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THE DISTRIBUTION AND ABUNDANCE OF DESERT TORTOISES ON THE NEVADA TEST SITE

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Santa Barbara Operations
130 Robin Hill Road, Goleta, California 93117

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ABSTRACT

This report presents the results of transect studies conducted from 1981-1986 to determine the distribution and abundance of desert tortoises (*Gopherus agassizii*) on the Nevada Test Site (NTS) and summarizes the current understanding of the distribution of this species on NTS. Seven hundred fifty-nine transects having a total length of 1,190.7 km were walked and 380 sign of tortoises were counted. The abundance of tortoises on NTS is low to very low relative to the other areas within this species' range. Tortoises appear to be more abundant on NTS on the bajadas and foothills of limestone and dolomite mountains than on mountains of volcanic origin. Sign of tortoises were found from 880 to 1,600 m and sign was more abundant at higher elevations (>1,200 m) than has been reported previously for Nevada. The scale of classification of vegetation associations available for NTS is too large to be useful for predicting tortoise abundance. Tortoises were found only in approximately the southern third of NTS. They probably do not occur in in Yucca Flat or anywhere else north of the Control Point. A map of the northern boundary of the range of desert tortoises on NTS is presented and additional studies of the distribution and abundance of tortoises on NTS are recommended.

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K. R. Rautenstrauch organized and analyzed the data and wrote this report. M. K. Cox, T. B. Doerr, R. A. Green, J. M. Mueller, T. P. O'Farrell, and D. L. Rakestraw provided editorial comments. V. R. Kelly organized and printed the final draft.

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1. INTRODUCTION

The desert tortoise (*Gopherus agassizii*) is the only animal species commonly found on the Nevada Test Site (NTS) that is listed under the Endangered Species Act of 1973 as threatened or endangered. The federal agency managing this site, the U.S. Department of Energy (DOE), is prohibited by the Endangered Species Act from conducting activities that may jeopardize this species or its critical habitat. To comply with this law and complete its mission on NTS, DOE must have an understanding of the distribution and abundance of desert tortoises on NTS. This information is needed during land-use planning to identify areas important to tortoises that should be preserved and areas where DOE facilities can be developed without jeopardizing the species. This information also is needed to assess the impacts of ongoing activities on tortoises.

Little information has been published on the distribution and abundance of desert tortoises on NTS or surrounding areas. While surveying reptile populations on NTS during 1959-1962, Tanner and Jorgensen (1963) found three tortoises in Frenchman Flat, three in Rock Valley, two in Jackass Flats, and one in Mercury Valley. They "found it more commonly in the *Larrea-Franseria* [*Ambrosia*] community and surrounding foothills ..." (Tanner and Jorgensen, 1963:6). Twenty-two desert tortoises have been found in three 9-ha enclosures built on the east bajada of Rock Valley in 1963. The growth (Medica et al., 1975; Turner et al., 1987; Germano, 1988), drinking behavior (Medica et al., 1980), and physiological ecology (Nagy and Medica, 1986) of these tortoises have been studied extensively.

The abundance of desert tortoises was estimated at three locations within 50 km of NTS: Crater Flats, Amargosa Valley (Karl, 1981), and the Desert National Wildlife Refuge (Schneider et al., 1982). Tortoises were uncommon in these areas. It is unknown, however, whether the abundance of tortoises on NTS is similar to these areas.

Transect studies were started at NTS in 1981 to assess impacts of DOE activities and determine the distribution and relative abundance of desert tortoises. During 1981-1984 transects were walked on and around Yucca Mountain, the possible location for a radioactive waste disposal site. Preliminary analysis of that work was reported in Medica et al. (1981), Collins et al. (1983), O'Farrell and Collins (1983, 1984), and Collins and O'Farrell (1985). In 1984 transects also were walked in Frenchman Flat and the surrounding mountains to determine the potential effects of the Liquified Gaseous Fuels Spill Test Facility on tortoises. In 1985 northern Frenchman and Jackass Flats were examined to delineate the northern boundary of the tortoise distribution on NTS. Areas within the known range of the tortoise in Jackass Flats, Rock Valley, Mercury Valley, and Frenchman Flat, were examined in 1986.

This report presents the results of these tortoise transect studies and summarizes the current understanding of the distribution and abundance of the desert tortoise on NTS.

2. STUDY AREA

The 3,500-km^2 NTS is located in Nye County, southwestern Nevada (Figure 1). NTS has been controlled by DOE and its predecessor agencies since 1951 primarily for the testing of nuclear technology and weapons. The following description of the environment of NTS comes primarily from the detailed descriptions by Beatley (1976) and O'Farrell and Emery (1976).

2.1 PHYSIOGRAPHY

The southern two-thirds of NTS is dominated by three large valleys or basins: Yucca, Frenchman, and Jackass flats (Figure 2). Mountain ridges and hills rise above gradually sloping alluvial fans (bajadas) and enclose these basins. During years of high precipitation, surface waters collect and form shallow lakes in the closed basins of Yucca (1,240 m elevation) and Frenchman Flat (970 m). Jackass Flats (990 m) is an open basin and drains to the southwest via Fortymile Wash. The smaller basins, Mercury, Rock, Topopah, and Mid valleys, also have drainage outlets.

The northern and northwestern sections of NTS are dominated by Pahute Mesa and Timber and Shoshone mountains (Figure 2). Rainier Mesa, elevation 2,341 m, is the highest point on NTS (Figure 2).

Elevations at the base of mountains on NTS are an average of 975 m in the south, 1,370 m in the central region, and 1,600 m in the northern part of NTS. Mountain peaks range from 1,400 to 1,800 m in the south and 2,100 to 2,300 m in the north (Figure 2). Associated with these elevational increases is the northern boundary of the Mojave Desert and the southern boundary of the Great Basin Desert within a broad east-west corridor of transition (Beatley, 1976).

2.2 GEOLOGY

NTS has two principal geologic areas based on the origins of mountain ranges. Most mountains in the southeast part of NTS are primarily limestones, dolomites, and shales from the late Precambrian and Paleozoic eras. These mountains (e.g., Buried Hills, CP Hills, Ranger Mountains, Specter Range, and Spotted Range) have rugged, steep slopes and jagged peaks. The weathering products from these sedimentary rocks usually are fine sands, silts, and clays. The mountains and mesas in the northern and western part of NTS are formed primarily from Tertiary volcanos (e.g., Pahute Mesa and Massachusetts, Skull, Timber, and Yucca mountains). These volcanics are mostly ash-flow tuffs of rhyolitic and quartz-latitic composition. Volcanic masses, in general, weather to sand.

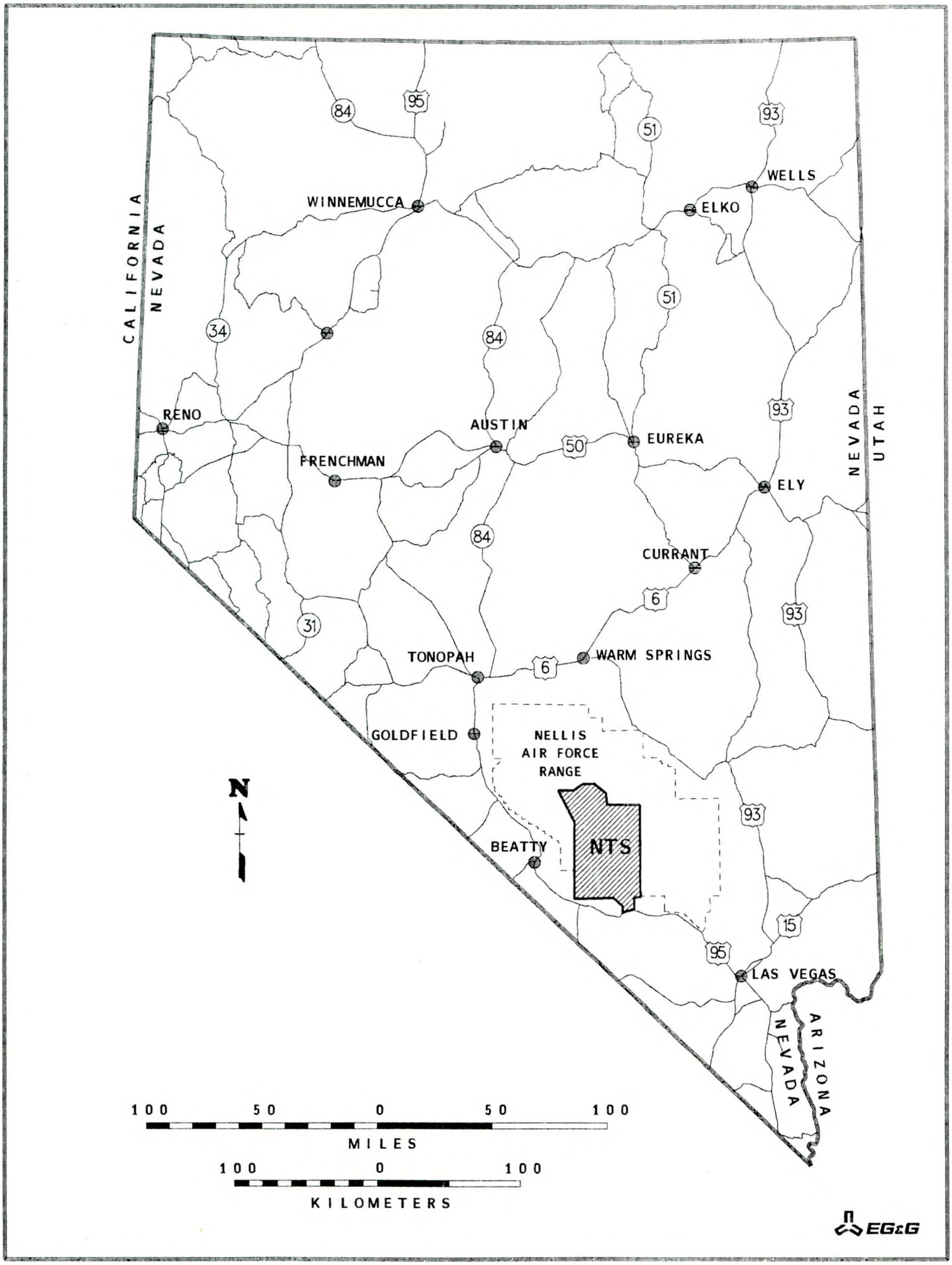


Figure 1 Location of the Nevada Test Site, southern Nevada.

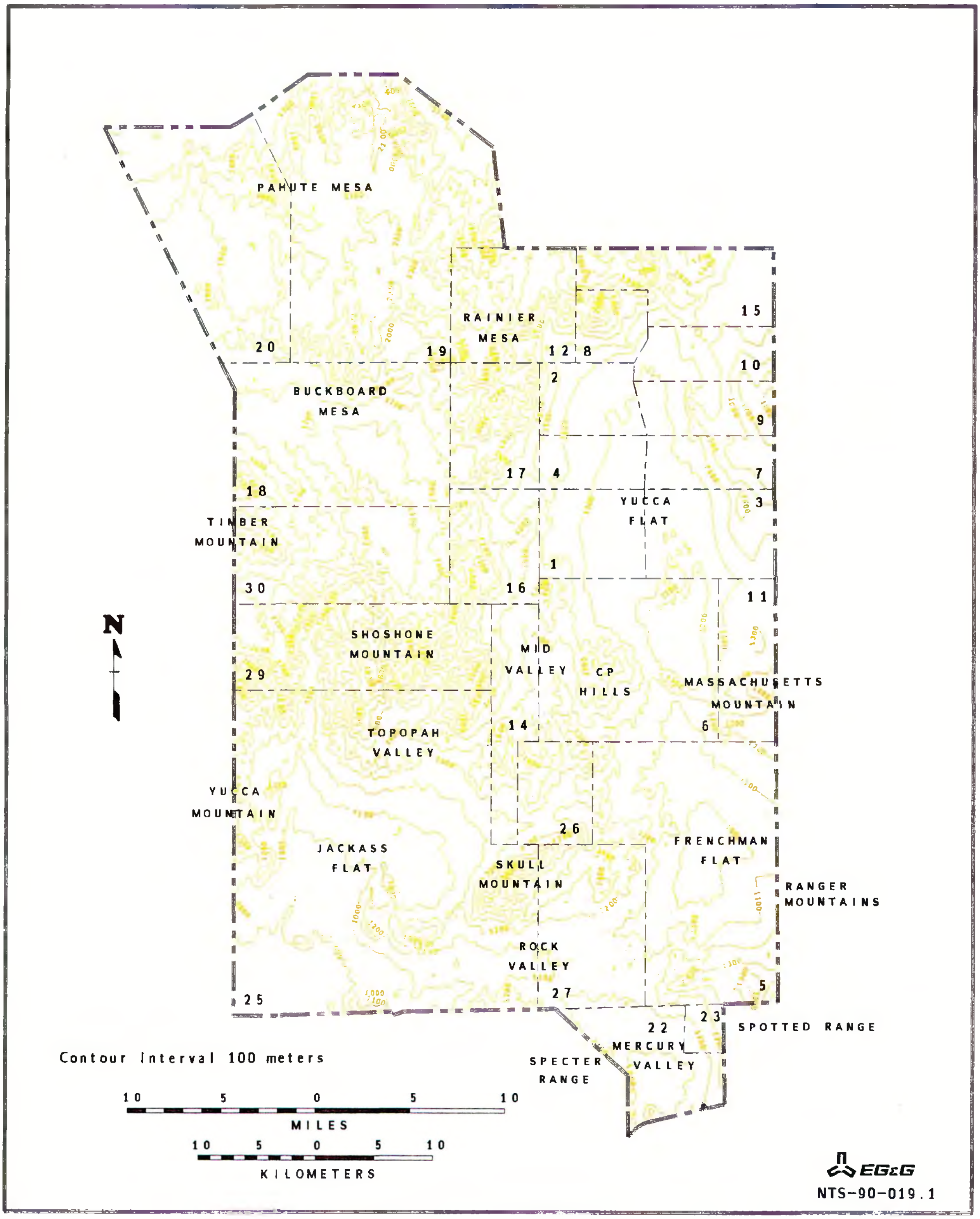


Figure 2 Major topographic features of the Nevada Test Site.

