PHYSICAL ENVIRONMENT AT THE KING RANCH TRAINING SITE

by

E. G. Wermund

prepared for

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W. L. Fisher, Director

The University of Texas at Austin

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SUMMARY

The King Ranch training site of the Texas Army National Guard is a relatively pristine site that has suffered little physical abuse. Except for possible past overgrazing (as evidenced by the mesquite growth), the land has been used only as pasture.

There is no record of major historical storms, but even a major hurricane would not damage the land. Surficial damages to the land surface and its vegetation are possible both when soils are saturated and during drought. Hurricanes are likely to make access to the site difficult; floodwaters from the Santa Gertrudis, Tranquitas, San Fernando, and Carreta Creeks would make U.S. Highway 77 impassable (Federal Emergency Management Agency, 1984). The fact that average annual precipitation is exceeded by evaporation indicates the potential for major drought. A drought would impact National Guard activities by limiting transportation because areas devegetated by traffic are attacked by wind deflation. During very dry periods, National Guard equipment and vehicles may potentially cause range fires.

The generally flat terrain has subtle topographic differences and soil and bedrock variations that will influence National Guard use. Multiple subtle low areas will pond water on saturated, weak clay substrates and soils, and vehicles may have difficulty crossing these areas. Locally, small high areas containing sands and coarser materials could allow spilled fuels and chemicals to rapidly infiltrate. Microdune topography peripheral to San Fernando Creek makes the terrain difficult for walking and its vegetation cover could be readily stripped by heavy equipment.

Relatively steep and gullied bluffs beside Cayo del Grullo may impede movement of training vehicles. Valley walls in minor streams also make access difficult. Locally on stream valley floors and on the tidal flats of the Cayo del Grullo, there is quicksand part of the year.

On the King Ranch training site, interdistributary muds (Victoria soils) make transportation and construction difficult because of their expansive and plastic clays and the corrosive nature of the materials on metals. The old distributary channels (Clareville soil) and the vegetated dunes (Delfina soil) provide stable materials; they also soak up anything spilled on the surface.

Ground water from the Evangeline aquifer is the only source of water in the area. Water wells in the vicinity of the Texas National Guard lease are used principally for residential and agricultural purposes. There is a large drawdown sink as a result of heavy past use, especially from 1960 through 1980. No evidence of contamination of ground water was found, according to the records of the Texas Water Development Board (TWDB). Nevertheless, a future program of hydrologic monitoring of surface and ground water that includes chemical analyses is recommended.

INTRODUCTION

The King Ranch training site of the Texas National Guard is located immediately southeast of Kingsville near the terminus of Texas Farm Road 2045 (fig. 1). The continuation of this road onto the King Ranch, beyond the guarded kiosk, bounds the northeast border of the site. The southwest border of the site is located on the northeast banks of the Cayo del Grullo and San Fernando Creek. The remaining boundaries are controlled by the barbed wire fences for the Bordo Nuevo and Pinto pastures.

The Texas National Guard will use this training site primarily for infantry exercises (Lt. Vaughn McCurry, personal communication, 1993). The infantry will construct minor fortifications, foxholes, and trenches. Infantry maneuvers will be supported by 4-wheel drive Hum-Vee and small tracked vehicles. Only small arms, primarily for firing blanks, will be used. Currently, there are no ranges for testing marksmanship with live ammunition.

The 7,210-acre training site shows little evidence of use by the Texas National Guard. The perimeter roads are locally rutted to about 6 inches as a result of 4-wheel drive traffic. The ruts

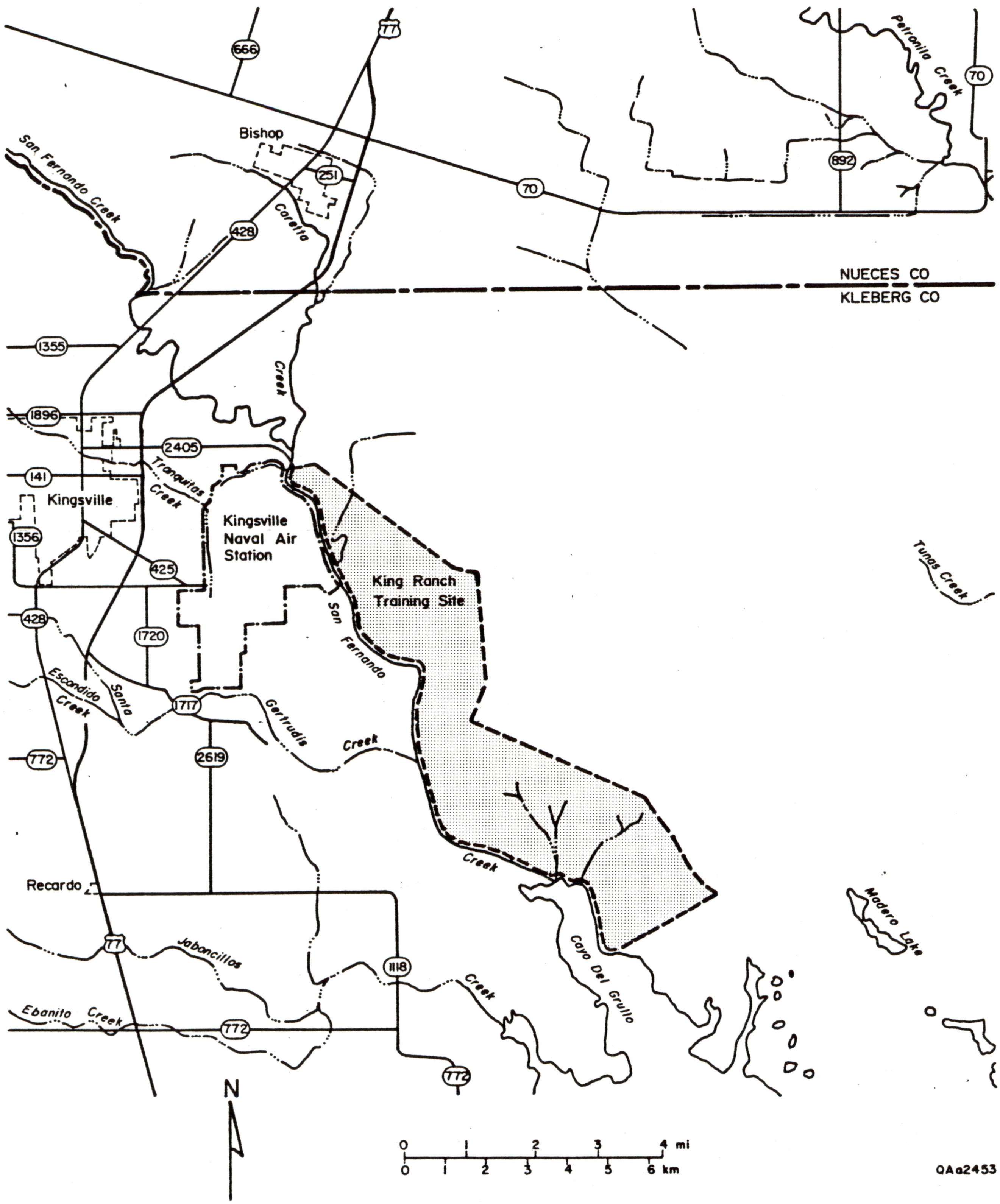

Figure 1. Location map for the King Ranch training site of the Texas National Guard.

may be caused by King Ranch vehicles as well as by National Guard traffic. The site is all uncultivated land on which pasture vegetation appears undisturbed, except where King Ranch personnel have cleared brush between the Ramos and Pinto wells.

The purpose of this report is to describe the physical setting of the King Ranch training site for future use in Environmental Assessments, and possibly in an Environmental Impact Statement, and to assist the Texas National Guard in developing an Integrated Training Area Management Plan. The environmental plan will be formulated to monitor and maintain the environment of the site.

CLIMATE AT THE KING RANCH TRAINING SITE

According to Larkin and Bomar (1983), the climate at the King Ranch training site is modified marine and subtropical subhumid. This climate is characterized by hot summers and dry winters. The marine climate is caused by the predominantly onshore flow of tropical marine air throughout most of the year from the proximate Gulf of Mexico. The flow of marine air onshore is modified by intermittent, seasonal flow of continental air, especially in the winter months.

Temperature and precipitation data were collected from the Texas Water-Oriented Data Bank. Monthly data were collected for the years 1953, 1963, 1973, and 1983, because these years were representative of both dry and wet years. During that period, the lowest recorded temperature was 39.5°F; the monthly mean lowest temperature, which occurred in December, was 41.2°F. The maximum recorded temperature was 99.3°F in June 1953; the monthly mean highest temperature in the 40 years was 95.5°F in July. According to Bomar (1983), Corpus Christi had a maximum temperature of 105°F in 1934, and that airport recorded a low of 11°F in 1889.

For the same period (1953 through 1983) at Kingsville, the maximum monthly precipitation was 12.6 inches in September 1973. No rain fell in November 1953. Mean monthly precipitation varies between 6.14 inches in September and 0.58 inches in March. According to Larkin and Bomar (1983), average annual precipitation was 26 inches, whereas the annual average gross lake surface evaporation rate was 63 inches for the period 1950 to 1979. Therefore, evaporation exceeds precipitation in normal years. However, as exemplified by Hurricane Beulah in the Rio Grande Valley, this area could receive 30 inches of rainfall in 3 days, given a major hurricane. The King Ranch training site is in an area where extreme weather conditions are common.

The variation in annual rainfall at Kingsville is shown on a hydrograph (fig. 2). From 1950 to 1991 the annual rainfall varied between a maximum of 52.5 inches for 1958 and a minimum of 13.9 inches for 1962. The mean annual rainfall was 27.8 inches, with a standard deviation of 9.9 inches. The standard deviation indicates a considerable spread of annual rainfall between wet and dry years, allowing for severe storms locally. Years in which hurricanes occurred do not have the highest annual rainfalls. Hurricane Allen in 1980 was accompanied by 36.3 inches annual rainfall, Beulah in 1967 by 37.0 inches, and Celia in 1970 by only 25.3 inches. However, Celia was unique in having extreme winds and little precipitation.

The nearest published wind data come from the Corpus Christi Airport, about 40 airline miles from the King Ranch training site, and they are unlikely to differ greatly from Kingsville data. Larkin and Bomar (1983) display wind roses for the four seasons at Corpus Christi Airport. Only the summer and winter months are shown here (fig. 3), accompanied by a table displaying summaries of variations in wind speed through the course of 20 years (table 1).

During the summer, the winds are unimodal when the predominant southeasterly winds prevail, whereas in the winter the winds are bimodal, with northerly winds having slightly greater frequency than the annual prevailing southeasterly winds. In summer the winds are generally lower in wind speed; in winter wind speeds exceeding 21 mph are common. On the King Ranch training site, the prevailing southeasterly winds are evident in the orientation of the unvegetated clay dunes and the vegetated clay-sand dunes.

