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ENVIRONMENTAL ASSESSMENT FOR SPILL TESTS OF NH_3 AND N_2O_4 AT FRENCHMAN FLAT, NEVADA TEST SITE

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August 1983

I. SUMMARY

Lawrence Livermore National Laboratory (LLNL) has assessed the environmental effects of a proposed series of liquefied ammonia (NH_3) and nitrogen tetroxide (N_2O_4) spill tests. This short-term program of field experiments is designed to simulate accidental releases of these materials from pressurized transport and storage vessels. The information gained from these studies is needed to determine the safety problems presented by accidental spills and to develop better models to predict the dispersion behavior of these heavy gases.

The proposed location for this series of spill tests is Frenchman Flat on the Nevada Test Site (NTS). Frenchman Flat is a desert alluvial basin with a dry lake bed or playa at the center. It was selected because it meets geophysical and meteorological requirements, it is remote from population centers, it is on a federal installation with controlled access, and it is advantageous in terms of cost and logistics.

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No permanent facilities would be constructed and surface disturbance would be minimal. The major concern is for the effects of the experimental releases of NH_3 and N_2O_4, gases that are toxic at high concentrations. The scope of the tests is such that Nevada guidelines for significant emission rates would not be exceeded. A modified Gaussian plume model was used to compute the downwind range to various significant concentrations of NH_3 and NO_2. These calculations were then used to estimate the potential effects of the spill tests on natural vegetation and wildlife. The highest NH_3 and NO_2 concentrations would be largely confined to the barren playa. No threatened or endangered plant or animal species are present in the test area.

II. PURPOSE AND NEED FOR ACTION

The proposed field experiments are designed to investigate the behavior of liquefied ammonia (NH_3) and nitrogen tetroxide (N_2O_4) when released into the atmosphere. These tests will simulate accidental truck-load sized spills of the two liquids in order to achieve better understanding of the safety problems posed by such incidents. The proposed series of NH_3 tests will help to meet the safety requirements of the United States Coast Guard (USCG), The Fertilizer Institute (TFI), and other interested organizations. The proposed N_2O_4 research will help to define the hazards that might be posed by atmospheric release of this rocket-fuel oxidizer. It will meet the needs of the United States Air Force (USAF) Engineering Services Laboratory (Environics Division), Tyndall Air Force Base, its affiliates at Hill Air Force Base, and the USAF Space Division.

The proposed experimental program is needed to achieve a better understanding of the movement and dispersion of liquefied NH_3 and N_2O_4 upon accidental release onto land from pressurized transport or storage vessels. Because these gases are heavier than air at the time of vaporization, they do not obey the classical laws of atmospheric dispersion. Existing dispersion models may not be adequate to predict the behavior of these hazardous substances. For example, liquefied NH_3 forms a liquid aerosol when released from a pressurized containment tank; subsequent evaporation and adiabatic cooling produces a cold, dense vapor cloud which existing models may not treat adequately. Nitrogen tetroxide will dissociate into a mixture of N_2O_4 and nitrogen dioxide (NO_2) as it disperses. This results in an effective decrease in the molecular weight of the mixture that must be coupled with the appropriate atmospheric dispersion parameters to adequately predict downwind concentrations. Other effects, such as deposition on the ground and oxidation may also be important and require investigation.

The Liquefied Gaseous Fuels (LGF) Program of LLNL has been involved since 1978 in field experiments similar to those proposed here. The LGF Program has thus far concentrated primarily on the hazards associated with atmospheric releases of liquefied natural gas (LNG). However, NH_3 and N_2O_4 are also dense gases with properties similar to LNG. They can be studied economically using the experimental and analytical tools developed for LNG. Thus, the proposed investigations are a logical extension of past LLNL work. Although the limited scope and short duration of the proposed experimental program will not allow a complete evaluation of dispersion models under a variety of atmospheric conditions, it does represent an ambitious first step in that direction.

III. DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

A. The Proposed Action

1. Introduction

LLNL proposes to conduct a series of tests, supported by the USCG and the USAF, at Frenchman Flat on the NTS to simulate accidental, tanker truck-sized spills for each of two liquefied gases. Each liquid, NH_3 and N_2O_4, would be spilled to investigate the safety problems they present during accidental release. In both cases, the tests would be conducted in the summer during the morning or early afternoon, so that dispersing vapors will briefly attain concentrations which are odorous, but not life threatening, at a range not more than 5.5 km (3.4 mi) *downwind* from the spill. Life-threatening concentrations will be largely confined to a barren playa (dry lake). The test series is proposed to be conducted over a two-to-three-month period. Each spill in the test series would be less than 10-min duration, and only about two tests would be conducted per week. Less than 140 tons of NH_3 (seven tanker trucks) and less than 40 tons of N_2O_4 (three tanker trucks) will be the total spilled.

No construction or permanent facility is proposed; a trailer park for command and control functions would be installed at a safe distance upwind. Holding tankers, dispensing equipment, monitoring equipment, and meteorological towers would all be installed on a temporary basis.

2. Project Description

The spill release point would be located near the southwest end of Frenchman Flat playa (dry lake) to take advantage of the persistent southwest winds. During a spill, approximately 3.2 km (2 mi) of the barren playa will lie in the immediate downwind direction. The liquids will be transported in approved tanker trailers and stored at NTS prior to testing. They will be moved to the Frenchman Flat spill area, where they will be released from the tanker trailer. When necessary, the liquids will be forced out of the tanker by high-pressure nitrogen gas from a standard trailer which will be located nearby.

Existing 10-m tall towers, 6-m tall masts, tower bases, gas sensors, anemometers, cameras, and other equipment will be set up on the playa in a wedge-shaped array downwind, along a southwest-northeast centerline passing through the spill point. The instrument arrangement will remain fixed throughout the series of tests, except for replacement of sensors between tests and other minor changes. A radio telemetry system will send data to the command and control trailer for display in real time. Wind and turbulence data from this network of towers will be used to determine when the wind is sufficiently steady and has a satisfactory speed and direction such that a test can be performed safely. Gas sensors will detect when the vapor cloud has passed the array, and if necessary, when a spill should be terminated. Special meteorological data will be obtained using a 20-m tower upwind of the spill point to determine the vertical wind profile and the atmospheric stability. TV and motion-picture cameras at fixed locations will be set up to view the spill area and to give a side view of the cloud some distance downwind of the spill point. TV monitors will be placed in the command and control trailer. The vapors of NH_3 and of N_2O_4 will be visible at distances close to the spill point because of aerosol droplet formation and light absorption, respectively. The initial vapor cloud size and direction of vapor cloud travel will be easily monitored.

Only a small number of tests would be performed in the proposed series and each spill would be less than 10 min duration. It is likely that for the NH_3 tests only four to six tests could be performed over a nominal one-month test period. Most of these will involve about 30 m^3 (7,900 gal) of liquid with one large test of 60 m^3 (15,800 gal). For the N_2O_4 there will be three kinds of experiments conducted over a one-month period: (1) portable foam vapor suppression system (PFVSS) tests--three to four spills (2-3 m^3 each), (2) dispersion tests--two spills (4-5 m^3 each), and (3) source definition tests--three to four spills (1-3 m^3 each). Thus, the total number of tests performed is estimated to be less than six NH_3 spills and less than ten N_2O_4 spills, and the series of tests would be completed in about two months of operation.

Upon completion of the tests, all trailers, towers, and other residuals and remaining equipment will be removed within three months of completion unless otherwise extended by permission from the DOE. Other similar tests may be proposed to utilize the equipment and be approved at the discretion of DOE. Any such tests will be proposed within a separate environmental assessment.

3. Project Operation

The spill test procedures will begin on the day preceeding a test with a readiness briefing presented to the DOE Representative by the Test Director. A security check will be made four hours prior to test to exclude all but designated test personnel. A follow-up weather and readiness briefing will be made three hours prior to the test. A facility control checklist will be started at the command and control center two hours prior to the test. At 45 min prior to the test, the Test Director will request permission to arm the spill facility, that is, to open a manual shutoff valve. At 20 min prior to test the facility will be pressurized and ready. The test will then be carried out, and the Test Director will advise the DOE Representative that the facility is ready to secure. Finally, the DOE Representative will release the facility for survey, and security guards can open the area to normal activity.

There will be no classified aspects of the proposed experiments. Therefore, the only security measures to be considered have to do with possible hazards of exposure to toxic vapors.

4. Hazardous Vapors

The proposed tests are designed to improve methods for safe transport and storage of NH_3 and N_2O_4 and for hazards forecasting in the event of accidental spills. Thus, it will be necessarily to handle and release these hazardous fluids in a safe and controlled manner during the study. Table 3.1 indicates the effects and exposure limits of various concentrations of NH_3 and N_2O_4.

Table 3.1

A Guide to the Effects of NH_3 and N_2O_4 at Various Concentrations

(Parts-per-Million by Volume)

	NH_3	N_2O_4 (as NO_2)
Immediately Dangerous[1]	> 2500 ppm	> 100 ppm
Emergency Exposure Limit (USAF)[2]	500 ppm (10 min)	30 ppm (10 min)
Permissible Exposure Limit (OSHA)[1]	50 ppm (8 hrs)	3 ppm (8 hrs)
Approximate Tolerant Odor[1,3]	25 ppm	3 ppm
Threshold Limit Value-Short Term Exposure Limit (TLV-STEL)[4]	35 ppm (15 min)	5 ppm (15 min)
Threshold Limit Value-Time Weighted Average (TLV-TWA)[4]	25 ppm (8 hrs)	3 ppm (8 hrs)

1 Occupational Health Guidelines, U.S. Dept. of Health and Human Services and U.S. Dept. of Labor

2 USAF Aerospace Medicine, Chemical Rocket Propellant Hazards, Vol. II, AFM 161-30 (1973).

3 Odor threshold for NH_3 is 5 ppm, but is unobjectionable to some at 50 ppm. Odor threshold for NO_2 is 3 ppm.

4 ACGIH (1979) American Conference of Governmental Industrial Hygienists, standard for chemical substances in the work place.

5. Personnel

There will be no more than six LLNL scientific and engineering personnel on duty to carry out the proposed series of tests. Other personnel involved will be the existing staff of NTS agencies, such as operations, weather, security, medical services, fire protection services, engineering and construction services for the trailer park, and others as may be required. Personnel from the USCG, the USAF, and other associated sponsors may be occasional visitors.

B. Alternatives to the Proposed Action

1. No Project

If this alternative is adopted, the proposed NH_3 and N_2O_4 spill tests will not be carried out. This is not considered to be a viable alternative, since this research is urgently needed to provide experimental data for verification and normalization of computer models which predict the effects of accidents involving these substances. The information will be used to make safer the shipping, storage, and handling of these substances.

2. Tests of a Different Magnitude

The scope of the project and the size of the tests could be reduced. However, this is not a reasonable alternative. Tests of the proposed magnitudes are the logical and necessary next steps beyond tests performed in the past. The proposed tests would effectively reproduce what might happen in the case of a tanker truck or railroad tanker accident. The data will be used to validate computer codes for accidents up to and perhaps somewhat beyond this size.

IV. EXISTING ENVIRONMENT

A. General Description and Land Use

Frenchman Flat is a desert alluvial basin with a playa (dry lake bed) in the center. It is on the east side of Area 5 of the NTS, astride the NTS-Nellis Air Force Range (AFR) boundary. The area is 17 km north of Mercury, Nevada (a DOE support facility on the NTS), and about 80 km northwest of Las Vegas, Nevada. The western boundary of the Desert National Wildlife Range (DNWR) is 3 km east of the NTS-Nellis boundary (Figs. 4.1 and 4.2). A shallow-burial storage site for low-level radioactive waste is 4 km north of the playa. Two km further north is a support location for the Defense Nuclear Agency (DNA), which is occasionally used for their projects. Mercury Highway, the main north-south access road in NTS, is 6 km west of the playa. Frenchman Flat has been used in the past for nuclear bomb tests, underground nuclear bomb tests, and non-nuclear explosives tests. Currently the area is occasionally used for non-nuclear explosives testing (U.S. Energy Research & Development Administration, 1977; U.S. Department of Interior, BLM, 1980). There will be no interference with these tests.

NTS is surrounded on the north, west, and east by Nellis AFR, except for approximately 19 km of the western boundary which is adjacent to public land administered by the Bureau of Land Management (BLM). Nellis AFR is used for bombing and gunnery practice. The portion of Frenchman Flat that is within Nellis AFR is not used as a practice range, though military aircraft do occasionally fly over. The large areas of desert to the south-east and west of NTS have been used for mining, farming, and grazing. The area is currently a sparsely populated rural region; the main economic activities are mining and grazing. The southern area is crossed by US Highway 95 which passes through Beatty (pop. 500, 75 km from Frenchman Flat), Lathrop Wells (pop. 40, distance 46 km), and Indian Springs (pop. 1800, distance 30 km). To the east of Nellis AFR is Highway 93. The nearest community in this area is Alamo (pop. 500), 90 km to the northeast of Frenchman Flat (U.S. Energy Research & Development Administration, 1977; U.S. Department of Interior, BLM, 1980).

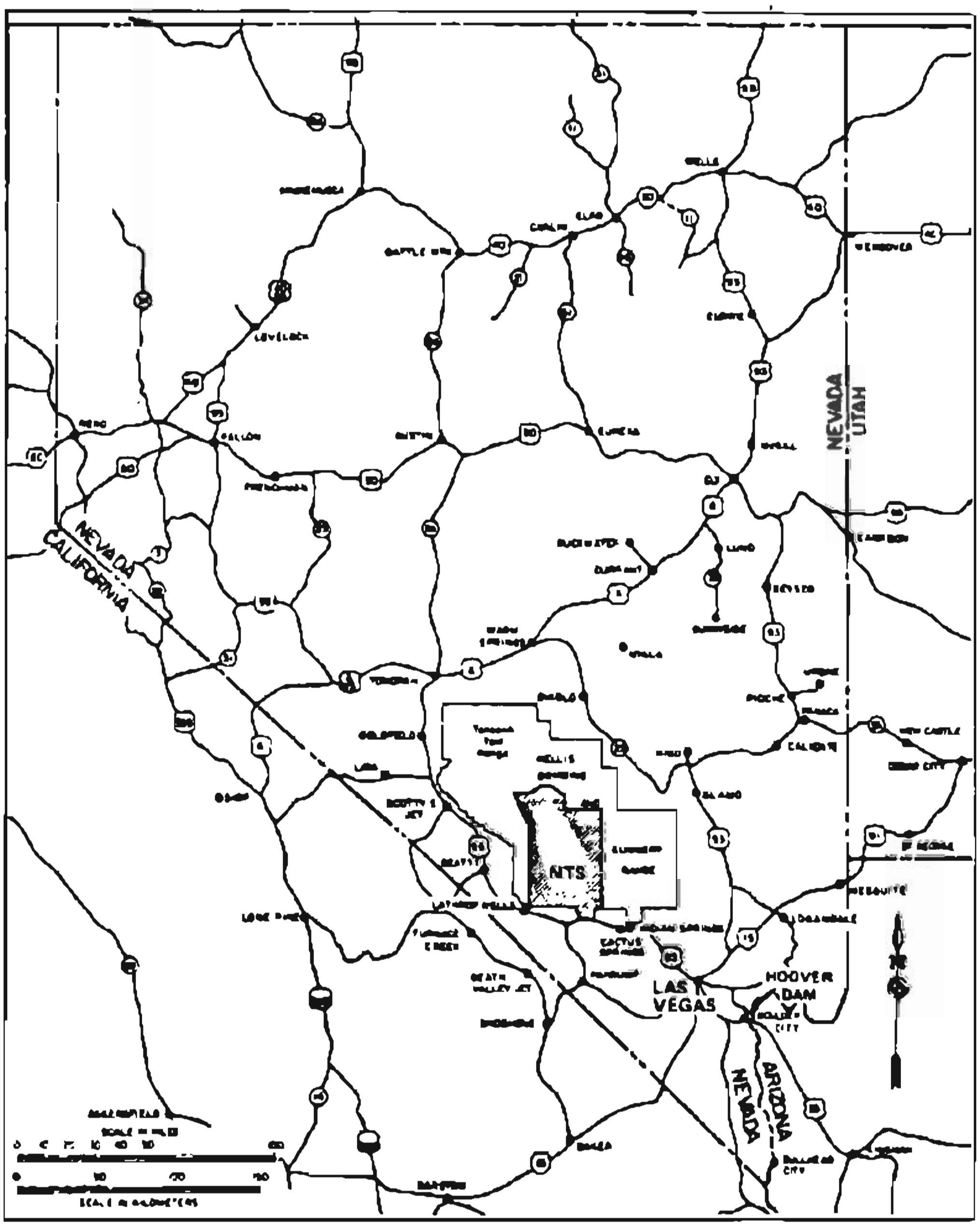

Fig. 4.1. Location Map, Nevada Test Site Environs.

