Environmental Impact Analysis Process

ENVIRONMENTAL ASSESSMENT

TESTING OF TITAN
SOLID PROPELLANT ROCKET MOTORS

EDWARDS AIR FORCE BASE, CA
DEC 1986

DEPARTMENT OF THE AIR FORCE

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
00121986	N/A	-

Title and Subtitle Environmental Impact Analysis Process Environmental Assessment Testing of Titan Solid Propellant Rocket Motors	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) Brown and Caldwell Consulting Engineers 723 S Street Sacramento, CA 95814	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) sponsoring agency and address	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited	
Supplementary Notes	
Abstract	
Subject Terms	
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU
Number of Pages 103	

ENVIRONMENTAL ASSESSMENT FOR THE TESTING OF TITAN SOLID PROPELLANT ROCKET MOTORS AT EDWARDS AIR FORCE BASE, CALIFORNIA

December 1986

Prepared For: Department of the Air Force
Headquarters, Space Division
El Segundo, California

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FINDING OF NO SIGNIFICANT IMPACT (FONSI)
TITAN SOLID PROPELLANT ROCKET MOTOR TESTS
EDWARDS AIR FORCE BASE, CALIFORNIA

DESCRIPTION OF THE PROPOSED ACTION

INTRODUCTION

To support the U.S. Department of Defense (DOD) Space Program, and to ensure access to space through the continued use of Titan solid propellant rocket motors, the U.S. Air Force (USAF) proposes to test fire Titan rocket motors at Test Stand IC, located at the Rocket Propulsion Laboratory (RPL), Edwards Air Force Base (AFB), California, during the period of February to December 1987.

PROPOSED ACTION

The proposed action calls for the renovation of an existing rocket motor test stand (Test Stand IC) located on Leuhman Ridge at RPL to conduct the static test firings. Test Stand IC was used to test F-1 liquid rocket engines until the early 1970s. Test stand renovation includes refurbishment and changes in structural, mechanical, and electrical systems, addition of a heat shield to protect the steel deflector plate, water collection basin improvements, and addition of instrumentation, control, and monitoring equipment.

Following renovation of the test stand facilities, one 5-1/2-segment and possibly one 2-segment Titan solid propellant rocket motor will be test-fired. In addition, up to six short-burn 2-segment tests will be conducted. The tests will be conducted to:

1. Evaluate revised launch criteria.

2. Monitor the structural dynamics of the motors during each test firing.

SUMMARY OF ENVIRONMENTAL IMPACTS

NATURAL ENVIRONMENT

Air Quality

The proposed Titan rocket motor test firings will not significantly impact air quality at Edwards AFB or surrounding areas. Primary constituents of the rocket exhaust emissions will be aluminum oxide

(Al_2O_3), hydrogen chloride (HCl), carbon monoxide (CO), and oxides of nitrogen (NO_x). Afterburning in the atmosphere oxidizes some of these constituents, particularly CO. Modeling of the Titan motor exhausts indicates that the general population will not be exposed to HCl concentrations greater than the National Academy of Sciences recommended limit for short-term public exposure (limit of 3 parts per million HCl in a 10-minute average). Maximum downwind concentrations of Al_2O_3 (as suspended particulates), CO, and NO_x will be within applicable federal and state standards.

The maximum downwind concentration of particulate matter less than 10 microns in diameter (PM_{10}) from the test firings will be significantly less than the state standard of 50 micrograms per cubic meter. However, ambient air quality data indicate some exceedences of the state standard occurred in 1985.

Soils

Implementation of the Titan testing program involves lowering of the water containment berm by 5 feet at Test Stand IC. Neither the lowering of the berm or the subsequent Titan tests will significantly affect the soils at Edwards AFB or the surrounding area.

Hydrology

No significant impacts to groundwater or surface water hydrology will result from the Titan motor tests. All water used for the Titan tests will come from the municipal groundwater supplies. Most of the deluge (cooling) water used in the tests will be conditioned with a carbonate buffer to mitigate the effects of HCl absorption and low pH. Some deluge water will precipitate as acid mist (pH of about 3) from the exhaust plume and exhaust cloud onto the ground surface. The amount of precipitation is estimated to be 0.01 inch in the test stand vicinity. The remainder of the deluge water not entrained into the exhaust gas stream will be collected and recycled or evaporated in concrete-lined channels and a basin located near Test Stand IC.

Water Quality

No impacts on water quality will result from the Titan tests. All deluge water contained in the channels and basin will be recycled and/or evaporated. The amount of mist that will precipitate from the exhaust onto the rocks and soil nearby is limited and will evaporate within about 1 hour, leaving inert nonhazardous compounds (mostly aluminum oxide and sodium chloride) on the ground surface. These compounds will become part of the desert soil. The amount of HCl deposition will be small and have no significant impact on ground or surface waters.

Biota

No significant impacts on the biota of Edwards AFB or surrounding areas are expected as a result of the Titan motor tests. Vegetation and habitat impacts from acidic mist will be extremely limited. No critical habitat for threatened or endangered species will be lost due to the Titan test program. Aquatic organisms will not be impacted. Limited ground animals in this area will be unaffected by the mist fallout. Birds will leave the area when the rocket is fired.

MAN-MADE ENVIRONMENT

Population

The renovation of Test Stand IC and the subsequent test program of the Titan rocket motors will have no significant impacts on population and housing at Edwards AFB or within surrounding communities. The Titan test program will utilize existing personnel at RPL and Edwards AFB. Temporary staff from the USAF Space Division, United Technologies-Chemical Systems Division, and their contractors will be on-site during renovation work and motor testing periods.

Socioeconomics

Test Stand IC was constructed in 1965. The proposed Titan test program is compatible with the surrounding land use, will require no land purchase and no construction work beyond the boundaries of the test stand area, and will not require new utility services, new transportation access, or additional employment. No significant impacts on the socioeconomics of Edwards AFB or Kern County California, are anticipated.

Safety

All regulatory agency safety procedures and guidelines will be followed. Safety monitoring will be conducted during the tests. For the large 2-minute test firings, a protective clear zone of about 1 mile will be established around the test stand and no one will be allowed into the immediate downwind area (approximately 10 miles downwind). A wind corridor has been established to minimize the chances of the exhaust cloud proceeding over housing areas. Essential test personnel will be located in a protected concrete bunker near the test stand. Exhaust cloud monitoring will be conducted.

Noise

Noise levels associated with the Titan test program will not significantly affect the general public due to the distance between the test site and the nearest unregulated area (3 miles). Noise produced during the test firings will be of short duration (2 minutes or less for each event), and at worst, will be a nuisance on two occasions. Portions of the RPL will be evacuated to minimize noise impacts on site.

Archaeology and Cultural Resources

The Test Stand IC area contains no unique archaeological or historic resources. As a result, the Titan test program will have no effect on archaeological or cultural resources.

FINDINGS

Based on the above, a finding of no significant impact is made. Copies of an Environmental Assessment of the proposed action, dated December 1986, can be obtained from:

HQ Space Division
Post Office Box 92960
Worldway Postal Center
Los Angeles, California 90009
ATTENTION: Mr. Robert C. Mason, SD/DEV

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LIST OF ACRONYMS AND ABBREVIATIONS

Act	Federal Endangered Species Act of 1973
AFB	Air Force Base
Al_2O_3	Aluminum oxide
APCD	Air Pollution Control District
C	Centigrade
Caltrans	California Department of Transportation
CHP	California Highway Patrol
Cl	Chloride
CO	Carbon monoxide
CO_2	Carbon dioxide
CSD	United Technologies Corporation-Chemical Systems Division
CWMB	California Waste Management Board
dB	Decibels
dB(A)	Decibels measured on A weighting scale
DFG	California Department of Fish and Game
DOD	United States Department of Defense
DOT	United States Department of Transportation
$Dyne/cm^2$	Dynes per square centimeter
EA	Environmental Assessment
EPA	United States Environmental Protection Agency
F	Fahrenheit
fps	Feet per second
gpm	Gallons per minute
H_2	Hydrogen
H_2CO_3	Carbonic acid
H_2O	Water
HCl	Hydrogen chloride
KSC	Kennedy Space Center
Lb	Pounds
Lb/ft^2	Pounds per square foot
Na	Sodium
$NaCl_3$	Sodium chloride (salt)
Na_2CO_3	Sodium carbonate
N_2	Nitrogen
NASA	National Aeronautics and Space Administration
NO_2	Nitrogen dioxide

NO_x	Nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
O_2	Oxygen
O_3	Ozone
OSHA	Occupational Safety and Health Administration
PIRA	Precision Impact Range Area
ppm	Parts per million
PM_{10}	Particulate matter less than 10 microns in diameter
Regional Board	California Regional Water Quality Control Board, Lahontan Region
RPL	Rocket Propulsion Laboratory
State Board	California State Water Resources Control Board
TSP	Total suspended particulates
ug/m^3	Micrograms per cubic meter
um	microns
USAF	United States Air Force
USFWS	United States Fish and Wildlife Service

1.0 PROPOSED ACTION AND ALTERNATIVES

The U.S. Air Force (USAF), Headquarters Space Division, El Segundo, California, is proposing to perform static test firings of Titan solid propellant rocket motors at the USAF Rocket Propulsion Laboratory (RPL), Edwards Air Force Base (AFB) in eastern Kern County between February and December 1987. In April 1986, a Titan 34D space launch vehicle experienced an in-flight failure several seconds after liftoff from Vandenberg AFB, California. At liftoff the Titan 34D is powered by two 5-1/2-segment solid propellant rocket motors. The cause of the failure may have originated in the solid propellant rocket motor. The manufacturer of the Titan solid propellant rocket motors, United Technologies Corporation-Chemical Systems Division (CSD), has researched and evaluated the potential causes of the misfiring and determined that it was probably due to one of the following:

1. Insulation separated from the steel casing.

2. The restrictor, which acts as a seal between the propellant in adjoining segments, separated from the propellant allowing it to burn through the insulation and casing.

3. Void space within the propellant which would lead to rapid, uneven burning.

Static test firings are proposed as follows:

1. One 5-1/2-segment Titan rocket motor with its normal 2-minute burn time.

2. One 2-segment Titan rocket motor with its normal 2-minute burn time (optional test).

3. Up to six short-burn tests (each about 2 seconds burn time) on a 2-segment Titan rocket motor.

Static tests are conducted on motors that are held down on the test stand rather than being launched. The rocket motors are manufactured in segments for ease of transportation. Each segment is about 10 feet in diameter and about 11 feet high. The segments will be stacked and mated on the test stand. Instrumentation will be attached to the rocket motors to monitor the tests. The motors will fire while being held to the test stand.

This Environmental Assessment (EA) addresses the environmental impacts associated with the proposed static test firings of the Titan solid propellant rocket motors. The EA documents the compliance of the static test program with applicable federal, state, and local environmental regulations and identifies mitigation measures which shall be implemented to minimize the environmental impacts of the proposed test program.

1.1 BACKGROUND

CSD is now using X-ray equipment to scan the propellant, casing, and liner of each Titan solid propellant rocket motor segment. Thus far, no problems have been found with the casings or the liners in any of the Titan segments examined. It appears that the Titan segment which misfired at Vandenberg AFB contained a flaw that other Titan segments do not have. However, CSD is continuing to inspect the fleet of Titan rocket motor segments.

1.2 PROPOSED ACTION

The USAF and CSD intend to conduct static test firings at Edwards AFB to determine:

1. If the acceptance criteria used by CSD are adequate. The Titan propellant and each Titan segment are subjected to a variety of tests. CSD has developed criteria for these tests to determine if each batch of propellant and each motor segment is acceptable.

2. If the placard temperature is correct or if it should be adjusted for the Titan propellant. The placard temperature is the ambient temperature range prior to ignition over which the Titan propellant functions properly.

3. If there are problems with the clevis joint. The clevis joint includes all connecting devices located where two Titan segments are joined together.

The motors will be tested with the nozzle pointing down. Testing in this configuration will provide better test results than the more conventional horizontal test firings or nozzle-up tests. The rocket segments that will be used in the tests at Edwards AFB will be X-rayed to determine that there are no flaws in the propellant, casings, or liners.

The proposed action consists of four major tasks: (1) modifications to the existing test stand, (2) transport and setup of rocket motor segments and necessary test equipment, (3) testing of the Titan rocket motors, and (4) operation of a deluge water recycling and treatment system. Each task is described in the following sections.

1.2.1 Project Location

Edwards AFB is located at the eastern edge of Kern County in the Mojave Desert at an elevation of approximately 2,300 feet. RPL is located in the northeast corner of Edwards AFB about 11 miles east of the main base. RPL is a research and development facility responsible for planning, formulating, and executing the USAF technology programs for rocket propulsion and related space technology. Both solid and liquid rocket motors are tested at a number of test stands located at RPL. Figure 1.1 shows the general location of Edwards AFB and RPL. Figure 1.2 shows the test stands and major areas of RPL. Test Stand IC, which will be used for the proposed tests, is located on top of Leuhman Ridge at an elevation of approximately 3,200 feet, or about 900 feet above the flat desert terrain west of Leuhman Ridge. The location of Test Stand IC is shown on Figure 1.3. The main buildings of the RPL are located about 1 mile south of this test stand. The nearest town is Boron, located approximately 3.5 miles north-northeast of the test site. The Desert Lakes housing area is approximately 3 miles north of the test site. The main base at Edwards AFB is about 11 miles west-southwest of the test site, and Death Valley is approximately 80 miles to the northeast.

1.2.2 Renovation of Test Stand IC

This test stand was previously used for the testing of liquid propellant motors. The liquid propellant testing structures and equipment have been removed, and the test stand is currently being modified to accommodate the Titan solid propellant rocket motors. Modifications include the removal of two tanks from the top of the test stand, buildup of the superstructure to support the Titan rocket motors, installation of a pylon adaptor to receive the 10-foot-diameter Titan rocket motors, and construction of a bonnet to restrain the motors during firings. The electrical and water supply systems have been completely overhauled.

Special equipment has been added to Test Stand IC to conduct and monitor the test firings. A silicon-phenolic heat shield material is being added to the steel deflector plate in the area where the high temperature exhaust will strike it. This material is designed to slowly wear away during the test to protect the steel deflector plate. A deluge water recycling and treatment system has been established to provide mitigation of low pH mist and control of solids disposal. Instrumentation, monitoring, and control equipment is being added to conduct the tests successfully and in accordance with up-to-date safety and reliability standards.

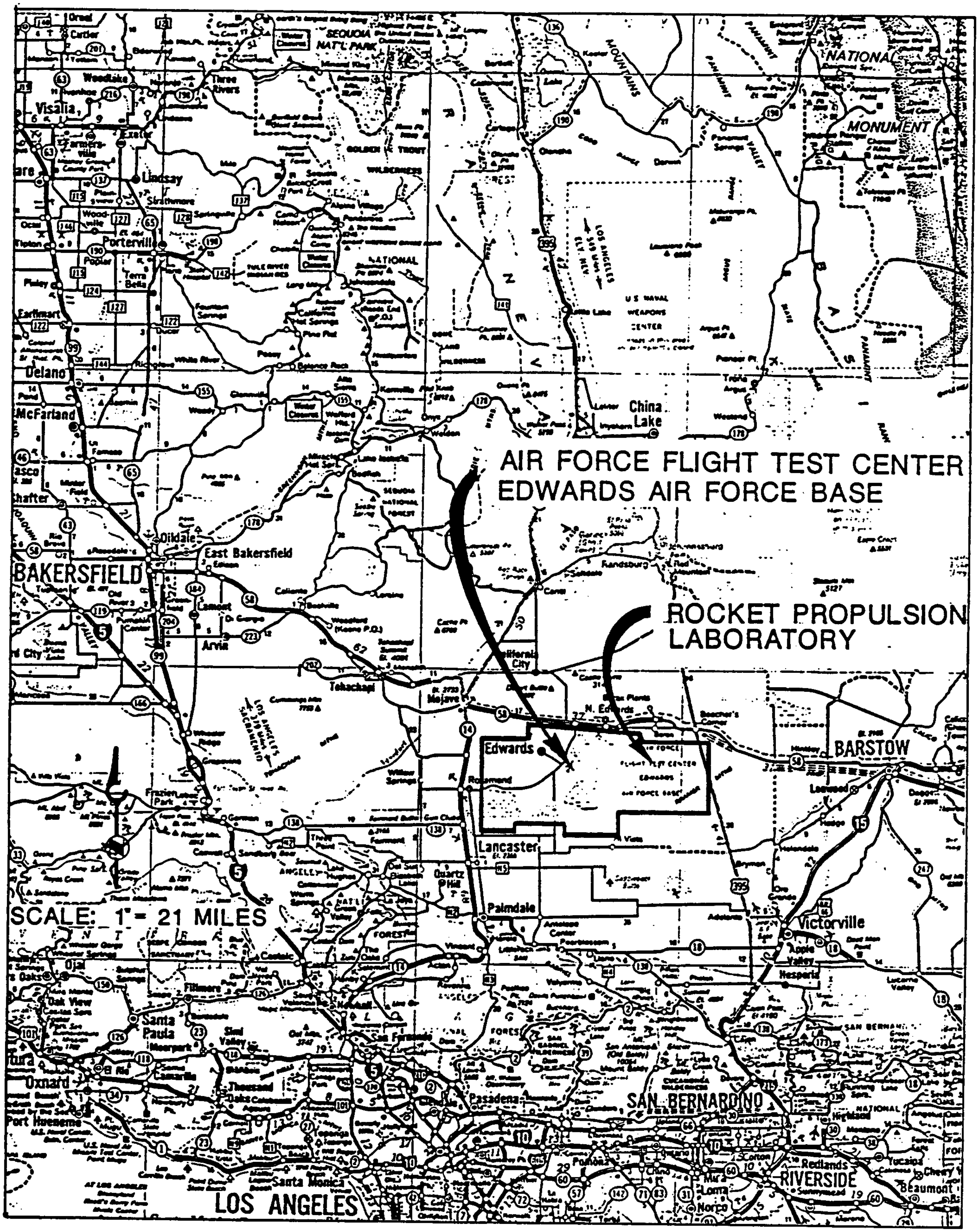


Figure 1.1 Location of Edwards Air Force Base

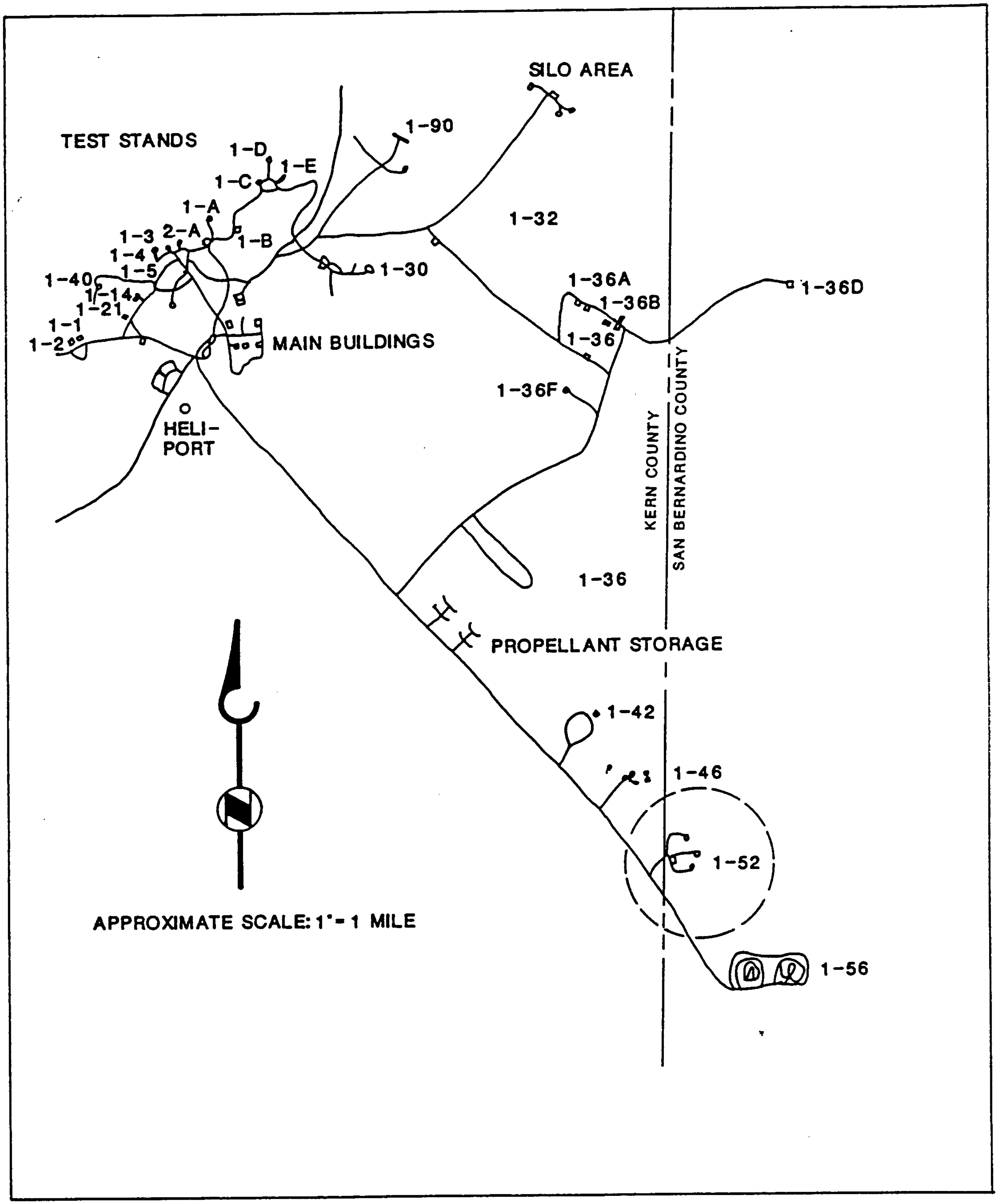
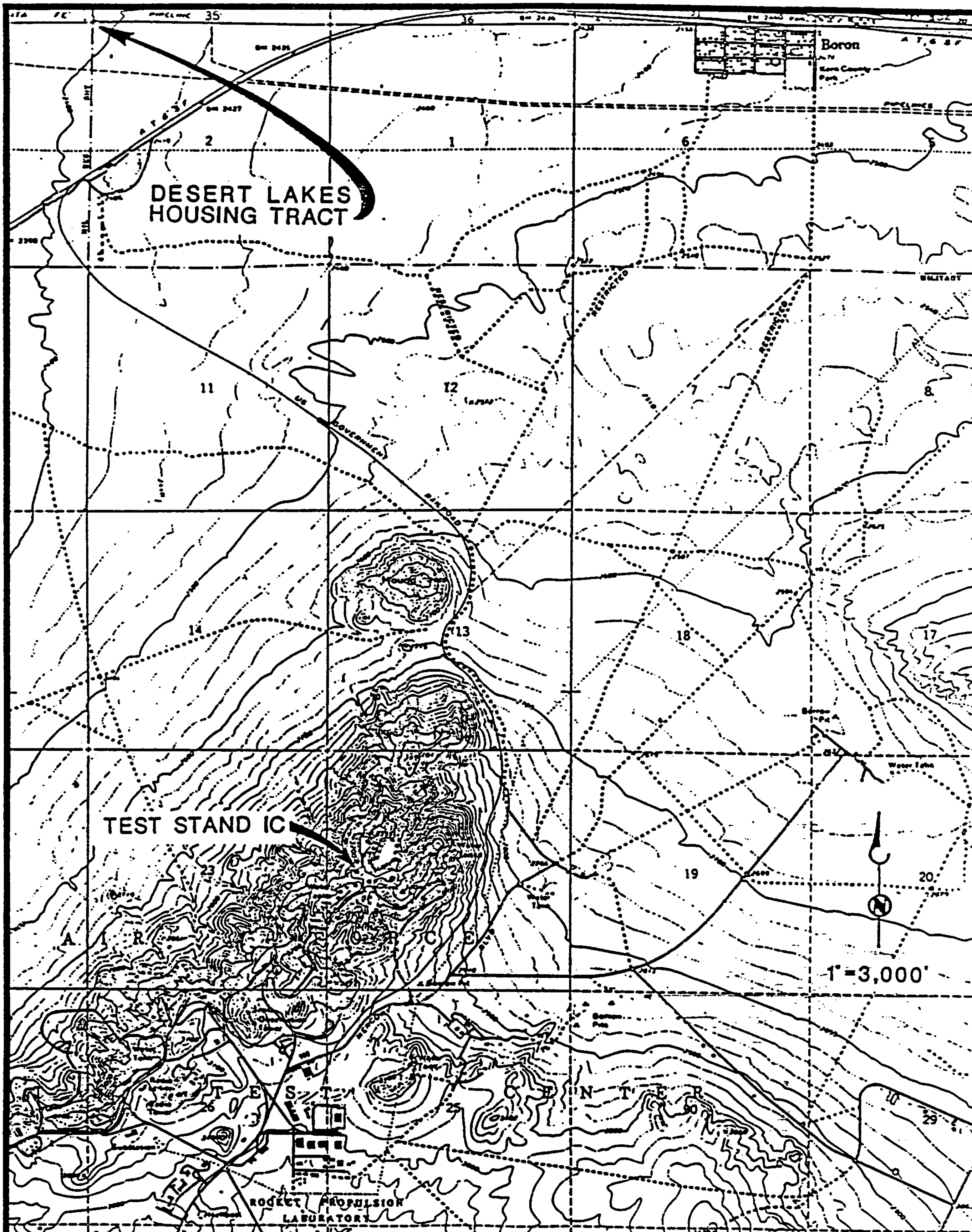


Figure 1.2 Rocket Propulsion Laboratory



.Figure 1.3 Location of Test Stand IC

1.2.3 Test Firing Setup

The rocket motor segments to be used for the test firings will be transported by truck from CSD storage facilities in southern California to RPL. The storage facilities and transportation routes are not identified in this EA for security reasons. Since each motor segment is fairly large, oversize regulations apply to the transport of such material. Regulations of the U.S. Department of Defense (DOD), U.S. Department of Transportation (DOT), and the California Highway Patrol (CHP) will be observed to ensure compliance in transport, movement, and handling of all Titan rocket motor segments. Segments will be stacked and mated according to CSD standard procedures and safety regulations. Following each test, the spent rocket motors will be disassembled and transported off site for detailed examination.

