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SURVEY AND EVALUATION OF THE ENVIRONMENTAL IMPACT OF NAVAL WEAPONS CENTER ACTIVITIES

James R. Quimette

Naval Weapons Center
China Lake, California

June 1974

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FOREWORD

The requirement for this report originated from early 1972 meetings of the Naval Weapons Center (NWC) Ad Hoc Environmental Quality Management Committee held in response to Navy implementation of the National Environmental Policy Act of 1969. As conceptualized by the Ad Hoc Committee, the report attempts to systematically describe the cumulative environmental impact of day-to-day activities at NWC, a major Navy research, development, test, and evaluation facility. In large part, this report is a compilation of existing data generated by NWC scientists, other government agencies, and universities. Previously unpublished data generated specifically for this study are also included.

This report was written during fiscal year 1973 whenever operational duties would permit. Parts were subsequently updated under final review in fiscal year 1974. Work on the study was financed by NWC overhead funds as one of the functions of the NWC Environmental Engineering Office.

This preliminary report is released at the working level. It is being released in preliminary form to make the information it presents available at this time. The conclusions presented are subject to revision at a later date because of the continuing nature of environmental impact.

Released by
W. N. SORBO, *Head*
Engineering Division
23 April 1974

Under authority of
CAPTAIN W. H. STURMAN, *Head*
Public Works Department

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(U) *Survey and Evaluation of the Environmental Impact of Naval Weapons Center Activities*, by James R. Ouimette. China Lake, Calif., Naval Weapons Center, June 1974. 248 pp. (NWC TM 2426, publication UNCLASSIFIED.)

(U) The report attempts to determine what cumulative effect a major Navy base and its associated community has had on a large land area in the fragile desert biome. The study is not an environmental impact statement, it is not submitted to present the anticipated impact of any particular proposed action, but to estimate the impact of all current day-to-day actions at the Naval Weapons Center (NWC), China Lake, California. It is designed to collect the required information into a package that can serve several functions: to provide source material for preparation of future environmental impact statements on specific projects at NWC; to provide baseline levels at NWC of critical environmental indicators; and to offer a methodology for evaluating environmental impact that can be used by other facilities and agencies. The report's three major sections give (1) a description of the environmental setting, consisting of background data on abiotic, biotic, and socioeconomic systems; (2) an inventory of residuals generated at NWC, broken down categorically into those that affect air, water, noise, and land quality, climate, depletion of resources, and other public health factors; and (3) the methodology used to evaluate environmental impact on the ecosystem receptors in the NWC vicinity.

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INTRODUCTION

A growing number of federal laws require all federal activities to be cognizant of the environmental consequences of their operations. In addition to the requirement of environmental impact statements for many future projects, implicit in the National Environmental Policy Act (NEPA), is the necessity to assess the effects of day-to-day activities. Other pollution-control legislation, such as the Clean Air Act and the Federal Water Pollution Control Act, requires that federal activities have an inventory of those pollution-causing activities.

In response to the spirit and the letter of the laws, this *Survey and Evaluation of the Environmental Impact of Naval Weapons Center Activities* has been prepared. This is an environmental impact statement whose purpose and scope differ from those usually submitted. It is not submitted to present the anticipated impact of any proposed action, but to estimate the impact of all current day-to-day actions. It is a systematic attempt to determine what cumulative effect a major Navy base and its associated community has had on a large land area in the fragile desert biome. This land, the size of the State of Delaware, had been only sporadically occupied by man prior to World War II; its dynamic natural processes had been effectively undisturbed until 30 years ago.

This organic environmental impact statement is designed to collect the required information into a package that can serve several important uses:

1. as source material for preparation of future environmental impact statements on specific projects;

2. to provide baseline levels of critical environmental indicators;

3. as an inventory for information on subjects of environmental concern.

The scope of this effort attempts to encompass those operations of NWC which are continuous in nature and for which little change is foreseen in future activity. Although this is not true for specific projects, the summation of all ordnance ground testing, for example, has changed little in the past few years. It is assumed the level of overall activity changes slowly enough so one could predict with reasonable accuracy future levels using 1972-73 as baseline. No one-time operations are explicitly assessed in this report although, in the case of NWC tests, they would have been part of a total sum. New future projects are not assessed in this report. The effect of NWC "products" in war, such as the use of NWC-developed missiles in Southeast Asia, does not lie within the scope of this work. Classified operations are not specifically addressed.

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Their generated residuals are summed into an inventory which has meaningful information content, but retains project confidentiality or secrecy.

The conceptual model of the NWC Omnibus EIS has developed as a subsystem of the generalized residuals environmental quality management system model[1] shown in Figure 1. As noted, the system is divided into two subsystems, with the ecosystem receptors acting as an interface between them. The subsystem that concerns this report is the "economic-technologic-ecologic subsystem" shown in expanded form in Figure 2. In Figure 2, the ecosystem receptors have been renamed.[2]

The format for this report was developed from the final EIS for the Trans-Alaska pipeline, one of the most comprehensive statements prepared to date.[3] As shown in Figure 3, one starts with a description of the environmental setting consisting of background data on abiotic systems (hydrology, geology, meteorology), biotic systems (plants, animals), and our superimposed socioeconomic systems (land use, demography, etc.). As a second major input, one provides an inventory of processes and residuals generated at NWC broken down categorically into those that affect air, water, noise, and land quality, climate, depletion of resources, and other public health factors.

The two environmental setting and inventory inputs are then used with the methodology for environmental impact analysis to determine an evaluation of environmental impact. Where standards and criteria exist, such as for maximum allowable limits for air, water and noise pollution, they have been used to create evaluations of environmental impact in the following range:

1	2	3	4	5
insignificant	low	moderate	large	

The scale is generally not linear; that is, twice a given level of an air pollutant does not necessarily generate twice the impact. Where standards and criteria do not exist, such as for "land pollution" and "visual pollution" resulting from roads, debris, and scarring from explosive testing, the appraisal is admittedly subjective. In these cases, the natural states of the abiotic and biotic ecosystems receptors are used as a basis of comparison. In this way, non-quantifiable aspects are considered, since the spectrum of environmental impact encompasses both the measurable and the intangible, as does the elusive abstraction we term "quality of life."

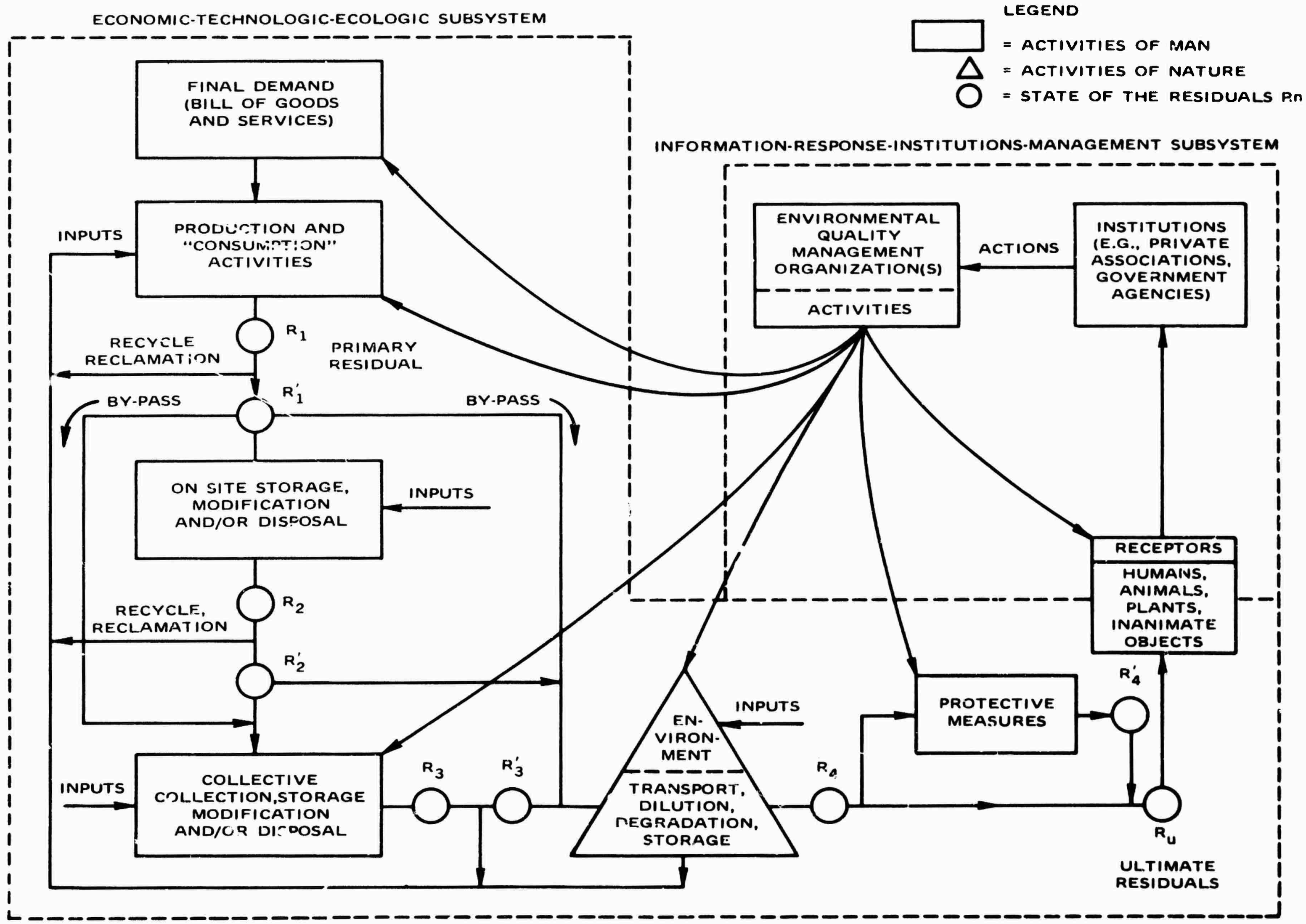

FIGURE 1. Generalized Conception of Residuals Environmental Quality Management System. Reprinted with permission from 10 Natural Resources Journal, p. 658 (1970).[1] Published by the University of New Mexico School of Law, Albuquerque, New Mexico.

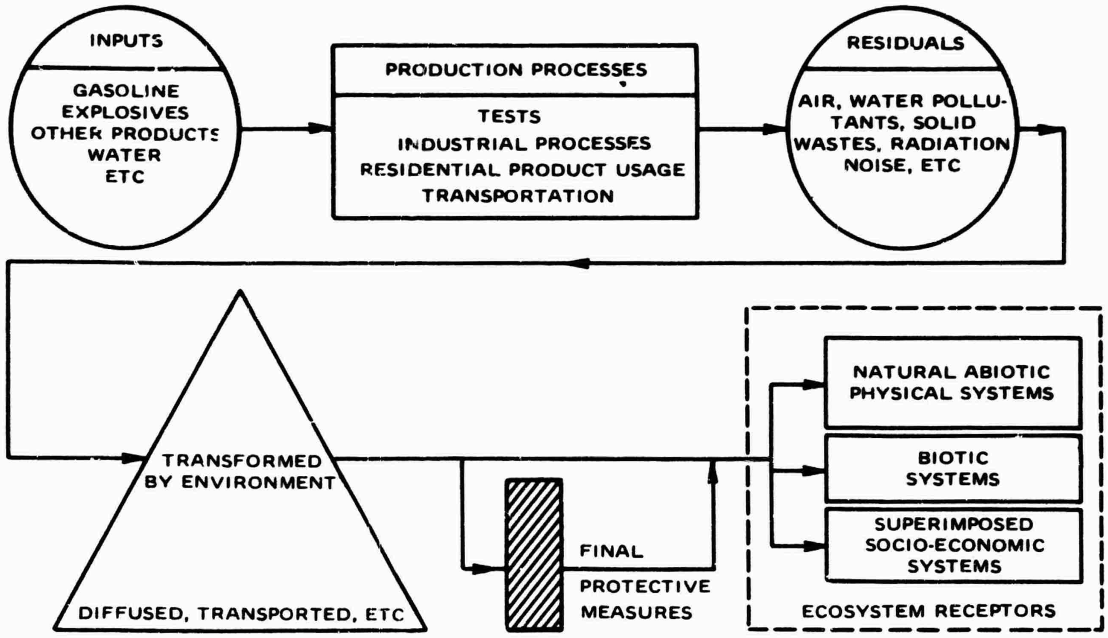

FIGURE 2. Summarized Environmental Impact Process.

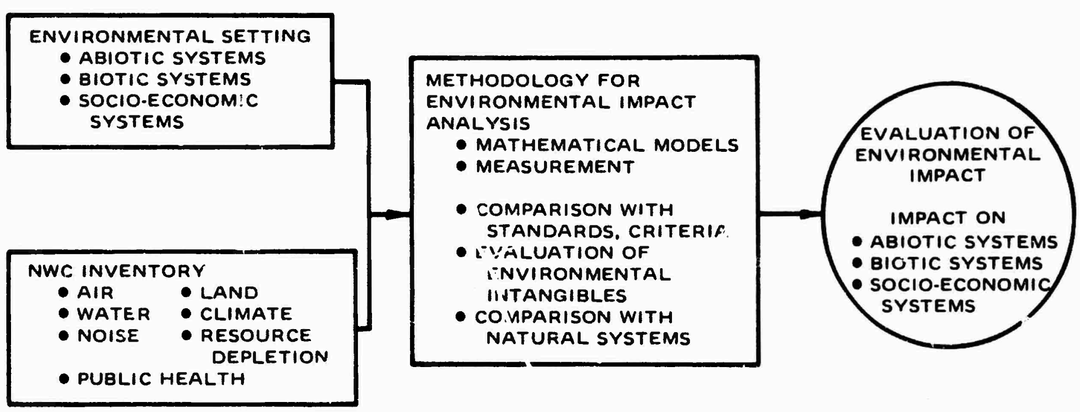

FIGURE 3. Format for Environmental Impact Evaluation of the Naval Weapons Center.

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3. Naval Facilities Engineering Command, 1970. Environmental Impact Statement Handbook. NAVFAC Misc.-EISH-70-11. 35 p.

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SUMMARY, HISTORY OF THE NAVAL WEAPONS CENTER

MISSION AND FUNCTIONS

The current mission of NWC is "to be the principal Navy RDT&E Center for air warfare and missile weapon systems." That mission is stated in NAVMATINST 5450.27 of 27 June 1972, which further defines the Center's functions: to "establish and maintain the primary (although not necessarily exclusive) in-house research and development capability for the following Navy and Marine Corps systems, subsystems and technologies:

- Strike aircraft/weapon systems and concept development
  - Aircraft/weapon simulation
  - Survivability analysis and test
- Air-launched weapons and associated avionics systems
  - Aircraft guns and ammunition
  - Guided and unguided weapons
  - Aircraft weapons control and aircraft/weapons interface
  - Air weapon system simulation and effectiveness evaluation
- Tactical missiles
  - Anti-ship cruise missiles
  - Point defense missiles
- Subsystems for weapon systems defined above
  - Propulsion
  - Guidance and control
  - Warheads
  - Fuzes
  - Launchers, handling equipment
- Strike warfare countermeasures
- Weather modification."

The scope of work entailed by these functions is exemplified further by the *Installation Survey Report, Naval Weapons Center*,[1] prepared for the Office of the Naval Inspector General, under the provisions of Executive Order 11508, by an installation survey team that convened at the Center on 3 through 6 October 1972:

Section VII, part of a Statement of Permanency signed by the Secretary of the Navy on 21 July 1971, states:

> *The Naval Weapons Center is a primary research, development, test, and evaluation activity of the Department of the Navy and is the principal Navy installation involved in the development of Air Weapons Systems and new ideas in related fields of science and technology. It is considered by the Secretary of the Navy to be a permanent installation of the Naval Shore Establishment.*

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DESIGNATION OF NWC LANDS

Two major land areas constitute NWC: The China Lake complex, 605,695 acres, and the Mojave "B"/Randsburg Wash Test Range complex, 487,308 acres. Minor acreages for the Mojave "B"/Randsburg Wash Test Range access road and miscellaneous rights-of-way complete the total of 1,095,926 acres. Figure 4 depicts NWC real estate.

Both the China Lake complex and the Mojave "B"/Randsburg Wash complex are located in the upper Mojave Desert of Southern California. Figure 5 shows the location of NWC in Southern California.

The China Lake complex lies in the counties of Inyo, Kern, and San Bernardino. The Mojave "B"/Randsburg Wash complex is entirely within San Bernardino County. Its eastern perimeter abuts the Fort Irwin Military Reservation, and the northeast corner is one-half mile southwest of Death Valley National Monument.

The NWC headquarters, located at the China Lake complex, is situated 120 air miles northeast of Los Angeles, California, in the extreme northeast corner of Kern County, California. Kern County government offices are located in Bakersfield, California, 80 air miles southwest.

The incorporated City of Ridgecrest, population 12,950 (1 September 1973), adjoins the Center's headquarters area boundaries on the west and south.

Other nearby communities are Inyokern, unincorporated, 10 miles west, population 700; and the Searles Lake communities, 18 miles east. The Searles Lake communities are a series of closely spaced unincorporated company towns that support three chemical companies mining Searles Lake deposits. These are West End, Borosolvay, Argus, and Trona. Their combined population is approximately 3,500.

STATUS AND USE OF LANDS BEFORE NWC USE

China Lake Complex

Prior to installation of a naval activity in the Indian Wells Valley, little use was made of these lands or of the contiguous high desert area. Seasonal livestock grazing, marginal dry farming, and small or individually-operated mines constituted the economy of the area from Mojave to Lone Pine.

During the early years of the twentieth century, temporary settlements flourished, then died, in support of construction work on the Los Angeles aqueduct. Some were merely "rag camps" to provide food and shelter for workmen on the unique engineering project that drains water from the eastern Sierra Nevada and Owens Valley for the City of Los Angeles.

One of the settlements, Inyokern, located on a branch line of the Southern Pacific Railroad, survived completion of the aqueduct construction. From about 1912 to 1942, when a research facility operated by California Institute of Technology came into the Indian Wells Valley, Inyokern was a little-known desert crossroads settlement with a mere handful of permanent residents. Before establishment of NWC in 1942, less than 200 people, engaged in marginal ranching operations, lived in Indian Wells Valley.

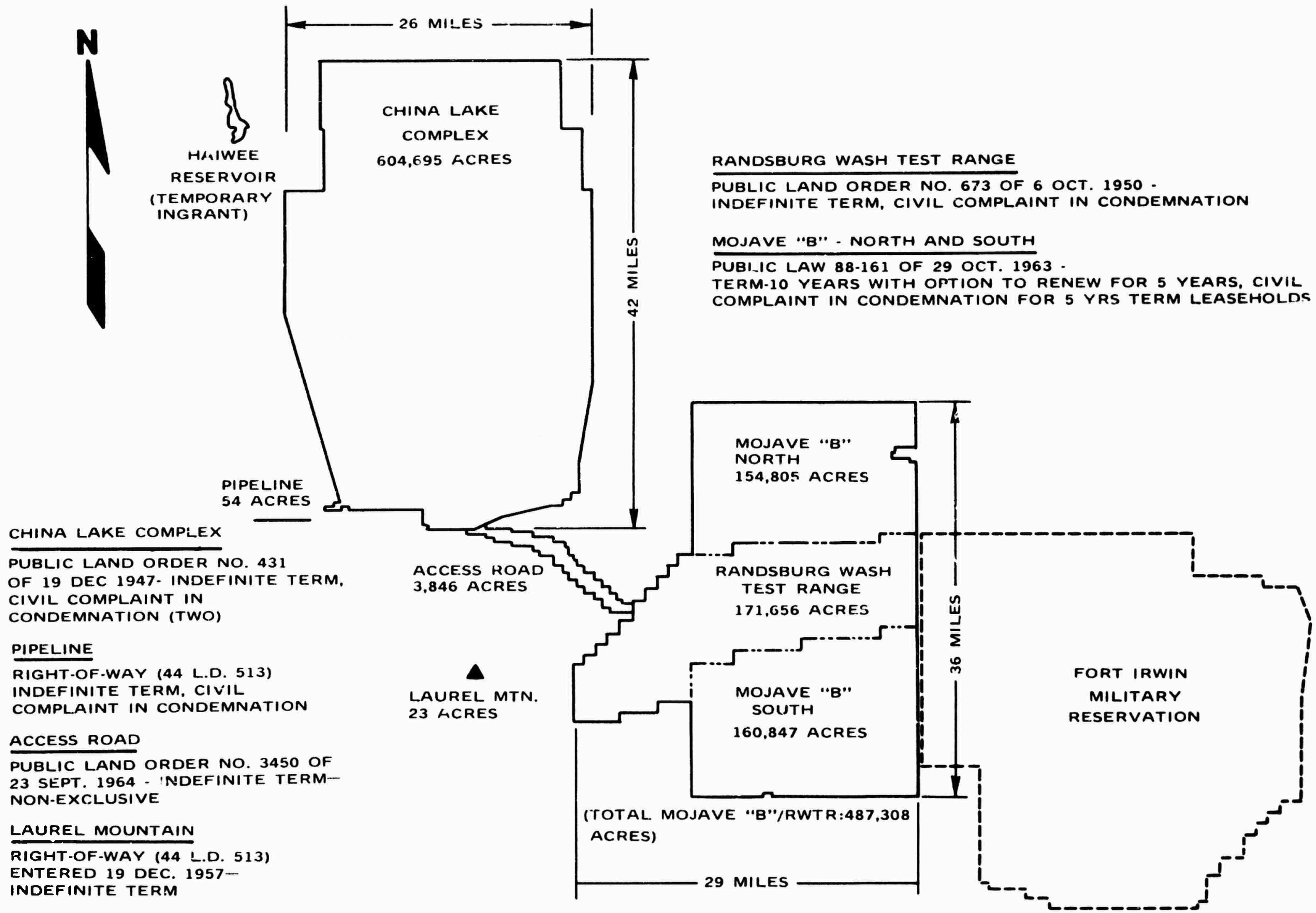

FIGURE 4. Designation of Naval Weapons Center Lands.

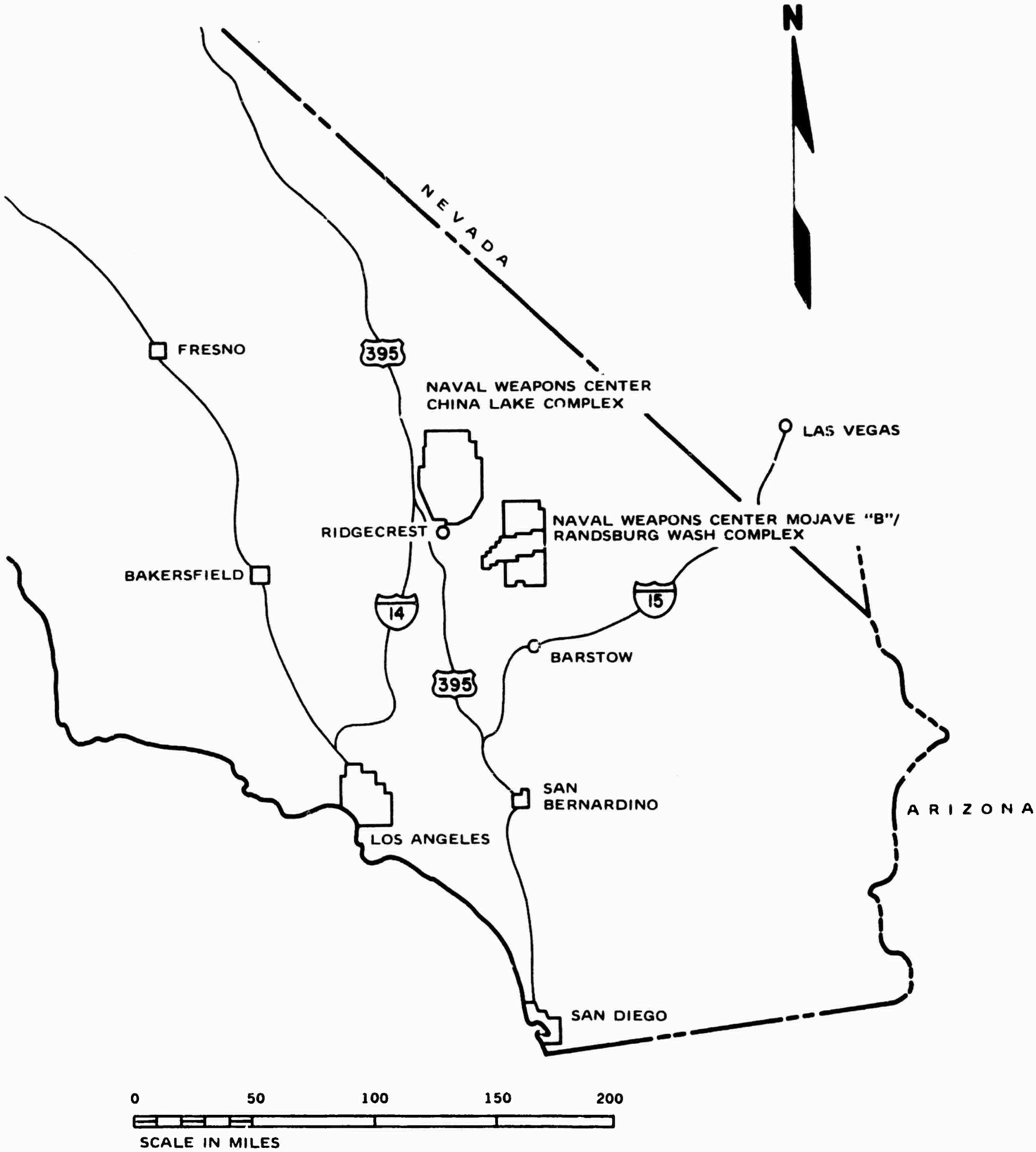

FIGURE 5. Location of the Naval Weapons Center in Southern California.

Purchase prices of real estate in the vicinity resulting from condemnation proceedings in 1949 whereby in addition to withdrawal of Public Lands the Navy in fee acquired scattered parcels of private lands needed to perform its mission reflect the total depression of the area in the early 1940s.

Unimproved land at what is now the intersection of China Lake and Ridgecrest Boulevards sold for $1.30 per acre. The same land, still undeveloped, was sold in 1970 by General Services Administration to a private developer for $6,573 per acre.

Grazing land on the western perimeter of the Center sold, in 1949, for $1.10 per acre. Land in the same region, just outside the NWC boundary, unimproved and without utilities, is today selling for $400 to $600 per acre.

Presence of NWC is directly responsible for current high land values in the immediate vicinity.

Immediately north of NWC are Owens (dry) Lake and the rugged Inyo Mountain Range. East of the Inyo Range is Saline Valley, completely undeveloped, where there is little water or prospect for water development. A salt works was established here during the late 1800s and early 1900s. Despite a large investment in equipment and materials to exploit the surface deposit, full-scale commercial operation of the salt works was never achieved.

Mojave "B"/Randsburg Wash Complex

Mojave "B"/Randsburg Wash areas are desolate stretches of desert, used only by a few prospectors and by freight wagons hauling borax minerals from the surface diggings in Death Valley to the railroad at Mojave.

Except for mining and a little seasonal grazing of domestic stock, this portion of NWC lands has been unoccupied during historic times. A small area in the southern part of Mojave "B" Range produces ephemeral grasses and annuals in years of normal rainfall to support marginal grazing during spring months. A few mines of unproven economic value have been worked sporadically in the Slate Mountains. Water sources are few and such springs as are found with potable water cannot be depended upon for perennial flow.

HISTORICAL SUMMARY

NWC was originally established as the Naval Ordnance Test Station, Inyokern, California, on 8 November 1943. The initial installation had a dual purpose: Its immediate functions were to support rocket development work of the California Institute of Technology for the World War II Office of Scientific Research and Development, to test air-launched rocket weapons, and to furnish primary training in the use of those weapons. Its long-range role was to serve as a nucleus from which to evolve a major postwar research, development, test, and evaluation center for naval weaponry.

Both the immediate and the long-range test and evaluation roles required year-round clear weather and large open spaces found in inland desert environments. During a reconnaissance flight to scout the general area, the Station planners discovered an unused airstrip suitable for immediate use as a temporary base for test and training operations near the small village of Inyokern.

From this beginning, the Station was located on an expanse of uninhabited wasteland that provided the required environmental characteristics. The site chosen was in the Upper Mojave Desert, 120 miles from Los Angeles.

While initial tests and training were being conducted from temporary facilities at the Inyokern airstrip, construction of test ranges and permanent technical installations began in late 1943 on adjacent desert and scrubland. This site was later named the China Lake Test Ranges because of its prominent topographic feature, the large flat playa of an extinct Pleistocene lake.

The first technical facility built at the China Lake site was a propellant processing plant, which was urgently needed for the fabrication of extruded rocket-motor grains. Within a few years several large test ranges, research laboratories, and small highly specialized production plants were added. Among these was the Salt Wells Pilot Plant, which pioneered in the development of chemical high-explosive booster charges for nuclear weapons (1945 to 1954). An 11,063-acre Naval Air Facility became operational in 1946. Michelson Laboratory, a $10-million structure now housing more than $20 million in research and technical equipment, was completed in 1948.

Concurrently, construction of housing for military and civilian personnel of the Station began with the erection of temporary accommodations, which were habitable by January 1944. Over the next few years, these accommodations were rapidly replaced with permanent family residences and bachelor apartments. Because only minimal shopping facilities or cultural amenities existed within 100 miles, the China Lake village was developed as a self-sufficient community complete with schools, shopping center, bank, service station, and cultural, religious, and recreational facilities. This unique Navy-owned and Navy-run civilian community has since evolved into a community of more than 11,000 population.

The technical plant, facilities, and land requirements grew even faster under the dual spur of increasing complexity in weapons and weapon-related work and of a steady expansion in the work scope and functions assigned to the Station. At the end of World War II, the Station took over the rocket development activities of the California Institute of Technology and assumed technical direction over a broad program of weapon research, development, test, and evaluation.

During a reorganization of naval laboratories in 1967, the Station was redesignated as the Naval Weapons Center and its research and development functions were again expanded. By 1972, the Center encompassed more than 1,700 square miles and the approximate "bock value" of its land holdings, facilities, and equipment was

Land	$ 1.9	million
Buildings and improvements	226	million
Scientific equipment and instrumentation	61	million
Industrial production equipment	24	million
	$313	million

Note that these "plant account" figures are not really representative of the true current worth of the Center's holdings, which is probably much closer to the latest estimated replacement costs of more than $1 billion.

Today, NWC is the Navy's largest facility for ordnance research and development.

NOTES

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2. Christman, A. B. 1971. History of the Naval Weapons Center, China Lake, California. Volume I. Sailors, Scientists, and Rockets. Naval History Division, Washington, D.C.

ENVIRONMENTAL SETTING OF THE NWC VICINITY

NATURAL ABIOTIC PHYSICAL SYSTEMS

Geology

The NWC China Lake Test Range complex is located in Kern, Inyo, and San Bernardino Counties. Terrain of this test range complex varies from the eastern extreme of Salt Wells Valley at 1,847 feet msl to the summit of the Argus Range, Maturango Peak, at 8,839 feet msl. The eastern perimeter of the Center is bounded by the crest of the Argus Range. These are typical desert mountains, generally arid and supporting no timber.

The northwest portion of the China Lake Test Range is situated in the Coso Range. These mountains are primarily volcanic in origin, with deeply cut step faults in basalt forming a series of mesas on the western side. The Cosos terminate beyond the northwest corner of the Center. The average elevation is 6,500 feet. Summit of the Cosos is Coso Peak, 8,156 feet msl, where a good stand of pinyon pine and juniper is found. Fresh water springs are few.