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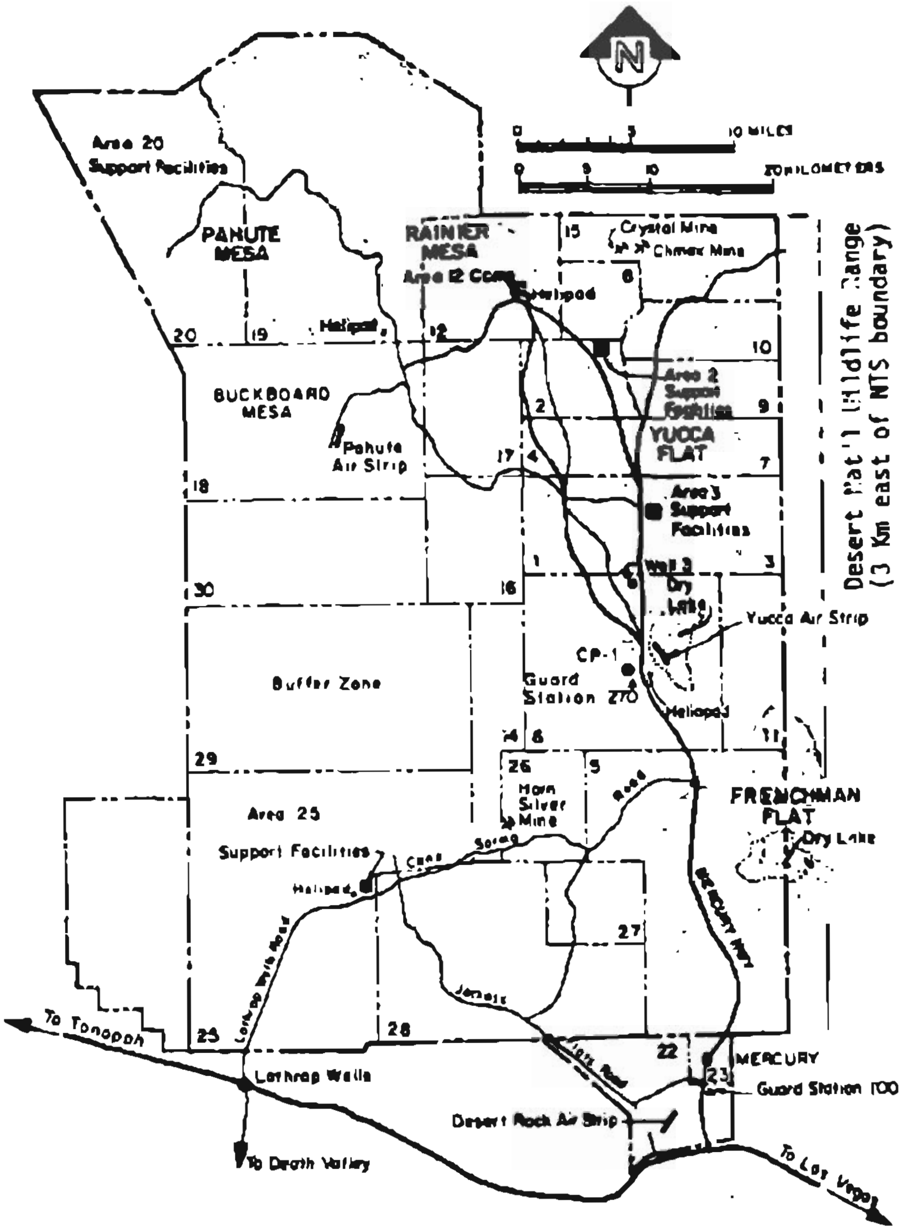

Fig. 4.2. Nevada Test Site, Frenchman Flat Location.

B. Topography, Geography, and Soils

Frenchman Flat is one of the three main valleys in NTS (Fig. 4.3). It is an oval-shaped basin with a large flat playa in the center and no external drainage for water. The walls of the basin are formed by mountains and ridges. Between the mountains and the valley floor are bajadas, sloping alluvial fans that merge with the valley floor (U.S. Energy Research & Development Administration, 1977; U.S. Department of Interior, BLM, 1980). The mountains are composed of Paleozoic sea-bed sediments consisting of limestone, dolomite, quartzite, shale, and conglomerates. During the Mesozoic period they were upthrust and folded. Portions of the mountains were covered with Tertiary volcanic deposits, principally rhyolitic and quartz-latitic tuffs. Quaternary deposits of eroded material from the surrounding mountains form the bajadas. The playa itself is formed of sedimentary deposits over 300 m deep which are derived from the surrounding mountains and bajadas. Its sands, gravels, silts, and clays form a level flood plain. Because the sediments are relatively impervious to water, large shallow ponds form on the playa during wet weather, their size varying from year to year (O'Farrell et al., 1965; U.S. Energy Research & Development Administration, 1977).

In addition to the natural features, there are several man-made topographic features. The center of the playa contains a large blast circle from the Small Boy surface nuclear blast. There are several subsidence craters from underground nuclear tests just north of the playa. On the northwest side of the playa there is a pond formed by dikes that contains water from a tritium migration test well (RNM2S). There is a continuous flow of water into the pond at a rate of 600 gpm. There are four wells on the west edge of the playa that supply potable water to the town of Mercury (U.S. Energy Research & Development Administration, 1977).

The soils of Frenchman Flat area are typical desert soils, formed slowly under conditions of low moisture and high temperature. The soils have formed over a mixture of limestone and alluvium, and tend to be quite alkaline (pH 8-9). Where there is a high proportion of limestone, such as in the southern portion of Frenchman Flat, the soils have high carbonate levels. This leads to the development of a restrictive hardpan, usually within 70 cm of the surface.

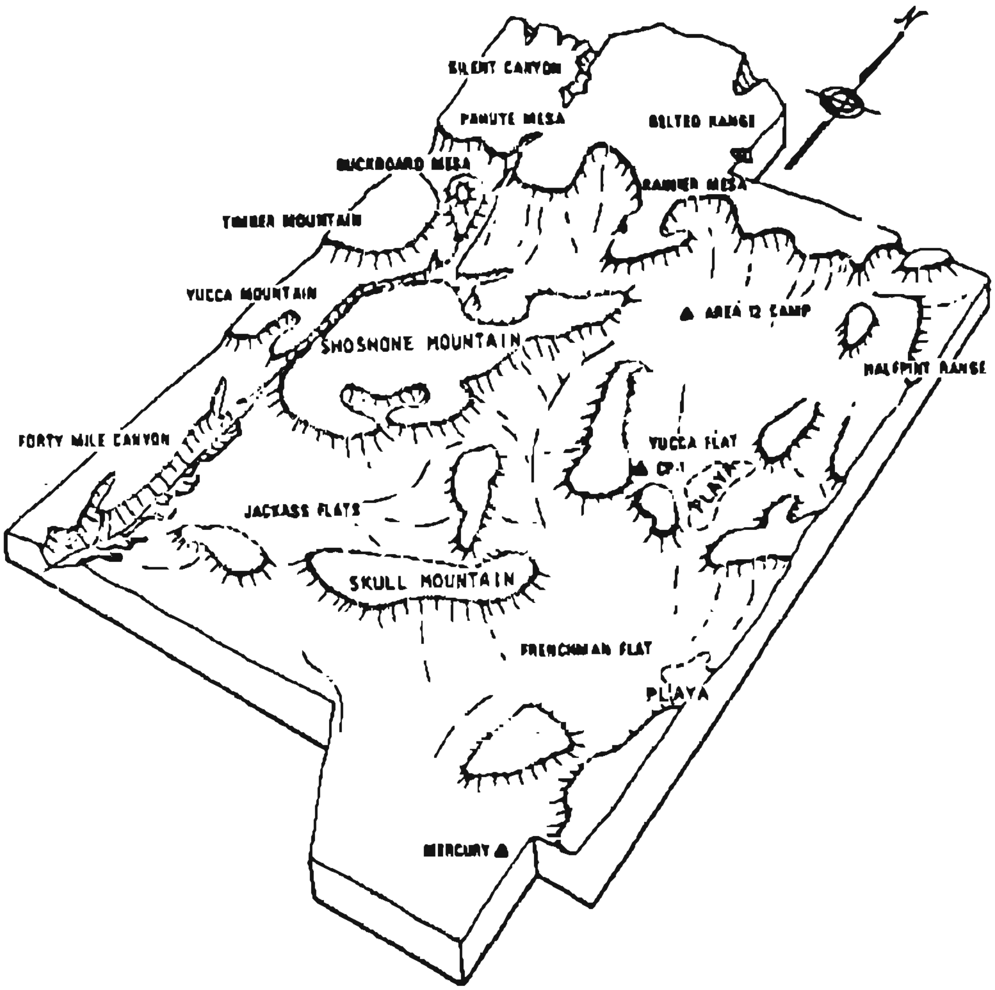

Fig. 4.3. Topography of Nevada Test Site.

The coarsest soils are found near the mountains and bajadas. Finer textured soils are found in the valleys and flats. They have little moisture retention capacity and almost no organic material in them. Because Frenchman Flat is a closed basin the lower elevation soils accumulate salts. The soils in and around Frenchman Flat have the highest salt concentrations of any of the soils on the NTS (O'Farrell et al., 1976; Allred et al., 1963; Romney et al., 1973).

C. Climate and Meteorology

There are two major air movement patterns that effect the weather at NTS. Pacific air flowing over the Sierra Nevada exerts its influence from fall through spring. Then, as the Pacific high-pressure area dissipates in summer, the warm, moist airmass in the Gulf of Mexico exerts its influence. This leads to two peaks in rainfall, the larger in winter and the smaller in late summer. The July and August summer rainfall often comes in intense thunderstorms that can cause local flashfloods. The average annual precipitation is largely a function of altitude within this region, with higher elevations receiving more than lower elevations. The valley floors, such as Frenchman Flat, average about 10 cm of precipitation per year. The higher mesas and mountains average 30 cm, with some precipitation falling as snow (U.S. Energy Research & Development Administration, 1977).

Average daily temperatures are lowest in January (2°C) and highest in August (24°C). Large daily fluctuations in temperature are common, especially on the valley floors. January temperatures at Frenchman Flat vary from -3°C to 12°C during a 24 hr period, while July temperatures show a daily range from 17°C to 36°C. At higher elevations the daily variation in temperature is not as pronounced. Winter temperatures are low there and the daily range is only a few degrees; in the summer the daily range may be more than 10°C (U.S. Energy Research & Development Administration, 1977).

There are three main influences on the directional wind patterns at the NTS: 1) large-scale movement of major air-pressure systems, 2) intermediate-scale air movements due to regional topographic features, and 3) localized effects due to terrain (Quiring, 1968). As with rainfall, the Pacific airmass influences the winds from fall through spring, while the Gulf of Mexico airmass controls the summer wind pattern. Northerly winds predominate in winter and southerly winds in summer. Since there is a general topographic trend toward higher elevations in the northern portion of the NTS, the differential heating of the surface results in southerly (upslope) winds during the day and northerly (downslope) winds at night. This intermediate-scale effect is most pronounced during the summer; it frequently overrides the large-scale pattern. In turn, this regional pattern is strongly influenced by local terrain effects, especially by the orientation of valleys and ridges (U.S. Energy Research & Development Administration, 1977).

The annual pattern of wind speeds on the NTS is marked by strong winds in the spring and mild winds in the fall. The daily cycle shows little wind at night, increasing wind speeds from morning to afternoon, and declining wind speed in the evening. Average hourly wind speeds may reach 9 m/sec on spring afternoons. Wind gusts are often much stronger than hourly averages. Gusts occur throughout the year, but are often recorded in conjunction with late summer thunderstorms. Gusts of 28 m/sec are noted every few years; very rarely, wind speeds have exceeded 45 m/sec (Quiring, 1968; Shinn and Cederwall, undated).

The wind patterns in Frenchman Flat have been studied in some detail (Cramer and Hogan, 1978; Quiring, 1968; Shinn and Cederwall, undated). Here local topographic features modify the broad pattern described above for the NTS. The basin itself is essentially flat, devoid of any relief that would give rise to eddies or local convention currents. However, wind flow patterns related to two nearby drainages exert considerable influence. The larger drainage, Mid Valley, lies to the northwest of Frenchman Flat; Nye Canyon adjoins Frenchman Flat to the northeast.

Since little afternoon sun strikes Mid Valley, it begins to cool soon after sunset. During the night, cool air flows southeasterly out of Mid Valley across Frenchman Flat. In conjunction with the prevailing summer southerlies, this results in northwest-to-west winds throughout the night. After sunrise, Mid Valley warms faster than Nye Canyon and a northeasterly airflow out of Nye Canyon dominates for a few hours. By midmorning the prevailing winds are out of the south, and by midday they are from the southwest. There is a consistent southwesterly wind through the afternoon. As the sun sets, cool air flowing downslope out of Mid Valley causes the wind to shift to a westerly direction. This directional pattern is most pronounced and consistent during the summer months.

Wind speeds at Frenchman Flat are generally light, 1-3 m/sec, from midnight to almost noon. As noon approaches, average hourly wind speeds increase rapidly, peaking at about 7 m/sec in the mid-afternoon. Wind speeds drop off gradually through the late afternoon and then decline more quickly after nightfall. Average wind speeds are usually below 3 m/sec. Figure 4.4 presents average hourly wind speeds and directions at Frenchman Flat for June (Quiring, 1968; Shinn and Cederwall, undated; Cramer and Hogan, 1978).