1.2.4 Testing of Titan Rocket Motors

1.2.4.1 Two-Minute Test Firings--

The 5-1/2-segment motor will contain 465,800 pounds (lb) of propellant and the 2-segment motor (if tested) will contain 206,120 lb of propellant. Each of these test firings will last for 2 minutes, during which extensive data regarding rocket performance, structural and thermal loads on the test stand structures and booster rocket, and other critical performance parameters will be obtained. The Titan solid propellant burns at a given rate from the core toward the casing in each segment. It takes 120 seconds for the propellant to completely burn within each segment. Therefore, a 2-segment motor burns for the same amount of time as a 5-1/2-segment motor.

The solid propellant used in the Titan rocket motors consists of ammonium perchlorate oxidizer, aluminized synthetic-rubber binder fuel, and various other additives to stabilize mass and control the burning rate. The combustion products at the nozzle will be particulates, consisting mainly of aluminum oxide (Al_2O_3), hydrogen chloride (HCl), and gaseous hydrogen (H_2), nitrogen (N_2), and carbon monoxide (CO). Various water sprays will be used to quench and cool the rocket and exhaust for the tests of 2-minute duration.

1.2.4.2 Short-Burn Test Firings--

The six short-burn tests will be substantially different from the 2-minute test firings. The purpose of the short-burn tests is to bring the motor case up to required pressure for about 1 second so that the performance of the joints between the motor segments can be adequately monitored. To do this, a maximum of 500 pounds of propellant will be ignited for each test within a 2-segment rocket motor. The motor will be filled with inert propellant-like material to provide weight and structural characteristics similar to a 2-segment motor full of solid propellant. The 500 pounds of propellant will burn in a maximum of 2 seconds to provide the pressure needed. The deluge water system is not required for these tests.

The air emissions and the exhaust plume will be much smaller for the short-burn tests than for the 2-minute test firings. Noise and other effects are also greatly reduced. Therefore, these tests are described in less detail than the 2-minute test firings.

1.2.5 Deluge Water Handling System

The 2-minute Titan rocket motor tests will require an extensive deluge water system since the exhausts will have a very hot, high-velocity gas stream, and the tests will be undertaken with the nozzle of the motor pointing down. A large deflector shield, called the flame bucket, will divert the exhaust to the horizontal. The deluge water system, which is primarily used to cool the flame bucket, is described in the following sections.

1.2.5.1. Water Quantity--

Each of the 2-minute test firings will require approximately 570,000 gallons of cooling (deluge) water. Table 1.1 shows the derivation of this number by test period. For both the 5-1/2- and 2-segment tests, it is estimated that 280,000 gallons will be lost to evaporation and dispersive spray during rocket motor ignition and the remaining 290,000 gallons will be collected.

Table 1.1. Water Flow Rates and Volumes for Each 2-Minute Test

Test period	Average flow rate, gpm	Duration, minutes	Water supply volume, gallons	Water volume collected, gallons
Start-up	70,000	2	140,000	140,000
Ignition	140,000	2	280,000	0
Shutdown	70,000	2	140,000	140,000
Quench	1,000	10	10,000	10,000
Total	-	-	570,000	290,000

No deluge water is needed to cool the flame bucket for the short-burn tests. A small amount of rocket motor quench water and washdown water will be used. At maximum, 10,000 gallons of water could be used for each of the short-burn tests. All of this water would be collected in the water channel containment system.

1.2.5.2 Water Containment and Treatment System--

The deluge water will be supplied from two existing storage tanks. A 3-million-gallon tank supplies a 120,000-gallon-per-minute (gpm) system, and a 400,000-gallon tank supplies a 20,000-gpm system. The larger system supplies water directly to the flame bucket, and the smaller system is for sprays and quench waters used above the flame bucket.

The deluge water will be collected in the basin at Test Stand IC and will flow into the 6-foot high concrete channels that connect Test Stands IC and ID. The collection system is shown on Figure 1.4. Cracks and leaks in these channels have been repaired. The system is scheduled to be tested for water tightness in January 1987. The estimated volume of storage available in these channels is 816,000 gallons. It is estimated that the depth of water in the channels after each 2-minute rocket motor test will be 1-1/2 to 2 feet.

The hydrogen chloride in the rocket exhaust has an affinity for water. When it dissolves in the deluge water, it becomes hydrochloric acid which lowers the pH of the water. The water handling system consists of pretreatment of the water with sodium carbonate to raise the pH to about 11 prior to the test. This is being done to mitigate the low pH which occurs in the mist fallout beneath the exhaust plume. Conditioning of the water will be performed by addition of sodium carbonate in the mixing basin, as noted on Figure 1.4.

1.3 ALTERNATIVE ACTIONS

Alternative actions to the proposed testing of Titan rocket motors at Edwards AFB include alternative types of tests and alternative sites for the tests.

1.3.1 Alternative Tests

Horizontal and nozzle-up static test firings were considered for this program but were rejected by the USAF and CSD because the forces acting on the rocket motors in these configurations are different than the forces in the nozzle-down launch position. The purpose of the proposed tests is to simulate as closely as possible the forces acting on the rocket motors during launch conditions. The nozzle-down tests were chosen for this reason.

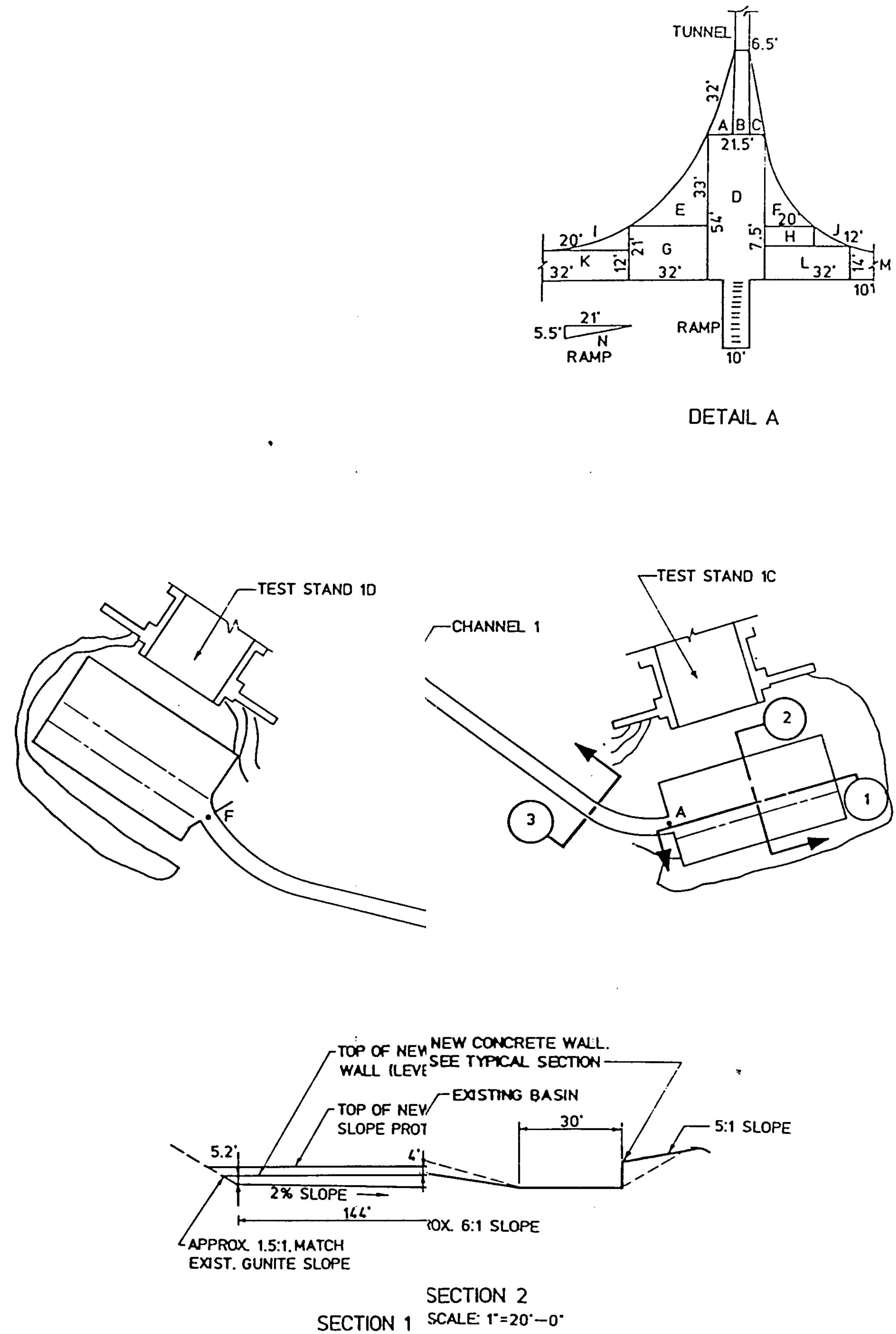


Figure 1. Test Stand 1C Deluge Water Capture System

1.3.2 Alternative Sites

The USAF and CSD conducted a nationwide search for the best site to conduct these tests. CSD examined the feasibility of conducting the tests at its Coyote Center facility near San Jose, California, and at one of the USAF launch bases. These sites were rejected because their test stands are designed for horizontal and nozzle-up tests, and launch pads are not adequate for static test firings. An entirely new test stand and flame deflector would be required to conduct nozzle-down tests at these sites. Testing at the National Aeronautics and Space Administration (NASA) Mississippi Space Center and NASA's Marshall Space Flight Center was also evaluated and rejected because of conflicts with other high-priority programs. The USAF evaluated four test facilities at RPL and determined that Test Stand IC was in the best working condition and best suited for these tests. Therefore, Test Stand IC at RPL was chosen for the static test firings.

1.4 NO-ACTION ALTERNATIVE

If the proposed tests are not conducted, the no-action alternative will require that the USAF stop using Titan rocket motors or risk another incident similar to the one at Vandenberg AFB. The no-action alternative is not feasible because the USAF must determine that the Titan solid propellant rocket motors are reliable and can be used to launch critical national defense payloads.

2.0 ENVIRONMENTAL SETTING

2.1 NATURAL ENVIRONMENT

2.1.1 Geology and Soils

Edwards Air Force Base (AFB) is located in the western portion of the Mojave Desert at an elevation of approximately 2,300 feet. Test Stand IC which will be used in the project, is located at the Rocket Propulsion Laboratory (RPL) on Leuhman Ridge at an elevation of 3,200 feet, about 900 feet above the desert floor to the west of Leuhman Ridge. This portion of the desert is dominated by the Antelope Valley, which is bordered to the south by the San Gabriel Mountains, to the northwest by the Tehachapi Mountains, and to the east by low hills. Layers of eroded material from the surrounding mountains have built up over bedrock to form alluvial fans. These layers of rock, sand, and alluvium are shallow along the base of the mountains, rock outcroppings, and butte formations, and become deep in the dry lakes or playas. The major playas within Edwards AFB are Rosamond Lake and Rogers Dry Lake. Rogers Dry Lake lies about 5 miles west of the test site. Rock outcroppings, ranging from small single rocks to small mountain or ridge formations spot the surface of the base. The test site is located on the Leuhman Ridge rock formation.

Soils in the test site area (below Leuhman Ridge) consist of a surface layer of blown sand covering sandy soil mixed with clay. Most of the soil layer is impermeable, and most of the rainfall washes down to the dry lake beds. The soils of the area are slightly alkaline with the pH ranging from 7.4 to 8.4 (U.S. Department of Agriculture, 1981). The slopes of Leuhman Ridge have shallow surface soils which cover bedrock. The top of the ridge is essentially rock, with little soil material.

Mountains to the north and south which form the west side of the Antelope Valley follow major faults. These include the San Andreas and Garlock faults which intersect at Gorman, approximately 70 miles west of the test site area. In addition to these major faults, several minor fault lines fan out across the Edwards AFB area (see Figure 2.1).

2.1.2 Meteorology

The climate at Edwards AFB is characterized by long, dry summers and mild, relatively dry winters. The mean seasonal and annual temperatures, precipitation, wind speeds, and wind directions are shown in

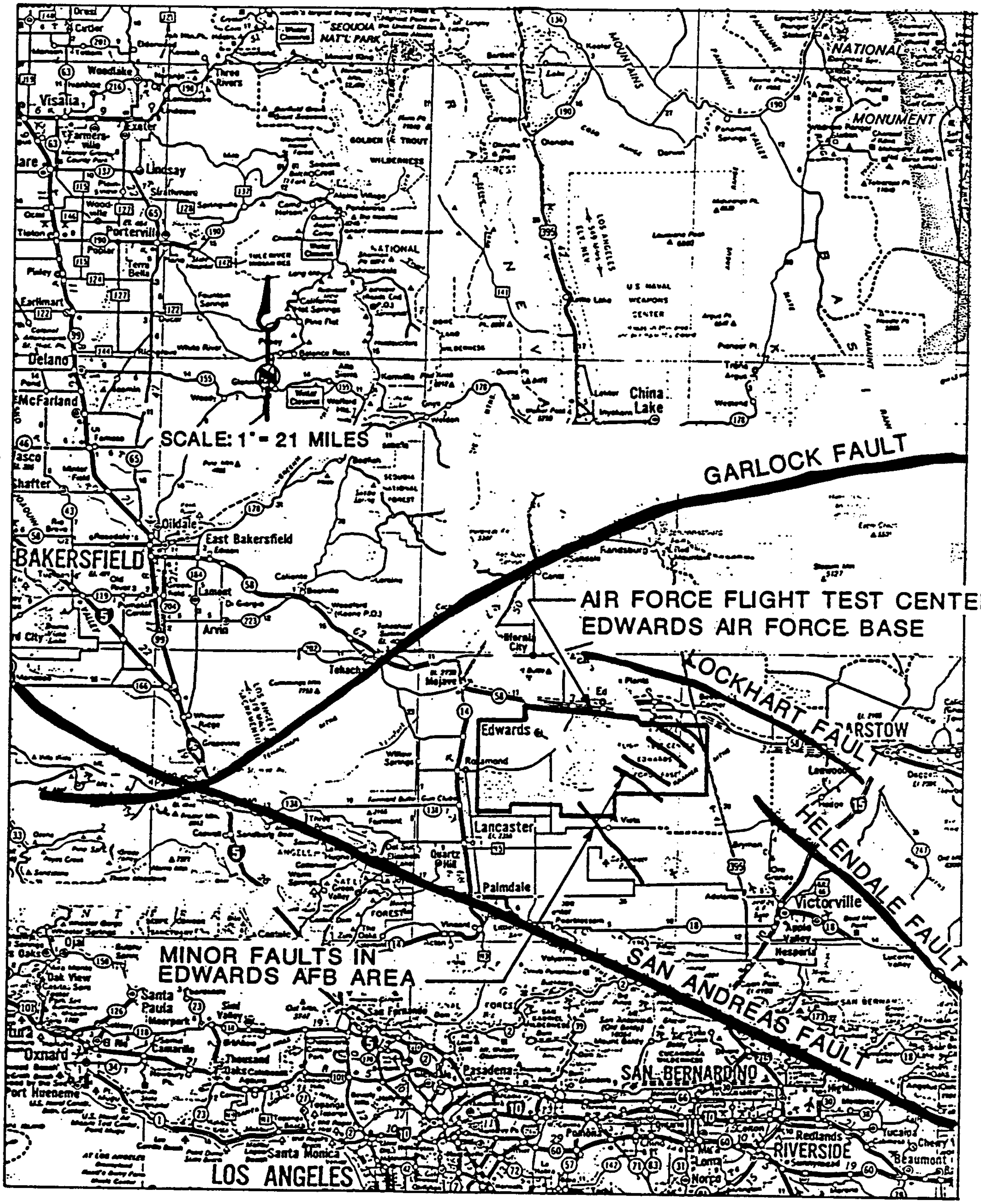
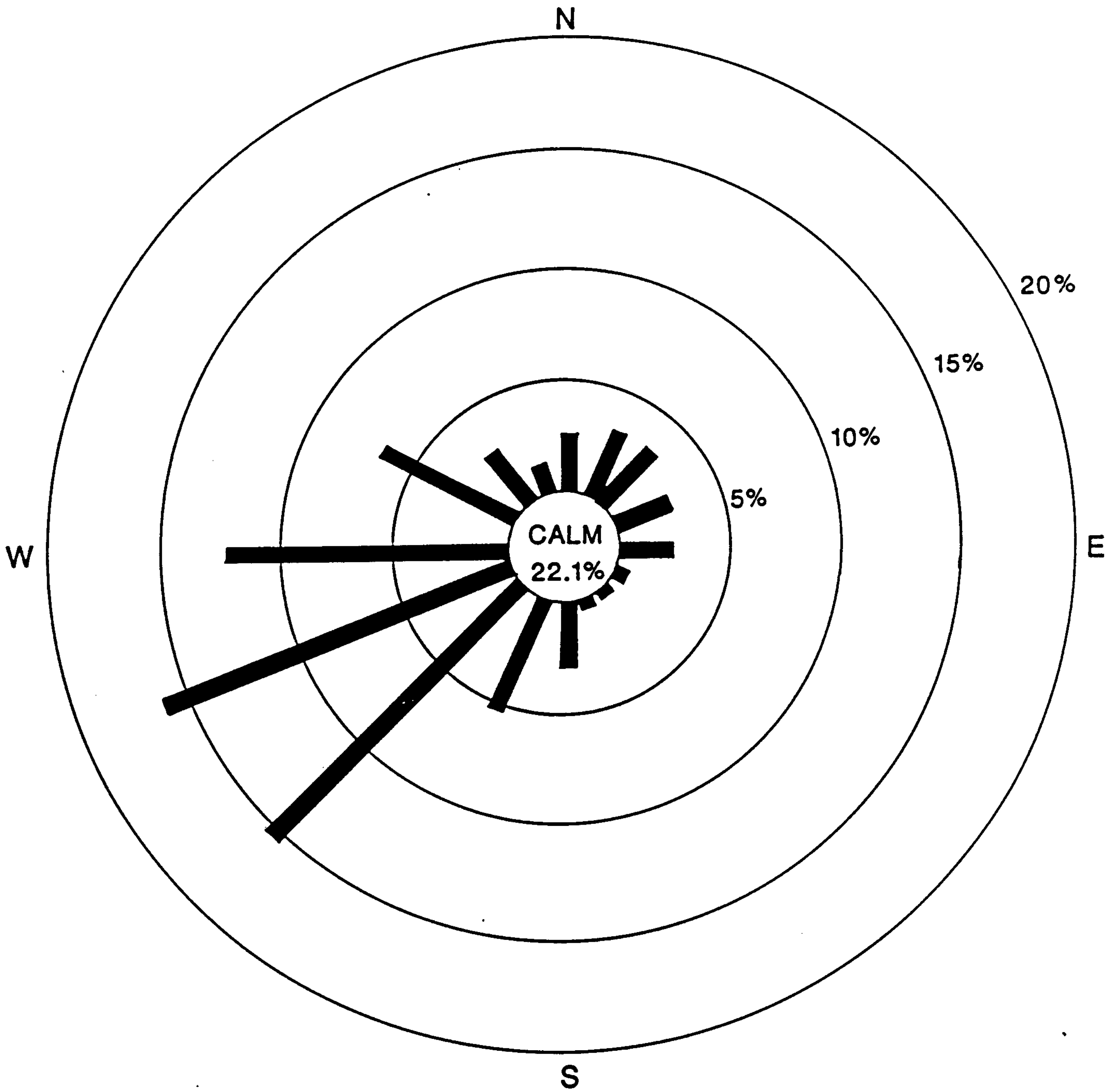
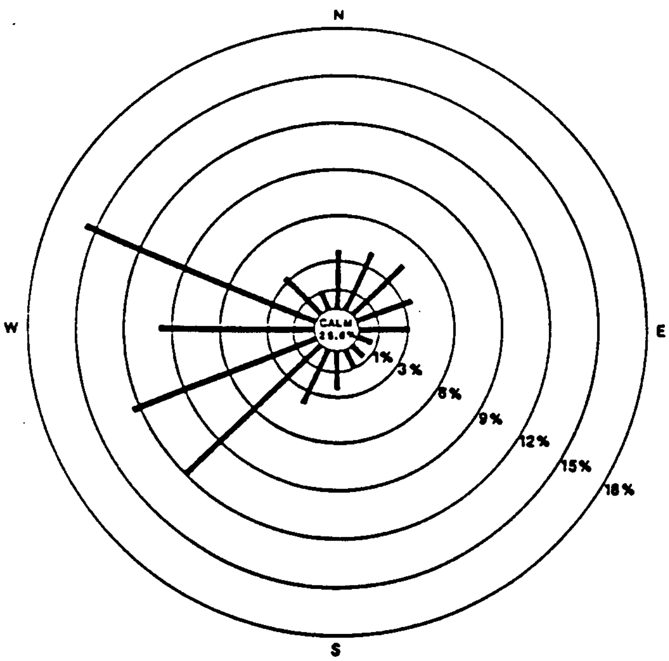


Figure 2.1 Geologic Faults in the Edwards Air Force Base Area



Note: Percentages Indicate Frequency By Direction of Surface Winds.
Source: LISOCS DOR Sep. 1974 – Aug. 1984

Figure 2.2 Annual Wind Rose



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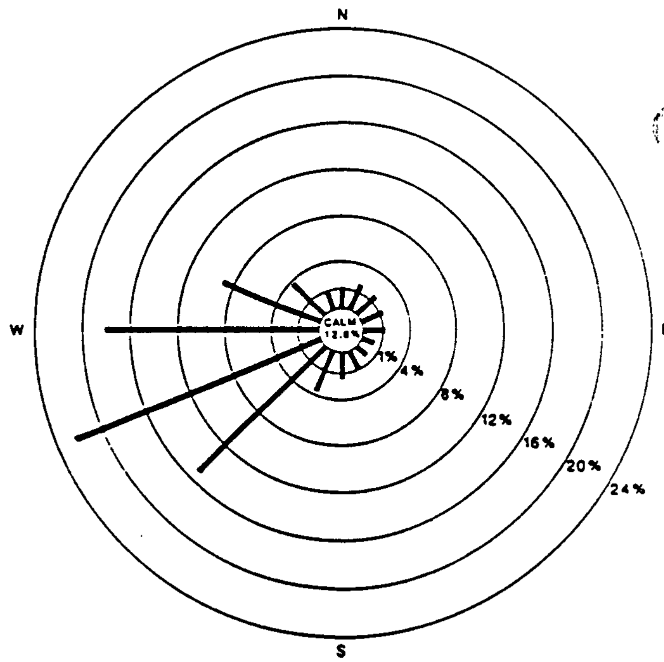

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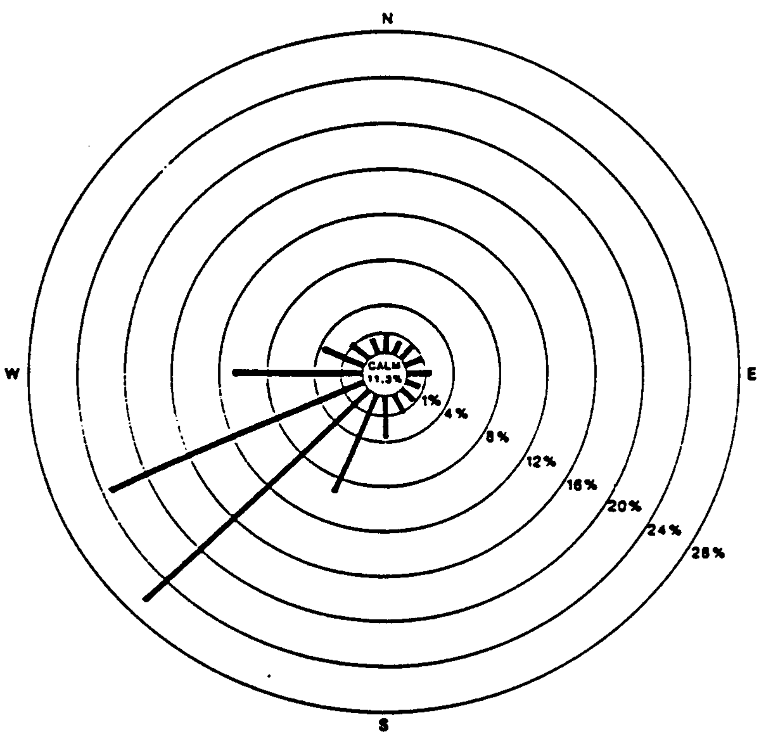

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Note: Percentages Indicate Frequency By Direction of Surface Winds.