Along the western edge of the Cosos, is a geothermal area with active hot springs and live fumaroles. This is the Coso Hot Springs/ Devil's Kitchen region.

The southwest one-quarter of the China Lake Test Range is the major part of the Indian Wells Valley, an area bounded on four sides by mountain ranges--the southern Sierra Nevadas on the west (8,448 feet maximum), the Cosos on the north, the Argus Range on the east, and the El Paso Mountains to the south (5,244 feet maximum). This area is a flood plain with several dry lakes, or playas, located on Center land. The Center is the recipient of the watershed.

Striking physiographic features of the valley boundaries include steep fault scarps along the base of the Sierra Nevada with broad alluvial fans extending from the mouths of the canyons. The fans have coalesced, sloping gradually eastward from the Sierra Nevada toward the playa area along the east side of the valley. Active sand dunes exist northwest of China Lake, the major valley playa.

The Indian Wells Valley basin is filled with interbedded strata of clay, sand, and gravel, with cumulative thickness of as much as 6,000 or 7,000 feet.[1] During three glacial epochs that covered the Sierra Nevadas with snow and ice, sediments were deposited in a large lake occupying the basin. Dry lakes, including China Lake in the Indian Wells Valley, are vestiges of the former large lake.

In the glacial lake, the combination of decaying organic material with lacustrine sediments, resulted in unpotable groundwater with deposition of minerals in the soils that render agriculture, under present technologies, uneconomical and unfeasible. Figure 6 shows the topography of the China Lake complex of NWC.

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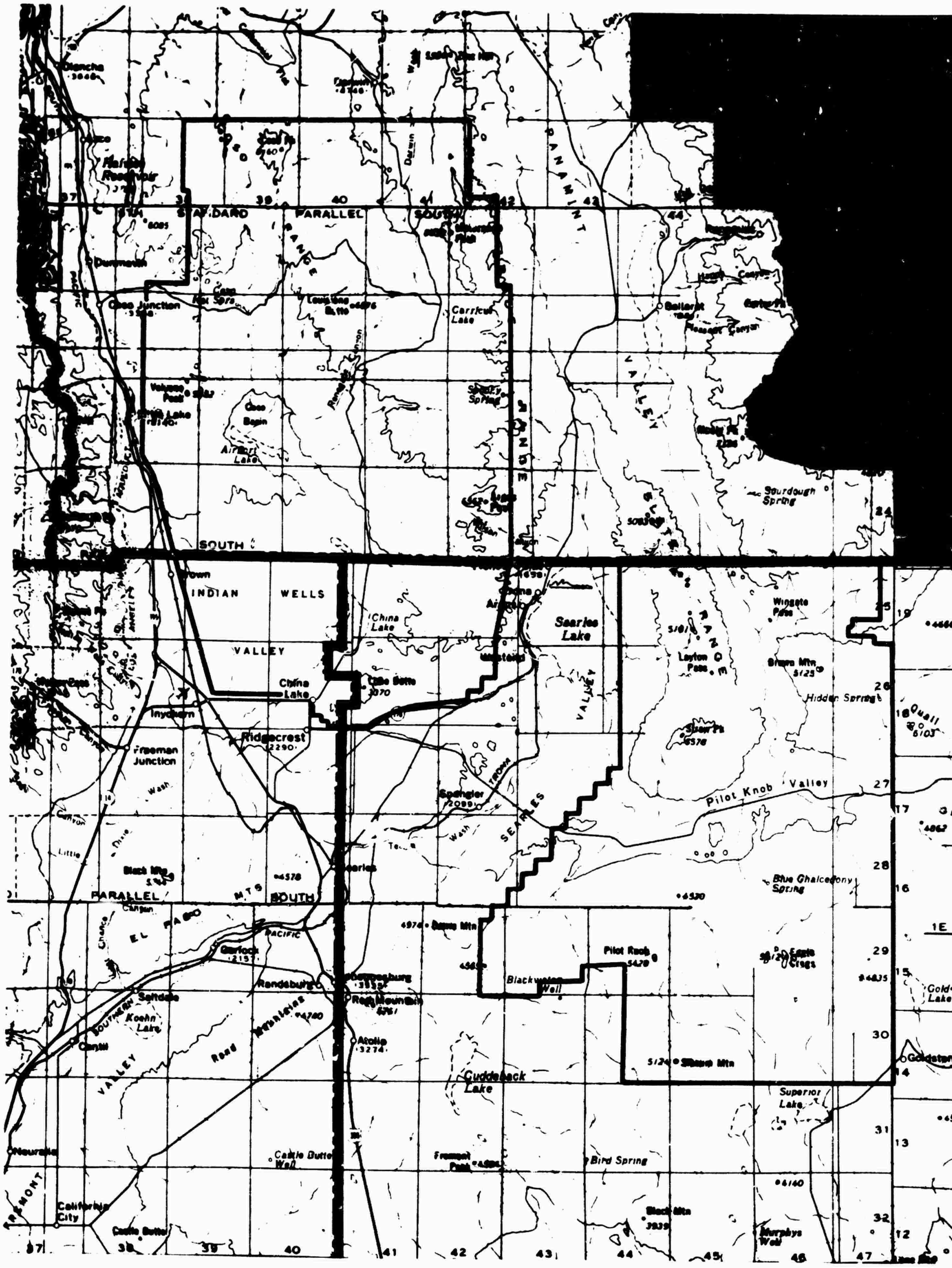


FIGURE 6. Topographic Features of the Naval Weapons Center and Vicinity.

The Randsburg Wash Test Range and the Mojave "B" Aerial Gunnery Ranges are located about 25 miles southeast of China Lake. The southern terminus of the Slate Range is in the northwest portion of this region. This is a dry mountain range averaging about 5,000 feet msl, with its summit at 5,578 feet.

A long trough runs east of the Slates. Elevation of this area within Center boundaries varies from less than 1,400 feet to 2,250 feet msl. Randsburg Wash intersects this narrow valley in an east-west direction. Here again, there is scant vegetative cover. The north-south valley is an extension of Panamint Valley and like the east-west drainage is composed of light friable soils.

The southeast sector of the Mojave "B" area contains a small range of volcanic mountains, the Eagle Crags. These are devoid of vegetation with a few ephemeral springs. Along the southern perimeter of Mojave "B" is a portion of Superior Valley sloping off toward a large dry lake beyond the Center boundary. Figure 6 shows the topography of the Mojave "B"/Randsburg Wash complex at NWC.

NWC lies within an active seismic area. The most severe earthquake occurred approximately 25 miles west of Ridgecrest in the Sierra Nevada with a magnitude of 6.3 (March 1946) on the Richter Scale. Three earthquakes of magnitudes 5.0 to 5.4 have occurred within a 10-mile radius of the community and approximately 20 earthquakes of magnitudes 4.0 to 5.4 have occurred within a 10 to 25 mile radius.[2]

One of California's major east-west trending faults, the Garlock Fault, crosses the Navy's access road to Randsburg Wash and runs the width of these test ranges.

Climate

The climate of NWC and vicinity is marked by aridity, hot summers, cold winters, and prevailing southwest winds. Meigs (1953)[3] gave the Indian Wells Valley an Ac. 14 classification, denoting a climate characterized by aridity, winter precipitation, a mean temperature in the coldest month of 0 to 10°C, and a mean temperature in the warmest month of over 30°C.

Russell (1926)[4] applied a revised Köppen classification of BWh (Hot Desert) to Indian Wells Valley and lower adjacent ranges, denoting a January isotherm greater than 32°F, less than 9.5 inches annual precipitation, and less than 3 months having greater than 100°F mean maximum. The Russell classification specifically differentiates the northern Mojave Desert, of which Indian Wells Valley is a part, from the warmer Coachella and Colorado Deserts to the south. Russell applied a BSk (Cold Steppe) classification to the higher elevations of the Coso and Argus Ranges, denoting a January isotherm of less than 32°F and between 9.5 and 14 inches annual precipitation. However, interpolation of Miller's (1962)[5] data at NWC during January places the 32°F isotherm at 8,500 to 9,000 feet msl, which is higher than virtually the whole Coso and Argus Ranges. In addition, there are no precipitation data to substantiate greater than 9.5 inches per year. Therefore, the BWh classification probably applies to all of NWC.

Weather data[6] collected at the Naval Air Facility (NAF) from 1946 to 1973 are summarized in Table 1. Average annual precipitation is 2.77 inches, prevailing winds are from the southwest at 7.7 mph average, the mean annual maximum temperature is 79.4°F, and the mean annual minimum is 48.5°F. The mean annual temperature is 64.0°F.

Climate of the Mojave "B"/Randsburg Wash portions of NWC is not as well understood as the China Lake portion. Data have been collected by the Jet Propulsion Laboratory (1972)[7] at the Goldstone Echo Site, just east of the NWC boundary. The 1971 rainfall at the site was 2.87 inches, almost exactly the NAF long-term average, but over twice the 1971 NAF total of 1.47 inches. The Goldstone data show a greater proportion of rain during the summer than at NAF. Temperature characteristics seem to be very similar to those of NAF. Russell (1926) applies a BWh classification to the entire Mojave "B"/Randsburg Wash portion of NWC.

Hydrology

Indian Wells Valley. Unconsolidated deposits in Indian Wells Valley are those from which NWC, Inyokern and Ridgecrest, the ranches, and all other groundwater users draw their water. All groundwater in Indian Wells Valley has as its source precipitation that falls within the drainage areas of Indian Wells Valley, Rose Valley, and Coso Basin. This water does not move in a stream or channel, but percolates through pore spaces in water-bearing formations from areas of replenishment toward points of discharge.[8]

There is no evidence of any underground source or movement of water from outside the drainage area considered. A very small quantity of groundwater underflow out of the valley to Salt Wells Valley occurs through a narrow channel, the most recent outlet of Pleistocene China Lake.[9]

In Indian Wells Valley, as in any groundwater basin, all pore space in all the deposits beneath the water table are saturated or full of water. All rocks and deposits do not, however, yield water to wells with the same facility. Consolidated rocks and the volcanic rocks around the margins of, and at depth beneath, the valley are generally of low permeability and do not yield water to wells except for minor quantities in fractures.

Not all the unconsolidated deposits yield water to wells in the same quantity. For example, loose rounded well-sorted gravel or sand yields water more freely to wells than does clay, silt, cemented sand, cemented gravel, or compacted poorly sorted angular material. The yields of wells are roughly proportional to the permeability of the water-bearing deposits.

The total quantity of groundwater available for pumpage from a groundwater basin is dependent on annual recharge, natural discharge, and usable groundwater-storage capacity.

Figure 7 shows steady-state recharge values for the deep aquifer areas.[10] Approximately two-thirds of the total recharge to the deep aquifer originates in the mountainous area southwest of the model area.

TABLE 1. NWC Weather Summary (1946-1973). (28 Years)

Month	Average air density, slugs/ft^3	Station pressure, millibars	Mean max. temperature, °F	Mean min. temperature, °F	Mean temperature, °F	Highest temperature, °F	Date	Lowest temperature, °F	Date	Greatest daily range, °F	Average daily range, °F
Jan	0.00227	939.7	57.1	29.0	43.0	77	23/48 20/71	0	13/63	50	29
Feb	0.00224	938.1	63.8	34.3	49.0	83	27/68 28/72	14	13/48 12/65	50	30
Mar	0.00221	935.5	69.0	39.7	54.4	92	31/66	17	2/71	54	30
Apr	0.00217	934.0	77.2	47.0	62.3	98	1/66	28	9/53 22/63	53	30
May	0.00214	932.4	85.8	55.2	70.5	107	26/51	34	1/67	50	30
Jun	0.00210	931.4	95.2	63.1	79.3	114	22/54 20,21/61	42	10/54	51	32
Jul	0.00207	933.0	102.2	70.0	86.2	116	14,15/72	52	5/64	51	32
Aug	0.00208	933.3	100.6	68.2	84.4	112	10/70 10/71	50	24,29/73	49	32
Sep	0.00211	933.4	93.9	60.2	77.1	110	1,2/50 6/55	39	26/70	52	34
Oct	0.00217	935.8	82.0	48.9	65.5	102	5/64	21	30/71	51	33
Nov	0.00223	938.8	67.8	37.3	52.4	88	1/62	18	20/64	52	31
Dec	0.00227	939.8	58.4	29.4	43.7	86	23/64	2	27/62	51	29
Total	...	...	...	...	...	...	...	...	...	...	...
Avg.	0.00217	935.4	79.4	48.5	64.0	...	...	...	...	...	31
Extreme	...	...	...	...	...	116	7/14,15/72	0	1/13/63	54	...

Month	Total heating degree days	Total cooling degree days	Days min. temperature, 32°F or less	Days max. temperature, 100°F or more	Mean temperature of dew point	Mean relative humidity	Average precipitation	Greatest precipitation in 24 hours	Days with precipitation 0.01 inch or more	Days with thunderstorms	Total snowfall, unmelted	Days with snowfall	Prevailing wind direction	Average hourly speed, MPH	Max. velocity peak gust, MPH	Direction of peak gust	Date	No. days clear[a]	No. days partly cloudy[a]	No. days cloudy[a]	Average cloudiness, %[a]
Jan	676	0	21	0	26	52	0.44	0.91	2	0	1	1	SW	5.7	77	SW	14/50	15	11	5	37
Feb	452	0	11	0	30	47	0.47	1.28	2	0	0	<1	SW	6.9	69	W	22/48	14	10	4	34
Mar	333	0	5	0	30	39	0.21	0.89	1	<1	0	<1	SW	9.1	81	W	19/52	15	12	4	34
Apr	136	2	1	0	34	34	0.15	0.88	1	<1	0	0	SW	9.9	69	N	2/57	16	11	3	31
May	32	32	0	1	37	29	0.03	0.16	1	<1	0	0	SW	9.9	66	SW	23/62	20	9	2	27
Jun	1	168	0	10	40	24	0.02	0.29	<1	<1	0	0	SW	9.1	68	WSW	20/47	25	4	1	15
Jul	0	354	0	23	44	23	0.12	0.87	<1	1	0	0	SW	8.7	66	NW	24/49	24	6	1	16
Aug	0	301	0	20	44	24	0.10	0.75	<1	1	0	0	SSW	8.4	53	ESE	11/53	26	4	1	14
Sep	1	108	0	7	40	26	0.21	0.94	1	<1	0	0	SSW	7.3	60	WSW W	16/46 24/49	25	4	1	13
Oct	77	6	<1	0	34	31	0.09	0.58	1	<1	0	0	SW	6.9	66	NW	23/56	22	8	1	21
Nov	382	0	8	0	30	42	0.50	1.03	2	<1	0	0	SSW	5.7	65	SW	18/50	19	9	2	26
Dec	659	0	22	0	27	52	0.43	1.14	2	0	0	<1	SW	5.3	71	SSW	4/53	16	[illegible]	4	34
Total	2,749	971	68	61	...	...	2.77	...	13	3	1	2	...	...	...	...	...	...	...	...	...
Avg.	...	...	...	...	35	35	...	...	...	...	...	...	SW	7.7	...	...	...	20	8	2	25
Extreme	...	...	...	...	...	...	...	1.28	...	...	...	...	...	...	81	W	3/19/52	...	...	...	...

[a] Cloudiness 1946 through 1964.

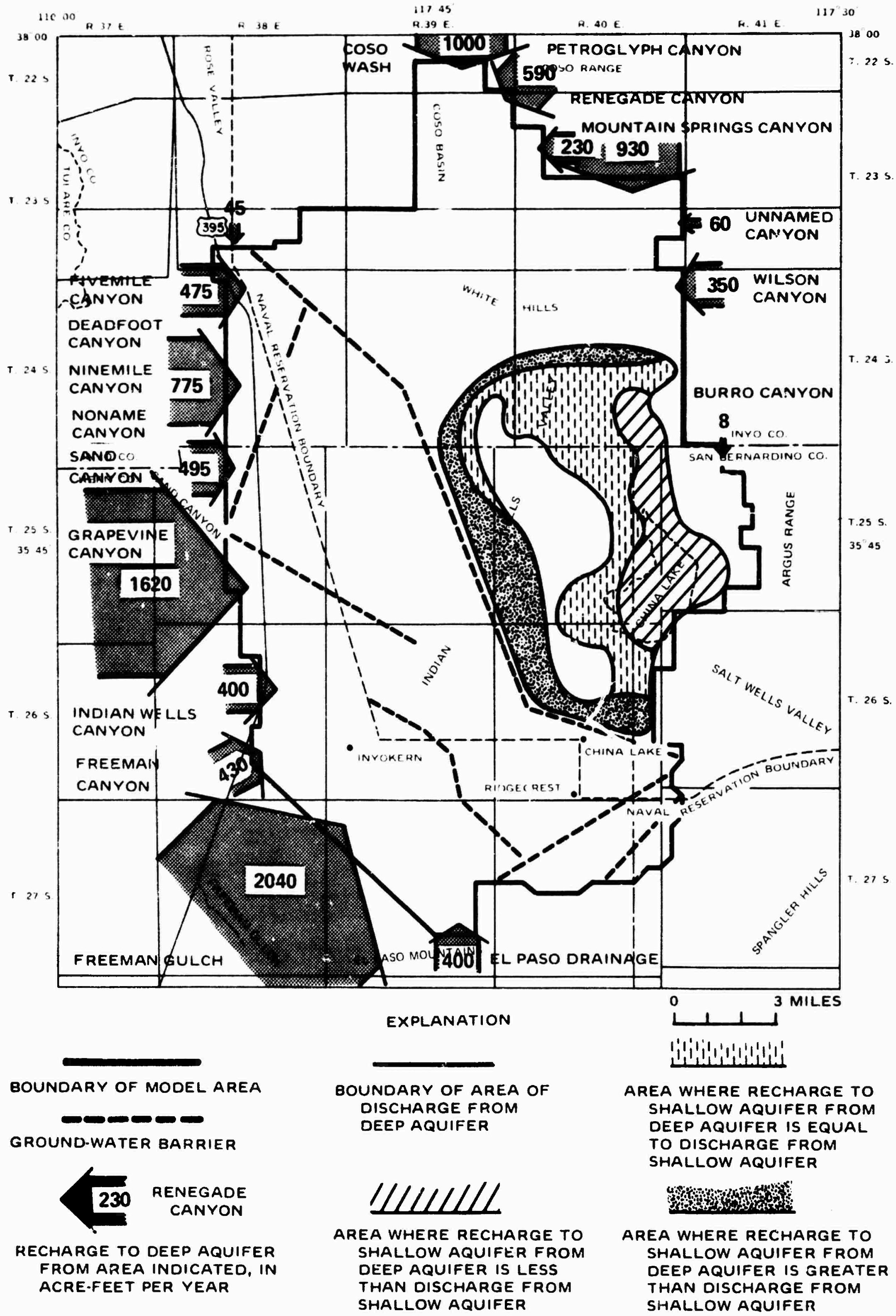


FIGURE 7. Groundwater Recharge and Discharge in Indian Wells Valley.

Recharge to the deep aquifer occurs as groundwater underflow from permeable materials in canyons of the Sierra Nevada and the Coso and Argus Ranges and as deep percolation of some of streamflow from Rose Valley and Freeman Gulch. An assumption was made that there was no recharge from deep percolation of precipitation on the valley floor.[11]

The orographic effects in the Sierra Nevada are assumed to be greater than in the Coso and Argus Ranges because more moisture is present in the air as it passes over the Sierra Nevada.

For altitudes greater than that of the lower valley the increase in annual precipitation was estimated by Lee (1913)[12] to be at the rate of 0.41 inch per 100 feet for the area west of Brown. On this basis, he estimated the annual precipitation at Brown (altitude, 2,395 feet) as 4 inches, at the base of the Sierra Nevada west of Brown 6 inches, and at the summit 22.5 inches. For the summit of the Argus Range, Lee estimated the average annual precipitation would be not more than 15 inches (almost certainly less than 9.5 inches). During the winter most of the precipitation in the mountains falls as snow.

Therefore, recharge was assumed to be available from areas on the eastern watershed of the Sierra Nevada above 4,500 feet altitude and from other areas above 5,000 feet. Within the surface drainage area of Indian Wells Valley there are 88 square miles above 4,500 feet in the Sierra Nevada and 102 square miles above 5,000 feet in the Coso and Argus Ranges. Recharge was apportioned to the individual streams in these categories on the basis of their drainage areas. The resulting recharge was distributed to nodes near the model boundary adjacent to the mouth of the canyons.[13]

In the Indian Wells Valley groundwater discharge occurs naturally by evapotranspiration and underflow into Salt Wells Valley and artificially by pumping from wells.

Perennial yield of a groundwater basin is the rate at which groundwater can be withdrawn year after year without depleting groundwater storage to such an extent that withdrawal at this rate is no longer feasible because of increased pumping costs or deterioration of quality. The estimated perennial yield of Indian Wells Valley, based on estimates of evapotranspiration and underflow at midvalley together with other groundwater data, is approximately 12,000 acre-feet per year[14]--about 4,000 acre-feet more than the estimated pumpage in 1953, but about 4,000 acre-feet less than the estimated total discharge.

The main water body occupies the central part of the valley--approximate boundaries are the Inyo County line on the north, an east-west line approximately 2 1/2 miles south of the NWC boundary on the south, the Argus fault zone on the east, the Sierra Nevada fault zone on the west, and a probable groundwater barrier about 2 miles south of Inyokern on the southwest. The containing formations include the younger alluvium and fan deposits, older alluvium, and younger and older lacustrine deposits. The bottom of the water body is considered to be the base of the older surface and the depth to non-water-bearing rocks. The saturated thickness at well 26/40-22P1 is about 1,275 feet, and the thickness is probably at least 1,000 feet beneath most of the central valley area.[15]

Most wells penetrate into the main water body only 50 to 400 feet, and they disclose differences in head of only a few feet within that range of penetration. With respect to land surface, the head, or water level, in wells that tap the main water body ranges from a few feet above on the east side of the valley in the vicinity of China Lake to 401 feet below in well 27/39-16F1 on the south side near the El Paso Mountains. However, the depth to water in most of the wells in the valley is between 100 and 200 feet.

Most of the main water body beneath the area underlain by the younger alluvium is unconfined; however, in the eastern part of the valley beneath China Lake and the area covered by windblown sand and interdune playa deposits, the main water body is confined by impermeable clay of the younger and older lacustrine deposits and the playa deposits. The area of confined water is north of a somewhat irregular and ill-defined line extending from the NWC Main Gate to Sandquist Spa and east of a line extending north from the Spa. South and west of this line the water body is largely unconfined.[16]

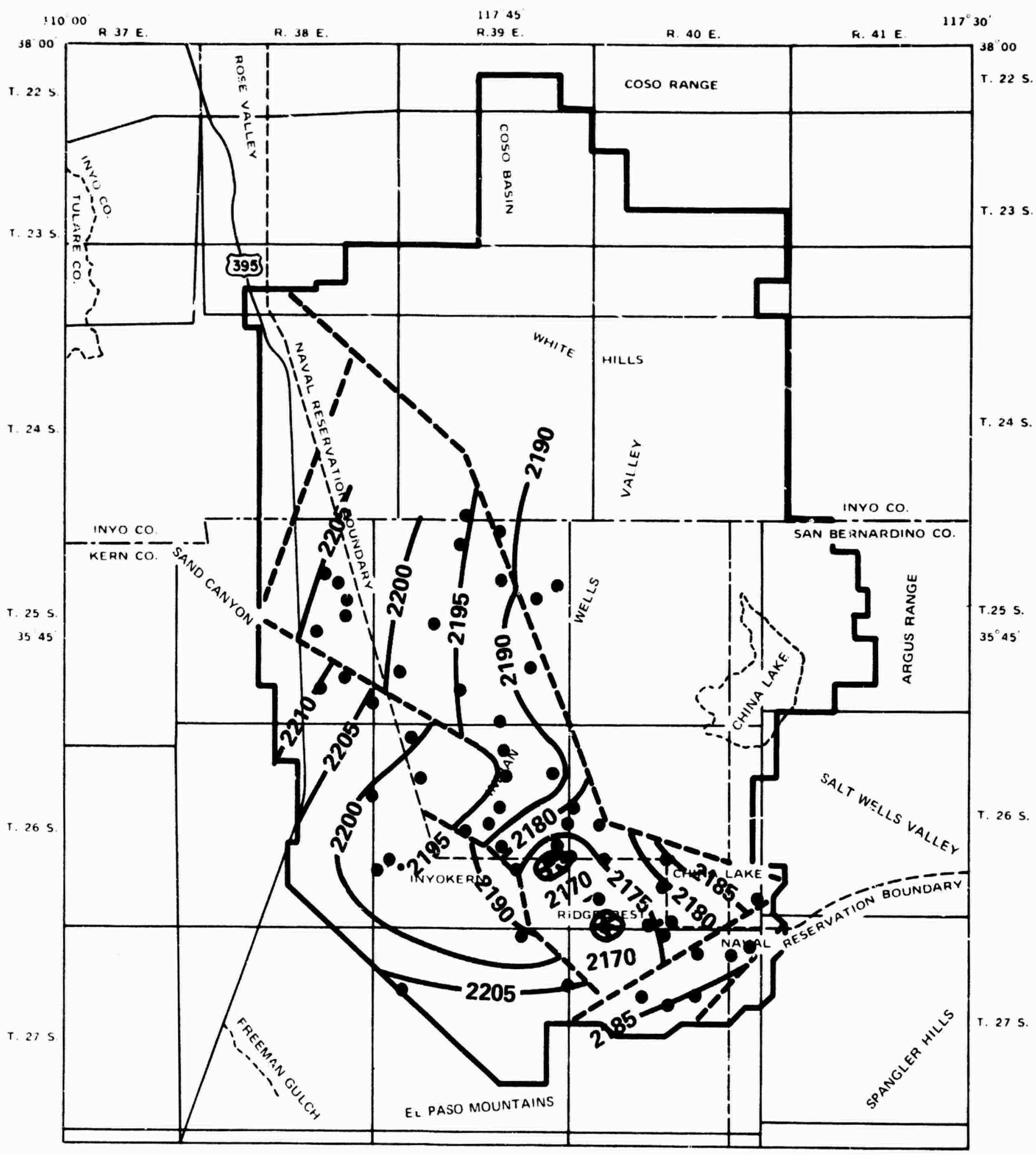
Most of the wells in use in the area draw water from the unconfined part of the main water body from depths less than 400 feet below land surface. These wells usually penetrate lenses of gravel or clay and gravel, and the yields of the wells which vary roughly in proportion to the amount of gravel penetrated range from almost nothing to more than 2,000 gpm. There are no wells of large yield in the central part of the confined water area. Of the wells that have been drilled there, only a few have ever been used for stock watering principally because of the poor quality of the water.[17]

The shallow water body lies above the confined part of the main water body principally beneath China Lake and vicinity. The base of the shallow water body is poorly defined, but roughly between 50 and 150 feet below land surface. Locally, appreciable difference in head exists between shallow wells and deeper wells. Wells 50 to 150 feet deep drilled into the shallow water body generally penetrate clay of very low permeability with occasional lenses of sand or sand and clay, yield water in very small quantities, and have a lower head than nearby deeper wells drilled into the confined part of the main water body.[18]

Groundwater moves from a source or place of high head toward an area of discharge or lower head. The head of a groundwater body is shown by the altitudes of the water levels in wells. Hence, water-level contours or lines connecting points of equal head on the water body indicate the configuration of its surface in the same manner that contours drawn on points of equal altitude of land surface indicate the configuration of the ground. Groundwater movement is perpendicular to the contour lines and toward points of lower head.

Figure 8 shows 1968 water-level contours for the deep aquifer in Indian Wells Valley.[19]

Temperature of groundwater normally fluctuates very little during the course of a year, the fluctuation being greatest in shallow wells and least in deep wells. Temperature of water in wells tapping deposits 50 to 150 feet below land surface usually is constant and approximately



EXPLANATION

BOUNDARY OF MODEL AREA

—2180— WATER-LEVEL CONTOUR, 1968

• WELL USED IN CONSTRUCTION OF WATER-LEVEL CONTOURS

GROUND-WATER BARRIER

INTERVALS 5 AND 10 FEET; DATUM IS MEAN SEA LEVEL

0 3 MILES

FIGURE 8. Groundwater-Level Contours, 1968, Indian Wells Valley.

equal to the mean annual temperature of the region. In the main water body in Indian Wells Valley this temperature is generally 68 to 70°F. In wells 50 to 452 feet deep the temperature is 76 to 83°F, which is above the normal geothermal gradient of 1 to 2°F for approximately each 100 feet of depth.

Mojave "B"/Randsburg Wash Complex. Recharge to the groundwater body in the Mojave "B"/Randsburg Wash complex occurs by direct infiltration of rain, subsurface flow from the adjoining areas, and percolation of the infrequent runoff that occurs during flash floods from the surrounding mountains.

Panamint Valley in the north Mojave "B" Range is a closed structural basin. From the meager data available, it is the opinion of the California Department of Water Resources that no water entering Panamint Valley escapes except by evaporation. Only a small quantity of groundwater is being pumped, none of which is on Navy property. Water in Panamint Valley beneath South Panamint dry lake is very salty, containing as much as 272,000 ppm. In some places fresh water can be obtained from shallow wells near the edge of the dry lake, but in general most water produced from deep wells is salty.[20]

Only two wells have been drilled in the Pilot Knob Valley (Randsburg Wash) area (28S/43E-12A1 and 28S/44E-8C1) which are owned by the U.S. Navy. Pump tests on these wells indicate that the transmissivity of the aquifer in this area is very low--about 1,000 gallons per day per foot. The groundwater gradient is very flat and appears to slope to the northwest. The low groundwater gradient and tranmissivity indicate that the quantity of groundwater moving through the aquifer is small and that under natural conditions the recharge and discharge to the aquifer is probably not more than about 100 acre-feet per year.[21]

The Garlock Fault is located along the north side of the aquifer and acts as a barrier to the movement of groundwater. Water-level data for wells 28S/43E-6B1 and 28S/43E-12A1 suggest that water levels may be as much as 400 feet lower on the north side of the fault than on the south side. However, these meager data are inconclusive.[22]

The aquifer near Randsburg Wash covers an area of about 30 square miles. The amount of recoverable water in storage depends on the saturated thickness of the aquifer, and its ability to release water from storage. Lack of well data precludes an appraisal, although estimates of storage can be made, based on hydrologic experience elsewhere. However, of more importance, is the ability of the aquifer to yield sufficient quantities of water to wells. Its low transmissivity makes recovery of this water difficult as well yields are small. Pump tests on well 28S/43E-12A1 indicate a specific capacity of 0.5 gpm per foot of drawdown. As recharge is minor, practically all of the pumped water would come from storage in the aquifer.[23]

In the southern segment of the Mojave "B" Range, where about 1,000 head of cattle are grazed seasonally under a lease administered by the Bureau of Land Management, water is mined by wind-powered pumps from fresh water reservoirs formed by subsurface sands and gravels of dry Superior Lake to the south.

Springs and Seeps. There are no perennial streams or lakes on NWC lands. A total of 49 springs and seeps have been identified on the China Lake Range area of NWC. Fresh water springs are few along the western edge of the Coso Range. Most occur above the 6,000-foot level in the central area of the Cosos. Numerous springs occur in the Argus Range between Argus and Maturango Peaks.

Water is extremely scarce in the Mojave "B"/Randsburg Wash Ranges. A few perennial springs exist in the Slate Range of the North Mojave "B" area. No springs and only a few seeps occur in the Randsburg Wash area. The southeast sector of the Mojave "B" area contains a few ephemeral springs. About a half dozen springs occur in the southwest sector of the Mojave "B" area.