2.3 SOILS

Soils on NTS have developed under xeric conditions and have coarsetexture, low organic matter content, a low carbon/nitrogen ratio, and little leaching or formation of horizons. Alluvial soils on bajadas are a mix of unconsolidated volcanic and sedimentary parent material. These soils are sorted along a particle-size gradient with boulders, cobbles, and gravels most abundant on upper bajadas and fine-textured sands and silts on the lower slopes and closed basins. Clay content normally is quite low at lower elevations except in closed basins. Wind-blown sand deposits cover some areas, such as some bajadas of the Specter Range and Jackass Flats. A caliche layer is found near the surface of most alluvial soils, especially those formed from limestone mountains. A surface pavement has formed where smaller particles on the soil surface have been removed by wind and rain. This pavement is best developed below the limestone mountain ranges.

Residual soils on gentle slopes of ridges and mesas are shallow. Soil and vegetation are restricted to depressions and cracks among outcrops of bare rock on steeper slopes.

2.4 CLIMATE

NTS has a climate characteristic of high deserts, with little precipitation, very hot summers, and moderately cold winters. The mean minimum annual temperature at 14 sites in Jackass Flats during 1962-1972 was 2.5° C and the mean maximum was 28° C (Beatley, 1974:248). The mean minimum and maximum temperatures at 16 sites in Yucca Flat was 0° and 29° C, respectively. Near-freezing temperatures have been recorded at the higher elevations of NTS in all months except July and August.

Annual precipitation in Jackass Flats during 1962-1972 averaged 14 cm. Annual precipitation at Yucca Flat averaged 18 cm (Beatley, 1974:248-249). About 60 percent of this precipitation occurred from September through March. Winter precipitation frequently occurs as snow which persists in northern Yucca Flat and to the north. Higher mountains commonly are snow-covered much of the winter. Snow seldom persists for more than a few hours in the southern valleys.

2.5 VEGETATION COMMUNITIES

The transition zone between the Mojave and Great Basin deserts crosses NTS. As a result, NTS has a diverse and complex mosaic of plant communities (Figure 3) comprised of species typical of both deserts and some common only in the transition zone between the deserts.

2.5.1 Mojave Desert

Plant communities typical of the Mojave Desert are found in the southern part of NTS in Jackass Flats, Rock Valley, Mercury Valley, and parts of Frenchman Flat (Figure 3). These communities are best developed below 1,200 m but are found as high as 1,400 m in favorable locations. The visually dominant plant in these communities is *Larrea tridentata*. *Ambrosia dumosa*

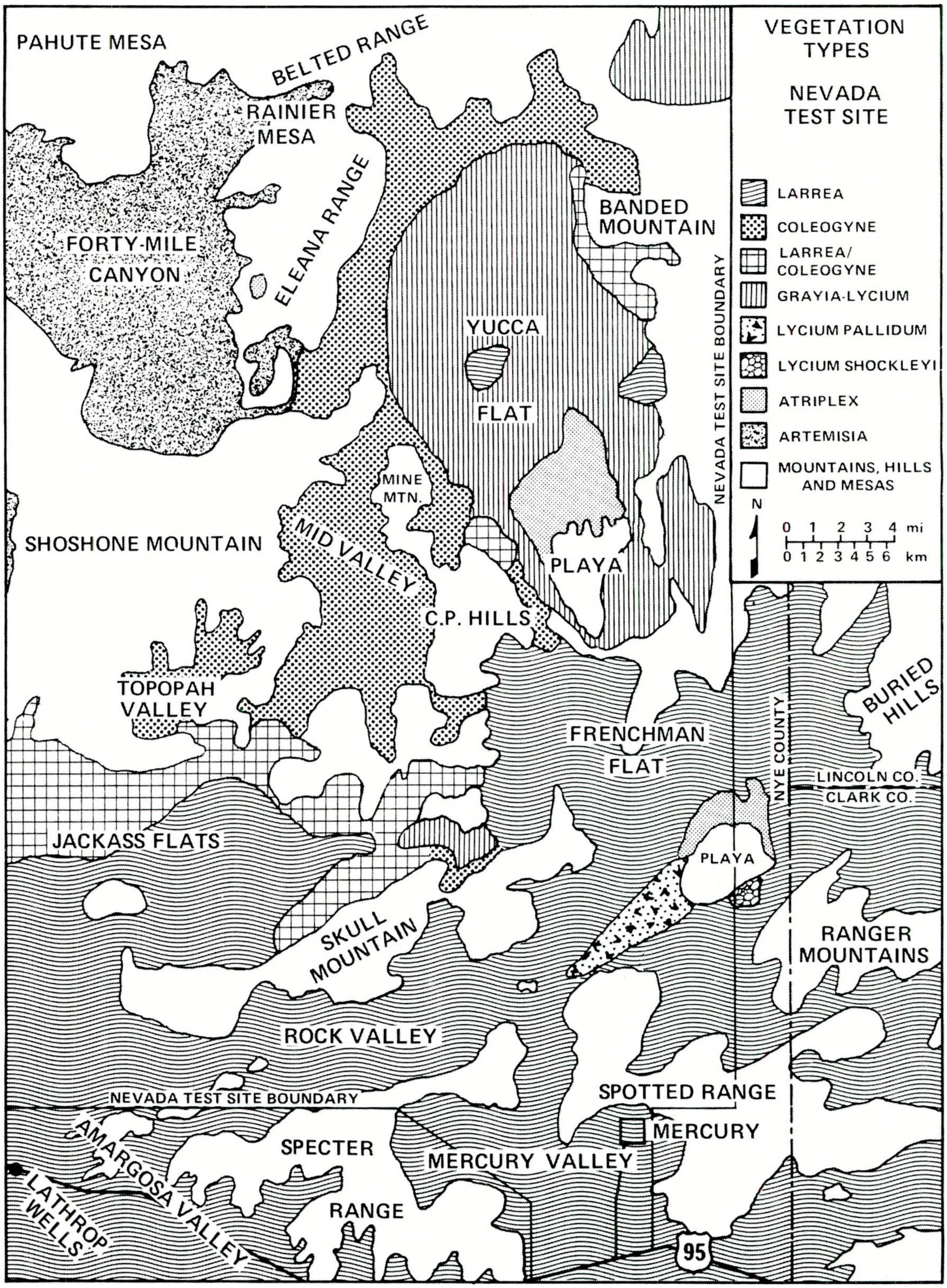


Figure 3 Distribution of vegetation associations on the Nevada Test Site (from O'Farrell and Emery, 1976).

is the common co-dominant on sites with deep, loose sand and a poorly developed desert pavement. *Lycium andersonii* and *Grayia spinosa* are most abundant at higher elevations on soils with less sand and more rock. *Atriplex confertifolia* is common in areas with a well developed surface pavement and caliche layer, and a fine-textured sandy or silty loam soil. *A. confertifolia* is the most abundant perennial on the rugged slopes of the limestone and dolomite mountains in this region. Shrub cover in Mojave Desert communities varies from 7.2 to 23.1%. Grasses and herbaceous perennials are common and annual herbs are abundant after periods of high rainfall.

2.5.2 Transition Desert

Beatley (1976) identified two categories of plant communities that typify the transition between the Mojave and Great Basin deserts: those on upper bajadas above the Mojave communities and those on lower elevations and floors of closed basins. *Coleogyne ramosissima* is the dominant species on the upper bajadas. It occurs in mixed stands with *L. tridentata* and other species of the Mojave Desert at elevations between 1,200 and 1,370 m and often in nearly pure stands between 1,370 and 1,500 m. Shrub coverage is high (45-51%) in stands of *C. ramosissima*. Diversity of plant species is low and herbaceous species are uncommon. *C. ramosissima*-dominated communities are well developed on the northern and eastern bajadas of Jackass Flats, western and northern Yucca Flat, and the floors and slopes of Topopah and Mid Valley (Figure 3).

Cold-air drainage at night into the enclosed Yucca and Frenchman flats creates a climate too cold for the Mojave Desert plant associations typically found at similar elevations in open basins. The floors of these closed basins usually are covered by stands of *G. spinosa* and *Lycium* spp. (Figure 3). Shrub cover varies from 32 to 37%. Herbaceous species are not as common as in the *L. tridentata* communities, but they are found consistently throughout the areas.

2.5.3 Great Basin Desert

The mountains and drainages above 1,525 m in most of the northern two-thirds of NTS are vegetated by communities typical of the Great Basin Desert. *Artemisia tridentata* is the most abundant species on deep soils and is replaced by *A. nova* in areas with shallow soils. *Pinus monophylla* and *Juniperus osteosperma* are common above 1,830 m. Valley floors in this region are dominated by *Atriplex confertifolia* or *A. canescens*.

3. METHODS

3.1 TRANSECT SURVEYS

3.1.1 Field Methods

Similar methods were used for all transect surveys conducted on NTS from 1981 to 1986. Biologists trained to identify tortoise sign walked transects of predetermined length and direction and searched for sign within 5 m of the transect. Sign was classified as living tortoise, tortoise carcass, burrow, scat, or egg. Only burrows with the shape typically constructed by tortoises (i.e., flat floor and round roof) were recorded. More than one sign found in a 1-m^2 area was recorded as one observation. Transects were walked from March through October.

Transect paths and tortoise sign were recorded on U.S. Geological Survey (USGS) topographic maps of 1:24,000 scale for all transects except those walked in Frenchman Flat in 1984. The exact locations of those transects were not recorded.

Most transects were 1-3 km long and spaced 200 m apart. Some transects at Yucca Mountain were 10 to 100 m apart. About 90% of the transects were straight. Others followed contours or topographic features.

3.1.2 Analyses

Locations of transects and tortoise sign were digitized and entered into a computerized Geographic Information System (GIS). The GIS was used to calculate transect length, tortoise sign per transect, sign per km walked on each transect, and total distance searched in the following nine geographic regions on NTS and surrounding area (Figure 4).

<u>Cane Spring Wash</u>--North of the Cane Spring Road from 2 to 6 km west of Mercury Highway (NTS Area 5) (Appendix 1a).

<u>CP Hills</u>--Bajadas and foothills south and east of CP Hills (NTS Areas 6 and 26) (Appendix 1b).

<u>Frenchman Flat</u>--Frenchman Flat from 0.1 to 13 km north and east of the playa (NTS Area 5). Most of this area is east of NTS on Nellis Air Force Range (Appendix 1c).

<u>Jackass Flats</u>--Jackass Flats from Fortymile Wash east to Wahmonie Flat (NTS Areas 14, 25, and 26) (Appendix 1d).

<u>Massachusetts Mountain</u>--Bajadas and foothills south and west of Massachusetts Mountain (NTS Areas 5, 6, and 11) (Appendix 1e).

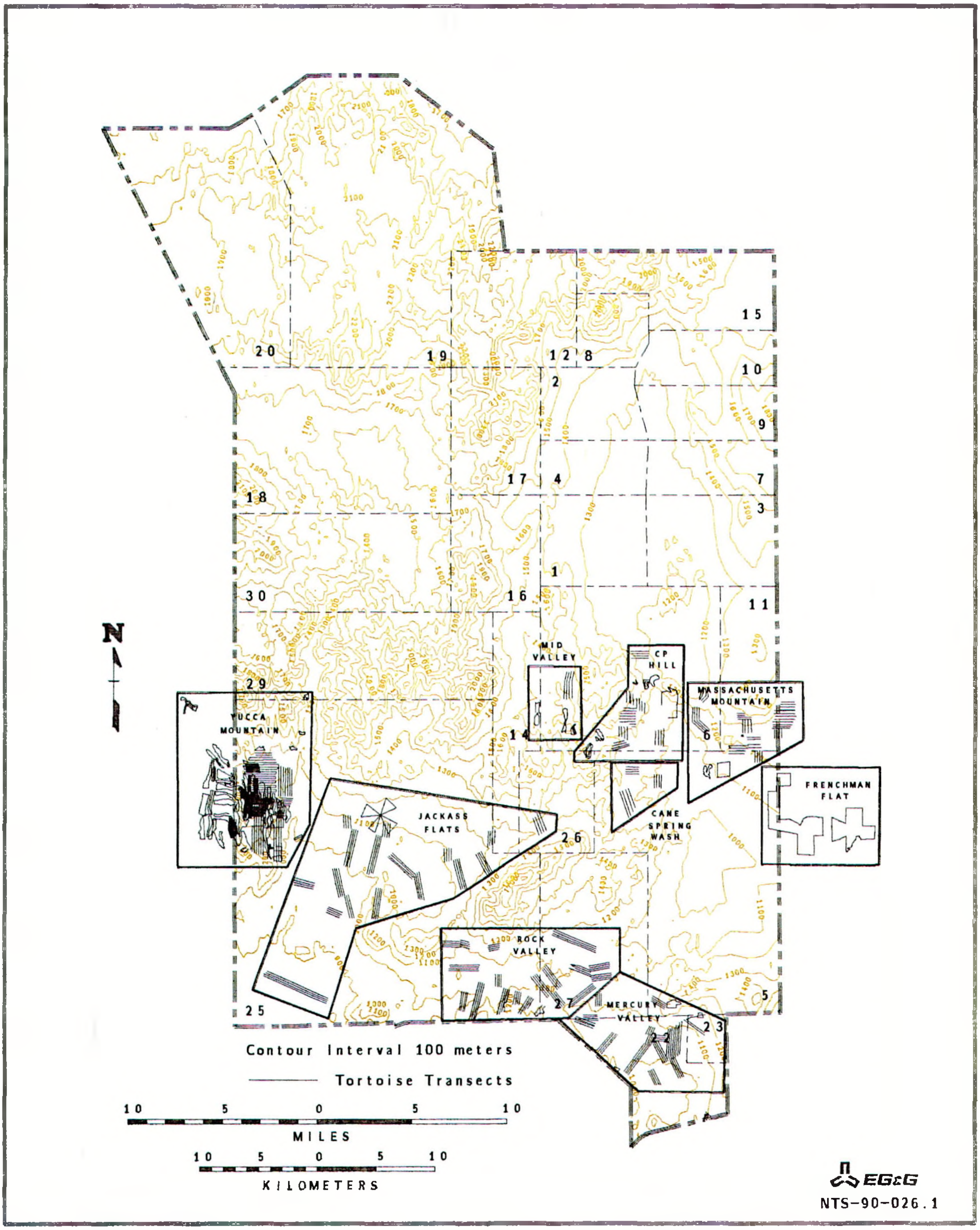


Figure 4 Location of transects walked from 1981 to 1986 to determine the abundance of desert tortoises within nine regions of the Nevada Test Site.

Mercury Valley--From zero to 11 km west of Mercury in Mercury Valley (NTS Areas 5, 22, 23, and 27) (Appendix 1f).

Mid Valley--The southern and eastern bajadas and foothills of Mid Valley and along Barren Wash southeast of Mid Valley (NTS Areas 6 and 14) (Appendix 1g).