D. Air Quality

Frenchman Flat is in the Nevada Intrastate Air Quality Control Region (AQCR). The Clark-Mojave AQCR, which includes the metropolitan Las Vegas area, is immediately to the east and southeast of Frenchman Flat. The Clark County boundary, about 5 km east of the proposed project area, is also the boundary of the Clark-Mohave AQCR.

There are no ambient air quality monitoring sites on or near the NTS. An analysis of 1974 and 1978 data from monitoring stations within the Nevada Intrastate AQCR showed some cases in which the 24-hr standards for particulates and sulfur oxides were exceeded (U.S. Department of Interior, BLM, 1980). There were no stations at which national air quality standards were exceeded for carbon monoxide, oxidants, or nitrogen oxides. Monitoring data for 1974 and 1978 in the Clark-Mohave AQCR indicated exceedances for particulates, carbon monoxide, and oxidants (U.S. Department of Interior, BLM, 1980). In 1981 the monitoring station at Las Vegas reported an annual arithmetic mean concentration for nitrogen dioxide of 48 $\mu g/m^3$ (0.025 ppm) (Nevada Division of Environmental Protection, 1982). This level is approximately one-half of the National Primary Air Quality Standard for nitrogen dioxide of 100 $\mu g/m^3$ (0.050 ppm). Since the proposed project area at Frenchman Flat is about 80 km northwest of the urban areas of Clark County, it is unlikely that significant ambient concentrations of nitrogen dioxide would be present.

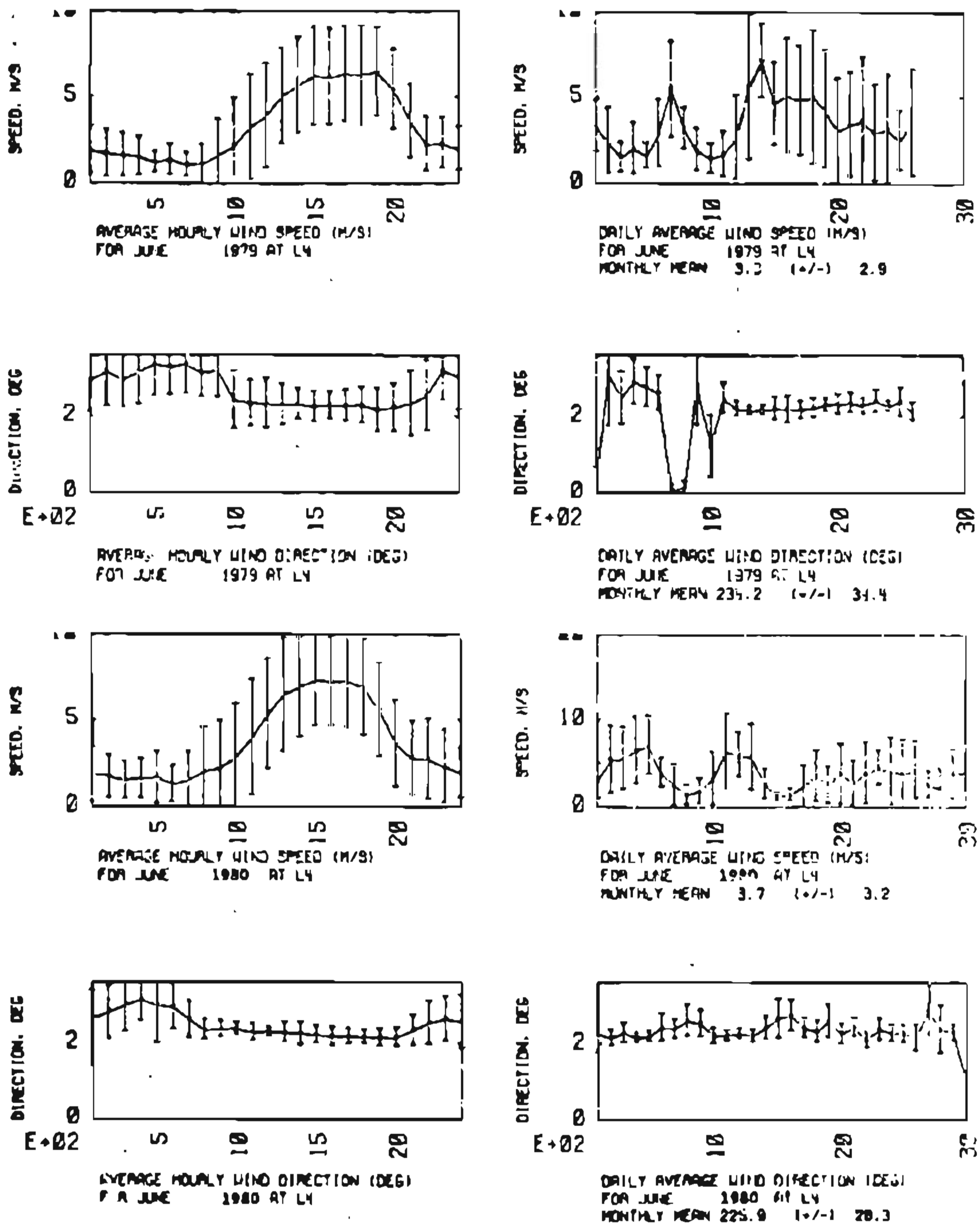

Fig. 4.4. Average windspeed in Frenchman Flat for June (1979-1980) from micrometeorological data, 2-m level, 62-m tower.

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E. Water Resources

1. Surface Water

There are three sources of water in Frenchman Flat: rainfall, runoff from the surrounding mountains, and a tritium migration test well (RNM2S) located northwest of the playa (U.S. Energy Research & Development Administration, 1977; O'Neal and Hogan, 1981). Direct rainfall on Frenchman Flat averages 10 cm per year. Runoff from the mountains occurs only during heavy storms and is quite variable from year to year (O'Farrell et al., 1976). Because the flat is a closed basin with a hardpan near the surface, water reaching the playa accumulates in shallow ponds. These ponds normally evaporate in a few hours to a few weeks, depending on their size and the time of year (U.S. Energy Research & Development Administration, 1977; O'Farrell et al., 1976). Water is pumped from the tritium test well at the rate of 3270 m^3/day (2.65 acre ft/day), and is directed to a diked area on the northwest side of the playa (Shinn, pers. comm.). The pumps at the well operate continuously, which has led to the formation of a permanent pond. Originally quite open, the pond has been progressively filling in with marsh vegetation each year since 1979 (Shinn, pers. comm.).

2. Ground Water

Frenchman Flat is within the Ash Meadows groundwater system. Depth to ground water here is about 200 m (660 ft); an unknown quantity of water recharges annually from the surface and the shallow alluvium into the deeper Palaeozoic carbonate rocks of the regional aquifer. The Ash Meadows groundwater system underlies the eastern two-thirds of the NTS and a large area to the north and east. Groundwater in this system generally flows at depth to the southwest, where most of it eventually discharges at Ash Meadows, along the California-Nevada border (U.S. Energy Research & Development Administration, 1977; U.S. Department of Interior, BLM, 1980; O'Farrell et al., 1976).

F. Biological Resources

1. Vegetation Associations

The NTS is in the transition zone between the Mojave Desert and the Great Basin Desert (Allred et al., 1963; O'Farrell et al., 1976). As a result, vegetation associations typical of both desert regions intermingle here in a complex pattern. Vegetation associations of the Great Basin are often found in cooler, high-elevation areas (above 1520 m), while those characteristic of the Mojave Desert usually occur at lower elevations (below 1200 m). Mid-elevations often support a mixture of vegetation types. Variations in local microclimate, such as cold air drainages associated with canyons, produce many exceptions to this general pattern. Thus, the distribution of vegetation types within the NTS is complex and closely associated with topography and exposure (O'Farrell _et al._, 1976; Allred _et al._, 1963).

There are six major vegetation associations in Frenchman Flat named for their dominant shrub species (O'Farrell _et al._, 1982):

- _Larrea tridentata_ (creosote bush)
- _Atriplex_ (salt bush)
- _Lycium pallidum_ (wolfberry)
- _Lycium shockleyi_ (wolfberry)
- _Ephedra-Atriplex_ (Mormon tea, salt bush)
- _Coleogyne ramosissima_ (blackbrush)

These associations form a mosaic around the playa, which is essentially devoid of plant life. Their distribution in the project area is shown in Figure 4.5. Typical shrub species found in each association are indicated in Table 4.1.

Table 4.1.
Typical Shrub Components of the Six Vegetation Associations Found in Frenchman Flat.

	Vegetation Association					
Shrub Species	*Larrea tridentata*	*Atriplex*	*Lycium pallidum*	*Lycium shockleyi*	*Ephedra*-*Atriplex*	*Coleogyne ramosissima*
Acamptopappus shockleyi	x	x		x		x
Ambrosia dumosa	x				x	
Artemisia spinescens	x	x				
Atriplex canescens	x		x			
A. confertifolia	x		x	x	x	x
Ceratoides lanata	x	x	x	x		
Coleogyne ramosissima						x
Encelia virginensis						x
Ephedra funereus						x
E. nevadensis	x				x	x
Grayia spinosa	x	x	x			
Hymenoclea salsola	x					
Krameria parvifolia	x				x	x
Larrea tridentata	x			x	x	
Lycium andersonii	x					
L. pallidum		x	x			
L. shockleyi	x	x		x		x
Opuntia spp.						x
Psorothamnus fremontii	x					
Stanleya pinnata		x				
Yucca baccata						x
Y. brevifolia	x					x

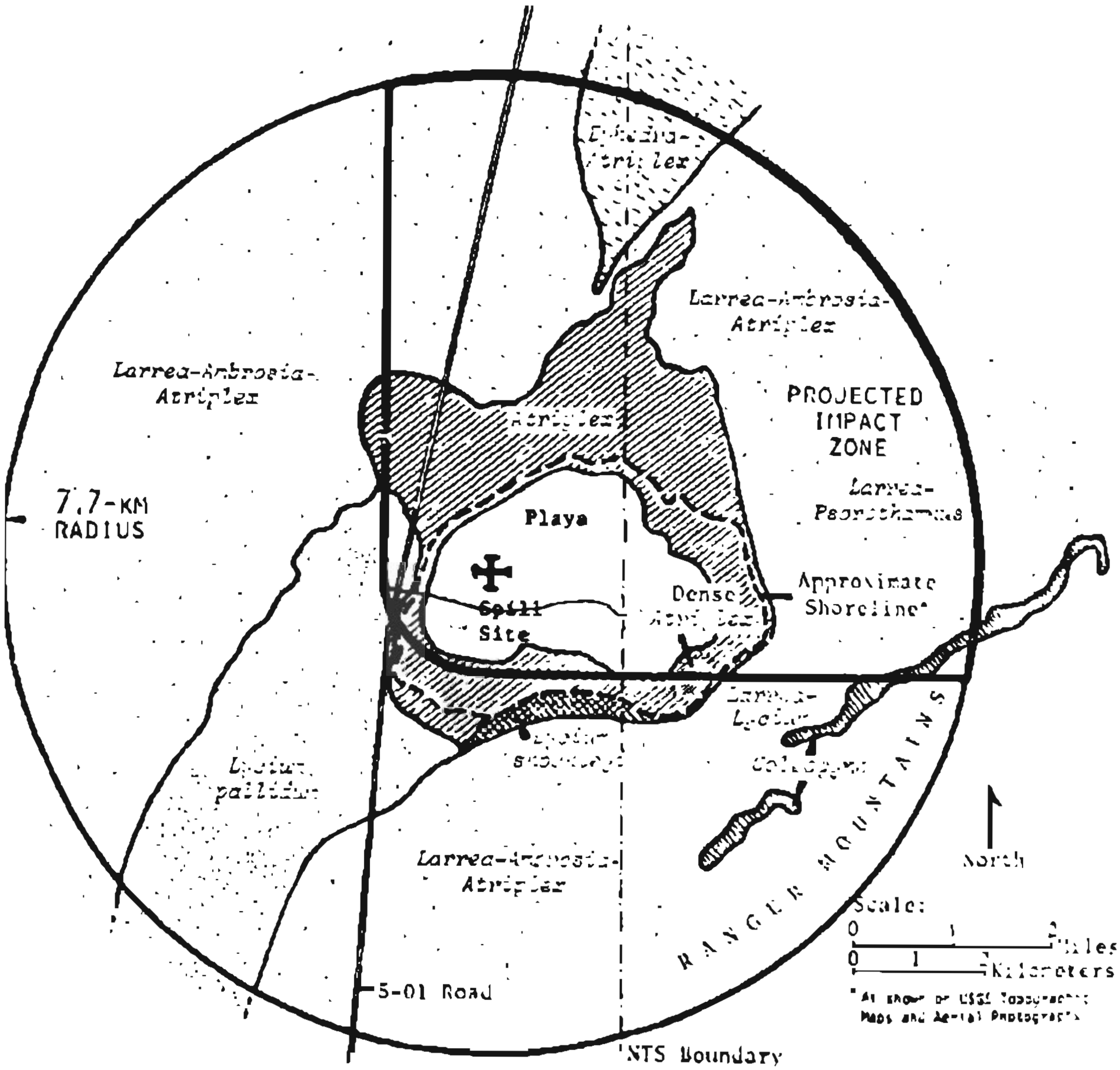

Fig. 4.5. Vegetation Associations, Frenchman Flat.

In addition to the six naturally occurring associations, there is a small freshwater marsh in a diked area on the northern edge of the playa. This marsh is maintained by water pumped from Well RNM2S (Shinn, pers. comm.).

The desert shrub association dominated by *Larrea tridentata* has the most extensive distribution in Frenchman Flat. It is found from just above the margin of the playa up onto the surrounding bajadas. In its pure form it is a Mojave Desert vegetation type. In Frenchman Flat there are three subtypes of the *Larrea* association which grade into each other without distinct boundaries.

Larrea-Lycium shockleyi subtype is found on the bajadas south of the playa, while the *Larrea-Psorothamnus* subtype is distributed on the bajadas to the east. The *Larrea-Ambrosia-Atriplex* subtype occurs to the northwest, northeast, and south of the playa. It is a mixture of Mojave (*Larrea* and *Ambrosia*) and Great Basin (*Atriplex*) species (O'Farrell *et al.*, 1982). In general, perennial shrub cover averages about 14% in the *Larrea* association.

The *Atriplex* association is found around the edge of the playa, immediately below the *Larrea* association. *Atriplex* is a Great Basin component and as such would be expected to occur at a higher elevation (O'Farrell *et al.*, 1976; O'Farrell *et al.*, 1982). Its presence at a lower elevation than the *Larrea* may be due to cold air draining into the closed basin at night. The dominant species, *Atriplex confertifolia* and *A. canescens*, vary in their relative abundance. Perennial shrub cover averages about 6%, even less than in the *Larrea* association; an exception to this is a small, dense stand of *Atriplex* southeast of the playa.

The *Lycium pallidum* association is found southwest of the playa. It forms a band running out of the project area to the southwest. This vegetation association is transitional between Mojave and Great Basin types; both *Atriplex* species are found as codominants throughout (O'Farrell *et al.*, 1982). The occurrence of this association at elevations lower than usually expected is probably due to cold air drainage into the basin, or possibly to the soil type (Allred *et al.*, 1963; O'Farrell *et al.*, 1976). This association forms a slightly denser shrub cover than the *Larrea*, averaging about 19%.