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NATURAL BIOTIC SYSTEMS

Flora

Evolution. The present vegetation in the Mojave Desert and NWC vicinity is relatively new in terms of geological time (Axelrod, 1950).[1] In the Early Pliocene Epoch, about 10 million years ago, the Mojave Desert consisted of "oak woodland, chaparral and scrub vegetation" (Axelrod, 1958, p. 503).[2] By the Middle Pliocene, about 6 million years ago, as part of a drying-out trend, the Mojave was characterized by "semi-desert scrub, scattered thorn forest, and mesquite grassland" (Axelrod, 1958, p. 503).[3] The elevation of the Sierra Nevada Range in the Late Pliocene and Quaternary, about 1 million years ago, brought even dryer climates in the Mojave Desert, resulting in the desert climax vegetation which presently exists (Axelrod, 1950).[4]

The NWC vicinity flora of the Early Pliocene is preserved in tuffs at Last Chance Gulch in the El Paso Mountains. Axelrod (1950, p. 242)[5] states that fossil evidence

> "show that arid sub-tropical scrub was still in the region. The existence of plains and savanna environments on adjacent slopes has been inferred on the basis of a large vertebrate fauna (Merriam, 1919). Rainfall at that time was somewhere near 15 inches yearly, distributed in the summer and winter months. Although temperatures probably were high in summer, winters must have been comparatively mild, with frosts largely unknown."

Middle Pliocene flora and fauna of the Coso Range on NWC are discussed by Shultz (1937),[6] and the following comments are made:

> "There seems to be little doubt that the assemblage from the Coso beds was essentially one of the plains. This is indicated not only by the constituency of the fauna, but also by the relative abundance of certain types. For example, more than 40 per cent of the assemblage consists of horses of the genus *Plesippus*.
>
> "It seems reasonable to infer that the climate was somewhat more humid than that represented by the desert conditions now prevailing in the region."

Pleistocene vegetation in the NWC vicinity has been inferred to be grassland. This has been supported by fossil finds of grazing animals, including bison, camels, and horses (Hay, 1927; Buwalda, 1914).[7,8] Axelrod (1950, p. 269)[9] cites a study by Laudermilk and Munz (1934)[10] in which it was found that sloths near Las Vegas were feeding on a "*Juniperus-Yucca* community similar to that now found at elevation of 5000 feet in this region." Since the site is at 1,500 feet elevation, it was concluded that the Pleistocene climate was less arid than that of the present.

However, change has occurred even more recently, throughout Quaternary time (less than 1 million years), when herbaceous plants and grasses rapidly evolved. This accompanied "the differentiation of the many numerous communities which now characterize these desert areas" (Axelrod, 1950, p. 275).[11]

Taxonomy. There are a number of taxonomic references on desert flora in California. Jepson (1925)[12] and Munz and Keck (1968)[13] are two of the more widely used references. Jaeger's (1941)[14] study is helpful in identifying desert wildflowers. Twisselmann (1967)[15] provides taxonomic information on NWC vicinity species in eastern Kern County.

Plant Community Delineation and Description. The distribution of plant communities at NWC is greatly affected by the vicinity climate which, in turn, is a result of the Sierra Nevada to the west. As elaborated upon earlier in this report, the climate is distributed into Köppen classification BWh (Hot Desert), which is dry. One finds that due to slightly cooler temperatures, higher elevations have a higher precipitation-to-evaporation ratio. In addition, soil type greatly affects plant distribution.

Jensen (1947)[16] delineated different vegetative zones in California, including the NWC vicinity. However, pinyon-juniper and sagebrush communities on NWC were not included. Billings (1950)[17] classified all of the NWC vicinity, except the Sierra, as falling into the "creosote bush zone."

The matrix of temperature, precipitation-evaporation ratio and soil type results in six distinct plant communities on NWC, as defined by Munz and Keck (1949).[18] They are as follows:

"Alkali Sink": On poorly drained alkaline flats and playas, such as China Lake, Mirror Lake, and Airport Lake. Major species include cattle spinach (*Atriplex polycarpa*), pickleweed (*Allenrolfea occidentalis*), Parry saltbush (*Atriplex Parryi*), and desert holly (*Atriplex hymenelytra*).

"Creosote Bush Scrub": On well-drained soil of slopes, fans, and valleys. Although usually found below 3,500 feet, at NWC it can be found even as high as 5,500 feet due to scanty precipitation. Major species include creosote bush (*Larrea divaricata*), cheese bush (*Hymenoclea salsola*), and burrobush (*Ambrosia dumosa*). Most of the Indian Wells Valley, other than the playas, consists of creosote bush scrub.

"Shadscale Scrub": In heavy soil of mesas and flats at 3,000 to 6,000 feet. It is often found between creosote bush scrub and

Joshua tree woodland and intergrades with creosote bush scrub in the NWC vicinity. Major species include shadscale (*Atriplex confertifolia*), spiny hop sage (*Grayia spinosa*), and winter fat (*Eurotia lanata*).

"Joshua Tree Woodland": On well-drained mesas and slopes. Although usually found from 2,500 to 5,000 feet, it is well represented at NWC at elevations up to 6,000 feet, due to limited rainfall. Major species include Joshua tree (*Yucca brevifolia*), blackbrush (*Coleogyne ramosissima*), junipers (*Juniperus*), paper bag bush (*Salazaria mexicana*), and California buckwheat (*Eriogonum fasiculatum*).

"Sagebrush Scrub": On deep pervious soil at elevations between 5,000 and 6,000 feet. This community is poorly represented on NWC, apparently because the minimum 8-inch precipitation requirement is not met. Major species include big sagebush (*Artemesia tridentata*), rabbit brush (*Chrysothamus*), antelope brush (*Purshia*), and fourwing saltbush (*Atriplex canescens*).

"Pinyon-Juniper Woodland": Found above the Joshua tree woodland and sagebrush scrub at elevations from 7,000 to 8,800 feet. Moderately represented on NWC on Coso and Maturango Peaks. Although normally requiring 12 to 20 inches precipitation, on NWC may be surviving on as little as 6 to 10 inches. Major species include pinyon pine (*Pinus monophylla*), junipers (*Juniperus*), and antelope brush (*Purshia*).

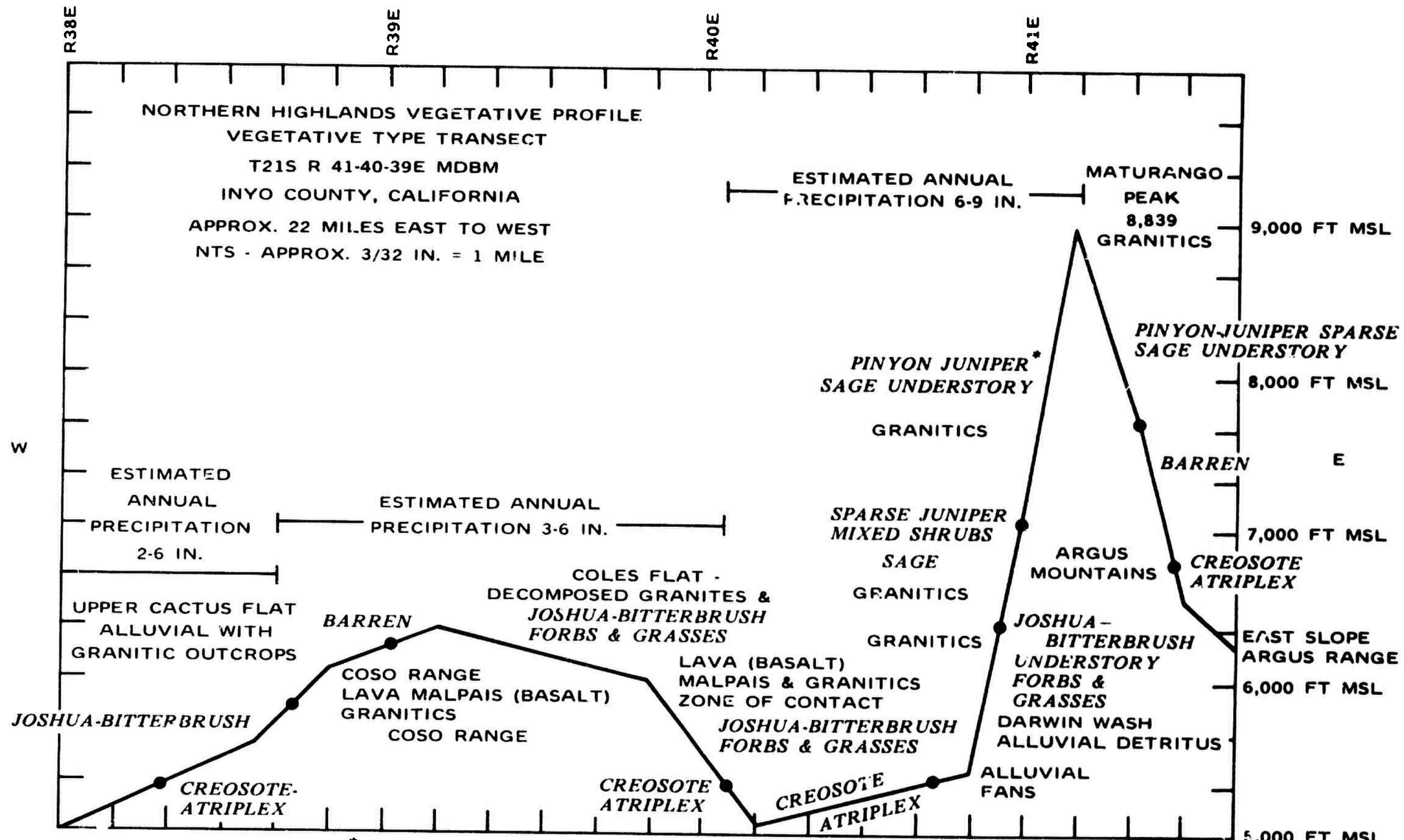
Figure 9, Northern Highlands Vegetative Profile, shows distribution of vegetation and estimated rainfall across the North Range on NWC.

Figure 10, Middle Desert Vegetative Profile, shows distribution of vegetation and estimated rainfall across the northern Indian Wells Valley.

Figure 11 shows spatial distribution of vegetative types across the entire NWC China Lake Range.

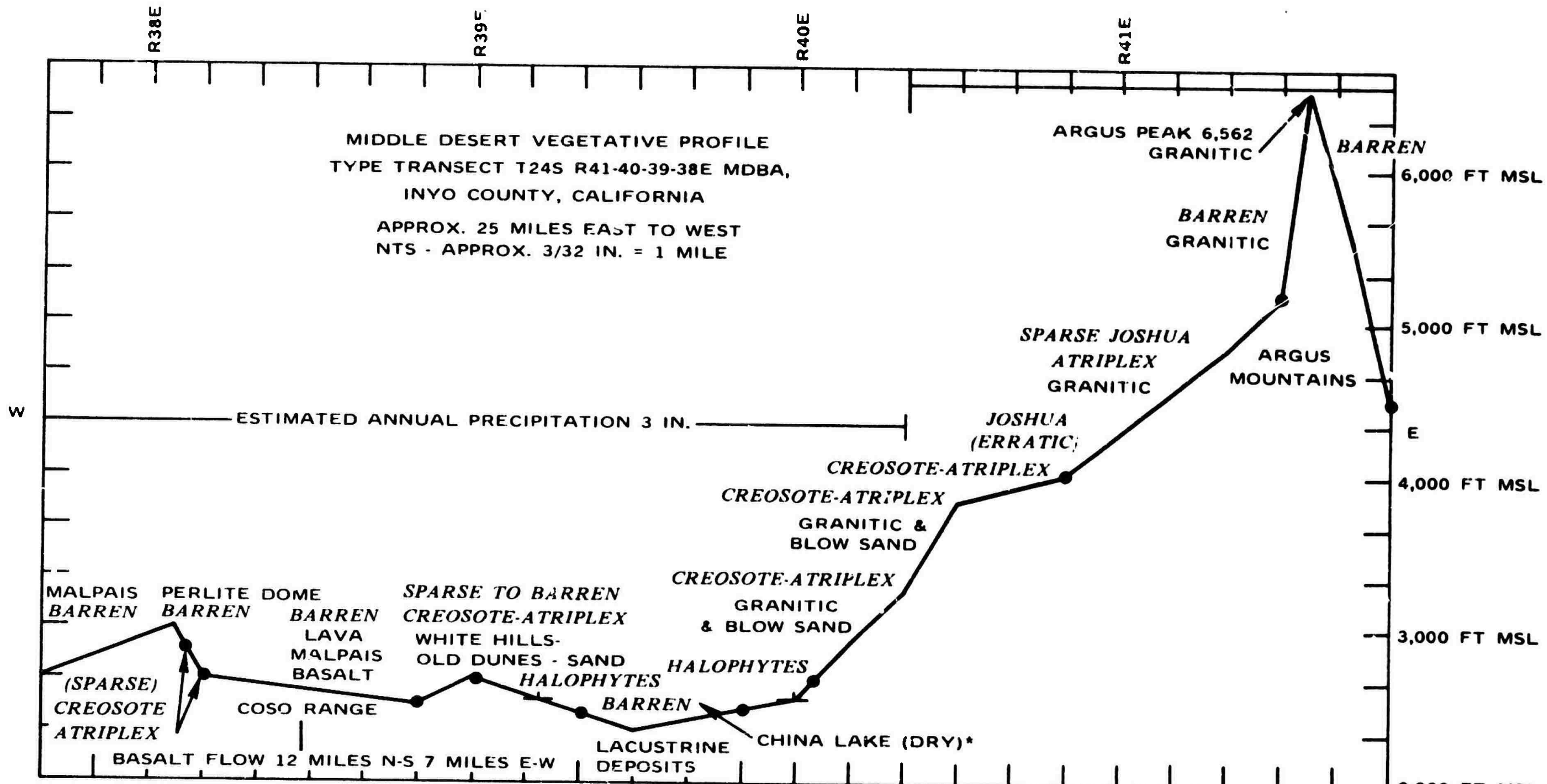
Ecology. McGinnies, et al. (1968)[19] have provided the most complete review to date of ecological research on the desert. They note a number of factors have been studied which affect vegetation, including climate, altitude, soil type, salinity, groundwater depth, and trace elements such as selenium. It appears that most research has been on the population level, determining characteristics and variable effects on single species. Individual studies have been performed on the more important NWC vicinity species such as *Larrea, Artemesia, Atriplex, and Yucca* (McGinnies, et al. 1968).[20]

There appear to be fewer studies at the community level on desert flora than on the population level. However, a number of key studies do exist. Diversity and distribution of vegetation have been studied quantitatively on the alkali sink community in Death Valley by Hunt (1966);[21] on the creosote bush community by Barbour (1969),[22] Chew and Chew (1965),[23] Gardner (1951),[24] and Went (1942);[25] on the shadscale scrub community by Billings (1949)[26] and Fautin (1946);[27] on the sagebrush scrub community by



* MAINLY SECOND GROWTH PINYON JUNIPER—RESULT OF EXTENSIVE CUTTING FOR CHARCOAL 1870's–1890's

FIGURE 9. North Range Vegetative Profile, Naval Weapons Center.



* PLEISTOCENE SHORELINES—LAST WELL DEFINED SHORELINE AT APPROX. 2,240 FEET MSL.

FIGURE 10. Middle Desert Vegetative Profile, Naval Weapons Center.

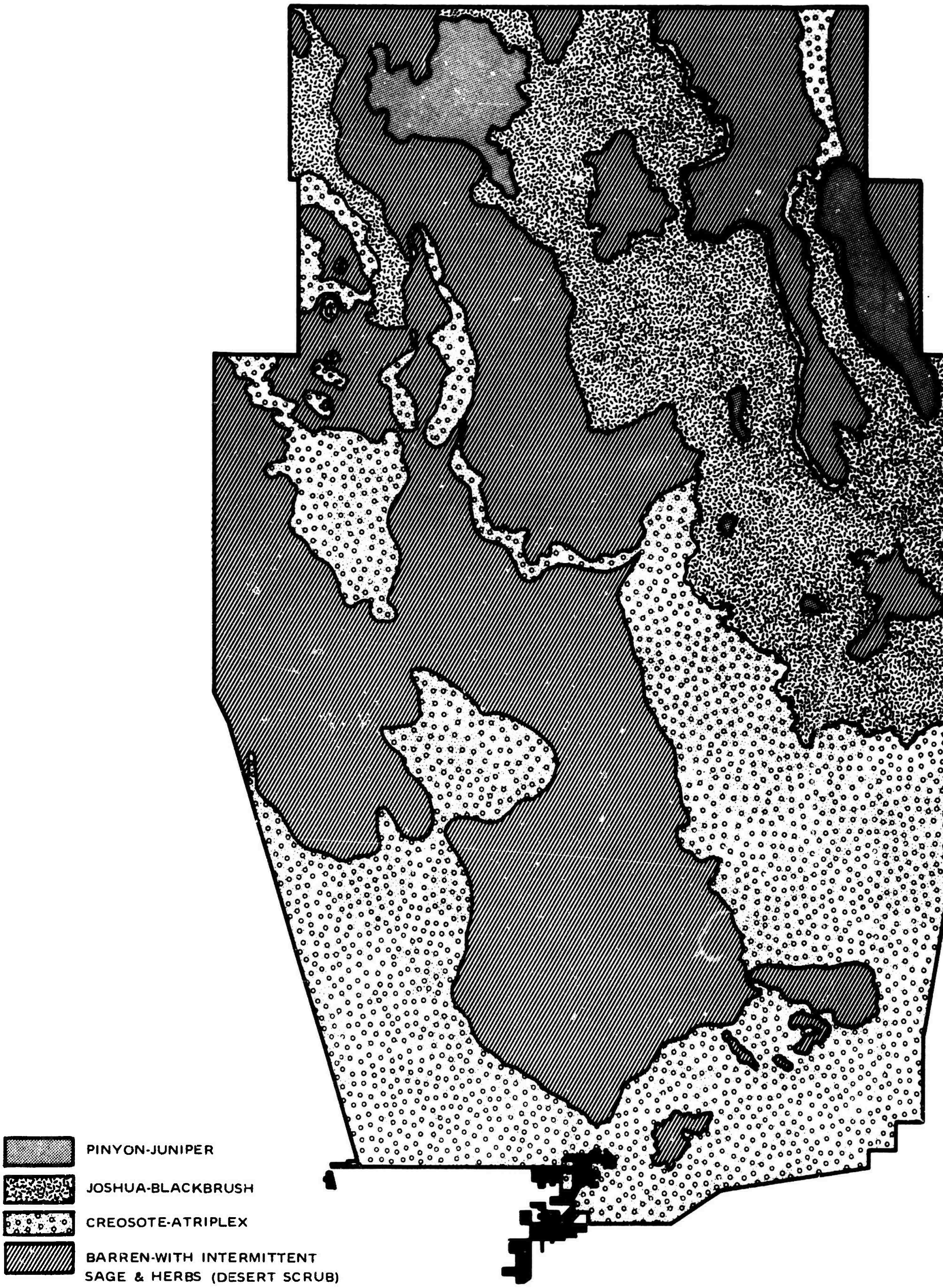


FIGURE 11. Major Plant Associations, China Lake Test Ranges, Naval Weapons Center.

Billings (1949)[28] and Fautin (1946);[29] and on the pinyon-juniper zone by Woodbury (1947).[30] Most of these studies were not done in the NWC vicinity, but much of the data can be extrapolated to this area.

Odum (1971)[31] notes that there exists little quantitative information on productivity and energy accumulation in desert plant communities. Chew and Chew (1965)[32] generated these data for a creosote bush community in southeastern Arizona, in a Sonoran-type desert at about 4,460 feet msl. They determined the net annual production to be approximately 1,400 kg/ha, or 6,100 megacal/ha. This is roughly one-tenth that of an average fertile region, which is about 50,000 megacal/ha (Odum, 1971, p. 44).[33] Chew and Chew (1965)[34] estimated that the net annual primary productivity of the *Larrea* community was about 0.03% of the annual solar radiation and about 0.1% of the available energy during the growing season. They estimated the efficiency of the *Larrea* community to be about one-seventh that of an average deciduous tree and one-twentieth that of an average conifer. Chew and Chew (1965)[35] attribute the low accumulation of energy to small leaf density and size and the spareness of shrub cover. Given the lack of summer rains, the *Larrea* community in the NWC vicinity would be even less efficient.

It does not appear that this type of quantitative production research and analysis has been performed on the other plant communities in the NWC vicinity. For the other plant communities, annual rainfall data could be used to get a rough production approximation, using a study by Walter (1954).[36] Using Walter's graphed data in Odum (1971),[37] one obtains the following:

Annual rainfall, in.	Annual net production, kg/ha
2-3	200-400
3-6	400-1,100
6-9	1,100-1,800

These numbers should be used only as guides, since temperature and seasonal distribution of rainfall cause significant variation about the mean figures given above. It should be noted that Chew and Chew's study area received almost 17 inches of precipitation during the study year,[38] which accounts for its productivity being much larger than the 400 kg/ha predicted by Walter's (1954)[39] data at NWC due to 3 inches annual precipitation.

Rare, Endangered, and Geographically Restricted Plants. Perhaps the only source of information on rare and endangered plant species in the NWC vicinity is the unofficial list distributed by the California Native Plant Society (1971).[40] Twisselmann (1967, p. 56)[41] notes that the only known surviving Kern County colony of carrizzo grass (*Phragmites communis* var *Berlandieri*) exists in the El Paso Mountains bounding the Indian Wells Valley on the south. This is not cited by the California Native Plant Society (1971)[42] as a rare or endangered plant.

Twisselmann (1967)[43] notes a number of plants which have range limits in the NWC vicinity. Plants which reach their northern and northwestern limits in the El Paso Mountains consist of the following:

Lepidium nitidum var. *Howellii*
Erodium texanum
Gilia aliquanta ssp. *aliquanta*
Gilia latiflora ssp. *elongata*
Phacelia pachyphylla

Plants that reach their northern or northwestern limits at other places in the Mojave Desert in Kern County include:

Allium fimbriatum var. *denticulatum*
Canbya candida
Eschscholzia parishii
Streptanthella longirostris var. *derelicta*
Nicolletia occidentalis
Perityle emoryi

Plants that reach their southern range limits in the Kern County part of the Mojave Desert are:

Triglochin debilis
Euphorbia vallis-mortae
Eucnide urens
Cymopterus panamintensis
Gilia brecciarum ssp. *argusana*
Gilia cana ssp. *speciosa*
Phacelia nashiana
Cryptantha decipiens
Cryptantha mohavensis
Mohavea breviflora

Plants which reach their western limits in the Kern County portion of the Mojave Desert consist of:

Cheilanthes viscida
Chorizanthe spinosa
Eriogonum Plumatella
Mirabilis Bigelovii var. *bigelovii*
Eschscholzia glyptosperma
Astragalus didymocarpus var. *dispermus*
Lotus salsuginosus var. *brevivexillus*
Mentzelia tricuspis var. *brevicornuta*
Echinocactus polyancistrus
Gilia brecciarum ssp. *neglecta*
Gilia hutchinsifolia
Gilia latiflora ssp. *latiflora*
Gilia latiflora ssp. *excellens*

Coldenia plicata
Cryptantha angustifolia
Monardella exilis
Chrysothamnus paniculatus

Fauna

Evolution. The evolution of NWC vicinity fauna is correlated with the flora, as discussed in the previous section. Early Pliocene fauna in the El Paso Mountains was investigated by Merriam (1919),[44] who determined the existence of large vertebrates. Middle Pliocene animals in the Coso Mountains were determined by Shultz (1937)[45] to also consist of large vertebrates, of which roughly half were horses. Pleistocene fauna in the NWC vicinity were studied by Hay (1927),[46] Buwalda (1914),[47] Laudermilk and Munz (1934),[48] and Fortsch (1972).[49] They found fossils of sloths and grazing animals such as bison, camels, and horses. Today on NWC only remnant populations of the large native vertebrates remain, consisting of small bands of deer and desert bighorn sheep. During the last century feral horses and burros have been indigenous.

Taxonomy. As with the flora, there are a number of taxonomic references on NWC vicinity fauna. Ingles (1965, 1954)[50,51] and Booth (1968)[52] are references on mammals, while Stebbins (1972, 1943)[53,54] is a principal reference on amphibians and reptiles. Two major bird references are Peterson (1961)[55] and Hoffman (1927).[56] Two taxonomic and general references on desert arachnids are Savory (1964)[57] and Cloudsley-Thompson (1958).[58] A major insect reference applicable to the NWC vicinity is Essig (1958).[59]

Animal Community Delineation and Description. The delineation of desert animals into communities has not been as successful as with the flora. The mobility of the animals which allows them to move among different communities appears to make community delineation unfeasible. McGinnies (1968, p. 570)[60] notes, ". . . desert animals are markedly less useful than are desert plants for estimating desert parameters."

Nevertheless, attempts at delineating plant-animal systems into biomes have been made. Desert biomes, among those proposed by Shelford (1945),[61] consist of the "Shadscale-Kangaroo Rat Biome (Cool Desert)"; "Creosote Bush-Desert Fox Biome (Hot Desert)"; and the "Juniper-Rock Squirrel Biome (Pinyon-Juniper Woodland)." All three of these lie within NWC boundaries.

The advantages and disadvantages of Shelford's proposed system is illustrated by Fautin's (1946)[62] study of sagebrush and shadscale scrub communities in Utah. He found that while plant communities had rather sharp boundaries, large animals (especially predators) ranged throughout them and from one major community to another. However, smaller animals were generally restricted to specific plant communities, rarely ranging to others.

Table 2 provides an inventory of principal animals on NWC. Table 3 provides an inventory of many animals in the Indian Wells Valley vicinity.

Ecology. As noted in McGinnies (1968),[63] almost all ecological research on desert animals is of a descriptive nature. Odum (1971, p. 396)[64] notes, "In going through all the vast amount of literature summarized in the UNESCO reports, one is impressed with the fact that almost all of the information on the deserts of the world is purely descriptive in nature; there is less known about the actual 'workings' of desert ecosystems."

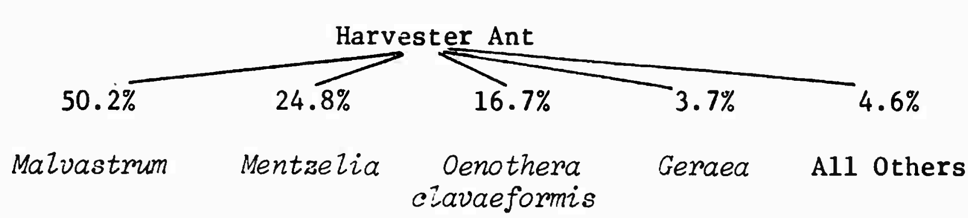
The biology and physiological adaptations of desert animals have been extensively studied by Cloudsley-Thompson (1954),[65] Schmidt-Nielson (1964),[66] Jaeger (1961),[67] G. W. Brown (1968),[68] Yousef, Horvath, and Bullard (1972),[69] UNESCO (1957),[70] and others. Studies on specific NWC vicinity animals include those by L. H. Brown and Carpelan (1971),[71] Lowe and Heath (1969),[72] Bartholomew and Hudson (1961),[73] McKnight (1958),[74] Woodbury and Hardy (1948),[75] and Dixon and Sumner (1939).[76]

Competition and predation among desert animals are discussed in a number of studies, including Sumner (1959),[77] T. C. Emmel and J. F. Emmel (1969),[78] Hadley and Williams (1968),[79] and Rosenzweig and Winakur (1969).[80] Quantitative studies on population ecology have been done by Beatley (1969),[81] Tevis (1958),[82] and Rosenzweig and Winakur (1969).[83] Energy flow, primary productivity, and efficiency in mammals of a creosote bush community have been quantitatively described by Chew and Chew (1970).[84]

Beatley (1969)[85] provided data relating Mojave Desert rodent population to rain and plant productivity. She found, "There appears to be a direct relationship between the seasonal success of winter annuals and reproduction in desert rodents, and the relationship is expressed the same season." It was found that the rodents could cycle a whole order of magnitude in numbers (Beatley, 1969).[86]

Rosenzweig and Winakur (1969)[87] found that rodent species diversity was inversely proportional to plant species diversity. They noted studies by MacArthur and MacArthur (1961)[88] and Pianka (1966)[89] which found the same inverse relationship with birds and lizards. It was also found that in spite of competition there is a great diversity in rodents occupying the same ecological niche. Trapping in 15 different plots in a *Larrea* community in Arizona resulted in 13 different species of rodents. The number of equivalent species* in each plot ranged from 1.0 to 3.56. The numerical mean of all plots was 2.18, while the geometric mean was 2.01.

Tevis (1958)[90] found that harvester ants, like the rodents, were also dependent upon desert annuals for food. During spring, their food web looks like this:



*The number of equivalent species is given by $1/\Sigma p_i^2$ where p_i is the proportion of individuals that are members of species i.

During the remainder of the year, it changes to this:

Harvester Ant			
52.0%	39.5%	4.7%	3.8%
Pectocarya	*Plantago*	*Malvastrum*	All Others

Thus, the harvester ant radically changes food preference as a function of time of year. Tevis noted that ants only eat roughly 1% of the seeds produced each year. He also noted that the population appeared to be stable. It can, therefore, be suggested that although, like the rodent, the ant is dependent upon annuals, there is little population fluctuation because their food web contains a number of different species, which increases stability (Slobodkin, 1961, p. 143; Paine, 1969).[91,92] In addition, the ants change food preferences when necessary and never consume more than about 1% of the available seeds, allowing plant productivity stability.

NWC data show that the upland game bird population is correlated with rainfall and plant productivity, as was found with the rodents. The upland game bird population is thought to lag rainfall by two years, which is not the case for rodents.

As is found with producer-consumer relationships, Slobodkin (1961)[93] notes that the stability of a predator-prey system is increased when a relatively large number of prey species is available for the predators. As mentioned above, Rosenzweig and Winakur (1969)[94] found there was a large variety of rodents in spite of competition. This rodent diversity would tend to stabilize the rodent-predator population. Analogously, large varieties of other prey such as lizards and birds would also stabilize predator (coyote, desert kit fox, others) population. Slobodkin (1961)[95] noted that predators tend to exert a damping effect on natural prey population oscillations. It appears the desert ecosystems, like other natural systems, are self-regulating due to feedback.

Chew and Chew (1970)[96] analyzed the energetics of mammals in a *Larrea* community in Arizona. Among the finds were:

1. Mammal density average 17.4/ha, or 4,600/sq. mi.

2. Two-thirds of the mammals were kangaroo rats (*Dipodomys merriami*).

3. The average biomass was 1.13 kg/ha, or 640 lb/sq. mi., of which 40% was kangaroo rat and 40% black-tailed hare (*Lepus-californicus*).

4. The mammals dissipated less than 2% of the net annual above-ground plant production.

5. The mammals got 49.3% of their caloric intake from seeds and 40.9% from leaves and stems.

Odum (1971, p. 396)[97] suggests that rodents play an important role in desert ecosystem energy stability:

> "Since microbial decomposers will be sharply limited by dryness, one wonders if this is compensated for by a seemingly large population of rodent herbivores, which, perhaps similar to the zooplankton of the sea, play an important part in nutrient cycling. As in all ecosystems adapted to extreme conditions, a relatively large amount of net production goes into storage of reproductive organs, thus providing a food source for consumers."