Rock Valley-- Bajadas south and east of Skull Mountain and bajadas and foothills north of the Specter Range (NTS Areas 22, 25, and 27) (Appendix 1h).

Yucca Mountain--From Fortymile Wash west to Crater Flat (NTS Area 25). Much of the area surveyed is west of NTS. (Appendix 1i).

The Kruskal-Wallis test (Conover, 1980:229-237) was used to determine if there were differences in sign counted/km for each transect among six of the nine regions listed above having >40 km of transects and known location and length of transects.

To determine if there were differences in abundance of tortoise sign among vegetation associations, the GIS was programmed to count the number of tortoise sign found in the vegetation associations in Figure 3. The GIS also measured the total length of transects walked in each association. Associations with less than 10 km of transects were combined. The percent of all sign found and percent of all transects walked in each association were compared to determine if sign was found in a greater or lesser proportion than search effort in each class. Information on vegetation was available only for NTS; therefore, many of the transects on Yucca Mountain were omitted from this comparison. Transects walked in Frenchman Flats in 1984 also were omitted because the exact locations of transects were not recorded. Statistical analysis of differences among associations was not possible because the sample units (segments of transects within each association) were of very different lengths and many were quite short, because most transect segments had no sign, and because sample size varied greatly among associations.

A similar evaluation was done to determine if tortoise sign was equally abundant at all elevations surveyed. The GIS calculated the number of tortoise sign found and distance walked in 100-m elevation classes. Information on elevation was available for all of NTS and Yucca Mountain.

3.2 POPULATION AND IMPACT MONITORING PROGRAMS

Areas where tortoises were known to occur in Rock Valley, Jackass Flats, the southern bajadas of CP Hills, and Frenchman Flat were searched in 1987 through 1990 as part of a tortoise population monitoring program. Areas at Yucca Mountain were searched in 1989 and 1990 to monitor the impacts of the Yucca Mountain Project on tortoises. Preactivity surveys were conducted in 1988 through 1990 in areas where construction activities were to occur.

During these searches, one to ten persons walked straight or meandering paths covering predetermined areas and searched for tortoises and burrows. Burrows were examined by shining lights inside or exploring with sticks. Tortoises were coaxed from burrows by tapping on the tortoise or burrow apron as described by Medica et al. (1986). Tortoises captured were measured and individually marked. Location of tortoises were recorded on 1:24,000-scale USGS maps or a 1:63,360-scale map of NTS. These locations were digitized and entered into the GIS to generate maps of tortoise locations.

4. RESULTS

4.1 TRANSECT STUDIES

Seven hundred fifty-nine transects having a total length of 1,190.7 km were walked on NTS from 1981 through 1986 (Table 1, Appendix 1a-i). Forty-five percent of these transects were walked at Yucca Mountain. Seventeen live tortoises and 363 other sign of tortoises were counted.

Sign counted per km walked differed among the six regions compared (Table 2; $T = 21.755$, df = 5, $P < 0.001$). CP Hills and Rock Valley had more sign counted/km ($P < 0.05$) than Yucca Mountain, Jackass Flats, and Massachusetts Mountain. Mercury Valley had more sign counted/km than Massachusetts Mountain ($P < 0.05$). Three regions were not included in this analysis because of small sample size or unknown transect length. Two of the three regions, Cane Springs and Frenchman Flat, had a mean sign/km similar to Jackass Flats and Massachusetts Mountain. No sign was found in Mid Valley (Table 1).

Percent of tortoise sign found was 4.8 and 3.5% greater than search effort in mountainous areas and areas dominated by *L. tridentata*, respectively (Table 3). Percent of sign found was 0.9 and 5.6% less than search effort in the *L. tridentata-C. ramosissima* and *C. ramosissima* associations, respectively. Only one sign of tortoises was found in the *C. ramosissima* association, a scat in the southwestern corner of the CP Hills area.

Sign of tortoises was found from 880 m elevation in the southwest part of Jackass Flats (Appendix 1d) to 1,600 m at the north end of Yucca Mountain (Appendix 1i). Tortoise sign was found in approximately the same proportion as distance walked in each 100-m elevation class (Table 4). Sign/km was highest in the 1,201-1300-m elevation class.

The northernmost sign of tortoises was found on the east slope of the CP Hills about 1 km south of the Control Point (Figure 5, 6, 7). This is one of the northernmost transects walked. No sign was found on 12.5 km of transects further north than this transect on the western edge of Yucca Lake (Appendix 1b).

4.2 POPULATION AND IMPACT MONITORING STUDIES

One hundred five tortoises were found during population and impact monitoring studies during 1987-1990 (Figure 8). Fifty-four of these tortoises were found at Yucca Mountain during 1989-1990. A relatively large number of tortoises also were found on the southeast bajadas of CP Hills, the southwestern part of Frenchman Flat, and along the Saddle Mountain Road in northeastern Jackass Flats. Areas searched where little or no sign of tortoises was found included 28 ha at the Radioactive Waste Disposal Facility in Frenchman Flat (NTS Area 5), 61 ha at the Scylla facility in Wahmonie Flat (NTS Area 26), and 102 ha around the Ballistic Research Laboratory in the southwestern part of Jackass Flats (NTS Area 25).

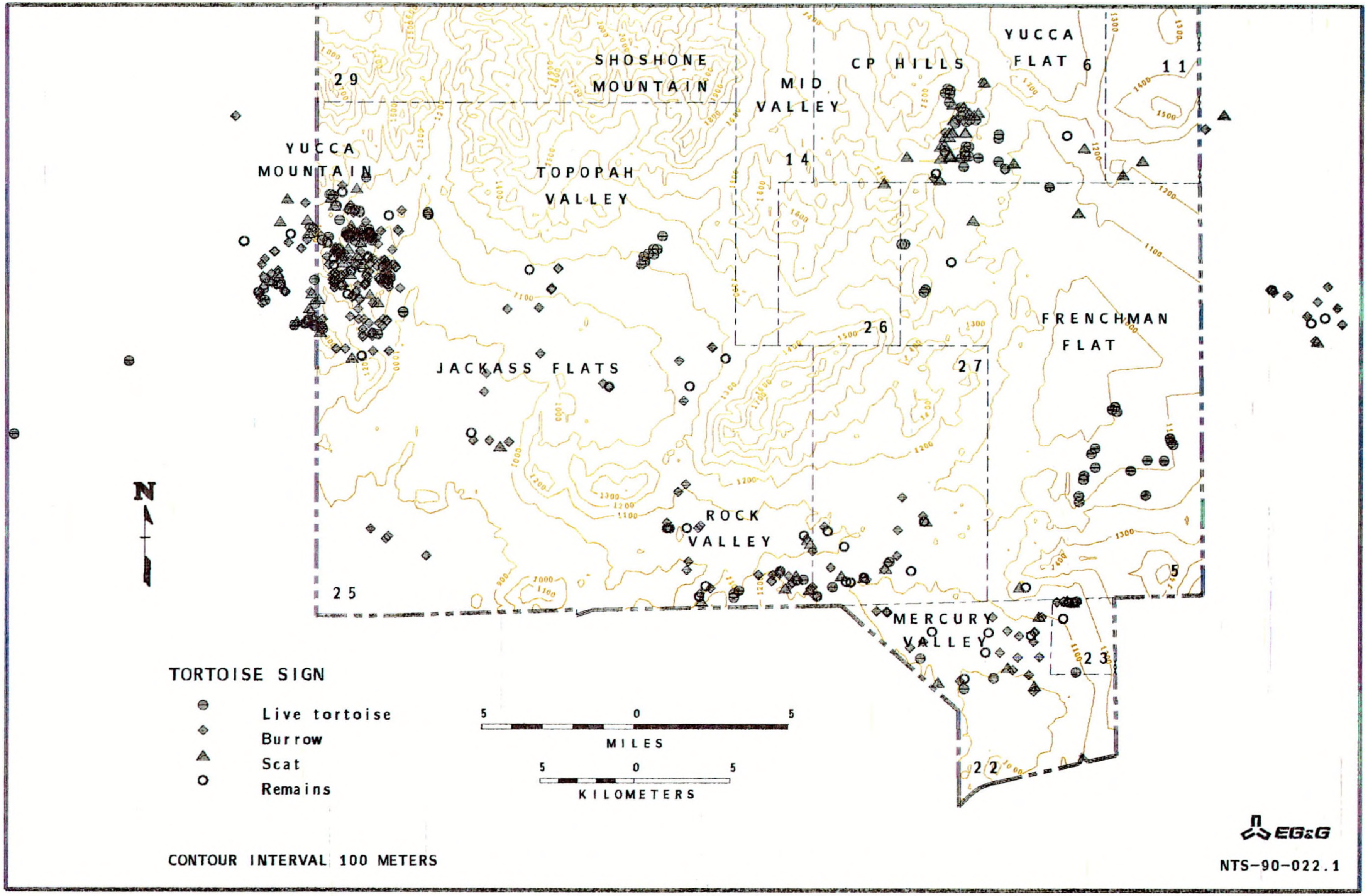


Figure 5 All sign of tortoises found on the Nevada Test Site during 1981-1986 transect studies and 1987-1990 population and impact monitoring studies.

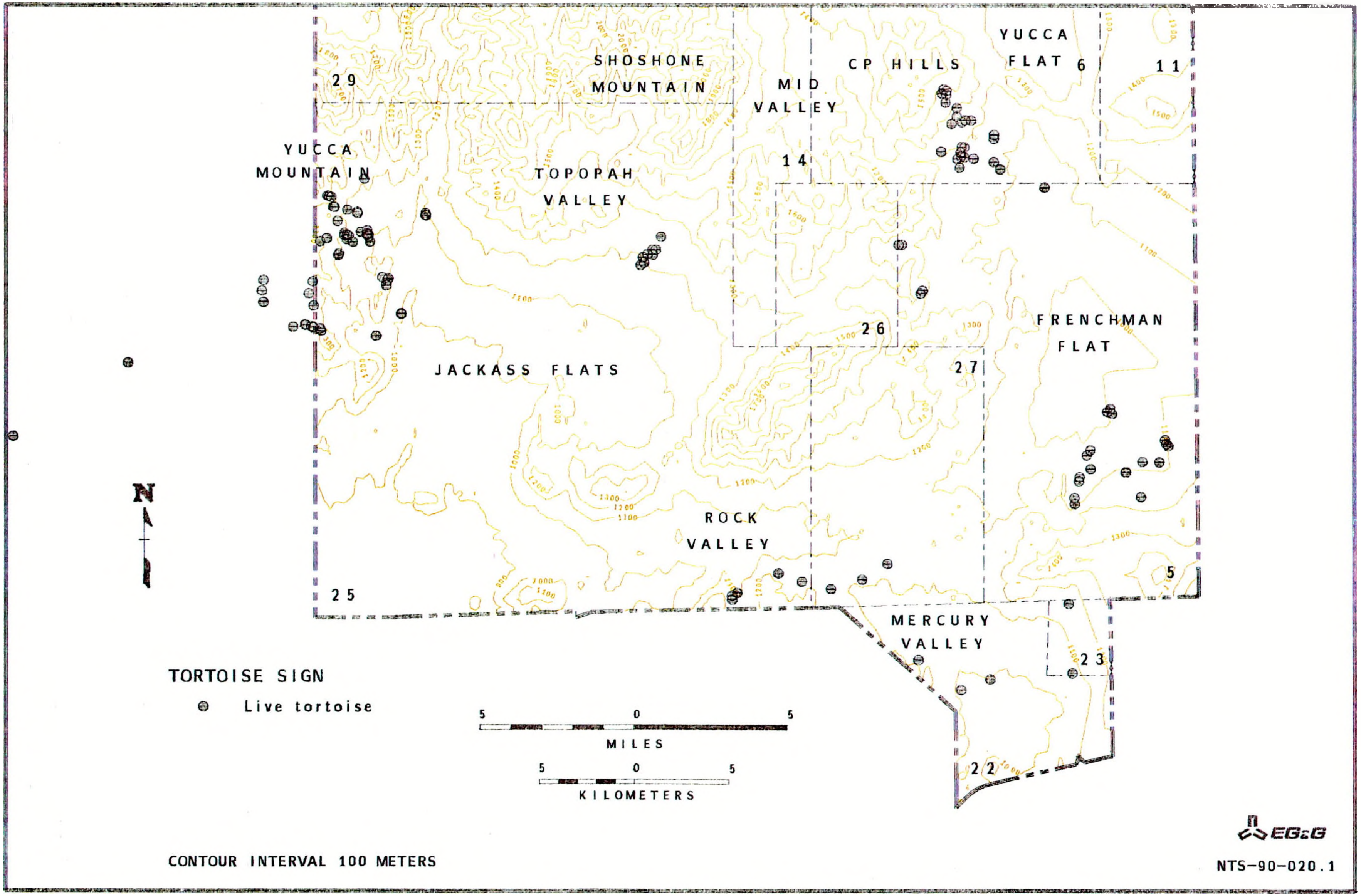


Figure 6 All tortoises found on the Nevada Test Site during 1981-1986 transect studies and 1987-1990 population and impact monitoring studies.

