DOE/NV/11718–245

The Relative Abundance of Desert Tortoises on the Nevada Test Site Within Ecological Landform Units

September 1998

WORK PERFORMED UNDER
CONTRACT NO. DE-AC08-96NV11718

Prepared for the
U.S. Department of Energy
Nevada Operations Office
Environmental Protection Division
P.O. Box 98518
Las Vegas, Nevada 89193-8518

Prepared By
Roy Woodward, Bechtel National
Kurt R. Rautenstrauch, Science Applications International Corporation
Derek B. Hall, Bechtel Nevada
W. Kent Ostler, Bechtel Nevada

DISCLAIMER NOTICE

CONTENTS

FIGURES

TABLE

This Page Intentionally Left Blank

ABSTRACT

Sign-survey transects were sampled in 1996 to better determine the relative abundance of desert tortoises on the Nevada Test Site (NTS). These transects were sampled within ecological land-form units (ELUs), which are small, ecologically homogeneous units of land. Two-hundred and six ELUs were sampled by walking 332 transects totaling 889 kilometers (km) (552 miles [mi]). These ELUs covered 528 km^2 (204 mi^2). Two-hundred and eighty-one sign were counted. An average of 0.32 sign was found per km walked. Seventy percent of the area sampled had a very low abundance of tortoises, 29 percent had a low abundance, and 1 percent had a moderate abundance.

A revised map of the relative abundance of desert tortoise on the NTS is presented. Within the 1,330 km^2 (514 mi^2) of desert tortoise habitat on the NTS, 49 percent is classified as having no tortoises or a very low abundance, 18 percent has a low or moderate abundance, 12 percent is unclassified land being used by the Yucca Mountain Site Characterization Project, and the remaining 21 percent still has an unknown abundance of desert tortoises. Based on the results of this work, the amount of tortoise habitat previously classified as having an unknown or low-moderate abundance, and on which clearance surveys and on-site monitoring was required, has been reduced by 20 percent.

This Page Intentionally Left Blank

1.0 INTRODUCTION

The Nevada Test Site (NTS) (Figure 1) is a 3,500-square-kilometer (km^2) (1,351-square-mile [mi^2]) installation managed by the U.S. Department of Energy, Nevada Operations Office (DOE/NV) for defense programs, environmental restoration, waste management activities, and nondefense research and development. Although DOE/NV and its predecessor agencies have used the NTS since 1950, a large portion of the area is undisturbed and supports diverse plant and animal communities. The desert tortoise (*Gopherus agassizii*) is the only species resident on the NTS that is classified under the Endangered Species Act as threatened. Desert tortoises are found only in the southern portions of the NTS, and the abundance of tortoises varies throughout that area (EG&G/EM, 1991). In some areas, such as the southern alluvial fans of the CP Hills and the lower hills surrounding Rock Valley, tortoises are relatively common. In other areas, such as the bottom of Frenchman Flat, they are rare (EG&G/EM, 1991).

Because the desert tortoise is classified as a threatened species (U.S. Fish and Wildlife Service [FWS], 1990), DOE/NV must implement the terms and conditions of a biological opinion to minimize impacts of its activities on this species. Mitigation actions typically required on the NTS include clearance surveys to find and remove tortoises from construction sites, monitoring of construction activities, restrictions on off-road driving, and fencing or covering of trenches. These methods may be effective, reasonable, and prudent in areas where tortoises are relatively common, but some are not useful in areas where tortoises are rare or absent. Therefore, the FWS has concurred that DOE/NV does not need to implement some mitigation actions for desert tortoises (e.g., clearance surveys, on-site monitoring) in those areas of the NTS where desert tortoises are not found or are found only in very low abundance (FWS, 1996).

Numerous studies have been conducted to gather information on the range, distribution, and relative abundance of desert tortoises on the NTS. Transect surveys designed to determine the distribution and relative abundance of desert tortoises were initiated in 1981. During 1981-1984, transects were walked on and around Yucca Mountain, the possible site of a high-level radioactive waste repository. In 1984, transects were walked in Frenchman Flat and the surrounding mountains to determine the potential effects of testing at the Hazardous Materials (HAZMAT) Spill Center on tortoises. In 1985, northern Frenchman and Jackass Flats were examined to better determine the northern boundary of the tortoise distribution on the NTS. Areas within the known range of the tortoise in Jackass Flats, Rock Valley, Mercury Valley, and Frenchman Flat were examined in 1986. The results of all these surveys are summarized in EG&G/EM (1991). During all surveys, 759 transects totaling 1,191 km (740 mi) were walked. Seventeen live tortoises and 363 other sign of tortoises were found, for an average of 0.32 sign observed per km walked. Using the criteria established by Karl (1981) for areas in southern Nevada (see Table 1), three areas were classified as having a low abundance of tortoises (CP Hills [0.79 sign/km], Rock Valley [0.46 sign/km], and Mercury Valley [0.41 sign/km]). Six other areas were classified as having no tortoises or a very low abundance of tortoises (hereafter called "very low") (Yucca Mountain [0.28 sign/km], Jackass Flats [0.19 sign/km], Massachusetts Mountain [0.14 sign/km], Frenchman Flat [0.13 sign/km], Cane Springs Wash [0.11 sign/km], and Mid Valley [0 sign]). Sign of tortoises was found at elevations from 880 to 1,570 meters (m) (2,894 to 5,163 feet [ft]), and sign was more abundant above 1,220 m (4,003 ft) than has been reported previously for Nevada. Tortoises were more abundant on the NTS on upper piedmont slopes and mountain