Quantitative energy flow studies like that of Chew and Chew (1970)[98] do not appear to have been done for the other desert biomes or plant communities. Fautin's (1946)[99] study also suggests that small rodents play a key role, not only in providing stability to higher trophic levels due to their large numbers of species, but perhaps also, as Odum suggests, in nutrient recycling.

Rare, Endangered, and Geographically Restricted Animals. The Mojave ground squirrel (*Citellus mojavensis*), a small desert-dwelling mammal resembling the Antelope ground squirrel, has been given rare status by the California Fish and Game Commission (California Department Fish and Game, 1974).[100] Presence of a good population of this rodent has been verified at NWC by the California Department of Fish and Game.

The California Department of Fish and Game recently verified the existence of a remnant population of the rare desert bighorn sheep (*Ovis canadensis nelsoni*) in the Argus Range and in the Eagle Crags area of NWC.

TABLE 2. Principal Animals on NWC.

Legend: Scarce = less than 5 observations per year
Occasional = 5 to 12 observations per year
Frequent = more than 12 observations per year

I. China Lake Test Ranges

A. Mammals

1. Native

Mule deer (occasional)
Estimate 100 (Coso Peak and Maturango Peak)
Mountain lion (scarce)
Verified sightings of 3 within last 2 years
Coyote (frequent)
Observed in all areas (animal and/or tracks, scats)
Badger (occasional)
Joshua-bitterbrush association and around sandy hills on dry lake bed (associated with kangaroo rat habitats)
Porcupine (scarce)
Pinyon-juniper (Coso Peak) existence inferred from girdling in cambium of pinyon trees
Ring-tailed cat (scarce, one live animal seen March 1974)
Dry canyons and rocky scarps
Kit fox (occasional)
Shy, nocturnal; dry lake bed and Joshua-bitterbrush (kangaroo rat and ground squirrel habitats); population judged to be frequent in certain areas from scats.
Bighorn sheep
Upper elevations of Argus; estimate 12-15 sheep; rare
Rodents:

Kangaroo rat	(frequent)
*Antelope ground squirrel	Plentiful in cycle when
Mojave ground squirrel	food plants are adequate
Rock squirrel and/or	
Beechy ground squirrel	
*Wood rat	
*Mice	
Bats	(frequent)
Jackrabbits	(frequent)
Atriplex and Joshua-bitterbrush	
Cottontail rabbits	(occasional)

2. Feral

Horses (frequent)
Estimate 200; seldom seen below 4,000 ft msl; population stable
Burros (frequent)
Estimate 350; all areas except FH; come as close as Lark Ramp Seep
Domestic cats (no observations)
Around foot of B Mountain and in vicinity of stables; have Security opinion on this

3. Domestic

Cattle
Seasonal November 1 to May 30 on portion of range

* All areas.

TABLE 2. (Contd.)

Dogs and cats (frequent)
In FH and immediately adjacent areas

B. Birds

1. Unmanaged

Golden eagles (frequent)
Observed in all areas seasonally
Red-tailed hawk (frequent)
All areas seasonally
Prairie falcon (frequent)
Canyons on west side of Argus and Coso Ranges; probably resident; nest sites known
American Kestrel (sparrow hawk) (frequent)
All areas; probably resident; around FH area and seasonal in wildlands
Night hawks and poor wills (frequent)
FH area and lower canyons; seasonal
Cooper's hawk (occasional)
Owls
Burrowing owl (frequent)
Resident in areas with good ground squirrel and kangaroo rat populations
Barn owl (occasional)
Old sheds, abandoned towers, etc.
Great horned owl (occasional)
Same as barn owl; occasional in FH treed areas
California roadrunner (frequent)
Resident all areas
Desert raven (frequent)
Resident all areas
Robins (frequent)
Seasonal (spring and fall) in FH area and canyons
Mockingbird (frequent)
Resident FH area
Starling (frequent)
Resident FH area and canyon wildlands during spring and summer
Red-winged blackbird (frequent)
Seasonal; nests around sewer lagoons and G-range swamps; feeds in FH area
Brown-headed cowbird
Same as red-winged blackbird
Yellow-headed blackbird
Same as red-winged blackbird
Vireos, western tanager, warblers, juncos, wrens, cedar waxwings, finches, martins, buntings, chickadees, nuthatches, etc. (frequent)
Seasonal in FH area and wildlands
Loggerhead shrikes, pinyon jays, LeConte thrashers, etc. (frequent)
Seasonal in wildlands
Hummingbirds (3 or 4 sp.) (frequent)
Seasonally in all areas
Aquatic and wading birds: Great blue heron, snowy and common egret, American avocet, black-necked stilt, killdeer, and other wading birds (frequent)
Seasonal in moist areas on G-ranges

2. Managed

a. Seasonal

Mallards, canvasback, merganser, bufflehead, shoveler, ruddy duck, teal, pintail, widgeon (frequent)

TABLE 2. (Contd.)

Canada goose, Ross's goose, snow goose. Seasonal (frequent)
Other waterfowl (frequent). Western grebe, pied grebe. Seasonal
Coot (frequent). Resident
White pelican (scarce)
Gulls (occasional)

b. Upland game birds

White-winged dove, mourning dove (frequent to occasional). Seasonal; depending on precipitation and food
California quail, Gambel's quail, mountain quail** (occasional to frequent). Resident wildlands; cyclic with climatic changes
Indian red-legged partridge (chukar)** Same as quail

c. Experimental exotics

Seesee partridge and crested tinamou (scarce)
Question as to whether population established

C. Reptiles

1. Snakes

Sidewinders and rattlesnakes (occasional)
Resident; mostly wildlands; shy; nocturnal (probably good population)
California king snake (occasional)
Red racer (occasional)
Rosy boa (scarce)
Gopher snake (frequent)
Glossy snake (occasional)
Leaf-nosed snake (occasional)

NOTE: All snakes are shy and in summer most are nocturnal; therefore, observations are relatively few unless trapping or night counts are taken; probably have good populations in proportion to rodent cycles.

2. Lizards

Chuckwallas (frequent)
Desert iguana (frequent)
Zebra-tailed lizard (frequent)
Side-blotched (frequent)
California spiny (frequent)
Whip-tailed (frequent)
Western fence lizard (blue belly) (frequent)
Night lizards (scarce)
Banded geckos (scarce)
Tortoise (occasional). Limited habitat

D. Amphibians

Western spadefoot toad (frequent)
FH area and moist locations, such as springs, etc.
Leopard frog (frequent). Springs
Tree frog (scarce).
Know of it only at Haiwee Spring
Salamanders. Could be expected around perennial springs; no investigation to determine species or population done to date

** "Managed", i.e., seasonal hunting when population estimates are favorable.

TABLE 2. (Contd.)

E. Fishes

1. Exotic

Rare and endangered transplant Mojave chub (*gila mohavensis*)
400 introduced into refuge; appear to be successful; no population estimate at this time

2. Feral

Goldfish (frequent)
In drainage channels on G-ranges

F. Invertebrates

Fairy shrimp
Fresh water crustaceans; cryptobiotic; occur in Mirror Lake (dry) when moisture and temperature conditions are favorable; common throughout desert playas; not considered rare or endangered.
Rock snails
Found occasionally in granite or basalt rock piles; common in elevation and terrain where found; dry. fragile shells found in rock shelters and caves showing prehistoric human occupancy
Tarantulas, scorpions, blister beetles, and other beetles
In most areas offering suitable habitat
Bees, wasps, ants, black widow spiders, orb weavers, etc. Common

II. Mojave "B"/Randsburg Wash Ranges

Native and feral

Same wildlife as on China Lake Test Ranges, except
deer;
horses, feral;
goldfish, feral;
domestic cats, feral;
mountain lions (possible, but no observations)
except for burros, all species scarce or occasional observations; burros frequent

Birds (occasional to frequent). Same, except pinyon jays, waterfowl, and wading birds; seasonal

Invertebrates. No fairy shrimp known although several playas and sag ponds appear to be likely if precipitation and temperature favorable

Reptiles. Same

Others. Same

TABLE 3. Checklist of the Amphibians, Reptiles, Birds, and Mammals of Indian Wells Valley and Surrounding Areas[a]

These lists are based on field observations of the compilers and on museum records. The areas covered in the lists include Indian Wells Valley, adjacent canyons, and mountain ranges to the level of the pinyon-juniper belt.

> *The use is for the* Survey and Evaluation of the Environmental Impact of Naval Weapons Center Activities *only and is a one time use. If further use is sought, i.e., quotations from the lists, permission must be obtained from the Maturango Museum Board of Trustees.*
>
> *The following wildlife checklists are not to be construed as a comprehensive survey of amphibians, reptiles, mammals, and birds occurring within NWC boundaries. They do represent a reasonably complete inventory of species found in the Indian Wells Valley and immediately adjacent foothill zones, but they do not include extensive areas of NWC North Ranges, Argus Range, Coso Mountains, or the Randsburg Wash and Mojave B Ranges.*

TABLE 3. (Contd.)

Habitat Types for Amphibians, Reptiles, Birds, and Mammals of the Indian Wel:: Valley and Surrounding Areas.

1	Urban developments
2	Rural developments, cultivated areas
3	Sewage ponds, marshes, drainage ditches
4	Alkali sink associations
5	Creosote bush scrub
6	Shadscale scrub
7	Joshua tree woodland
8	Sagebrush scrub
9	·' yon-juniper woodland
10	Wet ca·yons: (a) Sierran, (b) desert
11	Rock canyons
12	Open sky

Amphibians and Reptiles of Indian Wells Valley and Surrounding Areas[a]
by
Kristin Berry

	Habitat Type
Order Amphibia	
Family Ambystomatidae Mole Salamanders	
Tiger Salamander (*Ambystoma tigrinum*)	exotic: 1,3,10a
Family Hylidae Tree Frogs	
Pacific Treefrog (*Hyla regilla*)	1,2,3,10a
Family Bufonidae True Toads	
Western Toad (*Bufo boreas*)	1,2,3,10a
Red-spotted Toad (*Bufo punctatus*)	10b
Order Reptilia	
Family Testudinidae, subfamily Testudininae: Gopher Tortoises	
Desert Tortoise (*Gopherus agassizi*)	1 (captive), 4-7, 11
Family Gekkonidae Geckos	
Banded Gecko (*Coleonyx variegatus*)	4-9,10,11
Family Iguanidae Iguanid Lizards	
Desert Iguana (*Dipsosaurus dorsalis*)	4-7, 11 (uncommon)
Chuckwalla (*Sauromalus obesus*)	5(11), 7(11)
Zebra-tailed Lizard (*Callisaurus draconoides*)	4-7, 8?

TABLE 3. (Contd.)

	Habitat Type
Collared Lizard (*Crotaphytus collaris*)	11: 5,7,8,9?
Leopard Lizard (*Crotaphytus wislizenii*)	4-7,8
Desert Spiny Lizard (*Sceloporus magister*)	5,6,7,11
Western Fence Lizard (*Sceloporus occidentalis*)	9
Side-blotched Lizard (*Uta stansburiana*)	4-11
Desert Horned Lizard (*Phrynosoma platyrhinos*)	4-11
Family Xantusiidae Night Lizards	
Desert Night Lizard (*Xantusia vigilis*)	4(unc), 5, 7
Family Scincidae Skinks	
Gilbert's Skink (*Eumeces gilberti*)	10a, 10b
Family Teiidae	
Western Whiptail (*Cnemidophorus tigris*)	4-11
Family Anguidae Alligator Lizards	
Southern Alligator Lizard (*Gerrhonotus multicarinatus*)	exotic: 1; 10a?
Family Anniellidae Legless Lizards	
California Legless Lizard (*Anniella pulchra*)	7-10 (Sierras only at Walker Pass)
Family Leptotyphlopidae Slender Blind Snakes	
Western Blind Snake (*Leptotyphlops humilis*)	4-9,11
Family Boidae Boas	
Rosy Boa (*Lichanura trivirgata*)	4-7,10,11
Family Colubridae	
Spotted Leaf-nose Snake (*Phyllorhynchus decurtatus*)	4-7,11
Red Racer (*Masticophis flagellum*)	2,3,4-11
Western Patch-nosed Snake (*Salvadora hexalepis*)	4-9,10,11
Glossy Snake (*Arizona elegans*)	4-9,10,11
Gopher Snake (*Pituophis melanoleucus*)	2,3,4-11
Common Kingsnake (*Lampropeltis getulus*)	4-11
Western Ground Snake (*Sonora semiannulata*)	4-7,10,11
Western Shovel-nosed Snake (*Chionactis occipitalis*)	4-7,10,11
Utah Black-headed Snake (*Tantilla planiceps utahensis*)	4-11
Desert Night Snake (*Hypsiglena torquata deserticola*)	4-11
Family Viperidae, subfamily Crotalinae	
Northern Pacific Rattlesnake (*Crotalus viridis oreganus*)	8,9 (Sierran), 10a
Mojave Desert Sidewinder (*Crotalus cerastes cerastes*)	4-7,10,11
Panamint Rattlesnake (*Crotalus mitchelli stephensi*)	11: 5,7-9,10
Mojave Rattlesnake (*Crotalus scutulatus scutulatus*)	5,7

Abbreviations and Definitions for Bird Checklist

Status (Definitions taken from *The Distribution of the Birds of California*, by J. Grinnell and A. H. Miller, Cooper Ornithological Club, Pacific Coast Avifauna No. 2, Berkeley, California. 1944)

Res	RESIDENT	A species fixed in areal occurrence throughout the year.
SR	SUMMER RESIDENT	A species in residence during spring and summer periods, usually nesting in the area.
SV	SUMMER VISITANT	A species present in summer but not known to be in breeding residence.
WV	WINTER VISITANT	A species present during the intermigratory fall and/or winter periods.

TABLE 3. (Contd.)

M	MIGRANT	A species seen during spring and fall migration periods.
V	VAGRANT	A species which occasionally appears in an area outside its normal distribution area or off its usual migration route.

Abundance (Definitions taken from *Birds of North America*, by C. S. Robbins, B. Bruun, and H. S. Zim, Golden Press, New York. 1966)

C	COMMON	A common bird may be seen most of the time or in small numbers everytime by a person visiting its habitat at the proper season.
O	OCCASIONAL	An uncommon or occasional bird may be seen quite regularly in small numbers in the appropriate environment or season.
Ra	RARE	A rare bird occupies only a small percentage of its preferred habitat or occupies a very specific limited habitat. It is usually found only by an experienced observer.

* Presumed to occur here on the basis of known migration routes and distribution.

Birds of the Indian Wells Valley and Surrounding Areas[a]
by
Don W. Moore and John Dow

Family and Species	Abundance	Status	Habitat
Gaviidae:Loon Family			
Common Loon (*Gavia immer*)	Ra	V	3
Podicipedidae:Grebe Family			
Horned Grebe (*Podiceps auritus*)	Ra	V	3
Eared Grebe (*Podiceps caspicus*)	C	Res	3
Western Grebe (*Aectimophorus occidentalis*)	O	M	3
Pied-billed Grebe (*Podilymbus podiceps*)	O	M	3
Pelecanidae:Pelican Family			
White Pelican (*Pelecanus erythrorhynchos*)	O	M	3,12
Phalacrocoracidae:Cormorant Family			
Double-crested Cormorant (*Phalacrocorax auritus*)	Ra	V	3
Ardeidae:Herons and Bitterns			
Great Blue Heron (*Ardea herodias*)	O	M	3
Green Heron (*Butorides virescens*)	O	M	3
Common Egret (*Casmerodius albus*)	Ra	M	3
Snowy Egret (*Leucophoyx thula*)	O	M	3
*Black-crowned Night Heron (*Nycticorax nycticorax*)	Ra	V	3
*Least Bittern (*Ixobrychus exilis*)	Ra	M	3
American Bittern (*Botaurus lentiginosus*)	O	M	3

TABLE 3. (Contd.)

Family and Species	Abundance	Status	Habitat
Ciconiidae:Ibises			
•Wood Ibis (*Mycteria americana*)	Ra	V	3
Threskiornithidae:Ibises and Spoonbills			
White-faced Ibis (*Plegadis chihi*)	Ra	M	3
Anatidae:Swans, Geese and Ducks			
Whistling Swan (*Olor columbianus*)	O	WV	2,3
Canada Goose (*Branta canadensis*)	C	WV	2,3
White-fronted Goose (*Anser albifrons*)	O	WV	2,3
Snow Goose (*Chen hyperborea*)	C	WV	2,3
Fulvous Tree Duck (*Dendrocygna bicolor*)	Ra	V	3
Mallard (*Anas platyrhynchos*)	C	Res	3
Gadwall (*Anas strepera*)	O	WV	3
Pintail (*Anas acuta*)	C	WV	3
Green-winged Teal (*Anas carolinensis*)	C	WV	3
Blue-winged Teal (*Anas discors*)	C	WV	3
Cinnamon Teal (*Anas cyanoptera*)	C	SR	3
American Widgeon (*Mareca americana*)	O	WV	3
Shoveler (*Spatula cylpeata*)	C	WV	3
•Wood Duck (*Aix sponsa*)	Ra	V	3
Redhead (*Aythya americana*)	O	M	3
Ring-necked Duck (*Aythya collaris*)	O	V	3
Canvasback (*Aythya valisinera*)	C	WV	3
Greater Scaup (*Aythya marila*)	Ra	V	3
Lesser Scaup (*Aythya affinis*)	O	WV	3
Common Goldeneye (*Bucephala clangula*)	O	V	3
Bufflehead (*Bucephala albeola*)	C	WV	3
Ruddy Duck (*Oxyura jamaicensis*)	C	Res	3
Common Merganser (*Mergus merganser*)	O	M	3
•Red-breasted Merganser (*Mergus serrator*)	Ra	M	3
Cathartidae:Vultures			
Turkey Vulture (*Cathartes aura*)	C	WV	12
Accipiteridae:Kites, Hawks, and Eagles			
White-tailed Kite (*Elanus leucurus*)	Ra	V	2,3
•Goshawk (*Accipiter gentilis*)	Ra	V	2
Sharp-shinned Hawk (*Accipiter striatus*)	O	WV	2
Cooper's Hawk (*Accipter cooperi*)	O	WV	2,10
Red-tailed Hawk (*Buteo jamaicensis*)	C	Res	2-12
Swainson's Hawk (*Buteo swainsoni*)	Ra	M	2-12
•Zone-tailed Hawk (*Buteo albonotatus*)	Ra	V	2-12
Ferruginous Hawk (*Buteo regalis*)	O	WV	2,5 (telephone poles)
Golden Eagle (*Aquila chrysaetos*)	O	Res	4-8,10-12
Marsh Hawk (*Circus cyaneus*)	C	WV	2,3
Osprey (*Pandion haliaetus*)	Ra	SV	3,12
Falconidae:Falcon Family			
Prairie Falcon (*Falco mexicanus*)	O	Res	4-7,10-12
Peregrine Falcon (*Falco columbarius*)	Ra	WV,M	2,3,10
Sparrow Hawk (*Falco sparverius*)	C	Res	2-9,10-12
Phasianidae:Pheasants, Quail			
California Quail (*Lophortyx californicus*)	C	Res	2,7,10,11
Gambel's Quail (*Lophortyx gambelii*)	C	Res	2,5-7,10,11

TABLE 3. (Contd.)

Family and Species	Abundance	Status	Habitat
Mountain Quail (*Oreortyx pictus*)	C	Res	7-10
Chukar (*Alectoris graeca*)	C	Res	4-7,10,11
Rallidae:Rails, Gallinules, Coots			
Virginia Rail (*Rallus limicola*)	O	Res	3
Sora Rail (*Porzana carolina*)	O	Res	3
Common Gallinule (*Gallinula chloropus*)	Ra	V	3
American Coot (*Fulica americana*)	C	Res	3
Plovers:Charadriidae			
Semipalmated Plover (*Charadrius semipalmatus*)	O	M	3
Snowy Plover (*C. alexandrinus*)	O	M	3
Killdeer (*Charadrius vociferus*)	C	Res	2,3
Mountain Plover (*Eupoda montana*)	Ra	V	2,3
Black-bellied Plover (*Squatarola squatarola*)	Ra	M	3
Scolopacidae:Snipes, Sandpipers, etc.			
Common Snipe (*Capella gallinago*)	O	M	2,3
Long-billed Curlew (*Numenius americanus*)	O	M	2,3
Whimbrel (*N. phaeopus*)	O	M	2,3
Spotted Sandpiper (*Actitis macularia*)	O	SV,M	3
•Solitary Sandpiper (*Tringa solitaria*)	Ra	V	3
Wandering Tattler (*Heteroscelus incanum*)	Ra	V	3
Willet (*Latoptrophorus semipalmatus*)	C	M	3
Greater Yellowlegs (*Totanus melanoleucus*)	C	M	3
•Lesser Yellowlegs (*Totanus flavipes*)	O	M	3
Least Sandpiper (*Erolia minutilla*)	C	M	3
Dunlin (*Erolia alpina*)	O	M	3
Long-billed Dowitcher (*Limnodromus scolopaceus*)	C	M	3
Western Sandpiper (*Erunetes mauri*)	C	M	3
Marbled Godwit (*Limosa fedoa*)	O	M	3
Recurvirostridae			
American Avocet (*Recurvirostra americana*)	C	SR	3
Black-necked Stilt (*Himantopus mexicanus*)	C	SV	3
Phalaropodidae:Phalaropes			
Wilson's Phalarope (*Steganopus tricolor*)	C	M	3
Northern Phalarope (*Lobipes lobatus*)	C	M	3
Laridae:Gulls and Terns			
California Gull (*Larus californicus*)	C	M	3
Ring-billed Gull (*Larus delawarensis*)	O	M	3
•Laughing Gull (*Larus atricilla*)	Ra	V	3
Franklin's Gull (*Larus pipixcan*)	Ra	M	3
Bonaparte's Gull (*Larus philadelphia*)	R-O	V	3
Forster's Tern (*Sterna forsteri*)	C	M	3
Black Tern (*Chlidonias niger*)	C	M	3
Columbidae:Pigeons and Doves			
Band-tailed Pigeon (*Columba fasciata*)	Ra	V	10
Mourning Dove (*Zenaidura macroura*)	C	Res	1,2,5-9,10-12
Domestic Pigeon (*Columba livia*)	C	Res	1

TABLE 3. (Contd.)

Family and Species	Abundance	Status	Habitat
Cuclulidae:Cuckoos and Roadrunners			
Yellow-billed Cuckoo (*Coccyzus americanus*)	Ra	V	11
Roadrunner (*Geococcyx californianus*)	C	Res	4-9,11,12
Strigidae:Owls			
Barn owl (*Tyto alba*)	C	Res	1,2,7-10
Great Horned Owl (*Bubo virginianus*)	O	Res	7-11
Burrowing Owl (*Speotyto cunicularia*)	O	Res	2,3,4-7
Long-eared Owl (*Asio otus*)	O	M	1,9-10
Short-eared Owl (*Asio flammeus*)	O	WV	2,3
Caprimulgidae:Goatsuckers			
Poor-will (*Phalaenoptilus nuttallii*)	C	SR	1,6,7
Lesser Nighthawk (*Chordeiles acutipennis*)	C	SR	1,4,5,7
Apodidae:Swifts			
Vaux's Swift (*Chaetura vauxi*)	Ra	M	11
White-throated Swift (*Aeronautes saxatalis*)	O	SV,M	10,11
Trochilidae:Hummingbirds			
Black-chinned Hummingbird (*Archilochus alexandri*)	C	SR	1,5,7,10,11
Costa's Hummingbird (*Calypte costae*)	C	SR	1,5,7,10,11
Anna's Hummingbird (*Calypte anna*)	O	SR	1
Broad-tailed Hummingbird (*Selasphorus Platycercus*)	Ra	M	9,10
Rufous Hummingbird (*Selasphorus rufus*)	C	SV	1,10
Alcedinidae:Kingfishers			
Belted Kingfisher (*Megaceryle alcyon*)	Ra	M	3
Picidae:Woodpeckers			
Yellow-shafted Flicker (*Colaptes auratus*)	Ra	V	1,2,7,9,10
Red-shafted Flicker (*Colaptes cafer*)	C	WV	1,2,7,9,10
Lewis' Woodpecker (*Asyndesmus lewis*)	O	M	1,9,10
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	O	WV	1,10
Downy Woodpecker (*Dendrocopos pubescens*)	C	WV	1,10
Ladder-backed Woodpecker (*D. scalaris*)	O	SV,Res	7,10
Tyrannidae:Flycatchers			
Western Kingbird (*Tyrannus verticalis*)	C	SR	1,2,5,7,10
Ash-throated Flycatcher (*Myiarchus cinerascens*)	O	SV,Res	7,10
Black Phoebe (*Sayornis nigricans*)	O	Res	1-3,10
Say's Phoebe (*Sayornis saya*)	C	Res	1-3,4-7,10
*Gray Flycatcher (*Empidonax wrightii*)	Ra	Res	2,7,10
Western Flycatcher (*Empidonax difficilis*)	O	M	2,3,10
Olive-sided Flycatcher (*Nuttallornis borealis*)	Ra	M	1,2,5
Vermilion Flycatcher (*Pyrocephalus rubinus*)	Ra	V	1,3,10
Alaudidae:Larks			
Horned Lark (*Eremophila alpestris*)	C	Res	2,4-7
Hirudinidae:Swallows			
Violet-green Swallow (*Tachycineta thalassina*)	O	M	2,3,12

TABLE 3. (Contd.)

Family and Species	Abundance	Status	Habitat
Tree Swallow (*Iridoprocne bicolor*)	C	M	2,3,12
Bank Swallow (*Riparia riparia*)	Ra	M	2,12
Rough-winged Swallow (*Stelgidopteryx ruficollis*)	O	M	2,3,12
Barn Swallow (*Hirundo rustica*)	C	M	2,3,12
Cliff Swallow (*Petrochelidon pyrrhonota*)	C	M	2,3,12
Purple Martin (*Progne subis*)	Ra	V	2,3,12
Corvidae: Jays, Magpies, Crows			
Steller's Jay (*Cyanocitta stelleri*)	Ra	V	1,10
Scrub Jay (*Aphelocoma coerulescens*)	O	V	1,9,10
Black-billed Magpie (*Pica pica*)	O	V	2,3
Raven (*Corvus corax*)	C	Res	1,2,4-7,10,11+
Common Crow (*Corvus brachyrhynchos*)	Ra	V	1,2,10
Pinyon Jay (*Gymnorhinos cyanocephala*)	C	Res	9
Paridae: Titmice, Verdins, etc.			
Black-capped chickadee (*Parus atricapillus*)	Ra	WV, V	1
Plain Titmouse (*Parus inornatus*)	Ra	M	1,9
Verdin (*Auriparus flaviceps*)	Ra	Res,SV	1
Common Bushtit (*Psaltriparus minimus*)	O	V	9,10
Sittidae: Nuthatches			
Red-breasted Nuthatch (*Sitta canadensis*)	C	WV	1
White-breasted Nuthatch (*Sitta carolinensis*)	O	WV	1,10
Troglodytidae: Wrens			
House Wren (*Troglodytes aedon*)	C	M	1,2,10
Bewick's Wren (*Thryomanes bewickii*)	C	Res	1,2,10
Cactus Wren (*Camphlorhynchus brunneicapillum*)	C	Res	7
Long-billed Marsh Wren (*Telmatodytes palustris*)	C	Res	3
Rock Wren (*Salpinctes obsoletus*)	C	Res	11:5,7,10
Mimidae: Mockingbirds and Thrashers			
Mockingbird (*Mimus polyglottos*)	C	Res	1,7
California Thrasher (*Toxostoma redivivum*)	O	V	9
LeConte's Thrasher (*Toxostoma lecontei*)	C	Res	4,5,7
Crissal Thrasher (*Toxostoma dorsale*)	Ra	V	5
Sage Thrasher (*Oreoscoptes montanus*)	O	WV(4,6)	SR (6)
Turdidae: Thrushes and Bluebirds			
Robin (*Turdus migratorius*)	C	WV	1,2,10
Varied Thrush (*Ixoreus naevius*)	Ra	V	1
Hermit Thrush (*Hylocichla guttata*)	C	WV,M	1,7,9,10
Western Bluebird (*Sialia mexicana*)	O	WV	1,2,10
Mountain Bluebird (*S. currucoides*)	C	WV	1,5,7,9,10
Townsend Solitaire (*Myadestes townsendi*)	Ra	WV	1,10
Sylviidae: Gnatcatchers, Kinglets			
Blue-grey Gnatcatcher (*Polioptila caerulea*)	Ra	M	9,10
Black-tailed Gnatcatcher (*Polioptila melanura*)	O-Ra	Res	10,12
Golden-crowned Kinglet (*Regulus satrapa*)	Ra	V	1
Ruby-crowned Kinglet (*Regulus calendula*)	C	WV	1,9
Motacillidae: Wagtails			
Water Pipit (*Anthus spinoletta*)	C	WV	2,3

TABLE 3. (Contd.)

Family and Species	Abundance	Status	Habitat
Bombycillidae:Waxwings			
Bohemian Waxwing (*Bombycilla garrula*)	Ra	V	1
Cedar Waxwing (*Bombycilla cedrorum*)	C	WV	1
Ptilogonatidae:Silky Flycatchers			
Phainopepla (*Phainopepla nitens*)	O	SR,V	1,7
Laniidae:Shrikes			
Loggerhead Shrike (*Lanius ludovicianus*)	C	Res	2-7+
Sturnidae:Starlings			
Starling (*Sturnus vulgaris*)	C	Res	1,2
Vireonidae:Vireos			
Solitary Vireo (*Vireo solitarius*)	O	M	1,10
Warbling Vireo (*Vireo gilvus*)	O	M	1,10
Parulidae:Wood Warblers			
Black and White Warbler (*Mniotilta varia*)	Ra	M	1
Orange-crowned Warbler (*Vermivora celata*)	O	SV	1,10
Nashville Warbler (*V. ruficapilla*)	Ra	M	1
Yellow Warbler (*Dendroica petechia*)	O	SV	1,3,10
Audubon's Warbler (*D. auduboni*)	C	WV	1,2,7,10
Black-throated Grey Warbler (*D. nigrescens*)	O	M	6,7
Townsend's Warbler (*D. townsendi*)	O	M	1,7,10
* Hermit Warbler (*D. occidentalis*)	Ra	M	1,10
McGillivray's Warbler (*Oporornis tolmiei*)	C	M	1,10
Yellow-throat (*Geothlypis trichas*)	O	M	1,3,10
Yellow-breasted Chat (*Icteria virens*)	O	M	1,10
Wilson's Warbler (*Wilsonia pusilla*)	C	M	1,10
American Redstart (*Setophaga ruticilla*)	Ra	M	1,10
Icteridae:Blackbirds and Orioles			
Western Meadowlark (*Sturnella neglecta*)	C	Res	2,3
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	O	M	2,3
Red-winged Blackbird (*Agelaius phoeniceus*)	C	M	2,3
Scott's Oriole (*Icterus parisorum*)	O	SR	7
Bullock's Oriole (*Icterus bullockii*)	C	SR,M(5,7)	1,10
Hooded Oriole (*I. cucullatus*)	O	SV(SR)	1,10
Brewer's Blackbird (*Euphagus cyanocephalus*)	C	Res	1,2
Brown-headed Cowbird (*Molothrus ater*)	C	SR	1,2
Thraupidae:Tanagers			
Western Tanager (*Piranga ludoviciana*)	C	M,SV	1,5,9,10
Fringillidae:Finches, Towhees, Sparrows			
Black-headed Grosbeak (*Pheucticus melanocephalus*)	C	M	1,2,10
* Blue Grosbeak (*Guiraca caerulea*)	Ra	V	1,10
Luzuli Bunting (*Passerina amoena*)	Ra	M	10
Evening Grosbeak (*Hesperiphona vespertina*)	Ra	V	1
Purple Finch (*Carpodacus purpureus*)	Ra	V	1
House Finch (*Carpodacus mexicanus*)	C	Res	1,2,4-7,10

TABLE 3. (Contd.)

