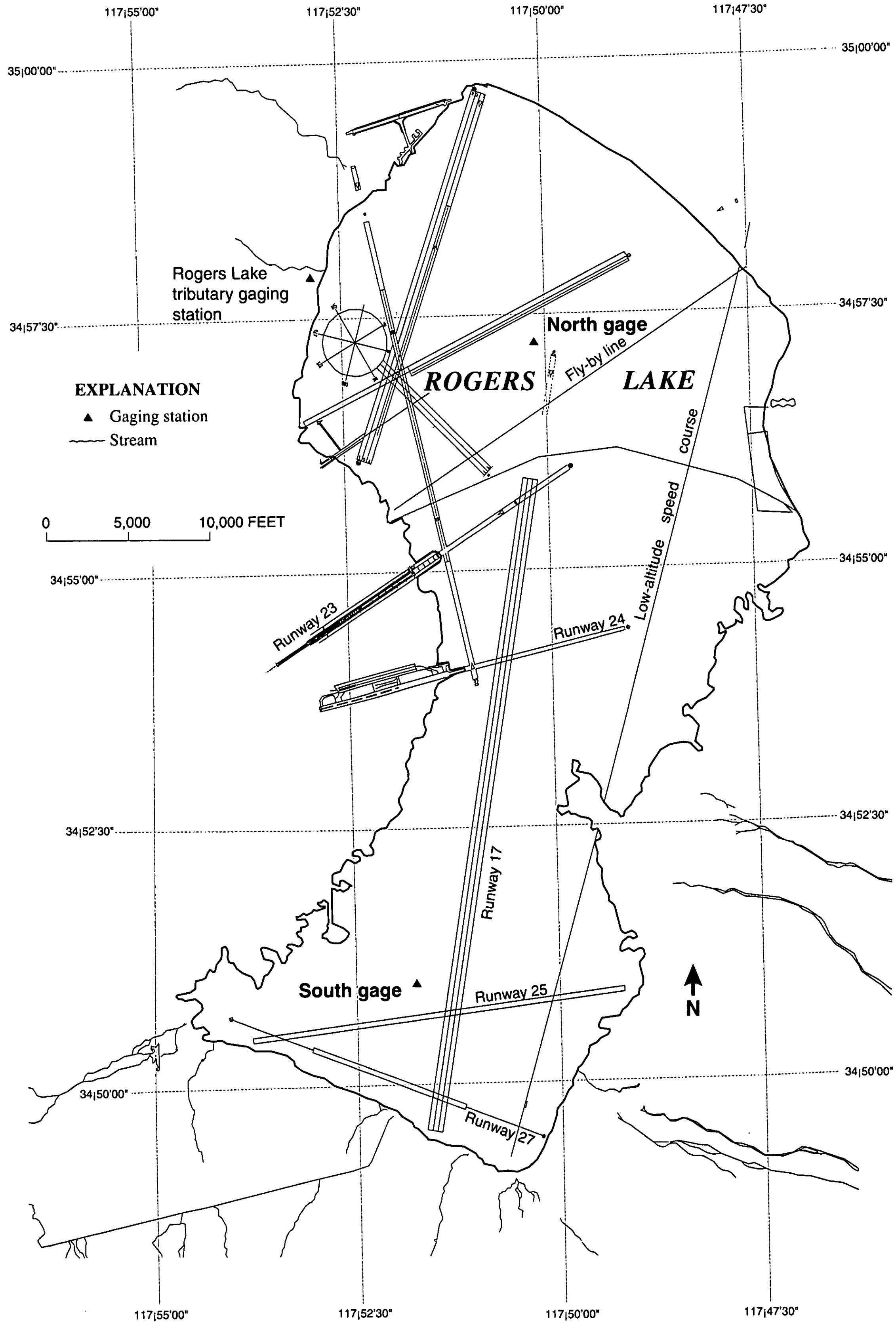

Figure 11. Tributary streams and gaging stations on or near Rogers Lake playa, Edwards Air Force Base, California. Fine lines indicate location of runways on playa.

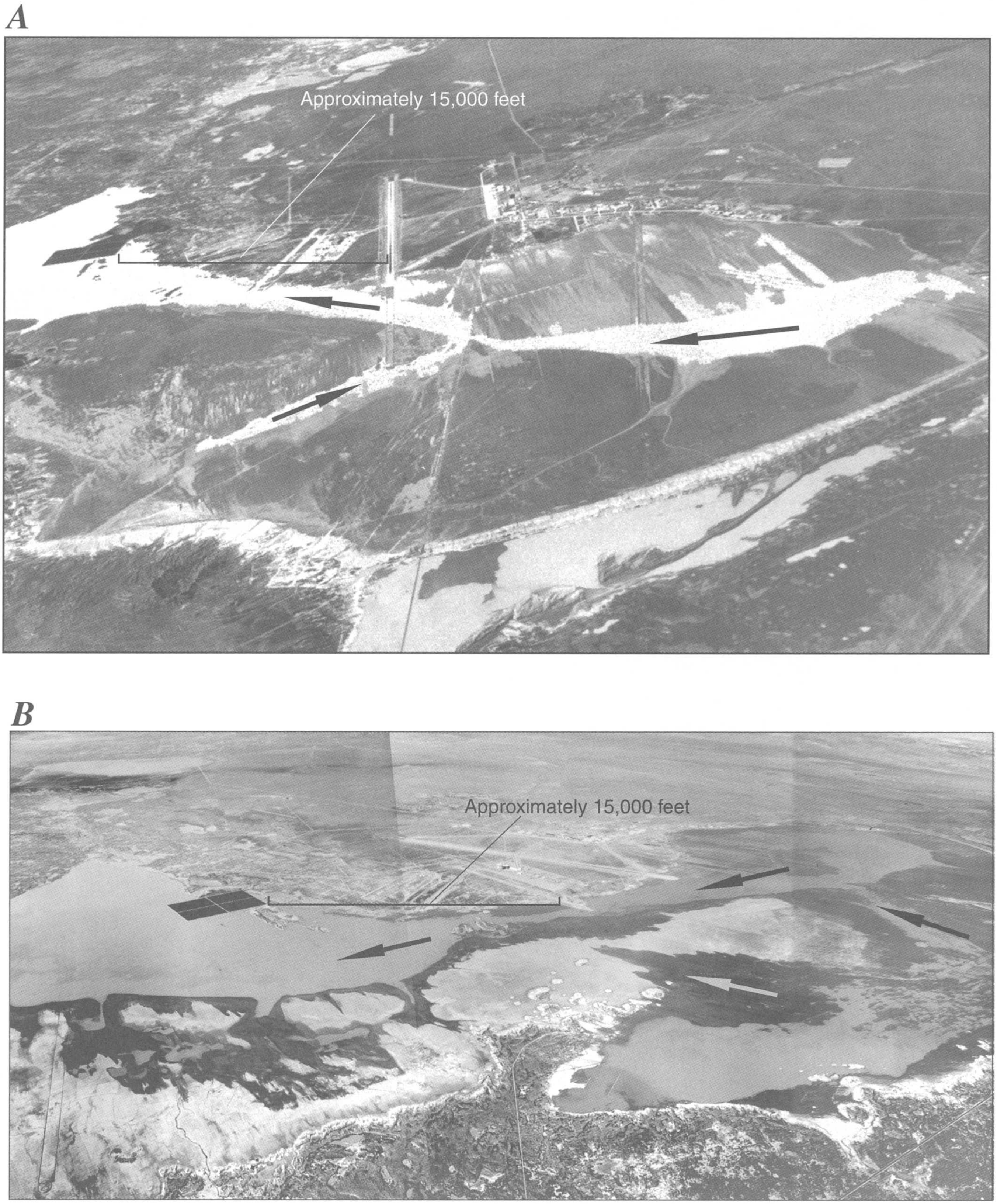

Figure 12. Aerial view of playa inundation, Rogers Lake, Edwards Air Force Base, California. *A*, March 1992. *B*, January 1995. View is to the west. Arrows indicate direction of flow. (Photographs courtesy of U.S. Department of the Air Force, 1995.)