Source: LISOCS for Sep. 1974– Aug. 1984.

Figure 2.3 Representative Seasonal Wind Roses

Table 2.1. Figures 2.2 and 2.3 show the annual wind rose and specific months, respectively. As shown on Figure 2.2, the wind blows from the west, southwest, or west-southwest most of the time.

Table 2.1 Climate for Edwards AFB

Parameter	Winter	Spring	Summer	Fall	Annual
Temperature, degrees F					
Mean temperature	48	66	79	53	61
Mean daily maximum	60	81	95	67	76
Mean daily minimum	35	51	63	37	46
Precipitation					
Mean relative humidity, percent	52	37	31	45	42
Seasonal mean precipitation, inches	2.69	0.37	0.42	1.42	4.86
Surface winds					
Prevailing direction, degrees azimuth	250	240	240	240	250
Mean speed, knots	7	11	9	6	9
Mean speed, mph	8.0	12.7	10.3	6.9	10.3

Source: Published data, Office of Staff Meteorologist, Edwards AFB, Data Base 1943-1984.

During the winter and spring months, a strong radiation (surface) inversion usually exists in the early morning. The radiation inversion is typically about 1,000 feet thick and generally disperses about 10 a.m. Pacific Standard Time (California Air Resources Board, 1979). Subsidence inversions occur infrequently during the winter months and are typically fairly weak with a base about 5,000 to 6,000 feet above the desert surface. During the summer months, high-pressure zones increase the number and strength of the subsidence inversions.

2.1.3 Air Quality

Edwards AFB is located within a portion of the Southeast Desert Air Basin which has limited air quality data. The states and the U.S. Environmental Protection Agency (EPA) designate the attainment status of air basins throughout the country for each pollutant. There are four designations possible for national air quality standards:

1. Does not meet primary standards.
2. Does not meet secondary standards.

3. Cannot be classified.
4. Better than national standards.

For the Kern County portion of the Southeast Desert Air Basin, EPA has concurred in the following designations (Code of Federal Regulations, Title 40, Part 81):

1. Total Suspended Particulates--Cannot be classified.

2. Sulfur Dioxide--Cannot be classified.

3. Nitrogen Dioxide--Cannot be classified or better than national standards.

4. Carbon Monoxide--Cannot be classified or better than national standards.

5. Ozone--Cannot be classified or better than national standards.

Ambient air quality data from 1980 to 1985 from monitoring stations in the Southeast Desert Air Basin are summarized in Table 2.2. Detailed air quality information is shown in Appendix A, and the most appropriate data for the RPL area are shown in Table 2.2. Ambient air quality standards are shown in Table 2.3.

Table 2.2 Worst Case Ambient Air Quality

Pollutant	Monitoring station location	Averaging time, hours	Estimated representative maximum in RPL area	Strictest standard
Ozone	Lancaster	1	0.19 ppm	0.12 ppm
Carbon monoxide	Lancaster	1	12.0 ppm	20 ppm
Nitrogen dioxide	Lancaster	1	0.11 ppm	0.25 ppm
Total suspended particulates	Lancaster	24	176 ug/m^3	260 ug/m^3
Particulate matter <10 microns in diameter	Barstow/ Mojave	24	82 ug/m^3	50 ug/m^3

Source: See Appendix A for detailed data.

Table 2.3 Ambient Air Quality Standards

Pollutant	Averaging time	Concentrations		
		California standards[b]	National standards[a]	
			Primary[c]	Secondary[d]
Oxidant[e]	1 hour	0.10 ppm (200 ug/m^3)	-	-
Ozone	1 hour	-	0.12 ppm (235 ug/m^3)	Same as primary standard
Carbon monoxide	8 hours	9 ppm (10 mg/m^3)	9 ppm (10 mg/m^3)	Same as primary standard
	1 hour	20 ppm (23 mg/m^3)	35 ppm (40 mg/m^3)	Same as primary standard
Nitrogen dioxide	Annual average	-	100 ug/m^3 (0.05 ppm)	Same as primary standard
	1 hour	0.25 ppm (470 ug/m^3)	-	-
Sulfur dioxide	Annual average	-	80 ug/m^3 (0.03 ppm)	-
	24 hours	0.05 ppm[f] (131 ug/m^3)	365 ug/m^3 (0.14 ppm)	- -
	3 hours	-	-	1,300 ug/m^3 (0.5 ppm)
	1 hour	0.25 ppm (655 ug/m^3)	-	-
Suspended particulate matter	Annual geometric mean	-	75 ug/m^3	60 ug/m^3
	24 hours	-	260 ug/m^3	150 ug/m^3
Suspended particulate matter (PM_{10})[g]	Annual geometric mean	30 ug/m^3	-	-
	24 hours	50 ug/m^3	-	-

[a]National standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once per year.
[b]The California standard for oxidant is a value that is not to be equaled or exceeded. The California standards for carbon monoxide, nitrogen dioxide, sulfur dioxide and PM10 are values not to be exceeded.
[c]National Primary Standards: the levels of air quality necessary, with an adequate margin of safety, to protect the public health.
[d]National Secondary Standards: the levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.
[e]Measured as ozone.
[f]At locations where the state standards for oxidant and/or suspended particulate matter are violated. National standards apply elsewhere.
[g]The California Air Resources Board has adopted an "inhalable" particulate standard.

Note: ppm - parts per million by volume; ug/m^3 - micrograms per cubic meter; mg/m^3 - milligrams per cubic meter.

Concentrations are expressed first in units in which standards were promulgated. Equivalent units given in parentheses are based upon a reference temperature of 25 degrees C and a reference pressure of 760 milligrams of mercury.

Source: California Air Resources Board.

The existing air quality, as shown in Table 2.2, is within air quality standards for carbon monoxide (CO) and nitrogen dioxide (NO_2). The peak ozone (O_3) concentration of 0.19 parts per million (ppm) is greater than the federal 1-hour standard of 0.12 ppm. The low population density of the area indicates that the violation of the O_3 standard is probably due to transport of O_3 from the Los Angeles Basin and possibly the San Joaquin Valley Basin. The representative peak total suspended particulate (TSP) concentration (176 micrograms per cubic meter (ug/m^3)) is greater than the federal secondary standard (150 ug/m^3) but not the federal primary standard (260 ug/m^3). The peak concentration for particulate matter less than 10 microns in diameter (PM_{10}) is greater than the state standard of 50 ug/m^3. However, there are limited PM_{10} data since PM_{10} measurements were only started in late 1984.

2.1.4 Surface Water Resources

The general drainage pattern in the area is from the mountains toward the dry lakes. There are no major surface water resources in the area. The Amargosa Wash, Littlerock Creek, and Big Rock Creek flow from the southern mountains across the valley to Rosamond and Rogers Dry Lakes. Amargosa Wash and Big Rock Creek are dry except during rainstorms.

In the vicinity of the test site, runoff from the eastern slope of Leuhman Ridge flows east to flat terrain. Runoff from the western slope of Leuhman Ridge flows into Rogers Dry Lake. Rogers Dry Lake generally contains water from February to May and is dry the remainder of the year.

2.1.5 Groundwater Resources

The principal aquifer of Antelope Valley is contained in the unconsolidated Tertiary-age alluvial and lacustrine deposits overlying pre-Tertiary-age basement rocks. These deposits consist of arkosic gravel, sand, silt and clay, and reach a thickness of 2,000 feet at the center of the basin. Where saturated, the alluvial and lacustrine deposits yield large quantities of water to wells. In addition to these deposits are the unconsolidated Pleistocene-age alluvial fan and windblown sand deposits. The fan deposits consist of graded gravels and sand of granitic origin. They are generally unsaturated. The windblown sand is stabilized and very fine- to fine-grained. The windblown sand lies above the groundwater table, but may contain small amounts of perched groundwater.

The principal aquifer is broken into a series of subunits. Edwards AFB draws water from the Lancaster and North Muroc subunits. The pattern of groundwater movement in the area is complex. Groundwater in the Lancaster subunit generally moves toward two large pumping depressions, one located south of Edwards AFB and the other located west of Lancaster.

Groundwater recharge to the area is primarily from subsurface inflow from adjoining areas. Recharge from infiltration of precipitation and from percolation of infrequent stream runoff is minor. Due to the low annual precipitation and high evaporation rate, recharge of underground aquifers from sources other than subsurface inflow is minimal (DMA Engineering, 1986).

Edwards AFB obtains its potable water exclusively from wells. All water production wells for RPL are located on the west slope of Leuhman Ridge and on the east margin of Rogers Dry Lake. The well nearest Test Stand IC is approximately 3 miles away. There are 15 existing wells within the general area (T. 10 N., R. 8 W., and T. 10 N., R. 9, W., SBM). Of these, seven have groundwater quality data available. Water quality data from groundwater samples collected between 1947 and 1958, were obtained from USGS Bulletin No. 91-6, 1962. These data are shown in Table 2.4. Regionally, groundwater quality is characteristically good. Locally, however, groundwater can be highly mineralized, relatively hard, and have a high sodium concentration. Total dissolved solids and electrical conductivity of some groundwater samples exceed the recommended drinking water standards for those parameters.

2.1.6 Biota

2.1.6.1. Vegetation--

Three plant community types have been observed in areas around the test site. These plant communities are the Joshua tree woodland, creosote bush scrub, and alkali sink. Vegetation in these plant communities are common to the desert environment and are characterized as an intermixture of the dominant species and species of abutting communities.

Joshua trees (*Yucca brevifolia*) exist in relatively open stands, becoming more dense on the alluvial fans above and around the dry lake beds. Scattered Joshua trees are found throughout the RPL area. Undergrowth shrub species common to the Joshua tree woodland include the burrobush (*Hymenoclea monogyra*), Mormon tea (*Ephedra* spp.), creosote bush (*Larrea divaricata*), cholla (*Opuntia* spp.), and several species of saltbush (*Atriplex* spp.). Herbaceous species existing in the Joshua tree woodland occur throughout the other major plant communities. These species include Mojave spineflower (*Chorizanthe spinosa*), desert cymopterus (*Cymopterus deserticola*), wild buckwheat (*Erigonum* spp.), fiddleneck (*Amsinckia* spp.), forget-me-not (*Myosotis* spp.), red stem filaree (*Erodium texanum*), desert candle (*Caulanthus inflatus*), brome grasses (*Bromus* spp.), and Indian rice grass (*Oryzopsis hymenoides*).

Table 2.4 Groundwater Quality in the Vicinity of RPL

Constituent[a]	Groundwater concentrations								Drinking water standards	
Well number	9/13-23B1	10/8-4A1	10/9-4D1	10/9-4D2	10/9-36G1		10/9-7A1[b]	10/9-7A2[c]		
Date of collection	4-17-52	4-2-52	2-8-57	8-9-58	1-?-47	7-22-47	b	c	Primary	Secondary[d]
Silica	36	42	—	7	40	37	33-40	33-42		
Iron	1.2	1.6	—	0	0.22	0.04	0-0.20	0-0.08		0.3
Calcium	86	44	4.3	3.0	18	16	7.5-14	14-23		
Magnesium	17	5.6	0.4	2.0	7.9	8.5	1.6-3.9	4.7-7		
Sodium	70	197	119	129	328	329	231-300	310-384		
Potassium	2.5	4.8	0.6	—	—	—	2.0-3.6	2.4-4.5		
Bicarbonate	187	115	213	188	351	360	298-330	275-302		
Carbonate			0	13	0	0	0	0		
Sulfate	178	162	58	70	195	191	95-109	132-146		250
Chloride	65	210	24	31	204	206	102-246	258-400		250
Fluoride	0.7	0.5	1.2	1.0	2.7	1.9	1.2-3.1	2.0-3.5	2.0	
Nitrate	5.2	1.1	—	1.0	8.0	1.7	0.3-3.3	1.2-2.1	45	
Boron	0.31	1.1	—	0	—	—	0.5-0.59	0.7-0.72		
Dissolved solids calculated	554	727	255	350	979	968	653-852	886-1,130		500
Hardness as $CaCO_3$	284	133	12	16	78	75	28-43	55-84		
Percent sodium	35	76	95	95	90	91	92-95	90-92		
Specific conductance, micromhos at 25°C	847	1,200	549	—	1,570	1,580	1,040-1,470	1,480-1,980		900
pH	7.8	8.1	7.7	8.3	7.9	7.4	7.4-8.1	7.1-7 9		
Temperature, (°F)	68	72	70	—	—	—	66	66-69		
Depth of well, feet	290	—	502	500	93.5	93.5	200	200		

Source: Bulletin No. 41-6 "Data on Wells in the Edwards Air Force Base Area, California," prepared by U.S. Department of the Interior, Geological Survey, June 1962.

[a]All data are in mg/l unless indicated otherwise.
[b]Samples were collected on 7-22-47, 5-6-48, 11-20-50, 4-10-53, and 1-7-58. The range of concentrations detected on these dates is shown.
[c]Samples were collected on 1-?-47, 4-10-53, 1-7-58, and 4-9-58. The range of concentrations detected on these dates is shown.
[d]Recommended maximum contaminant levels.

The creosote bush scrub plant community is generally distributed on the slopes, hills, and well-drained sandy flats and washes throughout the RPL area. Perennial species often associated with the creosote bush (Larrea divaricata) include the burrobush (Hymenoclea monogyra), Mormon tea (Ephedra spp.), brittlebush (Encelia farinosa), snakeweed (Gutierrezia spp.), shadscale (Atriplex canescens), winterfat (Eurotia lanata), cheesebush (Hymenoclea salsola), and rabbitbrush (Chrysothamnus mohavensis). Herbaceous species common to the creosote bush scrub community are similar to those discussed for the Joshua tree woodland, with the addition of the desert evening primrose (Oenothera deltoides) and the alkali mariposa lily (Calochortus striatus).

The alkali sink vegetation often referred to as saltbush scrub community covers low depressions and margins of dry lakes throughout Edwards AFB. Important shrub species of this community include Parry saltbush (Atriplex sp.), wedgescale (Atriplex truncata), shadscale (Atriplex sp.), four-wing saltbush (Atriplex sp.), and burrobush (Hymenodea monogyra). Scattered Joshua trees may also be found. Herbaceous species common in the alkali sink community are the same as for the Joshua tree woodland, but are less abundant. The alkali mariposa lily (Calochortus striatus) is also found in this community.

2.1.6.2 Wildlife--

Wildlife in the area consists mostly of small mammals, reptiles, and birds. Feral burros (Equus asinus) are the only large mammals currently known to utilize the Edwards AFB area. Domestic sheep (Ovis aries) are known to forage outside AFB boundaries. Other mammals known or expected to utilize habitats in the area are the desert kit fox (Vulpes macrotis arsipus), coyote (Canis latrans), black-tailed hare (Lepus californicus), cottontail rabbit (Sylvilagus audubonii), badger (Taxidea taxus), antelope ground squirrel (Ammospermophilus leucurus), mice (Peromyscus spp.), kangaroo rats (Dipodomys spp.), desert woodrat (Neotoma lepida), California ground squirrel (Citellus beecheui), and Mojave ground squirrel (Spermophilus mohavensis). Seed-eating small mammals are particularly abundant due to ephemeral growth during the winter and spring.

Reptiles are common throughout the study area. The desert tortoise (Gopherus agassizi) uses most of the habitat areas. Lizard species are abundant and include the collared lizard (Crotaphytus collaris), desert horned lizard (Phrynosoma platyrhinos), and side-blotched lizard (Uta stansburiana). The Mojave green rattlesnake (Crotalus scutulatus), garter snakes (Thamnophis spp.), and coachwhips (Masticophis flagellum) are also expected in the area.

Predatory birds common to the area include the ferruginous hawk (Buteo regalis), harrier (Circaetus spp.), red-tailed hawk (Buteo jamaicencis), rough-legged hawk (Buteo lagopus), American kestral

(*Falco sparverius*), turkey vulture (*Cathartes aura*), burrowing owl (*Athene cunicularia*), and the great-horned owl (*Bubo viginianus*). Other common birds in the area include the horned lark (*Eromophilia alpestris*), common raven (*Corvus corax*), roadrunner (*Geococcyx californianus*), white-crowned sparrow (*Zonotrichia leucophrys*), western meadowlark (*Sturnella neglecta*), and the cactus wren (*Heleodytes brunneicapillus*). The mourning dove (*Zenaida macroura*) and Gambel's quail (*Lophortyx gambelii*) are game birds which have also been observed in the area.

2.1.6.3 Threatened, Endangered, and Special Status Species--

The following list of potential special status plants and animals has been developed based on previous biological studies of the Edwards AFB area (USFWS, 1984 and Personal Communication, Mike Phillips, 1986) and from information obtained from the Natural Diversity Data Base, (California Department of Fish and Game (DFG), 1986).

Alkali mariposa lily (*Calochortus striatus*)
Mojave spineflower (*Chorizanthe spinosa*)
Desert cymopterus (*Cymopterus deserticola*)
Mojave ground squirrel (*Spermophilus mohavensis*)
Desert tortoise (*Gopherus agassizi*)

Alkali mariposa lily--Alkali mariposa lily is a small, smooth, perennial herb, 4 to 18 inches high. The flowers are lavender with purple veins and generally appear between April and June in the Mojave Desert. The plant is typically found in alkaline meadows and springy areas at elevations of 2,500 to 4,300 feet. The plant is associated with the creosote bush scrub habitat (Munz and Keck, 1959). All known populations of alkali mariposa lily on Edwards AFB are located on the southern and western margins of Rogers and Rosamond Dry Lakes. Alkali mariposa lily is a candidate for federal protection. It is in the U.S. Fish and Wildlife Service (USFWS) Category 2, species that may warrant listing but for which substantial biological information is not available.

Mojave spineflower--Mojave spineflower is a prostrate annual. During April through July, small flowers with three white, petal-like sepals appear. This plant occurs in sandy and gravelly places at elevations of 2,500 to 3,500 feet. It is associated with the creosote bush scrub and Joshua tree woodland habitats in the Mojave Desert (Munz, and Keck, 1959). Mojave spineflower has been found approximately 3 to 7 miles east of RPL in San Bernardino County. It is in USFWS Category 3C, plants which are more abundant or widespread than was previously believed and/or plants that are not subject to any identifiable threat.

Desert cymopterus--Desert cymopterus is a dwarf, stemless, smooth perennial herb, 4 to 6 inches high. The flowers are purple and generally appear in April in the Mojave Desert. The plant is typically found in sandy or gravelly areas at elevations of 2,500 to 3,100 feet. It is rare even in its preferred habitat. The plant is most often associated with creosote bush scrub and Joshua tree woodland habitats (Munz and Keck, 1959). It has been found approximately 3 to 7 miles east of RPL in San Bernardino County. Desert cymopterus is a candidate for federal protection. It is in USFWS Category 2.

Mojave ground squirrel--The Mojave ground squirrel is a small, brownish-gray, desert-dwelling ground squirrel. It is found in desert habitats at elevations of 1,800 to 5,000 feet. The animal is torpid from August to March, remaining underground in burrows. It is listed as a candidate species, Category 2, by the USFWS (FR 50:181, pp 37965) and as threatened by DFG.

Desert tortoise--The desert tortoise is a terrestrial desert turtle found in the cresote bush scrub habitat of the Mojave desert. It is active in April and May and aestivates during the cold winter months. It was listed as a candidate species, Category 2, by the USFWS (FR 50:181, pp 37965). On December 5, 1985, the USFWS "determined that listing the tortoise as an endangered species throughout its range is warranted, but precluded by other pending proposals of higher priority." (FR 50:235, pp 49868-49870.)

In addition to the species described above, the feral burro is a protected species under the wild horse and burro act, and the desert kit fox (*Vulpes macrotis arsipus*) is listed by DFG as a special animal. Special animals are not legally protected in California but they are of concern because they are associated with a habitat that is declining rapidly in California. There are several species of eagles and falcons which overwinter in the area that are listed as special animals by DFG. The bald eagle (*Haliaeetus leucocephalus*) and the peregrine falcon (*Falco peregrinus*) are both state and federally listed endangered species. The golden eagle (*Aquila chrysaetos*) is a fully protected species in California. Protected species cannot be hunted or collected for any purpose without a permit from DFG. The prairie falcon (*Falco mexicanus*) is not legally protected but it is listed by DFG as a species of special concern because its population is thought to be declining.

2.2 MAN-MADE ENVIRONMENT

2.2.1 Population

As shown on Figure 1.1, the test site lies in the southeast corner of Kern County which borders San Bernardino County on the east and Los Angeles County on the south. The site is about 90 miles northeast of downtown Los Angeles. The nearest cities are Lancaster, approximately 30 miles to the southwest, and Mojave, about 30 miles to the west-northwest.

Nearby communities include Rosamond, California City, North Edwards, and Kramer Junction. The closest community is Boron, located approximately 3.5 miles north-northeast of the test site with a population of about 2,000 people. In addition, a small housing area, Desert Lakes, is located approximately 3 miles north of the test site. The main base at Edwards AFB is about 11 miles west-southwest of the test site.

2.2.2 Socioeconomics

Geographically, Edwards AFB lies at the intersection of three counties, but its primary economic ties are with Kern and Los Angeles Counties. No direct access exists from population centers in San Bernardino County to Edwards AFB. Consequently, few base employees live in that county and little income is spent there. Base procurements from merchants in San Bernardino County are relatively insignificant, and do not contribute appreciably to the county's economy.