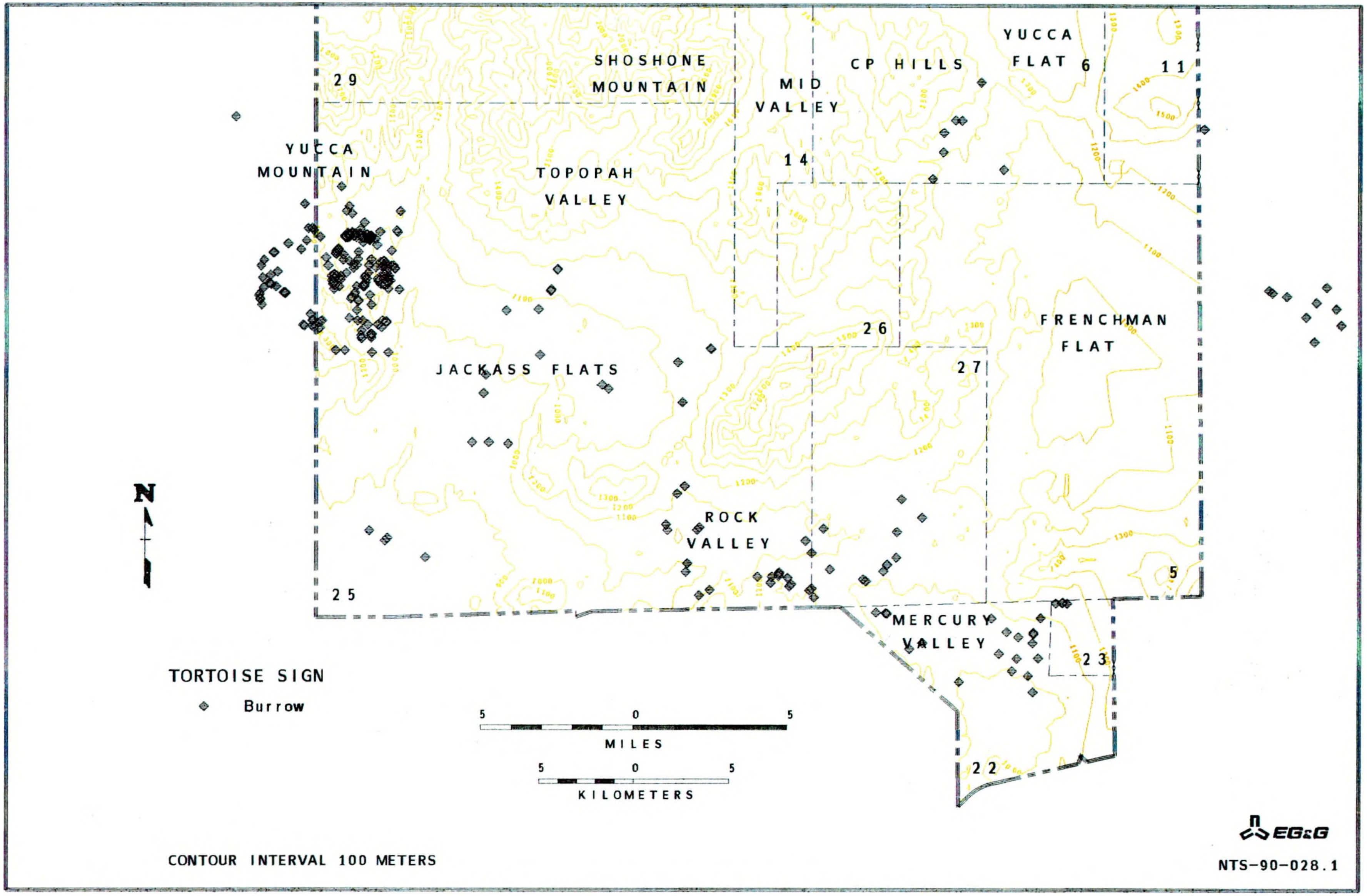


Figure 7 All tortoise burrows found on the Nevada Test Site during 1981-1986 transect studies.

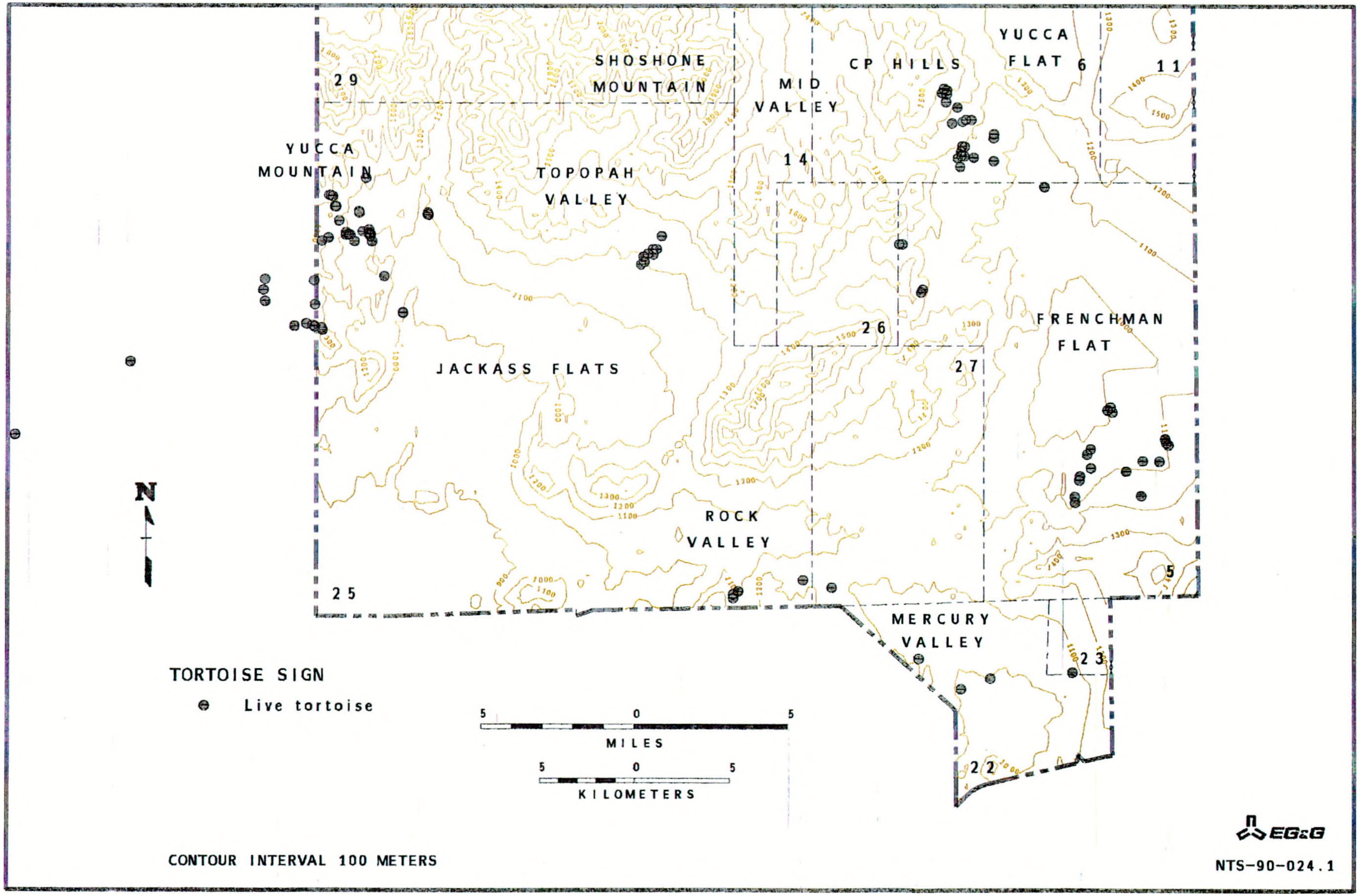


Figure 8 Tortoises found (N = 105) during population and impact monitoring studies on the Nevada Test Site and Yucca Mountain adjacent to the Nevada Test Site during 1987-1990.

Table 1. Distance walked and tortoise sign found in nine geographic regions of the Nevada Test Site during 1981-1986.

Region	*n* transects	km	$\bar{x}$[a]	tortoises	burrows	scat	carcasses
CP Hills	40	51.2	0.79	3	7	25	1
Rock Valley	77	136.9	0.46	3	37	10	13
Mercury Valley	62	103.9	0.41	1	24	7	11
Yucca Mountain	341	520.2	0.28	9	127	31	18
Jackass Flats	83	166.1	0.19	0	23	1	5
Massachusetts Mountain	46	58.9	0.14	0	1	5	1
Frenchman Flat	88	113.9	0.13	1	9	1	4
Cane Spring Wash	12	17.0	0.11	0	0	1	1
Mid Valley	10	22.8	0	0	0	0	0
All transects	759	1,190.9	0.31	17	228	81	54

[a] mean sign counted/km per transect for all regions except Frenchman Flat, which is mean sign for all transects combined.

Table 2. Results of Kruskal-Wallis multiple comparison tests of equality (Conover, 1980:229-237) of the ranks of tortoise sign counted per km on transects in six regions on the Nevada Test Site. The three lines under mean rank connect regions that did not differ ($P < 0.05$) in sign/km. The global Kruskal-Wallis comparison of differences among regions was significant ($T = 21.755$, df = 5, $P < 0.001$).

	Region					
	CP Hills	Rock Valley	Mercury Valley	Yucca Mountain	Jackass Flat	Massachusett Mtn.
n transects	40	77	62	341	83	46
$\bar{x}$ transect rank	398	360	350	316	306	275

(Lines under mean ranks connect: CP Hills–Rock Valley–Mercury Valley; Mercury Valley–Yucca Mountain–Jackass Flat; Yucca Mountain–Jackass Flat–Massachusett Mtn.)

Table 3. Distance walked, sign of desert tortoises found per km walked, and percent of all tortoise sign found (*N* = 194) and km walked (*N* = 616.5 km) within four vegetation associations on the Nevada Test Site during 1981-1986.

Vegetation association	Tortoise		% of Total	
	km walked	sign/km	Sign	km walked
Mountains	72.3	0.44	16.5	11.7
L. tridentata	468.0	0.33	79.4	75.9
L. tridentata-*C. ramosissima*	27.9	0.25	3.6	4.5
C. ramosissima	34.9	0.03	0.1	5.7
Other[a]	13.4	0	0	2.2

[a] Includes associations dominated by *Lycium* spp. and *Grayia* spp. (6.7 km), *Atriplex confertifolia* (6.5 km), and areas where vegetation association was not classified (0.2 km).

Table 4. Distance walked, sign of desert tortoises found per km walked, and percent of all tortoise sign found (*N* = 364) and km walked (*N* = 1081.3) within 100-m elevation classes on the Nevada Test Site and adjacent Yucca Mountain.

			% of total	
Elevation (m)	km walked	sign/km	Sign	km
800-900	23.0	0.17	1.1	2.1
901-1,000	48.7	0.25	3.3	4.5
1,001-1,100	288.2	0.35	27.5	26.7
1,101-1,200	488.8	0.33	44.8	45.2
1,201-1,300	126.8	0.48	16.8	11.7
1,301-1,400	68.1	0.19	3.6	6.3
1,401-1,500	26.8	0.37	2.8	2.5
1,501-1,600	9.4	0.11	0.3	0.9
1,601-1,700	1.5	0	0	0.2

5. DISCUSSION

5.1 RELATIVE ABUNDANCE

Transect studies similar to those reported here have been conducted elsewhere in Nevada (Karl, 1980, 1981; Garcia et al., 1982; Schneider et al., 1982) and in California (Luckenbach, 1982; Berry, 1986) and Arizona (Burge, 1979, 1980). To compare results among areas, Karl (1980, 1981) developed five categories of relative abundance of desert tortoises based on sign counted on 2.4-km transects. Converted to sign/km, and using the category titles given by Schneider et al. (1982), these categories are: none to very low (0-0.4 sign/km), low (0.4-1.5 sign/km), moderate (1.5-3 sign/km), moderately high (3-5 sign/km), and high (>5 sign/km).

Based on this classification system, there is a very low to low abundance of desert tortoises on NTS. Three of the nine regions surveyed (CP Hills, Mercury Valley, and Rock Valley) had average counts of sign in the low category. The other six regions were in the category of no tortoises to very low abundance.

In the only other reported transect study of tortoise abundance on NTS, Karl (1989) counted about 0.8 sign/km along 48 km of transects in Midway Valley and the surrounding hills at Yucca Mountain. This is twice as high as the measure for all of Yucca Mountain (Table 1).

Karl (1981) found an abundance of tortoises similar to that on NTS along 51 2.4-km transects in Nye County, Nevada. Seventy-four percent of these transects were in the category of no tortoises to very low abundance; the remainder had a low abundance. All areas adjacent to NTS that were surveyed had a very low abundance except Crater Flat west of Yucca Mountain, which had a low abundance (Karl, 1981:87). Schneider et al. (1982) also found a very low to low abundance of tortoises along Alamo Road and Desert Dry Lake, 40-50 km east of NTS in the Desert National Wildlife Range.

Although NTS has a low to very low abundance of desert tortoises relative to the rest of this species' range, many tortoises have been found in some areas of NTS. For example, at least 17 tortoises were found in a 171-ha section of Midway Valley at Yucca Mountain during 1990 and over 60 tortoises have been seen in the Yucca Mountain region during 1989-1990. Therefore, it should not be assumed that tortoises are absent from areas classified as having a very low abundance or that populations in such areas are so low that they will not be affected by disturbances in that habitat.

5.2 PATTERNS OF ABUNDANCE ON NTS

Desert tortoises on NTS appear to be more abundant on the bajadas and foothills of the predominately limestone, dolomite, and shale mountains of Precambrian and Paleozoic origin than near mountains of volcanic origin. The three regions having the highest counts of sign (Table 2) are on or adjacent to such mountains. Some of the regions with a lower abundance of sign (e.g., Yucca Mountain, Massachusetts Mountain/French Peak, and Jackass Flats) are on or surrounded by mountains primarily of volcanic origin. Greater abundance of caliche outcrops, desert pavement, or other characteristics of soil downslope from the Precambrian-Paleozoic mountains may be advantageous to tortoises. Schneider et al. (1982) suggested that tortoises may be more abundant elsewhere in Nevada where caliche outcrops are found. Desert pavement may be good for digging depressions that collect rainwater, as described by Medica et al. (1980).

Desert tortoises are most abundant throughout the Mojave Desert in areas where *L. tridentata* is a dominant shrub (Luckenbach, 1982; FWS, 1990). Abundance of sign on NTS was higher in the *L. tridentata* association than all other associations except areas classified as mountains (Table 3). The mountains have a diverse mix of the vegetation associations surrounding them. Therefore, it is not possible to interpret the relationship between tortoise abundance and vegetation within mountainous regions. Most of the area within the three regions on NTS with the highest counts of tortoise sign (i.e., CP Hills, Rock Valley, Mercury Valley) were classified by Beatley (1976) as the Mojave Desert bajada vegetation association dominated by *L. tridentata* (Figure 3). However, parts of the Jackass Flats, Frenchman Flat, Massachusetts Mountain, and Yucca Mountain where little or no sign was found also are classified by Beatley (1976) as the same *L. tridentata* association. Therefore, the scale of classification of vegetation associations currently available for NTS is not a useful predictor of tortoise abundance, at least within the Mojave Desert associations.

Little sign of tortoises has been found on transects in Nevada where *C. ramosissima* was a dominant or codominant plant (Karl, 1980, 1981; Schneider et al., 1982). A similar pattern was found on NTS. No sign of tortoises were found along the 22.8 km of transects walked in Mid Valley (Appendix 1g), where *C. ramosissima* is the dominant shrub (Figure 3) and only one sign was found elsewhere in this association. Seven sign of tortoises were found in areas such as the northern parts of Jackass Flats (Appendix 1d) and Yucca Mountain (Appendix 1i) where *C. ramosissima* and *L. tridentata* are codominants. However, many of the tortoises found during the population and impact monitoring studies (Figure 8) were in areas dominated by this *C. ramosissima-L. tridentata* association.