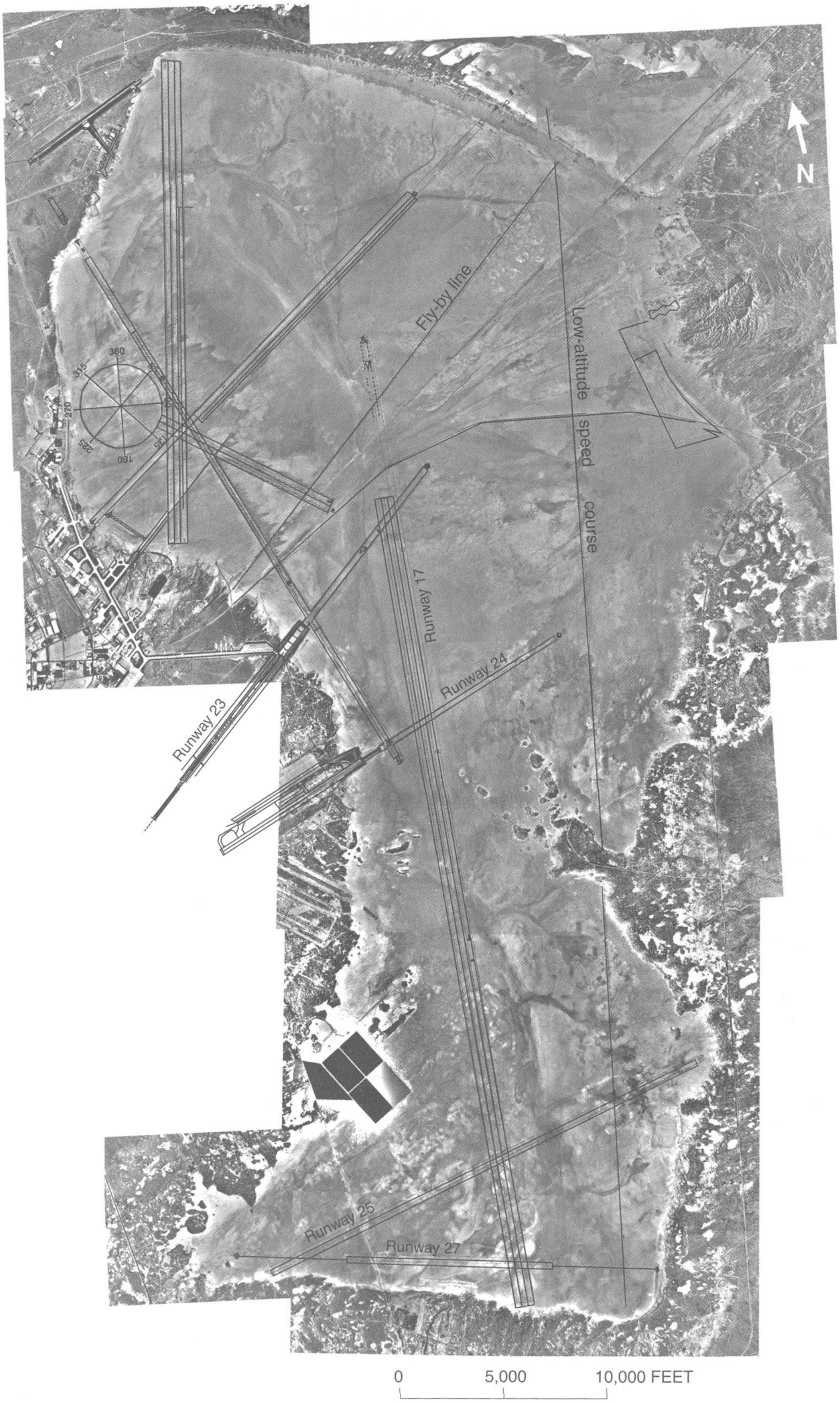

Figure 13. Dry conditions on Rogers Lake playa, Edwards Air Force Base, California. Fine lines indicate location of runways on playa. (From aerial photographs taken in 1990)

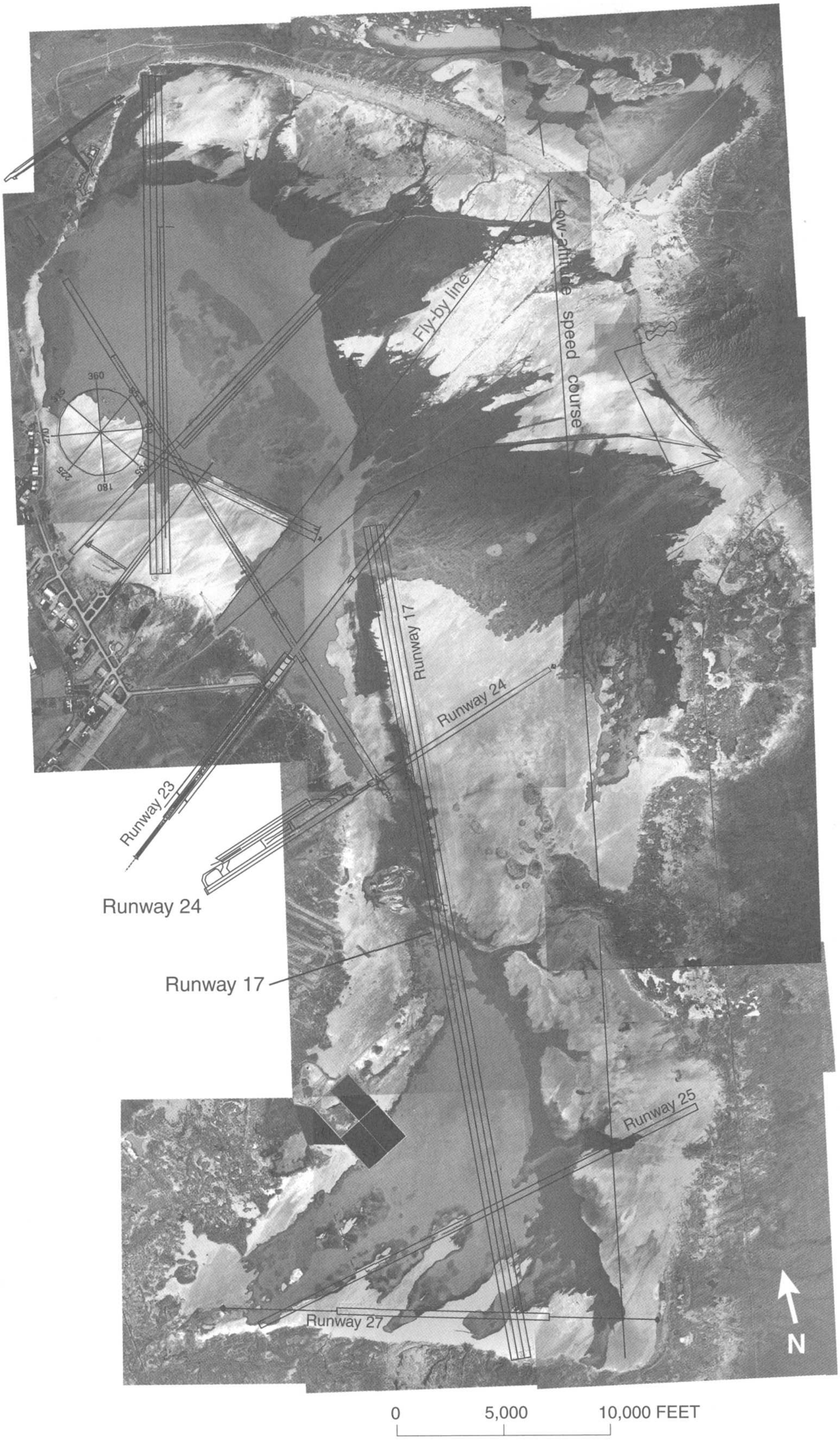

Figure 14. *Wetted conditions on Rogers Lake playa, Edwards Air Force Base, California. Fine lines indicate location of runways on playa. (From aerial photographs taken on March 8, 1991)*