This Page Intentionally Left Blank

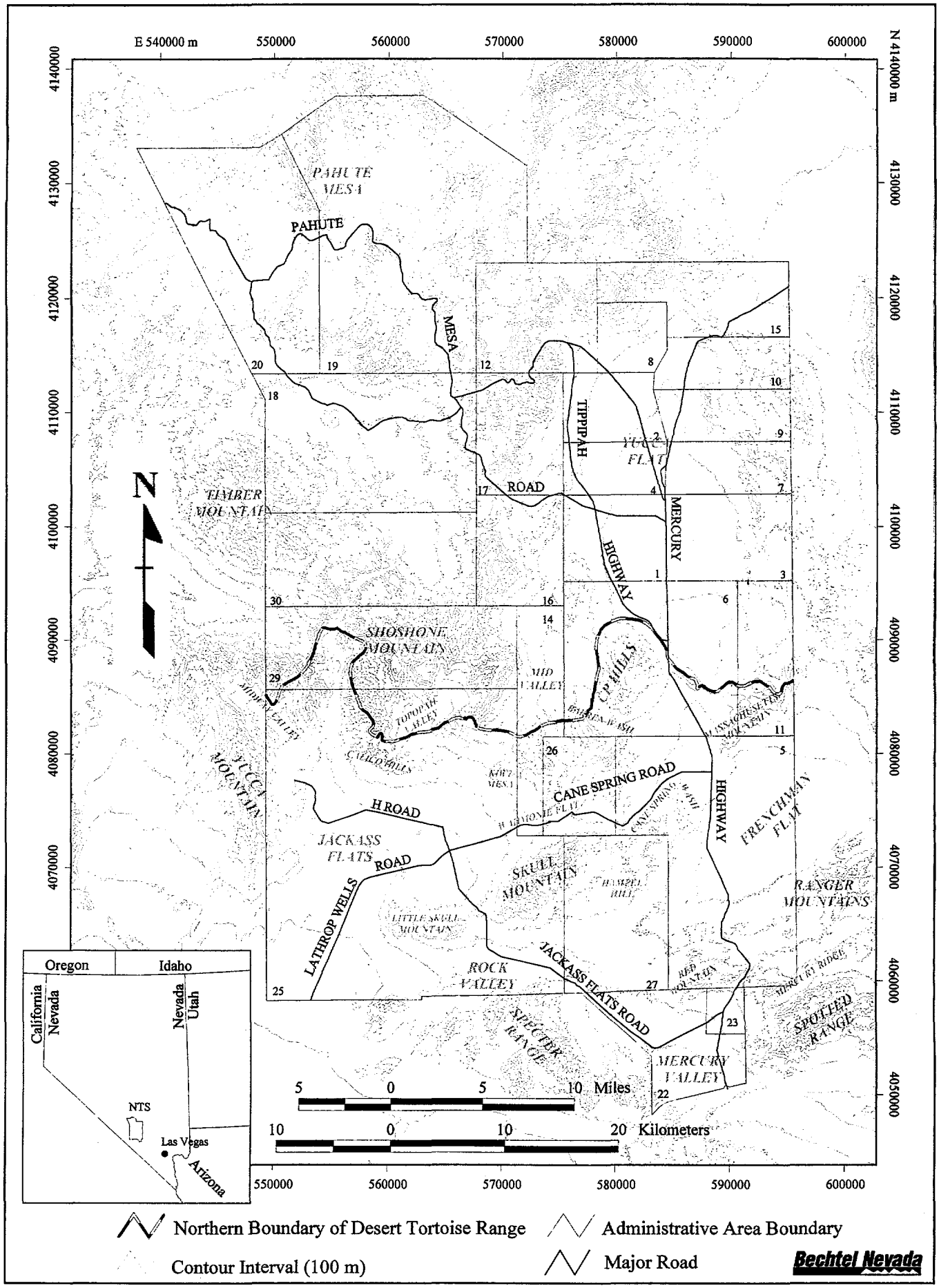

Figure 1. Major roads, topographic features, and administrative areas of the Nevada Test Site.

This Page Intentionally Left Blank

Table 1 Relationship of sign detected per kilometer of transect walked to categories of abundance of desert tortoises (from Karl, 1981)

Sign Detected/km Transect	Abundance Class	Density	
		Tortoises/mile^2	Tortoises/km^2
< 0.4	Very Low or None[a]	0-10	0-3.9
0.4–1.49	Low	10-45	3.9-17.4
1.5–2.99	Moderate	45-90	17.4-34.7
3.0–5.0	Moderately High	90-140	34.7-54.0
> 5.0	High	≥140	> 54.0

[a] Referred to as very low throughout this report.

slopes than in valley bottoms. They also were more common on or near limestone and dolomite mountains than on mountains of volcanic origin. Using the classification of vegetation associations developed by Beatley (1976), tortoises were rare or absent in the transition vegetation association on upper bajadas and mid-elevation valley bottoms dominated by blackbrush (*Coleogyne ramosissima*) and in the transition association found in the bottom of enclosed basins that is dominated by spiny hopsage (*Grayia spinosa*), wolfberry (*Lycium* spp.), and saltbush (*Atriplex* spp.). Tortoises were most abundant in mountainous areas with unclassified vegetation associations and in areas dominated by creosotebush (*Larrea tridentata*).

Additional studies were conducted at Yucca Mountain from 1989 through 1995 to evaluate the impacts of the Yucca Mountain Site Characterization Project on desert tortoises. During 1989, 55 km (34 mi) of transects were surveyed, primarily in Midway Valley and the slopes and ridges west of that valley, and an average of 0.85 sign was found per km walked (Karl, 1989). During ecological studies conducted from 1989 through 1995, 340 tortoises were marked in a 117-km^2 (45.2-mi^2) area (Lederle *et al.*, 1997). The minimum density of tortoises in two intensively studied areas (13 and 5 km^2 [5.0 and 1.9 mi^2]) was 11 to 13 adult tortoises per km^2 (28 to 34 per mi^2). These results suggest that tortoises are more abundant in Midway Valley and adjacent areas where these surveys and ecological studies were conducted, compared to other areas at Yucca Mountain that were surveyed during 1981-1984 (EG&G/EM, 1991).