No sign of tortoises were found along approximately 50 km of transects in areas north and northeast of Frenchman Lake. The dominant vegetation in this area is *A. confertifolia* or *A. confertifolia-L. tridentata* (Appendix 1c). Most sign found in the Frenchman Flat survey were within 2 km of the Ranger Mountains. The high clay content in the soils in the bottom of this enclosed basin may make it difficult for tortoises to dig burrows in this area. The high salt content in these soils also may be disadvantageous to tortoises.

Tortoise sign was more common at higher elevations on NTS than has been found during other transect studies in Nevada. Karl (1980) found tortoise sign in Clark County between 400 and 1,465 m and classified all areas above 1,067 m as having a low or very low abundance. Karl (1981) did not search areas above 1,220 m (4,000 feet) in Lincoln and Nye counties and considered this the general altitudinal limit for desert tortoises. Karl (1981) chose this elevation because it is approximately the ecotone between *L. tridentata* and *C. ramosissima*. Garcia et al. (1982) also classified areas above 1,220 m in Coyote Springs Valley as having no tortoises.

The general elevation limit of 1,220 m presented by Karl (1981) is not valid for NTS. The relative abundance of tortoise sign on NTS transects was approximately equal below (0.33 sign/km, n = 848 km) and above 1,200 m (0.37 sign/km, n = 233 km) (Table 4). At least nine of 54 tortoises (16%) found at Yucca Mountain during 1989-1990 were located above 1,220 m. A burrow with tortoise scat found at 1,600 m at Yucca Mountain is one of the highest elevations reported in the literature for desert tortoises. It is difficult, however, to use the data from NTS transects to identify the elevation above which tortoises are very uncommon or absent because only 38 km were walked above 1,400 m. Also, this transect technique may not be useful for detecting changes in abundance in areas where tortoises are very scarce. More work must be conducted to identify the combinations of vegetation and elevation above which tortoises are not found.

Further generalizations about the pattern of abundance of tortoises on NTS are not possible because no information was recorded on the type of habitat (e.g., slope class, soil characteristics) each transect bisected. Each transect may have covered more than one feature of interest; therefore, classification of area searched is difficult unless the distribution of the habitat feature has been mapped and computerized.

The following limitations and biases of the technique also prevent further interpretation of the NTS data. First, transects are not a very precise method for determining the abundance of tortoises. Turner et al. (1982) found that this technique was useful for distinguishing between areas of good and poor tortoise habitat but could not be used to further delineate degrees of habitat quality. Weinstein (1989) compared counts of sign along transects in areas with a similar abundance of tortoises. He concluded that the variation of sign counted per transect was so high that the accuracy of models using this data to predict abundance would be less than 50%. Second, more sign may be counted on transects walked later in a year because abundance of scat and new burrows increases as time since hibernation increases (Turner et al., 1982). Transects at NTS were conducted from March through October; no corrections were made for time of year surveyed. Third, the transect data presented in this report was collected over six years. Comparisons among areas may be biased if population abundance changed during that period.

However, some areas on NTS where tortoises appear to be abundant can be identified from searches conducted for the population and impact monitoring studies (Figure 8), and from other studies of tortoises. Tortoises appear to be commonly found in at least the following five areas on NTS. Because only a small portion of NTS has been searched intensively, there may be many more sites where tortoises are abundant.

Southern CP Hills--Twenty-one tortoises have been found on the southern foothills and bajadas of the CP Hills (Figure 8). Many sign of tortoises also were found in this area during transect surveys (Appendix 1b).

Southwestern Frenchman Flat--Seventeen tortoises have been found in southwestern Frenchman Flat on the north slopes of the Mercury Mountains less than 8 km north of Checkpoint Pass.

Eastern Rock Valley--Five tortoises were found on the eastern bajada of Rock Valley. Twenty-two tortoises were trapped in three 9-ha enclosures constructed in this area in 1963 (Medica et al., 1975).

Saddle Mountain Road--Eight tortoises were found within 1 km of the Saddle Mountain Road in northeastern Jackass Flats (Figure 8). Three other tortoises were found in this area during a search of a 24-ha site for the Yucca Mountain Project.

Midway Valley, Yucca Mountain--At least 17 tortoises have been found in a 171-ha area in the northern part of this small valley. Many other tortoises also have been found in the foothills surrounding this valley. This is within the area Karl (1989) found about 0.8 sign/km.

5.3 NORTHERN BOUNDARY OF THE RANGE OF TORTOISES ON NTS

The northern boundary of the distribution of desert tortoises occurs within or near the ecotone between the Mojave and Great Basin deserts. On NTS this ecotone occurs between approximately 1,220 m (the elevational limit of *L. tridentata*) and 1,525 m (the approximate elevational limit of *C. ramosissima*). The vegetation in this region is dominated by *C. ramosissima* or *L. tridentata*, *G. spinosa*, and *L. andersonii* (Figure 3).

Along the eastern edge of NTS, the range of the desert tortoise extends north at least to the south slopes of Massachusetts Mountain (Figure 9). Very few or no tortoises probably occur north of Massachusetts Mountain and the CP Hills within the watershed of Yucca Flat. There have been no reported sightings of tortoises in this basin. No sign of tortoises was found along 12.5 km of transects just west of Yucca Lake (Appendix 1b), during surveys for sensitive plant and animal species in Yucca Flat during 1983 (Collins and O'Farrell, 1984), or by Tanner and Jorgenson (1963) during their survey of reptiles on NTS. The only place in Yucca Flat where tortoises are likely to occur are the northern slopes of the CP Hills and Massachusetts Mountain.

The northern limit of this range extends west from Massachusetts Mountain to about the Control Point and then along the southern slopes of the CP Hills. From the CP Hills the limit of distribution extends westward

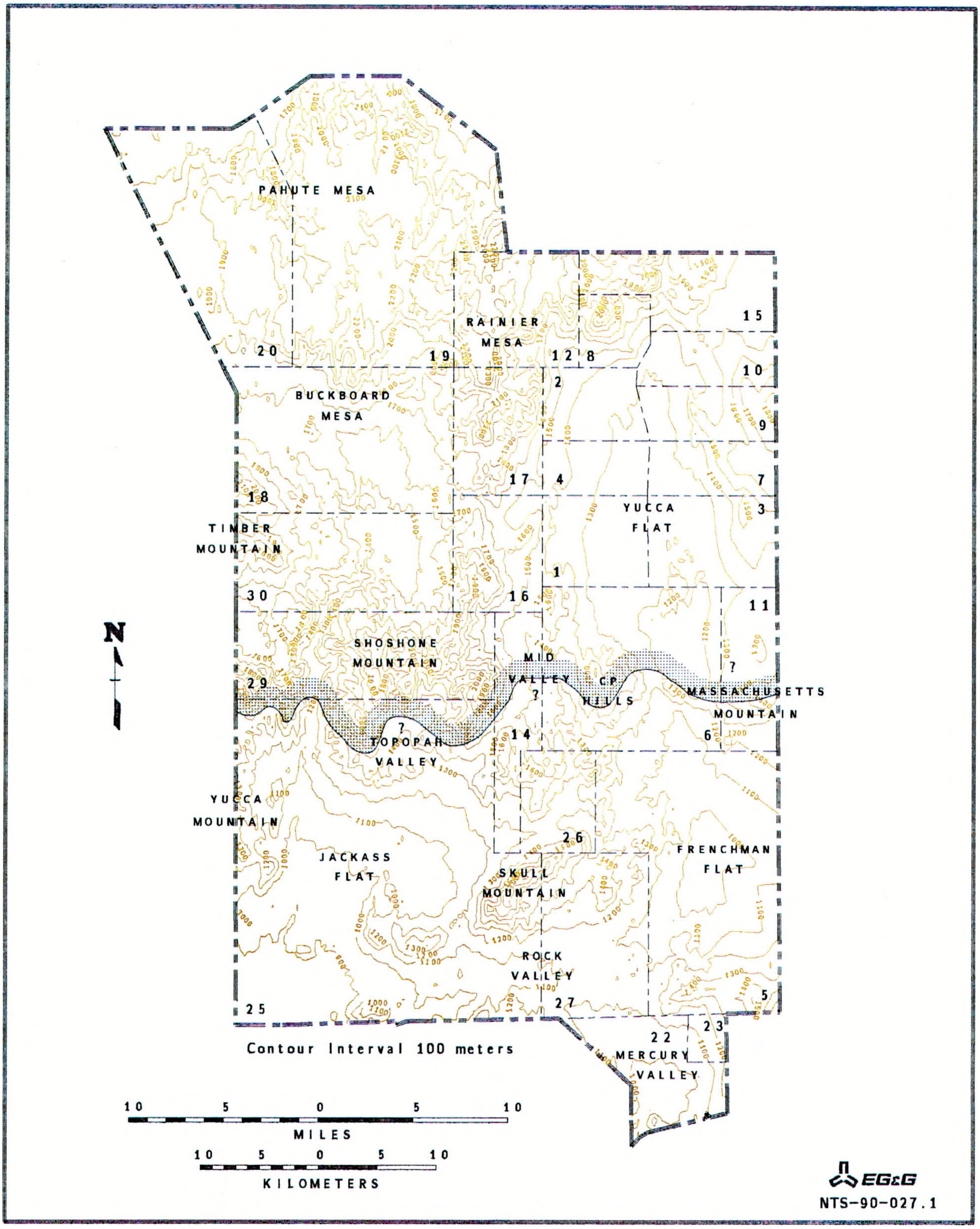


Figure 9 The northern limit of the range of desert tortoises on the Nevada Test Site (shaded area). Question marks represent areas where little or no information is available to determine if tortoises live there.

through Mid Valley and then to the eastern and southern slopes of Shoshone Mountain and the Calico Hills (Figure 9). Mid Valley is vegetated by almost pure stands of *C. ramosissima* (Figure 3). No sign of tortoises were found on 23 km of transects along the east side of this valley; however, more searches must be conducted before concluding that tortoises are not in this valley. Searches also must be conducted in Topopah Valley, which has vegetation similar to Mid Valley, to determine how far north tortoises are found there.

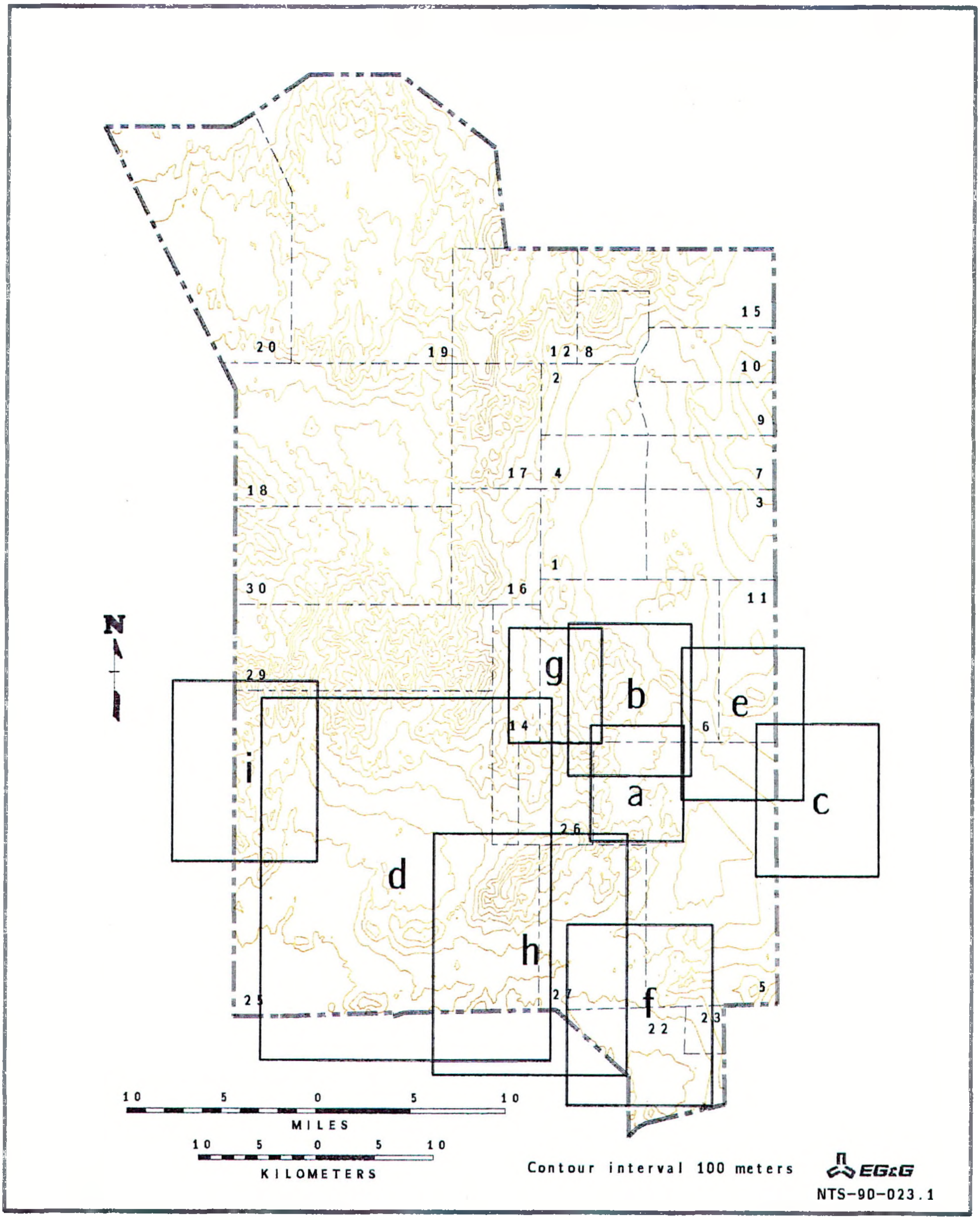
Along the western edge of NTS, sign of tortoises were found 1 km south of the Area 29 boundary during a search of a road in Forty-mile Canyon. To the west, tortoises are found at least as far north as the Prow of Yucca Mountain, which is about the same latitude as the boundary between NTS areas 25 and 29 (Figure 9).