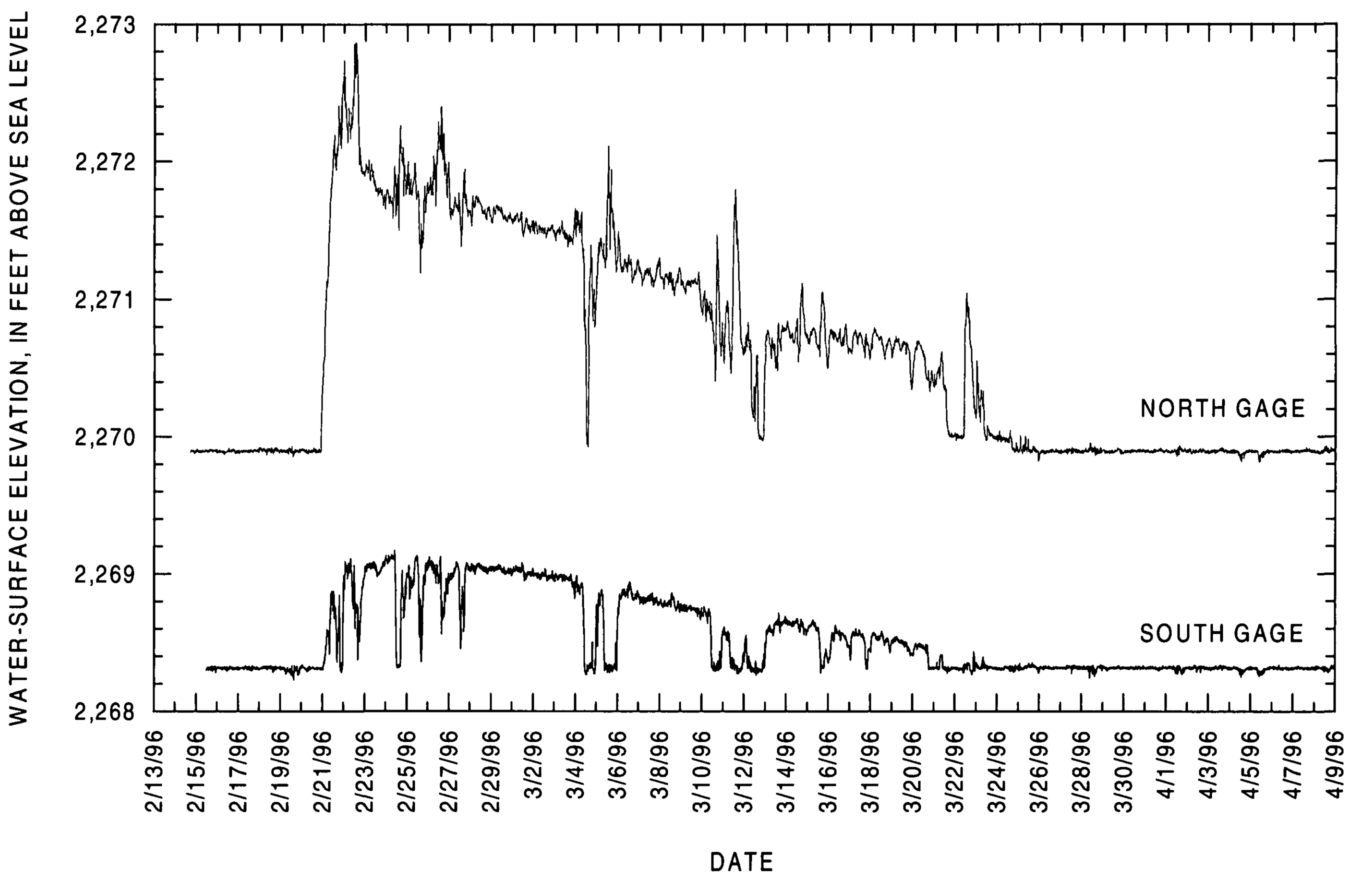

Figure 15. Water-surface elevation recorded at two gages on Rogers Lake, Edwards Air Force Base, California, during February and March 1996.

height was measured with a pressure sensor connected to a data recorder; the sampling interval was 15 minutes. Plots of the gage-height records are shown in fig. 15.

A storm on February 20–21, 1996, had a total measured rainfall of 0.9 in. at Rogers Lake tributary gaging station (figs. 11 and 16). Measurable rainfall began at 0200 hours Pacific Standard time (PST) on February 20, 1996, and continued at an even rate to 0600 hours on February 21, 1996. At the north lake gage, a rise in gage height at the sensor (0.10 ft above playa surface) was measured about 22 hours after the onset of rainfall, at 2400 hours on February 20, 1996. A rise in gage height was measured at the Rogers Lake tributary gaging station beginning at 2200 hours on February 20, 1996, about 20 hours after the onset of rainfall (fig. 16).

Gage-height records for both lake gages show a rise to maximum gage height on February 22, 1996, and a gradual decrease of water-surface elevation that remained below the gage-height sensors beginning on March 24, 1996. Gage-height records for both lake gages occasionally deviated for several hours above or below the running-mean gage height. The diurnal characteristic of some deviations indicates that they are related to increased wind during daylight hours. The temporary deviations in gage height are consistent with descriptions of the wind-driven movement of water across Rogers Lake (Motts, 1970; Motts and Carpenter, 1970).

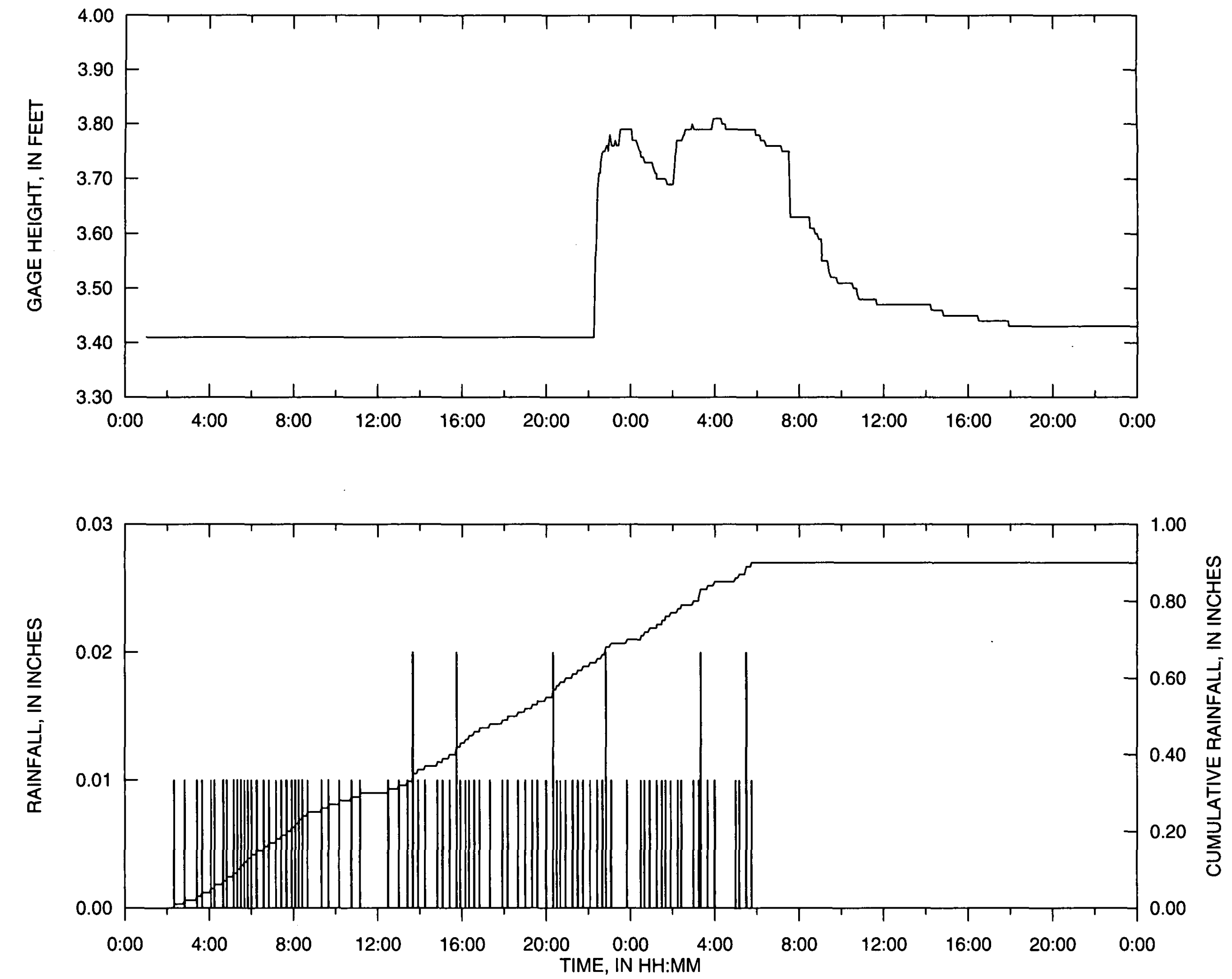

Figure 16. Stage and precipitation at Rogers Lake tributary gaging station near Edwards Air Force Base, California, February 20–21, 1996.

EROSIONAL SURFACE FEATURES

When viewed at its surface, Rogers Lake appears flat except for a perceptible lowering of the playa horizon from north to south. Numerous flow channels have formed on the playa, however. The flow channels have formed by the movement of water along downhill paths. Slight increases in depth caused the flow paths to channelize as rates of sediment transport increased.

Playa sediments are mostly silt and clay, and when they are wetted, they become easily erodible. Playa sediments erode when the force required to suspend sediment is exceeded by the force of flowing water. Erosional surface features will form where flow forces are greatest, along steep gradients, and where flow depth increases over wetted, fine sediments. On the playa, surface erosion occurs especially at abrupt changes in slope, such as at the entries to giant polygonal cracks, which are characteristic of most playas. When water flows into cracks, the cracks erode into fissures of sufficient width and depth to endanger vehicle traffic on the playa.

The largest erosional feature on Rogers Lake playa is the north-south flow channel which is most visible near South Base. The vertical exaggeration in figure 8*B* shows the constriction of flow to the west side of Rogers Lake playa. Transects W and X in figure 7 also show the steeper slope of 0.002 in the flow constriction.