Additional work also was conducted in Frenchman Flat during 1989-1995 to evaluate whether tortoises were present near the Radioactive Waste Management Site (RWMS) and the HAZMAT Spill Center. Twenty-nine preactivity surveys and eight zone-of-influence surveys, covering a total of 6.6 km^2 (2.5 mi^2), were conducted near the RWMS. Three preactivity surveys and two zone-of-influence surveys, covering 1.2 km^2 (0.5 mi^2), were conducted near the HAZMAT Spill Center. No tortoises or tortoise sign were found during any of these surveys (DOE/NV, unpublished data).

A study was conducted in 1993 to more accurately define the northern boundary of the range of desert tortoises on the NTS (Rautenstrauch *et al.*, 1994). Eighty-six, 30-m- (98-ft)-wide transects totaling 338.2 km (210.1 mi) were walked along this boundary and 53 tortoise sign were recorded. Tortoise sign was found along the northern edge of Jackass and Frenchman Flats.

Sign was found north of those valleys only in the Calico Hills at the south end of Topopah Valley and in the CP Hills at the extreme southern end of Yucca Flat. A revised map of the range of desert tortoises on the NTS was developed based on that study.

Based on these previous studies, DOE/NV and FWS identified two "exclusion zones" in Frenchman Flat where the likelihood of finding a tortoise was so low that they were excluded from the terms and conditions of the biological opinion. One of those zones is around the RWMS (Zone A, 29 km^2 [11 mi^2]) and the other is around the HAZMAT Spill Center (Zone B, 49 km^2 [19 mi^2]) (Figure 2). DOE/NV and FWS also identified 408 km^2 (157 mi^2) where a sufficient number of surveys had been conducted to determine that tortoises were absent or occurred at a very low abundance. In those areas, clearance surveys for desert tortoises are not required prior to ground-clearing activities, and an on-site monitor is not required during the activities (FWS, 1996, Appendix A). Those areas, labeled "none to very low" in *Figure 2*, include much of Mercury Valley, the Cane Springs Wash and Wahmonie Flats areas north of Skull Mountain, and the lower elevation areas in the middle of Jackass Flats. Also, 11 km^2 (44 mi^2) were identified where the abundance of tortoises was high enough to require all mitigation actions as specified in the terms and conditions of the biological opinion. These areas, labeled "low" in *Figure 2*, include the southern and eastern foothills and piedmont slopes of the CP Hills; the southern portion of Rock Valley along the edge of the Specter Range; an area in northeastern Jackass Flats, west of Kiwi Mesa; and the northern slopes and foothills of Mercury Ridge and Red Mountain, along the southern edge of Frenchman Flat. Insufficient data on tortoise abundance was available for an additional 533 km^2 (206 mi^2) (labeled "unknown" in *Figure 2*), within which DOE/NV is required to conduct all mitigation measures until sufficient information is collected.

During 1996, a new design was used in determining the relative abundance of desert tortoises on the NTS. That design involved conducting transect surveys for tortoises within ecological landform units (ELUs), which are small, ecologically homogeneous units of land (i.e., having similar elevation, slope, aspect, soil, geologic parent material, and vegetation throughout). ELUs are not to be confused with habitat types or vegetation types. They are simply small, uniform sampling units that could be defended as areas that are truly unoccupied or of very low tortoise abundance. Most previous efforts to determine the relative abundance of desert tortoises on the NTS involved walking numerous transects systematically placed within large, heterogeneous regions of the NTS. While the results of those surveys had application to large areas, they failed to identify the variability in habitat and tortoise abundance that exits in those large areas. For example, based on historical transects, the entire Mercury Valley received one classification, none to very low (*Figure 2*). It is known that there are some areas within Mercury Valley where desert tortoise abundance is low or even moderate. Utilizing smaller sample sizes allow this variability in tortoise abundance to be identified, if it exists. During 1996, 206 ELUs, totaling 528 km^2 (204 mi^2), were surveyed. Most of these ELUs were within the 533 km^2 (206 mi^2) previously classified as "unknown," having insufficient surveys to determine an abundance value. This report summarizes the results of those surveys and presents a new map of the relative abundance of desert tortoises on the NTS.