There is a very small patch (102 ha) of the Lycium shockleyi association on the southern side of Frenchman Flat. This is a transitional vegetation association; appropriately, it is found between a typical Mojave association (Larrea) and a typical Great Basin association (Atriplex). L. shockleyi is also found scattered throughout both of the latter associations. Typically, the L. shockleyi association forms a canopy cover of about 17% (O'Farrell, et al., 1982).

On the bajadas northeast of the playa and above the Larrea association is a wedge-shaped patch of the Ephedra-Atriplex association. This is a typical Great Basin vegetation type. The patch gradually widens as it extends northeast and out of the project area. Dominant shrubs in this association are Ephedra nevadensis and Atriplex confertifolia. Many of the shrub species found in the adjacent Larrea association appear as codominants in this association, particularly Krameria parvifolia and Ambrosia dumosa. Average cover in the Ephedra-Atriplex association is about 18%, similar to that of the Lycium associations (O'Farrell et al., 1982).

Finally, there are two narrow bands of fairly dense Coleogyne ramosissima running through the Larrea association to the southeast of the playa. This association is typical of the transition zone and is found at about 1000 m in Frenchman Flat. The stands of the Coleogyne association have an average cover of about 42%, the highest value for any association in the project area.

Over 700 plant species have been collected from the NTS and its environs (O'Farrell et al., 1976; Allred et al., 1963; Romney et al., 1973). Many of these are herbaceous annual plants that appear in the winter and spring seasons following significant fall rains. The abundance and productivity of these annuals is largely a function of the rainfall received between late September and early December. Many species require a minimum of 2.5 cm of rain for seed germination; more precipitation leads to greater germination and greater seedling survival. In some years there is an almost solid carpet of annuals covering the spaces between the shrubs. The species composition of these stands can vary somewhat from year to year.

Areas of the NTS that have been disturbed by human activity are often invaded by various introduced plants. Four species are particularly prominent in places such as roadsides and subsidence craters: two grasses (Bromus rubens and B. tectorum and two Russian thistles or tumbleweeds (Salsola iberica and S. paulsenni). They rapidly invade sites where the soil has been disturbed or the native shrubs have been removed and they can delay the natural revegetation by native plants (Allred et al., 1963; O'Farrell et al., 1976).

The pond on the north side of the playa was formed in 1979 when the dike was repaired. The dike has been regularly maintained since then and emergent marsh vegetation has become established (Shinn, pers. comm.). There has been no detailed botanical survey of the marsh, but the vegetation includes cattails, reeds, and sedges.

2. Threatened and Endangered Plants

There are no plant species on the NTS that have been officially listed as Threatened or Endangered by the U.S. Fish and Wildlife Service. However, six species that occur on the NTS have been recommended for federal Threatened status: Astragalus beatleyae, Frasera pahutensis, Galium hilendiae spp. kingstonense, Lathyrus hitchcockianus, Astragalus funereeus, and Scherocactus polyancistrus (Federal Register, Dec. 15, 1980, Vol. 45, No. 242). In addition, A. beatleyae is fully protected by Nevada law as a critically endangered species (Nevada Revised Statutes, 527.270). None of these six species are found in the proposed project area and none occur at Frenchman Flat (Rhoads et al., 1978; Mozingo and Williams, 1980).

The Northern Nevada Native Plant Society (NNNPS) maintains a "watch list" of plant species that may be in need of protection (NNNPS, 1983). These species are not included on the state or federal Threatened or Endangered lists at present, but might be recommended for listing in the future if new information indicates that it is warranted. One plant on the "watch list", Agave utahensis var. eborispina is represented in the Frenchman Flat area by a population about 8 km southeast of the playa (Rhoads et al., 1978).

3. Wildlife

The animal species found on the NTS, like the plants, include a mixture of forms from both the Mohave and Great Basin Deserts (Allred et al., 1963). Thus, the fauna is a diverse assemblage for such a desert region. Some species are restricted to particular plant associations, but most range widely through a number of vegetation types (O'Farrell et al., 1976).

No hunting, fishing, or grazing is allowed on the NTS. In the past, nuclear weapons testing has had a significant impact on natural ecosystem interactions. Since 1962, when atmospheric tests were halted, the weapons testing program has had only an indirect effect on animal populations through habitat modification. In general, there is now little human impact on natural population processes and species interactions on the NTS (U.S. Energy Research & Development Administration, 1977).

a. Fish

There are two introduced fish species on the NTS: goldfish (Carassius auratus) and golden shiners (Notemigonus crysoleucas) (O'Farrell et al., 1976). It is not known if either is present in the pond at Frenchman Flat.

b. Amphibians

There are no amphibians known to occur on the NTS (O'Farrell et al., 1976).

c. Reptiles

The NTS has a particularly diverse reptile fauna due to the overlap of species from both the Mojave and Great Basin Deserts (O'Farrell et al., 1976).

The desert tortoise (Gopherus agassizi) is found on the NTS and has been reported from the Frenchman Flat area (Tanner and Jorgensen, 1963). Although there have been no special studies of desert tortoise ecology or distribution on the NTS, the species here appears to be associated with the Larrea tridentata vegetation type. In a study conducted southwest of Las Vegas, the density of desert tortoises was estimated to be 36-44/km^2 (Burge and Bradley, 1976). The desert scrub vegetation in this study area was dominated by Larrea tridentata, although shrub cover was much less than in the corresponding association at Frenchman Flat. Desert tortoises are herbivorous, consuming low-growing vegetation. Burge and Bradley (1976) reported that the most important plants in the diet were the annual forb, Plantago insularis, and a shrub, the desert mallow (Sphaeralcea ambigua). The desert tortoise excavates and uses two kinds of burrows; one type serves as a hibernation den, while the other provides shelter from high surface temperatures in summer (Woodbury and Hardy, 1948).

The Nevada State Board of Fish and Game Commissioners has listed the desert tortoise as a protected species (Nevada Revised Statutes 501.110). The species is currently being reviewed by the U.S. Fish and Wildlife Service for protection under the Endangered Species Act of 1973 (U.S. Department of Interior, FWS, 1982). The Beaver Dam Slope desert tortoise population in southwest Utah has already been placed on the federal Threatened list.

There are 14 lizard species on the NTS, 11 of which probably occur at Frenchman Flat (Tanner and Jorgensen, 1963; O'Farrell et al., 1976). Three species are of Great Basin affinity and are restricted to Great Basin Desert vegetation associations: sagebrush lizard (Sceloporus graciosus), western fence lizard (S. occidentalis), and western skink (Eumeces skiltonianus). Those occurring predominantly in Mojave Desert vegetation associations are the banded gecko (Coleonyx variegatus), desert iguana (Dipsosaurus dorsalis), collared lizard (Crotaphytus collaris), chuckwalla (Sauromalus obesus), and desert night lizard (Xantusia vigilis). Lizard species found in transitional vegetation associations are the zebra-tailed lizard (Callisaurus draconoides), desert spiny lizard (Sceloporus magister), and western whiptail (Cnemidophorus tigris). Best described as generalists and occurring in almost all vegetation types are the side-blotched lizard (Uta stansburiana), leopard lizard (Crotaphytus wislizenii), and desert horned lizard (Phrynosoma platyrhinos). Most of the lizards on the NTS are insectivores, although some are herbivores and others are omnivores (Stebbins, 1966). The desert iguana and chuckwalla are herbivorous, while the leopard lizard, zebra-tailed lizard, and desert spiny lizard are omnivorous. The collared lizard also eats smaller lizards in addition to insects.

Seventeen species of snakes are known from the NTS; all of them probably occur at Frenchman Flat (Tanner and Jorgensen, 1963; O'Farrell et al., 1976). They are seldom observed or collected, and thus very little is known about population densities, habitat preferences, or activity patterns. The most common species seems to be the western shovel-nosed snake (Chionactis occipitalis). The sidewinder (Crotalus cerastes) and the speckled rattlesnake (C. mitchellii) are both venomous snakes which should be treated with respect. All of the snakes are predators, eating rodents, small birds, insects, lizards, and other snakes (Stebbins, 1966).

d. Birds

Because birds are so mobile, their distribution on the NTS forms a much more complex picture than that of mammals or reptiles. Flight enables birds to migrate to favorable habitats on a seasonal schedule. Thus, the pattern of mixing of the major desert biotas on the NTS is overlaid by the larger pattern of North American bird migration. Each of the more than 190 avian species found on the NTS can be put in one of four general categories based on its migratory pattern: spring-summer resident, fall-winter resident, seasonal migrant, or year-long resident (O'Farrell et al., 1976; Hayward et al., 1963).

Spring-summer residents breed on the NTS during those seasons and then migrate south to their wintering grounds. The cycle is complete when they return the following spring. Among the spring-summer resident species are turkey vulture (Cathartes aura), mourning dove (Zenaida macroura), poor-will (Phalaenoptilus nuttallii), western kingbird (Tyrannus verticalis), black-throated sparrow (Amphispiza bilineata), and chipping sparrow (Spizella passerina) (Hayward et al., 1963).

Fall-winter residents breed in regions to the north and migrate south to winter on the NTS. The majority of these are small passerine birds, usually seed-eaters; seeds of Russian thistle (Salsola spp.) are prominent in their diet (O'Farrell et al., 1976). Species that fall into this category include starling (Sturnus vulgaris), house finch (Carpodacus mexicanus), sage sparrow (Amphispiza belli), dark-eyed junco (Junco hyemalis), and white crowned sparrow (Zonotrichia leucophrys) (Hayward et al., 1963).

Each spring and fall, large numbers of migrants pass through the NTS. These birds are moving between their more northerly breeding grounds and their wintering areas to the south. Many are waterfowl that are attracted to the few areas of water along their migration routes through this desert region. Some stop at the artificial freshwater marsh on the north side of the Frenchman Flat playa. Representative migrant waterbirds include Canada goose (Branta canadensis), pintail (Anas acuta), green-winged teal (A. crecca), cinnamon teal (A. cyanoptera), American wigeon (A. americana), common snipe (Capella gallinago), and spotted sandpiper (Actitis macularia) (Hayward et al., 1963).

The last group of birds are the year-round residents; all members of this category breed on the NTS. Some of these are red-tailed hawk (Buteo jamaicensis), golden eagle (Aquila chrysaetos), chukar (Alectoris chukar), killdeer (Charadrius vociferus), roadrunner (Geococcyx californianus), and common raven (Corvus corax) (Hayward et al., 1963). In some of the year-long resident species, the same individuals may not be present all year; rather, some individuals migrate in as other move out of the area. With other species, such as the American kestrel (Falco sparverius), the ranks of year-long residents are increased by migrants in spring or fall. Among the resident species, the sage thrasher (Oreoscoptes mountanus), green-tailed towhee (Chlorura chlorura), and Brewer's sparrow (Spizella breweri) are typical Great Basin forms, while the lesser nighthawk (Chordeiles acutipennis), Costa's hummingbird (Calypte costae)., and LeConte's thrasher (Toxostoma lecontei), are typical members of the Mohave Desert avifauna (O'Farrell et al., 1976). In areas like Frenchman Flat, the Mohave bird species seem to predominate during the breeding season. Non-desert species that may breed in the marsh vegetation on the north side of the playa include American coot (Fulica americana) and red-winged blackbirds (Agelaius phoeniceus) (J. Shinn, pers. comm.).

There are no birds regularly occurring on the NTS that are currently listed as Threatened or Endangered under the federal Endangered Species Act of 1973 (U.S. Department of Interior, FWS, 1982; U.S. Energy Research & Development Administration, 1977). A few recent sightings of the endangered American peregrine falcon (Falco peregrinus anatum) in the vicinity of Yucca Flat probably involved transient individuals (O'Farrell et al., 1976). All birds of prey and the roadrunner are fully protected under Nevada law (Nevada Revised Statutes 501.110).

e. Mammals

There are 46 species of mammals known from the NTS (O'Farrell et al., 1976; Jorgensen and Hayward, 1965). Almost half of these are rodents, which are not commonly seen because they are small, usually nocturnal, and secretive. Other mammals include four species of bats, three different kind of rabbits, six carnivores, mule deer, and wild horses.

Though not obvious to the human observer, rodents are the most important group of mammals on the NTS in terms of biomass and species diversity (O'Farrell et al., 1976). Several species are typically found in Mojave Desert plant associations: round-tailed ground squirrel (Spermophilus tereticaudus), Merriam's kangaroo rat (Dipodomys merriami), southern grasshopper mouse (Onychomys torridus), and cactus mouse (Peromyscus eremicus). Typical rodents of the Great Basin Desert are found in both transitional and Great Basin plant associations. These include Townsend's ground squirrel (Spermophilus townsendii), Great Basin pocket mouse (Perognathus parvus), Great Basin kangaroo rat (Dipodomys microps), Ord's kangaroo rat (D. ordii), and sagebrush vole (Lagurus curtatus). Other rodents are not tied as stongly to particular vegetation types, but are associated with other environmental features. The desert kangaroo rat (Dipodomys deserti) is found in areas of loose sandy soil, often on disturbed sites. They are common in Frenchman Flat. The densities of rodent populations are highly variable from year to year. High rainfall years, with large production of winter annual vegetation, lead to good reproduction and high rodent densities the following spring and summer (O'Farrell et al., 1976; Jorgensen and Hayward, 1965).

Two of the rabbit species are common. The black-tailed jackrabbit (Lepus californicus) and the desert cottontail (Sylvilagus audubonii) are found in all vegetation types on the NTS (O'Farrell et al., 1976; Jorgensen and Hayward, 1965). Both are herbivores and their populations probably fluctuate with the production of winter annuals, though not as markedly as do the rodent populations.

Several species of large herbivores are found on or near the NTS (U.S. Energy Research & Development Administration, 1977; O'Farrell et al, 1976; Jorgensen and Hayward, 1965). The most common is the mule deer (Odocoileus hemionus); they usually inhabit the higher mesas, but come down to lower elevations during the winter. There is a herd of about 20 wild horses (Equus caballus) near Rainier Mesa, about 40 km northwest of Frenchman Flat. Burros (E. asinus) have been seen on rare occasions on the NTS, always in the vicinity of natural springs. There are no confirmed sight records of pronghorn antelope (Antilocapra americana) or desert bighorn sheep (Ovis canadensis), although pronghorn do occur to the north of the NTS and bighorn sheep are found to the east on the Desert National Wildlife Range. The only evidence of bighorn sheep on the NTS is a report of scat found in the mountains east of Frenchman Flat (Jorgensen and Hayward, 1965).

At the top of the food chain there are six mammalian predators: coyote (Canis latrans), kit fox (Vulpes macrotis), badger (Taxidea taxus), bobcat (Lynx rufus), mountain lion (Felis concolor), and long-tailed weasel (Mustela frenata) (U.S. Energy Research & Development Administration, 1977; O'Farrell et al., 1976; Jorgensen and Hayward, 1965). They may range through all vegetation associations on the NTS. Mountain lions, however, are very seldom found outside the high mesas in the northern section of the NTS. This reflects the distribution of mule deer, their preferred prey. In contrast, the coyote has a catholic diet and is found throughout the NTS; it is the most commonly observed mammalian predator in the area. Badgers and long-tailed weasels are secretive and rarely seen, in contrast with the kit fox which is rather tame and often seen. Kit foxes have been observed at Frenchman Flat (Shinn, pers. comm.).