A simple dendritic pattern of shallow headcuts joins along a fissure that extends northeast from runway 17 (fig. 17). The line of the existing fissure is nearly perpendicular to the elevation contour lines at that region of the playa. Slope along the fissure is 0.002, which is steeper than slope for other areas in the central part of Rogers Lake playa. As water flows down the steepest gradient, it enters the fissure which is oriented to continue the flow path in the same direction. At the entrance to the fissure, water flows more rapidly and causes local erosion at the confluence. Lowering of the channel bottom at the entrance causes erosion of the sediment to continue upstream in a process that resembles gullying of steeper lands.

The northeast end of the fissure continues as a straight, uneroded lineament (light marking) through rocky outcroppings (fig. 17). Although the origin of this lineament is not known, gullying has occurred along this feature, rather than creating the eroded feature spontaneously. As water transports sediment along the existing lineament, it has induced meanders that are typical of alluvial streams. Stream meandering involves a hydraulic reaction to sporadic deposits of sediment along a stream course. The meanders in this fissure often coincide with confluences of minor gullies where transported sediment deposits and redirects flow in the main channel. Meanders also can form in the straight lines of desiccation cracks.

Another lineament is evident at the north end of Rogers Lake playa (light marking, fig. 18). Erosion in the middle part of this feature has been incorporated into the north-south flow channel. The north and south ends of the lineament are uneroded in the photographs, and the middle part is eroded with short headcuts along both sides. More elaborate dendritic patterns occur along larger flow channels from the northeast and northwest that converge with this straight feature. The origin of the lineament is unknown. The lineament begins faintly at the northern playa margin and continues until diffusing into the wide, flat area near the navigation compass (see fig 5). The lineament probably represents an artificial disturbance to the playa and indicates that such disturbances can become sites of

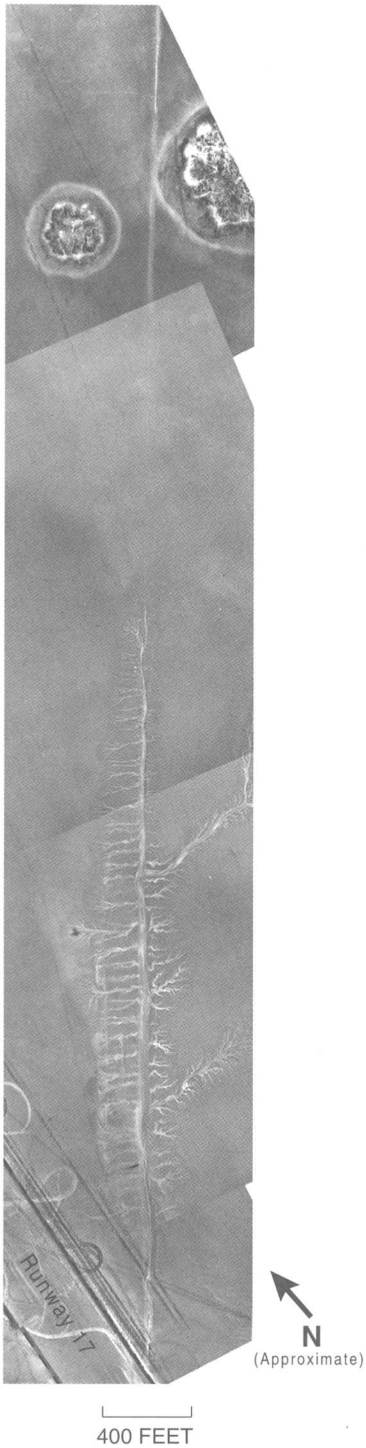

Figure 17. Headcut fissure at runway 17 on Rogers Lake playa, Edwards Air Force Base, California. (From aerial photographs taken in 1990)

Figure 18. Lineament (light marking) and headcut at north end of Rogers Lake playa, Edwards Air Force Base, California. The lineament is diffuse and uneroded to the north. Small headcuts extend laterally from the lineament where it enters the main flow channel. (From aerial photographs taken in 1990)

future erosion. Like the fissure at runway 17, this lineament is oriented nearly perpendicular to the elevation contours.

A flow path can also be captured in cracks that are not perpendicular to elevation contours. Transect R along runway 25 indicates that water should flow westerly in this steep area of the playa (fig. 9). The slope toward the playa center is 0.001 along the east end of runway 25. Among eroded fissures in this steep area of the playa, however, water flows both north and south before arriving at the south ponded area. Where no fissures dissect the playa surface, aerial photographs of water stains near the east end of runway 25 indicate that the flow direction is westerly.

DOCUMENTATION OF CRACK NETWORKS

Selected networks of cracks were documented by combining the 1990 aerial photographs (1:2,400 scale) of the playa with data from the ground survey during 1995 of cracked areas. Cracks photographed in 1990 were still measurable in 1995 on areas of the playa that had been repeatedly flooded. The 1995 surveys also indicated that new cracks were common in areas that had no cracks in 1990.

Areas enclosed by desiccation cracks differ noticeably across the playa. The average sizes of giant polygons formed by cracks are compared for different regions of the playa in figure 19. Many of the polygons shown in figure 19*A*, along runway 17 at the lower end of the sharp drop in slope, have diameters less than 100 ft. The giant polygons shown in figure 19*B*, with diameters often greater than 500 ft, are located where runway 25 crosses runway 17. Areas where giant polygons occurred during 1965–66 were mapped by Motts and Carpenter (1970). These areas are now characterized by smaller polygon, as shown in figure 19*A*.

Ground Surveys by Differential Global Positioning System

Crack networks were mapped in 1995 to document selected areas of active fissuring and erosion on Rogers Lake playa (fig. 20). A portable Differential Global Positioning System (DGPS) receiver was used to locate coordinates along the cracks and to store the data. The X-Y coordinates of crack networks were

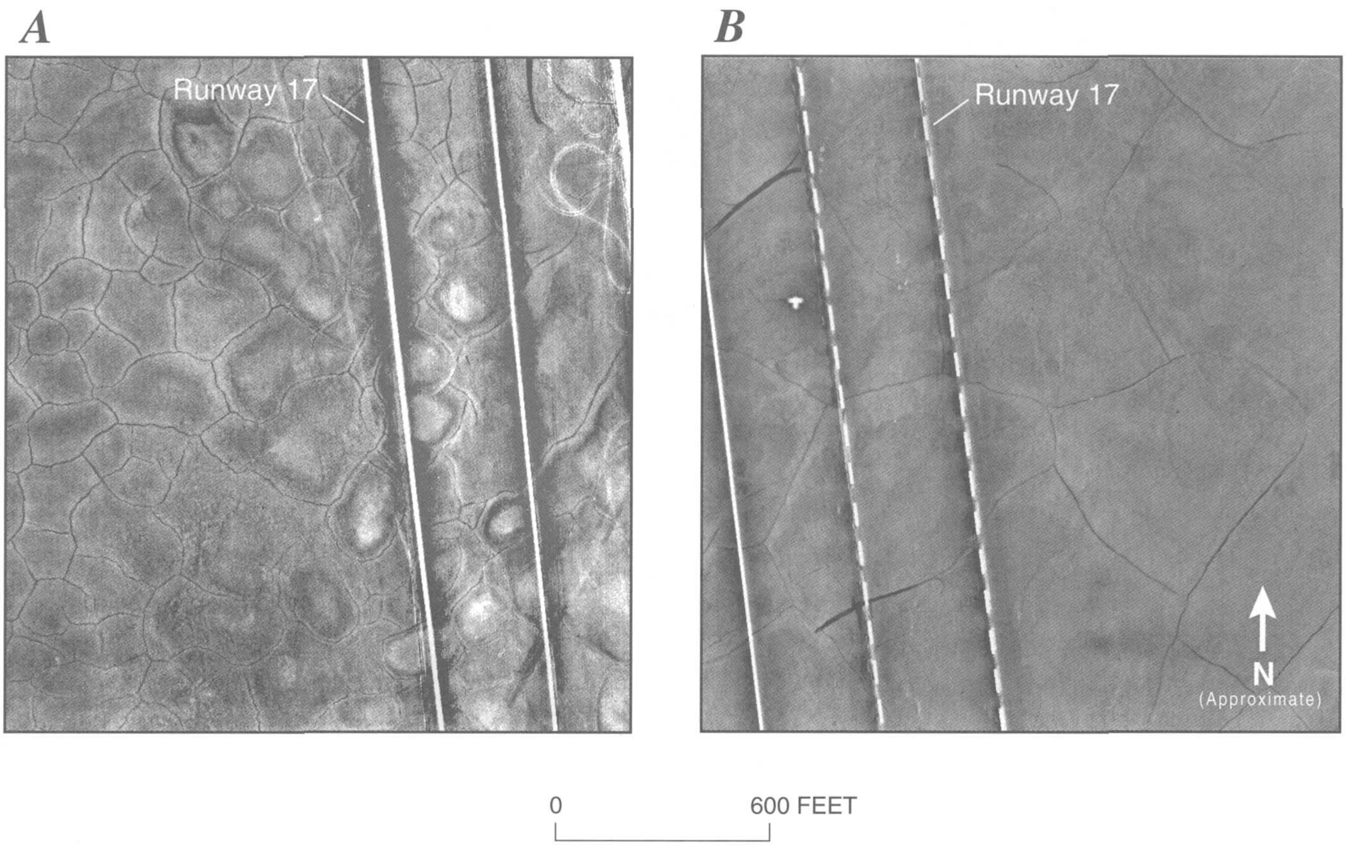

Figure 19. Examples of polygonal cracks in different regions of south Rogers Lake playa, Edwards Air Force Base, California. *A*, Dense network of small polygons (diameters less than 100 feet) near South Base. *B*, Giant polygons (diameters greater than 500 feet) near the intersection of runways 25 and 17. (Photographs taken in 1990)