5.4 RECOMMENDATIONS FOR FUTURE WORK

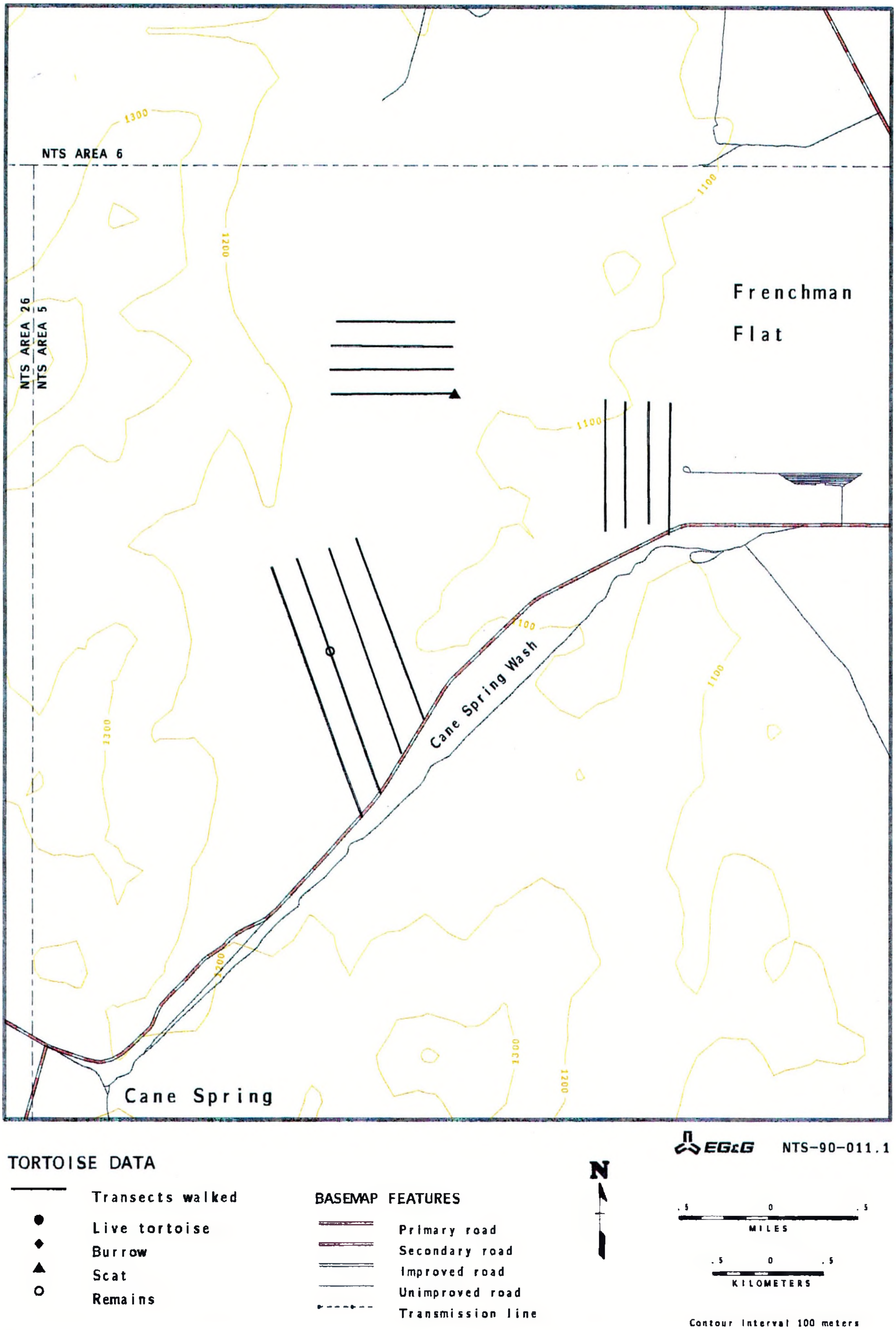
Although the transect studies and tortoise searches presented here provide some understanding of the distribution and abundance of tortoises on NTS, this information is of limited value for conserving tortoises because of the large geographic scale of discrimination that was used (i.e, mountain ranges and valleys, large vegetation associations). Additional studies using different techniques are needed to develop a better understanding of the spatial distribution of tortoises at a finer scale. This information is needed to assess the impacts of ongoing activities on desert tortoises and develop long-term plans for minimizing impacts of proposed activities. Because there are few ongoing or planned activities along the northern boundary of the desert tortoise range on NTS, especially west of CP hills, it is more important to study the pattern of relative abundance of tortoises throughout their range than to more clearly define their northern boundary.

The goal of future studies of the relative abundance of tortoise on NTS should be to develop a model that will accurately predict tortoise relative abundance throughout NTS at a spatial scale of 1 km^2 or less. Using this model, a map of the relative abundance of tortoises should be developed. This map could then be used by land use planners to identify areas where future activities should be located without impacting tortoises. Having and using this information when selecting the location of activities will save DOE time and money because costs for mitigating impacts will be substantially less if projects are developed where tortoises are least abundant. This model also can be used to identify areas that tortoises can be relocated into if their home range must be disturbed and for identifying areas and techniques for habitat improvement.

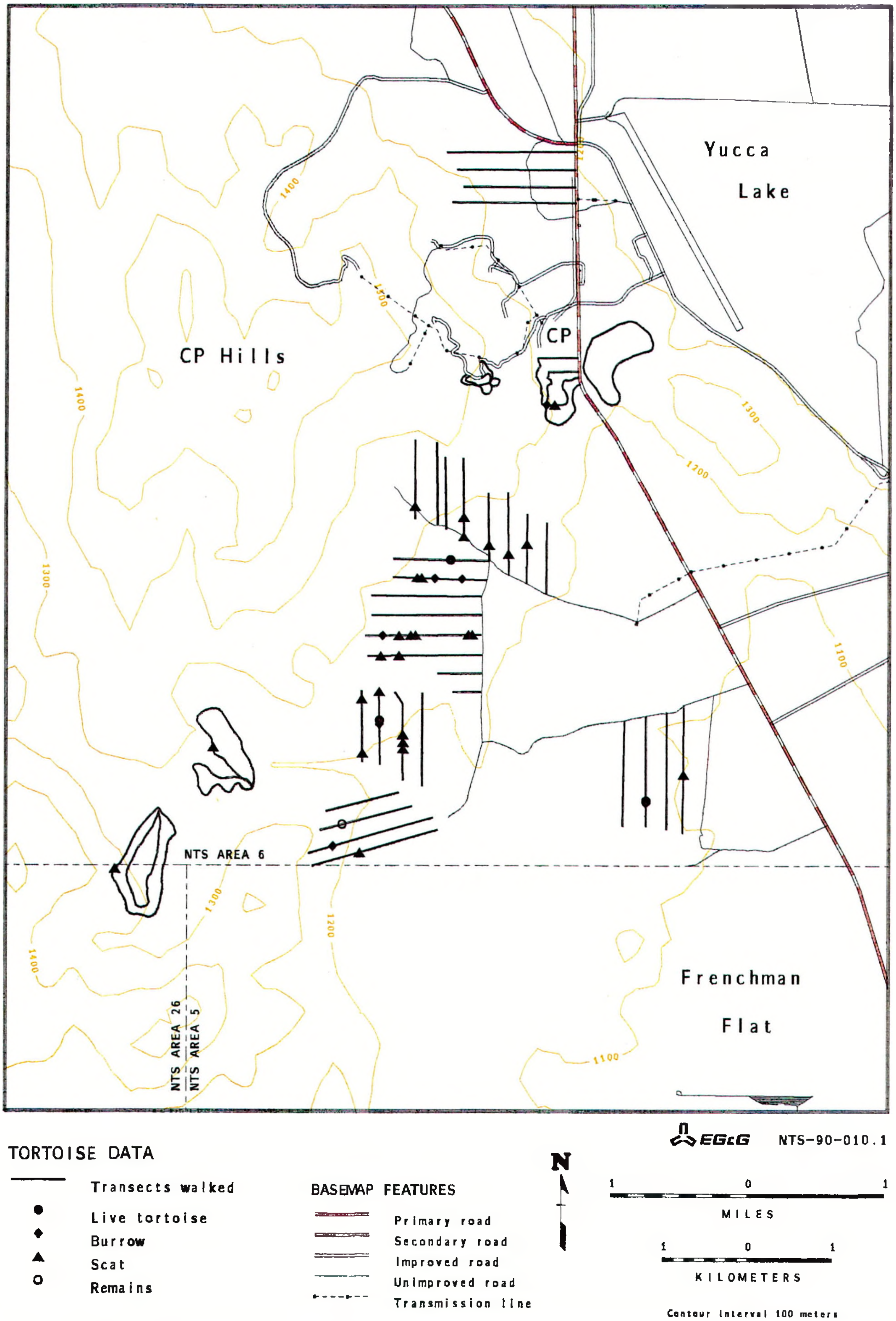
The transect technique used on NTS during 1981-1986 will not be useful for developing such a model and map because the abundance of tortoises cannot be precisely measured along transects. Searches for tortoises and tortoise sign within quadrats are a more useful method of assessing abundance (Bury and Luckenbach, 1977). Quadrats should be large enough to precisely measure relative abundance but small enough to encompass homogenous habitat. Habitat features that may affect the abundance of tortoises or be useful for predicting abundance (e.g., vegetation, nearest transition or ecotone area, soils, geology) should be measured at each quadrat and used as independent variables in the model. Variables should be selected that can be or have been measured by remote sensing to determine if remote sensing can be used to expand the results from sample plots to the entire NTS. The relationship between geology and abundance should be further explored and a better vegetation map with smaller units must be developed so the relationship between vegetation and abundance can be evaluated. A map of the soils on NTS also would improve this model. Soil characteristics that may affect tortoises, such as penetrability and composition, should be measured. Plots should be sampled throughout the range of tortoises on NTS but can be concentrated in areas where activities are ongoing or planned so this work also can be used as the initial step in an impact monitoring program.



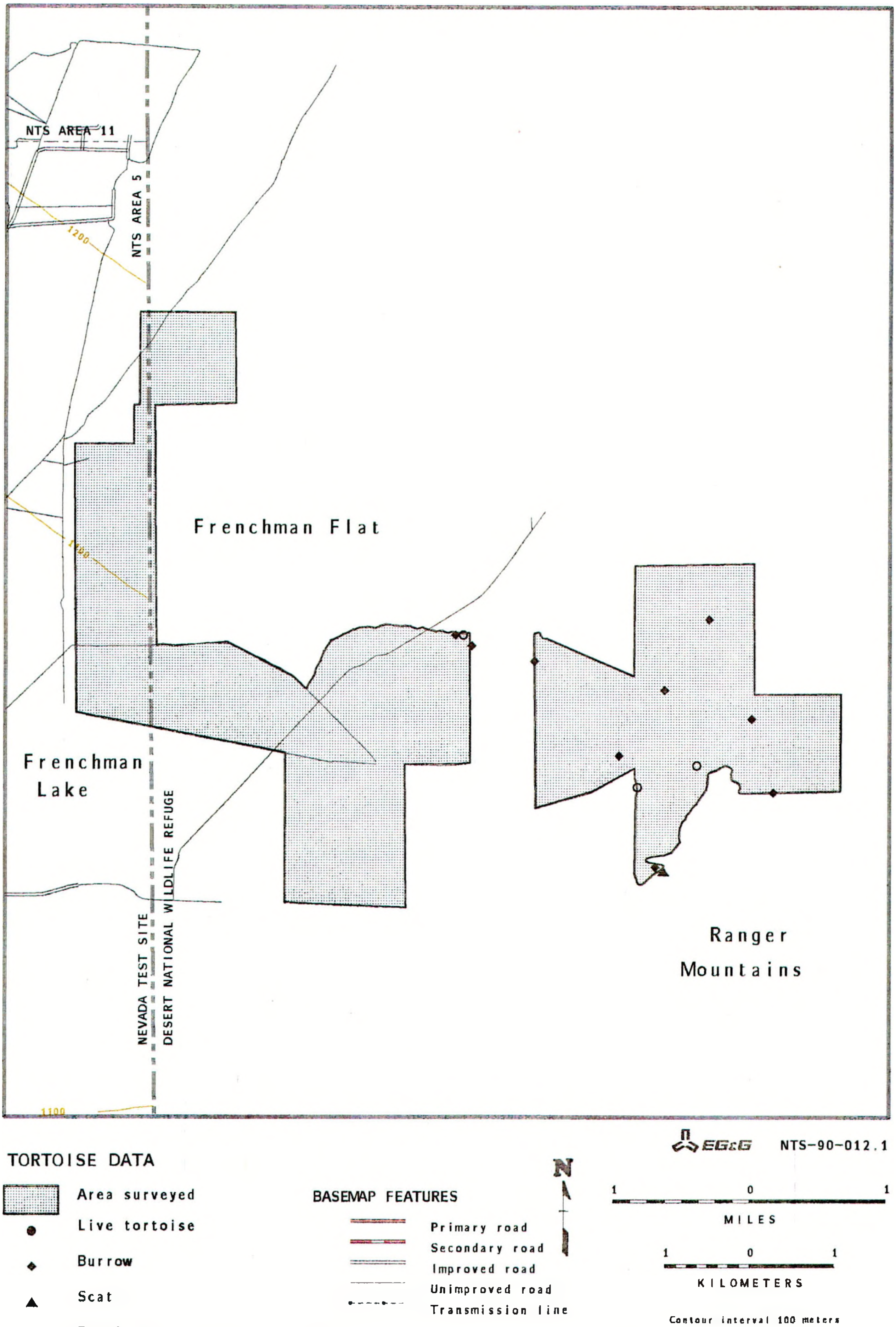
Appendix 1. Boundaries of the nine maps in Appendix 1 showing the transects walked and desert tortoise sign found on the Nevada Test Site 1981-1986.