Family and Species	Abundance	Status	Habitat
Pine Siskin (*Spinus pinus*)	O	M	1,9
American Goldfinch (*Spinus tristis*)	O	WV	1,2
Lesser Goldfinch (*Spinus psaltria*)	C	SV	1,4,7
Lawrence's Goldfinch (*S. lawrencei*)	O	M,SV	1,2,10
Green-tailed Towhee (*Chlorura chlorura*)	Ra	M	9
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	O	Res	1,7-9,10
Brown Towhee (*P. fuscus*)	O	Res	10
Savannah Sparrow (*Passerculus sandwichensis*)	C	M	2,3,4-7
• Vesper Sparrow (*Pooecetes gramineus*)	Ra	V	2,3,4-7
Lark Sparrow (*Chondestes grammacus*)	O	SV	2,5,8
Black-throated Sparrow (*Amphispiza bilineata*)	O	Res	4-7
Sage Sparrow (*Amphispiza belli*)	C	Res	5,6
Oregon Junco (*Junco oreganus*)	C	WV	1,2,5-9
Slate-colored Junco (*Junco hyemalis*)	Ra	WV	1,5-7
Chipping Sparrow (*Spizella posserina*)	O	M	5,6
Brewer's Sparrow (*Spizella breweri*)	O	Res	1,5-7
Black-chinned Sparrow (*S. atrogularis*)	Ra	SV	5,6
Harris' Sparrow (*Zonotrichia querula*)	Ra	M,WV	6,8
White-crowned Sparrow (*Zonotrichia leucophrys*)	C	WV	1,2,5-9,10
Golden-crowned Sparrow (*Z. atricapilla*)	O	WV	1,2,5-7
Fox Sparrow (*Passerella iliaca*)	C	M	2,3,5-7
Lincoln Sparrow (*Melospiza lincolnii*)	Ra	M	3
Song Sparrow (*M. melodia*)	C	WV	3,10
Ploceidae:Weaver Finches			
English Sparrow (*Passer domesticus*)	C	Res	1

Mammals of the Indian Wells Valley and Surrounding Areas[a]

by

Kristin H. Berry

	Habitat Type
Order Marsupialia	
Family Didelphidae	
Opossum (*Didelphis marsupialis virginiana*)	Sierran affinities: Jawbone, Dove Springs, etc.
Order Insectivora	
Family Soricidae Shrews	
Ornate Shrew (*Sorex ornatus ornatus*)	Little Lake
Crawford's Desert Shrew (*Notiosorex crawfordi*)	5,7+
Order Chiroptera	
Family Vespertilionidae	
Little Brown Myotis (*Myotis lucifugus carissima*)	
California Myotis (*M. californicus stephansi, M. c. californicus*)	
Yuma Myotis (*M. yumanensis sociabilis, M. y. yumanensis*)	
Long Eared Myotis (*M. evotis evotis*)	
Fringed Myotis (*M. thysanodes*)	
Long-legged Myotis (*Myotis volans interior*)	

TABLE 3. (Contd.)

	Habitat Type
Small footed Myotis (*M. subulatus melanorhinus*)	
Western Pipistrelle (*Pipistrellus h. hesperus*)	11: 5+
Big Brown Bat (*Eptesicus fuscus pallidus, E. f. bernardinus*)	
Red Bat (*Lasiurus borealis teliotus*)	
Hoary Bat (*L. cinereus cinereus*)	
Spotted Bat (*Euderma maculatum*)	
Townsend's Big-eared Bat (*Plecotus/Corynorhinus townsendii pallescens*)	
Pallid Bat (*Antrozous pallidus pallidus*)	
Family Molossidae	
Brazilian Free-tailed Bat (*Tadarida brasiliensis mexicana*)	
Order Lagomorpha	
Family Leporidae	
Black tailed Hare (*Lepus californicus deserticola*)	2-11
Audubon Cottontail (*Sylvilagus auduboni arizonae*)	2,3,5,7-11
Order Rodentia	
Family Sciuridae	
Beechey or California Ground Squirrel (*Otospermophilus beecheyi*)	7-10a
Panamint Chipmunk (*Eutamias panamintinus*)	9
Antelope Ground Squirrel (*Ammospermophilus leucurus*)	3-9,10,11
Mojave Ground Squirrel (*Citellus mojavensis*)	5
Family Geomyidae	
Botta Pocket Gopher (*Thomomys bottae*)	5,7+
Family Heteromyidae	
Little Pocket Mouse (*Perognathus longimembris*)	4-9,11
Long-tailed Pocket Mouse (*Perognathus formosus*)	4-9,11
Great Basin Pocket Mouse (*Perognathus parvus*)	8,9+ (Argus Mtns)
Yellow-eared Pocket Mouse (*Perognathus xanthanotus*)	7-9, Walker Pass only
Panamint Kangaroo Rat (*Dipodomys panamintinus*)	5-8+
Great Basin Kangaroo Rat (*Dipodomys microps*)	4
Merriam Kangaroo Rat (*Dipodomys merriami*)	4-8+
Desert Kangaroo Rat (*Dipodomys deserti*)	4-5
Family Cricetidae	
Western Harvest Mouse (*Reithrodontomys megalotis metaiotis*)	10
Canyon Mouse (*Peromyscus crinitus stephansi*)	11: 5,6,7+
Cactus Mouse (*Peromyscus eremicus eremicus*)	8,9
Deer Mouse (*Peromyscus maniculatus sonoriensis*)	4-11
Brush Mouse (*Peromyscus boylii boylii*)	9,10a
Pinyon Mouse (*Peromyscus truei montipinoris, P. t. truei*)	8,9?,10ab
Southern Grasshopper Mouse (*Onychomys torridus pulcher*)	4-9
Desert Woodrat (*Neotoma lepida lepida*)	11: 5-9; 7 without 11
Family Erethizontidae	
Porcupines (*Erethizon dorsatum*)	10a
Family Canidae	
Kit Fox (*Vulpes macrotis arsipus*)	4-9,10,11
Gray Fox (*Urocyon cineroargenteus*)	10a
Coyote (*Canis latrans*)	1-11
Family Procyonidae	
Ringtail Cat (*Bassariscus astutus willetti*)	5,7+, 10ab
Raccoon (*Procyon lotor psora*)	10a
Family Mustelidae	
Long-tailed Weasel (*Mustela frenata pulchra*)	4,7-10
Badger (*Taxidea taxus berlandieri*)	1-11
Spotted Skunk (*Spilogale putorius*)	4-9
Striped Skunk (*Mephitis mephitis*)	10a

TABLE 3. (Contd.)

	Habitat Type
Family Felidae	
Bobcat (*Lynx rufus baileyi, L. r. californicus*)	2-11
Order Artiodactyla	
Family Bovidae	
Bighorn Sheep (*Ovis canadensis*)	Desert Mtns: 8,9,10b
Order Perissodactyla	
Family Equiidae	
Burro	4-11

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SUPERIMPOSED SOCIOECONOMIC SYSTEMS

Land Use

General Land Use Patterns. When a desert location for weapons test and research was selected in 1942, specific environmental conditions were required. Chief among these were: (1) isolation from concentrations of population because of the experimental nature of the work; (2) year-round flying weather; (3) clear air with unrestricted visibility; and (4) reasonable certainty that these favorable conditions would be permanent.

The location of the Center with respect to the ownership and demographic composition of the surrounding area 30 years later is significant. The three counties in which the Center is situated are still sparsely populated for more than a 100-mile radius. Although about 75% of Kern County is in private ownership, the one-third of the county east of the Sierra Nevada is desert, primarily public domain. The following table illustrates the size of the three counties with respect to public ownership, population density, and NWC lands:

	Inyo County	San Bernardino County	Kern County
Total area, sq. mi.	10,091	20,131	8,152
Government ownership, sq. mi.	9,687	16,306	2,038
Percent of total county	96	81	25
NWC land, sq. mi.	720	887	104
County population per sq. mi.	1.21	31.0	39.4

Populations of Kern and San Bernardino Counties are concentrated in a few agricultural and industrial areas. The eastern third of Kern County is desert and, except for the Ridgecrest/China Lake communities, primarily vacant land. San Bernardino County, largest in the United States, is 90% desert. Inyo County's population density is the third lowest of California's 58 counties.

By far the largest land holder in the desert areas of California is the Bureau of Land Management of the U.S. Department of the Interior. Of the 16 million acres of California desert, the Bureau of Land Management administers 11 million.

Zoning is accomplished by city and county governments within their jurisdictions. The City of Ridgecrest has a zone plan as indicated in Figure 12. County zoning, where it exists, has been added to Figure 10. Kern County has zoned only scattered parcels in the area southwest of the China Lake complex, and these are Light Agricultural, Trailer Districts. Inyo County has zoned all the land along the north border of the China Lake complex as "open space."

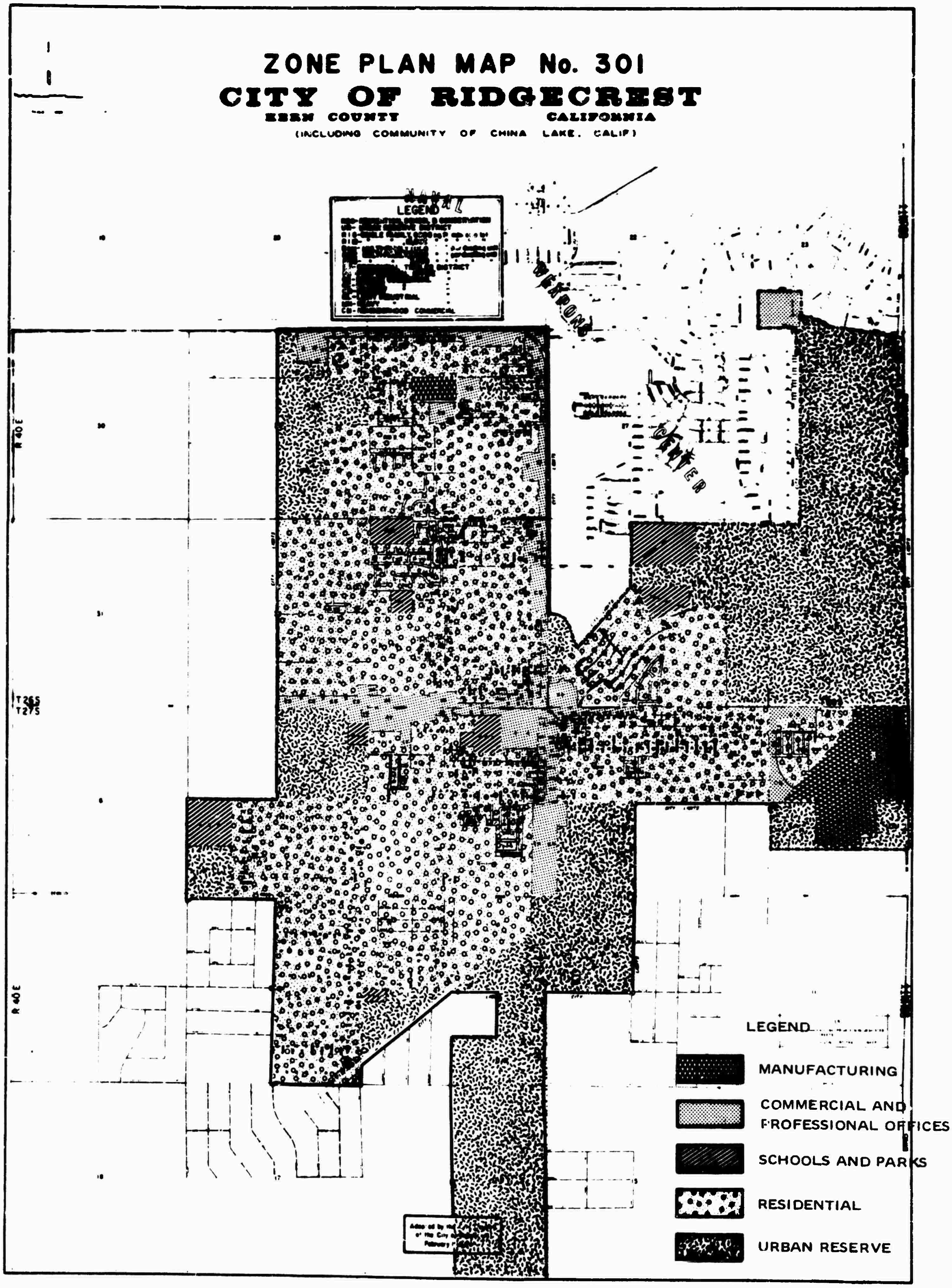

FIGURE 12. Zone Plan, City of Ridgecrest.

Land in San Bernardino County adjacent to the border of NWC properties is desert land. This land is zoned only as "open space" or "reserve."

NWC occupies a number of land areas:

		Acres
1.	NWC China Lake complex	604,695
2.	Randsburg Wash Test Range	171,656
3.	Mojave Aerial Gunnery Range "B"	315,652
4.	Mojave "B"/Randsburg Wash access road	3,846
5.	Laurel Mountain communication site	23
		1,095,872

NWC operates more than 25 test ranges and facilities, primarily in support of the Center's R&D programs. These facilities have been developed over the years in response to in-house needs arising from assigned weapon R&D projects as well as to meet the testing requirements of activities external to the Center.

The nature of the test effort can be summarized in the following general categories:[1]

1. Flight and firing tests of conventional and tactical munitions.
2. Flight tests of aircraft armament, fire control, and electronic countermeasure systems.
3. Environmental tests of inert and live ordnance.
4. Propulsion static tests of rocket motor propulsion systems.
5. Ordnance ground tests of fuzes, small and medium caliber guns, warheads, pyrotechnics, explosives, explosive propogation, etc.
6. Various specialized tests including high-speed track tests, CVA conflagration control tests, aircraft combat survivability tests, and tests of electro-optical sensors.

In addition, Fleet squadrons make significant use of NWC lands and airspace for operational training.

The majority of the test ranges and facilities required to support the work described above are located in the main China Lake complex with the balance in the Mojave "B"/Randsburg Wash area. Many of these test facilities and ranges overlap, sharing common airspace, landspace, instrumentation, and floating work crews. The varied terrain (flat, broad valleys, mountainous, isolated canyons, etc.) is required to meet the technical operational, and safety requirements of test programs.

It should be noted that the land and airspaces in Mojave "B" also provide operating areas for free-aerial gunnery, armament testing, drop zones, training, and remote piloted vehicle flights not only by the Navy but also by other co-users of the California Restricted Airspace R-2508, principally the Air Force's Flight Test Center at Edwards and the Production Flight Test Facility at Palmdale. The Mojave "B"/Randsburg Wash area is also used by the Center for the conduct of extremely high hazard or sensitive operations.

NWC does make limited use of small parcels of lands external to its boundaries in support of technical operations. Such uses are usually of short duration (such as a radar emitter site) or semi-permanent (such as a TV relay station). Looking toward the future, the Center has been engaged in discussions with local authorities regarding intermittent use of public lands contiguous to the Center as impact/operating areas in support of anticipated future RDT&E requirements of long range standoff air weapons and long range gun systems. The Center does not propose to acquire these lands but to obtain only authority to co-use, on an intermittent basis, whenever requirements dictate. Such use, in conjunction with use of adjacent Fort Irwin lands would provide flight lines and impact sites for future very long-range gun systems.

Airspace. NWC's restricted airspace, assigned by the Federal Aviation Agency, consists of the following areas:

R-2505 - surface to infinity
R-2524 - surface to infinity
R-2506 - surface to 6,000 feet msl
R-2508 - 20,000 feet msl to infinity

R-2508, covering 12,136 square miles, also encompasses restricted areas R-2502, R-2509, and R-2515, controlled by Fort Irwin, George Air Force Base, and Edwards Air Force Base, respectively,. These activities, plus Air Force Plant #42 at Palmdale comprise the membership of the R-2508 Complex Control Board, who share use of all restricted airspace within R-2508.

Airspace R-2508 overlays a portion of Death Valley National Monument and Kings Canyon-Sequoia National Park. Current policy of the Federal Aviation Agency on avoidance of sonic booms over national parks and monuments does affect and limit air operations and use of this airspace.[2]

Transportation Systems. The NWC vicinity is served by major highways State 14 and U.S. 395 connecting with Los Angeles and San Bernardino on the south and Reno to the north. State Route 178 connects with the Sierra Nevada mountains to the west and Trona to the east. An Inyo County road provides a connection from the terminus of State Route 178 to Death Valley.

NWC is served by two commercial airlines at Inyokern which connect to Los Angeles International Airport. Assorted rail, truck, and bus lines also serve Indian Wells Valley.

Recreational Resources. The Center operates an extensive recreation program for the benefit of the military personnel, civilian populace residing in Center housing, and employees who reside off Center. The annual budget for the NWC recreation program is $450,000. Almost all of the income is produced by the profits from the Employee Services Board's commercial activities and by user-pay charges.

The City of Ridgecrest does not have any parks at present. There is a County park within the City for which Ridgecrest plans eventually to assume the responsibility. The City also has acquired a number of parcels of land recently to create small neighborhood parks. Two years ago the City constructed a modern outdoor swimming pool complex.

Kern Desert Regional Park: A 106-acre park area purchased from the Center in June 1969. It has not yet been developed due to lack of funds. The only improvement to date has been the donation by the Center of an entrance feature at the time of the dedication of the park. A Kern County services facility is currently being constructed on a portion of this land.

County Park, City of Ridgecrest: Grassed area, playground equipment, activities building, picnic tables, tennis courts, outdoor basketball.

County Park, Inyokern: Grassed area, playground equipment, activities building, picnic table, shelter, outdoor basketball.

Red Rock Canyon State Recreation Area: An ultimate 6,700-acre park area designated by the State of California in August 1968. Located 35 miles southwest of the China Lake community area, it contains magnificent specimens of erosion-created multihued cliffs and canyons. Lacking water, it provides only "dry" campgrounds at present but negotiations are underway between the State and Los Angeles City Department of Water and Power to provide water from the Los Angeles' Bishop to Los Angeles aqueduct, which is near the park area.

Located within 65 miles of the China Lake Community area are Death Valley National Monument, Kings Canyon-Sequoia National Park, and Sequoia and Inyo National Forests. Death Valley National Monument is east of the Center with well-developed visitor facilities and highway access. West of NWC is the Sierra Nevada, where the Domelands Wilderness, as well as National Forest and Bureau of Land Management recreation facilities are located. The John Muir Wilderness and Kings Canyon-Sequoia National Park are located a short way north in the Sierra Nevada. Outside the wilderness area, the lands are under multiple use management, combining cattle grazing, logging, hunting, fishing, and other recreation uses.

Another attraction is Isabella Lake, a flood control and irrigation water storage reservoir operated by the U.S. Corps of Engineers. This lake has been developed jointly by the Corps and the County of Kern into a major attraction for swimming, fishing, speedboating, water skiing, and sailing activities. Forest Service campgrounds are located along the Kern River north of Isabella Lake.

Thousands of acres of national resource lands (formerly called public lands) administered by the Bureau of Land Management are open to designated public uses. These include rock hounding, motorcycle riding, hiking, hunting, and the like. In November 1973 the Bureau of Land Management published its "Interim Critical Management Plan" designating uses permitted on natural resource lands. Much of the open land surrounding the Center is national resource land.

Wilderness Resources. An abundance of wilderness resources is located in the vicinity of NWC. The Wilderness Act of 1964 (P.L. 88-577) directed the Secretaries of Agriculture and Interior to review every roadless area of at least 5,000 contiguous acres in national parks, forests, monuments, and refuges for suitability for preservation as wilderness. This process will be complete by 1975.

So far, within a 200-mile radius of China Lake, 13 areas within National Forests have been designated as wilderness. These occur in a wide variety of life zones, in such mountain ranges as the Sierra Nevada, Santa Lucia, San Rafael, San Gabriel, San Bernardino, and Palomar. The total acreage of these parcels is 1,190,000 acres, or almost 10% of all the United States' designated wilderness.[3]

In addition to the National Forest wilderness, large tracts of land are currently being designated as wilderness in our National Park System. Although official totals are not yet available, an estimated additional 1,000,000 acres will be available from National Parks and Monuments within a 200-mile radius of China Lake by 1975.

Huge tracts of de facto wilderness lie within, and in proximity of, NWC. De facto wilderness is defined here to mean a roadless area of at least 5,000 contiguous acres which is publicly owned. It is estimated that between 10,000 and 20,000 square miles of land within a 200-mile radius of China Lake is de facto wilderness. This is a figure which will probably decrease in the future with continuing intrusion by off-road recreational vehicles on national resource lands.

Archeological and Historic Resources on NWC.[4]

China Lake Ranges. For several years, exploration of mineralized remains of extinct Pleistocene animals scattered on the dry bed of China Lake has been carried out by the Los Angeles County Museum of Natural History under a permit from the Department of the Interior. Paleontologists have identified a large variety of animals of the Labrean types. A few significant artifacts have been found in the same area but no conclusive associations have been established. Species of extinct animals identified include mammoth, giant bison, direwolf, saber tooth cat, camel, horse, ground sloth, eagle, as well as a few aquatic birds and a reptile.

A number of sites of prehistoric and historic interest are preserved on the China Lake Test Ranges. Outstanding arrays of prehistoric rock art are found in numerous canyons throughout the region. Most of this rock art is in the form of petroglyphs pecked, etched, or abraded onto the surface of basalt scarps. A few caves contain painted designs of unknown age. Actual ages of the petroglyphs are not known. It is generally felt by archaeologists that some may be dated at 4,000 years or more. There is evidence that the antiquity of the rock art varies, indicated by differences in the degree of repatination of the basalt surface. Two areas, Big and Little Petroglyph Canyons, were designated a National Registered Historic Landmark by the National Park Service in 1965.

Historic sites include Old Coso, a mining village that flourished in the 1860s; numerous other mine and mill sites; and miners' cabins. A few remains of old ranches, corrals, and horse traps can be found adjacent to springs.

Another historic site is the Coso Hot Springs-Devil's Kitchen area where mineral hot springs, steam vents, and fumaroles occur. Coso Hot Springs was a small health spa during the early years of the century.

Mojave "B"/Randsburg Wash Ranges. A few prehistoric sites, such as petroglyphs, rock shelters, and occupation sites, are known in the region. Scarcity of water and long distances between springs probably account for the few sites found. Historic sites such as old mines are found in the Slate Range and on Brown Mountain adjacent to Wingate Pass.

Remains of a monorail that transported minerals from an Epsom salt mine just beyond the northeast corner of the Center across Randsburg Wash and through Layton Canyon to a terminus on the east side of Searles Lake are still visible.

Wingate Pass in the northeast corner of this range area was the route of the 20-mule team borax freight wagons. This route traverses the length of the Mojave "B"/Randsburg Wash Ranges around the south end of the Slate Range to Granite Well. An early-day automobile road also ran through the north-south axis of the area from Death Valley to Mojave.

Natural Resources Management. The Center conducts a broad and vigorous program of natural resource management and conservation.[5] This program includes cooperative efforts with the California State Department of Fish and Game and U.S. Department of Interior, and archeological investigations by the Los Angeles Museum of Natural History.

Formal wildlife management programs were begun with a cooperative management agreement executed in 1962 between the Department of the Navy, NWC, the California Department of Fish and Game, and the Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior.

A Natural Resources Advisory Council composed of key NWC civilian and military personnel meets to approve annual work plans, set public hunting seasons, and recommend policy. Technical advisors to the Council are members of the California Department of Fish and Game and the Bureau of Sport Fisheries and Wildlife. The Bureau of Land Management provides technical assistance, as requested.

Rare and Endangered Species Programs. In 1969-70, surveys of portions of NWC were conducted, in cooperation with the California Department of Fish and Game, University of California, and Bureau of Sport Fisheries and Wildlife to evaluate feasibility of developing refuges for appropriate subspecies of endangered and threatened desert fish. Three sites on the China Lake Test Ranges were determined suitable for several subspecies of desert fish. An initial plant was made during the summer of 1971.

In the late summer of 1971, a pilot program was inaugurated to establish a refuge on NWC lands, in the Mojave "B" Range, for endangered desert tortoises. This was a joint program undertaken by California Division of Highways, California Department of Fish and Game, and NWC. It was the first scientific attempt to preserve a desert reptile from possible extinction due to human encroachment into its habitat. A sample population of tortoises collected by the California Division of Highways on a freeway right-of-way that will destroy a large habitat were weighed, measured, and tagged before being placed in the refuge. Four were equipped with special electronic transmitters to pioneer a telemetry technique for future management of this threatened native reptile. Subsequently, a Desert Tortoise Reserve has been established on the Bureau of Land Management land a few miles south of the Center. The refuge on NWC continues to receive tortoises of unknown origin from many sources.

Special Wildlife Surveys and Studies. In 1970, the California Department of Fish and Game, with NWC assistance, conducted extensive aerial and ground surveys to determine populations and distribution of the rare species, desert bighorn sheep. A remnant population of bighorn was found in the Argus Range (NWC China Lake Test Ranges) and in the Eagle Crags area (Mojave "B"). Consideration for re-introduction of desert bighorn sheep in these areas is pending completion of a statewide program for management of bighorn sheep.

In 1969 and 1970, the Center cooperated with two groups of mammalogists in verifying the existence of a unique subspecies of kangaroo rat in the Argus Range. Los Angeles County Museum of Natural History made two field expeditions to the Junction Ranch area, and three were made by vertebrate zoologists from University of San Diego. Both groups were interested in determining whether a differentiated species of this rodent (*dipodomys panamintinus argusensis*) still exists on the west slopes of the Argus. First described as a distinct subspecies in 1931, this small mammal and several other species are thought to be relicts of late Pleistocene times when a chain of large lakes occupied what is now the desert floor. Both groups were successful in trapping study specimens of the Argus kangaroo rat and are engaged in research on related subspecies throughout the Pleistocene drainage area. Results of their studies have not yet been published.

Counts of feral horses and burros are made annually from helicopter and on the ground on both the China Lake Test Ranges and the Mojave "B"/ Randsburg Wash Ranges. Aerial counts are made through cooperation of the Naval Air Facility, which supplies aircraft and pilots for the program. Counts are made jointly by California Department of Fish and Game, U.S. Fish and Wildlife Service, and NWC personnel.

Seasonal surveys are made of springs and seeps used by domestic stock and by wildlife. Maintenance and repair are performed as manpower and schedules permit.

A five-year program of habitat improvement was completed in 1972 when the twentieth of a programmed project for installation of artificial watering devices for game birds and small mammals was finished. Location and installation of the watering devices (guzzlers) was a cooperative project between California Department of Fish and Game and the Center.

In order to distribute game birds and small mammals over a wider area of the range by making water available, the guzzlers are located on slopes where rainwater and snowmelt can be conserved. A 900-gallon, specially designed fiber glass tank is buried in the ground. A sloping catchment channels available water into the tank. Insulation to prevent evaporation of the stored water and cover for small wildlife is provided by brush piles over the tank. Birds and small game can reach the water by a ramp that prevents drowning. Guzzlers are fenced to protect them from depredation by feral burros. Even during extremely dry years the guzzlers have held sufficient water for use by wildlife.

Tanks are supplied by California Department of Fish and Game. Material for catchments and fencing is supplied by the Center. A number of the tanks have been installed by volunteer labor performed by Boy Scout Troops and their leaders as part of their conservation merit badge work. Where terrain is such that power equipment is required for installation of the tank, the Center has furnished equipment and operators. Scouts and other volunteers replenish insulating brush piles as needed, using tree trimmings from the housing area.

This method of water conservation for use by birds and small mammals is used throughout desert areas in the Southwest and has proven to be a successful method of enhancing wildlife habitat.

Public Hunting--Upland Game. Recommendations for public hunting of upland game are made by the Natural Resources Advisory Council. 1970 was the eighth consecutive year hunting was permitted in selected areas on the China Lake Test Ranges, comprising about 260 square miles. These areas are noted in Figure 13. Determination of hunting season recommendations is made when brood counts of game birds are conducted in the late summer. Overnight camping is permitted at specified sites during hunting weekends. Hunts are open to the general public and NWC personnel. Bag counts and license enforcement are handled by California Department of Fish and Game personnel during the special hunting weekends. Hunting is limited to quail, chukar, and rabbits during the state-wide legal season. All applicable regulations of the California Fish and Game Code are in force during the special hunts.

Live Trap and Transplant Upland Game birds. Chukar (Indian red-legged partridge) were introduced to NWC lands about 1942. Conditions in this area have proved highly favorable to reproduction of the birds. Since 1954, California Department of Fish and Game personnel have live-trapped chukar and native quail from Center lands for transplant to other areas. Distribution is determined by the California Department of Fish and Game to establish or improve populations in other areas suitable for the birds.

Trapping is done outside the 260 square miles of the China Lake Test Ranges where public hunting is seasonally permitted. In 1969 and 1970, at the recommendation of NWC, chukar trapping was moved to the Mojave "B" Range. No recreation access or hunting is permitted on this range, so controlled harvesting of the populations was recommended for the benefit of the species.

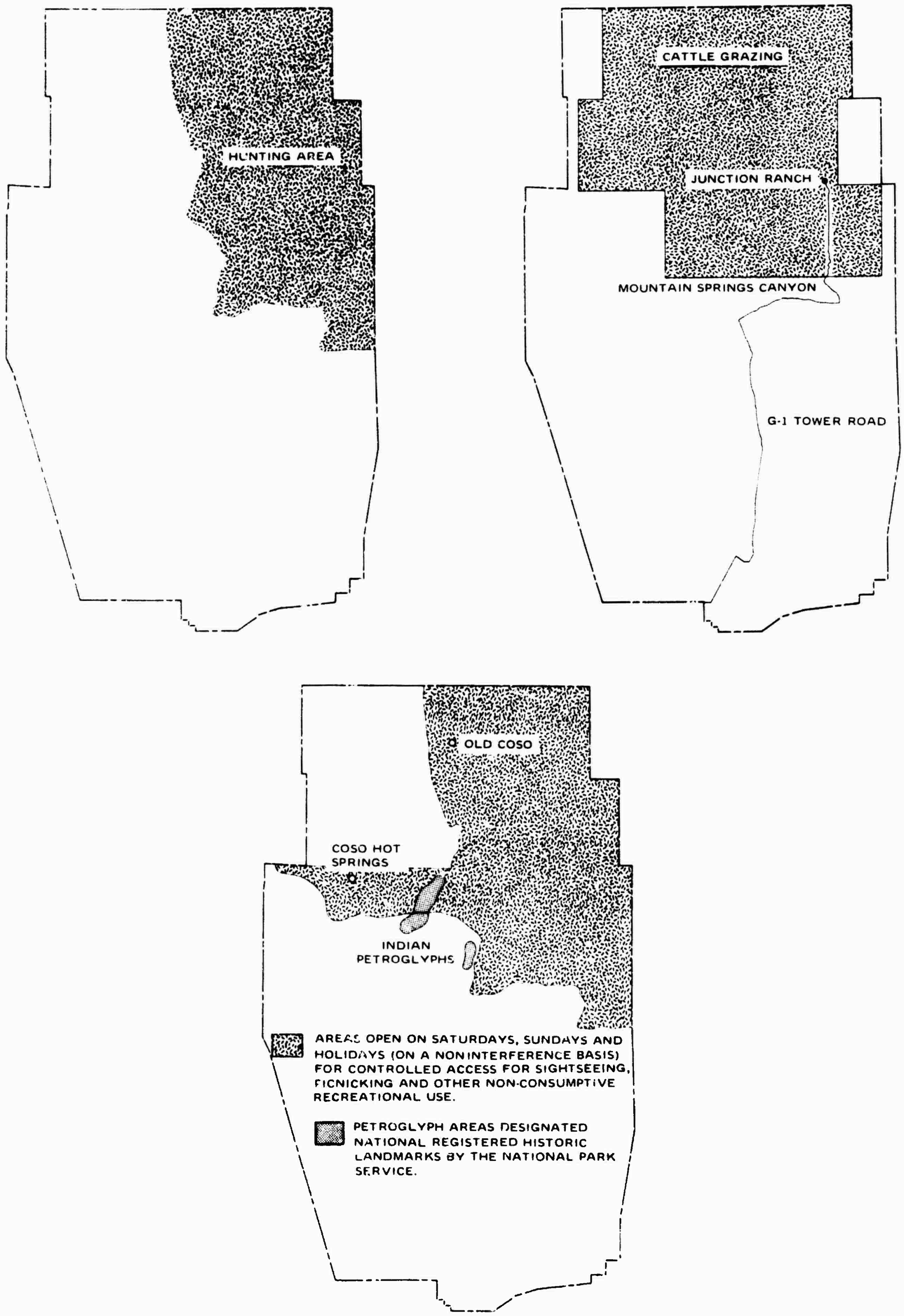

FIGURE 13. Recreational and Cattle Usage of the China Lake Test Ranges, Naval Weapons Center.