The economy of northern Los Angeles County is dominated by the airplane and aerospace industry. This area is sensitive to fluctuations in federal spending for military aerospace activities. The Palmdale-Lancaster area serves as a manufacturing, trade, and services center. In the past, this area has been fairly rural and isolated, but it has become rapidly urbanized and industrialized. Edwards AFB civilian employees tend to live in this area and base procurements from merchants in the area are common.

The southeastern Kern County economy, on the other hand, is based on agriculture and mining, with relatively few industries related to aerospace. The main Edwards AFB community and RPL are located in Kern County, and the economic benefits to Kern County are derived from the spending of disposable income generated at Edwards AFB and from base procurements.

RPL is located in the northeast corner of Edwards AFB about 11 miles east of the main base. RPL is a research and development facility responsible for planning, formulating, and executing the USAF technology programs for rocket propulsion and related space technology. Both solid and liquid rocket motors are tested at a number of test stands located in both Kern and San Bernardino Counties. Most of the RPL buildings are located about 1 mile from the proposed test stand on Leuhman Ridge.

2.2.3 Noise

Noise is generated by pressure fluctuations in the air. The human ear reacts to changes in sound pressure so that each doubling of sound pressure represents equal increases in loudness. The same type of relationship also applies to the human ear's frequency sensitivity. Therefore, both sound pressures and frequency are commonly expressed in logarithmic scales, where these relationships are linear with respect to loudness.

The common measure of sound pressure level is decibels (dB), with zero dB being the threshold of hearing. Examples of sound pressure levels are 40 to 50 dB in an office, 70 dB inside a car at highway speeds, 80 to 85 dB 50 feet from a highway with truck traffic, and 100 dB or more near an airport during aircraft flyovers.

At approximately 120 dB, the sound will be felt as a gentle pressure in the ear. At 140 dB, there will be a painful sensation in the ear and, at the lower frequency ranges, feelings of pressure on the body or vibrations of the rib cage. Sound pressures of 160 to 170 dB (typical of rifle shots at close range) may lead to permanent hearing damage after short exposure. Structural damage to dwellings will occur in the range of 130 to 140 dB for the predominately low frequency range, typical of rocket noise.

The ear does not hear all frequencies with equal acuity. Low frequencies are attenuated, while those essential for human speech are slightly amplified. Noise levels measured with the A-weighting network provide a good correlation of human reactions to noise levels and are useful for estimating audibility of sounds. Units for A-weighted pressure levels are listed in dB(A).

Criteria for noise intrusion and annoyance are generally based on integration of the noise events over time, including multiple events. Therefore, they are of questionable value for assessing a program such as that proposed for the Titan test firings, where the noise events will be of very short duration, and where the total test program is limited to approximately three events, and where the noise is so disproportionately weighted toward low frequencies.

Common community noise descriptors include the Community Noise Equivalent Level, (CNEL), the Day-Night Average Sound Level (Ldn), and different statistical descriptors, including levels exceeded for certain percentages of the time. The Kern County Noise Element of the General Plan uses L_{50} (the level exceeded for 50 percent of the time, or the "median level") as the criterion for acceptability of different land uses. This descriptor is appropriate for relatively continuous noise environments, such as near a roadway, but is practically meaningless in assessing rocket test noise. Since the rocket test lasts only 2 minutes, the L_{50} would be unaffected by it unless the measuring period were to be less than 4 minutes long, in which case it would be equal to the rocket noise level.

The Ldn is an energy-based average sound level for the entire 24-hour day, where nighttime noise levels occurring between 10 p.m. and 7 a.m. are adjusted by 10 dB to account for the additional sensitivity of people at that time. CNEL is a very similar descriptor with the exception that evening noise events, occurring between 7 a.m. and 10 p.m. are penalized by 5 dB. For the rocket testing, these descriptors would normally be equivalent, unless the testing occurs during the three evening hours, in which case the CNEL would be 5 dB higher.

Hearing loss criteria have been developed by the Occupational Safety and Health Administration (OSHA) for working environments, where workers are exposed to continuing high levels of noise. The highest noise level allowed at any time in a workplace under OSHA standards is 115 dB(A). A criterion which has been used by the National Aeronautics and Space Administration (NASA) and the U.S. Air Force (USAF) for "uncontrolled populations" is that the overall level shall not exceed 120 dB, corresponding to the approximate onset of pressure sensations in the ear and a general feeling of concern. At this level, and with low frequency noise dominating, gentle rattling of windows and walls may also be experienced.

Noise levels in the vicinity of the test site have not been measured. However, noise levels can reach 100 dB or more during aircraft testing on the nearby Precision Impact Range Area (PIRA). The Edwards AFB area is subject to frequent overflights of high-powered military aircraft that often fly faster than the speed of sound, creating "sonic booms."

2.2.4 Archaeology and Cultural Resources

The Edwards AFB area is rich in archaeological resources due to the centralized position of the Antelope Valley to geologic features in southern California and to the shallow lakes which once existed in the area. The margins of these now dry lakes are rich repositories of archaeological remains. As of November 1986, there are approximately 400 recorded prehistoric sites and 450 historic sites on Edwards AFB (Norwood, 1986).

Known prehistoric archaeological sites span at least 6,000 years and represent a variety of functions, including habitation, food procurement, quarrying, manufacturing, and burial of the dead. Historic resources consist of homesteads and associated features dating from the early part of the 20th century. No comprehensive study or synthesis of either paleontological or archaeological resources for the entire Air Force Base has yet been completed. The references "Cultural Resources Overview for Edwards Air Force Base" (Greenwood and McIntyre, 1980) and "Cultural Resources Management Plan for Edwards Air Force Base" (Greenwood and McIntyre, 1981) provide the most comprehensive background information on the history, prehistory, and ethnology of Edwards AFB in addition to excellent summaries of relevant geological, biological, and paleontological information.

Although no comprehensive survey of Leuhman Ridge has yet been attempted, various surveys have been completed in the general area, and at least one prehistoric archaeological site is known on the ridge itself (Personal Communication, Richard Norwood, December 1986). No archaeological or paleontological sites are known to exist sufficiently close to the project site to be of particular concern. A survey of the test site area was conducted in December 1986 and no cultural or paleontological resources were found (Robinson, 1987).

2.2.4.1 Test Stand History--

The six large existing rocket test stands on Leuhman Ridge were used primarily in the 1960s to support NASA's Saturn V program with its manned Apollo missions to the moon. The F-1 liquid fuel engines, used in the first stage of the Saturn V, were tested on these stands.

The first test stand to be built, Test Stand IA, was originally constructed for the USAF in 1956 for the Atlas rocket program. Following an Atlas rocket engine explosion on this test stand in 1958, Test Stand IA was modified under NASA direction by Rocketdyne for research and development testing on the F-1 engine. Test Stand IB was constructed in 1960, also for F-1 research and development testing. Test Stand IIA was built in 1959. This test stand was constructed to perform near-horizontal testing (rather than vertical nozzle-down testing on the other five test stands) for development of thrust chambers and injectors for the Saturn V. Test Stand IIA was operated up to the mid-1960s. Test Stands IA and IB were operated into the late 1960s.

Test Stands IC, ID, and IE were constructed for production testing of F-1 engines. IC was placed in operation in the spring of 1965, ID in the summer of 1965, and IE in the fall of 1965. The last F-1 test firing on these stands was in 1974. Test Stand IE was used primarily for qualification testing under environmental extremes and has the necessary facilities for cold and hot temperature conditions. Rocketdyne operated all six test stands through its contract with NASA (Personal Communication, Frank Will, 1986).

The test stands were constructed to safely handle 2 million pounds of thrust. Although each F-1 engine was designed for 1.5 million pounds of thrust, actual peak thrusts in excess of 1.8 million pounds were measured on these test stands occasionally. Due to the conservative design of the test stands, they are probably capable of handling thrusts well in excess of 2 million pounds. The USAF is considering the use of these stands for test firing rocket engines for a heavy-payload Saturn-class rocket currently under investigation (Personal Communication, Frank Will, December 1986; Pete Van Splinter, December 1986).

3.0 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

3.1 GEOLOGY AND SOILS

The proposed rocket motor tests at Edwards Air Force Base (AFB) will not adversely affect the geologic resources of the area. The tests will be conducted on an existing test stand (IC) that has been modified for the static tests of Titan rocket motors. The deluge water containment basin at Test Stand IC was recently repaired as part of the modifications to the test stand. This required regrading a berm of the water containment basin near Test Stand IC. This will not result in significant soil erosion.

3.2 AIR QUALITY--2-MINUTE TEST FIRINGS

The large quantity of combustion products that will be produced by the 2-minute rocket motor tests are potentially a significant source of emissions. The potential air quality impacts of the proposed testing program and measures to be implemented by the U.S. Air Force (USAF) to minimize those impacts are described in this section. The air quality impacts of the short-burn tests are described in Section 3.3.

3.2.1 Rocket Motor Emissions

This section describes the emissions, deluge water system, and afterburning reactions for the 2-minute test firings. The 2-segment test firing is fully described here, although it may not be conducted.

3.2.1.1 Emissions at the Rocket Nozzle--

The propellant used in the Titan motor consists of ammonium perchlorate oxidizer, aluminized synthetic-rubber binder fuel, and various other additives to stabilize mass and control the burning rate. The combustion products at the nozzle will consist of particulates (consisting mainly of aluminum oxide (Al_2O_3)), hydrogen chloride (HCl), hydrogen (H_2), nitrogen (N_2), water (H_2O), carbon dioxide (CO_2), and carbon monoxide (CO). The combustion process within the rocket motor will release oxygen (O_2). The O_2 released is then used to continue the combustion process. No O_2 is assumed to exist in the exhaust at the nozzle. Total emissions expected at the nozzle (or, more specifically, at the nozzle exit plane) are shown in Table 3.1. The location of the nozzle and the nozzle exit plane are shown on Figure 3.1.

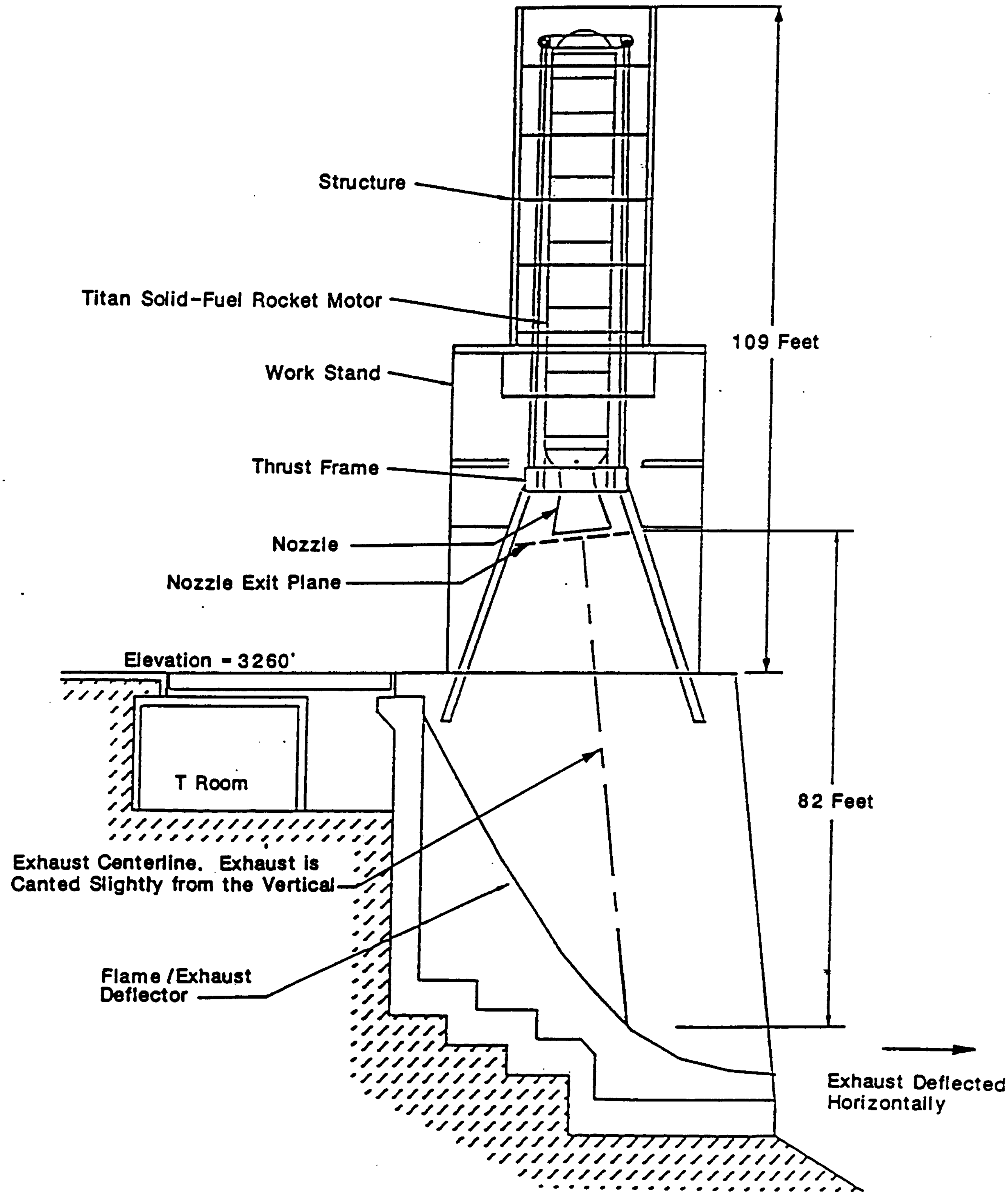

Figure 3.1 Side View of 5-1/2 Segment Motor

Source: Wyle Laboratories, August 6, 1986 ,Modified by Brown and Caldwell

The estimated emissions listed in Table 3.1 are based on years of technical development of the Titan solid propellant and its combustion characteristics. Specifically, these numbers are derived from a set of five volumes evaluating reaction products, completed in 1984 for the USAF (Lamberty and Hermsen, 1984). These documents describe the chemical reactions and equilibrium equations which apply during combustion in a Titan motor case. A computer program was developed as part of Lamberty and Hermsen's work to assess the possible reactions and determine which ones are predominate.

Table 3.1 Emissions at Nozzle

Rocket motor	Emissions, pounds per test						
	Al_2O_3[a]	HCl	H_2	N_2	CO	CO_2	H_2O
5-1/2-segment	140,514	96,080	11,330	38,950	129,510	13,026	32,436
2-segment[b]	62,178	42,516	4,880	17,235	57,310	5,733	14,353

[a]Assumed to be particulate matter.
[b]The 2-segment test is optional.

Note: Each test will be 2 minutes in duration because it takes 2 minutes for the propellant to burn from the core to the casing in each segment.

During the test, the exhaust will leave the rocket nozzle vertically downward (see Figure 3.1) at a temperature of about 3,330 degrees Fahrenheit (F). The exhaust velocity at the nozzle for the 5-1/2-segment motor is about 8,100 feet per second (fps) and for the 2-segment motor the exhaust velocity is about 6,200 fps.

The exhaust stream will strike a deflector plate mounted directly below the nozzle and will be deflected horizontally away from Leuhman Ridge in a west-northwesterly direction (see Figure 3.2). Because of the volume of exhaust and the velocity with which it leaves the rocket nozzle, the exhaust cloud is expected to extend up to 1/4- to 1/2-mile beyond the base of the test stand. Various water sprays will be used to cool the exhaust, provide sound suppression, and quench the motor case. These sprays total about 140,000 gallons per minute (gpm).

3.2.1.2 Afterburning Emissions--

The conversion of H_2 to H_2O, CO to CO_2, and N_2 to nitrogen oxides (NO_x) is assumed to take place in the afterburning process occurring in the exhaust cloud. This section describes the afterburning process.

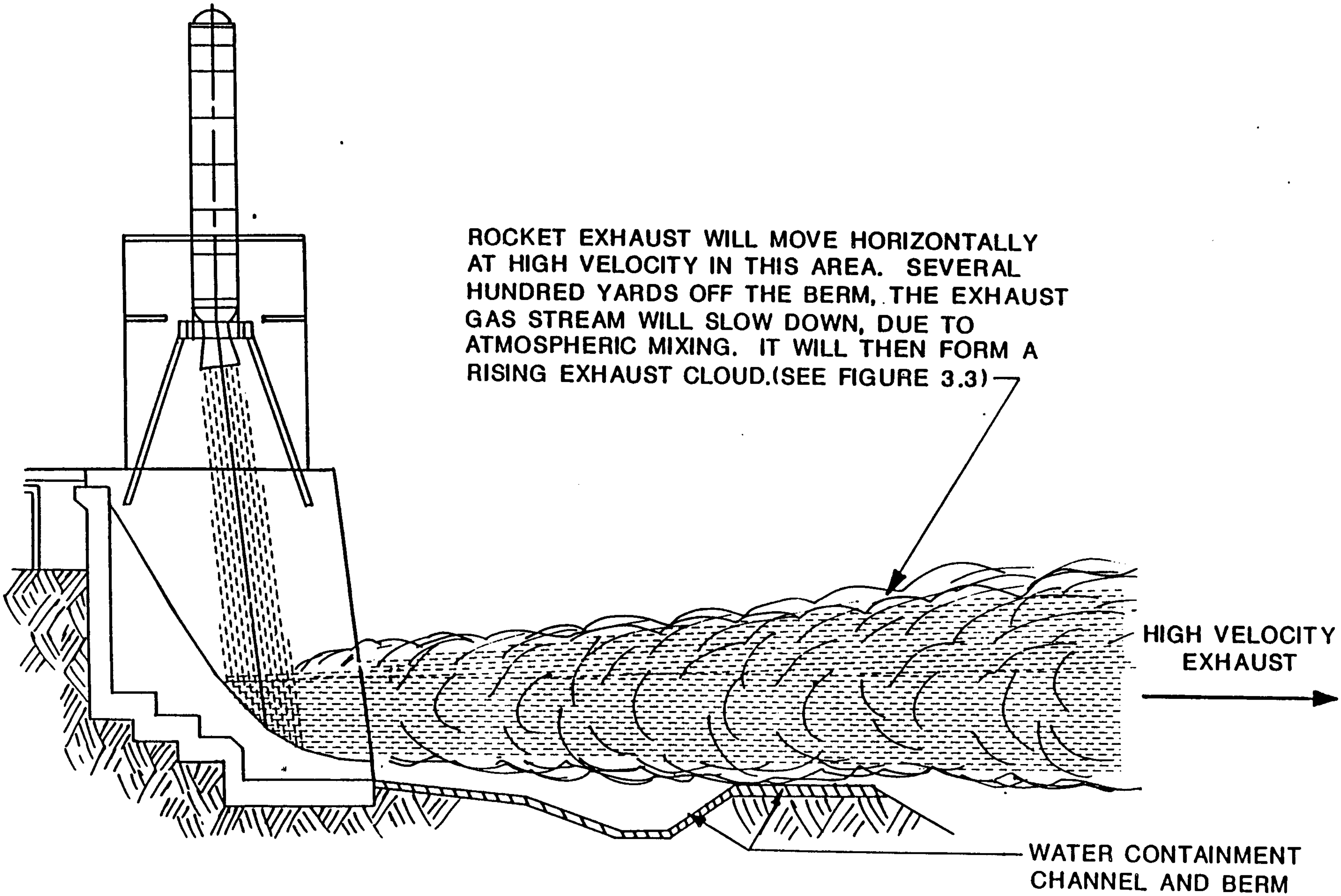

Figure 3.2 Side View of Test Stand During 2-Minute Test
(Water Deluge System Not Shown)

The conversion of H_2 to H_2O is an exothermic reaction that requires a small amount of activation energy. Therefore, it is assumed that all the H_2 is converted to H_2O.

The conversion of CO to CO_2 was estimated from measured values obtained from in-cloud measurements of Titan launches in 1977 at the USAF Eastern Test Range in Florida. The in-cloud measurements indicate only trace amounts (less than 1 part per million (ppm) of peak exhaust concentrations) of CO in the stabilized exhaust cloud (Bendura and Crumbly, 1977; Gregory et. al, 1978; Woods et al., 1979; and Wornom et al., 1979). Modeling the launch exhaust, assuming no CO afterburning, results in in-cloud CO concentrations that are much higher than actual measurements. The modeling work implies a reduction in CO of about 98.8 to 99.4 percent. Therefore, it was assumed that 99 percent conversion of CO to CO_2 will occur in the afterburning process for the Titan tests.

Nitrogen conversion (N_2 to NO_x) in the rocket exhaust is a complex process not entirely understood. It is clear, however, that some nitrogen is oxidized, based on exhaust cloud measurements from Titan launches. A conservatively high estimate of NO_x formation of 22,000 pounds has been made based on field information from Titan launches. The quantity of NO_x produced by the 2-segment rocket motor tests is assumed to be the same as for the 5-1/2-segment test. This assumption is conservative due to the lower velocities and lower amount of thermal energy released by the 2-segment tests. The lower exhaust velocities will entrain less O_2 from the ambient air. This will reduce the availability of O_2 for the conversion of N_2 to NO_x. In addition, the lower amounts of thermal energy released will reduce the size of the exhaust plume where the N_2 to NO_x reactions occur rapidly.

The estimated quantities of exhaust pollutants following afterburning are shown in Table 3.2. For more information on nitrogen and CO afterburning, see the Air Pollution Control District exemption support document (Brown and Caldwell, 1986).

Table 3.2 Rocket Exhaust Products Following Afterburning

Motor segment	Atmospheric exhaust products, pounds per test						
	Al_2O_3	HCl	N_2	NO_x[a]	CO_2[b]	CO	H_2O[c]
5-1/2	140,514	96,080	29,203	22,000	215,247	1,295	32,436
2	62,178	42,516	7,488	22,000	95,219	573	14,353

[a]Assumes 90 percent of the NO_x compounds is NO and 10 percent of the NO_x compounds is NO_2 (Cole and Sommerhays, 1979).
[b]Assumes 99 percent of the CO is converted to CO_2 during the afterburn.
[c]Does not include water entrained or vaporized from water deluge system.

3.2.1.3 Emissions From Deluge Water--

Section 3.2.2.2 describes the amount of deluge water vaporization expected and the amount of mist formed. Since the deluge water contains sodium carbonate, reactions with exhaust HCl will occur in the mist particles entrained in the exhaust plume. These reactions are described in Section 3.2.5 and are summarized here with respect to their impact on downwind air quality predictions.

In addition to the direct rocket exhaust emissions listed in Table 3.2, the deluge water and its chemical constituents entrained in the exhaust plume will add the following to the exhaust plume for each test:

1. Water vapor and water mist totaling 280,000 gallons.

2. Sodium chloride (common table salt) dissolved in the mist. The sodium carbonate added to the deluge water is largely transformed to sodium chloride due to the reaction with HCl.

3. Minor amounts of other dissolved salts and compounds contained in the deluge water.

These constituents are not considered "emissions" for air quality modeling purposes since they will largely settle or fall out of the exhaust cloud in the vicinity of the test stand or in the immediate downwind area. In summary, for purposes of air quality modeling of the exhaust cloud, the deluge water emissions are not significant and are not considered. The fallout of mist, particulates, and HCl is described separately (Section 3.2.5) and evaluated in Sections 3.4 and 3.5.

3.2.1.4 Exhaust Temperature--

The rocket exhaust temperature will be about 3330 degrees F at the nozzle. The water deluge system will help cool the exhaust to protect the test stand structure. The deluge water that vaporizes will lower the temperature of the exhaust at the flame bucket and help protect it. The remainder of the deluge water will be a mist entrained around the edges of the exhaust gas stream and will provide additional cooling of radiant heat around the exhaust stream. The exhaust gas stream will be projected immediately above the concrete berm located approximately 100 feet from the flame bucket. The berm is expected to experience an increase in temperature. However, the ground surface drops rapidly beyond the berm (essentially a talus pile) for 100 to 200 feet. The exhaust temperatures will be reduced rapidly as the exhaust plume projects beyond the berm due to the entrainment of large quantities of ambient air from turbulent mixing. At the point where the exhaust cloud begins to rise, the temperature within the cloud will be within a few degrees of the ambient air temperature.