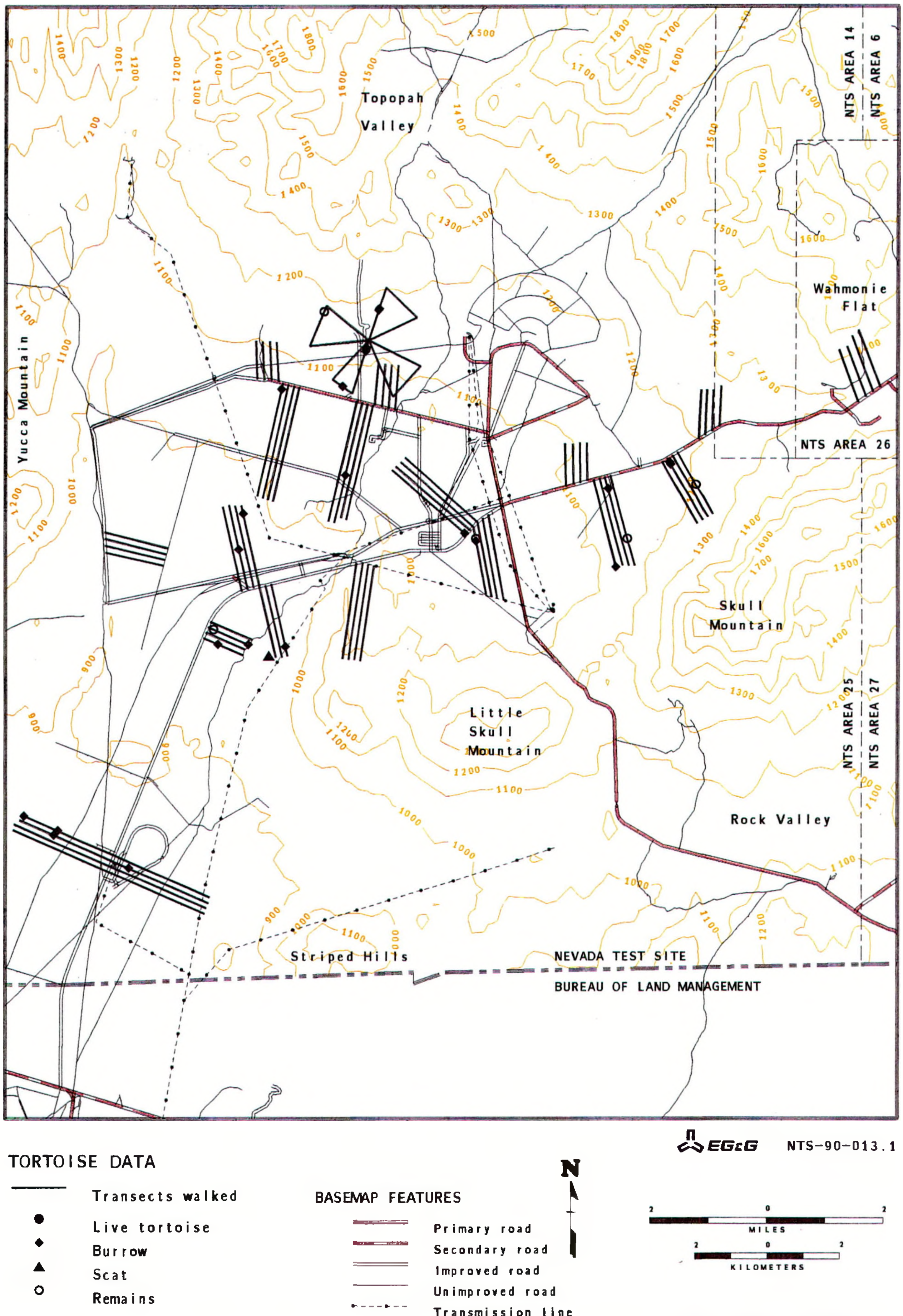
Appendix 1a. Transects walked and tortoise sign found northeast of Cane Spring Wash during 1985.



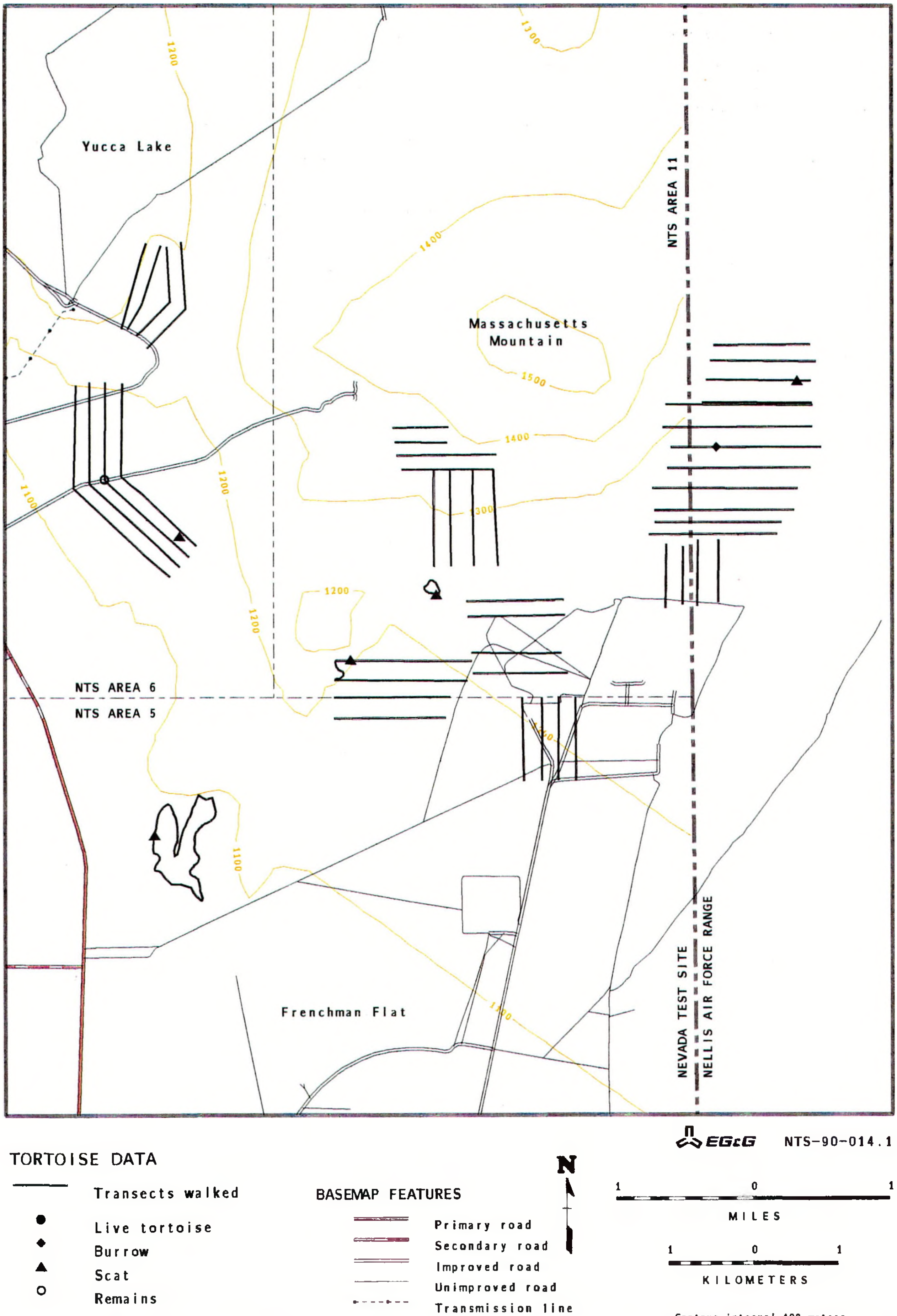
Appendix 1b. Transects walked and tortoise sign found around CP Hills during 1985-1987.



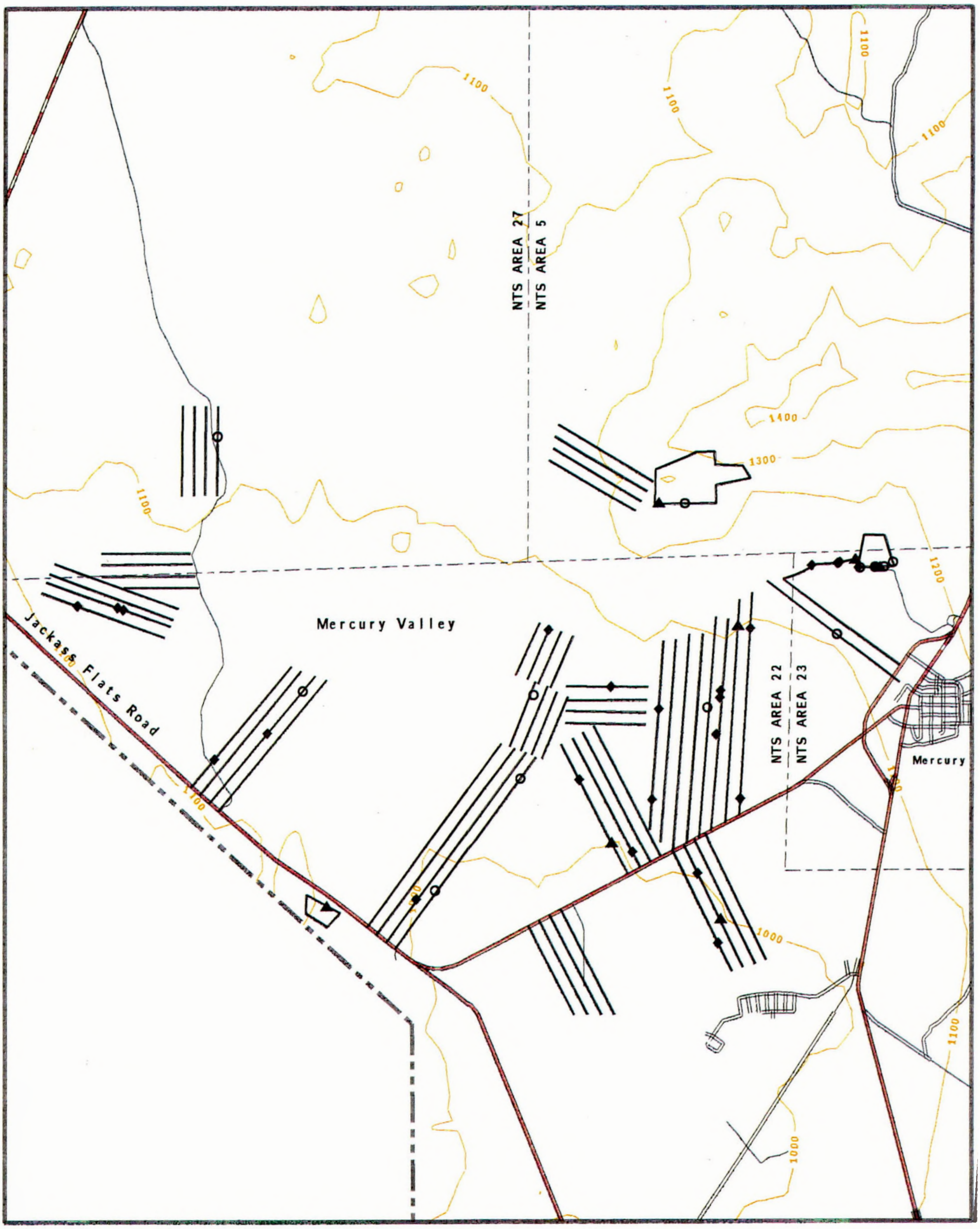
Appendix 1c. Tortoise sign found and area where transects were walked (N = 113.9 km) in the east half of Frenchman Flat in 1984. Topographic lines are shown only for that portion of the survey area on the Nevada Test Site.



Appendix 1d. Transects walked and tortoise sign found at Jackass Flats during 1981 and 1985-1986.



Appendix 1e. Transects walked and sign found around Massachusetts Mountain in 1984-1985.