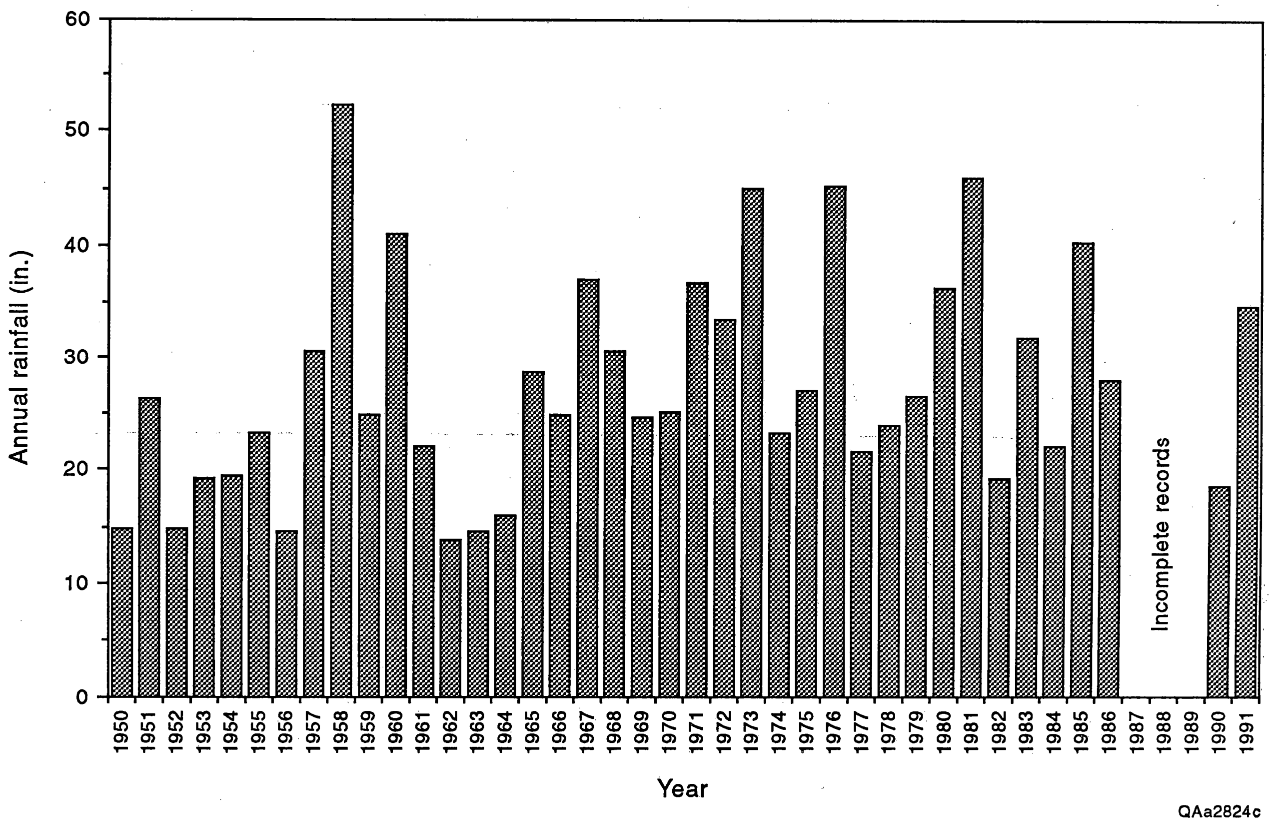

Figure 2. Hydrograph for Kingsville based on records of the Texas Water Development Board.

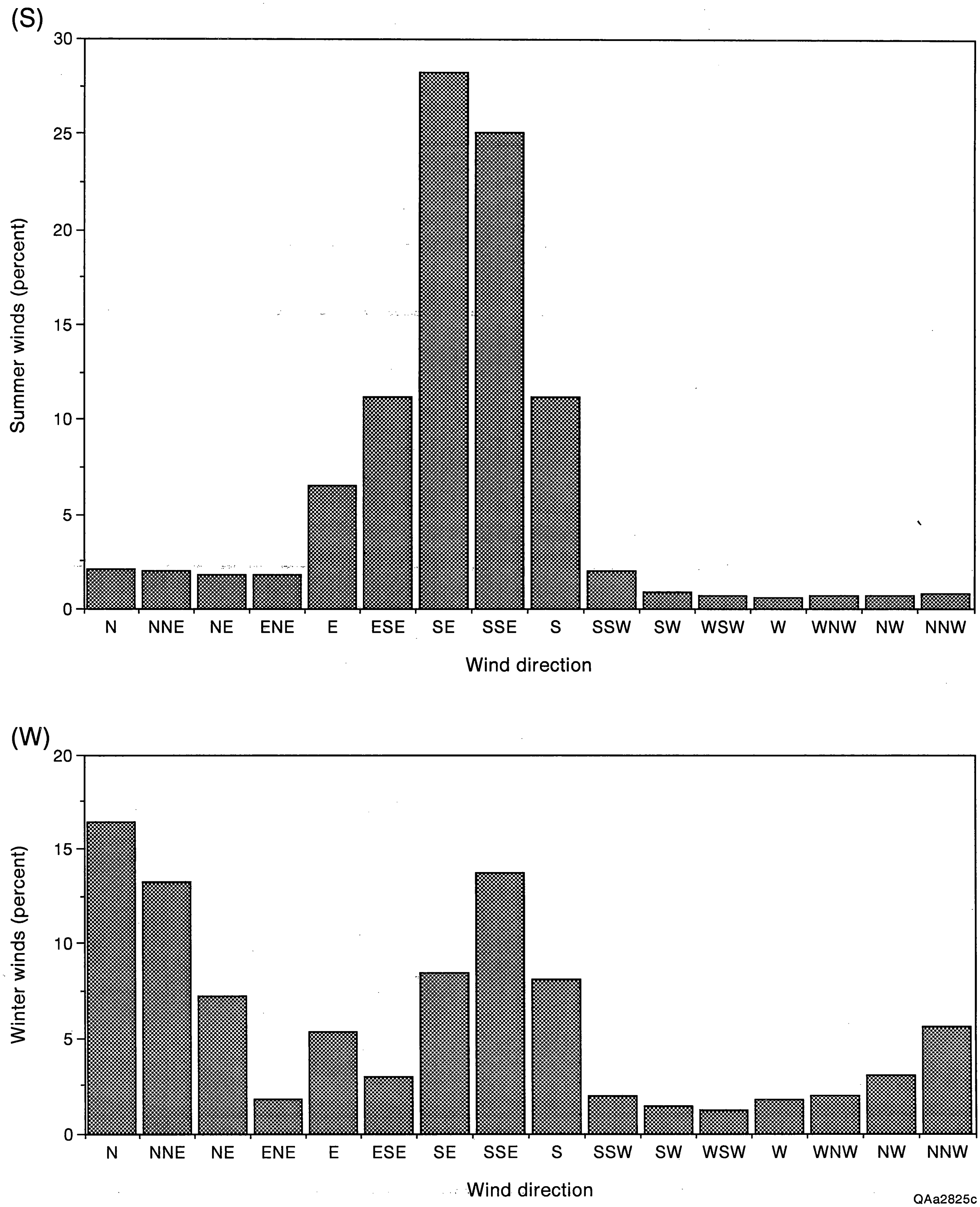

Figure 3. Winds measured at the Corpus Christi Airport. S = Summer winds, June–August. W = Winter winds, December–February. From Larkin and Bomar (1983).

Table 1. Relative occurrence and wind speeds at the Corpus Christi Airport, Summer and Winter 1961–1980 (after Larkin and Bomar, 1983). K = knots.

Summer

Direction	All (percent)	>18 K	14–18 K	11–13 K	8–10 K	4–7 K	1–3 K
N	2.100	0.000	0.000	0.000	0.400	1.600	0.100
NNE	2.000	0.000	0.000	0.300	0.700	8.000	0.200
NE	1.800	0.000	0.200	0.200	0.400	0.600	0.200
ENE	1.800	0.000	0.000	0.200	0.600	0.600	0.200
E	6.600	0.000	1.000	1.800	1.600	1.800	0.200
ESE	11.200	0.000	2.400	2.800	2.000	3.700	0.300
SE	28.300	1.400	7.600	6.200	4.900	7.700	0.500
SSE	25.100	1.400	6.800	4.500	5.400	6.600	0.400
S	11.300	0.000	1.800	2.000	2.700	4.300	0.500
SSW	2.000	0.000	0.000	0.400	0.400	1.000	0.200
SW	0.900	0.000	0.000	0.200	0.000	0.700	0.000
WSW	0.700	0.000	0.000	0.200	0.000	5.000	0.000
W	0.600	0.000	0.000	0.200	0.000	4.000	0.000
WNW	0.700	0.000	0.000	0.200	0.000	5.000	0.000
NW	0.700	0.000	0.000	0.200	0.000	5.000	0.000
NNW	0.800	0.000	0.000	0.200	0.000	6.000	0.000

Winter

Direction	All (percent)	>18 K	14–18 K	11–13 K	8–10 K	4–7 K	1–3 K
N	16.500	1.500	4.500	2.700	4.000	3.600	0.200
NNE	13.300	0.700	3.800	3.200	3.200	2.300	0.100
NE	7.300	0.200	1.900	1.600	1.700	1.700	0.200
ENE	3.600	0.000	0.500	0.600	0.600	1.600	0.200
E	5.400	0.000	0.400	1.000	1.400	2.400	0.200
ESE	3.900	0.000	0.500	0.200	1.000	2.000	0.200
SE	8.500	0.000	2.000	1.500	2.400	2.400	0.200
SSE	13.800	2.000	5.200	2.500	2.300	1.600	0.200
S	8.200	0.300	2.300	1.800	1.800	1.800	0.200
SSW	2.000	0.000	0.000	0.200	0.500	1.200	0.100
SW	1.500	0.000	0.000	0.100	0.300	1.000	0.100
WSW	1.300	0.000	0.000	0.000	0.200	1.000	0.100
W	1.800	0.200	0.400	0.000	0.000	1.200	0.100
WNW	2.000	0.000	0.400	0.200	0.000	1.300	0.100
NW	3.100	0.000	1.000	0.300	0.600	1.000	0.200
NNW	5.700	0.600	1.800	0.500	1.000	1.700	0.100

For planning purposes, the climate diagram derived by Diersing and others (1990) was constructed (fig. 4), shown here with monthly mean temperatures. We also constructed climate diagrams with maximum and minimum temperatures that affect the differences between temperature and precipitation curves. Wet soil periods are evident three times a year: a major wet period between August and October, a smaller brief interval in June, and a moist February. Deep dry-soil events occur from March to May, briefly in June, and moderately in November and December. These data are based on average values in a 30-year record (1953 through 1983), and environmental planning must recognize that favorable seasons of trafficability can be changed by a major rainfall.