mapped with distances between points of 3 ft or less, at an accuracy of plus or minus 3 ft. Few selective criteria were applied in the field, so the mapped cracks included a variety of widths and depths. Cracks that continued in a single direction for several tens of feet or longer were mapped more readily. Cracks were mapped without reference to aerial photographs of the playa.

Observed Changes in Erosional Features over Time

The playa flooded several times during the 5-year interval between aerial photography of the playa in 1990 and the DGPS surveys of crack networks in 1995. Consequently, changes in erosional features could be examined. Scaled maps of the surveyed crack networks were prepared for comparison with aerial photographs. Associated photographs of the crack networks were digitally scanned and photomosaics were prepared by reference to maps of the surveyed crack networks. To contrast visible cracks in the 1990 aerial photographs with undetected or "new" cracks, the survey lines from 1995 were placed on photomosaics of the crack networks (fig. 21). The maps of the surveyed crack networks were plotted using a hollow line on the photomosaics. Sections of the hollowed lines were darkened on close-up images (figs. 22–25) to indicate surveyed cracks that had no correlated marks in the aerial photographs.

In some cases, the terminus of an open-ended crack did not change detectably between 1990 and 1995 (fig. 22). More often, the open-ended cracks

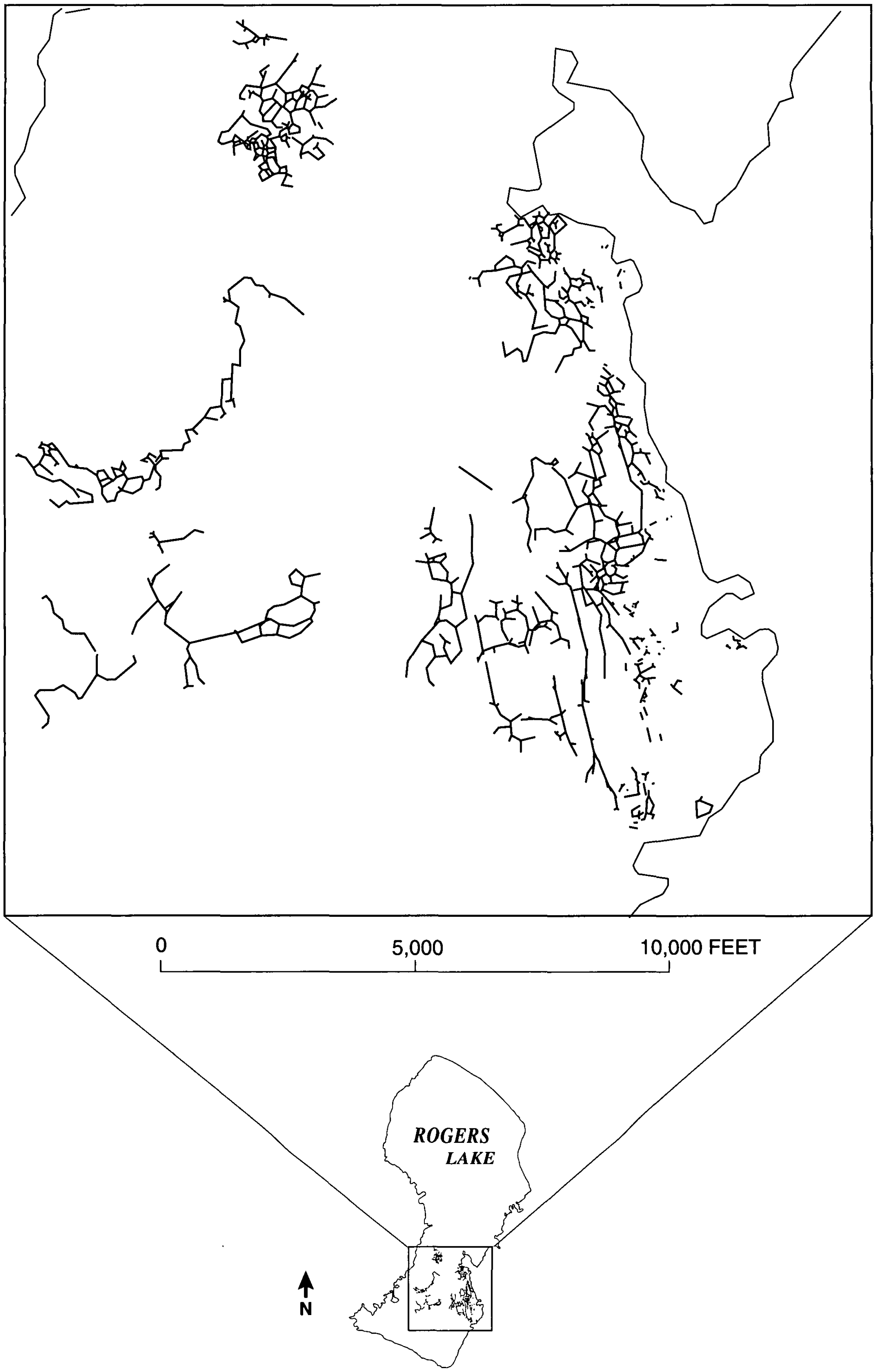

Figure 20. Location of cracks surveyed during 1995 in selected areas on Rogers Lake playa, Edwards Air Force Base, California.