Game Bird Enhancement Program. In the summer of 1968, two exotic species of game birds, the crested tinamou and the seesee partridge, were experimentally introduced into NWC by the California Department of Fish and Game. An initial plant of 80 crested tinamous and 200 seesee partridges was made at a secluded spring in the Argus Range on NWC land. The seesees were traded from Pakistan for California quail. The crested tinamou, a ratite bird about the size of guinea fowl, is native to South America. Various species are found throughout Central and South America, north to Mexico.

Cattle Grazing. The Bureau of Land Management administers the granting of permits and outleasing of NWC lands for cattle grazing. Currently, one permittee is grazing 528 cattle in the Maturango region, and 500 in the Coso region. Cattle are also grazed on Mojave "B" Range. These areas are noted on Figures 13 and 14.

Public Access. No fees or charges of any kind are made for recreational use of the China Lake Test Range by NWC. Requests for access by the public are handled through the Public Affairs Office of NWC. China Lake ranges are open for controlled public access on weekends, when range schedules permit. About 7,000 visitors are admitted annually. These areas are noted in Figure 13.

Archaeological Investigation. In March 1971, a permit was granted by the Department of the Interior, with endorsement of the Commander, NWC, for Los Angeles County Museum of Natural History to conduct archaeological investigation of three rock shelters on the North range. An additional exploration has been under way since 1969 on the dry bed of China Lake. Under permit from Department of Interior, the Los Angeles Museum of Natural History is conducting investigation of scattered artifacts found on the surface. Juxtaposition of flakes and fragmented mineralized bone of extinct Pleistocene fauna is currently being studied by paleontologists and archaeologists. Species of extinct animals identified include extinct mammals and birds classified as Labrean fauna. Man-made fluted projectile points, crescents, worked flakes, and cores have been found in apparent association with the bone fragments. No conclusions as to relationship between fossil animals artifacts have yet been drawn.

Uses by the Academic Community. An additional non-consumptive use by the public of NWC China Lake Test Ranges is field laboratory opportunity for college and university classes. On a non-interference basis, a number of academic institutions make periodic field trips to areas of special interest as part of regular class work. For example, vertebrate zoology and ornithology classes from California State University at Fresno make four to six trips per year. During such trips the students live trap, identify, study, and release a variety of small mammals, birds, and reptiles as an outdoor laboratory exercise. Ornithology classes net and band migratory songbirds in cooperation with national study programs. Other classes in geology, archaeology, and anthropology make regular visits.

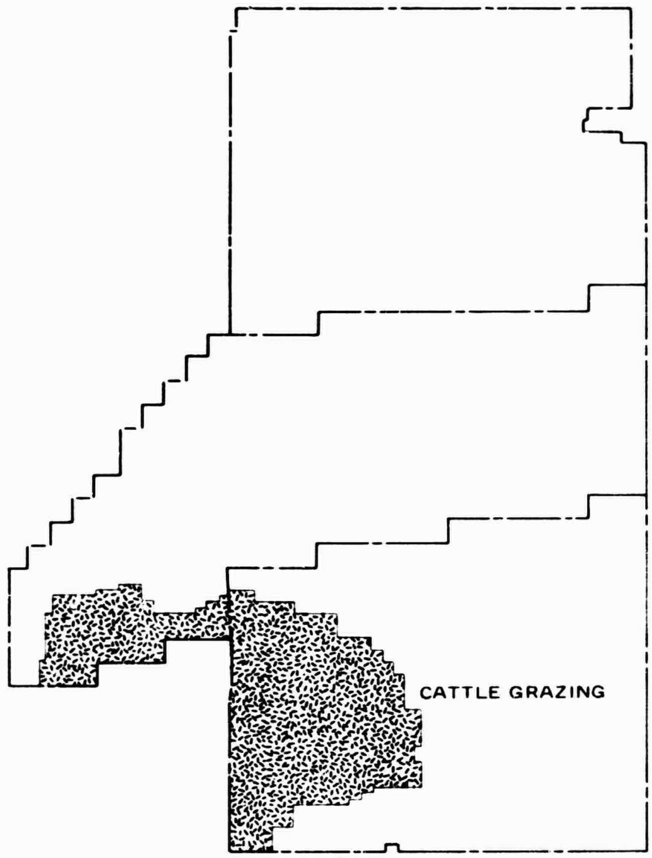

FIGURE 14. Cattle Usage of the Mojave "B"/Randsburg Wash Test Ranges, Naval Weapons Center.

Included in the institutions using the ranges of NWC for weekend study trips are University of California at Santa Barbara, Santa Barbara City College, and University of San Diego, as well as California State University at Fresno and several small private institutions. This use of the wild lands of NWC is increasing as areas of unspoiled wildlife habitat become constricted by development in areas near colleges and universities. Currently, several graduate students are conducting research for master's or doctoral degrees on NWC lands in approved study areas.

Information and Education Programs. Numerous free-lance feature writers and photographers are provided escort and assistance through the NWC Public Affairs Office when they request to tour the Center.

The Center is represented in a number of interagency groups and councils directed toward natural resources and wildlife management and conservation. Examples of these are the Desert Bighorn Council, the Desert Fishes Council, Eastern Sierra Interagency Wildlife Group, the Western Division of the Wildlife Society, and others.

Demographic Characteristics of Population

Because people who work at NWC live throughout the Indian Wells Valley (IWV), the population characteristics of the entire valley must be examined. For the purpose of taking the official census every 10 years, the NWC vicinity is broken into census tracts 53, 54, and 55.01 within Kern County.[6] For the sake of simplicity it is assumed here that the contributions of San Bernardino and Inyo Counties to the total population of IWV are negligible. This is based on the observation in 1970 that there were 31 residences in the San Bernardino County portion of IWV and 15 residences in the Inyo County portion. The total would, therefore, amount to less than 1% of the total valley population.

Figure 15 displays the delineation of census tracts 53, 54, and 55.01. Although C.T. 55.01 encompasses a large area outside of IWV, the great majority of private lands lie within the valley; therefore, it can be assumed that population data for rural IWV can be given by C.T. 55.01. As noted by the map, C.T. 54 corresponds to the City of Ridgecrest and its immediate vicinity, and C.T. 53 corresponds to the China Lake housing area of NWC. Table 4 provides population distribution data within IWV.[7] China Lake contains about half the valley's population.

Table 5 gives 1970 U.S. Bureau of Census data for C.T. 53, 54, and 55.01, and the State of California.[8,9] The California data are used as norms by which to compare the local areas.

As noted by the census data, China Lake has half the state percentage of non-white population. Ridgecrest and rural IWV have less. IWV has less than half the percentage of broken families than the state. A much greater percentage of males 16 years old or over are in the work force in China Lake; this is true to a lesser degree in the remainder of IWV. Male unemployment in China Lake is less than half that of the state. Unemployment among females in the valley is over twice that of the state. In Ridgecrest the percentage of mothers with small children who work is 1.5 times that of China Lake.

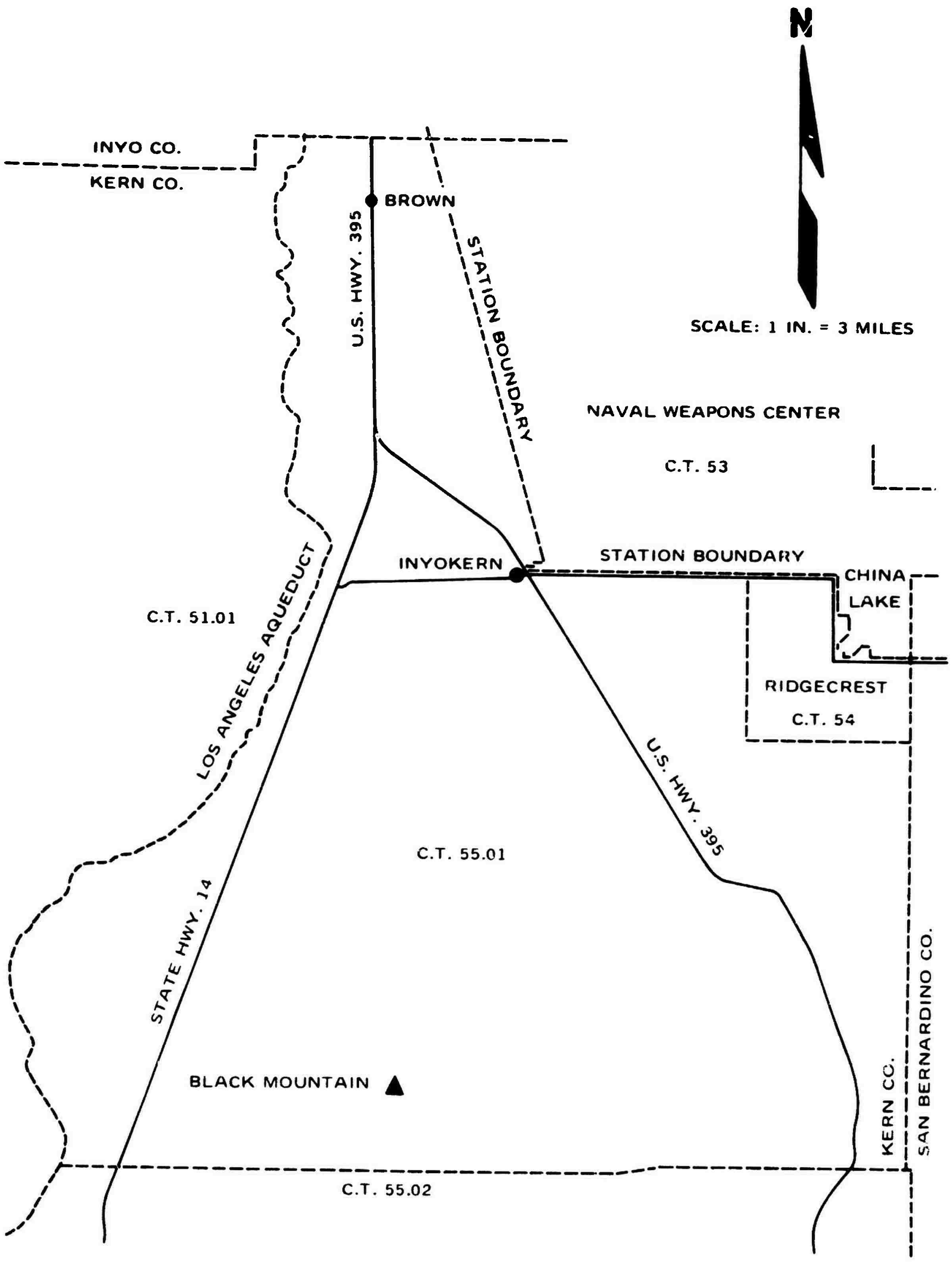

FIGURE 15. U.S. Bureau of Census Tracts for the Naval Weapons Center and Vicinity.

TABLE 4. Indian Wells Valley (IWV) Population.

Census tract	1960 U.S. Census population	1970 U.S. Census population	Projected 1980 population[a]	% of total IWV population, 1960	% of total IWV population, 1970	Projected % of total IWV population 1980
53 (China Lake, NWC)	11,748	11,105	10,800	65	52	45
54 (Ridgecrest and vicinity)	5,506	8,499	10,500	31	40	44
55.01 (rural IWV)	716	1,738	2,700	4	8	11
Total IWV	17,970	21,342	24,000	100	100	100

[a] Provided by Kern Co. Planning Commission.

The 1969 median family income in China Lake was 28% higher than that for California. The remainder of IWV was approximately the same as the state. Over half the families in China Lake had other income sources, such as private investments and military retirement, while the figure for the remainder of IWV was less than one-third. The percentage of families receiving public assistance or welfare in China Lake was about one-third that of the state; however, rural IWV had over the state average.

As of January 1973, NWC had 137 positions filled by Ph.D. graduates, whose average salary is $24,100. NWC had a total of 1,664 positions filled by persons having at least a bachelor's degree, whose average salary was $20,100. NWC had 2,857 positions filled by non-college graduates, whose average income was approximately $12,200. Average salary paid by NWC was in excess of $15,000.

The median number of rooms per housing unit in China Lake is slightly less than that of Ridgecrest, while slightly greater than that of rural IWV. The median number of people per occupied unit in China Lake is greater than in Ridgecrest and much greater than in rural IWV. The median rent paid by residents of China Lake is 18% less than the state median rent; Ridgecrest rent is 8% less, while rural IWV is 25% less than the state. The median value of owner-occupied units in Ridgecrest is 72% that of the state, while the median value in rural IWV is 49% that of the state.

In conclusion, the population of the valley has stable family and employment characteristics. The expendable income is high, as reflected in the fact that China Lake makes 28% more money and pays 18% less rent than the state median. This is also reflected in rural IWV, where housing values are less than half that of the state, while income remains the same.

TABLE 5. 1970 Demographic Data by Census Tract for Project Vicinity.

Item	Census Tract 53 (China Lake)	Census Tract 54 (Ridgecrest)	Census Tract 55.01 (project vicinity)	California
Total population	11,105	8,499	1,738	19,957,715
Percent Negro	2.6	1.5	0.1	7.0
Percent other	2.9	1.3	1.0	3.5
Persons per household	3.35	3.05	2.79	...
Type of family:				
All families	2,716	2,268	490	5,001,255
Percent husband-wife families	93	91	92	85.5
Percent families with male head	2	2	2	3.0
Percent families with female head	4	7	6	11.5
Employment status:				
Male, 16 years old and over:	3,912	2,812	654	6,808,039
Labor force	3,590	2,413	510	...
Percent of total	91.8	85.8	78.0	72.6
Civilian labor force	2,592	2,408	506	...
Employed	2,537	2,318	466	...
Unemployed	55	90	40	...
Percent of civilian labor force	2.1	3.7	7.9	4.3
Female, 16 years old and over:	3,278	3,970	658	7,234,678
Labor force	1,405	1,402	253	...
Percent of total	42.9	47.2	38.4	42.1
Civilian labor force	1,396	1,402	253	...
Employed	1,293	1,318	236	...
Unemployed	103	84	17	...
Percent of civilian labor force	7.4	6.0	6.7	2.9
Not in labor force	1,873	1,568	405	...
Married women, husband present:	2,581	2,096	478	...
In labor force	1,059	981	176	...
With own children, under 6 years	959	557	101	...
In labor force	234	204	33	...
Percent of married women, husband present, with own children under 6 years, in labor force	24.4	36.6	32.7	...
Class of worker:				
Total employed, 16 years old and over:	3,830	3,636	702	..
Private wage and salary workers	617	1,814	313	...
Government workers	3,171	1,513	293	...
Local government workers	247	372	54	...
Percent government workers	82	42	42	...
Self-employed workers	42	286	96	...
Unpaid family workers	...	23	...	...
Income:				
1969 median family	$13,760	$11,058	$10,213	$10,732
1969 mean family	$14,030	$12,397	$10,092	$12,226
1969 unrelated individuals:				
Median	$3,572	$3,200	$2,444	$ 3,221
Mean	$6,543	$5,702	$3,228	$ 4,735

TABLE 5. (Contd.)

Item	Census Tract 53 (China Lake)	Census Tract 54 (Ridgecrest)	Census Tract 55.01 (project vicinity)	California
Type of income in 1969 of families:				
All families	2,727	2,347	540	...
With wages or salary income	2,732	2,170	434	...
Mean wage or salary income	$13,468	$11,298	$10,612	$11,098
With nonfarm self-employment income	107	277	87	...
Mean nonfarm self-employment income	$2,082	$8,795	$4,724	$ 9,016
With farm self-employment income	44	21	25	...
Mean farm self-employment income	-$264	...	-$226	$ 4,286
With Social Security income	69	312	98	...
Mean Social Security income	$980	$1,516	$2,252	$ 1,677
With public assistance or public welfare income	48	81	35	...
Percent of total families	1.8	3.5	6.5	4.8
Mean public assistance or public welfare income	$1,141	$763	$1,244	$ 1,464
With other income	1,383	693	169	...
Percent with other income	51	29	31	40
Mean other income	$1,020	$2,203	$1,034	$ 2,644
All housing units:				
Owner-occupied	27	1,984	499	...
Renter-occupied	3,142	804	124	...
Vacant year-round	231	184	57	...
For rent	228	90	10	...
Vacant less than 2 months	228	71	8	...
Median rent asked	$49	$106	$95	...
Other	3	56	41	...
Rooms:				
Median rooms per unit	4.4	4.7	4.0	...
All occupied housing units	3,169	2,788	623	...
Persons:				
Median, all occupied units	3.2	2.6	2.3	...
Median, owner-occupied units	3.7	2.7	2.3	...
Median, renter-occupied units	3.2	2.5	2.1	...
Units with roomers, boarders, or lodgers	5	44	6	...
Persons per room:				
1.00 or less	2,195	2,573	566	...
1.01 to 1.50	216	170	33	...
1.51 or more	34	45	24	...
Units with all plumbing facilities—1.01 or more	252	215	52	...
Contract rent:				
Specified renter-occupied units[a]	3,117	795	113	...
Median	$97	$109	$88	$ 118
Other occupied units	...	1,456	189	3,160,337
Median value	...	$18,900	$12,900	$26,116

[a] Excluded one-family homes on 10 acres or more.

Economic Base

Location of the Center in eastern Kern County enhances the economy of a sparsely populated area by a total annual budget (fiscal year 1972) of $166 million, of which $71 million is payroll. NWC employs approximately 1,000 military personnel and 4,500 civilians.

Evolution of the City of Ridgecrest, with its healthy economy, is a direct outgrowth of the location of NWC in Indian Wells Valley. Little economic benefit is derived by the community from highway or tourist traffic. Without the Center, the City of Ridgecrest would be hard put to maintain economic vigor. Location of the community, physiographic features, soils limited water resources, and climate offer scant potential for other economic opportunity.

NWC attracts to the area representatives of many phases of industry and development. Many of these maintain facilities in the immediate area. Such facilities range from assigned consulting and sales personnel to permanent branch offices or plants.

There are three manufacturing plants in the community area. These are Kerr-McGee Chemical Corporation, Stauffer Chemical Company, and Arrowsmith Tool and Manufacturing Corporation. In the nearby Trona area, Kerr-McGee Chemical Corporation and the Stauffer Chemical Company operate large chemical mining and processing operations. This major industrial complex has been on a firm and constant expansion program for some 50 years.

The following data[10] are provided for the Indian Wells Valley Labor Market Area in September 1971, which includes Trona-Argus areas of Searles Valley, Ridgecrest, China Lake (NWC), Inyokern, and Randsburg. The estimated area population was 28,000.

Persons employed:

280	Construction	1,000	Retail trade
1,100	Manufacturing	50	Wholesale trade
400	Trans/comm/utilities	125	Finance/real estate/insurance
850	Services	5,500	Government
1,051	Military personnel	---	Agriculture

Payrolls:

Naval Weapons Center	$ 70,500,000
Utility	1,585,000
Contractors	3,015,000
Schools	3,683,500
Chemical companies	14,437,500
All other	11,865,000
	$104,586,000

The following table historically traces the building permits issued for the City of Ridgecrest:

Year	No. permits issued	Total dollars
1965	230	$1,855,860
1966	272	3,187,794
1967	211	2,630,450
1968	270	3,789,791
1969	290	3,787,779
1970	385	6,359,747

Taxable retail sales in 1970, according to the California State Board of Equalization, were $22.74 million from 255 outlets.

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10. Ridgecrest Chamber of Commerce, 1971. Community Characteristics, Ridgecrest and Indian Wells Valley.

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8. American Association of University Women, China Lake Branch, 1967. Indian Wells Valley Handbook.

INVENTORY OF NWC ACTIONS HAVING POTENTIAL ENVIRONMENTAL IMPACT

ACTIVITIES AFFECTING AIR QUALITY

NWC Tests and Evaluation

Flight, Firing, and Ordnance Ground Tests. A total of 39,057 pounds of rocket propellant was used in 1971. EG+G, Inc. (1971)[1] and NWC have derived emission factors for aluminized composite propellants, assumed to consist of 15% Al, 71% NH_4ClO_4, and 14% hydrocarbon binder. The emission factors are as follows:

Emission factor. lb/lb fuel

Pollutant	EG+G	NWC
HCl	0.21	0.22
CO	0.28	0.25
Particulate (Al_2O_3) . .	0.34	0.21
NOx	0.068	$<10^{-6}$
Hydrocarbons	<0.01	<0.01

Then, assuming all rocket propellant was of the composition above and using EG+G data, then the following emissions resulted in 1971:

4.1 tons HCl, 5.5 tons CO, 6.6 tons Al_2O_3, and 1.3 tons NOx.

A total of 205,119 pounds of high explosives was used by NWC in 1971. Emission factors for three different high explosives provided by the Propulsion Development Department, NWC, are as follows:

Emission factor, lb/lb fuel

Pollutant	HBX	Composition B	TNT
CO	890	940	1200
C	12	<0.01	170
CH_4	<0.01	1.6	4.2
Al_2O_3	49	<0.01	<0.01
Al	22	<0.01	<0.01

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High explosives use is distributed among a large number of similar compositions. However, a large percentage of use is made up of the three compositions above. Making the simplifying assumption that all high explosives use is evenly distributed among HBX, Composition B, and TNT, then the following emissions result:

52 tons CO, 3.2 tons C, 0.1 ton hydrocarbon, 0.9 ton Al_2O_3, and 0.3 ton Al.

A total of 10,182 pounds of smokeless powder was used by NWC in 1971. No emissions factors are yet available. However, the emissions are similar to those of some explosives, and the usage is only 5% that of explosives. Therefore, it may be assumed within 5 to 10% error that emissions from smokeless powder are insignificant with respect to high explosives.

Propulsion Static Tests. A total of 12,480 pounds of aluminized composite propellant was used in 1971. Using the aforementioned emission factors for the propellant, the following emissions result:

1.3 tons HCl, 1.6 tons CO, 2.1 tons Al_2O_3, and 0.42 ton NOx.

A total of 15,565 pounds of liquid fuel and propellants was used in 1971, of which a great majority consisted of ethylene and propylene oxides (EO and PO). Although no quantitative emissions factors are available, only CO and NOx would be significant pollutants, with NOx at a much lower relative level. Let it, therefore, be assumed that 1 ton of CO was produced from the 7.8 tons of EO and PO, and less than 0.1 ton of each of the other pollutants was produced.

Environmental Tests. A total of 72,000 gallons of JP-5 fuel was burned outdoors in shallow pans in an unconfined turbulent fashion. Emission factors derived from a McClellan Air Force Base (1971)[2] study of JP-4 fires are as follows:

Pollutant	Emission factor, lb/lb fuel
Particulates	
Solid	0.131
"Condensible"	0.064
Total	0.195
CO	0.204
CH_4	0.024
C_2H_4	0.029
Acetylene	0.009
Formaldehyde	0.011
NOx	0.003

Emissions factors for this type of burning of JP-4 fuel have been generated by Kirtland Air Force Base (1973).[3] They are as follows:

Pollutant	Emission factor, lb/lb fuel
CO	<0.56
NOx	0.0042
Hydrocarbons	0.137
Particulates	0.128
SOx	<0.001

Assuming JP-5 emissions are the same as JP-4, then the following emissions would result from 48,000 gallons burned:[4]

0.7 ton NOx, 22 tons particulates, 23 tons hydrocarbons, 95 tons CO, and less than 0.2 ton SOx.

Polycyclic aromatic hydrocarbons are produced by open burning of JP-4 and JP-5 fires. Emissions factors are provided by the Environmental Protection Agency (EPA) (1972).[5] The following table shows resultant quantities due to environmental tests.

Compound	Pounds produced, NWC, 1971
Naphthalene	1.6
Acenaphthylene	1.0
Fluorene	2.2
Phenanthrene/Anthracene	8.7
Methyl phenanthrenes	13
4,5 - Methylene phenanthrene	6.3
Fluoranthenes	19
Pyrene	29
Benzofluorenes	4.8
Methyl pyrenes	2.1
Benzo (m,n,o) fluoranthene	7.3
Benzoanthracene/Chrysene	12
Benzo fluoranthenes	9.2
Benzo (a)pyrene, Benzo (e)pyrene and perylene	11
Indeno (1,2,3-c,d) pyrene	9.6
Benzo (g,h,i) perylene	7.5
Anthanthrene	2.5

Approximately 7,350 pounds of solid propellant and explosive were used in environmental testing. Using the aforementioned emissions factors for aluminized composite propellants and high explosives, the following emissions result:

0.17 ton NOx, 0.85 ton Al_2O_3, 0.7 ton CO, and 0.53 ton HCl.

Specialized Tests. The NWC supersonic naval ordnance research track (SNORT) in the testing of rockets and missiles used 53.3 tons of propellants and 20 tons of explosives in 1971. Using the aforementioned emissions factors for composite aluminized propellant and high explosives, the following emissions result:

3.6 tons NOx, 24 tons CO, 0.03 ton hydrocarbons, 0.85 ton non-Al_2O_3 particulates, 18 tons Al_2O_3, and 11 tons HCl.

The CVA and minideck conflagration control tests open-burned a total of 156,000 gallons of JP-5 fuel in 1972. Using the Kirtland Air Force Base (1973)[6] emissions factors for open-burned JP-4, the following emissions result:

2.4 tons NOx, 320 tons CO, 68 tons hydrocarbons, less than 0.6 ton SOx, and 73 tons particulates.

Using the EPA (1972) data,[7] the following amounts of polycyclic aromatic hydrocarbons were produced:

Compound	Pounds produced, 1971
Naphthalene	5.2
Acenaphthylene	3.4
Fluorene	7.2
Phenanthrene/Anthracene	28
Methyl phenanthrenes	44
4,5 - Methylene phenanthrene	21
Fluoranthenes	63
Pyrene	98
Benzofluorenes	16
Methyl pyrenes	6.9
Benzo (m,n,o) fluoranthene	24
Benzo (a)pyrene, Benzo(e)pyrene and perylene	38
Indeno (1,2,3-c,d) pyrene	32
Benzo (g,h,i) perylene	25
Anthanthrene	8.3

NWC Waste Pyrotechnics, Explosives, and Propellants (PEP) Disposal

Explosives Ordnance Disposal (EOD). Waste PEP consisted in 1971 of 3.2 tons pyrotechnics, 178 tons explosives, and 34.5 tons propellants. A wide variety of compounds was used in each category. A total of 182.5 tons or 98% of explosives was in the form of plastic explosives such as HBX and most propellants were composite. Therefore, let it be assumed that the emissions are the result of only HBX and composite propellants, for which data are known. Using NWC emissions factors, the following emissions would then result from explosives disposal:

83 tons CO, 1.2 tons C, 2.0 tons Al, 4.6 tons Al_2O_3, and 2.3 tons NOx.

Propulsion Department Disposal. Waste PEP consisted in 1971 of 1.0 tons pyrotechnics, 4.9 tons explosives, and 17.2 tons propellants. A wide variety of compounds was used in each category. Let it be assumed that explosives, usage was evenly divided among HBX, Composition B, and TNT, for which NWC emissions data are available. The following emissions would then result:

2.4 tons CO, 0.15 ton C, less than 0.01 ton CH_4, and 0.057 ton Al_2O_3.

Assuming that all propellants were aluminized composite propellants, then the following emissions would result:

3.6 tons HCl, 4.8 tons CO, 5.8 tons Al_2O_3, and 1.2 tons NOx.

NWC Industrial Operations

Large Boilers. Plants 1 through 5 are the largest boilers on NWC and the only ones which use #6 residual fuel oil. The usage was as follows in 1972: Plants 1 and 2, 49,952 gallons; Plants 3 and 5, 54,322 gallons; and Plant 4, 146,151 gallons. In addition, the following amounts of natural gas were used in 1972 at the largest plants: Plant 1, 215 million cubic feet; Plant 2, 98.1 million cubic feet; and Plant 4, 99.0 million cubic feet. The Environmental Protection Agency (1973)[8] compiled emission factors for boiler plants using residual oil and natural gas. Using these data, the following estimates are made of pollution generated from large NWC boilers in 1972:

Pollutant	Tons
SO_2	24
SO_3	0.30
Particulates	6.9
CO	4.1
Hydrocarbons	2.0
NOx	31

Housing and Small Boiler Use of Natural Gas. NWC housing and miscellaneous operations used 369 million cubic feet of natural gas and 1.20 million gallons of propane in 1972. Using the emission factors provided by EPA (1973),[9] the following pollutants resulted in 1972:

18 tons NOx, 3.7 tons CO, 1.5 tons hydrocarbons, 0.11 ton SOx, and 3.5 tons particulates.

Volatile Liquid Storage and Handling. NWC has a fuel farm located at the Naval Air Facility, consisting of six underground storage tanks which are all pressure vented to prevent vapor loss. Individual tank information is as follows:

Tank size, gal	Fuel stored
100,000	JP-5
100,000	JP-5
50,000	JP-5
50,000	JP-5
50,000	JP-4
50,000	Aviation gas

Environmental Protection Agency (1973)[10] computed emission factors for storage and handling of volatile liquids. Assuming an 11 pound per 1,000 gallon throughput working loss, and a throughput of 2.4 million gallons, then 13 tons of hydrocarbons result annually.

Solvents Use. Table 17 provides a categorical listing of 1972 solvent demand at NWC. A number of the solvents, including trichloroethane, acetone, ethanol, and methanol are virtually unreactive in the formation of oxidants (Altshuller, 1966).[11] This reduces the total amount of possible photochemically reactive solvents to less than 12,000 gallons annually. Assuming an average density of 7 lb/gal, the annual total photochemically reactive solvent demand at NWC is about 84,000 pounds. Although some use of the solvents is dispersed geographically over the entire station, most of the use is confined to the industrial area of NWC, totaling about 30 to 50 square miles. Assuming that all the solvent is evaporated, then approximately 42 tons of photochemically reactive hydrocarbons are emitted annually.