Because of the threat of hurricanes from June to October, training plans must have contingencies. According to Bomar (1983), there is a one-in-eight chance of the eye of a hurricane coming onshore in the vicinity of the King Ranch training site each year. Two hurricanes have struck near the King Ranch training site in recent years. Hurricane Celia came ashore at Corpus Christi in 1971 with maximum sustained winds of 130 mph, minor rainfall, and a surge of 9 ft. The eye of Hurricane Allen passed over Port Mansfield in 1980, with maximum sustained winds of 115 mph and a surge of 12 ft.

GEOMORPHOLOGY (TERRAIN)

The King Ranch training site lies within the Gulf Coastal Plain province; the plain here slopes southeastward about 3 ft/mi. The attitude of the plain is controlled by the effects of runoff and wind on the proximal deltaic plain of the Beaumont Formation. The plain forms a flat terrain that represents 95 percent of the training site. There, the elevation of the plain is slightly more than 45 ft at the north boundary of the site, and the plain is about 25 ft at the southern limits. The lowest elevation of the site is sea level, where the site drops into the Cayo del Grullo. The mouths of the several streams eroding headward into the site also approach sea level. Maximum relief at the site approximates 47 ft.

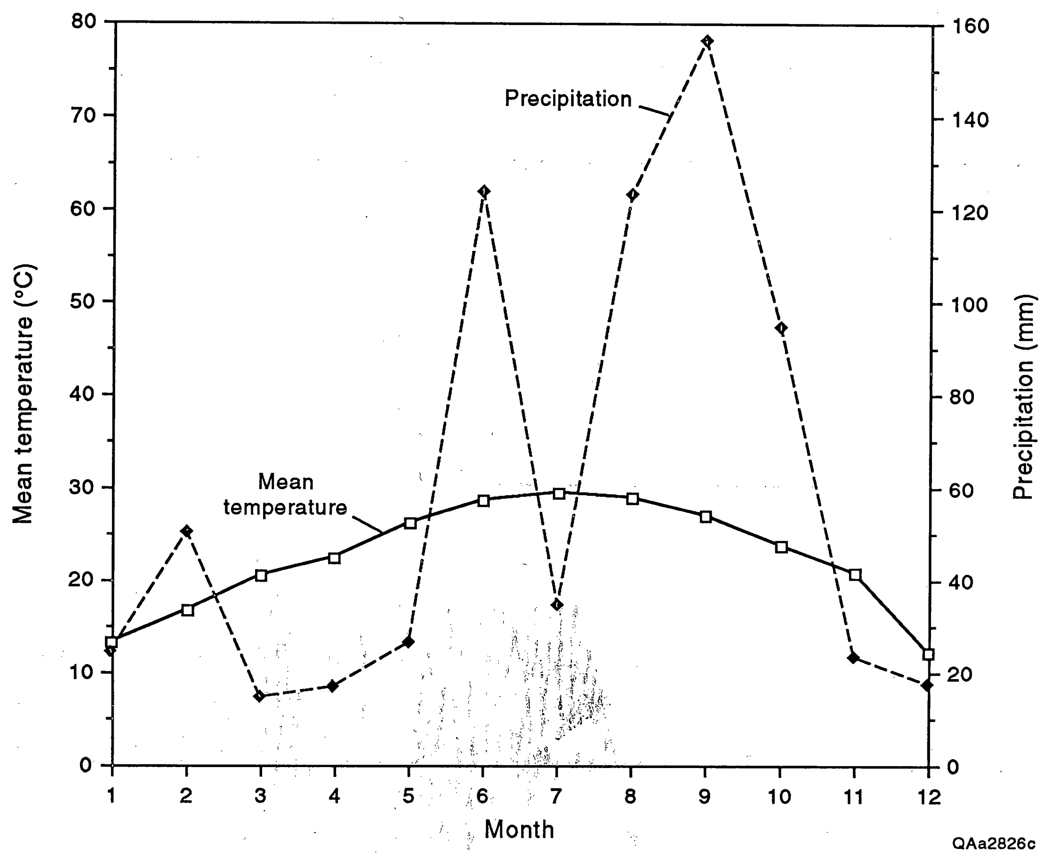

Figure 4. Climate diagram of the Kingsville vicinity based on data of the Texas Water Development Board.

The coastal plain slope, the principal surface at the site, has dunes of varied size superposed as positive features. The dunes are concentrated at the southern end of the training site, where they are stabilized by brushy vegetation. The largest dune is a vegetated clay-sand dune nearly 20 ft high that covers about 600 acres. Several other dunes are present that are 5–10 ft high and about half the areal extent of the largest dune. There are also several low (about 10 ft maximum height) clay dunes that are 1 acre or less in areal extent that are present on the Cayo del Grullo tidal flats at the south tip of the site. Clay-sand and clay dunes might become mobilized if the vegetation were stripped by excessive traffic of heavy vehicles. Other subtle positive topography, less than 10 ft high and as much as 0.25 mi wide, occurs over the old channels on the deltaic plain of the Beaumont Formation. These form the most stable areas on the training site.

The coastal plain pastures have numerous subtle depressions that in wet weather are shallow ponds with saturated clays beneath them. They occur frequently on the interfluvial portions of the Beaumont deltaic plain. These depressions will be traps for vehicles on maneuvers unless they are all located and avoided. Many are small, about 40 ft across, but some may be as large as 500 ft in diameter; they are all generally less than 1 ft deep. They should be accurately located on maps as they are found. They are not readily mapped on the ground in pasture land because the vegetation obscures them from view. One mapping solution may be the interpretation of thermal infrared imagery, 8–14 microns wave length, collected best at night after a rain during the wet season.

The other principal geomorphic units are the bluffs along Cayo del Grullo and valley walls of streams. The bluffs vary from 25 to 40 ft high, higher to the north. At the south they are very steep, approaching vertical locally. These bluffs are incised by deep, narrow headward-eroding gullies that deposit low fans where they flow onto the tidal flats. Here the bluffs would not be readily traversed even by tracked vehicles. The bluffs to the north have slopes of 5 to 20 percent, and headwardly eroding gullies are more widely spaced and do not have vertical walls. Below the bluffs are extensive tidal flats that will probably not be used by the Texas

National Guard. Publicly available aerial photographs were not sufficient in scale or coverage for time-series analyses of progressive gully erosion.

On this site, the largest streams have steep valley walls and flat valley floors. The floors are covered by fine sands that are sculpted by fluvial and eolian processes. Small coppice dunes are sometimes present in dry weather. In wet weather the valley floors have local quicksand areas to be avoided.

From the eastern bluffs of the Cayo del Grullo to near the midline northwest to southeast on the training site, there is a microdune topography that reflects typical coastal physical processes. The grass, mostly Kleberg bluestem, grows in clumps that trap wind-blown sediment. Following the addition of eolian sediment, the grass grows upward on the newly trapped material. Between the clumps, the soil is nearly bare and is the rill loci for sheetflow runoff during rainfall. The minimal relief that results may be as much as 2 ft nearest the Cayo del Grullo, diminishing inland farther from sediment sources on the tidal flats. An orientation of the clumps lining normal to the slope is suggested, which hints at downward mass movement on a relatively unstable slope. The end result is a microterrain on which it is difficult to walk, and on which one can drive a wheeled vehicle in only the lowest available gear at slowest speeds. It is suspected of being a fragile terrain on which a tracked vehicle such as a tank would readily tear out all the vegetation, making it more susceptible to damage by severe wind and sheetflood erosion.

SURFACE HYDROLOGY

The principal stream in the vicinity of the King Ranch training site is San Fernando Creek. This generally southeastward-flowing creek is shown as an intermittent stream on U.S. Geological Survey topographic maps. The stream is entrenched about 15 ft deep in a valley. The valley floor varies from about 40 ft wide at U.S. Highway 77 to more than 200 ft wide at the south boundary of the Kingsville Naval Air Station, where the stream bounds the northwesternmost part of the training site. Four western tributaries—the Tranquitas, Santa Gertrudis, Jaboneillos, and Ebanito Creeks—are also intermittent and do not transect the King Ranch training site. The only eastern tributary is the Carreta Creek, which flows from near Bishop to the Farm Road 2045 entrance to King Ranch.

On the King Ranch training site, there are only two minor through-going streams, also intermittent. One unnamed stream originates near the Palo Mercado well and flows south across the site in a narrow vegetated valley about 1 mi east of the King Ranch security gate. Much of the year it carries away irrigation water. The Pinto Creek flows southwest from the Pinto well in a broad flat valley whose steep walls transect the lower tenth of the site. These intermittent streams form a dendritic stream network.

Before World War II, the region was predominantly pasture. More recently, the valley floors have been alluviated by runoff from modern agricultural practices. On the flat terrain, much soil is moved by sheetflow, largely controlled by plowed furrows. The bulk of the flow is confined to older interbasin areas of the deltaic plain of the Beaumont Formation, where it is often trapped in long-standing ponds waiting either slow infiltration into clay soils or evaporation. Winds deflate bared surfaces by moving sand and dry clay chips.

The only stream flow information in the vicinity of the King Ranch training site is from a partial record station on Tranquitas Creek where it flows under U.S. Highway 77 (fig. 5). A partial record station is a particular site at which limited streamflow and/or water quality data are collected systematically over a period of years for hydrologic analyses (U.S. Geological Survey, 1974, 1975–1992). This small drainage basin is only 48 mi^2, but its gauge history is the best available representation of flood potential in the vicinity. Except for 1979, when a rate of annual stream discharge was given as 0 ft^3/sec, all other records gave only gauge height. Table 2 compares the records of gauge height with those of annual rainfall. It is noteworthy that the highest reported gauge heights, 6.88 ft in 1980 and 4.50 ft in 1967, were during the years of Hurricanes Allen and Beulah, respectively. The eyes of both of these tropical cyclone storms