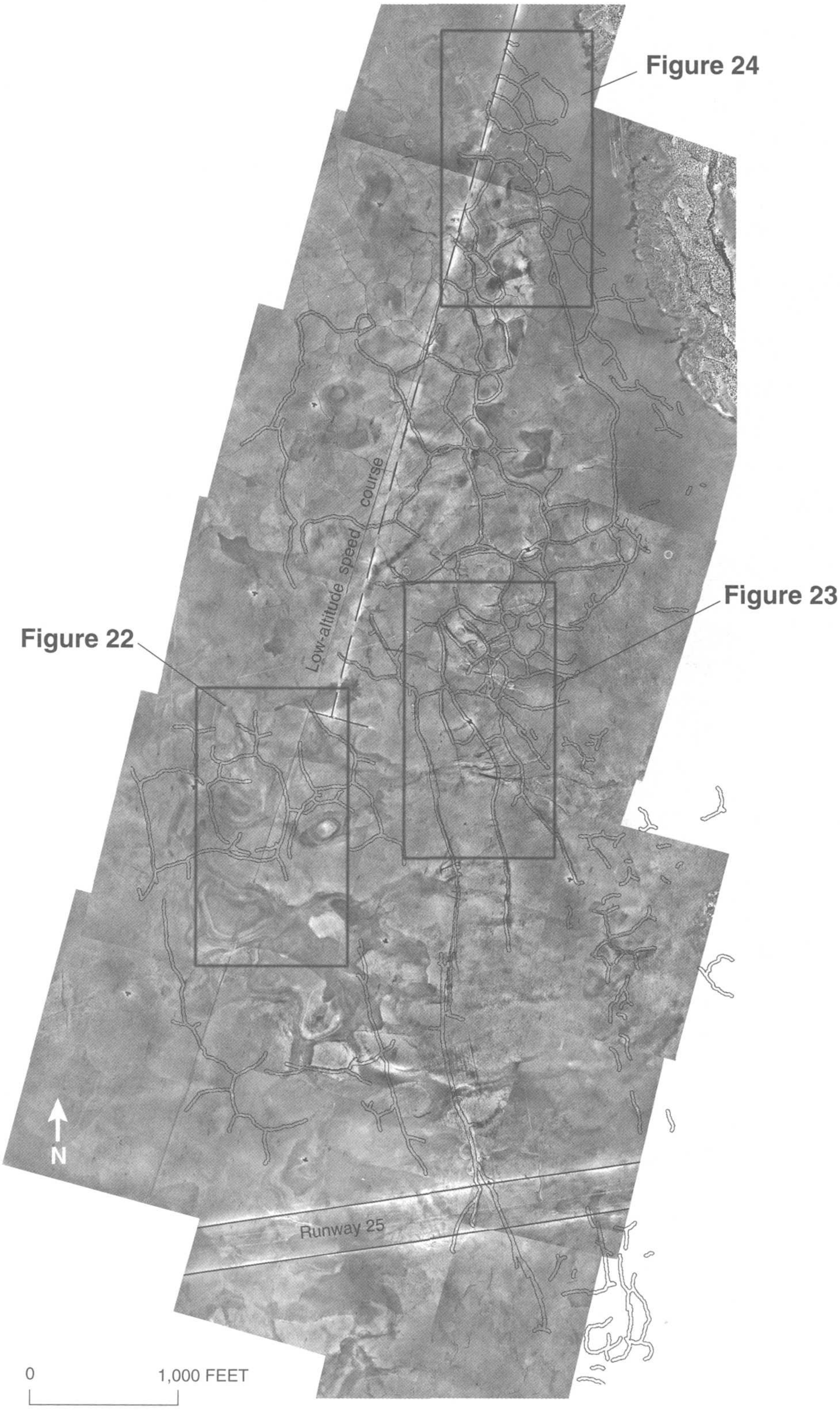

Figure 21. Areas of east Rogers Lake playa, Edwards Air Force Base, California, near low-altitude speed course, overlain with lines from crack surveys. Hollow lines indicate cracks surveyed in 1995. (From aerial photographs taken in 1990)

Figure 22. Detail of figure 21 near south end of low-altitude speed course and small ponded areas on Rogers Lake playa, Edwards Air Force Base, California, overlain with lines from crack surveys. Results of crack surveys are indicated by a hollow line. Darkened sections of the lines represent surveyed cracks that have no correlated marks on the aerial photographs of the playa. See figure 21 for location. (From aerial photographs taken in 1990)

Figure 23. Detail of figure 21 in area of long fissures on Rogers Lake playa, Edwards Air Force Base, California, overlain with lines from crack surveys. Results of crack surveys are indicated by a hollow line. Darkened sections of the lines represent surveyed cracks that have no correlated marks on the aerial photographs of the playa. See figure 21 for location. (From aerial photographs taken in 1990)

extended farther in the same direction and branched (fig. 23). The terminus of an open-ended crack occasionally corresponded to a dark stain on the wetted playa (fig. 22). The correspondence could indicate sedimentation in a ponded area or erosion of local flow paths toward low areas.

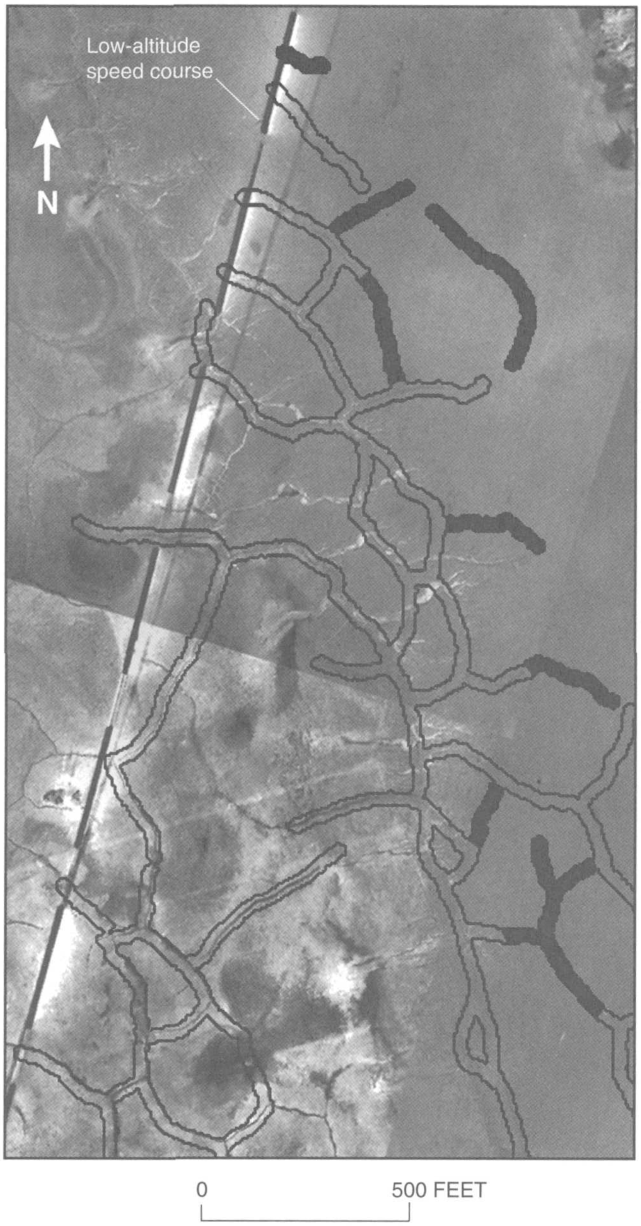

Figure 24. Detail of figure 21 near north end of low-altitude speed course and margin of Rogers Lake playa, Edwards Air Force Base, California, overlain with lines from crack surveys. Results of crack surveys are indicated by a hollow line. Darkened sections of the lines represent surveyed cracks that have no correlated marks on the aerial photographs of the playa. See figure 21 for location. (From aerial photographs taken in 1990)

If a photographed crack was not subsequently mapped by ground survey, the absence of a mapped crack could not be taken as evidence of "healing" of the crack by sediment deposition. For cracks in the 1990 aerial photographs that were not mapped in 1995, the possibilities are that cracks either had healed or were not mapped. Because there are so many cracks on Rogers Lake playa, some cracks visible in the photographs probably were not mapped during the ground surveys. Furthermore, it seems unlikely that some cracks would be filled and obscured by sediment deposition while adjacent cracks would remain visible.

However, cracks mapped in regions where photographs show no cracks can be taken as evidence of the appearance of new cracks. In most crack networks, the ground surveys showed cracks in 1995 that were imperceptible in the 1990 photographs (fig. 24).

According to personnel who surveyed cracks on the playa, cracks often were identified in fine sediments that had settled into older cracks. At runway 17, cracks were surveyed that previously had been resurfaced by bulldozer (artificial loops in figure 25 are bulldozer tracks). Although the mapping of the cracks by ground survey was incomplete, the good match between the mapped cracks and the aerial photographs indicated that these features had not healed or been obliterated by sediment deposition during inundations of the playa between spring 1990 and spring 1995.

The filling of cracks by sedimentation is a much slower process than subsidence-related formation of cracks. The rate of playa sedimentation since the last ice age has been estimated at less than 1 ft per 1,000 years (Stone, 1956, p. 270). Although local erosion may transport sediment rapidly into some cracks, substantial sedimentation across the playa surface was not observed from flooding between 1990 and 1995.

This comparison indicates that aerial photographs can be taken as needed to monitor changes in the playa caused by erosion and continued fissuring. The ability to distinguish cracks in the aerial photographs (1:2,400 scale) was demonstrated by good comparison between aerial photographs and ground surveys of polygonal cracks. Aerial photography is sufficient to detect changes in crack networks and fissure location, given visible reference marks on the playa for registration to digital maps. The flow paths of water across the playa can be determined from aerial photographs and from sedimentation in large flow channels.