3.2.2 Model Description

The air quality model and results for the 2-minute test firings are described in this section.

3.2.2.1 Meteorological Scenario--

Cold-temperature-induced stresses on the rocket motor are of most interest to the USAF and United Technologies Corporation-Chemical Systems Division (CSD). However, these stresses can be analyzed in warm-weather periods by cooling the rocket motor to the required temperature for analysis. Therefore, the test firings can be undertaken in summer as well as other seasons. It would be easier and less costly to complete the tests in cooler weather, and it is likely that the 2-minute tests will be completed prior to the summer of 1987. However, there are no specific limitations on the test firings due to air temperature and, therefore, the modeling work has assumed a variety of ambient air temperatures likely to occur in the daytime periods over all seasons at Edwards AFB. The meteorological parameters associated with these test periods are shown in Table 3.3.

Table 3.3 Meteorological Parameters for Rocket Motor Test Modeling

Parameter	Late morning/early afternoon
Temperature, degrees F	40 to 100
Wind speed, knots	5, 7, 9[a]
Radiation inversion	No
Subsidence inversion	No
Atmospheric stability	Unstable

[a]Modeling at 20 knots is being conducted to determine if downwind concentrations would be higher than predicted at 5, 7, and 9 knots.

3.2.2.2 Modeling Methodology--

The dispersion modeling used to estimate downwind concentrations from the 5-1/2-segment rocket motor test is briefly described in this section. The model (box model described below) that was used to estimate the downwind concentrations involves a conservative (worst-case) approach. Since this model and approach showed no air quality problems, more detailed modeling was not necessary.

A box model that assumes a trivariate Gaussian distribution in the vertical and horizontal (x, y, and z) directions was selected to estimate the maximum ground level pollutant concentrations at various receptors. The trivariate Gaussian distribution model is given in EPA's Workbook of Atmospheric Dispersion Estimates AP-26, (Turner, 1970). The trivariate Gaussian distribution is also used in the following EPA models:

1. Mesopuff
2. Mesopuff 2.0 (Scire et al., 1983)
3. Inpuff 2.0 (Peterson and Laudas, 1986)

The quasi-instantaneous dispersion parameters (sigma (x), sigma (y), and sigma (z)) given in AP-26 were used for the Titan exhaust cloud modeling. The quasi-instantaneous dispersion parameters were used instead of the Pasquill-Gifford (P-G) (Turner, 1970; Hanna et al., 1982) dispersion parameters because of the short averaging time required for the downwind concentrations and the short rocket exhaust release time (2 minutes). A comparison of the maximum estimated ground-level concentrations for the quasi-instantaneous and P-G dispersion parameters indicate that the quasi-instantaneous dispersion parameters predict higher maximum peak ground-level concentrations by factors ranging from 2.2 to 2.4. Therefore, to be conservative, the quasi-instantaneous dispersion parameters were used. A representation of exhaust cloud formation is shown on Figure 3.3.

The exhaust cloud stabilization height was determined using Briggs buoyant plume rise equation modified for a plume only slightly inclined from the horizontal (Dumbauld and Bjorkland, 1972). In addition, the energy due to afterburning and the energy required to vaporize a portion of the deluge water was considered in estimating the exhaust cloud rise. The range of exhaust cloud heights estimated for the 5-1/2-segment Titan test at the Rocket Propulsion Laboratory (RPL) is 3,500 to 4,900 feet above the test stand. The height range for the 2-segment test is 2,930 to 3,540 feet above the test stand.

The amount of deluge water vaporized by the rocket exhaust was estimated using the conservation of energy principle and the location of the deluge water jets. The conversion of the initial chemical energy of the solid rocket fuel to thermal and kinetic energy was approximated using the mass of the rocket exhaust, the exhaust exit velocity, and assuming an adiabatic process. The maximum amount of water that could be vaporized in 2 minutes by the exhaust gas stream is estimated at 104,000 gallons assuming all energy was used to vaporize water.

However, the estimated amount of water that will be in direct contact with the core of the exhaust plume is about 32,500 gallons for the 5-1/2-segment test. The external deluge water jets are not expected to significantly penetrate the core of the plume due to the large

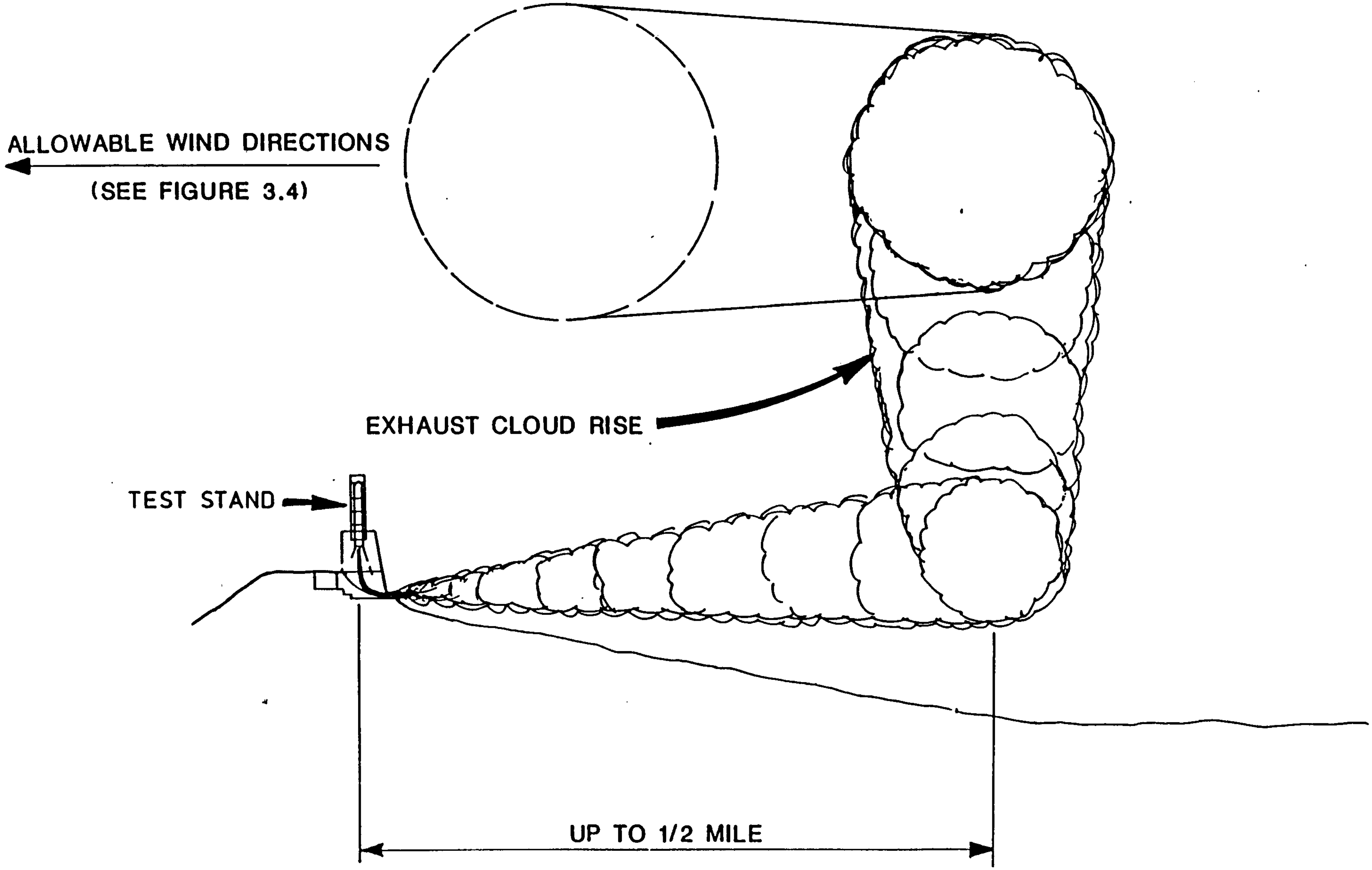

Figure 3.3 Exhaust Cloud Formation and Rise -- 2-Minute Test Firing

differences in velocity and momentum. However, some of this deluge water will be vaporized. To be conservative, an additional 27,500 gallons of water is assumed to be vaporized for a total of 60,000 gallons or 22 percent of the total amount of deluge water applied. Due to the lower total energy in the 2-segment exhaust, less deluge water is expected to be vaporized. It is estimated that approximately 8 percent (22,400 gallons) of the total amount of deluge water will be vaporized.

Visual observations of scale model rocket test firings in November 1986 at Norco, California, and full-scale F-1 liquid rocket test firings at RPL from the 1960s, indicate that a large amount of the deluge water is entrained in the exhaust cloud as a fine mist. A portion of the fine mist will evaporate and the rest will precipitate.

An energy balance of the exothermic and endothermic afterburning reactions (CO to CO_2, H_2 to H_2O, and N_2 to NO_x) discussed previously was incorporated into the cloud rise modeling.

3.2.2.3 Model Assumptions--

The assumptions used when estimating the downwind concentrations of the rocket exhaust cloud are listed below. A short explanation of their effect on the estimated concentrations is also included.

1. The total amount of exhaust emissions is assumed to be released into the atmosphere. No losses of HCl or Al_2O_3 are assumed. (However, the water deluge system will remove a portion of the HCl exhaust emissions by absorption into water droplets, and will have the capability of neutralizing much of the HCl in the exhaust, see Section 3.2.5.)

2. The wind speed is assumed constant with altitude through the exhaust cloud. This is a conservative assumption with respect to downwind pollutant concentrations.

3. Gravitational settling was not included in the modeling process. The size distribution of the Al_2O_3 particles within the exhaust cloud is uncertain. Particles range in size from 0.05 micron (um) to 40 um with an estimated 50 to 75 percent of the particles less than 10 um. The particles that are 10 um or less will have dispersion characteristics similar to gases. The 40-um particles have a settling velocity of approximately 0.6 fps. At this settling velocity, about half of the 40-um particles will settle within 8 miles downwind from the 5-1/2-segment motor test at a wind speed of 5 knots. Therefore, gravitational settling will reduce the predicted downwind ground-level particulate concentrations slightly.

4. The conversion of N_2 to NO_x is assumed to be the same as monitored Titan launches. The amount of deluge water to be applied to the exhaust of the proposed Titan tests at Edwards AFB is significantly larger than the amount of deluge water applied to the Titan launches monitored in 1977. Therefore, there will be less conversion of N_2 to NO_x for the proposed Titan tests. To be conservative, this reduction in the conversion rate of N_2 to NO_x was not considered in the modeling process.

3.2.3 Model Results

3.2.3.1 Maximum Concentrations From Rocket Exhaust--

The maximum ground level concentrations and the distance downwind at which the maximum concentrations of Al_2O_3, HCl, and NO_2 occur due to the Titan tests at RPL are shown in Tables 3.4, 3.5, and 3.6. The 2-segment test results in higher downwind concentrations than the 5-1/2-segment test due to the lower stabilized exhaust cloud height of the 2-segment test. In addition, the estimated ground level concentrations at sites located 3.5 and 3.0 miles downwind, respectively, are also shown in Tables 3.4, 3.5, and 3.6. These values assume the exhaust cloud passes directly over Boron or the Desert Lakes housing tract. It should be noted that the predicted maximum ground level concentrations occur at a greater distance downwind than either the Desert Lakes housing tract or Boron. The exhaust cloud will not have dispersed sufficiently from its final stabilized height to produce maximum downwind concentrations at Boron or the Desert Lakes housing tract, assuming the wind blows the exhaust directly toward these areas.

3.2.3.2 Maximum Downwind Concentrations--

The estimated maximum ground-level concentrations due to the proposed Titan tests at RPL are added to the ambient air monitoring data presented in Table 2.2. The total estimated maximum downwind concentrations are shown in Table 3.7.

Table 3.4 Maximum Downwind Concentrations of Al_2O_3

Distance downwind, miles	Wind speed, knots	Averaging time, hours	5-1/2-segment concentration, ug/m^3	2-segment concentration, ug/m^3
7.5[a]	5	24	27.7	31.3
6.8[a]	7	24	22.9	27.2
5.6[a]	9	24	21.8	9.2
3.5	5	24	9.5	12.3
	7	24	9.4	12.2
	9	24	7.6	3.7
3.0	5	24	6.5	8.7
	7	24	6.7	8.9
	9	24	7.4	3.5

[a]Distance downwind where the maximum concentration occurs.

Note: Assumes test conducted late morning to afternoon (after 10 a.m. PST).

Table 3.5 Maximum Downwind Concentrations of HCl

Distance downwind, miles	Wind speed, knots	Averaging time, minutes	5-1/2-segment concentration, ppm	2-segment concentration, ppm
7.5[a]	5	10	1.04	1.27
6.8[a]	7	10	1.21	1.40
5.6[a]	9	10	1.28	1.43
3.5	5	10	0.50	0.65
	7	10	0.59	0.75
	9	10	0.57	0.79
3.0	5	10	0.30	0.46
	7	10	0.42	0.54
	9	10	0.41	0.58

[a]Distance downwind where the maximum concentration occurs.

Note: Assumes test conducted morning to afternoon (after 10 a.m. PST).

Table 3.6 Maximum Downwind Concentrations of NO_2[a]

Distance downwind, miles	Wind speed, knots	Averaging time, hours	5-1/2-segment concentration, ppm	2-segment concentration, ppm
7.5[b]	5	1	0.055	0.064
6.8[b]	7	1	0.050	0.055
5.6[b]	9	1	0.041	0.050
3.5	5	1	0.018	0.026
	7	1	0.019	0.025
	9	1	0.017	0.025
3.0	5	1	0.011	0.019
	7	1	0.014	0.019
	9	1	0.012	0.019

[a]The concentrations assume an initial distribution of 90 percent NO and 10 percent NO_2 and an oxidation rate equal to a peak ozone concentration of 0.19 ppm (Cole and Sommerhays, 1979).
[b]Distance downwind where the maximum concentration occurs.

Table 3.7 Estimated Total Maximum Downwind Concentrations

Pollutant	Averaging time, hours	Ambient air maximum[a]	Maximum concentration due to rocket test	Total maximum downwind concentration	Standard[b]
O_3, ppm	1	0.19	0	0.19	0.12
CO, ppm	1	12.0	0	12.0	20
NO_2, ppm	1	0.11	0.026	0.136	0.25
TSP, ug/m^3	24	176	31	207	260
PM_{10}, ug/m^3	24	82	16-23	98-105	50
HCl, ppm	1/6	0	1.43	1.43	3[c]

[a]See Table 2.2.
[b]Most stringent standard from Table 2.3.
[c]NAS criteria.

The modeling results presented in Table 3.7 show the cumulative impacts of the rocket motor tests and the maximum ambient air quality concentrations. Table 3.7 indicates that the impacts due to the rocket motor tests will not increase the maximum measured values above the state or federal standards except for particulate matter less than 10 um in diameter (PM_{10}). The measured ambient air concentration of PM_{10} presently exceeds the state standard. The impact due to the rocket motor tests is to increase the maximum air concentration of PM_{10} for 2 days between February and December 1987. This is not considered significant.

The maximum estimated 10-minute average HCl concentrations are 0.58 ppm at 3 miles downwind and 0.79 ppm 3.5 miles downwind. The maximum downwind concentration of HCl is predicted to be 1.43 ppm. There is no state or federal short-term standard for HCl; however, the recommended short-term public exposure limit put forth by the National Academy of Sciences is 3 ppm average for 10 minutes (1980).

Acidic precipitation will occur near the test site due to two conditions:

1. A portion of the deluge water is expected to reach the outer surface of the exhaust stream and be atomized on contact due to the large differences in momentum and velocity between the exhaust gas stream and the deluge water stream. The water mist will entrain HCl from the outer edges of the exhaust plume and become acidic. Measurements of the pH for Titan launches indicate a range of 0.5 to 1.0 with the mist settling to the ground in the vicinity of the launch site. Since the water at RPL will be buffered with sodium carbonate, the pH of the mist is expected to be about 3 (see Section 3.2.5).

2. The exhaust plume will entrain a significant amount of the deluge water due to vaporization and turbulent gas mixing. As the cloud entrains air and the exhaust cools, a portion of the entrained water vapor will condense onto the Al_2O_3 particles and precipitate from the cloud. This amount will be small (less than 1 percent of the water vapor) when compared to the precipitation due to the mist as discussed in Section 3.2.5.

3.2.4 Summary of Air Quality Impacts

The Titan rocket motor tests will not cause established air quality standards or criteria to be exceeded in the surrounding area for NO_2, HCl, CO, and TSP. The representative peak ambient air PM_{10} concentration was estimated to be 82 micrograms per cubic meter (ug/m^3). This PM_{10} concentration currently exceeds the state standard of 50 ug/m^3. The addition of the estimated PM_{10} impacts due to the rocket tests (16 to 23 ug/m^3) would increase the estimated peak PM_{10} concentration. Due to the lack of monitoring data available for PM_{10}, the small number of rocket tests (3), and the short duration of each test (2 minutes), the PM_{10} impacts are not considered significant.

3.2.5 Precipitation in the Vicinity of Test Stand

The exhaust gas stream will entrain the deluge water in two different phases:

1. Water vapor--The estimated amount of water vapor in the exhaust plume is a combination of the water vapor present at the nozzle (4,000 gallons for the 5-1/2-segment test and 1,700 gallons for the 2-segment test), and the vaporized deluge water (about 60,000 gallons for the 5-1/2-segment test and 22,400 gallons for the 2-segment test).

2. Water mist--The remainder of the deluge water is assumed to be in the form of mist (220,000 gallons for the 5-1/2-segment test and 257,600 gallons for the 2-segment test).

The mist is produced by a shearing force that occurs due to the large differences in velocity and momentum between the water jets and the exhaust gas stream.

Precipitation near the test stand will occur primarily from the mist entrained into the exhaust cloud. The condensation of the vaporized water onto the Al_2O_3 particulates will be negligible (under 1 percent) due to the large amount of ambient air in the exhaust cloud (greater than 99.9 percent by weight at stabilized height) and the low relative humidity of the ambient air (20 to 50 percent). In addition, a portion of the mist will evaporate due to the low relative humidity. To be conservative, no evaporation of the mist was assumed when estimating the mist precipitation in the vicinity of the test stand.

The mist droplets will collect (scrub) a portion of the HCl and Al_2O_3 in the exhaust cloud. The scrubbing mechanisms are different for the HCl and Al_2O_3, as described below.

For water droplets with low concentrations of aqueous HCl, the equilibrium partial pressure is about two orders of magnitude less than the equilibrium partial pressure of the gas phase HCl (approximately 1 dyne/square centimeter ($dyne/cm^2$ (aqueous) to 98 $dyne/cm^2$ (gas phase) at 15 degrees centigrade (C) (Cramer, et al., 1970)). Therefore, essentially all gas phase HCl that comes in contact with the water droplets will be absorbed down to a pH of about 1 (Cramer, et al., 1970).

The amount of HCl scrubbed out is estimated to be about 30 percent of total HCl rocket emissions. This removal percentage was estimated from monitored Titan launches and is approximate due to the error involved in determining the volume of the Titan launch exhaust clouds at relatively long downwind distances (4 to 27 miles) (Gregory, et al., 1978 and Wornon, et al., 1979). The removal percentage was estimated by comparing the total mass of HCl in the exhaust at the nozzle to the total mass of HCl in the exhaust cloud, as it traveled downwind. The total mass of HCl in the exhaust cloud was calculated from the average concentration measured in airplane fly-throughs and from the estimated cloud volume at the time of the sampling fly-throughs.

The water droplets scrub the Al_2O_3 by impingement of the Al_2O_3 particles onto the water droplets as the water droplets settle. This scrubbing mechanism requires an impact between the Al_2O_3 particles and the water droplets. This is a less efficient scrubbing process than the HCl absorption process. The amount of Al_2O_3 removed is estimated to be about 5 to 20 percent of total Al_2O_3 rocket emissions. This range was estimated by comparison of the HCl/water droplets and Al_2O_3/water droplets scrubbing mechanisms. The monitored Titan launches are inconclusive in determining a removal percentage of Al_2O_3 due to the large amounts of debris entrained in the exhaust cloud. However, some removal of Al_2O_3 particles does occur (Bendura, et al., 1977, Gregory, et al., 1978, Woods, et al., 1978, and Wornom, et al., 1979).

The deluge water will be buffered with sodium carbonate (Na_2CO_3) and will have an initial pH of about 11. Therefore, the water mist produced by the shearing action of the rocket exhaust velocity and momentum will also have a pH of about 11.

When the mist absorbs HCl in the exhaust cloud, the HCl will dissociate and react with the Na_2CO_3 in the following reaction:

$$2HCL + Na_2CO_{3\,(aq)} \longrightarrow 2Na_{(aq)}^{+} + 2Cl^{-}_{(aq)} + H_2O + CO_{2\,(g)}$$

Note that at a low pH (pH <3) the aqueous carbonic acid (H_2CO_3) changes to water (H_2O) and carbon dioxide (CO_2) gas. (Morel, 1983). Therefore, the final concentration of carbonates in the mist will be small (approximately 10^{-5} Molar). The aqueous sodium ions (Na^+) and aqueous chloride ions (Cl^-) will combine to form common salt (NaCl) when the mist evaporates. The final pH of the mist after the reactions between the HCl and the Na_2CO_3 take place, should be about 3.

The maximum amount of precipitation that could occur from the test was estimated by assuming that all 220,000 gallons of the mist deluge water precipitated within 1 mile. This assumption is conservative due to the following reasons:

1. The smallest droplets (less than 10 um) will behave as a gas and disperse as the exhaust cloud disperses.

2. The large amount of ambient air at a low relative humidity (at initial stabilized height, 99.9 percent ambient air by weight at a relative humidity between 20 and 50 percent) will cause a portion of the mist to evaporate.

Assuming the 220,000 gallons of deluge water precipitates within 1 mile, the amount would be about 0.01 inch of precipitation average. This will be a thin moisture film that will evaporate within about 1 hour under the average annual evaporation rate of 80 inches per year in the Mojave Desert (Linsley and Franzini, 1979). This would be typical in late winter, daytime conditions. Summer daytime conditions would evaporate this water in less than 1 hour.

The maximum amount of Al_2O_3 (20 percent) that could precipitate is about 28,000 pounds or about 0.001 pounds per square foot (lb/ft^2). The maximum amount of NaCl that could precipitate and form upon evaporation is approximately 20,000 to 46,000 pounds. If this settled within 1 mile of the test stand, it would form about 0.001 $lb/sq\ ft^2$ of NaCl.

3.2.6 Worst-Case Analysis

3.2.6.1 Rocket Test Abort/Failure--

If problems arise during the 2-minute Titan test firings, the rocket motor case will be ruptured and propellant combustion will proceed faster than normal. This analysis addresses the air quality impacts if a rocket failure or rupture were to occur during the 2-minute test firings.

The modeling methodology used to estimate the maximum downwind concentrations for a Titan test failure is similar to the approach used to model a successful Titan test except for the changes listed below. It should be noted that the entire propellant does not detonate instantaneously in any failure scenario. There is a sudden release of pressure when the motor case is ruptured. This causes propellant pieces to be ejected from the case and allows much faster and uncontrolled combustion of propellant.

1. Differences Between a Successful Test and a Failure. The physical differences in the rocket exhaust release are as follows:

   a. The combustion products will be released over a very short time period for a rocket failure.

   b. There will be no cooling from the deluge water for a failure.

c. The combustion products will be released radially for a failure.

d. A rocket failure would spread the exhaust radially with a depth roughly equal to the height of the Titan rocket. This would allow for the initial entrainment of large amounts of ambient air (O_2). Therefore, to be conservative, the conversion of N_2 to NO_x is assumed to proceed to completion.