Incineration. NWC burns non-water soluble classified material in a typical small-scale single chamber incinerator. Burning, which lasts an average of 3 hours, is done weekly. An average of 1.5 tons per week is burned, consisting mostly of plastic, typewriter ribbon, and glossy papers. Using EPA (1973)[12] emissions factors for emissions from a typical small-scale domestic single chamber incinerator without a primary burner, the following estimates are made of emissions during 1972:

> 1.4 tons particulates, 0.02 ton SO_x, 120 tons CO, 39 tons hydrocarbons, and 0.039 ton NO_x.

Because the high percentage of plastics consumed by classified burning operations is not representative of the average inputs for the EPA (1973) emission factors,[13] the emissions above should be considered speculative.

Fire Division Practice. The NWC Fire Division conducts weekly fire fighting practice near the Naval Air Facility. In each episode, 700 to 800 gallons of JP-5 fuel are open-burned for approximately 3 minutes. An estimated total of 35,000 gallons per year is burned for this operation. Emission factors derived from a Kirtland Air Force Base (1973) study[14] of open JP-4 fires are as follows:

Particulates	0.128 lb/lb fuel
NOx	0.0042 lb/lb fuel
CO	<559 lb/lb fuel

Combining the two studies results in the emission factors used in this analysis, which are as follows:

Pollutant	Emission factor lb/lb fuel
Particulates	0.0128
Hydrocarbons	0.137
Carbon Monoxide	0.56
SOx	<0.001
NOx	0.0042

Using these emission factors, the following annual emissions result from fire practice:

15 tons particulates, 16 tons hydrocarbons, 67 tons CO, less than 0.1 ton SOx, and 0.5 ton NOx.

Transportation

Aircraft. Armitage Field at NWC is the home of the Naval Air Facility and the Air Test and Evaluation Squadron Five. In 1971 there were 36,680 takeoffs and landings, of which 29,088, or 79.3% were jet operations. The predominant engine types were J-33, J-48, J-52, J-79, and TF-30. The other 20.7% of the takeoffs and landings were divided among helicopters, light piston, and transport piston aircraft.

EPA (1973) compiled emission factors[15] for aircraft by landing and takeoff cycle (LTO). The emission from the 14,544 turbojet LTOs are as follows:

81 tons particulates, 15 tons SOx, 180 tons CO, 190 tons hydrocarbons, and 37 tons NOx.

The emissions from the 3,800 remaining LTOs, assumed to all be transport piston, are as follows:

9.5 tons particulates, 0.2 ton SOx, 580 tons CO, 76 tons hydrocarbons, and 0.8 ton NOx.

Thus, total estimated annual emissions from NWC aircraft are

90 tons particulates, 15 tons SOx, 760 tons CO, 270 tons hydrocarbons, and 38 tons NOx.

NWC Official Motor Vehicles. There are 1,600 gasoline-powered government vehicles on NWC. The total gasoline consumption was 733,000 gallons in 1972, while the total diesel consumption was 169,000 gallons. Using the EPA (1973) emissions factors,[16] the following annual emissions result from government vehicles:

Pollutant	Gasoline-powered	Diesel-powered
CO, tons	850	19
Hydrocarbons, tons .	120	3.1
NOx, tons	62	31
Particulates, tons .	3.0	1.1
SOx, tons	1.8	2.3

Unofficial NWC Vicinity Vehicles. There are about 14,000 private automobiles registered on the Center. There are an additional estimated 4,300 autos not associated with NWC in Ridgecrest. Given the vehicular flow in the Ridgecrest-China Lake vicinity, it is assumed that an average of 10,000 autos per day are used, with an average of 20 miles per day driven. This gives a total of 73 million auto miles driven per year in the vicinity. Using EPA (1973) emission factors,[17] the following emissions result:

6,800 tons CO, 960 tons hydrocarbons, 490 tons NOx, 24 tons particulates, and 14 tons SOx.

Unofficial Auto Travel on Highways 395 and 14 in Indian Wells Valley. State Highway 14 and Interstate Highway 395 are major highways which carry heavy traffic from the Los Angeles metropolitan area to the south to the Sierra Nevada resorts to the north. California Division of Highways figures show that an average of 3,400 cars per day travel the highways, which pass for 31 miles through the western side of Indian Wells Valley. Using EPA (1973) emissions factors,[18] the highways contribute the following annual emissions:

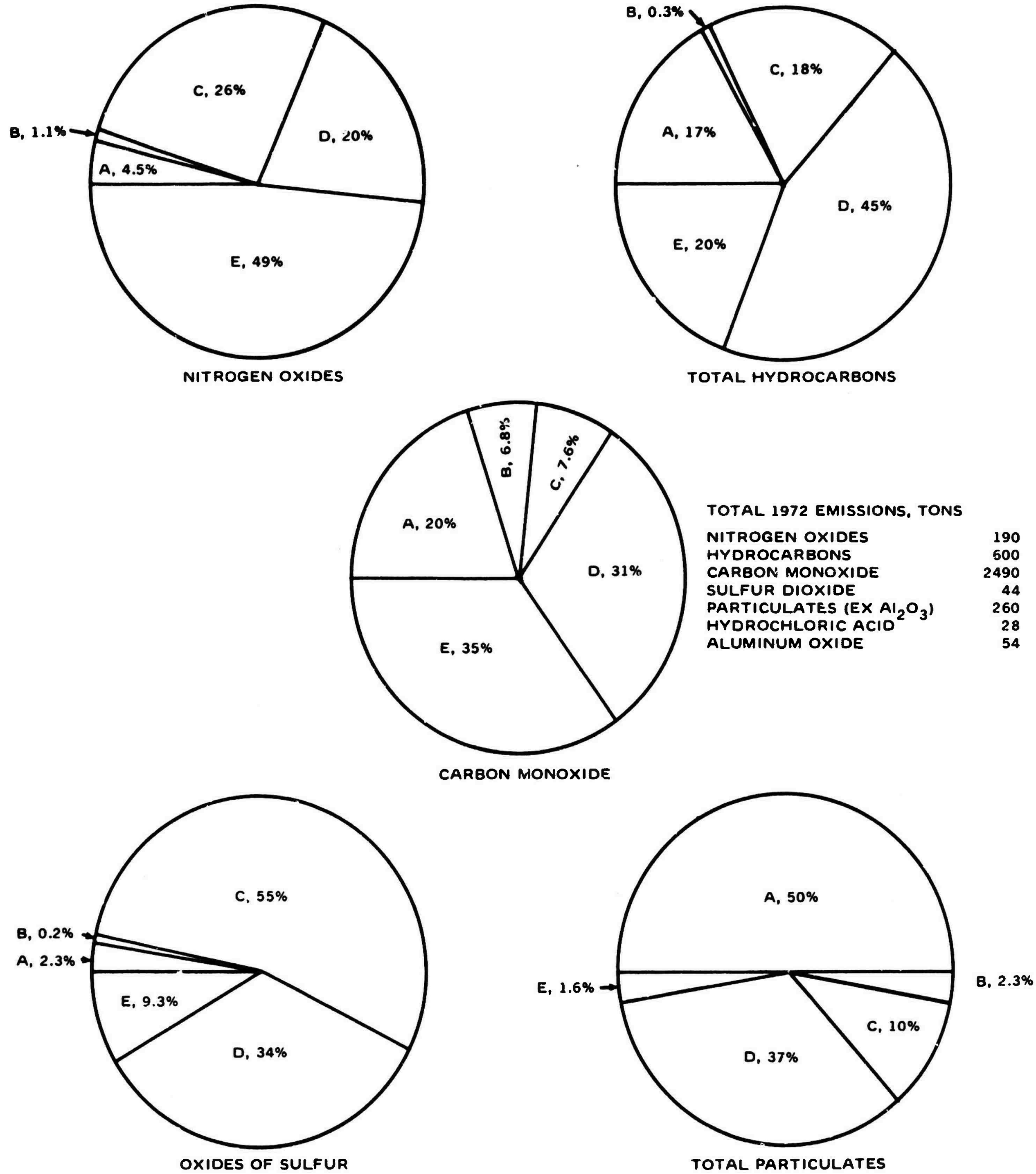
2,100 tons CO, 260 tons NOx, 390 tons hydrocarbons, 7.6 tons SOx, and 13 tons particulates.

Air Pollution Summary and Inventory

Table 6 breaks down by major category and subcategory the annual emissions resulting from NWC and automobile operations in the Indian Wells Valley. Figure 16 provides the relative distribution of emissions

TABLE 6. Annual Air Pollution Inventory for NWC and Vicinity (in Tons).

Item	NOx	CO	Hydro-carbons	SOx	Particulates		
					Excl. Al_2O_3	Al_2O_3	HCl
NWC tests:							
Flight, firing, and ordnance ground tests (excluding aircraft emissions)	1.3	57	0.1	<0.01	3.2	7.8	4.1
Propulsion static tests	0.4	2.6	<0.1	<0.01	<0.1	2.1	1.3
Environmental tests	0.9	96	23	<0.2	23	0.85	0.53
Specialized tests							
SNORT high-speed track	3.6	24	0.03	<0.01	0.85	18	11
CVA and minideck conflagration control	2.4	320	78	<0.6	73		<0.01
NWC waste pyrotechnics, explosives, and propellants disposal	3.5	100	<2	<0.1	1.4	25	11
NWC industrial operations:							
Large boilers	31	4.1	2.0	24	6.9		<0.01
Housing and small boiler use of natural gas	18	3.7	1.5	0.11	3.5		<0.01
Volatile liquid storage and handling	<0.01	<0.01	13	<0.01	<0.01		<0.01
Solvents use	<0.01	<0.01	42	<0.01	<0.01		<0.01
Classified material incineration	0.04	120	39	0.02	1.4		<0.01
Fire division practice	0.5	67	16	0.01	15		<0.01
Transportation:							
Aircraft operations	38	760	270	15	90		<0.01
Motor vehicles:							
Official	93	860	120	4.1	4.1		<0.01
Unofficial:							
Ridgecrest-China Lake autos	490	6,800	960	14	24		<0.01
Highways 395 and 14 autos	260	2,100	390	7.6	13		<0.01
Total all official operations	190	2,490	600	44	260	54	28
Total all official and unofficial operations	940	11,300	2,000	66	290	54	28



TOTAL 1972 EMISSIONS, TONS

NITROGEN OXIDES	190
HYDROCARBONS	600
CARBON MONOXIDE	2490
SULFUR DIOXIDE	44
PARTICULATES (EX Al_2O_3)	260
HYDROCHLORIC ACID	28
ALUMINUM OXIDE	54

A—NWC TESTS
B—NWC WASTE PEP DISPOSAL
C—NWC INDUSTRIAL SOURCES
D—NWC AIRCRAFT
E—NWC OFFICIAL VEHICLES

FIGURE 16. Air Pollution Emissions Inventory for Official Naval Weapons Center Activities.

from NWC official sources. It is seen that the mobile transportation sources provide the bulk of NOx, CO, and hydrocarbons. NWC tests produce half the officially generated particulates, while the industrial sources produce over half the SOx.

Figure 17 is similar to Figure 16, but the effects of private automobiles in Indian Wells Valley are included. It is seen that the private automobiles contribute over three-quarters of all NOx, hydrocarbons, and carbon monoxide to Indian Wells Valley. Surprisingly, they also contribute one-third of all the SOx, which in other communities is usually dominated by stationary heating and industrial sources.

It is possible to determine the spatial distribution of air pollution emissions throughout NWC. For this purpose, NWC was divided into a number of functional areas, and the emission sources, including unofficial automobiles, were divided among them. Table 7 summarizes the emissions originating in each area.

Using a technique analogous to that developed by MITRE (1972),[19] the relative magnitude of total air emissions for each functional area was determined. The technique is as follows:

Let A_{ij} be the annual inventory of pollutant i in functional area j

Let S_i be the national secondary standard for pollutant i, in micrograms per cubic meter

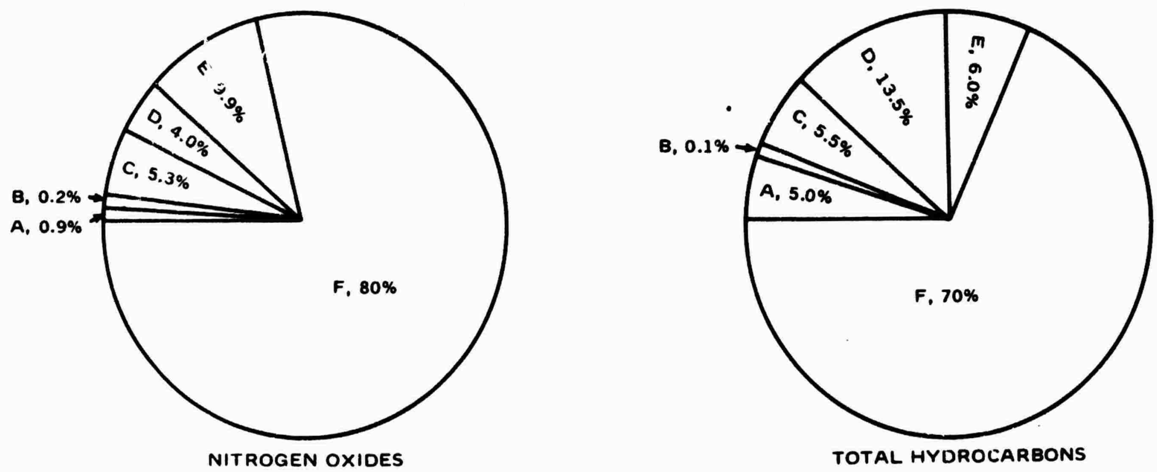
Let $B_{ij} = A_{ij}/S_i$ be the weighted inventory

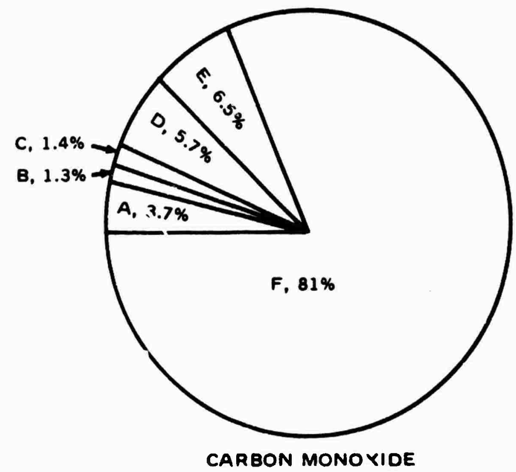
Then, let $I_j = \sqrt{\sum_i B_{ij}^2}$ be the air pollution index for area j

The results of the technique are given in Table 8. This puts the total air pollution problem in spatial perspective. The housing areas are shown to be the major contributor, followed by the Naval Air Facility. These are displayed in Figure 18.

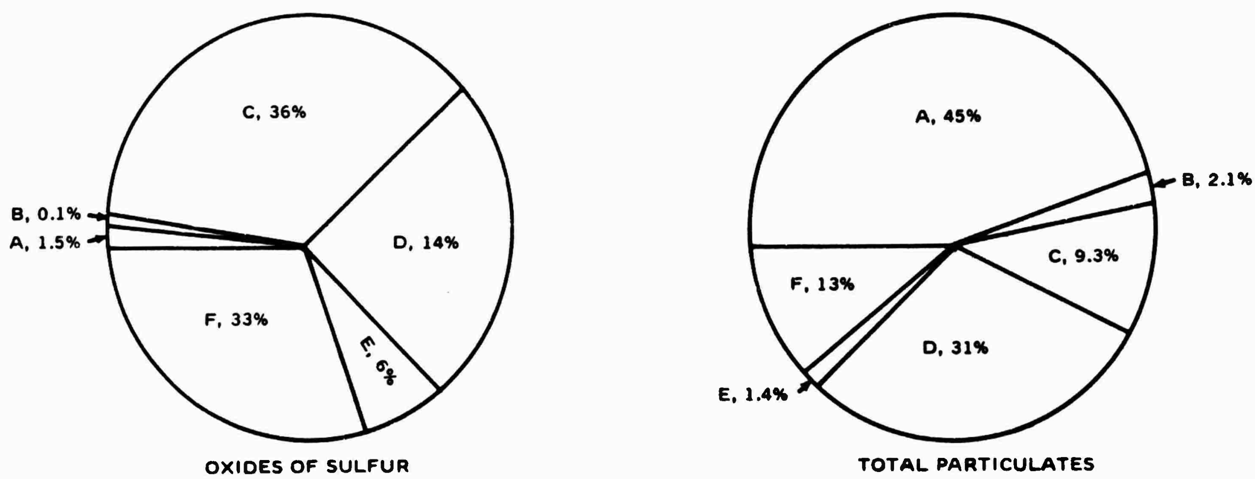
Air emission density indices were determined for each area based upon the size of each. Large functional areas would tend to have smaller density indices since emissions would be distributed over a large area. Ambient air pollution concentrations would, therefore, tend to be lower, resulting in less air pollution impact. The results are given in Table 9. Again, the housing areas and the Naval Air Facility appear to be the most "polluted." However, in comparison with the South Coast Air Basin,[20] even these areas have low air emissions densities.

Identification of all stationary sources of air contaminants at NWC, shown in Figure 19, was completed by Perliter and Ingalsbe, Inc. (1973).[21]





TOTAL 1972 EMISSIONS, IN TONS	
NITROGEN OXIDES	940
HYDROCARBONS	2000
CARBON MONOXIDE	11300
SULFUR DIOXIDE	66
PARTICULATES (EX. Al_2O_3)	[illegible]90
HYDROCHLORIC ACID	28
ALUMINUM OXIDE	54



A—NWC TESTS
B—NWC WASTE PEP DISPOSAL
C—NWC INDUSTRIAL SOURCES
D—NWC AIRCRAFT
E—NWC OFFICIAL VEHICLES
F—UNOFFICIAL VEHICLES IN INDIAN WELLS VALLEY

FIGURE 17. Air Pollution Emissions Inventory, Naval Weapons Center and Local Unofficial Automobiles.

TABLE 7. Annual Inventory of Air Emissions by NWC Functional Area (in Tons).

Functional area	NOx	Hydrocarbons	CO	SOx	Particulates
Naval Air Facility (AF)	100	410	1,500	22	110
Ground and air ranges (GR, AR)	21	98	550	1.3	92
SNORT area (SN)	20	20	170	.69	20
Michelson Lab. area (ML)	58	150	870	1.9	11
Propulsion Lab. area (PL)	64	150	820	16	36
China Lake-Ridgecrest Housing area (HC, RC)	420	740	5,300	17	26
NWC vicinity total	690	1,600	9,200	59	290
Highways 395 and 14 emissions	260	390	2,100	7.6	13
Indian Wells Valley total	950	2,000	11,300	67	300

TABLE 8. Air Emissions Indices for NWC Functional Areas.

Functional area	AP index, $I_j = \sqrt{\Sigma B_{ij}^2}$	Relative AP index, $I_{R_j} = I/I_{max}$
Naval Air Facility (AF)	3.35	0.53
Ground and air ranges (GR, AR)	1.66	0.26
SNORT area (SN)	0.41	0.06
Michelson Lab. area (ML)	1.12	0.18
Propulsion Lab. area (PL)	1.32	0.21
China Lake-Ridgecrest housing area (HC, RC)	6.29 (I_{max})	1.00
Mojave "B"/Randsburg Wash (MB, RA)	<.01	<.01

TABLE 9. Air Emissions Density Indices for NWC Functional Areas.

Functional area	Area, sq. mi. = A_j	$I_{A_j} = I_j/A_j$	Relative density, $I_{RA_j} = I_{A_j}/I_{A_{max}}$
Naval Air Facility (AF)	11.3	0.296	0.76
Ground and air ranges (GR, AR)	850	0.0020	0.0050
SNORT area (SN)	27.8	0.015	0.038
Michelson Lab. area (ML)	8.5	0.132	0.34
Propulsion Lab. area (PL)	39.0	0.034	0.087
China Lake-Ridgecrest housing area (HC, RC)	16.2	0.388 (max.)	1.0
South Coast air basin (metropolitan Los Angeles)	8,680	1.11	2.86

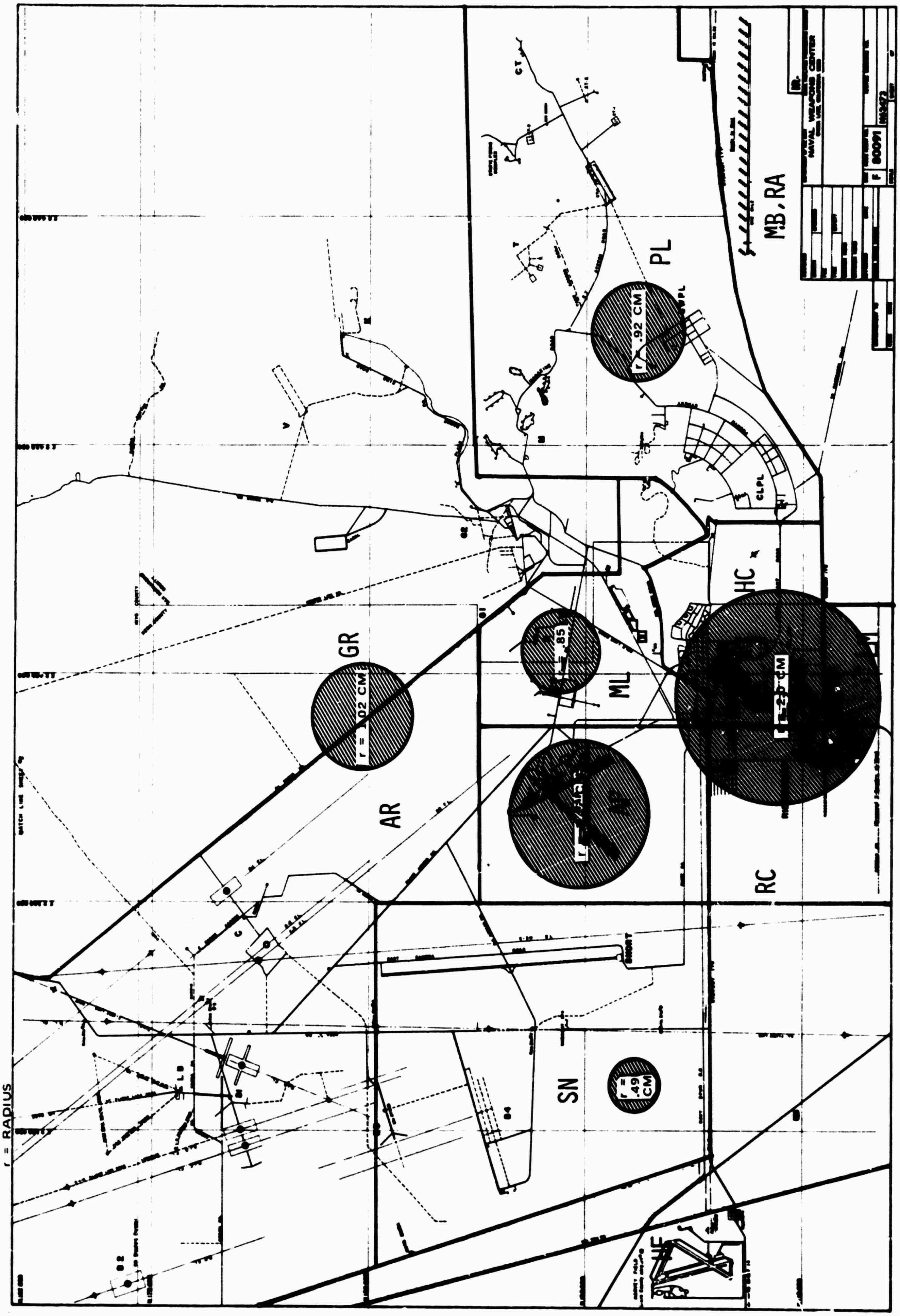


FIGURE 18. Air Pollution Indices by Naval Weapons Center Functional Area.

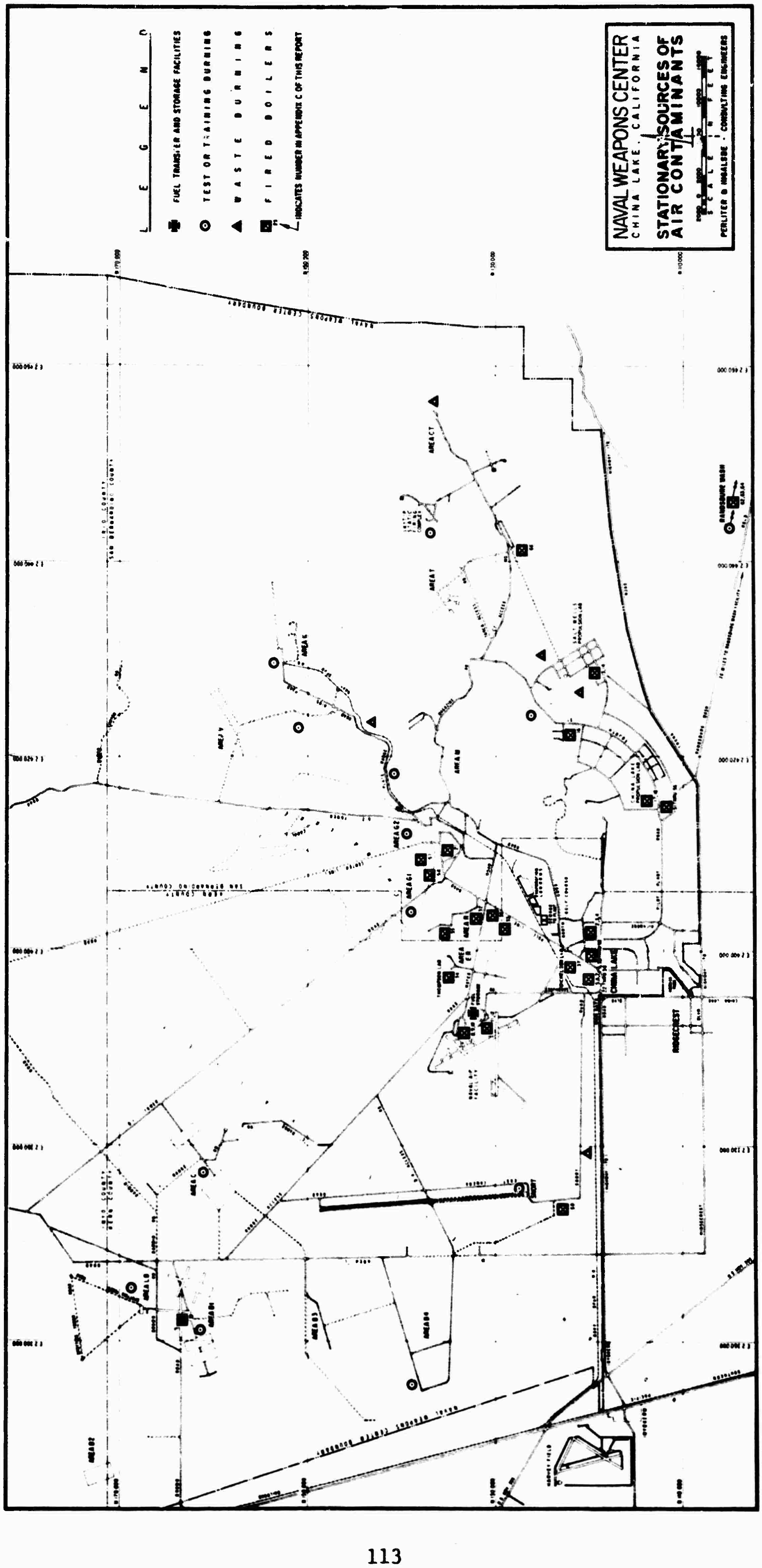


FIGURE 19. Stationary Sources of Air Contaminants, Naval Weapons Center.

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ACTIVITIES AFFECTING WATER QUALITY

As discussed in the Environmental Setting section of this report, there are no ephemeral or continuous streams, rivers, or lakes on NWC. There are a number of springs and seeps on NWC, but they are located in remote areas where no structure exists. Pollution of naturally occurring surface water is, therefore, not a possibility. However, there are a small number of NWC activities which create limited surface and sub-surface flow of waste water, having the potential for affecting ground-water quality.

Sewage Treatment Plant

The principal NWC activity affecting water quality is the collection and treatment of sewage. NWC housing and administration areas are the sources of sewage to the sewage plant. The collection system consists of a network of sewer pipes which feeds into one of the four outfall sewers. The total length of sewer pipes of all sizes at NWC is approximately 98 miles. Table 10 provides a waste flow record for 1971.

Figure 20 is a flow chart which traces the fate of the effluent from the NWC uses to the air and ground. Roughly 500 to 700 acre-ft/yr of the effluent seep underground. The sewage treatment plant is located near the dry China Lake, and the groundwater level at the overflow site is about 3 to 7 feet below the surface. The effects on groundwater table in the overflow vicinity are seen in Figure 21. Sewage treatment consists of grit removal, comminution, primary sedimentation, secondary sedimentation, pond oxidation, sludge digestion, and drying. The plant is, in general, designed to treat sewage at a rate of 2 million gallons per day. Water quality data on the effluent[1] and comparison to the proposed EPA definition of secondary treatment levels[2] are as follows:

Constituent	NWC average Jan. 1972-June 1973	EPA level, monthly average
pH	8.33	6.0-9.0
Specific conductivity. . .	779 ppm	. . .
Total dissolved solids . .	551 ppm	. . .
Chlorides	85.1 ppm	. . .
Biochemical oxygen demand.	18.9 ppm	30 mg/els
Soluble biochemical oxygen demand	9.56 ppm	. . .
Suspended solids	. . .	30 mg/els
Fecal coliform bacteria. .	. . .	200/100 ml

The groundwater body into which the effluent is seeping is naturally brackish, is unfit for consumption, and has total dissolved solids (TDS) of 2,000 ppm in the overflow area. TDS slightly closer to the dry China Lake approaches 37,000 ppm. The recipient groundwater is, therefore, poorer in quality than the effluent itself.