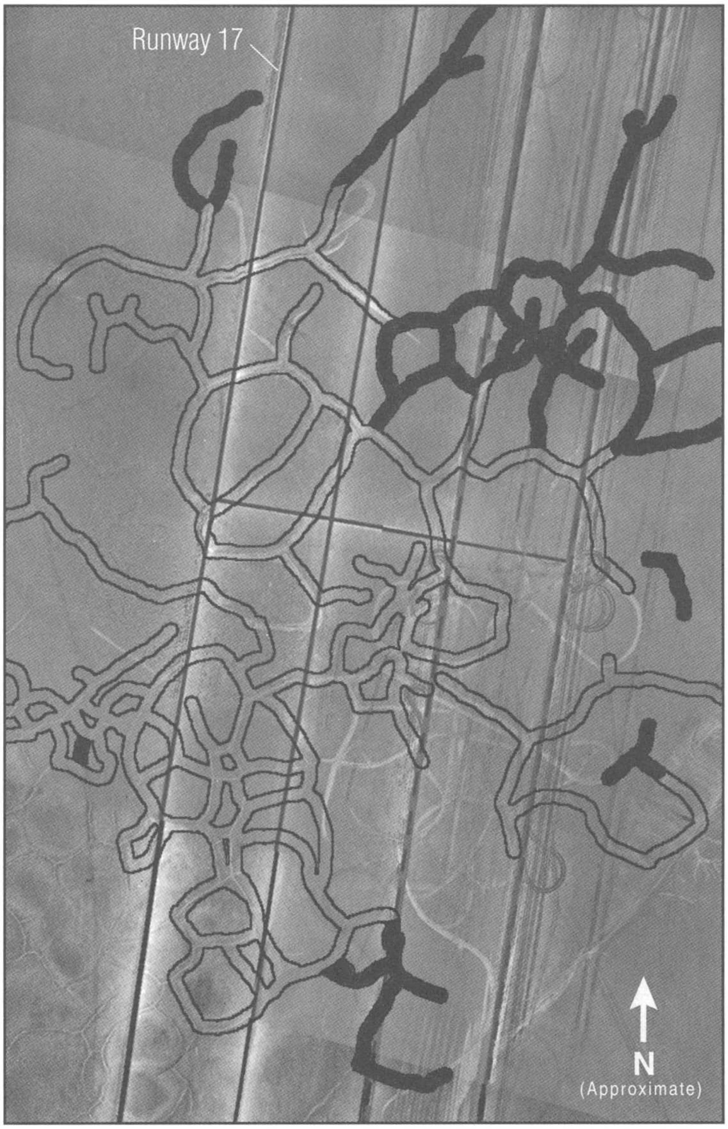

Figure 25. Area of Rogers Lake playa, Edwards Air Force Base, California, at runway 17 near South Base, overlain with lines from crack surveys. Light artificial loops visible in lower right are bulldozer tracks. Results of crack surveys are indicated by a hollow line. Darkened sections of the lines represent surveyed cracks that have no correlated marks on the aerial photographs of the playa. See figure 21 for location. (From aerial photographs taken in 1990)

SUMMARY

A topographic map of Rogers Lake playa with 0.5-foot contour intervals was prepared from transects surveyed between 1991 and 1995. Software-generated contours were refined through comparison with aerial photomosaics. Measurements of transects at reference marks recorded the location and elevation of topographic features such as flow channels and alluvial deposition. Water flow on the playa has eroded features in response to crack formation and random disturbances to the playa surface.

Comparisons of aerial photographs and crack surveys confirm that

1. Existing cracks did not disappear after repeated flood inundations between 1990 and 1995;

2. New cracks appeared within existing patterns and within smooth regions of the playa;

3. New cracks were coincident with bulldozer tracks seen in aerial photographs;

4. Fissures eroded along cracks aligned with the steepest slopes;

5. Areas with new, giant polygons in 1965–66 had developed denser networks of polygons by 1990–95.

The aerial photographs display a more detailed network than is practical to obtain by ground surveys. Surveyed cracks coincide well with the cracks in the 1990 aerial photographs, indicating that monitoring of surface features by aerial photography is possible and reliable.

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Table 1. Elevations and locations of bench marks and reference marks for transects on Rogers Lake playa, Edwards Air Force Base, California

Mark name	Elevation, in feet above sea level	Latitude	Longitude	Mark name	Elevation, in feet above sea level	Latitude	Longitude
			Bench marks				
BM 1RLB	2,270.84	34°56'36.91"	117°50'45.25"	BM L68	2,282.20	34°57'35.22"	117°46'54.17"
BM 3RLB	2,271.88	34°54'05.49"	117°50'30.36"	BM L68	2,282.20	34°57'35.22"	117°46'54.17"
BM 4RLB	2,269.06	34°49'30.24"	117°51'29.77"	BM MUROC	2,274.73	34°53'56.86"	117°51'18.17"
BM 5RLB	2,274.30	34°59'44.26"	117°50'40.26"	BM OFH	2,270.03	34°50'21.13"	117°53'44.99"
BM 7ARLB	2,278.86	34°52'40.31"	117°51'54.29"	BM T1140	2,291.33	34°59'01.26"	117°48'51.33"
BM 7BRLB	2,269.74	34°52'40.42"	117°51'52.64"	BM X1139	2,362.50	34°57'36.27"	117°53'40.77"
BM JP1	2,276.11	34°55'30.11"	117°51'47.74"				
			Reference marks				
3	2,268.42	34°49'50.39"	117°51'26.02"	5.4	2,269.94	34°50'48.16"	117°50'01.13"
4	2,268.42	34°50'07.16"	117°51'22.22"	5.5	2,271.58	34°50'50.76"	117°49'33.96"
4.1	2,268.92	34°49'30.24"	117°51'05.64"	5.6	2,273.18	34°50'52.53"	117°49'13.51"
4.2	2,268.41	34°49'30.52"	117°50'42.92"	5.6	2,273.18	34°50'52.53"	117°49'13.51"
4.25	2,269.05	34°49'30.33"	117°50'32.54"	5.7	2,274.39	34°50'53.73"	117°49'00.39"
4.3	2,271.17	34°49'29.95"	117°50'09.21"	5.7	2,274.39	34°50'53.73"	117°49'00.39"
5	2,267.85	34°50'28.45"	117°51'17.49"	6	2,268.14	34°50'55.46"	117°51'11.87"
5.1	2,267.93	34°50'41.39"	117°51'14.55"	7	2,267.93	34°51'10.93"	117°51'08.87"
5.11	2,268.26	34°50'39.48"	117°51'38.70"	7.1	2,272.20	34°55'32.40"	117°48'24.02"
5.12	2,268.25	34°50'37.14"	117°52'03.70"	7.11	2,272.91	34°55'33.05"	117°48'00.79"
5.13	2,268.64	34°50'34.61"	117°52'29.55"	7.12	2,273.84	34°55'33.07"	117°47'37.56"
5.14	2,268.47	34°50'32.14"	117°52'54.61"	7.13	2,275.57	34°55'33.50"	117°47'06.08"
5.15	2,268.58	34°50'29.65"	117°53'22.18"	7.2	2,270.52	34°55'30.47"	117°51'20.65"
5.16	2,268.46	34°50'27.75"	117°53'44.55"	7.3	2,270.40	34°55'30.61"	117°50'55.48"
5.17	2,269.65	34°50'25.54"	117°54'07.26"	7.3	2,270.40	34°55'30.61"	117°50'55.48"
5.2	2,268.23	34°50'43.57"	117°50'50.50"	7.4	2,270.47	34°55'30.62"	117°50'34.87"
5.3	2,269.29	34°50'45.97"	117°50'27.36"	7.4	2,270.47	34°55'30.62"	117°50'34.87"
7.5	2,271.09	34°55'31.04"	117°50'11.93"	9.15	2,274.30	34°57'26.69"	117°47'13.20"
7.6	2,271.24	34°55'31.26"	117°49'50.19"	9.2	2,270.60	34°57'38.25"	117°52'16.69"
7.7	2,271.37	34°55'31.57"	117°49'29.07"	9.3	2,270.50	34°57'37.10"	117°51'51.30"
7.8	2,271.50	34°55'32.11"	117°49'04.14"	9.4	2,270.72	34°57'36.29"	117°51'26.02"
7.9	2,271.82	34°55'32.32"	117°48'43.26"	9.5	2,270.57	34°57'35.47"	117°51'01.61"
8.0	2,270.82	34°56'37.24"	117°53'00.41"	9.6	2,270.38	34°57'34.53"	117°50'37.67"
8	2,268.19	34°51'31.39"	117°51'03.98"	9.7	2,269.75	34°57'33.92"	117°50'11.47"
8.1	2,272.74	34°56'37.66"	117°49'11.00"	9.71	2,269.84	34°57'34.11"	117°50'15.22"
8.11	2,272.52	34°56'37.97"	117°48'47.86"	9.8	2,271.39	34°57'32.54"	117°49'46.37"
8.12	2,273.09	34°56'38.14"	117°48'23.45"	10.0	2,270.81	34°58'55.22"	117°51'49.74"
8.13	2,273.56	34°56'38.54"	117°47'57.38"	10	2,268.75	34°52'11.53"	117°50'55.29"
8.14	2,273.86	34°56'38.37"	117°47'32.18"	10.2	2,270.54	34°58'55.47"	117°51'34.33"
8.15	2,274.27	34°56'38.49"	117°47'16.73"	10.2	2,270.54	34°58'55.47"	117°51'34.33"

Table 1. Elevations and locations of bench marks and reference marks for transects on Rogers Lake playa, Edwards Air Force Base, California—Continued