2. Cloud Rise. Due to the large heat release in a short time and the absence of water cooling, the cloud is predicted to rise to about 8,200 to 9,800 feet, depending on the wind speed. This maximum cloud rise assumes the absence of or a weak subsidence inversion.

3. Impacts Due to a 5-1/2-Segment Titan Failure. The maximum concentrations due to a Titan failure would occur about 14 to 18 miles downwind. The increase in pollutant maximum concentrations due to a rocket failure are shown in Table 3.8. These numbers are extremely small, have no significant effect on downwind air quality, and would not violate any standards.

Table 3.8 Estimated Maximum Downwind Concentrations With a Rocket Failure

Pollutant	Concentration				
	Wind speed, knots	Ambient air maximum[a]	Maximum due to failure	Maximum downwind	Standard[b]
Al_2O_3,[c] ug/m^3 (TSP)	5	176	3.8	180	260
	7	176	3.1	179	—
	9	176	2.8	179	—
HCl,[d] ppm	5	0	0.14	0.14	3.0
	7	0	0.16	0.16	—
	9	0	0.17	0.17	—
NO_2,[e] ppm	5	0.11	0.04	0.15	0.25
	7	0.11	0.04	0.15	—
	9	0.11	0.03	0.14	—

[a]See Table 2.2.
[b]Most stringent standard or criterion.
[c]Averaging time is 24 hours.
[d]Averaging time is 10 minutes.
[e]Averaging time is 1 hour.

3.2.6.2 Nonbuoyant Exhaust Cloud--

A worst-case scenario assumes that all of the thermal energy within the rocket exhaust plume vaporizes deluge water. If this occurs, there will not be a significant difference between the internal temperature of the exhaust cloud and the ambient air temperature. Therefore, there would be no buoyant cloud rise. This is not expected to occur, but has been calculated for safety reasons in the event deluge water is able to penetrate the core of the exhaust plume to a greater extent than predicted.

The 2-segment test was used to determine the downwind concentrations for a nonbuoyant exhaust cloud because the heat release from the 2-segment motor is less than the heat release of the 5-1/2-segment motor; therefore, the 2-segment motor will have a greater probability of forming a nonbuoyant exhaust cloud.

The drop in temperature would probably not allow the afterburning reactions (H_2 to H_2O, CO to CO_2, and N_2 to NO_x) to proceed to completion. To be conservative, the afterburning reactions were assumed not to occur. Table 3.9 shows the estimated downwind concentrations due to the rocket exhaust from the 2-segment test. Table 3.10 shows the cumulative downwind concentrations due to the rocket exhaust and the existing ambient worst-case concentrations.

The concentrations shown in Table 3.10 exceed the state standards for total suspended particulates (TSP) and PM_{10}. The HCl concentrations exceed the standards set by the National Academy of Sciences. While a nonbuoyant exhaust cloud is considered very unlikely, this worst-case scenario was used in determining the required direction of the prevailing winds at the time of the test to minimize the potential impact on downwind populations. The receptor located 9.5 miles from the test stand is the eastern boundary of RPL at U.S. Highway 395. The location of this receptor assumes the cloud is directed by a westerly wind.

The maximum ground-level concentrations for the exhaust emissions at U.S. Highway 395 (Table 3.10) are below the strictest standards or criteria with the exception of PM_{10}. However, the particulate concentrations were averaged over a 24-hour period to be comparable to the federal and state particulate standards. The peak concentrations (1 minute averaging time) are significantly higher. The estimated peak concentrations of Al_2O_3 at the U.S. Highway 395 receptor for the nonbuoyant cloud scenario is about 6,200 ug/m^3. The entire cloud would pass the receptor within a period of 20 to 30 minutes, depending on the wind speed.

Table 3.9 Downwind Pollutant Concentrations From the Nonbuoyant Exhaust Cloud of a 2-Segment Motor

Pollutant	Distance downwind, miles	Wind speed, knots		
		5	7	9
Al_2O_3[a], ug/m^3 (TSP)	3	246	184	123
	3.5	183	137	116
	9.5	56	40	31
CO,[b] ppm	3	4.6	3.3	2.6
	3.5	4.0	2.9	2.2
	9.5	1.1	0.8	0.6
HCl,[c] ppm	3.0	15.3	11.3	8.9
	3.5	12.8	9.7	7.7
	9.5	2.4	2.2	1.9

[a]Twenty-four hour averaging time.
[b]One-hour averaging time.
[c]Ten-minute averaging time.

Table 3.10 Cumulative Concentrations for Nonbuoyant Plume Rise and Worst-Case Ambient Air

Pollutant	Downwind distance, miles	Wind speed, knots			Standard[a]
		5	7	9	
AL_2O_3,[b] ug/m^3 (TSP)					260
	3	422	360	299	
	3.5	359	313	292	
	9.5	232	216	207	
PM_{10},[b] ug/m^3					50
	3	205-266	174-220	144-174	
	3.5	174-219	150-185	140-169	
	9.5	110-124	102-112	97-105	
CO,[c] ppm					20
	3	16.6	15.3	14.6	
	3.5	16.0	14.9	14.2	
	9.5	13.1	12.8	12.6	
HCl,[d] ppm					3
	3	15.3	11.3	8.9	
	3.5	12.8	9.7	7.7	
	9.5	2.4	2.2	1.9	

[a]Most stringent standard or criteria.
[b]Averaging time is 24 hours.
[c]Averaging time is 1 hour.
[d]Averaging time is 10 minutes.

Due to the high peak concentrations of Al_2O_3, visibility along U.S. Highway 395 may be impaired and could cause a safety hazard. To be safe, coordination with the California Highway Patrol (CHP) and possibly California Department of Transportation (Caltrans) is needed so that short-term road closure plans and/or signs warning motorists of the dusty air can be prepared.

3.2.7 Mitigation Measures

The RPL has a sophisticated meteorological monitoring system using 19 instrumented towers. This system collects data on wind speed, wind direction, air temperature, and air temperature difference between 6 and 54 feet above the ground. This information is automatically updated every 5 minutes. These data and other meteorological observations are used to determine if the requirements established by RPL and Edwards AFB for a specific test firing are met. The requirements for the Titan tests are likely to be as follows:

1. No thunderstorms within at least 10 nautical miles.
2. No precipitation in the downwind area.
3. Wind speed greater than 5 knots.
4. Wind direction such that the plume will not blow over an inhabited area--allowable wind direction is 260 to 310 degrees azimuth.
5. A decrease in temperature greater than 1 degree F between 6 and 54 feet above the ground. This condition is not met if a surface inversion is present.
6. Tests in daylight hours only.

The data collection system and criteria are described in detail in the "Air Emissions Inventory for the Air Force Rocket Propulsion Laboratory Operations in Kern County" submitted to the Kern County Air Pollution Control District on September 19, 1986, by RPL. An instrumented balloon will be sent aloft prior to the 5-1/2-segment test to confirm wind speeds and directions and other data at altitudes up to 10,000 feet.

The nonbuoyant exhaust cloud scenario was assumed when determining the wind direction range which directs the exhaust cloud away from inhabited areas. An acceptable wind corridor was established by calculating the estimated ground level concentrations at inhabited areas for different trajectories of the nonbuoyant exhaust cloud. The allowable wind direction range for the Titan tests is 260 to 310 degrees azimuth. The location of the wind corridor is shown on

Figure 3.4. The wind corridor shown on Figure 3.4 indicates that the exhaust cloud will exit the RPL area boundary and pass U.S. Highway 395 at approximately 9-1/2 to 12 miles downwind.

Since the only potentially significant air quality impact in off-site areas will be along U.S. Highway 395, coordination with state highway officials will be undertaken. This coordination is a precaution against the unlikely event of a nonbuoyant plume rise and high dust (Al_2O_3) concentrations at ground level in this area.

The acid mist fallout near the test stand will be mitigated through use of sodium carbonate conditioning of the deluge water. This will keep the mist from reaching the extremely low pH levels experienced near launch sites. Monitoring of the mist pH and HCl concentrations in the mist fallout is planned at least for the first test firing to confirm the estimates and predictions made in the Environmental Assessment (EA).

3.3 AIR QUALITY--SHORT-BURN TEST FIRINGS

The short-burn test firings will emit much smaller quantities of air pollutants and have less potential impact on air quality than the 2-minute firings described in Section 3.2.

3.3.1 Description of Short-Burn Tests

A series of up to six short-burn Titan test firings will be conducted at Test Stand IC sometime between February and December 1987. This series of tests will probably be conducted after the 2-minute, 5-1/2-segment test which is currently scheduled for late winter or early spring, 1987. Each short-burn test will be separated by several days from the next such test.

The short-burn tests will be conducted within a 2-segment Titan rocket motor which will have a small amount of active propellant. The motor will be essentially filled with inert propellant-like material which will not burn during the test. The formulation of this inert material is similar to active propellant, except that the ammonium perchlorate is replaced with salt and other compounds. The purpose of the inert propellant is to provide weight and structural characteristics similar to active propellant.

The motor will be fitted with a small nozzle (about 2 to 4 inches in diameter) to provide the gas pressure needed within the motor case. The active propellant will burn in the motor for less than 2 seconds. However, due to the small nozzle size, combustion products will continue to exit the nozzle after the propellant has burned. The pressure will gradually be reduced within the motor case as exhaust products leave the nozzle. It is estimated that up to 90

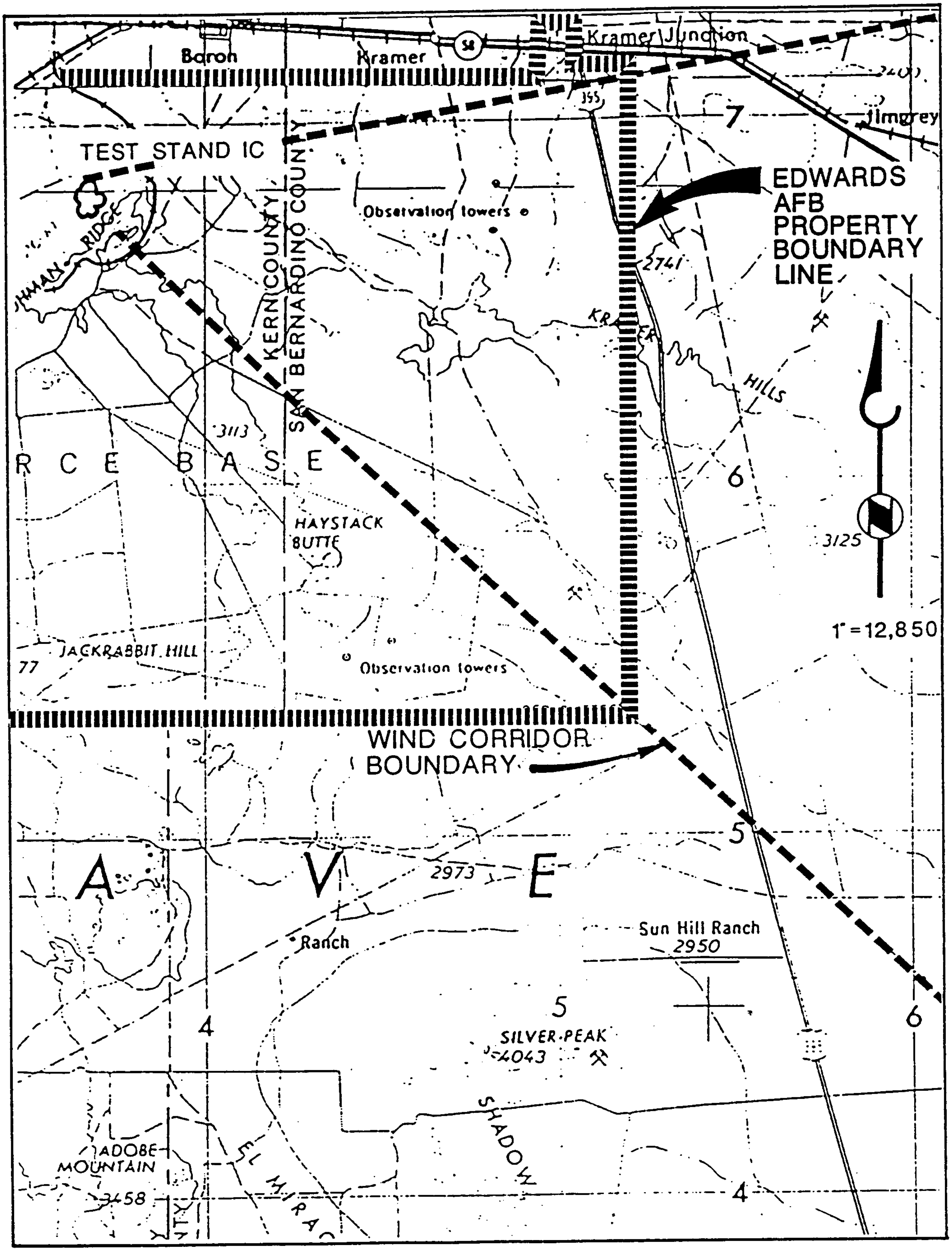

Figure 3.4 Location of Wind Corridor

seconds will be required for the motor case pressure to reach ambient air pressure. The rate of exhaust emissions will gradually drop to zero over this 90-second time period. About 75 percent of the total emissions will be released within the first 20 seconds.

3.3.2 Air Emissions--Short-Burn Tests

Up to 500 pounds of Titan solid propellant will be burned for each test. There is the possibility that the propellant formulation could be slightly different than Titan propellant. However, the propellant will still be Class 1.3 propellant, the exhaust products will not be significantly different than Titan propellant exhaust products, and the emissions will be no greater than indicated in Table 3.11.

Table 3.11 Emissions for Each Short-Burn Test

Constituent	Emissions following afterburning, lbs[a]
Al_2O_3	151
HCl	103
NO_x	95
CO_2	231
CO	1
H_2O	35

Note: Emissions total more than 500 pounds due to atmospheric afterburning.

[a]Assumes Titan propellant.

Afterbrning of H_2, CO, and N_2 is assumed to be essentially complete due to the rapid mixing of air with the exhaust gases. CO conversion to CO_2 is estimated at 99 percent as discussed for the 2-minute tests. It is conservatively assumed that complete conversion of N_2 to NO_x will occur. Complete conversion of H_2 to H_2O is assumed.

3.3.3 Exhaust Cloud Rise--Short-Burn Tests

The exhaust will strike the deflector plate and be directed horizontally. Exhaust velocity will be much less than for the 2-minute tests described previously, and the exhaust cloud will form immediately adjacent to the test stand. The exhaust emitted during the first 10 to 20 seconds will rise in an exhaust cloud about 250 to 370 feet above the deflector plate. The last 50 to 60 seconds of exhaust will rise only 50 to 130 feet due to the reduced quantity of emissions.

3.3.4 Dispersion Modeling--Short-Burn Tests

The dispersion modeling used for the short-burn tests is similar to the modeling used to predict downwind concentrations for the 2-minute test firings with the following exceptions:

1. No restriction on wind direction was assumed; therefore, RPL building areas were considered receptors.

2. Due to the relatively small exhaust cloud rise, terrain effects were estimated.

If the wind is from the northeast, north, northwest, or west, the exhaust cloud will travel over Leuhman Ridge and RPL building areas. Due to the size of Leuhman Ridge and the exhaust cloud heights, downdrafting of the exhaust cloud will probably occur. The dispersion modeling assumes a worst case scenario of exhaust cloud traveling to RPL areas and then brought down to ground level by turbulent eddies. This method is described by Turner (1970).

Other than the immediate test stand area, the RPL areas 1 mile away were considered the worst-case receptors. Concentrations in this area are shown in Table 3.12. Concentrations at off-site locations, such as Boron and Desert Lakes, would be less than the concentrations shown in the table. The concentratons shown in Table 3.12 are very low and will not result in violations of air quality standards.

Table 3.12. Predicted Downwind Concentrations at RPL for Short-Burn Tests[a]

Constituent	Wind speed, knots	Averaging time	Downwind concentrations at RPL with downdrafting
HCl, ppm	5	10 min.	0.09
	7	10 min.	0.13
	9	10 min.	0.08
Al_2O_3, ug/m^3	5	24 hrs.	1.3
	7	24 hrs.	2.1
	9	24 hrs.	1.0
NO_2,[b] ppm	5	1 hr.	0.02
	7	1 hr.	0.02
	9	1 hr.	0.01

[a]RPL is located approximately 1 mile south of Test Stand IC.
[b]Calculated by the ozone limiting method.

There should be little or no acid or particulate fallout since no deluge water will be used. The small amount of fallout that could possibly occur would be in the immediate test stand area. This area will be washed down after the test and the wash water will drain into the containment basin and water channel system (see Figure 1.4).

The stringent meteorological conditions required for the 2-minute tests will not be needed for the short-burn tests. The short-burn tests should not be conducted under inversion conditions or when thunderstorms are in the immediate vicinity. There should be a wind speed of at least 5 knots, although no restrictions on wind direction are needed. RPL's standard safety procedures should be followed. Personnel should remain away from the exhaust cloud while it is in the test stand vicinity and up to about 1 mile downwind to insure that HCl concentrations have dispersed to safe levels.

3.4 SURFACE WATER AND GROUNDWATER RESOURCES

Each of the 2-minute test firings will require about 590,000 gallons of deluge water and a few thousand gallons of additional washdown water. All water will be supplied from existing wells. Fire suppression water, if needed, will also be supplied from existing wells. Each test will generate approximately 210,000 gallons of wastewater from the deluge water system plus a few thousand gallons from washdown operations. The wastewater will be collected in channels, and recycled and evaporated, as described in Section 1.2.5.2, so there will be no discharge to surface waters or recharge of groundwater. The 280,000 gallons that will be carried off in the exhaust will be partially evaporated. The remainder will be small water droplets or mist. Some of this mist will fall out near the test stand and some will be carried long distances in the exhaust plume (see Section 3.2.5).

CSD conducted small-scale (825-lb) rocket motor tests on November 3 and November 20, 1986, at the Wyle Laboratories facility in Norco, California. The purpose of the tests was to simulate as closely as possible the test conditions at Edwards AFB so that information could be obtained on the durability of the ablative material on the flame bucket. The water system was scaled in relation to motor heat release rates. When the small-scale rocket fired, the deluge water was entrained in the exhaust and was carried off in the exhaust cloud. Therefore, no data were obtained on the after-test deluge water quality. No mist or mist fallout was observed and no data were collected on the mist. Data collected on cooling water after Space Shuttle launches at Kennedy Space Center (KSC) show that the pH ranges from 1.6 to 2.0 due to HCl absorption (Fluor Engineers Inc., 1983). The pH of mist in exhaust plumes from Titan launches has been about 0.5 to 1.0 (Bendura and Crumbly, 1977; Gregory, et al., 1978; Woods, et al., 1979 and Wornom, et al., 1979).

Based on these data, the USAF and CSD have decided to install a deluge water treatment system consisting of pretreatment of the water with sodium carbonate to raise the pH prior to each test. This will prevent the after-test pH from dropping if deluge water with HCl in it is trapped in the water collection channels. The primary benefit of the pretreatment step will be to keep the pH of the mist above the low pH values observed in Titan launches.

The collected water will be contained in the concrete-lined channel connecting Test Stands IC and ID. Initially, raw water will be conditioned in the channel with sodium carbonate, then pumped to the 3-million-gallon tank in a temporary pipeline. After the first test, the water will be reconditioned for the next test and the solids will be removed from the channel.

The sodium carbonate will be mixed into the water hydraulically within a portion of the concrete-lined channel (see Figure 1.4). After the water is completely mixed and stabilized (3 to 4 days) the solids will be allowed to settle and the water will be conveyed to the 3-million-gallon tank. If the solids do not settle adequately, they will be filtered using in-line cartridge filters before the water is conveyed to the storage tank. The solids will be removed from the channel, chemically analyzed, and disposed of in accordance with all federal, state, and local regulations and policies. After the first test is completed, the water will be sampled and analyzed to determine the amount of conditioning needed before the second test. After the final test, the water will be left in the channel to evaporate. The solids remaining in the channel after evaporation of the water, will be disposed of in accordance with all federal, state, and local regulations and policies. The solids to be disposed are not expected to be hazardous.

The fallout near Test Stand IC is likely to coat the rocks and soil with a small amount of moisture. The increased buffering capacity of the water, due to sodium carbonate additions, should keep the pH of this precipitated mist to about 3.

Some of the ablative heat shield material will erode and vaporize during each 2-minute test firing. The ablative material is a silicon-phenolic compound. Approximately 5,000 pounds of the material could be eroded during each test. Some of the eroded material may be broken off in small pieces which will either fall into the water collection basin or be blown over the basin and fall on the desert floor. Most of the eroded material, however, is expected to be oxidized. The phenolic material will become either CO or CO_2. These additional CO and CO_2 emissions are small compared to the rocket exhaust emissions. The silicon compounds would likely be emitted as small particles which would become part of the Al_2O_3 exhaust stream. These represent a very small percent of the rocket motor particulate emissions and are not significant enough to be taken into account in the modeling procedure.

For the short-burn test firings, the deluge water system will not be used. There will be some quench water used for rocket motor cooling, and washdown water will be needed after each test for cleaning the test stand structure and the immediate area. Maximum water usage will be 10,000 gallons per test. Water conditioning with sodium carbonate will not be necessary for the short-burn tests. Some acid fallout may occur near the test stand. Therefore, washdown water may be slightly acidic (pH between 3 and 6). The water will all be collected in the water channel system and left to evaporate. Remaining solids after evaporation will be disposed according to all applicable state and federal regulations.

In summary, there will be no discharge to surface waters or groundwater and, therefore, no adverse impacts on these resources are expected.

3.5 BIOTA

The testing of Titan rocket motors at Test Stand IC is not expected to significantly impact the vegetation and wildlife of the RPL area. All activities will be conducted within the existing test stand area and will not result in the loss of any additional habitat. Increased personnel activity and elevated noise levels associated with the modifications to the test stand and the test firings will temporarily disturb wildlife in the immediate vicinity.

As previously discussed in Section 3.2.5, an acidic mist of about pH 3 will be formed by contact of the deluge water with the rocket exhaust during ignition and will fall out over approximately 1 square mile of the area near Test Stand IC. The effect on airborne and terrestrial species of the Mojave Desert is discussed below.

Research performed on numerous plant species indicates that pH 2.5 HCl acid treatments were generally no more injurious than distilled water controls (pH = 4.3), whereas pH 1.7 solutions caused significant amounts of injury (Granett, 1977 and 1984). Damage appeared as necrosis (death) of cells located in the vicinity of the stomata, minute openings in a leaf or stem through which gases pass. Agriculturally important and ornamental species were found to be the most sensitive, being primarily broadleaf species. Literature reviews on the effects of hydrogen chloride (EPA, 1976) report large differences in species sensitivity to the gas and acid mist. Cell wall thickness and amount of intercellular space appear to influence the severity of symptom expression. A pH of 3.0 would be considered a mildly acidic concentration. Xerophytic (desert or dry environment adapted plants) would generally be more resistant to acid exposure due to the presence of thick cutin (waxy epidermal cells) and reduced numbers and protected location of stomata.

Ground animals in the vicinity of the test site may come in contact with the acidic mist for short periods of time. This is not expected to have any significant impact on wildlife because the pH of the mist will be near 3.0, the exhaust cloud will remain over any single point a relatively short time, and any mist settling out of the cloud will evaporate within about 1 hour.

Airborne species that might be exposed by flying through the plume could be exposed to concentrations of HCl that would irritate eye and respiratory tract membranes (greater than 10 ppm HCl). It is unlikely that this will occur because birds will initially be frightened away by the noise of the test. Experience at CSD facilities in San Jose, California, indicates that birds have been observed to fly through downwind exhaust clouds formed from solid rocket propellant burning operations (Titan propellant and other propellants), but avoid direct contact with the most concentrated portions of the plumes, especially if large temperature differences exist between the plumes and ambient air. No observations of adverse effects on avian wildlife have been observed at existing CSD facilities from such plumes and exhaust clouds (Personal Communication, Wayne Warwick, December 1986).