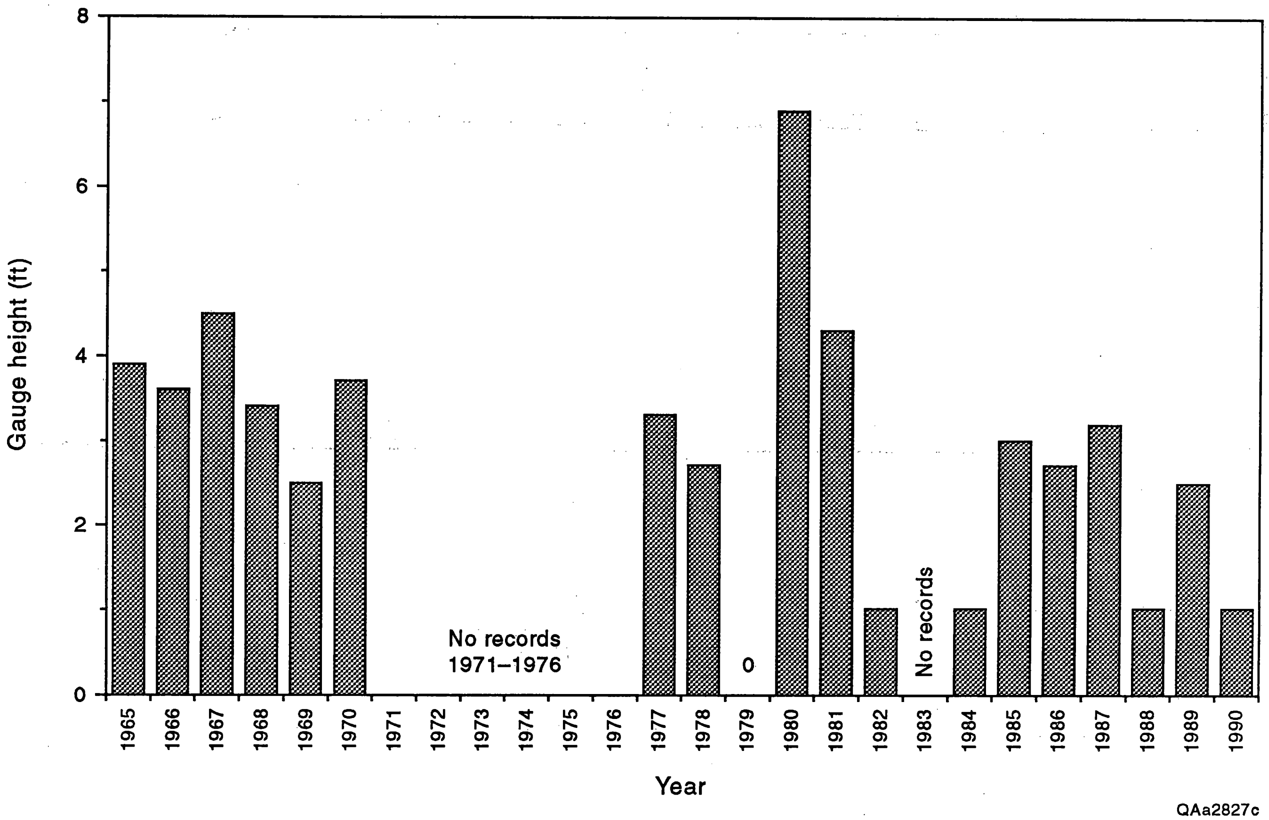

Figure 5. Gauge station heights for the U.S. Geological Survey partial record station on Tranquitas Creek at U.S. Highway 77.

Table 2. Comparison of gauge-station records of the U.S. Geological Survey partial record station on Tranquitas Creek at U.S. Highway 77 and annual rainfall at Kingsville Airport.

Year	Rainfall (inches)	Flood stage (ft)
1950	14.900	N.D.*
1951	26.400	N.D.
1952	14.800	N.D.
1953	19.400	N.D.
1954	19.600	N.D.
1955	23.500	N.D.
1956	14.700	N.D.
1957	30.600	N.D.
1958	52.500	N.D.
1959	25.000	N.D.
1960	41.100	N.D.
1961	22.300	N.D.
1962	13.900	N.D.
1963	14.600	N.D.
1964	16.000	N.D.
1965	28.800	3.900
1966	25.000	3.600
1967	37.000	4.500
1968	30.700	3.500
1969	24.700	3.500
1970	25.300	3.700
1971	36.770	0.200
1972	33.600	0.000
1973	45.200	0.000
1974	23.400	0.000
1975	27.200	0.000
1976	45.300	0.000
1977	21.800	3.300
1978	24.200	2.700
1979	26.620	0.000
1980	36.300	6.900
1981	46.000	4.300
1982	19.320	1.000
1983	31.900	0.000
1984	22.300	1.000
1985	40.400	3.000
1986	28.160	2.700
1987	0.000	3.200
1988	0.000	1.000
1989	0.000	2.500
1990	18.700	1.000
1991	34.800	

*N.D. = No data available.

came onshore south of Kingsville. Because of the hurricane potential and the small drainage network, serious flooding may possibly impact the area and even isolate the training site.

Federal Emergency Management Agency (1984) maps show that the 100-year floodplain (Zone A of the national flood insurance rate program) of Santa Gertrudis, Tranquitas, San Fernando, and Carreta Creeks crosses U.S. Highway 77 above the bridges. No 500-year floodplain (Zone B of the same program) is shown on the map. On the training site, the 100-year flood rises to 15 ft in Pinto Creek and the unnamed creek to the west. It rises to 35 ft where the pipelines cross the tidal flats of the Cayo del Grullo. Across from the Bordo Nuevo well and in the next San Fernando Creek tributary to the south, 100-year flooding could occur.

SOILS AT THE KING RANCH TRAINING SITE

A general soils map of Kleberg County was published by the Soils Conservation Service in 1977 (fig. 6). There are no modern soils series maps of Kenedy and Kleberg Counties nor of the unimproved pastures of the King Ranch training site (R. Schmidt, personal communication, 1993). There is preliminary mapping on 1:24,000-scale black-and-white aerial photographs of croplands in Kleberg County. On those photographs, one observes a differentiation of coarser versus finer soils that is in general agreement with the geologic mapping. This new soils mapping was performed in 1988 and includes the most modern classification system of the Soils Conservation Service.

According to the older mapping, the King Ranch training site is dominated by the Victoria-Clareville series of clays and clay loams. These soils form over the Beaumont Formation, with the Victoria soils forming on interdistributary and lake basin muds and the Clareville soils forming on channelized deposits (described in this report in the geology of the site). Victoria soils are dark, rich in clay, strongly expansive, and corrosive. They are recommended for agriculture but condemned for construction, septic tanks, landfills, and recreation. The Clareville soils, which are increasingly loamy, are better tolerated for the previously cited uses.

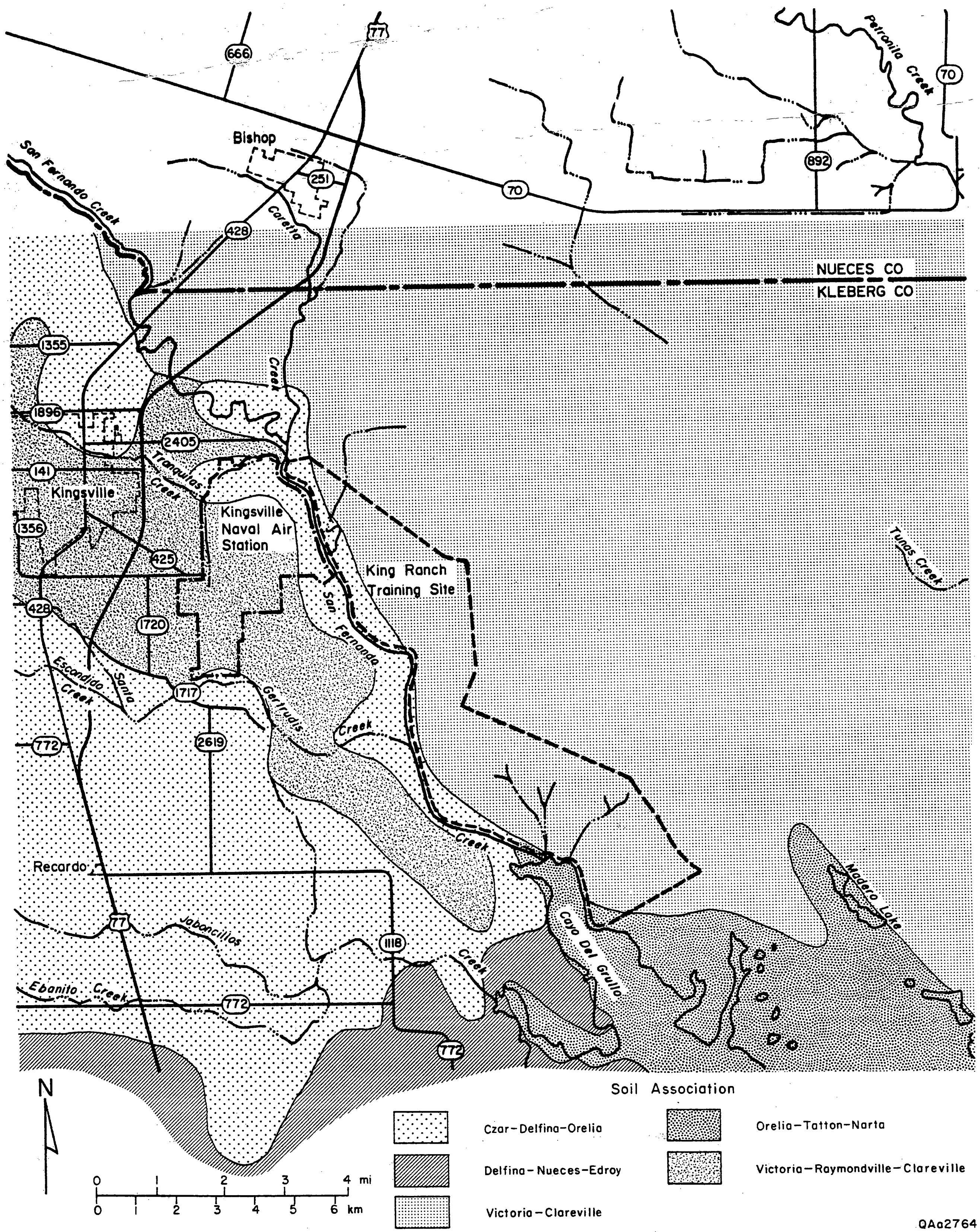

Figure 6. General soils map of the vicinity of the King Ranch training site of the Texas National Guard. From a general soils map of the U.S. Department of Agriculture, Soil Conservation Service (1992).

Where vegetation is stripped and soils are saturated in Victoria soils, vehicles are easily bogged down.

Along San Fernando Creek and the northwestern border of the training site, a band of Czar-Delfina-Orelia soils occurs in and along valley walls. These soils are poorly to well drained sandy loams, loamy fine sands and sandy clay loams. Because of the larger complement of sand, these soils have moderate bearing strength, low shrink swell, and moderate water management capabilities. They should not hinder training activities at the site.

Along the southwestern boundary of the training site and along the upper reaches of Cayo del Grullo, the Orelia-Tatton-Narta soil series occurs. These soils are poorly drained, frequently ponded, loamy sand soil types. They commonly hold a high salt content related to local evaporation pans and are strongly affected by wind action. The active clay dunes, described in the geology, commonly occur in this soils series.