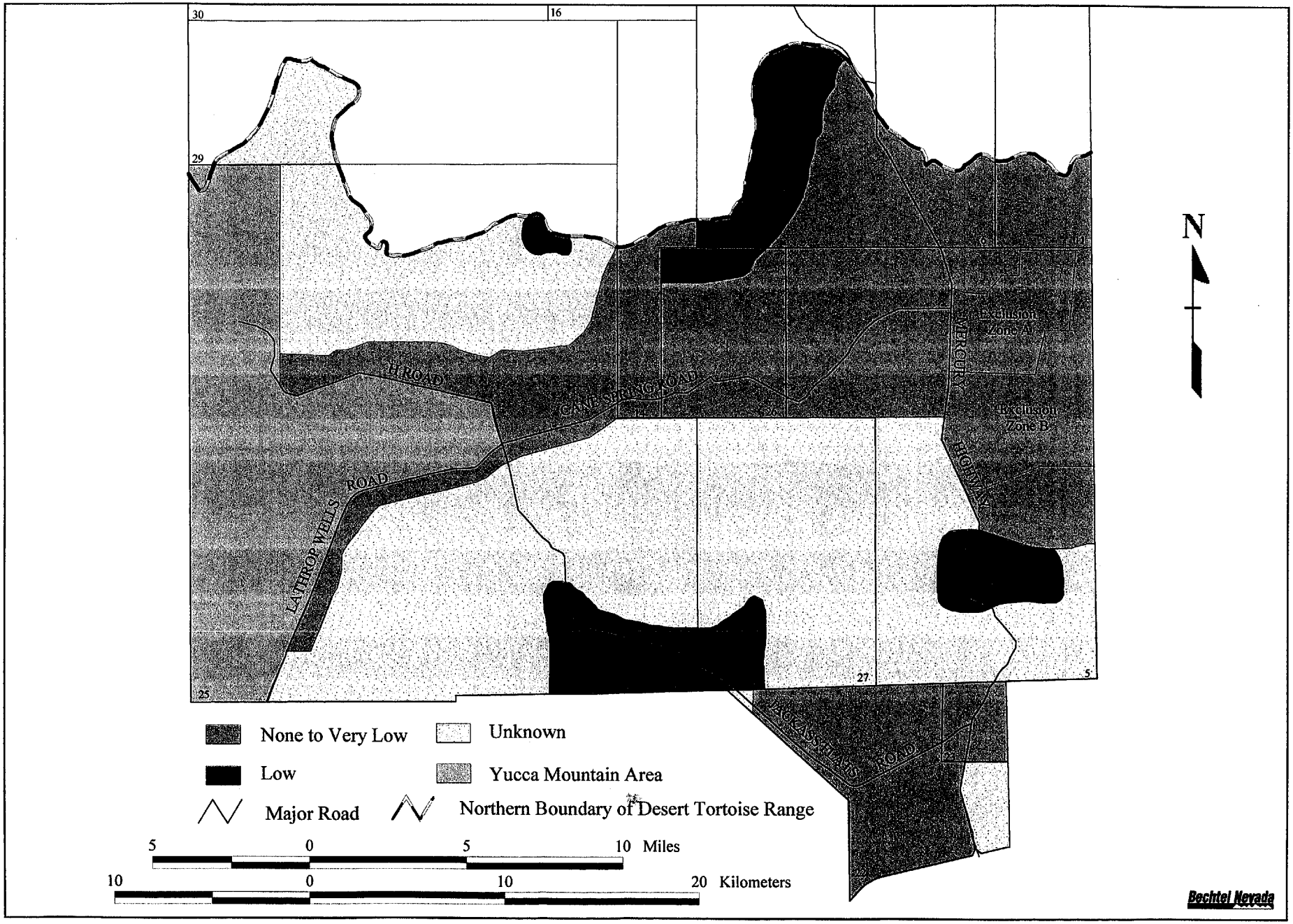

Figure 2. The relative abundance of desert tortoises on the Nevada Test Site prior to 1996 field surveys (adapted from FWS, 1996: Appendix A).

This Page Intentionally Left Blank

2.0 STUDY AREA

The natural environment within the range of the desert tortoise on the NTS has been described in detail by Beatley (1976), O'Farrell and Emery (1976), and EG&G/EM (1991). In this area, the landscape is dominated by two large valleys, Frenchman and Jackass Flats. During years of high precipitation, surface water collects and forms a shallow lake in the closed basin of Frenchman Flat (945 m elevation [3,100 ft]). Jackass Flats (915 m [3,000 ft]) and all smaller valleys in this region have drainage outlets. Elevations at the base of mountains in the southern third of the NTS range from 1,000 to 1,250 m (about 3,300 to 4,100 ft) and mountain peaks range from 1,400 to 1,800 m (about 4,600 to 5,900 ft). Most mountains in the southeastern part of the NTS (e.g., Ranger Mountains, Specter Range, Spotted Range, CP Hills) are primarily limestones, dolomites, or shales from the late Precambrian and Paleozoic eras. The mountains in the south-central and western parts of the NTS (e.g., Massachusetts, Skull, Timber, and Yucca Mountains) were formed primarily from volcanic activity during the Tertiary era (Stewart and Carlson, 1978; Frizzell and Shulters, 1990).

The NTS straddles the transition zone between the Mojave and Great Basin Deserts. Plant communities typical of the Mojave Desert are found in the southern part of the NTS in Jackass Flats, Rock Valley, Mercury Valley, and parts of Frenchman Flat. The visually dominant plant in these communities is creosotebush and, depending upon the area, white bursage (*Ambrosia dumosa*), shadscale saltbush (*Atriplex confertifolia*), spiny hopsage, and Anderson's wolfberry (*Lycium andersonii*) are the most common co-dominants. Within the transition zone between the two deserts, blackbrush is the dominant species on upper bajadas and in the bottoms of mid-elevation valleys with drainage outlets. Blackbrush occurs in mixed stands with creosotebush and other species at elevations between 1,200 and 1,370 m (about 3,937 to 4,495 ft), and in nearly pure stands between 1,370 and 1,500 m (about 4,495 to 4,921 ft).

The mean minimum and maximum daily temperatures at Camp Desert Rock (southeast corner of the NTS, elevation 1,005 m [3,300 ft]) during 1978-1986 were 9.6 and 24°C (49 and 75°F), respectively. The average annual precipitation was 19.3 centimeters (cm) (7.6 inches [in]) (unpublished data, U.S. National Weather Service, Nuclear Support Office, Camp Desert Rock, Nevada). Variations in climate throughout the site are described by Beatley (1975).

This Page Intentionally Left Blank

3.0 METHODS

The relative abundance of desert tortoises was measured during 1996 by walking transects within selected ELUs.

3.1 Identification of Ecological Landform Units

Ecological landform units were chosen as the sampling unit for this study because they are ecologically homogeneous units of land and thus are useful for making management decisions about biological resources. In addition, many of the biotic and abiotic characteristics used to delineate ELUs probably are important factors for habitat selection by desert tortoises. For example, soil characteristics measured within ELUs (e.g., texture) may be indicators of the ability of tortoises to dig and maintain burrows within an area (Wilson and Stager, 1992). Also, because annual plants make up a large portion of the diet of desert tortoises on the NTS (Nagy and Medica, 1986; Rakestraw *et al.*, 1995), productivity of those plants may influence the abundance of tortoises within an area. Thus ELUs may be useful for determining the pattern of relative abundance of desert tortoises on the NTS.

Ecological landform units were delineated for the southern portions of the NTS using 1:24,000-scale aerial photographs; SPOT (Satellite Pour l'Observation de la Terre) satellite imagery; and topographic, soil, and geological maps. Boundaries of ELUs were drawn on acetate overlays and transferred to digital prints of the Nevada Test Site Grid Map (DOE/NV, 1995).