Bats have been little studied on the NTS. Four species have been found: pallid bat (Antrozous pallidus), California myotis (Myotis californicus), western pipistrelle (Pipistrellus hesperus), and Townsend's big-eared bat (Plecotus townsendii) (U.S. Energy Research & Development Administration, 1977; O'Farrell et al., 1976; Jorgensen and Hayward, 1965). More effort spent studying bats of the area would probably yield several more species. All of the bats are insectivores.

There are no mammals on the NTS that are currently listed as Threatened or Endangered under the federal Endangered Species Act of 1973 (U.S. Energy Research & Development Administration, 1977; O'Farrell et al., 1976; U.S. Department of Interior, FWS, 1982). The wild horse population on the NTS is protected under federal law (Wild Free-Roaming Wild Horse and Burro Act of 1971). The kit fox is classified as a Nevada protected mammal (Nevada Revised Statutes 501.110).

C. Cultural Resources

Human occupation of the NTS and its environs extends back to about 10,000 B.C. (U.S. Energy Research & Development Administration, 1977). A number of aboriginal hunting and gathering cultures were present in this long prehistoric period. When the first European settlers entered the area, it was occupied by the Paiute Indians. From about 1849 until the establishment of the NTS, the land was mainly used for livestock grazing and mining.

Investigations of archaeological and historical features of the NTS have resulted in the identification of numerous archaeological sites and several locations having historical intrest (Worman, 1969, Desert Research Institute archaeological site reports on file in DOE/NV office). These sites have been recorded in the Site Record File of the Nevada State Museum. None of them have been placed on the National Register of Historic Places and none are believed to meet the criteria for nomination for inclusion on the National Register.

Both historic and prehistoric sites on the NTS tend to be located near springs, in canyons, and at or near the bases of mountains. The larger valleys show little sign of early human occupation. No archaeological or historic sites have been reported at or near Frenchman Flat and it is extremely unlikely that they exist here (U.S. Energy Research & Development Administration, 1977; Douthett, pers. comm.).

V. ENVIRONMENTAL CONSEQUENCES

A. Proposed Action

1. Impact Analysis

Since an environmental assessment of the proposed project must focus on the effects of the N_2O_4 and NH_3 releases, it is important to estimate concentrations of these materials at various distances downwind of the spill point. Existing models are not entirely adequate for predicting the dispersion characteristics of these heavy gases. One of the important objectives of this research is to acquire field data that can be used to evaluate and improve such models; thus, preliminary estimates of distances to particular concentrations are necessarily approximate. Nevertheless, several standard air quality computational methods and a more plausible modified dispersion code were investigated in order to arrive at estimates of the downwind range to certain significant NO_2 and NH_3 concentrations.

The codes used in these calculations all require the input of meteorological data. Fortunately, such data were collected at Frenchman Flat for several years and there is a great deal of information available on frequencies of wind speed, wind direction, and atmospheric stability conditions. The system included a meteorological tower installed in 1978. The tower is 62 m (200 ft) in height with four instrumented levels (3, 10, 30, and 60 m). Wind direction, wind speed, standard deviation of wind direction (σ_θ), vertical turbulence, temperature, humidity, and barometric pressure were recorded. Each sensor was sampled once per second. A microprocessor-based data acquisition system made possible detailed on-line calculations of the turbulent wind fluctuations and the mean values used in atmospheric stability indices. A data base was prepared that included 3-min as well as hourly summaries. In addition, four automatic weather stations measuring wind speed and direction were operated at sites (FF1, FF2, FF3, and Kay Bunker) previously utilized by the National Weather Service, Nuclear Weather Support Office. These stations provided summaries every 8 min, and operated with a high degree of reliability.

As a result of these studies, the wind flow patterns across the Frenchman Flat basin during the proposed mid-July through September test period are well documented. A simulation was performed using three years of data (1979-81) from the 62-m tower to investigate the possibility of wind direction meanders after a spill test is started. The criteria to conduct a day-time test (8 AM to 4 PM) were that for 9 min prior to the test release the wind direction would be within 10° of the sensor array centerline (225°), wind speeds would be 2-8 m/sec, and intensity of turbulence (standard deviation of wind direction) less than 30°. During the succeeding hour of each possible test period the statistics showed a dependable wind persistence, both in direction and speed. It was found that in less than 3% of all hypothetical test periods did the cloud of released gas meander more than 30° from the array centerline, and in all cases the trajectories of hypothetical clouds were within 35° of the array centerline when they reached a distance of 7 km (Fig. 5.1). This figure shows all 115 trajectories satisfying the test criteria. Further analysis has shown that the judgement of the test director concerning wind steadiness, in addition to the test criteria, would eliminate the few erratic trajectories shown in Fig. 5.1 and result in trajectories which are all quite regular and predictable.

In order to estimate the downwind range to significant concentrations of NO_2 and NH_3, it is necessary to take account of wind speed and turbulence. The mean wind speed (u) will transport a transient cloud of material downwind, while the turbulence, especially σ_θ, will spread and dilute the cloud. The atmospheric stability and the surface roughness determine the value of σ_θ at any particular time. Atmospheric stability categories are conventionally classified according to ranges of σ_θ following the Nuclear Regulatory Commission NRC Safety Guide 1.23 as follows:

Stability Category (Pasquill-Gifford classes)		σ_θ (degrees of wind direction)
Very Unstable	A	> 22.5
Unstable	B	22.5-17.5
Slightly Stable	C	17.5-12.5
Neutral	D	12.5-7.5
Stable	E	7.5-3.75
Very Stable	F	< 3.75

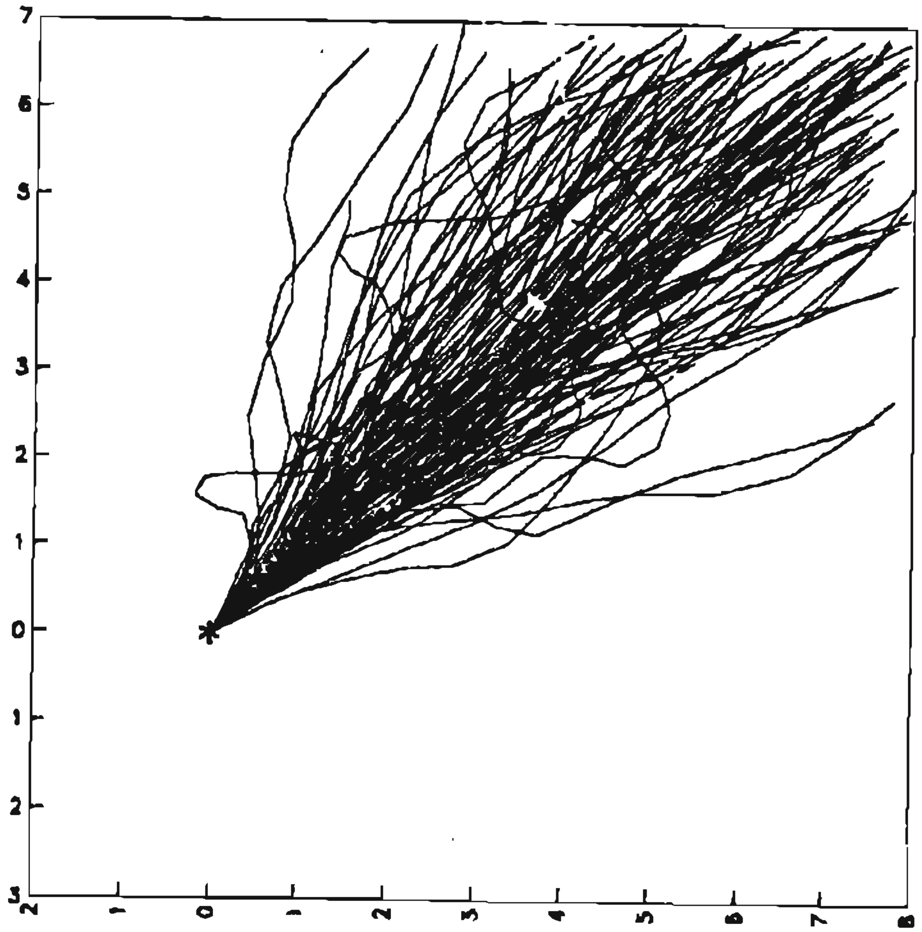

Fig. 5.1. Trajectories of 115 cases of simulated tests subsequent to meeting the test criteria: 8 AM-4 PM, wind direction within 10° of 225°, windspeed between 2 and 8 m/sec, and standard deviation of wind direction less than 30° (9 min prior to test).

116e/3a

Table 5.1
The Joint Frequencies of Atmospheric Stability Categories and Wind Speed Classes for Periods Meeting the Test Criteria.

	Stability Category						
Wind Speed	A	B	C	D	E	F	Total
2-3 m/sec	2	1	2	0	0	0	5
3-4	7	3	5	0	0	0	15
4-5	4	4	7	1	0	0	16
5-6	2	2	12	13	0	0	29
6-7	0	3	12	13	0	0	28
7-8	1	1	7	13	0	0	22
Total	16	14	45	40	0	0	115

The 115 test periods meeting the test criteria were found to occur mostly after 10 AM and the most frequent case was wind speed 4-6 m/sec and Stability Category C (slightly unstable). The results are summarized in Table 5.2.

Table 5.2
The Frequency of Periods Meeting the Test Criteria by Hour of the Day and the Average and Worst (Least Dispersive) Meteorological Conditions Observed for Each Hourly Period.

		Dispersion Conditions Wind speed (m/sec) - Stability	
Hourly Period	No. of Spills	Average	Worst
8 - 9 AM	2	5.3 - D	5.2 - D
9 - 10 AM	4	5.3 - C	7.5 - D
10 - 11 AM	7	4.0 - C	2.1 - C
11 - 12 AM	16	5.7 - C	4.9 - D
12 - 1 PM	10	6.1 - C	6.7 - D
1 - 2 PM	20	5.4 - C	5.7 - D
2 - 3 PM	26	5.5 - C	5.2 - D
3 - 4 PM	30	5.9 - C	5.0 - D
	115		

By examining the meteorological data base, it was found that the test criteria will also eliminate all occurrences of stable cases (Categories E and F) from possible test periods (Table 5.1). In approximately 90 days of data, there were 115 periods when tests could have been conducted.

It was found that of 115 test cases, the least dispersive test period was for a wind speed of 4.9 m/sec and neutral stability (Category D). During the summer months, the atmospheric stability was found to be neutral (Category D) to very unstable (Category A) in all periods meeting the test criteria: daytime 8 AM-4 PM, wind speed 2-8 m/sec, wind direction within 10° of 225°, and standard deviation of wind direction (σ_θ) less than 30° for nine minutes prior to the test.

Estimates of downwind dispersion of NO_2 and NH_3 were made using three standard air pollution codes: a steady-state Gaussian plume model, an instantaneous Gaussian puff model, and the particle-in-cell code PATRIC. In these calculations, comparisons were made using realistic combinations of wind speed and atmospheric stability categories.

It was found that the continuous (steady-state) Gaussian plume model (Hanna et al., 1982) overestimates the dispersion distances for low gas concentrations because of the short duration (4 min) of the spills. It would require a spill duration in excess of an hour for the concentration at 7-8 km to reach steady state in a 2 m/sec wind. The Gaussian puff model (Hanna et al., 1982) also overestimates the dispersion distance because it assumes an instantaneous release, which is then translated downwind as a single puff. PATRIC, the particle-in-cell method (Lange, 1978), assumes the gas is neutrally buoyant, and uses a transient 4-min release, but distributes the mass horizontally over 250 grid intervals and vertically over 20 m grid intervals. Because of these grid scales and the local mean velocity and diffusive velocity assumptions, the mass is initially transported vertically in an unrealistic manner causing lower concentrations to appear near the ground. Thus, PATRIC tends to underestimate gas dispersion distances. A research code, FEM3, under development as a heavy gas, near-field dispersion predictor was utilized for comparison. This code (Chan et al., 1981) is a sophisticated, three-dimensional finite element hydrodynamics method. It showed that heavy gas effects are not very important for low concentrations and for the longer distances downwind.

In order to improve the estimation procedure, the Gaussian plume model was modified to account for a finite duration of release and to include the along-wind dispersion component. The transport velocity was corrected for height using a vertical power law function used by EPA (Irwin, 1979), and an initial source geometry was assumed (σ_y = 5 m, σ_z = 1 m) corresponding to an initially heavy gas. Dispersion due to shear was determined by the method of Wilson (1981).

This modified transient Gaussian plume technique was considered to provide the most accurate and realistic basis for estimating the concentrations of NO_2 and NH_3 at various distances downwind of the release site. In order to present a worst-case scenario for impact assessment, calculations were made for the largest planned N_2O_4 and NH_3 spills using the least dispersive atmospheric conditions meeting the test criteria: 4.9 m/sec wind speed and Stability Category D (neutral).

The results for the N_2O_4 release are shown in Table 5.3. The calculations assumed a maximum spill rate of 2.5 m^3 liquid N_2O_4/min for 2 min and took account of the complete dissociation of N_2O_4 into NO_2 at the distances involved.

Table 5.3
The Calculated Downwind Dimensions of Significant Concentrations for the N_2O_4 Two-Minute Planned Release, Least Dispersive Case of 4.9 m/sec Wind at Stability Category D (Neutral).

NO_2 Concentration	Downwind Range (Centerline)	Cloud Width (σ_y)
1000 ppm	500 m	38 m
50 ppm	2650 m	183 m
30 ppm	3350 m	232 m
10 ppm	5500 m	354 m
3 ppm	9600 m	550 m

The results for the NH_3 release are shown in Table 5.4. The calculations assumed a maximum spill rate of 15 m^3 liquid NH_3/min for 4 min. Because of the short spill duration and rapid vaporization rate for both N_2O_4 and NH_3 the downwind exposure period will always be less than 10 minutes.

Table 5.4
The Calculated Downwind Dimensions of Significant Concentrations for the NH_3 Four-Minute Planned Release, Least Dispersive Case of 4.9 m/sec Wind at Stability Category D (Neutral).

NH_3 Concentration	Downwind Range (Centerline)	Cloud Width (σ_y)
1500 ppm	1700 m	130 m
500 ppm	3400 m	235 m
50 ppm	11,500 m	628 m
25 ppm	16,000 m	794 m

Since both N_2O_4 and NH_3 vapors are toxic, occupational exposure must be carefully monitored. All personnel working within the spill area, when the valves are unlocked, will wear approved protective clothing, and be trained in the use of and carry approved respiratory equipment. Some pertinent facts about NO_2 gas concentrations are listed below (all concentrations in parts per million (ppm) by volume):

A) 3 ppm-8 hrs. This is the ACGIH Threshold Limit Value - Time-Weighted Average (TLV-TWA). Workers can be repeatedly exposed to this level of concentration without adverse effects.