GEOLOGY OF THE KING RANCH TRAINING SITE

Three gently southeast-dipping formations constitute the principal geologic units of the coastal plain region containing the King Ranch. The formations are the Goliad, Lissie, and Beaumont Formations (fig. 7). The Goliad Formation is Pliocene with a minimum age of 1.8 million years, whereas the other formations are Pleistocene and probably younger than 100,000 years (Brown and others, 1975; Brewton and others, 1976). The Goliad Formation in this region is composed of numerous conglomerates and sandstones in which the gravel and sand particles are mainly limestone. The near-surface Goliad rocks are cemented by calcite, but the same strata are highly permeable in the subsurface. The unit is an upper delta plain or alluvial fan. The Lissie Formation is composed of abundant sands and fine silts with minor clays and probably a middle to upper delta plain deposit. The Beaumont Formation is composed of fine sands and silts in abundant silty clays and represents the lower or distal delta plain. Each of the younger formations onlaps the next older formation. Modern wind-blown layers of fine

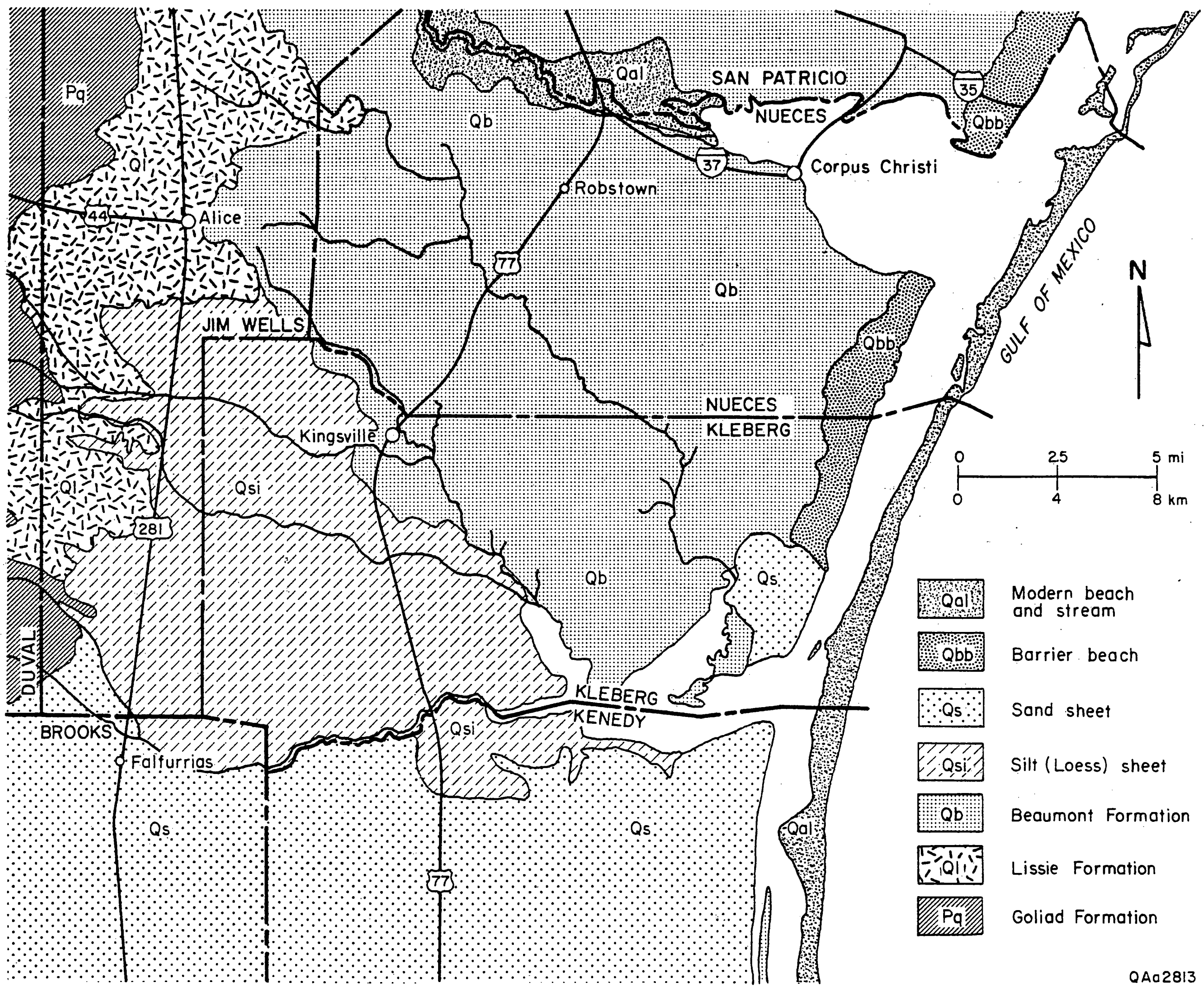

Figure 7. Areal geologic map of the vicinity of the King Ranch training site of the Texas National Guard (after Brewton and others, 1976).

sand and silt (loess) mask these formations. All three units are important aquifers in the subsurface.

Based on reinterpretation of both 1:24,000-scale black-and-white aerial photomosaics and 1:65,000-scale color infrared transparencies, as well as field examination of surficial materials, 11 mappable units were identified in the vicinity of the King Ranch training site (fig. 8). Previous mapping by Brown and others (1980) was the basis for reinterpretation. Most of the units occur on or adjacent to the training site but are not equally extensive. The units have a very young age; all are youngest Pleistocene or Holocene and even Modern, less than 20,000 years old. A description of each surficial unit follows.

Distributary and fluvial sands and silts, including levee and crevasse splay deposits.—This unit has a Pleistocene and Holocene age, generally younger than 15,000 years, and occurs on the plains north of the Cayo del Grullo. Several channels transect the training site; they have been minor local aquifers capable of providing stock tanks except during droughts. The sands in these deposits are fine to very fine grained, because they were deposited near the mouth of a large delta system composing the Beaumont Formation. The channel courses commonly follow slightly higher ground, in part because the better draining soils attract more brush and grass, which catch wind-blown sediments.

The distributary and fluvial sands are composed of quartz sand with minor clay strata. They have a high infiltration capacity at the surface and may form localized aquifers useful for cattle. They frequently form slight rises of stable slopes on the coastal plain. The sands have moderate foundation and bearing strength, are stronger when wet, and are relatively incompressible, having no plasticity. The fluvial sands are readily excavated, especially when dry. They form thick fine loamy sand soils that are good croplands and grasslands. As long as the plant cover is not broken, they are stable. Where the plant cover is removed, frequently by heavy vehicular traffic, they become readily erodable, especially by wind.

Interdistributary mud, including flood basin and bay deposits.—This unit lies between the above channel units and has the same age. In composition, it is very different, being

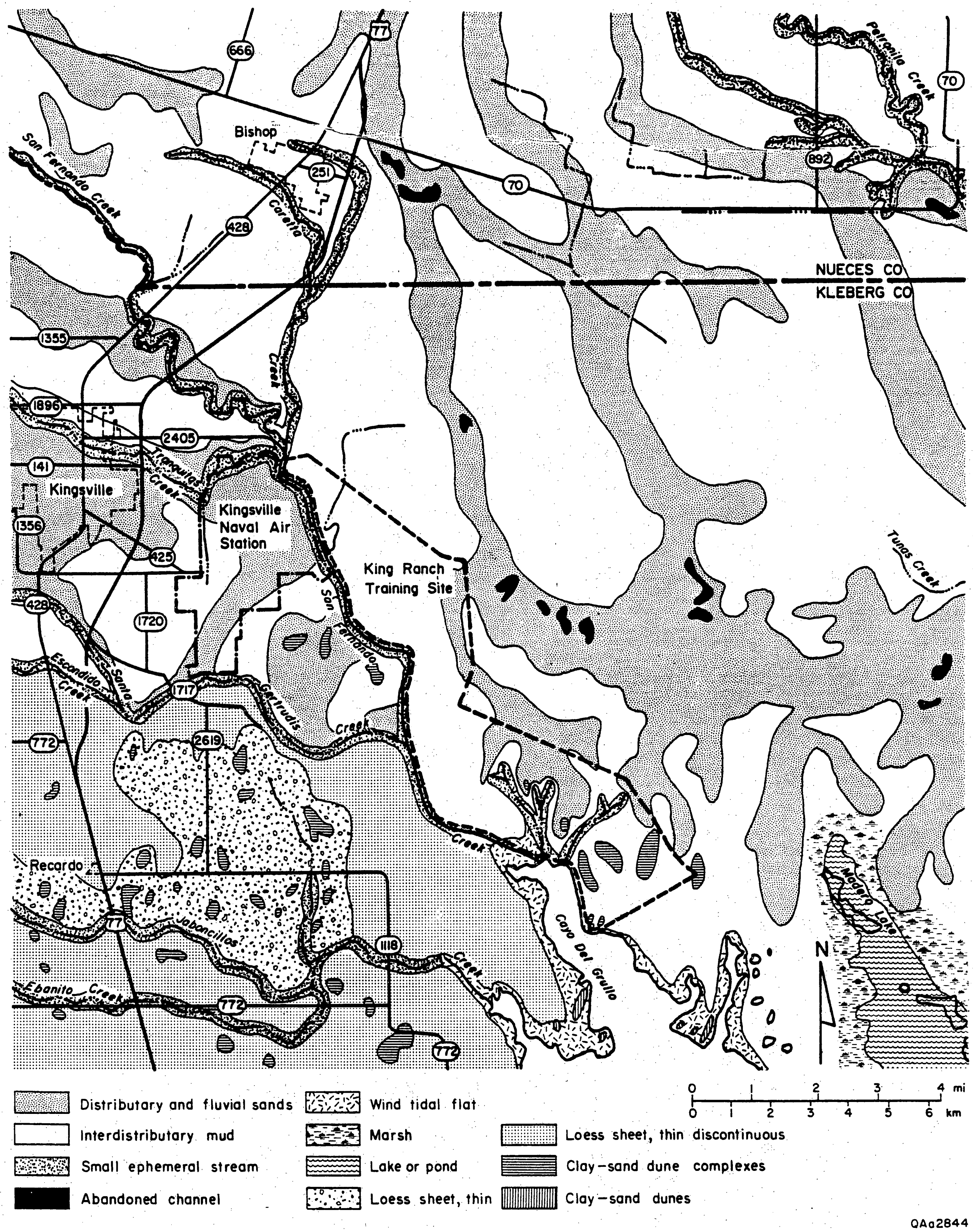

Figure 8. Surficial geologic units of the vicinity of the King Ranch training site of the Texas National Guard, modified after Brown and others (1980).

constituted of the finest particles in the area, more clay than silt. It forms poorly drained soils and therefore does not support the brushy plants; grass dominates. The unit occurs in low areas and holds standing water after rains. The unit can be transitionally mapped into the mud-filled lakes or ponds described below.

The interdistributary basins are composed of predominantly expansive clay muds, more stable where calcareous. The unit is relatively impervious and can hold standing water for long periods in wet seasons. The muds commonly have high shrink-swell potential and may be very plastic. They have weak foundation and bearing strength, which is aggravated as they increase saturation. They form dark-clay soils generally occupied by grasses. A thick vegetative cover may provide a stable surface to vehicles if the cover remains unbroken.

In this unit, a small uncovered landfill occurs near the northern boundary of the site. On investigation, we found that the dump had been excavated by the King Ranch personnel and contains numerous old empty containers of insecticides. No National Guard materials are found in the dump. There is no potential for leakage into a sensitive environment, but it would be worthwhile to cover this dump. A similar site should be possible for National Guard wastes in this same unit. In the absence of large waste accumulations, it may be environmentally efficient and cost effective to move training wastes offsite.