3.2 Transect Selection and Survey Protocol

The relative abundance of desert tortoises was measured within selected ELUs by walking tortoise sign-survey transects using the methods of Berry and Nicholson (1984). This technique has been used to determine the relative abundance of desert tortoises throughout the range of this species in the United States (Luckenbach, 1982; Karl, 1980,1981; Berry, 1986).

Most of the ELUs selected to be surveyed were in or adjacent to areas of unknown tortoise abundance (*Figure 2*). In addition, some ELUs were surveyed in areas already classified as having a very low or low abundance of tortoises in order to compare the 1996 results with those from previous years. Most mountainous areas having an unknown abundance of tortoises, particularly Skull and Little Skull Mountains, were not sampled because these areas are not likely to be considered for future development activities.

The number and length of tortoise transects within each ELU was determined based on the size of the ELU, with approximately 2 percent of each ELU being sampled. Transects were 10 m (33 ft) wide, thus 1 hectare (ha) (2.5 acre [ac]) was sampled for each 1 km (0.6 mi) walked. The location and shape of transects were determined subjectively to include as much of each ELU as possible, and then were drawn on 1:24,000-scale topographic maps to allow field personnel to locate the starting point. Except in small or narrow ELUs, most transects were divided into segments that formed a closed triangle or four-sided polygon, allowing the observer to start and end the transect at the same point which enhanced sampling efficiency.

Each observer used a global positioning system unit to locate the starting point of each transect, and used compass bearings and pace counts to determine their location along the transect. All sign of desert tortoises observed within 5 m (16.4 ft) of either side of the transects was recorded. Sign was classified as tortoise, carcass, burrow, scat, or egg. Only burrows with the shape typical of burrows constructed by desert tortoises (i.e., flat floor and round roof; Luckenbach, 1982) were recorded. Number of sign observed per transect was adjusted by counting all sign found in a 1 m^2 (10.7 ft^2) area as one sign (Berry and Nicholson, 1984).

The total number of adjusted sign per km of transect was calculated. These values were translated into relative abundance classes using the conversion factors outlined by Karl (1981) for Lincoln and Nye counties, Nevada (*Table 1*).

3.3 Map Production

ELUs were used as the basic units for assigning relative abundance classifications. A total of 206 ELUs were classified and mapped based on the total number of adjusted sign per km of transect as discussed above. There were, however, over 700 ELUs within the range of the desert tortoise that were not sampled for relative abundance of tortoises during 1996. If any of these unsampled ELUs fell entirely within the boundaries of the "unknown," "none to very low," or "low" areas on the historical tortoise abundance map (*Figure 2*), they were assigned that historical classification. ELUs that overlapped classification boundaries on the historical map were assigned to whichever classification represented the greater percentage within that ELU; i.e. if >50 percent of an ELU fell within an area that was historically defined as having "unknown" tortoise abundance, and the rest of the ELU had been designated as "none to very low," then the entire ELU was classified as "unknown."

Sampled ELUs that overlapped into the Yucca Mountain Area were included in this analysis. Unsampled ELUs that overlapped into the Yucca Mountain area were classified using the historical classification and were also included in this analysis. ELUs that were entirely within the Yucca Mountain area were excluded from this analysis.

4.0 RESULTS AND DISCUSSION

4.1 Transect Surveys

Two-hundred and six ELUs were sampled (Figure 3) by walking 332 transects totaling 889 km (552 mi). These ELUs covered 528 km^2 (204 mi^2). Two-hundred and eighty-one sign were counted: 246 burrows, 14 scat, 12 carcasses, 7 tortoises, and 2 egg fragments. An average of 0.32 sign was found per km walked. This is the same as the average amount of sign found on 1,191 km (740 mi) of transects walked in the 1980s (EG&G/EM, 1991). An average of 4.43 km (2.8 mi) were sampled per ELU (range = 0.93-18.70 km [0.6-11.6 mi]), which is 2.4 percent of each ELU sampled.

One-hundred and forty ELUs, covering 367 km^2 (142 mi^2) (70 percent of the area sampled), had less than 0.4 sign found per km walked and therefore were classified as having a very low abundance of tortoises. No sign was found in 93 of these ELUs, covering 190 km^2 (74 mi^2) (36 percent of the area sampled). Sixty-three ELUs, covering 155 km^2 (60 mi^2) (29 percent of the area sampled), had from 0.4 to 1.49 sign per km walked and were classified as having a low abundance of tortoises. Three ELUs, covering 6 km^2 (2 mi^2) (1 percent of the area sampled), had more than 1.5 sign found per km and were classified as having a moderate abundance of tortoises. The greatest amount of sign found was 2.1 per km in a small (0.2-km^2 [0.1-mi^2]) ELU on the east side of Fortymile Wash in the northwestern corner of Jackass Flats.

In general, ELUs having a low or moderate abundance of tortoises were interspersed throughout those having a very low abundance (*Figure 3*). The largest contiguous concentration of ELUs with a low or moderate abundance was in the western portion of Mercury Valley (Area 22). Seven of nine ELUs, covering 20 of 33 km^2 sampled (8 of 13 mi^2) (61 percent), had a low or moderate abundance. These ELUs were in or near the low hills that separate Mercury and Rock Valleys to the north of the Specter Range. These ELUs are contiguous with the portion of Rock Valley classified in FWS (1996) as having a low abundance of tortoises (*Figure 2*). Three of nine other ELUs, covering 12 of 20 km^2 (5 of 8 mi^2) (60 percent) sampled in the eastern and southern portions of Mercury Valley, including two in Area 23 near Mercury, also had a low abundance. Mercury Valley was classified as having a very low abundance in FWS (1996). Based on 1996 surveys, it is apparent that much of this area has a low, rather than a very low, abundance of tortoises.