TORTOISE DATA

——	Transects walked
●	Live tortoise
◆	Burrow
▲	Scat
○	Remains

Primary road
Secondary road
Improved road
Unimproved road
Transmission line

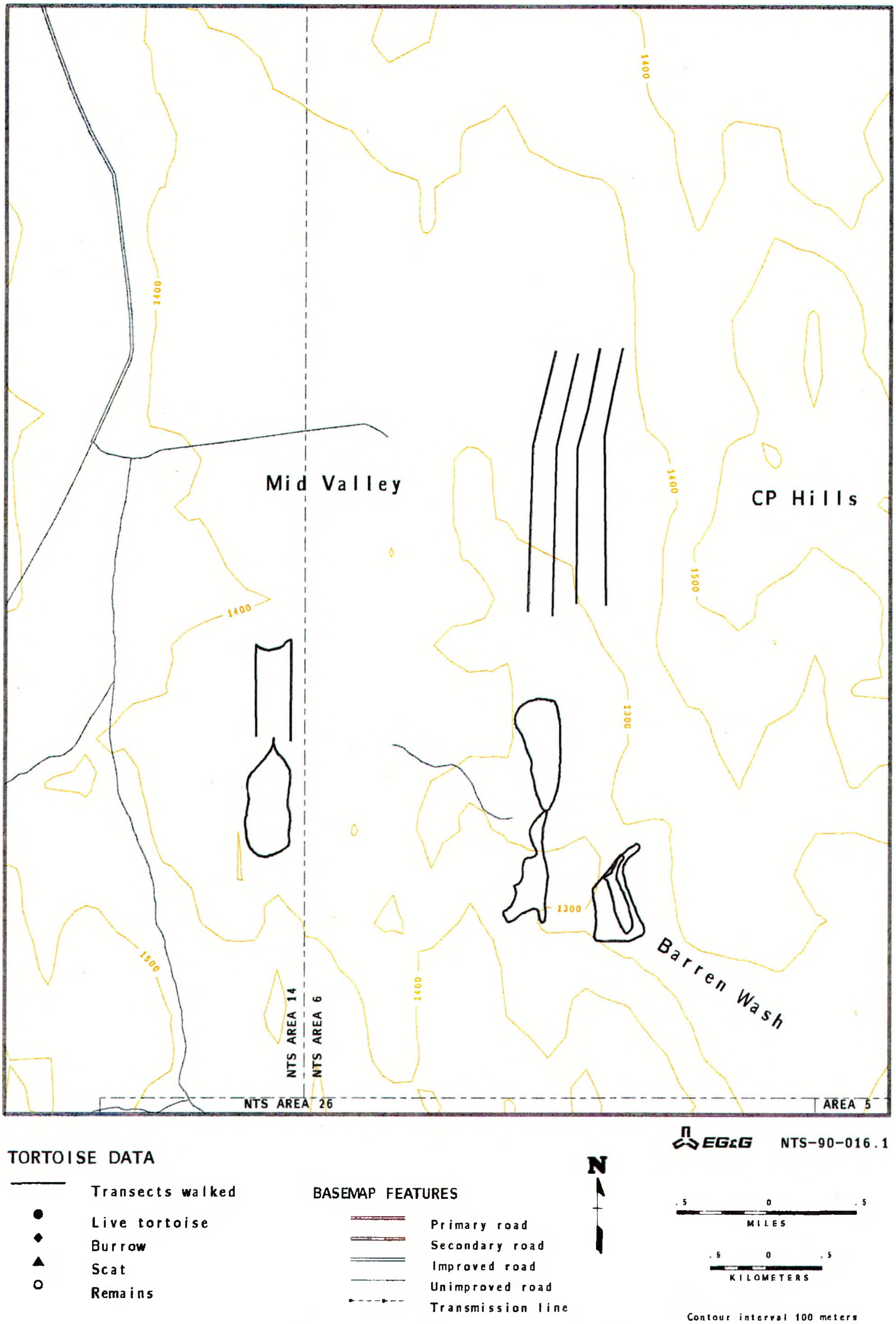
N

1 0 1 MILES

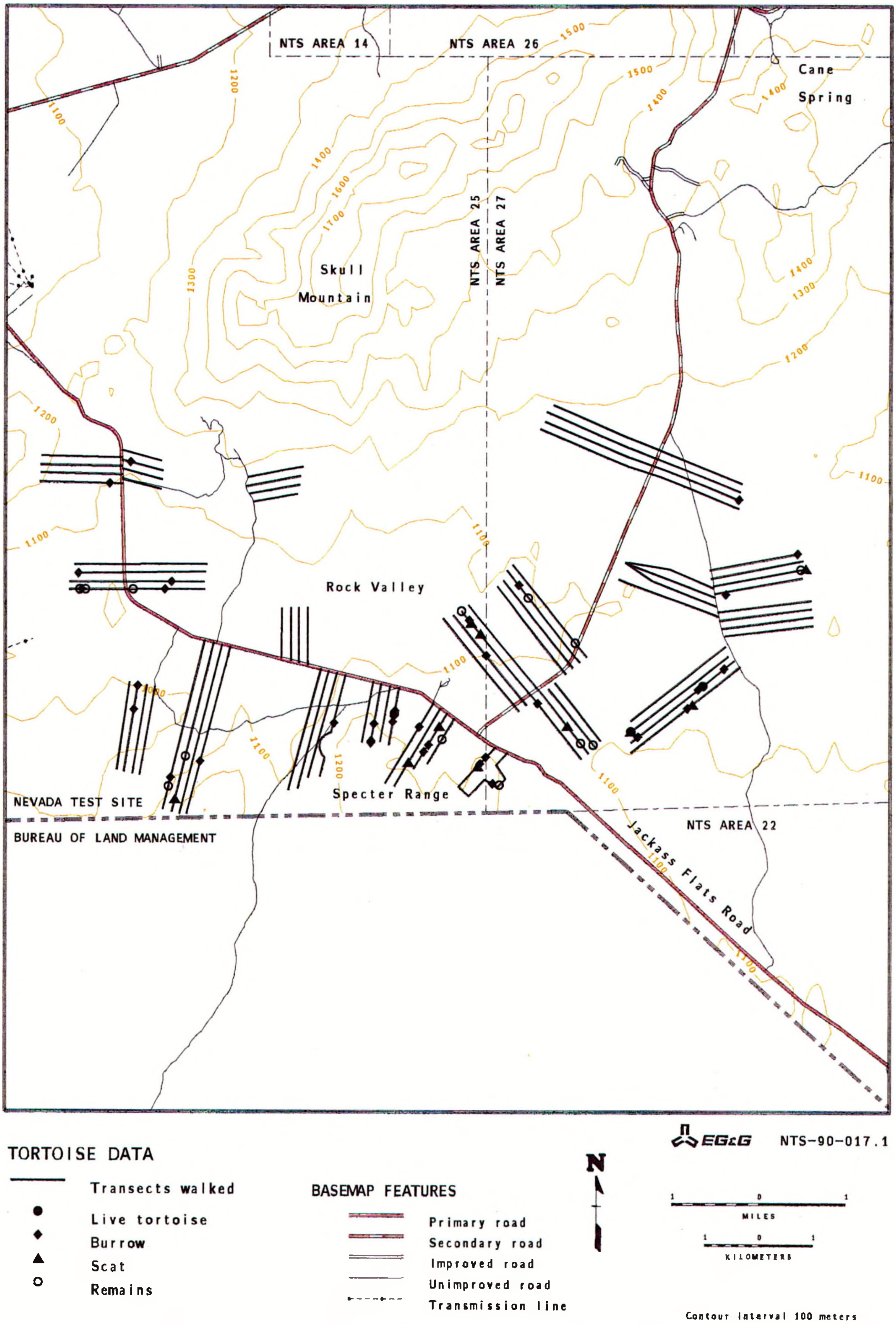
1 0 1 KILOMETERS

Contour interval 100 meters

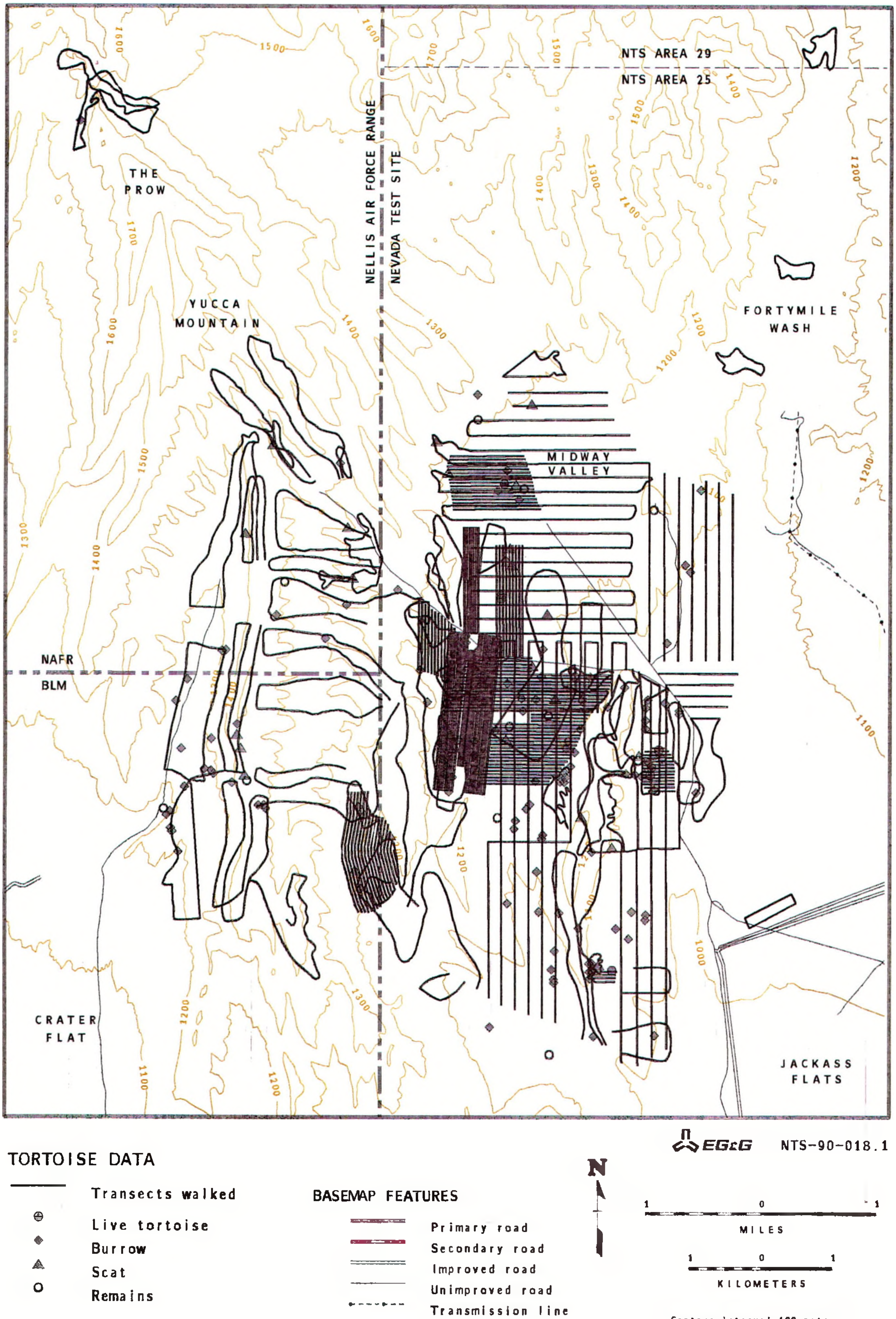
Appendix 1f. Transects walked and tortoise sign found in Mercury Valley during 1986.



Appendix 1g. Transects walked and tortoise sign found in Barren Wash and the south end of Mid Valley in 1985.



Appendix 1h. Transects walked and tortoise sign found in Rock Valley during 1986.



Appendix 1i. Transects walked and tortoise sign found at Yucca Mountain during 1981-1984.

LITERATURE CITED

Beatley, J. C. 1974. Effects of rainfall and temperature on the distribution and behavior of *Larrea tridentata* (Creosote-bush) in the Mojave desert of Nevada. Ecology 55:245-261.

Beatley, J. C. 1976. Vascular plants of the Nevada Test Site and Central-southern Nevada: ecologic and geographic distributions. U.S. National Technical Information Service, TID-26881, Springfield, Va. 308 pp.

Berry, K. H. 1986. Desert tortoise (*Gopherus agassizii*) research in California, 1976-1985. Herpetologica 42:62-67.

Burge, B. L. 1979. A survey of the present distribution of the desert tortoise, *Gopherus agassizi*, in Arizona. Proc. Desert Tortoise Council Symp. 1979:27-74.

Burge, B. L. 1980. Survey of the present distribution of the desert tortoise, *Gopherus agassizi*, in Arizona: additional data, 1979. Proc. Desert Tortoise Council Symp. 1980:36-60.

Bury, R. B., and R. A. Luckenbach. 1977. Censusing desert tortoise populations using a quadrat and grid location system. Proc. Desert Tortoise Council Symp. 1977:169-178.

Collins, E., and T. P. O'Farrell. 1984. Surveys for plant species of concern on northern and eastern Yucca Flat, Nevada Test Site, Nye County, Nevada. U.S. Dept. Energy Topical Report, EG&G/EM Santa Barbara Operations Report No. 10282-2039. 17 pp.

Collins, E., and T. P. O'Farrell. 1985. 1984 biotic studies of Yucca Mountain, Nevada Test Site, Nye County, Nevada. U.S. Department of Energy Topical Report, EG&G/EM Santa Barbara Operations Report No. 1183-2057. 54 pp.

Collins, E., T. P. O'Farrell, and M. L. Sauls. 1983. Survey for desert tortoise on the possible site of a high-level nuclear waste repository, Nevada Test Site. Proc. Desert Tortoise Council Symp. 1983:19-26.

Conover, W.J. 1980. Practical nonparametric statistics. Second ed. John Wiley & Sons, Inc., New York, NY. 493 pp.

Garcia, J., K. H. Berry, and P. B. Schneider. 1982. The distribution and relative abundance of the desert tortoise (*Gopherus agassizii*) in Coyote Spring Valley, Nevada, with a discussion of possible impacts of the MX Project Development. Proc. Desert Tortoise Council Symp. 1982:12-35.

Germano, D. J. 1988. Age and growth histories of desert tortoises using scute annuli. Copeia 1988:914-920.

Karl, A. 1980. Distribution and relative densities of the desert tortoise in Nevada. Proc. Desert Tortoise Council Symp. 1980:75-87.

Karl, A. 1981. The distribution and relative densities of the desert tortoise, *Gopherus agassizii*, in Lincoln and Nye Counties, Nevada. Proc. Desert Tortoise Council Symp. 1981:76-92.

Karl, A. 1989. Yucca Mountain Project: Investigations of desert tortoise abundance and distribution on the focused baseline study area, fall 1989 field studies. Enviornmental Science Assoc., Inc., San Francisco, Ca.

Luckenbach, R. A. 1982. Ecology and management of the desert tortoise (*Gopherus agassizii*) in California. Pages 1-37 in R. B. Bury, (ed.). North American tortoises: conservation and ecology. U.S. Fish and Wildlife Service Wildlife Res. Rep. 12. 126 pp.

Medica, P. A., R. B. Bury, and R. A. Luckenbach. 1980. Drinking and construction of water catchments by the desert tortoise, *Gopherus agassizii*, in the Mojave Desert. Herpetologica 36:301-304.

Medica, P. A., R. B. Bury, and F. B. Turner. 1975. Growth of the desert tortoise (*Gopherus agassizi*) in Nevada. Copeia 1975:639-643.

Medica, P. A., C. L. Lyons, and F. B. Turner. 1986. "Tapping": a technique for capturing tortoises. Herp Review 17:15-16.

Medica, P. A., T. P. O'Farrell, and E. Collins. 1981. Survey of Yucca Mountain, Forty-Mile Canyon, and Jackass Flats in Nye County, Nevada for Desert Tortoise, *Gopherus agassizii*. U.S. Department of Energy Topical Report, EG&G/EM Santa Barbara Operations Report No. 1183-2438. 10 pp.

Nagy, K. A., and P. A. Medica. 1986. Physiological ecology of desert tortoises in southern Nevada. Herpetologica 42:73-92.

O'Farrell, T. P., and E. Collins. 1983. 1982 biotic survey of Yucca Mountain, Nevada Test Site, Nye County, Nevada. U.S. Department of Energy Topical Report, EG&G/EM Santa Barbara Operations Report No. 10282-2004. 38 pp.

O'Farrell, T. P., and E. Collins. 1984. 1983 biotic studies of Yucca Mountain, Nevada Test Site, Nye County, Nevada. U.S. Department of Energy Topical Report, EG&G/EM Santa Barbara Operations Report No. 10282-2031. 38 pp.

O'Farrell, T. P., and L. A. Emery. 1976. Ecology of the Nevada Test Site: a narrative summary and annotated bibliography. U.S. Department of Energy Report No. NVO-167. 249 pp.

Schneider, P. B., R. J. Turner, and K. E. Bohuski. 1982. Distribution and relative density of desert tortoises at six selected sites in southern Nevada. Proc. Desert Tortoise Council Symp. 1982:36-50.

Tanner, W. W., and C. D. Jorgensen. 1963. Reptiles of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser. 3(3). 31 pp.

Turner, F. B., P. A. Medica, and R. B. Bury. 1987. Age-size relationships of desert tortoises (*Gopherus agassizi*) in southern Nevada. Copeia 1987:974-979.

Turner, F. B., C. G. Thelander, D. C. Pearson, and B. L. Burge. 1982. An evaluation of the transect technique for estimating desert tortoise density at a prospective power plant site in Ivanpah Valley, California. Proc. Desert Tortoise Council Symp. 1982:134-153.

U.S. Fish and Wildlife Service. 1990. Assessment of biological information for listing the desert tortoise as an endangered species in the Mojave Desert. U.S. Fish and Wildlife Service, National Ecology Research Center, Fort Collins, Co.

Weinstein, M. N. 1989. Modeling desert tortoise habitat: can a useful management tool be developed from existing transect data? Ph.D. Thesis. University of California, Los Angeles. 121 pp.

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