Abandoned channel and course, mud filled.—This unit is more common up on the delta plain north of the King Ranch training area. Most abandoned channels are probably Holocene or Modern; many are ox-bow-shaped abandoned stream meanders. They are composed of a dense clayey mud that may be quite sticky. The impervious sediment does not adequately support vegetation.

The abandoned channels resemble the interdistributary muds in physical properties except that they contain a larger proportion of clay. This results in an even weaker and more plastic material in which vehicles more readily bog down. However, the area in which these deposits occur is small.

Small ephemeral stream deposits, alluvium and erosional, sand, silt, and mud, commonly barren sparse vegetation inland, headward eroding.—This unit, the Modern stream courses, is composed of reworked older materials that now forms thin Modern deposits. The alluvial deposits have variable grain size dominated by fine sand, which is sorted by stream flow during wet times and winnowed by wind to form a lag during dry periods. This alluvium is thin because headward erosion dominates depositional processes in the poorly integrated streams. The streams support sparse tree vegetation because bank storage is impoverished by ground-water declines.

The deposits are mostly quartz sands and silts deposited in steep banks and onto a valley floor. The valley sediments are generally stable with moderately strong bearing strength where sand is the dominant grain size. Vehicles may have difficulty traversing the steep valley walls.

Wind-tidal flat, sand and mud, occurring locally in lower stream valley near bay heads, transitional between bay and stream.—This unit is also a Modern unit, occurring where the ephemeral streams are controlled by bay levels. The sediments are very fine grained and dominated by silt and fine sand. Locally the sediments may be organic rich as a result of the accumulation of algae, and they also contain concentrations of evaporated salts. Dessication cracks form polygonal patterns with peels of upper crusty thin layers. The wind tidal flat borders most of the southwestern limits of the King Ranch training site.

The mixed mud, sand, and shell of the wind tidal flat provides a weak bearing surface for vehicular traffic, especially when wet. Local areas of well-sorted silt and fine sand may be quick. The high corrosion potential requires avoiding the emplacement of metal structures. The flats are subject to inundation, which may be very rapid toward the mouths of ephemeral streams.

Marsh, freshwater, and poorly drained depressions, with distribution varying with climatic cycles.—These Modern units are composed of only muds, silts, and clay; sands are absent. The muds are dark colored and rich in organic residues. They commonly occur in the lowest topography within the interdistributary muds between channel sands. The unit is characterized by fresh-water marsh vegetation and is not important on the King Ranch training site except in a minor area at the headwaters of Palo Pinto Creek.

The physical properties of the depressions holding long stands of fresh water and marsh are similar to those of the interflood basin muds, except that clay and comminuted organic debris are more abundant in the interflood basin muds. The clays may be plastic, depending upon their source. The low terrain and weak materials may be traps for heavy vehicles or even pickups without 4-wheel drive.

Coastal lake or pond.—This modern unit has the same properties as the previous unit except that the standing water is not fresh. Light-colored muds are the dominant sediment type, mostly silt with some clay. Because these are frequently wetted/dried areas where evaporation is high, salts are locally concentrated, and vegetation, even grasses, may be sparse.

Like the previous lake unit, sediments filling the low areas include a high percentage of clay, frequently plastic. Also, in these lakes the sediments are more corrosive; metal structures emplaced permanently below ground surface degrade rapidly.

Loess sheet, thin, silty, and overlying calichified Pleistocene fluvial sand.—This unit occurs only west of the King Ranch training site, across the Cayo del Grullo wind-tidal flats. Silt is the dominant grain size, followed by very fine sand. These unconsolidated deposits continue to be readily destabilized by wind erosion wherever the vegetative cover is broken, especially where the underlying Pleistocene channel complexes are indurated by caliche. They form low mounds (dunes) of fine sand and silt that become readily airborne enough to cause mechanical problems in unmaintained equipment.

Loess sheet, thin, discontinuous, silty, and overlying Pleistocene deltaic mud and calichified sand.—The loess sheet is better stabilized in contact with the interdistributary deposits, and vegetation is denser over this unit. The unit provides a stable surface as long as wide spaces do not become denuded of vegetation.

Clay-sand dune complexes, inactive, grass or brush-covered.—These dunes are dominantly Holocene and are commonly located at distal channel systems on the lowest deltaic plain. They are dominated by fine sand and commonly exceed 40 ft thick. Several large dune complexes occur in the southernmost part of the King Ranch training site.

Quartz silt and fine-grained sand provide a stable base for construction and transportation as long as the vegetative cover remains in place. There is high infiltration complementing runoff down dune flanks.

Clay-sand dune complexes, accretionary, active, locally sparse grass, commonly originating from wind-tidal flat or playa sources.—The active clay-sand dune complexes are Modern and best evident on or near the wind-tidal flats. They are slow to produce vegetation. Several such complexes are found near the western boundary of the King Ranch training site along the Cayo del Grullo. Where the dunes are actively accreting, they should be avoided for construction and transportation. Only vegetation will stabilize these features after lengthy periods of relatively wet weather.

KING RANCH GROUND-WATER HYDROLOGY

The ground-water hydrology reported here is based on a literature search and the use of records of the Texas Water Development Board (TWDB). Their measurements of water levels were used to examine potentiometric surfaces and decline curves. Their measurements were also used to evaluate water chemistry and water quality. TWDB records are quite good; they have a useful longevity and have been recorded from 1933 through 1992 in many representative wells.

No new measurements of drawdown in pumping wells were made to determine new values of transmissivity, and no new water samples were collected for chemical analyses. Future collections of new ground-water data may be recommended at selected wells in relation to current and projected training on King Ranch as part of future environmental monitoring plans.

Hydrologic Units (Cross Sections)

In Kleberg County and at the King Ranch training site, there is only one hydrologic unit identified by the TWDB well-monitoring program, an unconfined aquifer known as the Evangeline aquifer (TWDB, 1992c). As used here, it includes the Goliad, Lissie, and Beaumont Formations; the Beaumont Formation crops out on the surface in most of the county. Shafer and Baker (1973) and Baker (1979) identified two hydrologic units (fig. 9): the Chicot and Evangeline aquifers. The shallower Chicot aquifer overlies the Evangeline aquifer, and no clear confining bed exists between the two units. Each hydrologic unit is composed of intercalated sandstones and shales in which the sands are thicker and more continuous near the surface and decrease downdip. The Evangeline aquifer contains thicker and more permeable sands consistently in the middle of this hydrologic unit. Environmental planners for the training site should be aware of the connection between the ground surface and an unconfined aquifer that is as much as 1600 ft thick.

In the first Kleberg County wells to utilize ground water, water was found nearly at the surface. Ground water flowed generally southeast toward the Laguna Madre, reflecting drainage and topography. Base level for ground water inland from Baffin Bay (Cayo del Grullo) has been the San Fernando, Carreta, and Escondido-Santa Gertrudis Creeks. As late as 1933, a well 10 mi northeast of the training site intercepted water at 2 ft below the ground surface. In the same year, an early well on the King Ranch adjacent to the training site found water at 12 ft below the surface. By 1955 and 1967, new King Ranch wells near the training site found water at depths of 143 ft and 155 ft. Also in 1967, a new well on the northeast city limits of Kingsville found water at a depth of 235 ft.

These differences are reflected by potentiometic maps of the ground-water surface in 1933 (fig. 10) and 1992 (fig. 11). Prior to 1933, the well field supplying municipal water to Kingsville had already developed a cone of depression approaching 10 ft deep over an area larger than the city. Outlying areas were unaffected by pumpage at that time. By 1992, the

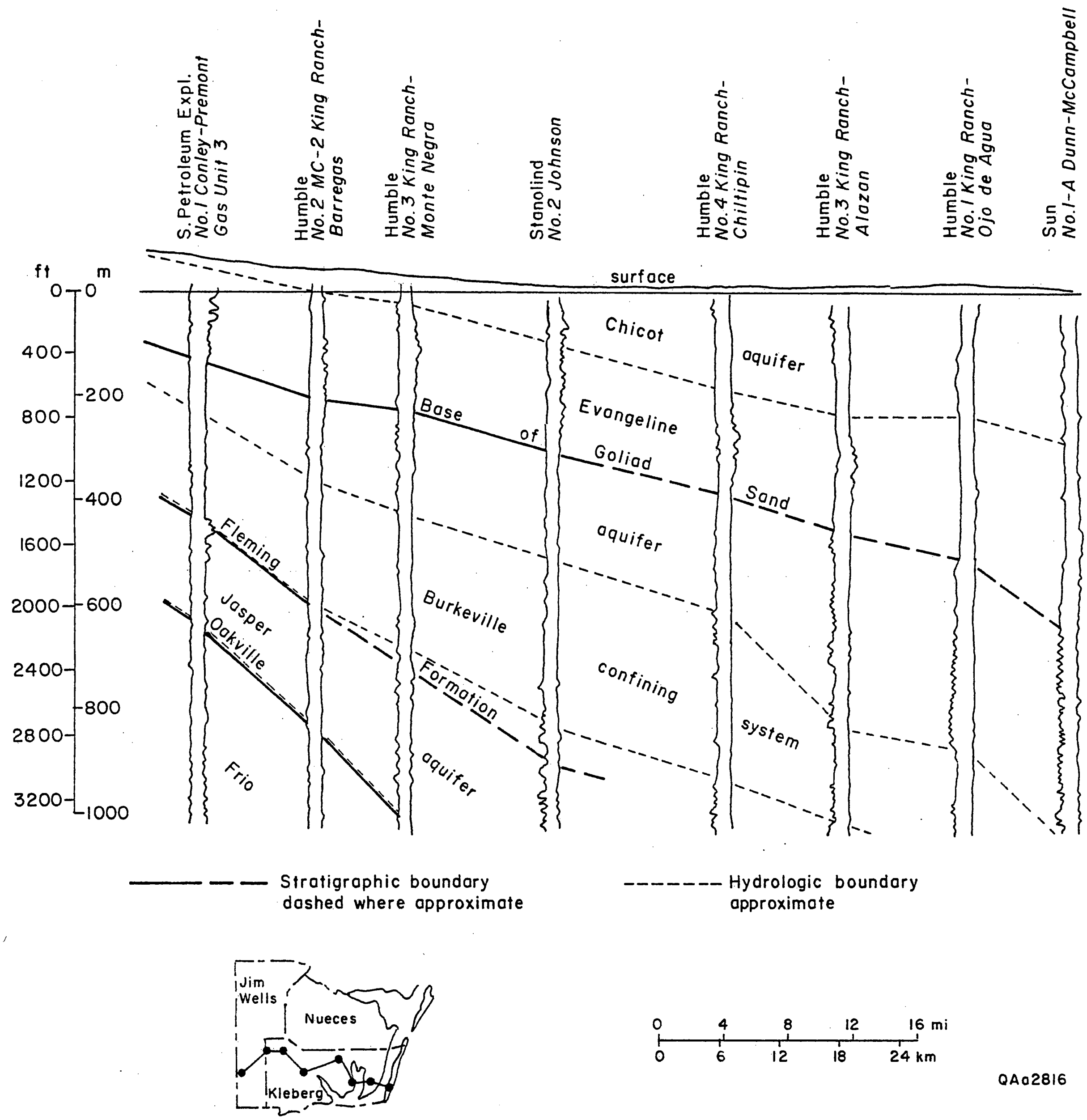

Figure 9. Hydrologic units in the Kingsville area (from Baker, 1979).