Twenty-two of 78 ELUs in Area 27 and the southern half of Area 5 had a low abundance of tortoises; the remainder had a very low abundance (*Figure 3*). These 22 ELUs covered 45 km^2 (17 mi^2) of the 161 km^2 (62 mi^2) (28 percent) sampled there. This region includes the upper piedmont slopes and hills in southern Frenchman Flat and the hills and mountains separating Rock and Mercury Valleys from Frenchman Flat (e.g., Mercury Ridge, Red Mountain, Hampel Hill). Much of this area was classified as having an unknown abundance of tortoises in FWS (1996).

Thirteen of 19 ELUs, covering 45 of 62 km^2 (18 of 24 mi^2) (73 percent) sampled in northern Area 5 and southern Are 6 in the northwest corner of Frenchman Flat and surrounding hills, had a very low abundance of tortoises (Figure 3). The six ELUs with a low abundance, covering

This Page Intentionally Left Blank

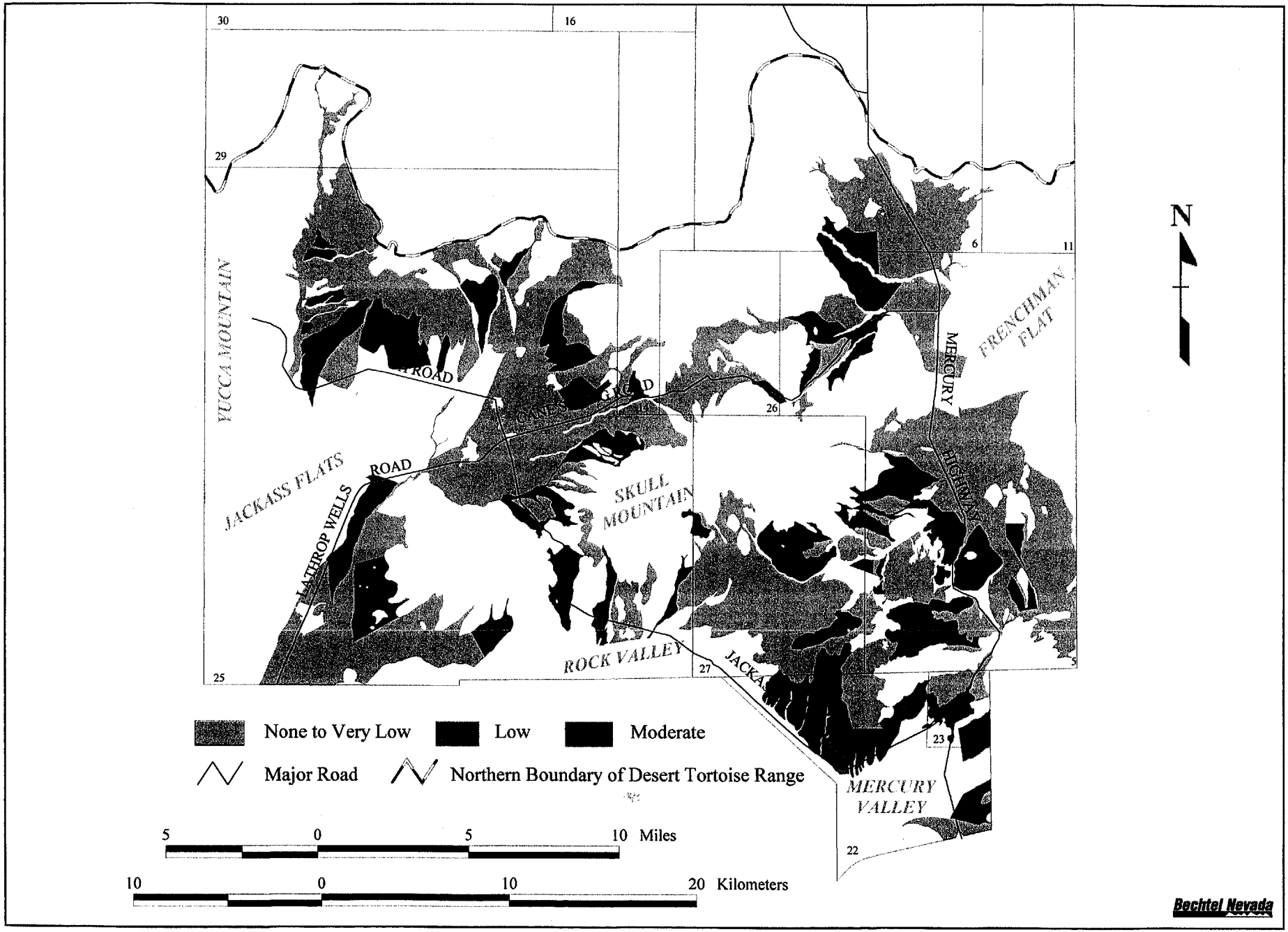

Figure 3. The relative abundance of desert tortoises on 206 ecological landform units on the Nevada Test Site surveyed during 1996.

This Page Intentionally Left Blank

17 km^2 (7 mi^2) (27 percent) were in the hills adjacent to or near Barren and Cane Spring Washes. Much of this region was classified as having a very low abundance of tortoises in FWS (1996).

As was found during previous surveys (EG&G/EM, 1991), most ELUs (26 of 43, covering 71 of 104 km^2 [28 of 40 mi^2] sampled, 68 percent) surveyed in northern Jackass Flats had a very low abundance of tortoises. There were, however, 18 ELUs (covering 33 km^2 [13 mi^2]) (32 percent) scattered along the middle and upper portions of the piedmont slope along northern and northeastern Jackass Flats that had a low or moderate abundance.