The testing of Titan rocket motors at Test Stand IC will not significantly impact any threatened and endangered species. As discussed in Section 2.1.6, the bald eagle and the peregrine falcon are the only federally listed threatened and endangered species in the area. These birds overwinter in the Mojave Desert. If one of these species happened to come in contact with the plume, it would likely occur after the noise had died down, the plume temperature had cooled to near ambient air temperature, and most of the mist had settled out of the cloud. At worst, there may be some irritation of eye and respiratory tract membranes. This is not expected to be a life-threatening situation.

Populations of alkali mariposa lily are not expected to be impacted at all by the firings. All known habitats are located on the southern and western margins of Rogers and Rosamond Dry Lakes. Suitable habitat capable of supporting these plants to the west and east of Leuhman Ridge is not likely to exist based on topography and local knowledge (Personal Communication, Mike Phillips, December 1986).

Mojave spineflower and desert cymopterus have been found approximately 3 to 7 miles east of the test site in San Bernardino County. As discussed in Section 3.2.7, the plume will travel in this direction. These species are listed as candidate species by the USFWS (see Section 2.1.6.3). These species are not normally in evidence at the surface until the April to May flowering period. The perennial living tissues are 4 to 6 inches underground at this time. It is unlikely that acidic mist from the plume will have any adverse impact on these plants due to their distance from the test area.

3.6 POPULATION

The testing of Titan rocket motors is expected to create no significant impact on population and housing in the test site area. Personnel associated with the tests will be temporarily living in the area. Most staff at RPL are permanent, and the Titan tests have no effect on USAF or RPL staff. There have been between 80 and 120 construction personnel at the test site since August 1986. The repairs to the test stand are nearing completion, consequently the construction staff is being reduced. During the static test firings, there will be about 15 construction personnel to operate various systems and approximately 50 USAF and CSD test personnel.

3.7 NOISE

The noise impacts of the proposed rocket testing are based on previous rocket noise information, literature studies, and on the information on rocket motor parameters, meteorological data, and geometric elements at and near the test stand. The results of this study are presented in a report by Peter Klaveness and Associates (1986) and summarized in this section. The noise levels that humans will be exposed to at the test site, RPL facilities, and nearby residential and employment centers are described in this section. This assessment concentrates on the large 2-minute test firings; the noise from the short-burn tests will be much less than the 2-minute tests.

3.7.1 Noise Levels

The main noise-sensitive receptors included in the study are:

1. Personnel at the test site.

2. Personnel at the RPL.

3. The town of Boron, which is partially shielded from the test stand by Leuhman Ridge, at a distance of 3.5 to 4 miles.

4. The Desert Lakes housing tract west of Boron and directly south of the U.S. Borax mine.

5. The rest stop off Highway 58, west of Boron.

6. The community of North Edwards and scattered residences to the northeast, toward Peerless Valley.

7. Kramer Junction at the intersection of U.S. Highway 395 and Highway 58.

8. The residential community at Edwards AFB.

Noise level contours were calculated to distances beyond 30 miles, with potential receptors at Mojave, Lancaster, and Palmdale.

The exhaust flow from the rocket motor is the source of noise during the static rocket tests. The noise level generated depends on the parameters shown in Table 3.13. During the proposed testing, sound will be generated by shear movements within the exhaust flow at the boundary layer between the high-speed exhaust and the still air.

Table 3.13 Rocket Motor Parameters—2-Minute Tests

Parameter	5-1/2-Segment	2-Segment
Sea level thrust	1.2-1.34 Mlbs[a]	113 Klbs[a]
Nozzle diameter, inches	37.7	27.7
Exit diameter, inches	106.6	78.3
Exit velocity, feet/second	8,144	6,200
Burn time, seconds	120	120
Weight of propellant, Klbs[a]	466	206

[a]M = million K = thousand

The noise levels from the test firing of the 5-1/2-segment rocket motor are shown in the form of noise level contours on Figures 3.5 and 3.6. Figure 3.5 shows the overall levels, while Figure 3.6 shows the A-weighted noise levels. The contours indicate the typical "lobed" distribution of the sound. One lobe extends toward the rest stop on Highway 58, and the other toward Lancaster. The noise level predictions are summarized in Table 3.14. As shown in this table, the Occupational Safety and Health Administration (OSHA) standard of 115 decibels measured on the A-weighting scale (dB(A)) (highest noise level allowed at any time in a work place) is not exceeded in any of the nearby communities. Noise levels for the 2-segment tests are expected to be 12 dB(A) lower than those shown for the 5-1/2-segment test.

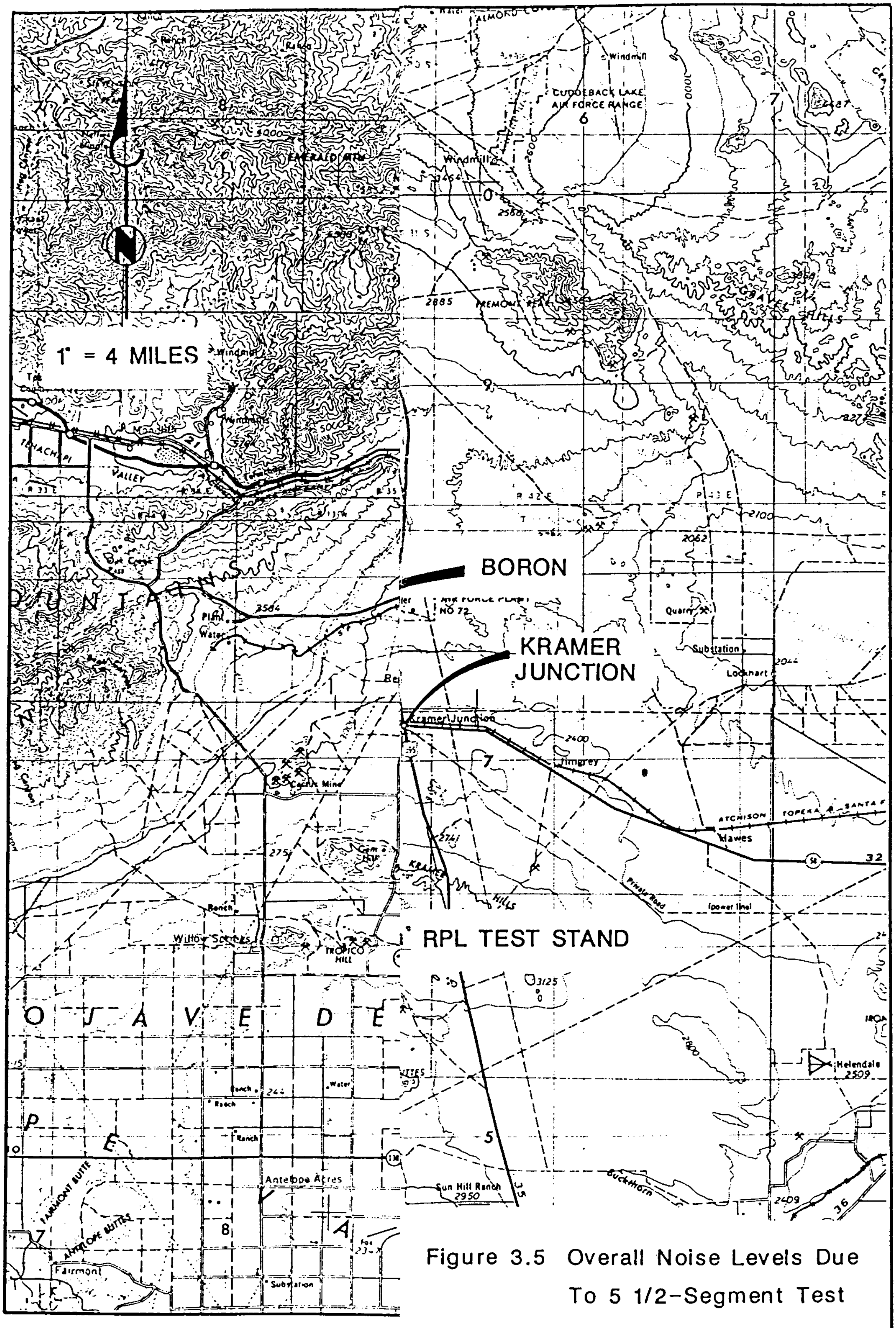

Figure 3.5 Overall Noise Levels Due To 5 1/2-Segment Test

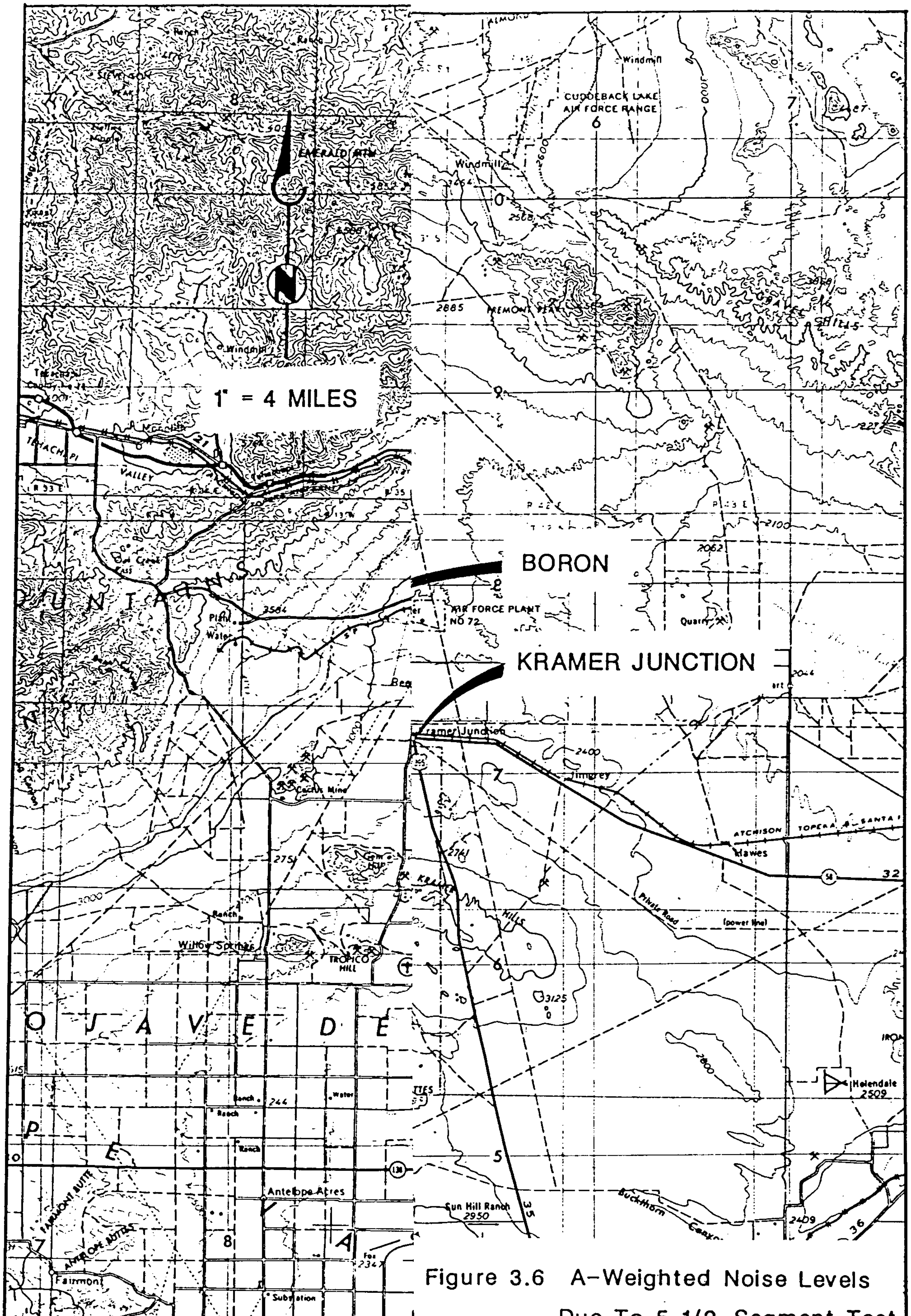

Figure 3.6 A-Weighted Noise Levels Due To 5 1/2-Segment Test

Table 3.14 Predicted Noise Levels Due to 5-1/2-Segment Test

Location	Sound pressure level, dB	A-weighted sound pressure level, dBA
Test Stand IC	193.5	—
Control room		
Outside	130	125
Inside	-	75
RPL	100-110	95-105
Desert Lakes	110	96
Boron	90-102	75-85
North Edwards	95-100	70-75
Edwards Main Base	85	60
Kramer Junction	85	60

The personnel at the test site could be exposed to very high to high sound pressure levels. Exterior sound pressure levels at the control bunker will exceed 130 dB. The control room is constructed underground and built in a manner that could withstand the explosion of a rocket motor. Thus, it is assumed that the sound transmission loss from the exterior to the interior will exceed 60 dB. Interior sound pressure levels will then be less than 75 dB(A).

Personnel at the RPL will benefit by partial shielding from the source since Leuhman Ridge will act as a barrier. Sound pressure levels shown on Figure 3.6 indicate that levels could range between 95 and 105 dB(A) outside.

The maximum noise level at any residential location is predicted to be 110 dB overall and 96 dB(A) at the Desert Lakes housing tract during the 5-1/2-segment motor test. The 2-segment test will generate 98 dB overall and 84 dB(A) at this location. In Boron, the overall noise level will be between about 90 and 102 dB.

The most impacted areas of North Edwards and the scattered residences to the northeast, will experience noise levels between 95 and 100 dB overall and 70 to 75 dB(A). At Edwards, the overall levels will be around 85 and the A-weighted approximately 60 dB(A). The levels at Kramer Junction will be similar to those at Edwards.

Focusing of sound, due to wind and temperature differences at elevations above the test stand, is possible and could increase the predicted noise levels described here. A model predicting these effects is being examined by USAF personnel to determine its applicability and, if used, to determine whether certain meteorological conditions should be avoided. The use of the model does not appear critical to the off-site predictions and the criteria to determine acceptable test conditions.

3.7.2 Impacts

3.7.2.1 Planned Test Conditions--2-Minute Test Firings--

Estimates show no risk of structural damage to residential buildings. Structural damage to dwellings occurs in the range of 130 to 140 dB for octave band noise in the frequency range of the rocket motor tests (Guest, 1973). The probability of damage depends on the test duration. Initial damage normally involves plaster cracking. Window damage should normally not occur for levels below 145 dB and is unlikely below 150 dB.

Personnel at RPL will not be in danger of suffering hearing damage. However, any personnel at the site not within the confines of the control room could suffer hearing damage or at least some pain. The noise levels beyond the Edwards AFB boundaries will be below known criteria for hearing damage, and feeling of physical pressure or discomfort, including ear pain. During the test firing, noise levels will be sufficiently high over a wide area to interrupt outdoor conversations. Indoor conversations and other activities, such as television or radio listening or telephone conversations, will not be disturbed, if windows are kept closed. If windows are open, conversations and other activities will be slightly disturbed for 2 minutes during the test firings.

Nighttime test firings are not planned. If a nighttime test must be conducted, it would cause residents in Boron, Desert Lakes, and parts of the desert community towards North Edwards to awaken. This would be the case for the 5-1/2-segment rocket motor in particular. For the 2-segment motor, awakening due to nighttime firings would be limited to Desert Lakes and the west part of Boron.

There is a minor potential for a startle reaction for automobile drivers in the immediate vicinity of Desert Lakes and the highway rest stop during the firing of the 5-1/2-segment motor. Drivers of automobiles and trucks at cruising speeds on Highway 58 may become aware of the test through the noise, but startle reactions are not expected. No startle reaction is expected during the firing of the 2-segment motor.

3.7.2.2 Failure/Abort Conditions--2-Minute Test--

If it becomes necessary to terminate the 2-minute test firing by splitting the motor case, a high amplitude pressure wave with a short duration will be generated. This sudden change in the form of energy will produce sound pressure levels in excess of those obtained by the normal propellant combustion process and exhaust gas flow. The chances of this failure/abort condition occurring are very low.

Working from the overpressure contours of Class 1.3 propellant, approximations of sound pressure levels for the worst event have been developed (Peter Klaveness & Associates letter, dated December 16, 1986). A-weighted levels have not been predicted because no frequency information is available for a motor failure event.

The maximum noise level at Boron and Desert Lakes would be just below 135 dB overall. At North Edwards, the noise level would be 124 to 126 dB, and at Edwards main base about 123 dB. At RPL, the maximum noise level would be at or above 145 dB, depending on the distance from the test stand. Unlike the noise of the burning rocket motor, the sound of the failure would be omni-directional, without lobes of maximum sound radiation.

According to the 1973 NASA report on the Space Shuttle main engine tests, moderate chest wall vibrations are expected at noise levels above 130 dB and aural pain is likely at levels above 140 dB. For a person at Desert Lakes, therefore, a failure would likely result in feelings of physical pressure and possibly minor pain in the ears. There should be little risk of spontaneous damage to observers' hearing at Boron or Desert Lakes. Structural damage to buildings is unlikely at Boron or Desert Lakes, although not impossible (e.g., for highly stressed, large windows). Significant structural damage due to test failure/abort is unlikely beyond the immediate RPL area. The combined probability of the failure event occurring, and, if it did, damage occurring beyond the immediate area, is very low.

In case of a failure blast of this type, the likelihood of a startle reaction by automobile drivers makes temporary signs on Highway 58 and other local roadways advisable. The sound levels at Desert Lakes are not considered sufficiently high to warrant evacuation. At RPL, evacuation is recommended within 1 mile of the test stand, and between 1 and 3 miles all personnel should be indoors during the tests. Personnel inside buildings within the 1- to 3-mile area need not wear hearing protection. Security and other personnel who are outside buildings yet within 3 miles of the test stand should wear hearing protection during the 2-minute test firings.

3.7.2.3 Noise From Short-Burn Tests--

The noise from the short-burn tests will be significantly less than the 2-minute tests in both intensity and length of time. The peak levels (first few seconds of each test) at RPL will be about 77 to 87 dB, at Desert Lakes 87 dB, and at Boron about 70 to 80 dB. No significant impact will occur in any areas other than the immediate test stand area. Personnel within 1/2 mile of the test stand should wear hearing protection, if not indoors.

3.7.3 Mitigation Measures

The potential significant noise impacts of the rocket motor testing and remote chance of failure of the motor include hearing damage to personnel outside of the bunker room at the test site, speech interference, and possible startle reactions for automobile drivers during tests of the 5-1/2-segment motor.

Mitigation measures for both controlled and uncontrolled populations should include an information program where both populations are informed before the first test of the likelihood of loud sound levels, and of their origin. Signs should be posted along certain roads, as well as at the rest stop, to warn of loud noise levels, to minimize the possibility of driver distraction and possible accidents.

Personnel at RPL should be evacuated within 1 mile of the test stand for the 5-1/2-segment test, and personnel in the 1- to 3-mile area should remain indoors during the test to guard against hearing damage in the unlikely event of a motor failure. Nighttime testing should not be allowed.

3.8 ARCHAEOLOGY AND CULTURAL RESOURCES

Test Stand IC is located on Leuhman Ridge in a highly disturbed area. If archaeological resources were ever present in this area, they were likely destroyed by the excavation for the existing test stands, water channels, storage tanks, and other existing structures.

An archaeological site survey was conducted in December 1986 to determine if there are any archaeological sites in the vicinity of the test stand. There is at least one prehistoric archaeological site on Leuhman Ridge, but there are no cultural or paleontological resources known to be located at or sufficiently near the test site to be of concern (Robinson, 1987). The regrading of a section of the water containment system berm and other construction activities associated with the renovation of Test Stand IC will not affect any archaeological resources.

The rocket tests could indirectly affect archaeological or paleontological resources within the broader area of Leuhman Ridge and the surrounding desert if they cause fires in the surrounding desert. Emergency response vehicles, equipment, and staff could possibly harm archaeological resources, depending on the extent and severity of the fires. This is an unlikely event because the flame bucket and water deluge system at Test Stand IC have been designed to prevent flames from reaching the surrounding area.

No new public viewing areas should be established for the Titan rocket motor tests. If the public are invited to view the tests, the existing Space Shuttle viewing area at the main base should be used. This will prevent any possible impact on archaeological resources due to large crowds of people.

Test Stand IC is not an historically significant structure. It has been modified several times since its construction in 1965, to accommodate various kinds of rocket motor tests. The general area of the test stands may be of historical interest due to the role this area has played in the development of the United States space program.

In summary, the proposed testing of Titan solid propellant rocket motors at Test Stand IC will not directly or indirectly affect any archaeological or paleontological resources in the area. There will be no effect on properties included in or eligible for the National Register of Historic Places. A report describing the site survey and results has been sent to the State Historic Preservation Office.

3.9 SAFETY

The rocket motor segments to be used for the test firings will be transported by truck from CSD storage facilities in southern California to RPL. Shipping approval for all explosives is being obtained from the U.S. Department of Defense (DOD), U.S. Department of Transportation (DOT), and the CHP. Storage and transportation routes are not disclosed for security reasons. Segments will be stacked and mated according to CSD and DOD standard procedures and safety regulations. Following each test, the spent rocket motors will be disassembled and transported off site for detailed examination.

The USAF and CSD will follow the standard safety procedures required by regulatory agencies and conduct safety monitoring during the test firings. There will be a telephone hot line connecting the test control bunker with the operations office at RPL so that potential problems can be quickly communicated. Fire and medical personnel and equipment will be located at RPL and the main base during the test firings.

The USAF has determined that a clear zone with a minimum radius of 1,250 feet around test Stand IC will be required for the 2-minute tests based on the quantity/distance relationship for Titan propellant. A larger clear zone will be required for noise mitigation. All roads will be closed and any RPL offices within the clear zone will be evacuated. Only personnel essential to the operation of the test will be allowed in the clear zone.

A few test personnel will be located in an underground concrete bunker at Test Stand IE, approximately 800 feet from Test Stand IC. The outside air intake will be turned off during and immediately after the test so that no outside air enters the control bunker. Self-contained breathing apparatus will be available in the control bunker. HCl atmospheric monitoring inside the control bunker and outside will be used to provide information for the operating crew's safety.

The staff in the control bunker will receive continuous reports on weather conditions from the Edwards AFB meteorologist. If wind patterns shift to a direction that would carry the exhaust plume for the 2-minute tests over an inhabited area, the test will be delayed. Weather criteria for the 2-minute tests are listed in Section 3.2.7.

When all criteria have been met and the test firing commences, the base meteorological and safety staff will provide continuous visual monitoring of the exhaust plume and exhaust cloud. If a significant ground cloud forms near the test stand (this is unlikely, but theoretically possible), this cloud will be monitored carefully to determine where it will be carried by the wind and an assessment made for any additional on-site or off-site safety needs. No one (other than test personnel in the control bunker) will be allowed within the cone-shaped downwind area shown on Figure 3.4 between the test stand area and U.S. Highway 395, for the 2-minute test firings.

In the event of a ground cloud moving to the east, the most likely requirement is that a portion of U.S. Highway 395 would need to be closed because of poor visibility from dust in the exhaust cloud. The CHP and Caltrans will be alerted on the days of the test firings. Since it will take some time (about 30 to 80 minutes) for the exhaust plume to travel to the highway, depending on wind speed, there will be adequate time to coordinate the plume movement with highway authorities. The CHP and Caltrans may wish to close a section of the highway for a few minutes or otherwise alert motorists to the problem.

The runway at Edwards AFB will be closed during the 2-minute test firings. This will prevent air traffic from encountering the exhaust plume.

There are two fixed tanks of hydrazine located about 2,200 feet from Test Stand IC. Liquid hydrazine is an extremely flammable substance that may explode in the heat of a fire. It is a poisonous substance that may be fatal if inhaled, swallowed, or absorbed through the skin. CSD and the USAF are concerned that a shock wave may affect the fixed tanks in the event of a rocket misfire. CSD and the USAF are evaluating the problem and will determine if it will be necessary to transfer the hydrazine from the fixed tanks or protect the tanks from a shock wave.