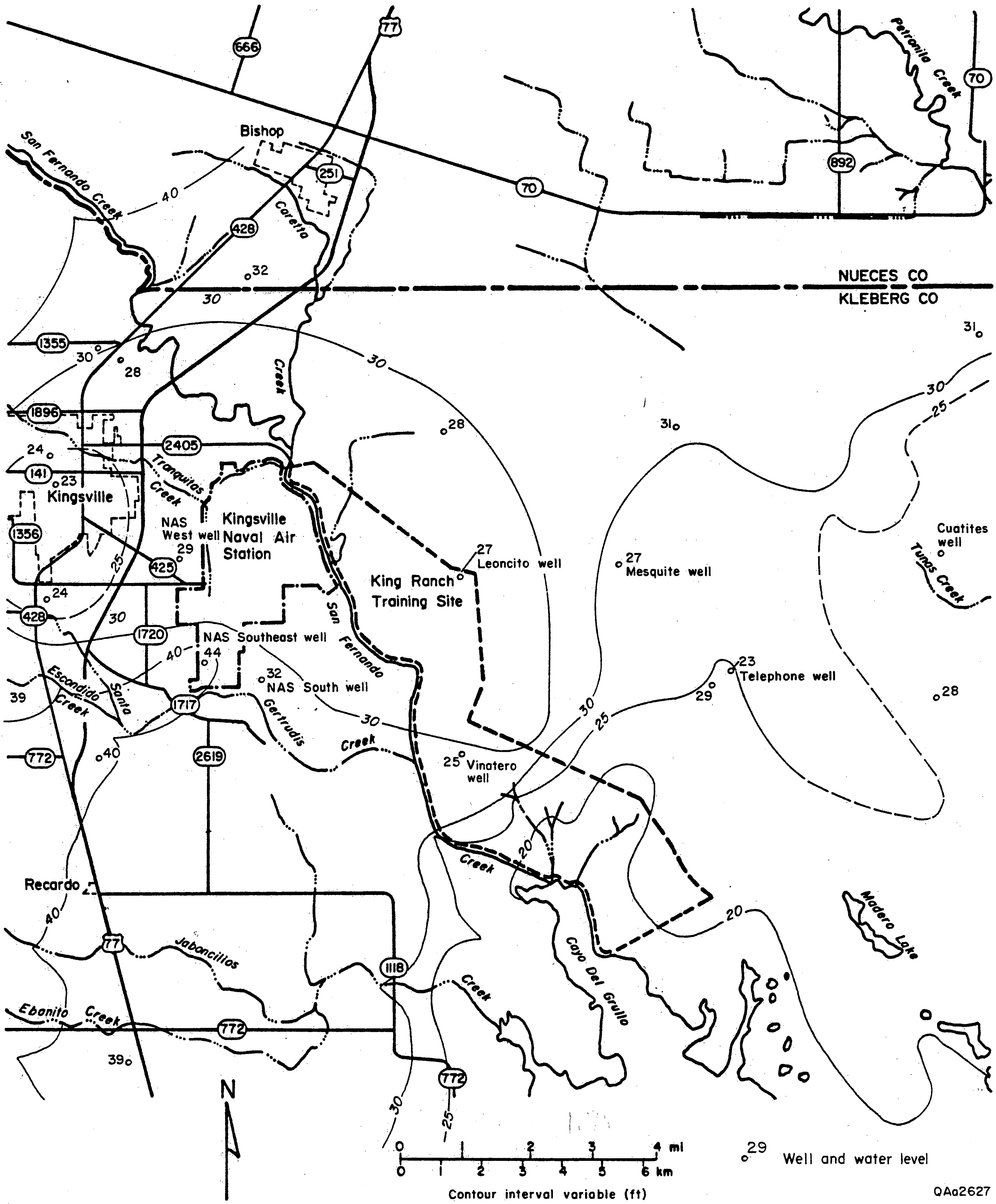

Figure 10. Potentiometric map of the Evangeline unconfined aquifer, 1933, in the vicinity of the King Ranch training site of the Texas National Guard. Data from the Texas Water Development Board.

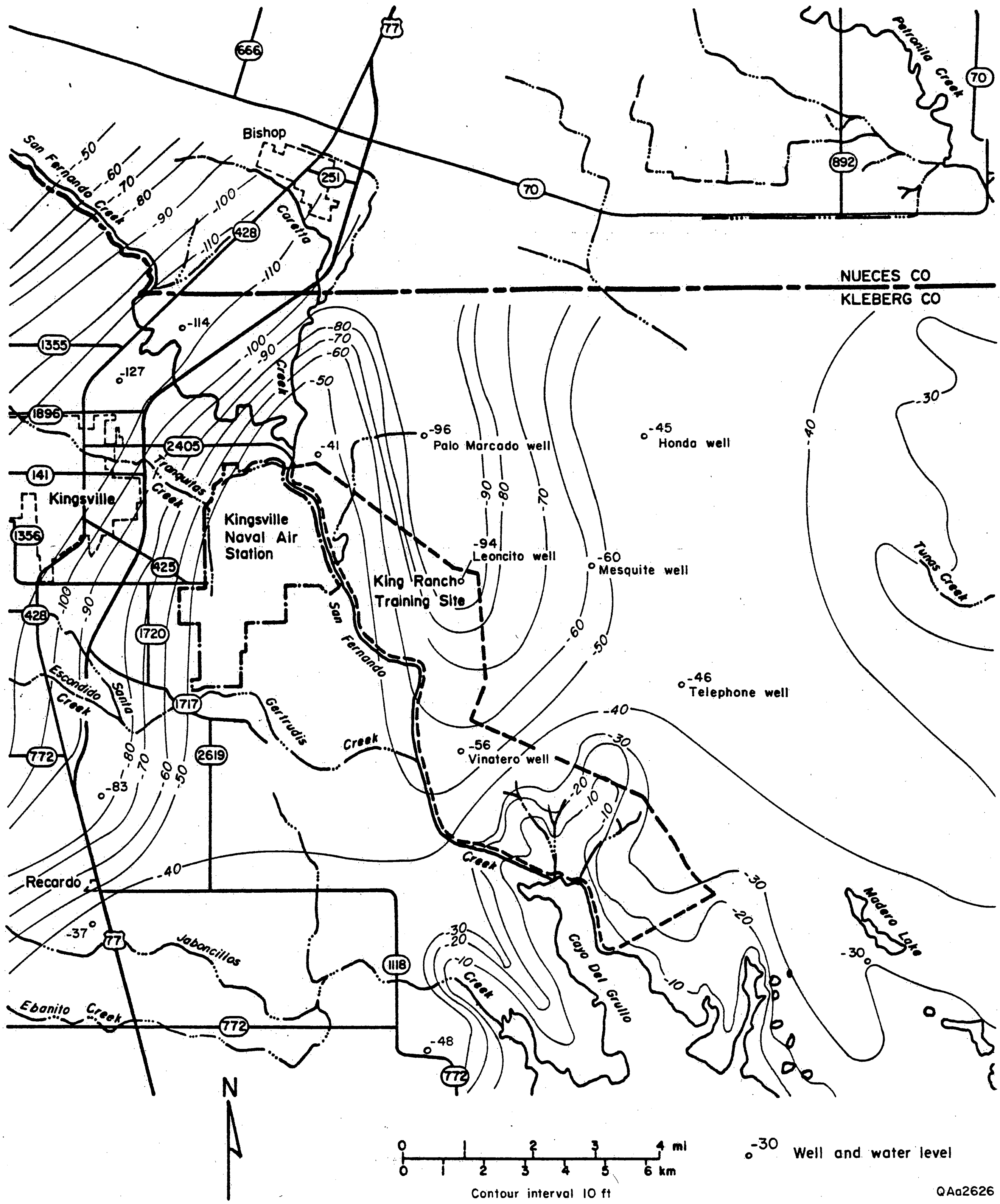

Figure 11. Potentiometric map of the unconfined Evangeline aquifer, 1992, in the vicinity of the King Ranch training site of the Texas National Guard. Data from the Texas Water Development Board.

cone of depression had deepened, increased gradient, enlarged, and changed shape and orientation. Larger and deeper areas of significant drawdown reflect both municipal use and agricultural exploitation of ground water for irrigation. Remnants of the 1933 potentiometric surface remain only south of Kingsville in the sand sheet west of Cayo del Grullo and east of Bishop between Carreta and Petrollina Creeks. The area of drawdown does not affect the King Ranch training site, which continues to have Cayo del Grullo as a primary base level for ground water.

The historical decline of water levels in the Evangeline aquifer in the vicinity of the King Ranch training site is shown in figure 12. Water levels in the graphs and maps are elevation referenced to sea level. Differences in the drawdown curves for the Leoncitas, Vinatero, and Telephone water wells reflect their distance from the area of deepest ground-water withdrawal. All the agricultural wells (fig. 12) display similar shapes: a moderate decline until 1945, a steeper decline until 1984, and modest recovery since. This pattern reflects human use of the ground water; the pattern does not reflect the rainfall hydrograph (fig. 2). No doubt there is local recharge, but it cannot keep pace with pumpage.

The water supply well for the Kingsville Naval Air Station reflects the buildup of naval aviator training during World War II (fig. 13). Wells on the outskirts of the air station do not show increased use for that time, but the record is limited to 1941, prior to the major expansion of the air base.