4.2 Revised Map of Tortoise Abundance

A revised map of the relative abundance of desert tortoises on the NTS (Figure 4) was created by combining the results of 1996 surveys with the historic classifications shown in *Figure 2*. In those ELUs where data from 1996 surveys differed from the previous classification, data from the 1996 surveys was used. Within the 1,330 km^2 (514 mi^2) of habitat on the NTS considered for this study, (including 154 km^2 [59 mi^2] of unclassified habitat in the western portion of the NTS being used by the Yucca Mountain Site Characterization Project), 658 km^2 (254 mi^2) (49 percent) are classified as having no tortoises or a very low abundance of tortoises. This includes most of Frenchman Flat (including the exclusion zones [*Figure 2*]), much of Jackass Flats, and portions of Mercury and Rock Valleys. Areas totaling 238 km^2 (92 mi^2) (18 percent) have a low abundance, primarily along the southern boundary of the NTS and in the CP Hills. Three small areas, totaling 6 km^2 (2 mi^2), have a moderate abundance of tortoises. The remaining 274 km^2 (106 mi^2) (21 percent of tortoise habitat on the NTS) still have insufficient data to determine abundance of tortoises. These areas primarily are on Skull Mountain, Little Skull Mountain, and in the Spotted Range.

Based on the original tortoise abundance map (*Figure 2*), 649 km^2 (250 mi^2) were classified as having an unknown or low tortoise abundance, and tortoise clearance surveys and on-site construction monitoring were required as mitigation within these areas. Based on the revised map (*Figure 4*), 518 km^2 (200 mi^2) are currently classified as having unknown, low, or moderate tortoise abundance and tortoise clearance surveys and on-site construction monitoring are required in these areas. Therefore, the amount of tortoise habitat on the NTS requiring mitigation decreased by 20 percent (131 km^2 [51 mi^2]).

In summary, transect surveys conducted in 1996 provide additional information about the pattern of relative abundance of desert tortoises on the NTS. As has been found in previous efforts on the NTS, most areas surveyed in 1996 had a very low abundance of tortoises. Areas with a higher abundance generally were in the southeastern part of the NTS and in or near hills and the base of mountains. These surveys resulted in a more accurate map of tortoise abundance for land-use planning. Mitigation efforts can be focused in a cost-effective manner on those areas of the NTS where desert tortoises are most abundant.

This Page Intentionally Left Blank

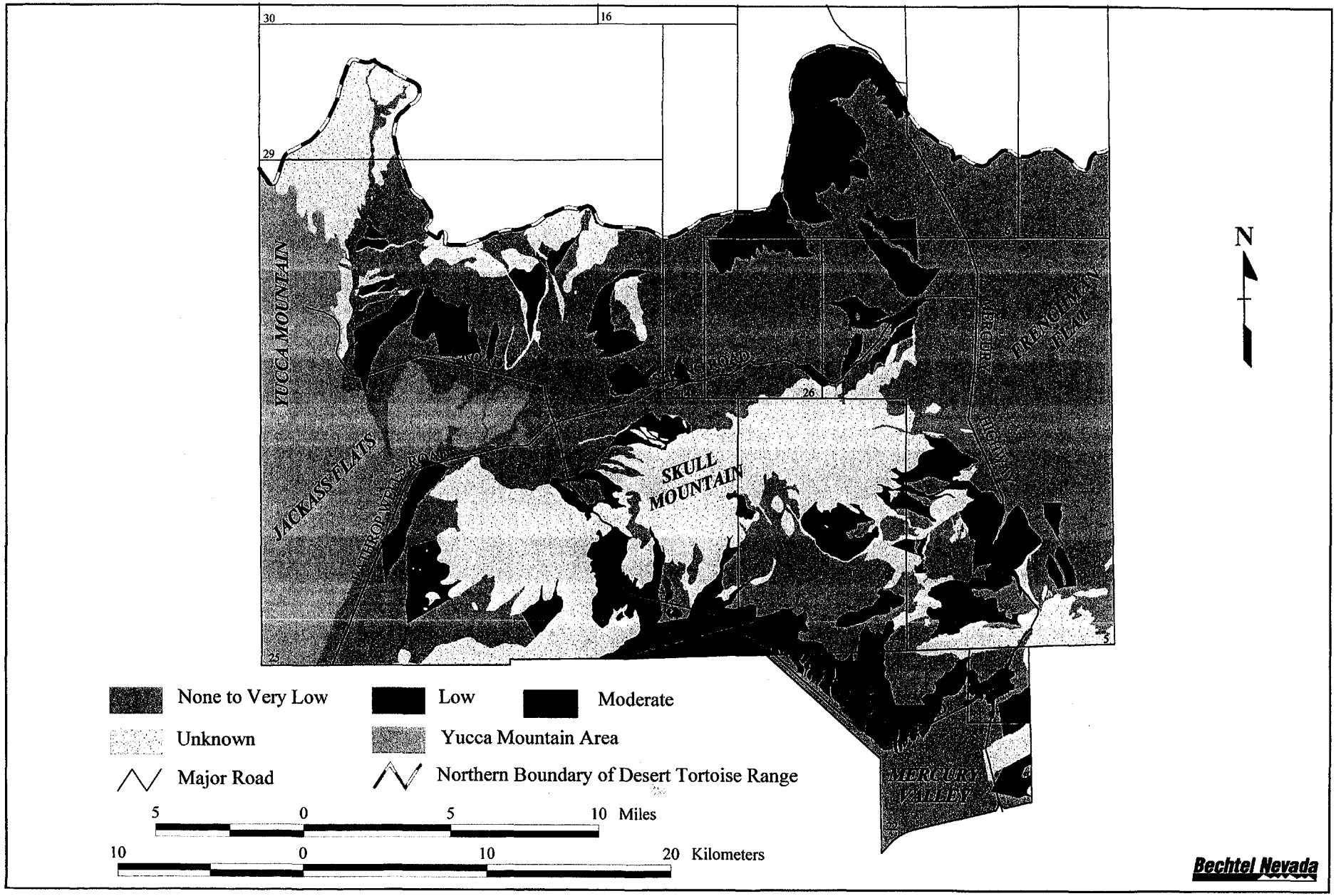

Figure 4. The relative abundance of desert tortoises on the Nevada Test Site, based on 1996 field surveys and historic data (FWS, 1996: Appendix A).

This Page Intentionally Left Blank

5.0 LITERATURE CITED

Beatley, J. C., 1976. Vascular plants of the Nevada Test Site and central-southern Nevada: ecologic and geographic distributions. TID-26881. National Technical Information Service, Springfield, Virginia.