B) 5 ppm-15 min. This is the ACGIH Threshold Limit Value - Short-Term Exposure (TLV-STEL). Workers can be exposed to this level without suffering from irritation, chronic, or irreversible tissue change or narcosis of sufficient degree to impair self-rescue. The STEL should not be longer than 15 min and should not be repeated more than four times per day, with at least 60 min between each exposure. The STEL is not a separate exposure limit but should supplement the TLV-TWA, since there are recognized acute effects from high short-term exposures to NO_2.

C) 5-20 ppm. NO_2 has a distinct pungent odor at 5 ppm and may be slightly irritating to the mucous membranes at 20 ppm.

D) 30 ppm for 10 min. Air Force recommended emergency exposure limit (AFM 161-30).

E) 100 ppm for 10-15 min. Delayed pulmonary edema may follow after exposure to these levels of NO_2 unless the person receives medical treatment within 5-6 hrs.

F) 200-300 ppm. NO_2 concentrations in this range are visible to the human eye as a brownish-yellow cloud.

G) 200-700 ppm for a few breaths. Exposures of this extent will produce severe pulmonary damage which may result in fatal pulmonary edema within 5-8 hrs unless the person receives immediate medical treatment.

Some pertinent facts about NH_3 gas concentrations are listed below:

A) 1 - 5 ppm. This is the odor threshold as stated by the AIHA Hygienic Guide. The odor is penetrating and pungent. Because of its low threshold of odor, NH_3 is treated as a material with good warning properties. Concentrations of this level for sustained lengths of time are non-injurious.

B) 25 ppmv - 8 hrs. This is the ACGIH (1982) Threshold Limit Value (TLV). Workers can be exposed to this level for 8 hrs without suffering any ill effects other than, perhaps nasal dryness and barely noticeable eye irritation.

C) 35 ppmv - 15 min. This is the ACGIH Short-Term Exposure Limit (STEL). Workers can be exposed to this concentration without suffering from irritation or irreversible tissue change or narcosis of sufficient degree to impair self-rescue. The STEL should not be longer than 15 min and should not be repeated more than four times per day, with at least 60 min between each exposure. The STEL is not a separate exposure limit but should supplement the TLV-TWA.

D) 300 ppmv - 60 min. Maximum concentration tolerated without serious disturbances (one hour exposure).

E) 400 - 700 ppmv - 60 min. Nose and throat irritation. Eye irritation with tearing. Infrequent short (one hour) exposure ordinarily produces no serious effect.

F) 500 ppmv - 10 min. National Academy of Science emergency exposure limit.

G) 2000 - 10,000 ppmv. No permissible exposure. Inhalation of these concentrations causes convulsive coughing, severe eye irritation, dyspnea, bronchospasm, chest pain, and laryngeal spasm or edema which may be fatal. Consequences can include bronchitis or pneumonia and a residual reduction in pulmonary function. Exposure to 10,000 ppmv (1%) can cause death in a few minutes, while 2000 ppmv (0.2%) can cause fatal respiratory tract irritation in 30 min.

a. Air Quality

(1) Nitrogen Tetroxide tests. The proposed series of N_2O_4 spill tests will not have a significant adverse impact on air quality. The State of Nevada Guidelines for Significant Emission Rates of nitrogen oxides are set at 40 tons/yr. The total quantity of N_2O_4 to be vaporized in these releases will not exceed this amount. The State of Nevada has also set as a Guideline for Significant Air Quality Impact an annual arithmetic mean NO_2 concentration of 14 $\mu g/m^3$. This guideline will not be exceeded at the Nye County line, 8 km northeast of the spill point, at the eastern border of Area 5 of the NTS, or at any other location outside the controlled area. In addition, the Nevada Ambient Air Quality Standard of 100 $\mu g/m^3$ NO_2 as an annual arithmetic mean (a factor of seven higher than the guideline) will be satisfied by a considerable margin of safety. Since these are transient releases, these guidelines may not be applicable. Every effort wil be made to assure that the tests comply with whatever state and federal regulations are appropriate.

(2) Ammonia tests. The proposed series of NH_3 spill tests will have no significant adverse impact on air quality. The State of Nevada does not regulate NH_3 as an air pollutant. In the absense of a specific standard or federal regulation for the emmision of NH_3, the State of Nevada has adopted 10% of the TLV as a screening tool for locations in which the general public has access. The TLV is the standard for the eight-hour exposure of employees in the work place (see Table 3.1).

b. Water Resources

Neither the N_2O_4 nor the NH_3 tests are expected to have any impact on the water resources of the Frenchman Flat area. Groundwater resources will not be affected in any way by the proposed project. The only surface water that could be contacted by the released gases is in the artificial marsh on the north side of the playa. Although gas concentrations will be relatively high (50 ppm NO_2, 1500 ppm NH_3) at this distance from the release point, neither NO_2 nor NH_3 are expected to combine with the water to any significant extent. If the trajectory of an NO_2 or NH_3 cloud carried gas of the expected concentration over the marsh, the period of exposure would be no more than 10 min. Using a deposition velocity of 0.01 m/sec (McMahon and Denison, 1979; Horvath, 1982), the amount of gas deposited in a given test would be less than 0.5 g/m^2 for NO_2 and less than 3.4 g/m^2 for NH_3. These quantities would have no detectable effect on water quality.

c. Biological Resources

(1) Nitrogen Tetroxide tests. The area that could be affected by the largest proposed N_2O_4 release is shown in Fig. 5.2. This assumes that the release would be made under the least dispersive conditions (4.9 m/sec wind speed and neutral stability). Thus, the downwind distances to the various significant NO_2 concentrations (50, 10, and 3 ppm) shown in Fig. 5.2 represent the worst case for the largest spill. The dashed lines indicate the possible width of the NO_2 cloud, going out to a distance of 2 σ_y on either side of the centerline (assuming a wind direction of 225°). The solid lines enclose the area covered by all trajectories of simulated tests that met the test criteria (see Fig. 5.1). This represents the total area that might be at risk of exposure to the NO_2 cloud. The area that would actually be exposed during the largest release would be within this envelope and would actually be much smaller than the area at risk.

Our experience has shown that when the test criteria are met, i.e., daytime tests with steady winds between 2 and 8 m/sec, the gas clouds move downwind at very nearly the wind speed and do not persist for much longer than the spill duration. Steady winds, ground heating by the sun, and the ambient turbulence in the atmosphere mix the gas cloud with air and keep it moving steadily downwind. Consequently, the longest time period that any given point is likely to be exposed to the NO_2 cloud would be less than 10 min.

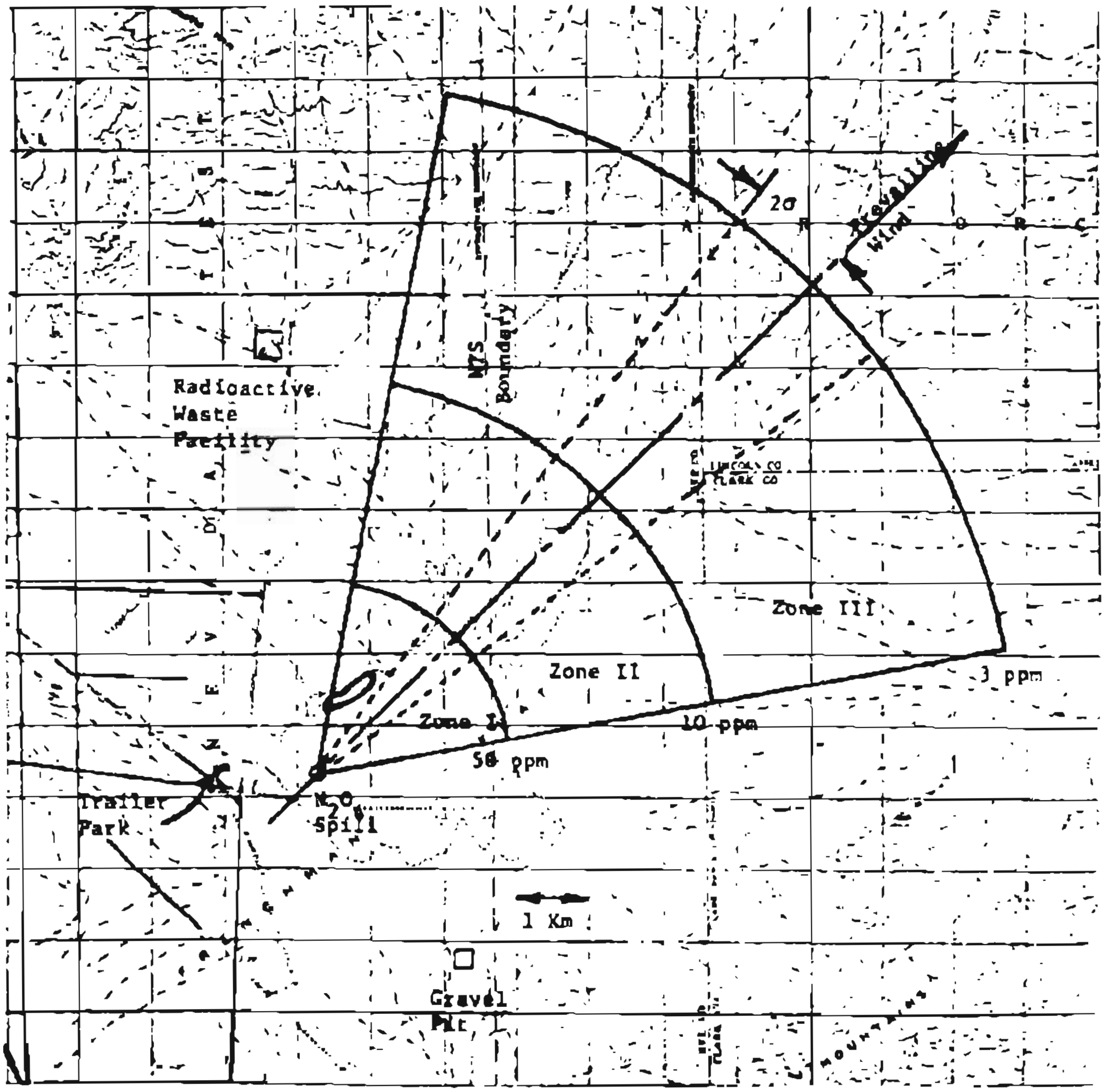

Fig. 5.2. Concentration zones for a two-minute planned release of liquid N_2O_4 at 2.5 m^3/min (least dispersive case meeting the test criteria) with lateral boundaries enclosing all trajectories out of 115 periods meeting the test criteria.

116s/3s

playa, the NO_2 concentration multiplied by time (CT) dosage values for vegetation will not exceed 10-20 ppm-hr during the largest proposed spill test. Little leaf damage resulted from similar CT values in experiments involving longer exposures at lower NO_2 concentration (Taylor et al., 1975). Thus, there is no reason to expect loss of vegetation as a result of the NO_2 spill tests. At most, some leaf damage may occur in a small area near the north side of the playa. Furthermore, there are no rare, threatened or endangered plant species in the section of Frenchman Flat that could be exposed to NO_2 levels of 10 ppm or higher.

(a) Wildlife. Wildlife populations in Frenchman Flat will not suffer significant impact from the proposed N_2O_4 spill tests. Most of the area that may be exposed to NO_2 concentrations above 50 ppm during the largest planned spill is dry lake bed which does not support animal life. The only wildlife habitats that might be subjected to these higher NO_2 levels are the artificial marsh and adjacent *Atriplex* association. Nitrogen dioxide concentrations between 10 and 50 ppm could extend up to 3 km northeast of the playa through the *Atriplex* and *Larrea*-*Ambrosia*-*Atriplex* desert shrub associations.

Like the studies of NO_2 effects on plants, most animal research has been concerned with NO_2 exposures that resemble those experienced in smog conditions. Thus, this work deals with relatively low NO_2 concentrations (0.3-25.0 ppm) and long exposure times (hours to months). Mammalian subjects such as mice, rats, rabbits, and dogs have been used exclusively. An extensive review of the literature on NO_2 effects is presented in Coffin and Stokinger (1977). These studies have usually demonstrated injury to the tissues of the lungs and trachea, with some impairment of respiratory function. There may also be increased susceptibility to infectious diseases of the respiratory tract, especially pneumonia.

Many months of exposure to NO_2 concentrations below 10 ppm generally results in lung damage, slightly increased susceptibility to pneumonia, but no mortality (Coffin and Stokinger, 1977). At NO_2 concentrations between 10 and 50 ppm, some mortality has been reported and susceptibility to respiratory infection is increased significantly. The few studies that have shown mortality

(2) Vegetation. The proposed N_2O_4 spill tests will have no significant impact on the natural vegetation of the Frenchman Flat basin. During the largest planned spill, concentrations of NO_2 higher than 50 ppm will be almost entirely confined to the dry lake bed, which is barren of vegetation (Fig. 5.2). The only vegetated areas that might be exposed to such levels of NO_2 are the artificial marsh on the north side of the playa and the adjoining *Atriplex* shrub association. The area to the northeast of the playa that could experience NO_2 concentrations between 10 and 50 ppm supports the *Atriplex* and the *Larrea-Ambrosia-Atriplex* associations.

Most experimental studies of the effect of NO_2 on plants have been designed to simulate smog exposure. As a result, the concentrations used have often been relatively low (0.1-25.0 ppm NO_2) and the exposure times have ranged from hours to months. Agricultural or ornamental plant species have usually been tested; there are limited data available on the response of desert species such as those found at Frenchman Flat. One study with NO_2 plus SO_2 (sulfer dioxide) determined that no injury will occur to some desert species (*Atriplex*, *Ephedra*, *Sphaeralcea*, and others) for 2-hr exposures up to 2 ppm NO_2 (Hill *et al.*, 1974).

No plant mortality has been reported in long-term exposures to NO_2 concentrations up to 25 ppm (Mudd and Kozlowski, 1975). The usual response is leaf damage, including the appearence of necrotic areas and lesions. Damage generally does not exceed 50% of the total leaf area of the affected plant. The necrotic leaves are sometimes dropped (abscission) and this may be accompanied by a reduction in photosynthesis and a slowing of the rate of growth. Exposure to higher NO_2 levels (up to 250 ppm) for shorter periods (0.5-8.0 hr) resulted in abscission rates as high as 90%, although all plants recovered within 6 weeks (McLean et al., 1968).

There are no experimental data on the response of vegetation to very short NO_2 exposures (< 30 min) similar to those that might occur downwind of the proposed spill tests. However, NO_2 concentration (C) and exposure time (T) are of approximately equal effectiveness in inducing leaf damage in plants, even at high NO_2 concentrations (McLean et al., 1968). At Frenchman Flat, even in the marsh and adjacent *Atriplex* association on the north side of the in laboratory animals exposed to this range of NO_2 concentrations have involved either weeks of exposure or deliberate introduction of respiratory pathogens following the exposure (Gardner, 1980). In other experiments, even long-term exposure at these NO_2 levels did not result in mortality when the animals were not challenged with infectious agents (Coffin and Stokinger, 1977).

Among animals, there appear to be species differences in sensitivity to NO_2. Rabbits kept in an atmosphere of 10 ppm NO_2 for two weeks suffered 50% mortality, yet no deaths were recorded in hamsters exposed to 25 ppm for six months or rats exposed to 12.5 ppm for 30 weeks (Coffin and Stokinger, 1977). There have been no studies of the effects of NO_2 on either birds or reptiles. Because of their generally lower level of metabolic activity, reptiles may be less sensitive to NO_2 than are mammals or birds.