3.10 SUMMARY OF IMPACTS AND MITIGATION MEASURES

The environmental impacts of the Titan solid propellant rocket motor testing at Edwards AFB are summarized in Table 3.15. Mitigation measures which will reduce the impacts to insignificant levels are also identified in the table.

Table 3.15 Summary of Impacts and Mitigation Measures

Environmental resource	Impacts	Mitigation measures
Geology and soils	No impacts.	None required.
Air quality—2-minute test firings	PM_{10} standard of 50 ug/m^3 is currently exceeded (82 ug/m^3). Rocket tests will add 16 to 23 ug/m^3. Under worst-case conditions of a nonbuoyant exhaust cloud, the PM_{10} concentration could reach 174 ug/m^3 and the TSP concentration could reach 299 ug/m^3.	RPL weather conditions (no thunderstorms within 10 nautical miles, wind speed greater than 5 knots, and no inversions) will be met. In addition, the tests will be conducted only when the wind is blowing from 260 to 310 degrees azimuth. This will prevent the exhaust cloud from blowing over an inhabited area.
	Acidic mist will be created by contact of deluge water with exhaust stream. Mist will settle to the ground in the vicinity of the test site.	Deluge water will be buffered with sodium carbonate to raise pH of mist to about 3.
	Under worst-case conditions of a nonbuoyant exhaust cloud, visibility may be restricted on U.S. Highway 395.	CHP and Caltrans will be notified of tests so that short-term road closure plans and/or signs warning motorists can be prepared.
Air quality—short-burn tests	No significant impact.	None required.
Surface water and groundwater	No discharge to surface waters or groundwater.	Deluge water contained in the channel and basin will be recycled or evaporated.
	Fallout of acidic mist will coat rocks and soil near test site with a small amount of moisture. There will not be sufficient water to create runoff.	pH of mist should be about 3 due to sodium carbonate buffering.
Biota	Acidic mist will not threaten the health of plants or animals in the area.	pH of mist should be about 3 due to sodium carbonate buffering.
Population	No impacts.	None required.
Noise	Noise levels at nearest residential area (96 dB(A)) should not exceed OSHA standard of 115 dB(A).	None required.
	For 2 minutes during each test, outdoor conversations over a wide area will be interrupted. Indoor conversations and other activities will not be disturbed.	Highway signs will alert motorists to test firing noise.
	Potential high noise levels in RPL area with rocket failure event.	Evacuate RPL area within 1 mile of test stand. Between 1 and 3 miles of test stand, personnel will stay inside buildings during the tests.
Archaeology and cultural resources	No impacts.	None required.
Safety	Possible failure of rocket motors during firing.	All regulatory agencies' safety procedures will be followed. Safety monitoring will be conducted during tests. Telephone hotline. Fire and medical personnel available. Clear zone of at least 1,250 feet will be established. Roads will be closed in clear zone. Essential test personnel will be located in protected concrete bunker.
	Possible effect from rocket failure on liquid hydrazine tanks near test site. Potential release of toxic gas.	Fixed tanks are under investigation by RPL and CSD to define necessary safeguards.

4.0 REGULATORY REVIEW

4.1 AIR QUALITY

Air emissions within Kern County are regulated by the Kern County Air Pollution Control District (APCD). Any person or organization proposing to construct, modify, or operate a facility or equipment that may emit pollutants from a stationary source into the atmosphere must first obtain an Authority to Construct from the APCD. The APCD issues permits and monitors new and modified sources of air pollution to ensure conformance with national, state, and local standards for air quality and to ensure that emissions from such sources will not interfere with the attainment and maintenance of air quality standards.

The APCD determines which emission sources and levels have an insignificant impact on air quality and, therefore, are exempt from permit requirements. Under Rule 202.1, the APCD also exempts experimental research operations from permit requirements if the following requirements are met. Failure to satisfy these requirements will result in the revocation of an exemption and require compliance with other APCD requirements.

1. The purpose of the operation is to permit investigation, experimentation or research to advance the state of knowledge or the state of art of a particular control technology or industrial process.

2. The APCD Control Officer is notified, in writing, of the purpose, goals, and objectives of the project, measures to be taken to minimize the emission of air contaminants, the proposed installation date, the planned start-up date, the expected duration of the test, and test schedules.

3. The cumulative total days of operation will not exceed 180. If the applicant intends to continue operation of the technology or process for more than 180 days, a compliance schedule for obtaining necessary permits is required.

4. Official test results (if the project involves air pollution control devices) are submitted to the APCD, in writing and in final form, no more than sixty (60) days after each test sequence is complete.

5. The APCD Control Officer has granted prior written approval.

The U.S. Air Force (USAF) has been granted a research exemption from the permit requirements under Kern County APCD Rule 202.1 for the testing of Titan solid propellant rocket motors at Edwards Air Force Base (AFB). The rocket motor testing program meets the requirements listed above. Although relatively large quantities of pollutants will be emitted during each test, the tests will be of short duration, and the tests will be scheduled to take place during optimal meteorological conditions to maximize dispersion and minimize the impacts of the testing on downwind air quality. Specific mitigation measures are identified in Section 3.2.7. Appendix C contains the research exemption.

4.2 WATER QUALITY

In the Edwards AFB area, the California Regional Water Quality Control Board, Lahontan Region (Regional Board), issues National Pollutant Discharge Elimination System (NPDES) permits for discharges of wastes to surface waters and waste discharge requirements for discharges of wastes that may affect groundwater quality. A report of waste discharge, describing the project, was submitted to the Regional Board in the fall of 1986. The Regional Board determined that there would be no discharge to surface waters or groundwater so the testing program was exempted from an NPDES permit and waste discharge requirements. Appendix B contains the Regional Board's waiver.

4.3 ENDANGERED SPECIES

The Federal Endangered Species Act of 1973, as amended, (the Act) extends legal protection to plants and animals listed as endangered or threatened by the U.S. Fish and Wildlife Service (USFWS). The Act authorizes the USFWS to review proposed federal actions to assess potential impacts on listed species. In addition to species listed by the USFWS, the California Department of Fish and Game (DFG) protects species listed as threatened and endangered under the California Rare and Endangered Species Act. USAF Regulation 126-1, Conservation and Management of Natural Resources, Chapter 5, paragraph 12, dated March 20, 1984, states that species proposed for or under review for proposed listing should be considered in environmental planning and be provided protection when feasible. Candidate species fall in this category. While the USAF is not obligated by the federal or state Endangered Species Acts to protect state-listed species, it is USAF policy to work cooperatively with DFG to protect state-listed species.

As described in Section 3.4, the testing of Titan solid propellant rocket motors at Edwards AFB will not significantly affect any federal- or state-listed species. The USFWS and the DFG will review this Environmental Assessment (EA).

4.4 SOLID AND HAZARDOUS WASTES

The State Water Resources Control Board (State Board) and the Regional Board, together with the California Waste Management Board (CWMB), are the principal state agencies responsible for nonhazardous solid waste management in the Edwards AFB area. The State Board and Regional Board are responsible for regulating the types of solid waste that can be received at landfills for the purpose of protecting surface water and groundwater resources. The State Board establishes the minimum standards for landfill siting, construction, and closure, while the CWMB is primarily concerned with minimum landfill operating standards. The Kern County environmental health agency acts as the local enforcement agency for the CWMB. The California Department of Health Services (DHS) regulates the storage, treatment, and disposal of hazardous wastes.

As described in Section 3.3, the testing of Titan rocket motors at Edwards AFB will not generate hazardous wastes. The sludge produced by the water recycling system will be chemically analyzed and disposed in accordance with all federal, state, and local regulations and policies. This sludge is not expected to be hazardous.

4.5 HISTORIC AND CULTURAL PRESERVATION

The National Historic Preservation Act requires that the USAF assess the impact of the project on properties included in, or eligible for, the National Register of Historic Places. The purpose of this is to ensure that an adequate evaluation of potential conflicts with archaeological and historic sites is completed and that appropriate mitigation measures are implemented. A field survey is required to assess the impact of each project at Edwards AFB on these cultural and historic resources.

An evaluation has been completed for the Titan rocket testing at RPL and supports a "No Effect" determination. A report on the cultural and historic impacts of this project will be coordinated with the California State Historic Preservation Office in January 1987.

4.6 TRANSPORTATION AND SAFETY REGULATIONS

There are many regulations, guidelines, and criteria issued by several agencies which pertain to the transportation, handling, and firing of solid propellant rocket motors. The Titan propellant is a Class 1.3 propellant (U.S. Department of Defense (DOD) classification). Several safety regulations evolve from this classification to ensure that the risks of fire and other accidents are minimized or eliminated. Agencies which have pertinent regulations include the following:

1. California Department of Health and Safety (Cal OSHA) (safety and working place regulations).

2. California Highway Patrol (transport of hazardous cargoes).

3. DOD (explosive safety standards and transportation regulations).

4. U.S. Department of Transportation (transportation regulations).

In addition, CSD has its own set of standards and criteria for handling its rocket motors. These standards and criteria supplement regulatory agency controls.

4.7 NOISE STANDARDS

The Occupational Safety and Health Administration (OSHA) has established an upper limit of 115 dB(A) as the highest allowable noise level in the workplace. A criterion used by the National Aeronautics and Space Administration and the USAF for uncontrolled populations is that the overall noise level not exceed 120 dB (McClellan, 1968). These levels are not expected to be exceeded in areas off of Edwards AFB.

The Kern County Noise Element of the County General Plan uses noise criteria associated with relatively continuous noise environments. These criteria are not suitable for short-term events such as rocket tests, although technically, the Titan test firing noise will comply with the County Noise Element criteria.

5.0 LIST OF AGENCIES AND INDIVIDUALS CONTACTED

The following individuals were contacted during the preparation of the EA.

U.S. Air Force
- Capt. Emil Barchichat SD/YXT
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APPENDIX A

REPRESENTATIVE AMBIENT AIR QUALITY

APPENDIX A

REPRESENTATIVE AMBIENT AIR QUALITY

Ambient air quality monitoring data for the closest desert stations during the period 1980 through 1985 were used to estimate the ambient air quality at the Rocket Propulsion Laboratory (RPL). A summary of the seasonal peak concentrations for O_3, NO_2, TSP, and PM_{10} are shown in Table A-1.

The monitoring stations are located at Lancaster (O_3, NO_2, and TSP), Barstow (TSP and PM_{10}), and Mojave (PM_{10}). The locations of RPL and the monitoring stations are shown on Figure A-1.

Ozone

The ozone concentrations tend to decrease from 1980 through 1985. The peak hourly concentration is 0.29 parts per million (ppm) for the spring of 1980. The peak hourly concentration for 1985 was 0.19 ppm and occurred in the fall. The peak 1985 concentration of 0.19 ppm was used as the representative peak ozone concentration at RPL.

Nitrogen Dioxide

The maximum hourly concentration of 0.22 ppm occurred in the fall of 1981. This value appears to be an outlier, the next highest peak value is 0.11 ppm. The 0.11 ppm concentration was used as the representative peak NO_2 concentration.

Total Suspended Particulates

For TSP, the second highest seasonal peak concentration for each season was considered as the representative ambient air quality peak. The second highest seasonal peak concentration occurs at Boron (385 ug/m^3) for the fall of 1980. The second highest seasonal peak occurred at Lancaster (176 ug/m^3) in the fall of 1980. The 385 ug/m^3 concentration appears to be an outlier, and the 176 ug/m^3 concentration was used as the representative peak ambient air concentration for RPL.

Particulate Matter Less Than 10 Microns (PM_{10})

PM_{10} data have been monitored only since late 1984. The second highest seasonal concentration for Barstow is 54 ug/m^3. The second highest peak for Mojave is 82 ug/m^3. The monitoring of PM_{10} data is

Table A-1. Ambient Air Quality Summary

Station: Lancaster

Pollutant: Ozone, parts per million (ppm)

Seasonal concentrations	1980[a]	1981	1982	1983	1984	1985
Winter, peak hour[b]	0.11	0.14	0.12	0.08	0.10	0.13
Spring, peak hour[c]	0.29	0.20	0.15	0.16	0.18	0.18
Summer, peak hour[d]	0.25	0.21	0.16	0.18	0.17	0.19
Fall, peak hour[e]	0.14	0.14	01.4	0.08	0.14	0.13
Annual geometric mean	0.041	0.048	0.036	0.037	0.039	0.040

Pollutant: Nitrogen Dioxide, ppm

Seasonal concentrations	1980a	1981	1982	1983	1984	1985
Winter, peak hour	0.07	0.08	0.08	0.09	0.09	0.07
Spring, peak hour	0.06	0.06	0.07	0.07	0.11	0.07
Summer, peak hour	0.09	0.07	0.07	0.08	0.07	0.08
Fall, peak hour	0.08	0.22	0.08	0.09	0.11	0.08
Average geometric mean	0.012	0.012	0.012	0.015	0.018	0.015

Pollutant: Total Suspended Particulates, micrograms per cubic meter (ug/m^3)

Station: Lancaster

	1980	1981	1982	1983	1984	1985
Winter						
Peak	156	105	76	98	114	72
Second peak	138	91	62	90	109	66
Spring						
Peak	164	132	113	129	180	316
Second peak	123	125	91	120	163	131
Summer						
Peak	244	112	93	99	112	134
Second peak	148	110	81	89	91	129
Fall						
Peak	295	110	95	177	135	116
Second peak	176	99	94	78	132	100
Annual geometric mean	93.0	68.0	53.4	53.5	72.9	70.6

Station: Boron

	1980	1981	1982	1983	1984	1985
Winter						
Peak	81	129	107	63	99	98
Second peak	77	88	51	60	92	64
Spring						
Peak	113	127	113	170	130	199
Second peak	88	80	99	132	121	125
Summer						
Peak	426	110	140	79	117	109
Second peak	289	91	93	75	69	84
Fall						
Peak	419	66	69	107	129	109
Second peak	385	57	69	94	72	85
Average geometric mean	73.2	51.8	43.0	45.3	59.3	54.5

Pollutant: Particulate Matter Less Than 10 Microns, ug/m^3

Station: Barstow

	1980	1981	1982	1983	1984	1985
Winter						
Peak	N/D[f]	N/D	N/D	N/D	N/D	N/D
Second peak	N/D	N/D	N/D	N/D	N/D	N/D
Spring						
Peak	N/D	N/D	N/D	N/D	N/D	N/D
Second peak	N/D	N/D	N/D	N/D	N/D	N/D
Summer[g]						
Peak	N/D	N/D	N/D	N/D	N/D	43
Second peak	N/D	N/D	N/D	N/D	N/D	35
Fall						
Peak	N/D	N/D	N/D	N/D	N/D	89
Second peak	N/D	N/D	N/D	N/D	N/D	54
Annual geometric mean	N/D	N/D	N/D	N/D	N/D	38[h]

Station: Mojave

	1980	1981	1982	1983	1984	1985
Winter						
Peak	N/D	N/D	N/D	N/D	N/D	N/D
Second peak	N/D	N/D	N/D	N/D	N/D	N/D
Spring						
Peak	N/D	N/D	N/D	N/D	N/D	N/D
Second peak	N/D	N/D	N/D	N/D	N/D	N/D
Summer						
Peak	N/D	N/D	N/D	N/D	N/D	108
Second peak	N/D	N/D	N/D	N/D	N/D	82
Fall						
Peak	N/D	N/D	N/D	N/D	N/D	56
Second peak	N/D	N/D	N/D	N/D	N/D	49
Average geometric mean	N/D	N/D	N/D	N/D	N/D	59.9[h]

Source: California Air Resources Board, Air Quality Data 1980 through 1985.

[a]Reported as oxidant and ozone.
[b]January through March.
[c]April through June.
[d]July through September.
[e]October through December.
[f]No data available.
[g]Two measurements were reported for the time period.
[h]Data presented are valid, but incomplete in that an insufficient number of valid data points were collected to meet EPA and/or ARB criteria for representativeness.
[i]Not applicable.

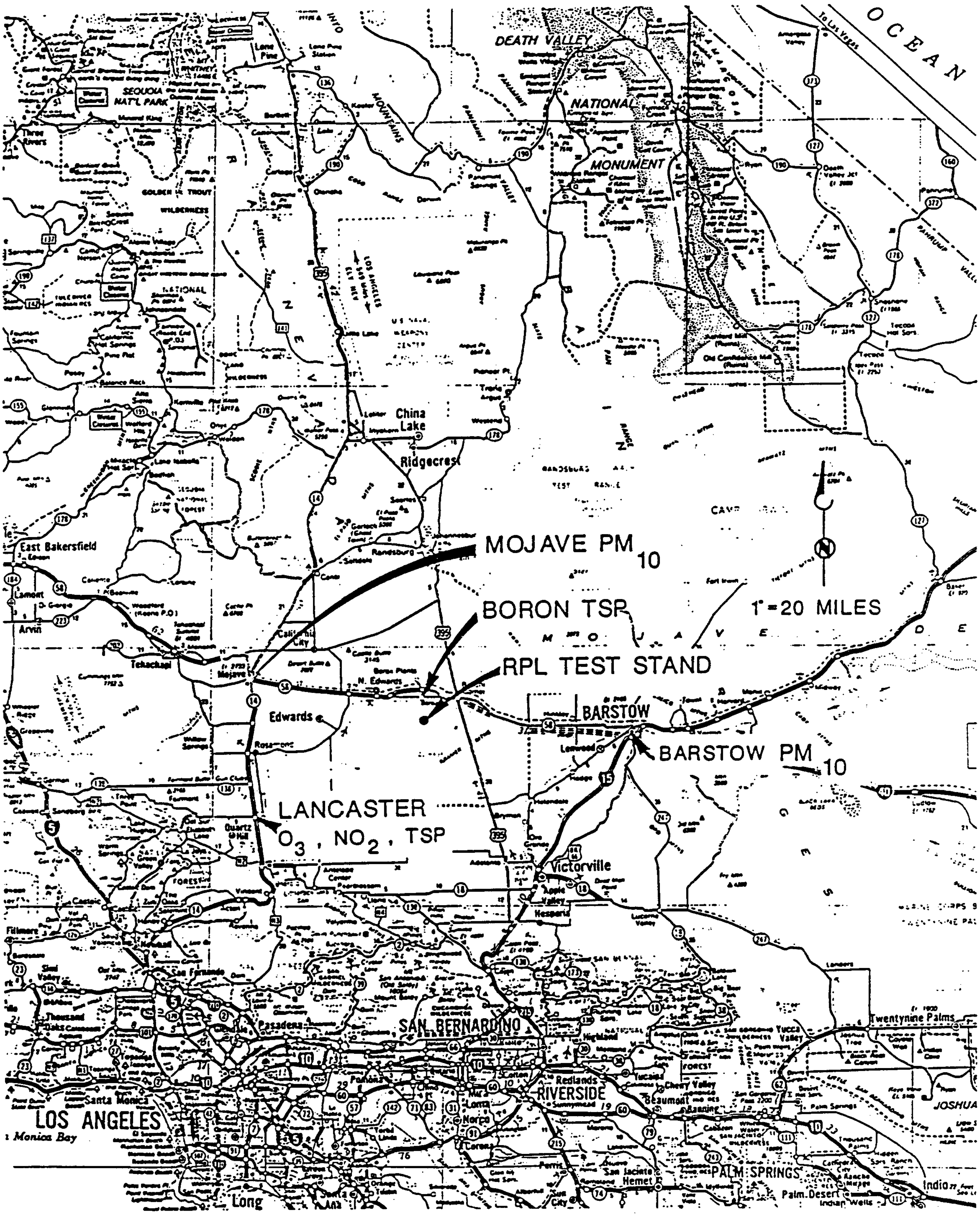

Figure A-1. Location of Ambient Air Monitoring Stations recent, and the amount of recorded data are small with a high variance. A concentration of 82 ug/m^3 was selected as a representative peak PM_{10} ambient air concentration for RPL.

Carbon Monoxide (CO)

Since the impacts due to increased concentrations of CO are negligible, the peak 1985 concentration of 12.0 ppm was used.

APPENDIX B

WAIVER OF WASTE DISCHARGE REQUIREMENTS

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD,
LAHONTAN REGION

STATE OF CALIFORNIA—THE RESOURCES AGENCY

GEORGE DEUKMEJIAN, *Governor*

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD—
LAHONTAN REGION
?92 LAKE TAHOE BOULEVARD
P.O. BOX 9428
SOUTH LAKE TAHOE, CALIFORNIA 95731-2428

December 8, 1986

Robert Wood, Acting Chief
Office of Environmental Planning, Management, and Compliance
AFFTC/CVE
Edwards AFB, CA 93523

WAIVER OF WASTE DISCHARGE REQUIREMENTS FOR TITAN ROCKET MOTOR TEST, EDWARDS AFB ROCKET PROPULSION LABORATORY

Dear Mr. Wood:

On November 17, 1986, additional information was submitted to the Regional Board by Thomas Troyer, AFRPL Environmental Coordinator, as part of the report waste discharge for the planned Titan Rocket Motor tests, which will be conducted at the Edwards AFB Rocket Propulsion Laboratory (RPL). Information, regarding this project was previously submitted by your office on October 29, 1986.

The information submitted indicates that approximately 500,000 gallons of cooling water will be generated during each of the three Titan Rocket Motor tests which are proposed to be conducted in 1987. It is our understanding that cooling water for the tests will be chemically conditioned in existing concrete lined channels at the RPL. Once chemically treated to adjust the pH, the cooling water will be stored or evaporated in an above ground storage tank. We have reviewed the report of waste discharge for this project and have concluded that a waiver of waste discharge requirements would not be against the public interest because of (1) the limited nature of the tests; (2) the wastes will be chemically conditioned to adjust the pH; and (3) the expected concentrations of heavy metals appear to be below levels that would constitute a significant potential threat to water quality. Therefore, pursuant to Section 13269 of the California Water Code, we are waiving waste discharge requirements for the three proposed Titan Rocket Motor test. It should be understood that this waiver will be revoked for failure to adhere to the following condition:

> The Titan Rocket Motor tests are conducted as described in the report of waste discharge.

If you should have any questions concerning this matter, please contact Tracie Billington or Eric Hong in our Victorville office at (619) 245-6583.

Yours truly,

O. R. BUTTERFIELD
EXECUTIVE OFFICER

Robert S. Dodds
Supervising Engineer

cc: Regional Board Members
Thomas G. Troyer/AFRPL-SEH, Edwards AFB
Cheryl Vinson/United Technologies
Perry Schafer/Brown & Caldwell

APPENDIX C

KERN COUNTY AIR POLLUTION CONTROL DISTRICT
RESEARCH EXEMPTION

KERN COUNTY AIR POLLUTION CONTROL DISTRICT

1601 "H" Street, Suite 250
Bakersfield, California-93301
Telephone (805) 861-3682

LEON M HEBERTSON, M.D
Director of Public Health
Air Pollution Control Officer

Date: 18 December 86

Cheryl R. Vinson
Environmental Engineer
United Technologies
& Chemical Systems
P.O. Box 50015
San Jose, CA
95150-0015

Dear ~~Mrs~~ Ms. Vinson:

Thank you for your recent letter in which you requested that the project described as static testing of Titan booster rocket engine

be exampted, pursuant to Rules 202.1 and 426 of the KCAPCD Rules and Regulations, from the requirements of Regulations II and IV (except Rule 419).

A review of your exemption application has revealed that you have provided the following information:

- x Statement of the project's goal.
- x Description of measures to be taken to minimize emissions.
- x Proposed installation date, planned startup date.
- x Expected duration of project.
- x Expected air contaminants emissions testing schedule.

Because you x have ___ have not fulfilled the requirements of Rule 202.1, the District x hereby grants an exemption for this project ___ requests that you provide the remaining information.

Please be aware that if you have been granted an exemption, you must provide this office with the following to retain it:

a. Official air pollutant test results no more than 60 days after the completion of each test sequence.
b. Running record of days of operation submitted monthly beginning one month after startup.

Thank you for your cooperation. Should you have any questions please telephone the Air Quality Control Division at (805) 861-3682.

Sincerely,

LEON M. HEBERTSON, M.D., A.P.C.O.

Thomas Paxson, P.E., A.S.E. III