——, 1975. Climates and vegetation pattern across the Mojave/Great Basin Desert transition of southern Nevada. *American Midland Naturalist* 93:53-70

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

Berry, K. H., and L. L. Nicholson, 1984. The distribution and density of desert tortoise populations in California in the 1970s. Pages 26-60. *In*: K. H. Berry (ed.), The status of the desert tortoise (*Gopherus agassizii*) in the United States. Desert Tortoise Council Report to U.S. Fish and Wildlife Service on Order No. 11310-0083-81. Portland, Oregon.

DOE/NV [U.S. Department of Energy, Nevada Operations Office], 1995. Nevada Test Site Grid Map, A Grid System Photo Locator Map of The Nevada Test Site. U.S. Department of Energy, Remote Sensing Laboratory, Las Vegas, Nevada.

EG&G/EM [EG&G Energy Measurements, Inc.], 1991. The distribution and abundance of desert tortoises on the Nevada Test Site. EGG 10617-2081. National Technical Information Service, Springfield, Virginia.

Frizzell, V. A., Jr., and J. Shulters, 1990. Geologic map of the Nevada Test Site, southern Nevada. U.S. Geological Survey, Miscellaneous Investigations Series Map I-2046.

FWS [U.S. Fish and Wildlife Service], 1996. Final Programmatic Biological Opinion for Nevada Test Site Activities. U.S. Fish and Wildlife Service, Reno, Nevada.

——, 1990. Endangered and threatened wildlife and plants; determination of threatened status for the Mojave population of the desert tortoise. Federal Register, 55:12178-12191.

Karl, A. E., 1989. Yucca Mountain Project: Investigations of desert tortoise abundance and distribution on the Focused Baseline Study Area, Fall 1989 field studies. Report prepared for Environmental Science Associates, Inc., San Francisco, California.

——, 1981. Distribution and relative densities of the desert tortoise, *Gopherus agassizii*, in Lincoln and Nye counties, Nevada. Proceedings of the Desert Tortoise Council Symposium 1981:76-92.

———, 1980. Distribution and relative densities of the desert tortoise in Nevada. Proceedings of the Desert Tortoise Council Symposium 1980:75-87.

Lederle, P. E., K. R. Rautenstrauch, D. L. Rakestraw, and J. M. Mueller, 1997. The distribution and relative abundance of desert tortoises at Yucca Mountain. U.S. Department of Energy, Civilian Radioactive Waste Management, Management and Operating Contractor Report B00000000-01717-5705-00033 REV 00. Las Vegas, Nevada.

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 Research Report 12. Washington, D.C.

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 L. A. Emery, 1976. Ecology of the Nevada Test Site: a narrative summary and annotated bibliography. EGG 10282-2031. National Technical Information Service, Springfield, Virginia.

Rakestraw, D. L., E. A. Holt, and K. R. Rautenstrauch, 1995. Diet of desert tortoises at Yucca Mountain, Nevada, and implications for habitat reclamation. U.S. Department of Energy, Civilian Radioactive Waste Management, Management and Operating Contractor Report B00000000-01717-5705-00028. Las Vegas, Nevada.

Rautenstrauch, K. R., G.A. Brown, and R. G. Goodwin, 1994. The northern boundary of the desert tortoise range on the Nevada Test Site. EGG 11265-1103. National Technical Information Service, Springfield, Virginia.

Stewart, J. H., and J. E. Carlson, 1978. Geological map of Nevada (1:500,000 scale). U.S. Geological Survey and Nevada Bureau of Mines and Geology, Reston, Virginia.

Wilson, R. W., and R. D. Stager, 1992. Desert tortoise population densities and distribution, Paiute Valley, Nevada. *Rangelands* 14:239-242.

DISTRIBUTION

U.S. Department of Energy,
Nevada Operations Office
Las Vegas, Nevada
Joe Fiore, AMNS
Kennith Hoar, EPD
Robert Furlow, EPD
Technical Information Resource Center
Public Reading Facility

U.S. Department of Energy,
Yucca Mountain Site Characterization Office
Las Vegas, Nevada
Wendy Dixon (2)

U.S. Bureau of Land Management
Las Vegas, Nevada
Sidney Slone

U.S. Fish and Wildlife Service, Suboffice No. 1
Las Vegas Field Office
Las Vegas, Nevada
Michael Burroughs

U.S. Fish and Wildlife Service, Nevada State Office
Reno, Nevada
Robert Williams

U.S. Geological Survey, Biological Resources Division
Las Vegas, Nevada
Philip Medica

Desert National Wildlife Refuge Complex
Las Vegas, Nevada
Richard Birger

Death Valley National Park
Death Valley, California
Richard Martin

Nellis Air Force Base
Las Vegas, Nevada
Susan Barrow (2)

Nevada Department of Wildlife, Region I II
Las Vegas, Nevada
Mike Wickersham

Ash Meadows National Wildlife Refuge
Ash Meadows, Nevada
David Ledig

Bechtel Nevada
Environmental Monitoring
North Las Vegas, Nevada
Susan Livenick (7)

Defense Special Weapons Agency
Mercury, Nevada
Laurence Ashbaugh

Desert Research Institute
Las Vegas, Nevada
Roger Jacobson (3)

University of Nevada Las Vegas,
Harry Reid Center for Environmental Studies
Las Vegas, Nevada
Don Baepler

IT Corporation
Las Vegas, Nevada
Mary Lou Brown

Nevada Natural Heritage Program
Carson City, Nevada
Glenn Clemmer

Lawrence Livermore National Laboratory
Las Vegas, Nevada
Willie Cooper

Los Alamos National Laboratory
Las Vegas, Nevada
Jim Ogle

Sandia National Laboratories
Las Vegas, Nevada
Larry Posey

The Nature Conservancy
Las Vegas, Nevada
James Moore

DOE Office of Scientific and Technical Information
Oakridge, Tennessee (2)