In animals exposed to NO_2, the concentration has a much greater effect in determining the mortality rate than does exposure time (Gardner, 1980). Short exposures to high NO_2 concentrations have considerably more weight than long exposures to low concentrations, even though CT values are equal. For example, mice exposed to 28 ppm for 0.25 hr (CT = 7 ppm-hr) had a 55% increase in mortality over controls after challenged with pneumonia pathogen, while other mice exposed to 1.5 ppm for 4.7 hrs (CT = 7.05 ppm-hr) had only a 6.4% increase in mortality (Gardner, 1980). Experimental data regarding the effects on animals of NO_2 concentrations higher than 50 ppm are not available. Exposures of a few min to an hour at NO_2 concentrations of 50-100 ppm are considered potentially life-threatening to humans (Coffin and Stokinger, 1977) and could be expected to cause mortality among exposed wildlife.

The results of this research on NO_2 effects suggest that three impact zones can be defined downwind of the proposed spill site (Fig. 5.2). Zone I is an area that could be exposed to 50 ppm NO_2 or more for as long as 10 min during the largest planned test. Any wildlife that were present in an exposed location within this zone might be killed or seriously injured. Zone II could be exposed to NO_2 concentrations of 10 to 50 ppm for a similar period of time. Animals found within Zone II might suffer damage to the respiratory system; there is a very low probability of mortality. Nitrogen dioxide concentrations in Zone III will be less than 10 ppm. At these NO_2 levels and with such a short exposure period, no mortality is expected and the only effects on wildlife are likely to be irritation of the respiratory tract and possible minor lung damage.

Most of Zone I is barren playa which does not support any wildlife populations. If the NO_2 cloud follows the most probable trajectory during the largest planned test, NO_2 concentrations of 50 ppm and above will be confined to the playa. However, it is possible that the NO_2 cloud could move over the artificial marsh or the adjoining Atriplex shrub habitat. In neither case would there be significant impact to wildlife populations.

In the first case, marsh-dwelling birds such as red-winged blackbirds (Agelaius phoeniceus) and American coots (Fulica americana) may be exposed to levels of NO_2 that could cause mortality. These species are both common and widely distributed throughout the western United States. Such mortality (if it occurred) would have no significant impact on their populations in the region. In the second case, very few animals are likely to be active on the surface in the Atriplex habitat at the time of the test, which would be near midday in the summer. A few species of lizards and small birds, as well as black-tailed jack rabbits (Lepus californicus), might be exposed to potentially lethal concentrations of NO_2. The number of individuals at risk is unknown. The area that could be affected is small in relation to the total area of similar habitat in Frenchman Flat, the species that are likely to be exposed are widespread and abundant, and any mortality would be rapidly compensated through reproduction and immigration from the surrounding habitat.

Other wildlife species such as snakes and small rodents that might occur in Zone I are expected to be in their burrows at the time of day when a spill test would be conducted. There would be little or no danger to these animals. Many wildlife species normally plug the entrances of their burrows with loose dirt; this physical barrier would prevent exposure to NO_2. However, the gas is unlikely to penetrate an open burrow because of the temperature difference between the burrow air and the NO_2 cloud (Geiger, 1965). If a burrow were somehow to become filled with NO_2, the gas would dissipate within one minute based on a time estimate $r/4v$, where v is the deposition velocity and r is the burrow radius (J. Shinn, pers. comm.).

A reconnaissance survey on June 15-16, 1983 found no evidence of desert tortoise (Gopherus agassizi) in Zone I (Leitner, memo, July 5, 1983, Appendix). Even if a few individuals of this species were present in Zone I, they would almost certainly be protected from exposure to NO_2 by their normal behavior cycle. In late summer, when the spill tests will be carried out, desert tortoises will be either estivating in their dens continuously or will emerge to feed only at the coolest time of the day near dawn. It is extreemly unlikely that they would be active on the surface at the time of the N_2O_4 releases.

The reconnaissance survey identified two dens in Zone I that may be in active use by kit foxes (Vulpes macrotis). Again, it is very unlikely that individuals of this species would be exposed to potentially lethal concentrations of NO_2. They would normally be protected in their dens at the time tests would be conducted.

The wildlife species at risk in Zone II are essentially the same ones that are found in the desert shrub habitat of Zone I. Individual animals active at the surface could suffer minor damage to the respiratory system and there is the possibility of some deaths, although this seems very unlikely because of the short exposure time (10 min or less).

The reconnaissance survey observed tortoise dens in Zone II along a wash about 4-5 km northeast of the spill point (Leitner, memo, July 5, 1983, Appendix). This was the only site at which evidence of desert tortoise activity was found. Since NO_2 concentrations would be relatively low in this area, and since the animals would in all likelihood be in their burrows at the time tests are carried out, no adverse effects on this species are expected. The same conclusion would apply to any kit fox that may be present in Zone II.

While the area included in Zone III is quite large, the relatively low NO_2 concentrations here should ensure that there is no impact to wildlife populations, even during the largest planned test.

(3) Ammonia tests. The area that could be affected by the largest proposed NH_3 release is shown in Fig. 5.3. This assumes that the release would be made under the least dispersive conditions (4.9 m/sec wind speed and neutral stability). Thus, the downwind distances to the various significant NH_3 concentrations (1500, 500, and 50 ppm) shown in Fig. 5.3 represent the worst case for the largest spill. The dashed lines indicate the possible width of the NH_3 cloud, going out to a distance of 2 σ_y on either side of the centerline (assuming a wind direction of 225°). The solid lines enclose the area covered by all trajectories of the 115 cases of simulated tests that met the test criteria (see Fig. 5.1). This represents the total area that might be at risk of exposure to the NH_3 cloud. The area that would actually be exposed during the largest release would be within this envelope and would actually be much smaller than the area at risk. The longest time period that any given point would be exposed to the NH_3 cloud during this test is 10 min.

(a) Vegetation. The proposed NH_3 spill tests are not expected to significantly impact the natural vegetation of Frenchman Flat. Even during the largest planned spill, exposure times will be brief (10 min or less) and the highest NH_3 concentration (> 1500 ppm) will be largely restricted to the barren playa (Fig. 5.3).

Since NH_3 is a very uncommon air pollutant, there has been little research regarding its phytotoxic effects. The data that are available indicate leaf damage rather than plant mortality even with exposure to very high concentrations (National Research Council, 1979). Studies of accidental NH_3 spills in Ontario found no plant mortality even at the immediate site of releases (Temple et al., 1979). In these cases damage was restricted to the exposed leaves; leaf abscission was often noted, but no permanent injury occurred. There have been few experimental investigations of the effects on plants of high NH_3 concentrations (1000 ppm or above). The studies that have been conducted demonstrate species differences in sensitivity to NH_3. Exposures to 1000 ppm NH_3 for 8 min or less produced 50% leaf damage in buckwheat and tobacco, while 250 ppm for 4 min resulted in equivalent injury to tomatoes (National Research Council, 1979). In all species tested, leaves appeared to be most sensitive to NH_3, while woody stems were quite resistant to damage and seeds were susceptible only when wet (Pacific Northwest Laboratory, 1981; National Research Council, 1979).

During the largest planned NH_3 test, it is possible that the trajectory of the gas cloud would result in brief exposure of the vegetation in the artificial marsh or adjacent Atriplex shrub association to NH_3 levels on the order of 1000-2000 ppm. If this were to happen, some leaf damage and loss of foliage could occur. The affected plants would show decreased rates of photosynthesis and reduced growth until this foliage was replaced. No rare, threatened, or endangered plant species would be affected, since none occur in this section of Frenchman Flat.

(b) Wildlife. The proposed NH_3 spill tests will have no significant impact on wildlife populations in Frenchman Flat. Even in the case of the largest planned test, the highest concentrations of NH_3 (> 1500 ppm) will be almost entirely restricted to the dry lake bed, which is essentially devoid of animal life (Fig. 5.3).

There have been relatively few experimental studies of the effects on animals from acute exposure to NH_3; however, the available data suggest that animals are less sensitive to NH_3 than are plants (Pacific Northwest Laboratory, 1981). Several studies of laboratory species indicate significant mortality resulting from short-term exposures to NH_3 concentrations of 5000 to 25,000 ppm. Mice and guinea pigs exposed to 20,000-25,000 ppm NH_3 for 10-30 min showed mortality ranging up to 50% (Hilado et al., 1978; Underwriters Laboratories, 1933). Other researchers using mice, cats and rabbits have reported up to 50% mortality from exposures of 1 hr to NH_3 concentrations of 5000 to 10,000 ppm (Wands, 1981). These high concentrations produce severe damage to the upper respiratory tract, as well as less serious pathological effects on the bronchioles and alveoli of the lungs.

There are very few reports of mortality to experimental animals from even long-term exposure to NH_3 concentrations on the order of 1000 ppm. Most studies have found little or no ill effect on species such as guinea pigs, rats, rabbits, dogs, and monkeys as a result of exposures ranging from many hours to many days at this NH_3 level (Wands, 1981; National Research Council, 1979). However, there is some evidence that short-term exposure to these concentrations can increase susceptibility to secondary respiratory infection. Cats, for example, were found more likely to contract bronchitis and bronchopneumonia after only 10 min exposure to 1000 NH_3 (Dodd and Gross, 1980).

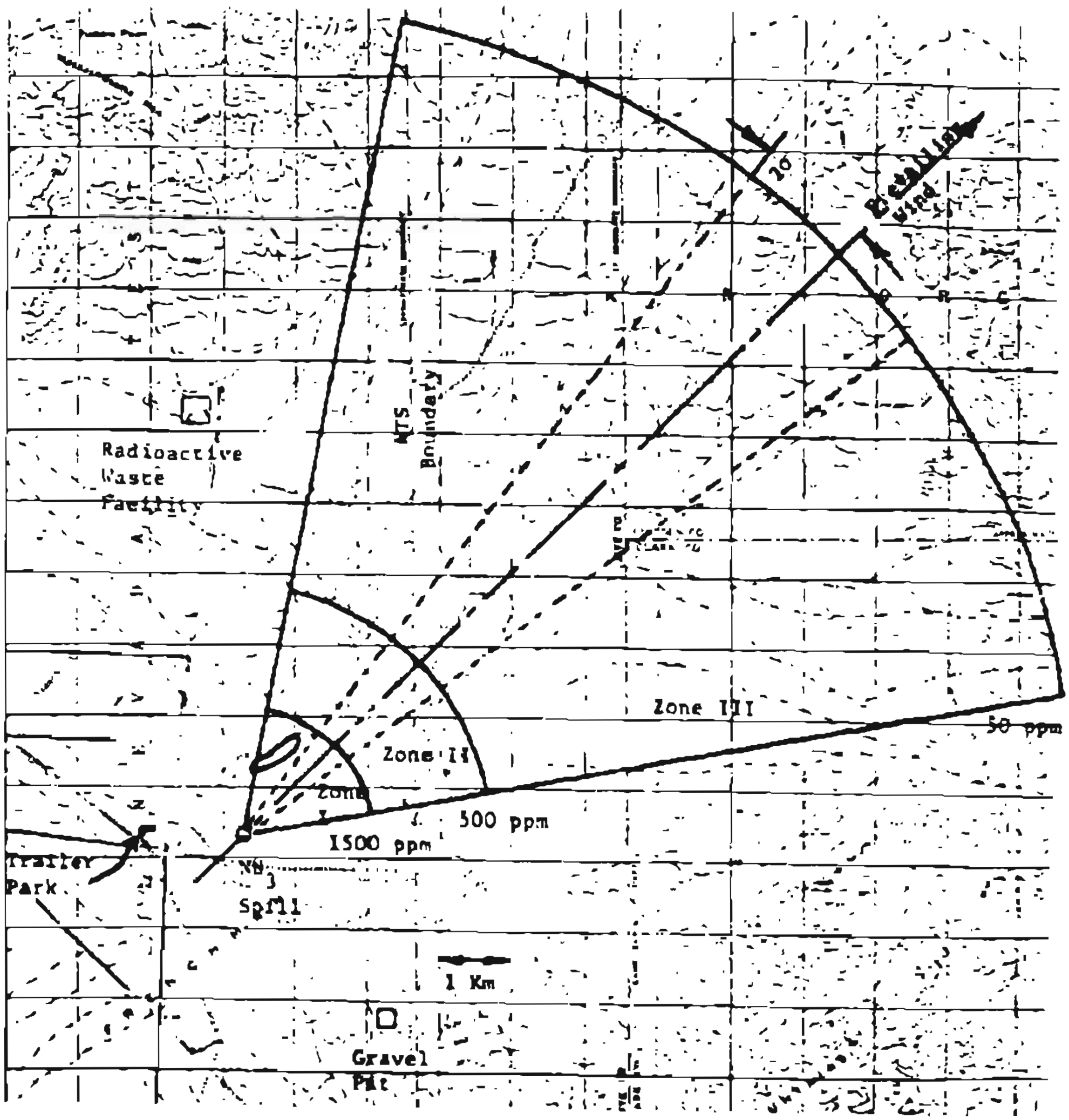

Fig. 5.3. Concentration zones for a four-minute planned release of liquid NH_3 at 15 m^3/min (least dispersive case meeting the test criteria) with lateral boundary enclosing all trajectories out of 115 periods meeting the test criteria.

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Long-term studies have found no mortality and no significant pathological changes in animals exposed to NH_3 concentrations below 500 ppm for many days to weeks (Wands, 1981; National Research Council, 1979).

Based on these experimental data, three impact zones have been defined (Fig. 5.3). Zone I includes the area that could be exposed to 1500 ppm NH_3 or more for up to 10 min during the largest planned test. Wildlife within this zone might be killed or seriously injured if they were active on the surface during the test. Zone II could be exposed to NH_3 concentrations ranging from 500 to 1500 for a comparable period of time. Animals present within Zone II could suffer some injury from NH_3 exposure, but there is a very low probability of mortality. Finally, concentrations in Zone III would be in the range from 50 to 500 ppm NH_3. These levels of NH_3 would at most result in minor irritation to any wildlife present here.

Zone I is smaller for the largest NH_3 test than for the comparable N_2O_4 release. Although a large portion of the area at risk of exposure to NH_3 concentrations of 1500 ppm or higher is dry lake bed, it does include the artificial marsh and a small section of Atriplex shrub habitat (less than 1 km^2).

As in the case of the N_2O_4 test, there could be some mortality of birds in the marsh or of lizards and small birds in the Atriplex habitat. Again, the species that might be affected are common and their populations would recover rapidly from such a loss.

Most wildlife species would be sheltered in burrows during the day when the tests would occur and would not be exposed to high concentrations of NH_3 even if the trajectory of the cloud took it into the Atriplex habitat.

The reconnaissance survey on June 15-16, 1983 (Appendix) found no sign of desert tortoise activity in Zone I, so no adverse impact on this species is expected as a result of NH_3 test series. One potentially active kit fox den was identified within Zone I. Since any kit foxes present would in all probability be protected in their den at the time the tests are carried out, no adverse effects are expected.