Mark name	Elevation, in feet above sea level	Latitude	Longitude	Mark name	Elevation, in feet above sea level	Latitude	Longitude
Reference marks—Continued							
8.2	2,270.63	34°56'37.25"	117°52'43.97"	10.3	2,270.68	34°58'56.06"	117°51'08.41"
8.3	2,270.51	34°56'37.33"	117°52'17.55"	10.4	2,271.15	34°58'56.69"	117°50'42.72"
8.4	2,270.51	34°56'37.30"	117°51'57.24"	10.5	2,271.73	34°58'57.30"	117°50'19.21"
8.5	2,270.52	34°56'37.20"	117°51'38.09"	10.6	2,271.79	34°58'57.94"	117°49'51.28"
8.6	2,270.53	34°56'37.04"	117°51'11.93"	10.7	2,272.86	34°58'58.66"	117°49'26.11"
8.7	2,270.49	34°56'37.04"	117°50'23.09"	10.8	2,275.36	34°58'59.33"	117°49'00.92"
8.8	2,270.79	34°56'37.17"	117°49'58.85"	11	2,268.49	34°52'31.21"	117°50'50.52"
8.9	2,271.86	34°56'37.78"	117°49'35.31"	11.1	2,268.88	34°52'40.38"	117°50'48.94"
9.0	2,270.66	34°57'39.31"	117°52'46.79"	11.2	2,271.67	34°52'40.28"	117°50'23.43"
9	2,268.57	34°51'50.97"	117°50'59.64"	11.3	2,278.46	34°52'39.86"	117°49'49.16"
9.1	2,270.95	34°57'31.68"	117°49'18.84"	12	2,270.13	34°52'52.97"	117°50'45.95"
9.11	2,272.28	34°57'30.74"	117°48'54.00"	13	2,271.09	34°53'12.26"	117°50'41.80"
9.12	2,272.37	34°57'29.91"	117°48'28.90"	14	2,270.89	34°53'31.21"	117°50'37.20"
9.13	2,272.41	34°57'28.77"	117°48'03.34"	15	2,271.39	34°53'54.15"	117°50'32.65"
9.14	2,273.42	34°57'27.65"	117°47'39.19"	16	2,268.47	34°52'40.37"	117°51'15.08"
9.15	2,274.30	34°57'26.69"	117°47'13.20"	17	2,268.91	34°52'40.15"	117°51'37.09"
18	2,269.00	34°52'59.32"	117°51'32.19"	50.11	2,270.47	34°52'27.97"	117°50'04.37"
19	2,268.95	34°53'18.21"	117°51'26.94"	50.12	2,271.38	34°52'39.68"	117°50'02.37"
20	2,269.51	34°53'39.09"	117°51'22.20"	50.13	2,272.53	34°52'49.23"	117°50'01.13"
21	2,268.77	34°52'18.49"	117°51'42.98"	50.14	2,276.24	34°53'10.13"	117°49'59.17"
22	2,269.21	34°51'58.18"	117°51'47.85"	50.15	2,271.96	34°53'30.97"	117°49'56.59"
22.1	2,270.19	34°51'54.12"	117°51'48.40"	50.16	2,271.79	34°53'51.76"	117°49'54.12"
23	2,268.46	34°51'32.97"	117°51'54.31"	50.17	2,272.00	34°54'12.46"	117°49'51.32"
24.4	2,268.09	34°51'11.78"	117°51'59.47"	50.2	2,269.90	34°49'43.55"	117°50'23.05"
25	2,268.18	34°50'50.49"	117°52'04.71"	50.3	2,270.18	34°50'03.95"	117°50'21.62"
26	2,268.25	34°50'33.22"	117°52'08.73"	50.4	2,270.83	34°50'24.16"	117°50'19.57"
27	2,268.58	34°50'15.82"	117°52'12.49"	50.4	2,270.83	34°50'24.16"	117°50'19.57"
28	2,270.24	34°49'48.82"	117°52'18.80"	50.5	2,269.63	34°50'46.77"	117°50'17.77"
29	2,269.85	34°54'16.64"	117°51'14.30"	50.6	2,269.68	34°51'06.48"	117°50'15.10"
30	2,270.17	34°54'39.71"	117°51'07.59"	50.6	2,269.68	34°51'06.48"	117°50'15.10"
31	2,270.30	34°54'58.99"	117°51'03.48"	50.7	2,269.63	34°51'27.05"	117°50'12.11"
32	2,270.33	34°55'54.34"	117°50'47.51"	50.8	2,269.89	34°51'46.90"	117°50'09.53"
33	2,270.51	34°56'15.32"	117°50'46.43"	50.9	2,269.70	34°52'08.25"	117°50'06.78"
34	2,270.55	34°56'59.04"	117°50'42.06"	BULLET	2,269.75	34°53'59.87"	117°51'00.99"
35	2,270.47	34°57'17.96"	117°50'39.07"	REBAR	2,272.65	34°52'41.76"	117°49'24.86"
40	2,269.06	34°50'57.87"	117°53'45.19"	RM 22	2,272.91	34°54'53.22"	117°51'34.28"
50.1	2,269.78	34°49'31.33"	117°50'24.06"	TELEBOX	2,271.01	34°49'56.66"	117°52'44.99"

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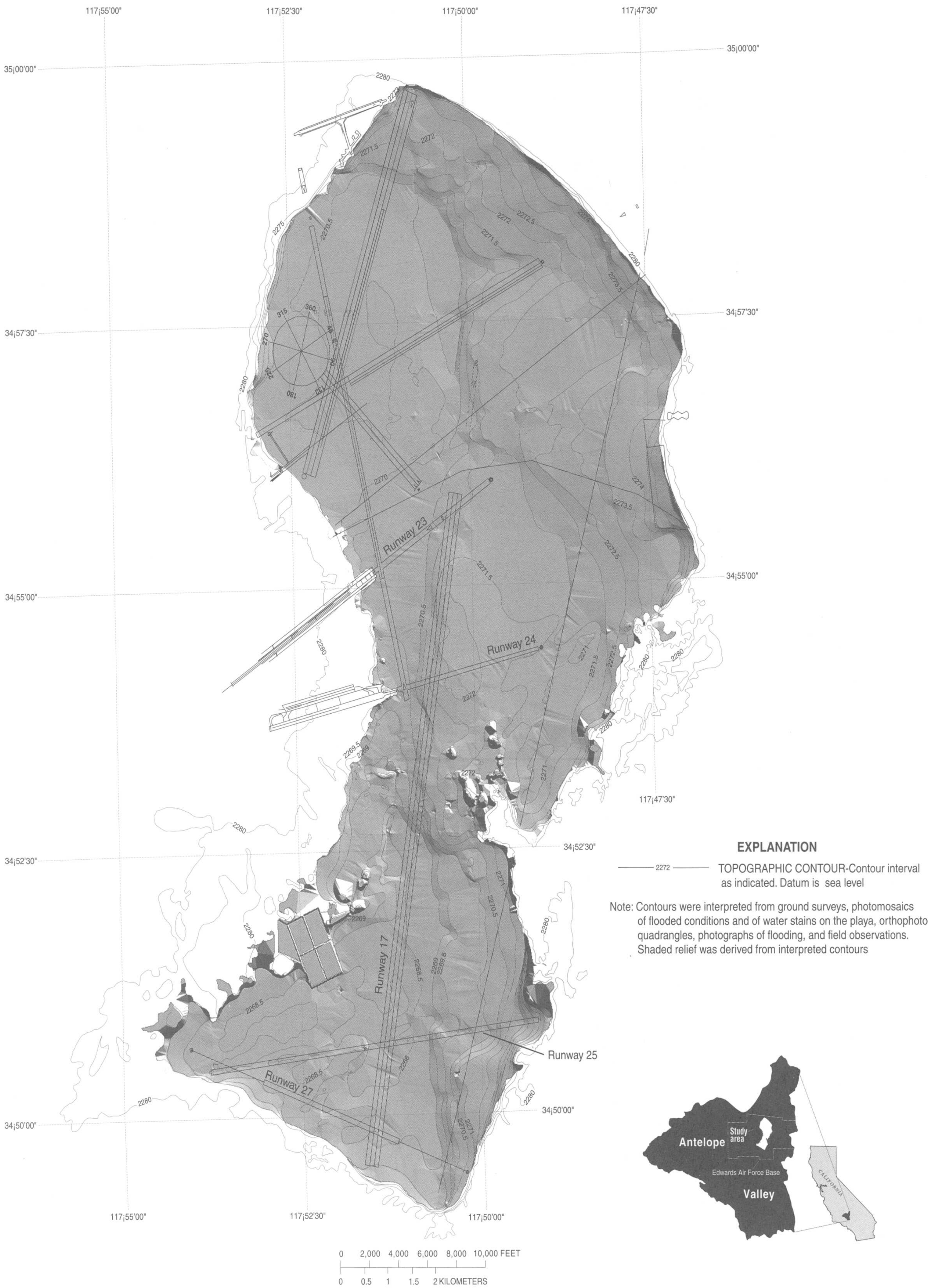

Figure 5. Elevations and locations of runways on Rogers Lake playa, Edwards Air Force Base, California. (Elevations were surveyed between 1991 and 1995.)

Dinehart and McPherson—TOPOGRAPHY, SURFACE FEATURES, AND FLOODING OF ROGERS LAKE PLAYA, CALIFORNIA—WRIR 98-4093