Cation-Anion Chemistry

In Kleberg County, the TWDB has analyzed 112 wells for water quality (TWDB, 1992a). Although the oldest record dates from 1961, when the total dissolved solids (TDS) was 988 mg/L, it was 1968 before most chemical analyses began. There is little continuity or length of annual records for any one well. Sixty wells have only 1 record, and 22 wells have more than 3 years of records. The largest TDS recorded is 6313 mg/L, in 1970; the smallest TDS was 628 mg/L, in

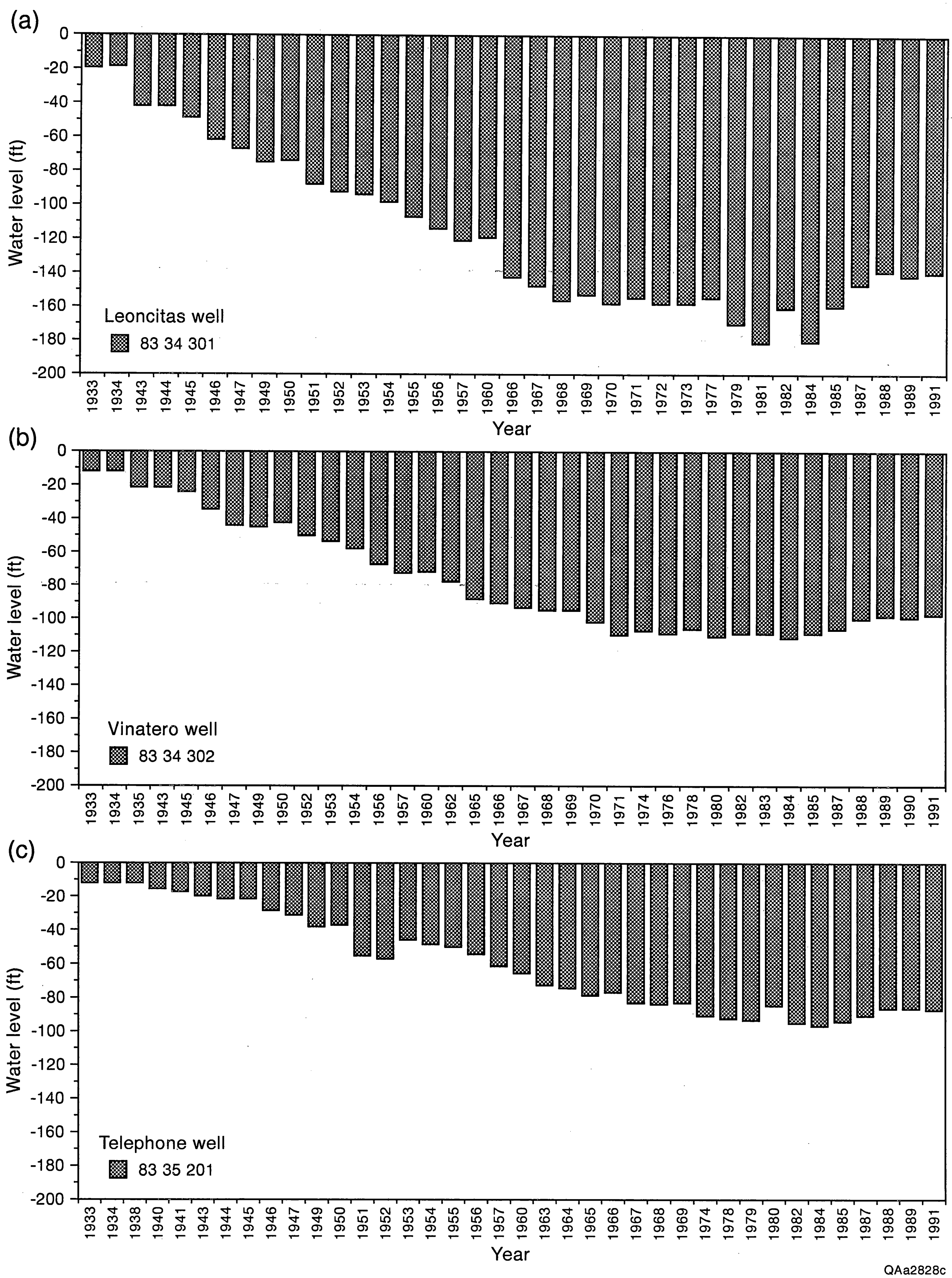

Figure 12. Drawdowns in agriculture water wells nearest the King Ranch training site of the Texas National Guard. Location of wells is shown in figure 10. Numbers in the lower left corner of the drawdown graphs are Texas Water Development Board identifications.

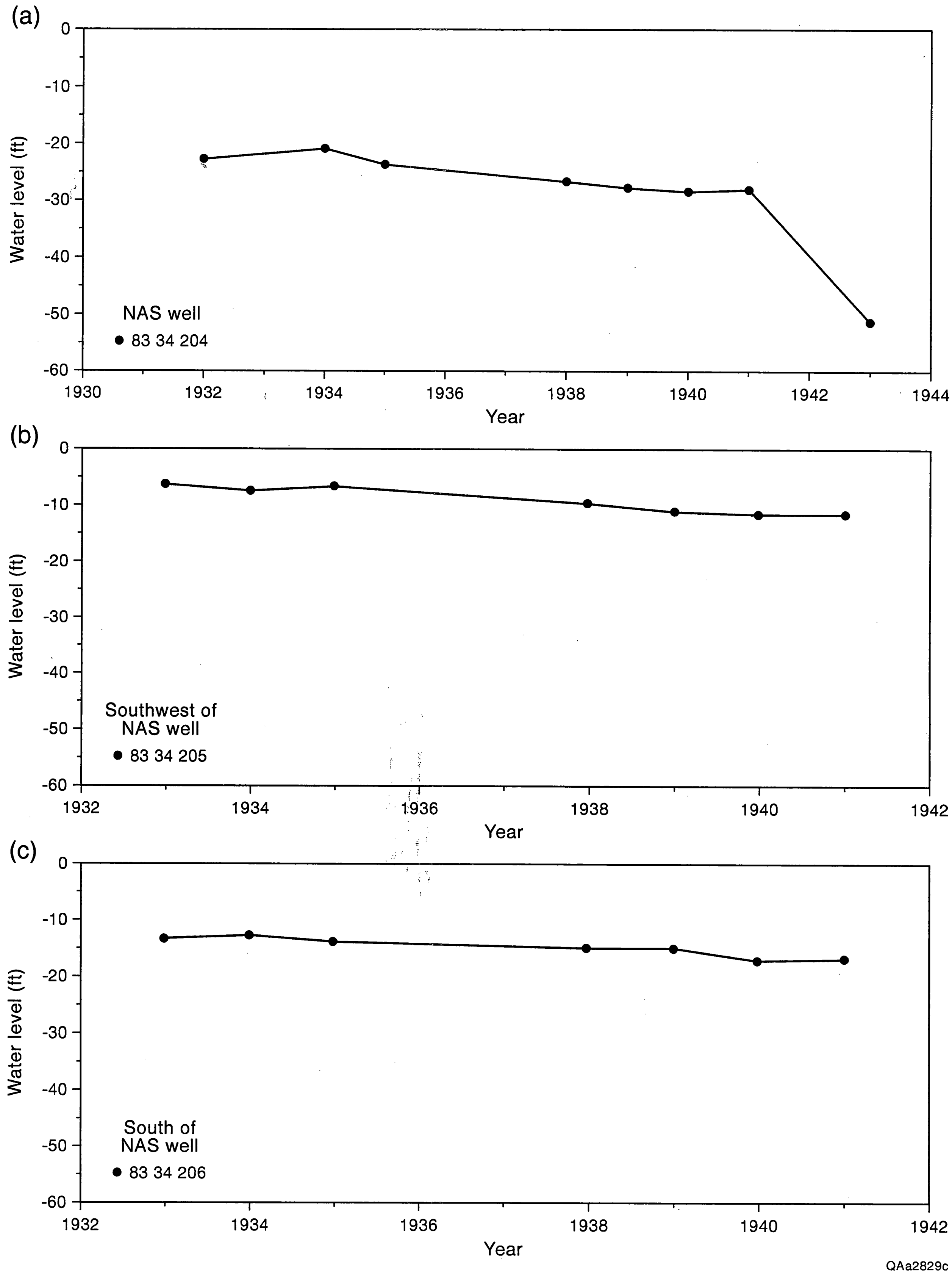

Figure 13. Drawdowns in water wells about the Kingsville Naval Air Station. Data from the Texas Water Development Board.

1968. In any single well with multiple records, the largest difference is 5455 mg/L. In four wells having more than 2 years of records, the largest TDS is more than twice the lowest value. The TDS values in part reflect the proximity of the coastline to marine water.

A comparison of the cation-anion balance in 12 wells having standard chemical analyses for 1968 and 1992 shows only minor variations in concentrations. No evidence of major alterations in ground-water chemistry from irrigated agriculture is apparent. The largest differences in potassium and nitrate are 20 and 15.3 mg/L, but these were not in the same wells. Modest evidence of salt water intrusion is suggested by three analyses. In three wells the chlorine differences are larger than 100 mg/L; the largest difference in chlorine is 287 mg/L. One of these wells is located on the Kingsville Naval Air Station (NAS), and two wells are on the coast near Laguna Madre in eastern Kleberg County. The NAS well is on the perimeter of a large drawdown area (fig. 11) not far from the King Ranch training site. The Leoncitas well on the north boundary of the training site has a long-term record of analyses, and the analyses show no significant variation for any ions analyzed.

No analyses are available for toxic metals or organic compounds, pesticides, and defoliants that are known to have been used at the NAS or on local crops. It may be advisable to acquire analyses of toxic metals and organic fuels from the NAS and of pesticides/defoliants from nearby cropped areas if a long-term monitoring plan is needed for the training site. The Texas National Guard lease at King Ranch is too new for any weathering and dissolution of spent ammunition or spills of fuels or solvents to have impacted ground water at the training site.

FUTURE PLANNING OF ENVIRONMENTAL IMPACTS

Various environmental factors will impact future planning of National Guard programs on the King Ranch training site. Such activities include scheduling exercises, travel, construction, vehicle maintenance, munitions use, and water supplies.

Contingency planning will be needed for times in the hurricane season (June–October) when extreme flooding, such as immediately after the landward passage of a hurricane, will eliminate access to the site. There is a one-in-eight chance of a hurricane each year, and a major hurricane could produce as much as 30 inches of rain in 3 days. Other than wet periods produced by hurricanes, the major wet periods each year are in June and between August and October. At these times, it may be necessary to allow the land to dry out. The driest months are March–May and November–December.

Travel on the property could be limited on saturated clays of the interdistributary deltaic plain, particularly in low spots, where vehicles could bog down. Travel may be limited in or near steep bay-bluffs that are entrenched by gullies and in narrow stream valleys with steep walls. In broad stream valleys and on tidal flats, quicksand may pose a threat to vehicles. During droughts, vehicles may devegetate old dunes and old channel surfaces and remobilize the sand.

If metal structures are placed in the ground, builders should be made aware of the corrosion potential of soils and sediments of the tidal flats and interdistribuary channels. Special designs may be required over high shrink-swell clays. Refueling and washdowns of vehicles are best over tight muds and not on sandier soils where recharge is active. Any new landfills or dumps are best placed on the tight clays, where no recharge to ground water can occur. If firing ranges will be constructed, they are also best placed on clay soils.

REQUIREMENTS FOR FUTURE ENVIRONMENTAL MONITORING

Baseline data as well as periodic collections of future data are necessary for preparing a King Ranch training site environmental monitoring plan. These data include both areal data, where data needs exist (fig. 1), and site data, the King Ranch lease. The areal data include TWDB records on weather, water levels, and water quality. In addition, a regular periodic collection of aerial photographs could be interpreted to track local changes that may affect site decisions.

Priority baseline data not collected in this study but required in future monitoring include chemical analysis from upgradient and downgradient sampling of surface water in streams that transect the site and ground water in adjacent water wells. The Texas National Guard should ascertain what kinds of toxic materials and fuels have been used at the NAS and whether there is any history of spills. They may also wish to learn which chemicals are employed in upgradient agriculture. Depending on the strictness of Guard requirements, the Guard may require that its own monitoring wells be drilled.

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