Much of Zone II lies within the playa; the area off the playa that could be exposed to NH_3 concentrations between 500 and 1500 ppm is mostly Atriplex habitat. Mortality or even serious injury to animals directly exposed within this zone is very improbable.

No harmful effects on wildlife populations are expected within Zone III.

d. Cultural Resources

The proposed NH_3 and N_2O_4 spill tests are not expected to adversely impact cultural resources. There appear to be no archaeological or historical sites at Frenchman Flat and the proposed project will not require any new surface disturbance or permanent construction.

2. Mitigation Measures

a. Air Quality

Air quality permits from the State of Nevada may be required for the tests. The tests will be performed within the specifications and constraints of these permits and whatever mitigation measures necessary to conform to these specifications will be implemented. Monitoring, both on- and off-site, will be done in accordance with the General Operating and Security Instructions.

b. Water Resources

Since the proposed project will have no impact on surface or groundwater resources, no mitigation measures will be required.

c. Biological Resources.

(1) Vegetation. Since the proposed N_2O_4 and NH_3 spill tests are expected to have no significant adverse impact on the natural vegetation of Frenchman Flat, no mitigation measures are called for.

Nevertheless, certain steps will be taken to monito ne effects of the project on vegetation downwind from the release site. Prior to the largest N_2O_4 and NH_3 spill tests, a survey will be conducted to determine the condition of the vegetation in those areas considered to likely to be exposed to the highest gas concentrations. Approximately two days after each of the two releases, the areas surveyed and/or any others receiving high exposure levels will be resurveyed. Visual examination and photomonitoring of dominant and subdominant plant species will be carried out as part of this effort. A report will be submitted to the Environmental Office, DOE Nevada Operations Office.

(2) Wildlife. The project is not expected to have any significant adverse impact on wildlife populations at Frenchman Flat. A reconnaissance survey for evidence of kit fox and desert tortoise populations was carried out on June 15-16, 1983 over an extensive area of Frenchman Flat downwind (north and east) of the proposed spill point (P. Leitner, memo, July 5, 1983, Appendix). The only desert tortoise population found was well outside the area that could be exposed to lethal concentrations of NH_3 or NO_2. Two potentially active kit fox dens were found within a zone that could be exposed to lethal concentrations of these gases. However no impact is expected because the animals should be in their dens at the time spill tests are conducted. To assure that this will be true the tests will not be conducted until after 9:30 AM. As a result of these findings, no other mitigation measures will be required to protect wildlife resources.

The artificial marsh should be surveyed for bird use before the largest proposed N_2O_4 and NH_3 releases. If significant numbers of waterfowl are found here, carbide or firecracker guns will be used to temporarily frighten them away just prior to the tests.

d. Cultural Resources

Since there will be no clearing of land areas or extensive offroad vehicle travel, there should be no impact on cultural resources should they exist in the Frenchman Flat area. Consequently no mitigation measures will be necessary. However, if any artifacts or other items of archaeological or historical interest are discovered in the course of the proposed project, established NTS guidelines will be followed to ensure their protection.

3. Unavoidable Adverse Impacts

If the project is carried out and the proposed mitigation measures are implemented, certain adverse impacts will still remain. The release of N_2O_4 and NH_3 to the atmosphere is necessary for the purposes of these tests. However, the amounts involved are such that there will be no significant impact on air quality. It is possible that small areas of natural vegetation close to the spill site in a downwind direction could suffer temporary damage. No loss of vegetation is expected and no rare, threatened, or endangered plant species are present in the area that might be impacted. There is a small risk of death or injury to a few individuals of certain wildlife species that may be present in areas close to the release point. No rare, threatened, or endangered wildlife species are at risk within the project area. Two species of concern, the kit fox and the desert tortoise, are very unlikely to be exposed to high concentrations of NO_2 or NH_3. They are either absent (desert tortoise) or are present in very low numbers (kit fox) in habitat that could be exposed to dangerous levels of these two gases. Furthermore, they should be underground in their burrows during the test periods. Low concentrations of these gases will drift onto lands being managed by the U.S. Fish and Wildlife Service which are being considered for wilderness designation. There will be a distinctive odor present during the tests (less than 10 min) but no harmfull effects will occur because of the low concentrations.

4. Cumulative Environmental Effects

The environmental impact of the proposed project will be temporary and transient. Release of N_2O_4 and NH_3 to the atmosphere will involve limited amounts of these materials for brief periods of time. Dispersion and mixing with the regional air mass will occur quickly and even the total of all releases during this test program will not result in a significant impact on air quality. Only the largest planned test in each series (N_2O_4 and NH_3) has the potential to harm vegetation or wildlife. Although these two releases could possibly affect the same area, it is very unlikely. Even if this cumulative exposure did occur, changes in plant and animal numbers or diversity would not be expected to result from this test program.

B. Alternatives to the Proposed Action

1. Impact Analysis

a. No Project

Under this alternative, no environmental impact would occur.

b. Tests of a Different Magnitude.

If the scope of the proposed N_2O_4 and NH_3 spill test program were reduced, the environmental impact would also be reduced. However, the objectives of the program could not be achieved and the information required to help ensure safe transport and storage of these substances could not be obtained.

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TRIP REPORT

Field Survey of Proposed LGF Spill Test Area at Frenchman Flat, NTS

Philip Leitner

Biology Department
Saint Mary's College
Moraga, CA 94575

July 5, 1983

An assessment of the potential environmental effects of NH_3 and N_2O_4 spill tests proposed by the LLNL Liquefied Gaseous Fuels Program was completed on June 13, 1983. This analysis indicated that if the tests were carried out at Frenchman Flat on the Nevada Test Site, the highest downwind gas concentrations would be largely confined to the barren dry lake bed. However, under worst case meteorological conditions the largest planned N_2O_4 release could result in an NO_2 concentration as high as 50 ppm at 2.65 km downwind from the spill point. Thus, NO_2 concentrations capable of killing or injuring exposed wildlife might reach habitat areas near the edge of the dry lake bed. The largest planned NH_3 release would result in exposure of a considerably smaller area to potentially lethal NH_3 concentrations; nevertheless, some wildlife habitat might be affected.

Two wildlife species of concern were identified as potentially occurring in areas near the dry lake bed that might receive dangerous concentrations of NH_3 or NO_2. These species are the kit fox (Vulpes macrotis) and desert tortoise (Gopherus agassizi); both are protected under Nevada law. Since no wildlife surveys had been carried out in the areas considered to be at risk of exposure to dangerous NH_3 or NO_2 concentrations, a site visit was arranged for June 15 & 16, 1983. The primary purpose of the visit was to conduct a search for any evidence of kit fox or desert tortoise populations in the area downwind of the proposed spill point. A secondary objective was to document general wildlife usage of this area.

APPENDIX

METHODS

A reconnaissance wildlife survey was conducted over much of the area downwind from the proposed spill point. The habitat up to 10 km northeast of the spill point was examined for any signs of kit fox or desert tortoise activity. The survey sampling effort was concentrated in those areas most likely to be impacted by NH_3 or N_2O_4 releases. All areas surveyed are indicated on the attached map.

The procedure was for two or more persons to drive by automobile to a pre-selected point and then to walk through a representative area of habitat. Special attention was paid to tracks or burrows that might give evidence of the two species of concern. Observations were also made of sightings or other sign of additional wildlife species. All personnel were instructed regarding the usual appearance and dimensions of kit fox and desert tortoise burrows.

Those participating in this survey included Joseph Shinn, Richard Cederwall, David McIntyre, Donald Holman, and John McClure, all from LLNL. The other participant was Philip Leitner (Biology Department, St. Mary's College).

RESULTS

No kit fox were seen during the two day survey period. However, several burrows that could have been utilized by this species were identified. Their locations are shown at points 1, 2, and 3 on the attached map.

Site 1 represents a den that appeared to be in active use; it was located in pile of dirt at an abandoned bunker. Site 2 was an apparently active den on the edge of an old dirt road. Site 3 was an inactive burrow that may have been used by kit fox in the past.

Sites 1 and 2 are within the area defined as Zone I for NO_2 in the Environmental Assessment document; Site I is within Zone I for NH_3 as well. Thus, these sites could be exposed to lethal concentrations of NH_3 (Site 1) or NO_2 (Sites 1 and 2). However, any kit fox present would be at risk of exposure only if they were above ground during the daytime test period, an unlikely situation. Site 3 is well out at the edge of Zone II for NO_2 and thus NO_2 concentrations here would never cause death or serious injury to exposed animals.

No desert tortoises were seen during this survey, although there was considerable search efffort during early morning hours when these animals were most likely to be active above ground. No sign of desert tortoise tracks or dens was found in the saltbush (Atriplex spp.) association near the dry lake bed. Survey work in the creosote bush (Larrea tridentata) association farther upslope to the north of the dry lake bed uncovered no evidence of this species either. The only place in which apparent desert tortoise dens were found is indicated as Site 4 on the attached map.

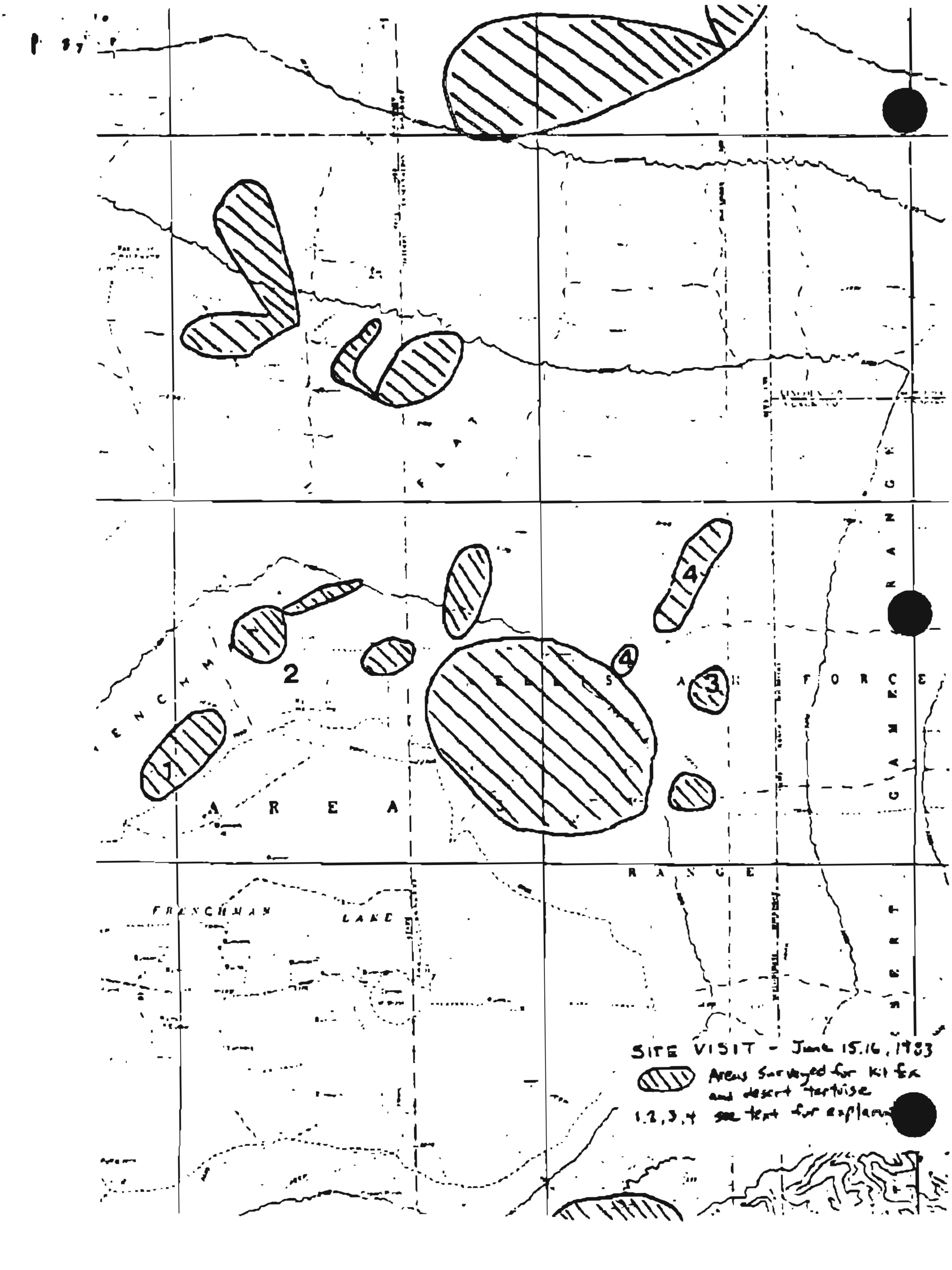
In Site 4 about a dozen potential desert tortoise burrows were seen along the banks of a major wash that comes down from the northeastern slopes toward the Frenchman Flat dry lake bed. Some of the burrows looked quite inactive, while others appeared to have been used during spring 1983. The most reasonable conclusion is that a small desert tortoise population exists along this wash above the 3100 ft contour. It seems likely that the animals were estivating in their dens at the time of the survey (mid-June).

A freshwater marsh has formed at the northwest margin of the dry lake bed, where water from a test well is impounded by a dike. Marsh vegetation consisting mainly of cattails (Typha sp.) and willows (Salix sp.) has grown up to a height of 3-4 m near the point at which the water enters. In those parts of the diked area more remote from the water inflow, the vegetation consists mostly of sedges and reeds which reach a height of 0.5-1.5 m and dry out during summer. There is no open water that might attract waterfowl or shorebirds. The only wildlife seen were a few mourning doves (Zenaida macroura) and red-winged blackbirds (Agelaius phoeniceus).

The dry lake bed supports little vegetation or animal life. It is primarily a flat barren surface of alkali-saturated clay. Scattered structures of various kinds left over from the atmospheric nuclear testing program of the 1950s are visible. Where ditches or shallow trenches were excavated, small clumps and rows of shrubs and low trees have become established. There is essentially no vegetation on the dry lake bed along the proposed spill centerline from the spill release point toward the 62-m meteorological tower. Some wildlife can be seen on the dry lake bed, including species that use the scattered vegetation and the abandoned structures for cover. During the survey, a coyote, several jack rabbits, whip-tailed lizards, mourning doves, Brewer's blackbirds, and Say's phoebes were observed on the dry lake bed; however, all were seen in the area to the south of the proposed spill area.

CONCLUSIONS

The wildlife survey indicated that the proposed spill tests would not adversely impact the desert tortoise population at Frenchman Flat. The only area in which this species was found would not receive dangerously high concentrations of NH_3 or NO_2. Although a few kit fox may occur within a zone that could possibly be exposed to lethal concentrations of NH_3 or NO_2, they would in all likelihood be in their dens at the time of the tests. The freshwater marsh at the edge of the old lake bed does not support and does not appear to be attractive to significant bird populations. Thus, few, if any, animals would be exposed to dangerous concentrations of NH_3 or NO_2 even during the largest planned spill tests.


SITE VISIT - June 15,16, 1983
Areas Surveyed for Kit Fox and desert tortoise
1,2,3,4 see text for explanation
FRENCHMAN LAKE
AREA
RANGE
2
1
3
4
4

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