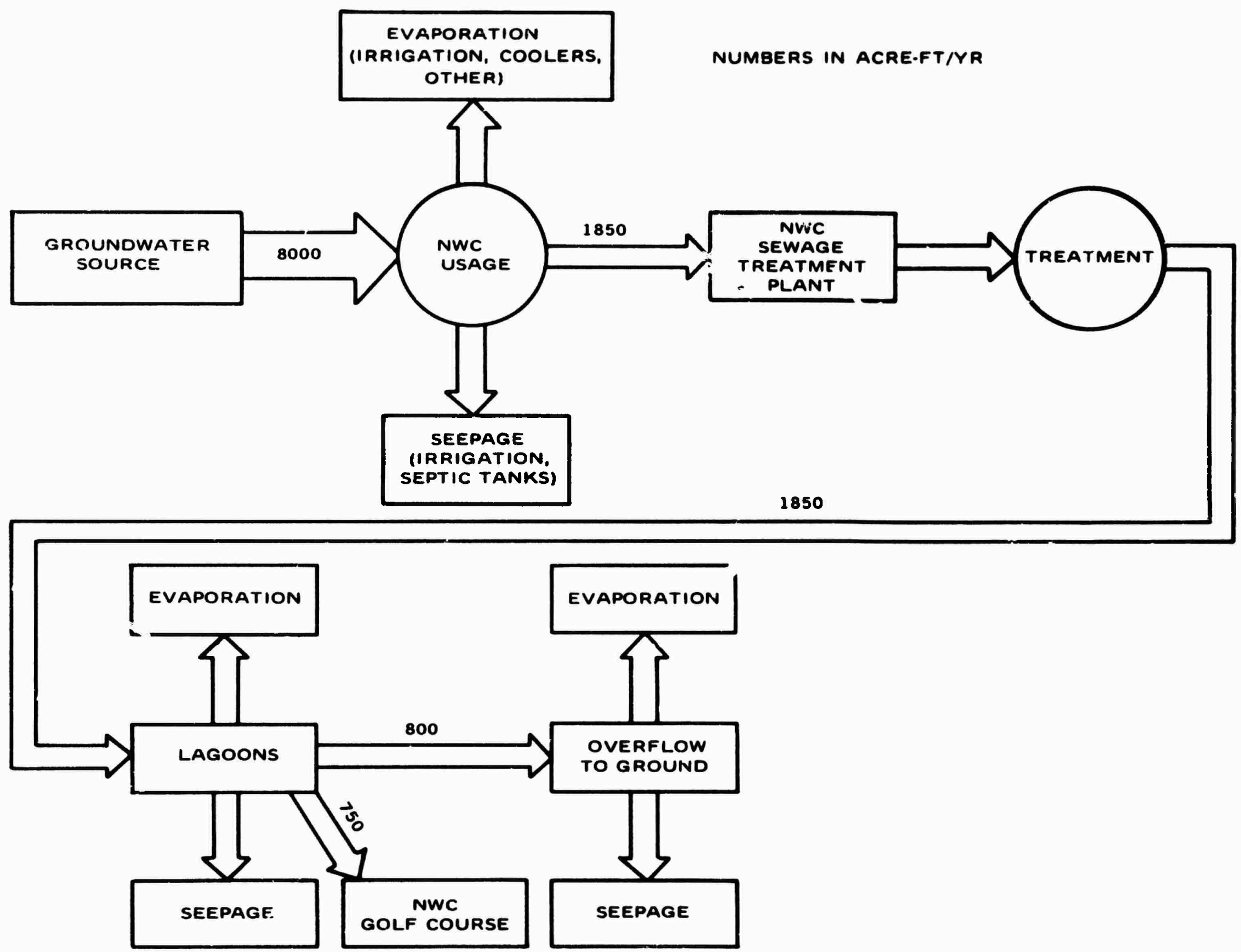

FIGURE 20. Flow of Sewage Effluent, Naval Weapons Center.

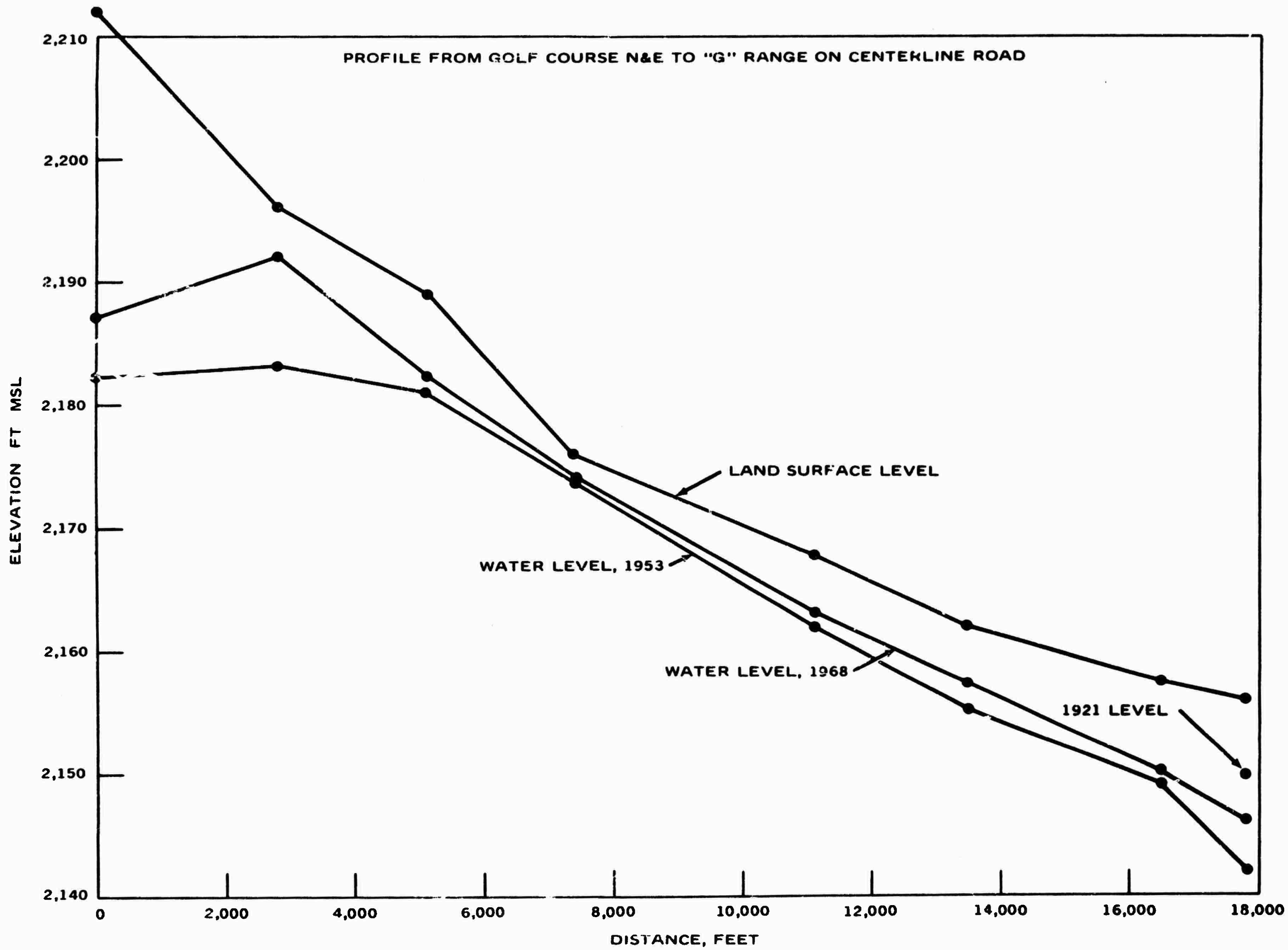

FIGURE 21. Local Groundwater-Level Change in Vicinity of Sewage Treatment Plant, Naval Weapons Center.

Michelson Laboratory Acid Drain Line

Industrial waste from the acid drain at Michelson Laboratory photo lab is carried by a trench to a leaching field near the China Lake. The effluent is not treated prior to discharge. Although the flow is not metered, a rough estimate of the flow is 100 gpm for 10 hr/day, or about 50 acre-ft/yr. A sample mineral analysis[3] is provided as Table 11. The effluent is high in TDS and silver. A significant percentage of the effluent seeps underground. Groundwater depth at the trench site is about 40 feet below the surface. No degradation of groundwater has occurred as a result of the drain.

Effluent From Propulsion Laboratories

The China Lake Propulsion Laboratory has a separate disposal facility consisting of an Imhoff tank and leaching field. In addition, there are a number of other leaching fields in the Salt Wells area, serving propellant plants and outlying buildings. Groundwater appears to be at least 800 feet below the surface in the Salt Wells Valley. Therefore, there is a small probability of any groundwater degradation.

Effluent From Naval Air Facility

The Naval Air Facility has a separate disposal facility consisting of an Imhoff tank and leaching field. The effluent quality and the groundwater quality at the leaching field are similar to that of the main sewage treatment plant. However, the level to groundwater at the Naval Air Facility is 35 feet, significantly greater than for the main plant. Therefore, its impact on groundwater quality could be less.

Scattered Septic Tanks

There are a large number of septic tanks serving scattered isolated buildings on NWC. Most lie in the Indian Wells Valley. An exhaustive inventory[4] has been completed by Perliter and Ingalsbe, Inc. (1973) of NWC groundwater contaminant sources. They are shown on Figure 22.

TABLE 10. NWC Waste Flow Record for Year 1971.

Month	Total flow, gal	Total flow, gal		Golf course use, gal
		Maximum day	Minimum day	
January	41,582,000	1,923,000	1,170,000	3,450,000
February	41,431,000	1,444,000	1,193,000	8,271,000
March	38,293,000	1,490,000	1,231,000	9,647,000
April	44,793,000	1,705,000	1,119,000	16,484,000
May	49,406,000	1,914,000	1,469,000	26,284,000
June	54,954,000	2,294,000	1,474,000	31,996,000
July	58,760,000	2,372,000	1,760,000	51,816,000
August	68,832,000	2,830,000	1,784,000	33,246,000
September	63,586,000	2,441,000	1,668,000	30,174,000
October	51,224,000	1,982,000	1,524,000	20,208,000
November	47,712,000	1,708,000	1,246,000	7,704,000
December	41,039,000	1,560,000	1,104,000	4,848,000
Total	601,612,000	[illegible],830,000	1,104,000	244,128,000

TABLE 11. Acid Drain Mineral Analysis, ppm.

Ingredient	Result (1)	Result (2)	Result (3)
Calcium (Ca)	19.2	17.6	88.0
Magnesium (Mg)	88.8	5.9	124.0
Sodium (calculated)(Na)	869	136	1.206
Bicarbonate (HCO_3)	753	121	959
Sulphate (calculated)(SO_4)	1,070	78	1,686
Chloride (Cl)	400	154	524
Total hardness ($CaCO_3$)	460	112	728
Calcium hardness (as $CaCO_3$)	96	88	220
Magnesium hardness ($CaCO_3$)	364	24	508
Phenolphthalein alkalinity ($CaCO_3$)	0	0	0
Methyl orange alkalinity ($CaCO_3$)	672	108	856
Total dissolved solids	3,290	413	4,690
Specific conductivity (Micromhos @ 25°C)	4,700	590	6,700
Hydrogen-ion concentration (pH)	6.2	7.9	5.6
Silica (SiO_2)	Interference	4.1	Interference
Fluoride (F)	2.10	0.88	0.98
Boron (B)	5.38	1.33	7.9
Iron (Fe)	1.6	0.0	6.2
Synthetic detergents (apparent ABS)	0.79	0.17	1.5
Phosphate (PO_4)	Interference	0.00	Interference
Silver, Ag	0.749	0.000	0.344

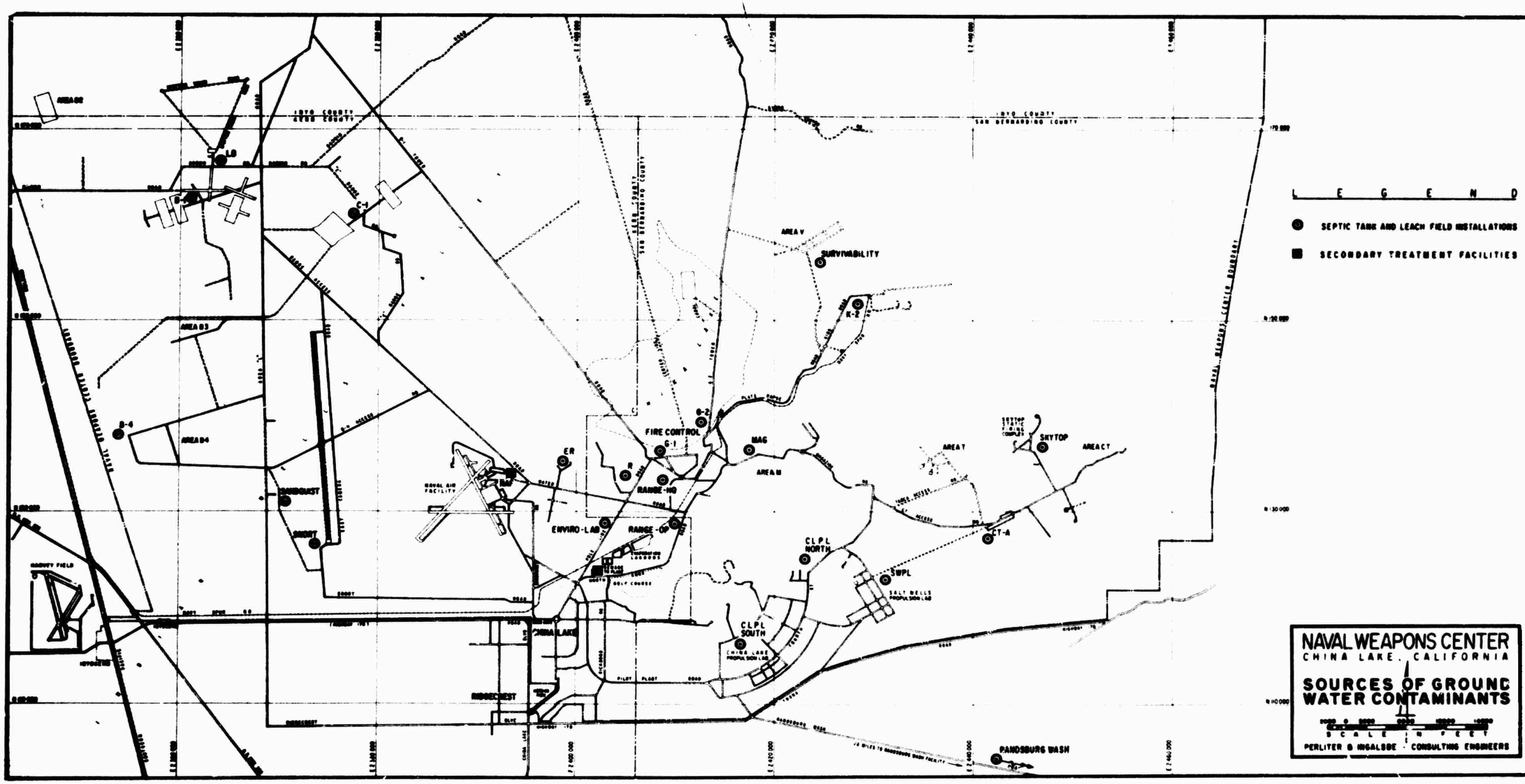

FIGURE 22. Sources of Groundwater Contaminants, Naval Weapons Center.

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ACTIVITIES AFFECTING NOISE

NWC, in conducting its official business, has a number of sources which contribute to noise in Indian Wells Valley. Aircraft is a major source, while motor vehicles and explosive tests and disposal are secondary sources of noise.

Aircraft

The two sources of aircraft noise at NWC are the Naval Air Facility and the high-speed R-2506 test range approach corridor. The noise generated from the Naval Air Facility was investigated by Bolt, Beranek, and Newman, Inc. (1970).[1] Perceived noise level contours for flight and ground runup operations are given in Figure 23.

The aircraft noise generated in the high-speed R-2506 test range approach corridor was measured by the Navy Aircraft Environmental Support Office.[2] Perceived noise level contours for this operation are given in Figure 24.

Motor Vehicles

Privately owned motor vehicles are major sources of noise at NWC. Studies at NWC show that automobiles and buses are the predominant sources of on-street noise, while motorcycles are principally responsible for off-road noise.

Motor vehicle noise was measured at three different sites in the NWC housing areas in early 1973. The sites were picked for the following characteristics:

Site A: The backyard of a dwelling facing dry Mirror Lake, principal designated off-road vehicle recreation area for Center residents. The backyard location efficiently masks Richmond Road street traffic, thus providing an accurate assessment of off-road motorcycle noise.

Site B: The front window of a duplex 30 feet from a major arterial in the high density Wherry Housing area. There is heavy street traffic, with approximately 80% of the noise due to automobiles.

Site C: A duplex located in a lower density Old Duplex residential area at NWC. It is approximately 400 yards to the nearest off-road vehicle recreation area.

The community noise was measured and recorded at each of the sites. The hourly and composite noise levels at each of the sites are given in Table 12.

The day-night average sound level, L_{dn}, is a composite rating scale for describing the outdoor environment. L_{dn} is the average noise for the

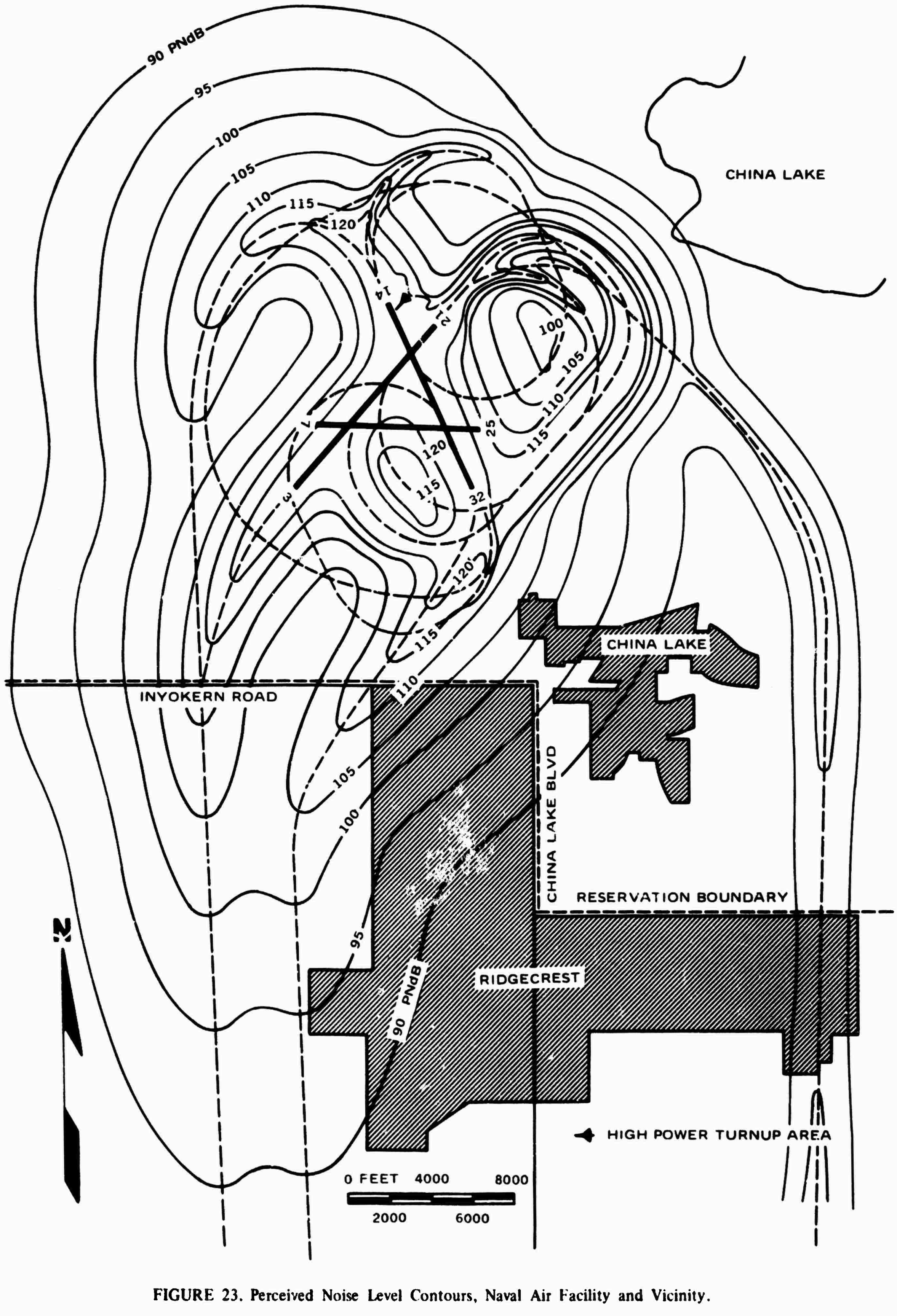

FIGURE 23. Perceived Noise Level Contours, Naval Air Facility and Vicinity.

FIGURE 24. Perceived Noise Level Contours, Airspace R-2506 in Indian Wells Valley.

TABLE 12. Hourly Noise Levels (HNL) and Day-Night Average Sound Levels (L_{dn}) at Three NWC Residential Sites (January and February 1973)

Unit	Time of day	Site A			Site B	Site C
		Day 1	Day 2	Day 3	Day 1	Day 1
HNL	2400	37.0	...	...	43.7	39
	0100	36.0	...	...	41.0	38
	0200	30	...	...	35	37
	0300	30	...	...	35	37
	0400	30	...	...	35	35
	0500	30	...	...	35	39
	0600	30	...	...	...	45
	0700	36.8	...	...	...	52
	0800	37.2	...	...	...	50.6
	0900	38.5	...	...	...	49.7
	1000	40.0	45.2	49.8	...	54.7
	1100	43.2	47.1	52.4	...	51.4
	1200	46.0	49.7	47.4	59.2	51.8
	1300	41.0	49.1	46.3	57.9	51.2
	1400	40.0	45.9	58.6	61.3	48.4
	1500	56.0	55.2	54.0	61.1	49.4
	1600	57.6	54.3	59.9	61.3	49.9
	1700	39.9	...	...	60.3	46.4
	1800	39.1	...	...	57.8	47.3
	1900	41.0	...	...	56.0	47.4
	2000	39.2	...	...	56.9	43.1
	2100	38.8	...	...	55.7	47
	2200	36.4	...	...	51.4	38.0
	2300	36.5	...	...	45.8	38.5
L_{dn}	...	48	47	50	57	50

day. Any specific value of L_{dn} represents the average A-weighted sound level that would exist as a constant value if all the acoustic energy from all noise events were first weighted according to the time of day and distributed over the 24-hour day.[3] An in-depth discussion of L_{dn} and its utility in predicting human response to noise is presented in the section Evaluation of Environmental Impact of NWC Activities.

Table 12 shows that Site B was the noisiest, having an L_{dn} of 57. Site A had an L_{dn} valued from 47 to 50, while Site C had an L_{dn} value of 50. The noisiest hours were recorded in the afternoon at Site B, while the greatest number of quiet (HNL < 40 dBA) hours in a day, 18, was recorded at Site A. It is seen that substantial variations in noise occur in different residential areas at NWC, depending largely on motor vehicles. Figures 25, 26, and 27 graphically show hourly variation.

Weapons Testing and Explosives Ordnance Disposal

Weapons testing is a potential source of noise to Ridgecrest and China Lake residents. The closest NWC target center, C Range, is located 10 miles from inhabitants. Small charges are generally used in weapons practice and testing. Therefore, the potential for noise intrusion is low.

Explosives up to the 2,000-pound class are detonated in Burro Canyon in the Argus Mountains. The noise is detectable in the inhabited areas of Indian Wells Valley and resembles a sonic boom. The impulse R.M.S. noise recorded west of Ridgecrest is 80 dBD. Linear impulse values (2 Hz lower cutoff frequency) tend to be substantially higher, ranging from 100 to 120 dB throughout the Ridgecrest-Inyokern area. Sound levels from these impulsive blasts are highly dependent upon meteorological conditions.[4]

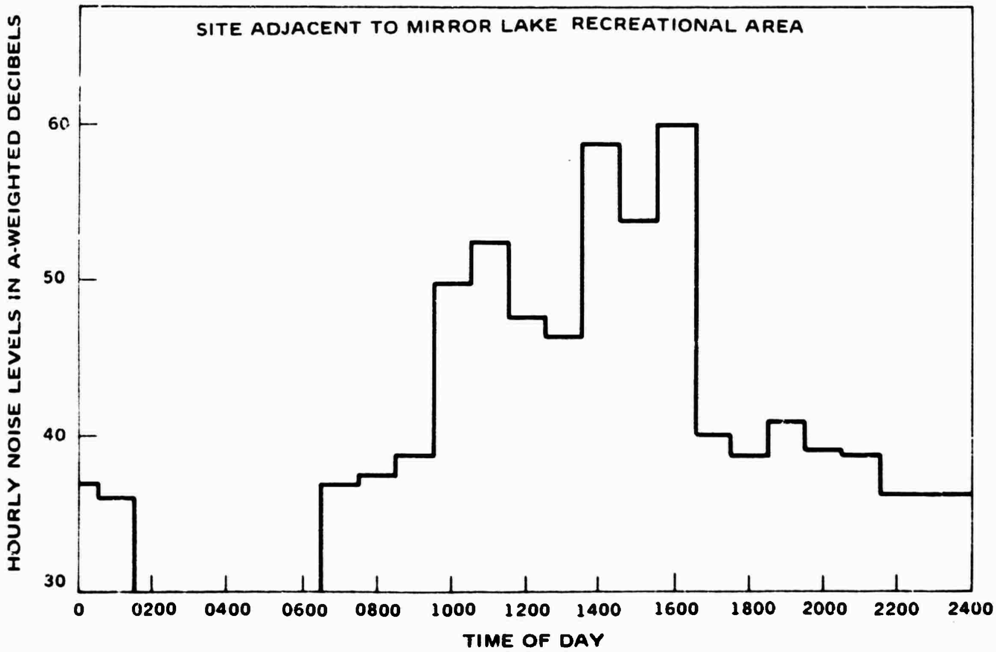

FIGURE 25. Hourly Noise Levels, Adjacent to Mirror Lake Off-Road Vehicle Recreational Area, Naval Weapons Center.

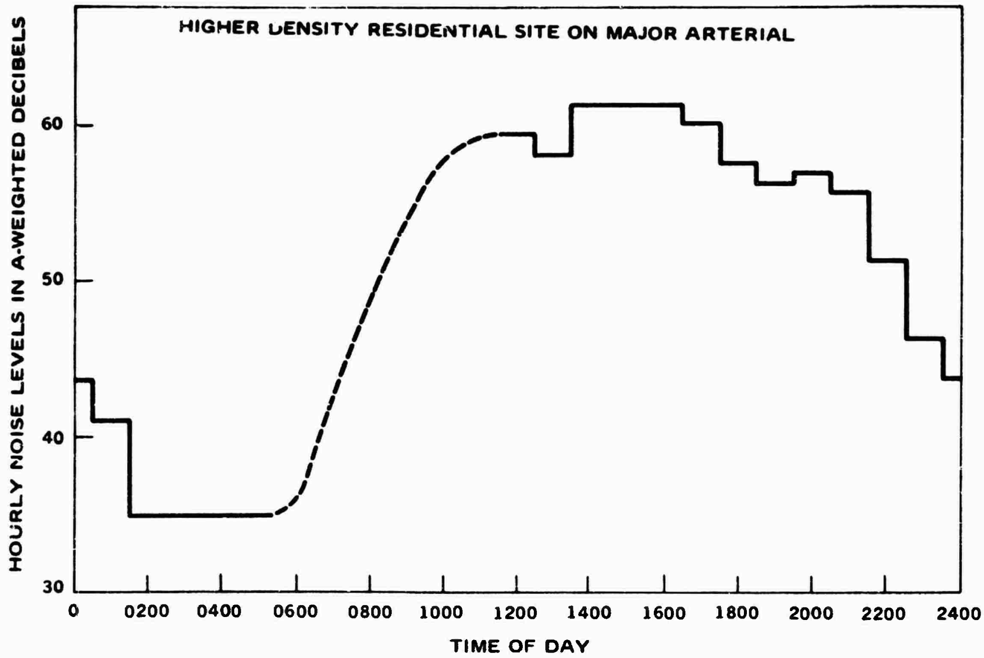

FIGURE 26. Hourly Noise Levels, Higher Density Residential Site on Major Arterial, Naval Weapons Center.

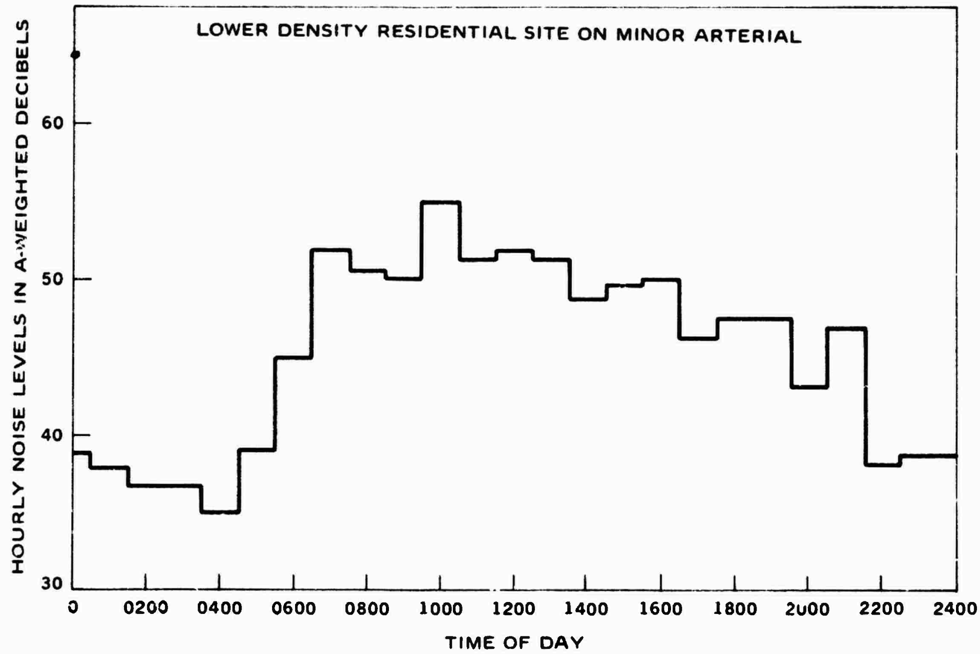

FIGURE 27. Hourly Noise Levels, Lower Density Residential Site on Minor Arterial, Naval Weapons Center.

NOTES

1. Bolt, Beranek, and Newman, Inc. 1970. Noise from Certain Aircraft Operations, Naval Weapons Center, China Lake, California. Report No. 1958.

2. Aircraft Environmental Support Office, Nov. 1973. Perceived Noise Levels Under Loft Approach to "C" Target, Naval Weapons Center, China Lake, California. Report No. AESO 311-74-6. Naval Air Rework Facility, North Island, Calif. 92135.

3. Environmental Protection Agency, July 1973. Public Health and Welfare Criteria for Noise. No. 550/9-73-002. U.S. EPA, Washington, D.C. 20460.

4. Reed, J. W., 1972. "Attenuation of Blast Waves by the Atmosphere". Journal of Geophysics, March 20, 1972.

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1. National Bureau of Standards, 1971. Fundamentals of Noise: Measurement, Rating Schemes, and Standards. NTID 300.85, U.S. EPA.

ACTIVITIES AFFECTING LAND QUALITY

Weapons Testing

Due to testing operations at NWC a number of areas have become "spoiled" or contaminated. Spoilage can occur due to the presence of live ordnance, residual ionized radiation, or hazardous materials. Figure 28 shows contamination in the China Lake Range. Figure 29 shows contamination in the Mojave "B"/Randsburg Wash Ranges.

Roads

Land and other natural resources are depleted by the construction of official roads. There are four major action factors to be considered:

1. Alteration of the land itself by creating non-natural drainage patterns, thereby accelerating soil erosion.[1,2]

2. Interference with or destruction of natural wildlife habitats. This can include damaging or modifying springs or other water sources.

3. Creation of visual pollution or aesthetic degradation of resources by creating irreversible scars on the land.

4. Risk of illegal use of roads by trespassing motorcyclists and other vehicles. Opening up a fragile de facto wilderness area to illegal motorcycle use could impair the land much more rapidly than any official activity for which the road was designed.

Figure 30 shows roads which currently exist on the China Lake Range portion of NWC. Figure 31 shows roads which currently exist on the Mojave "B"/Randsburg Wash Range portion of NWC.

Refuse Disposal

At NWC there are 18 refuse dumps. In some localities two dumps are provided, one for salvageable material and one for refuse. Figure 32 shows the general locations of all known dumps located at NWC.

Following is a brief description of known dumps, numbered according to Figure 32:

1, 2: Two pits (14' x 50' x 500') maintained for exclusive use of Center residents. One pit is used for lawn clippings, tree trimmings, and the like and is a cut and cover operation. The other pit is for dry refuse and is covered when the pit becomes full.

3, 4: Two dumps in the Salt Wells Propulsion Laboratory area. Number 3 site is for salvageable material. Number 4 site is for unsalvageable material.

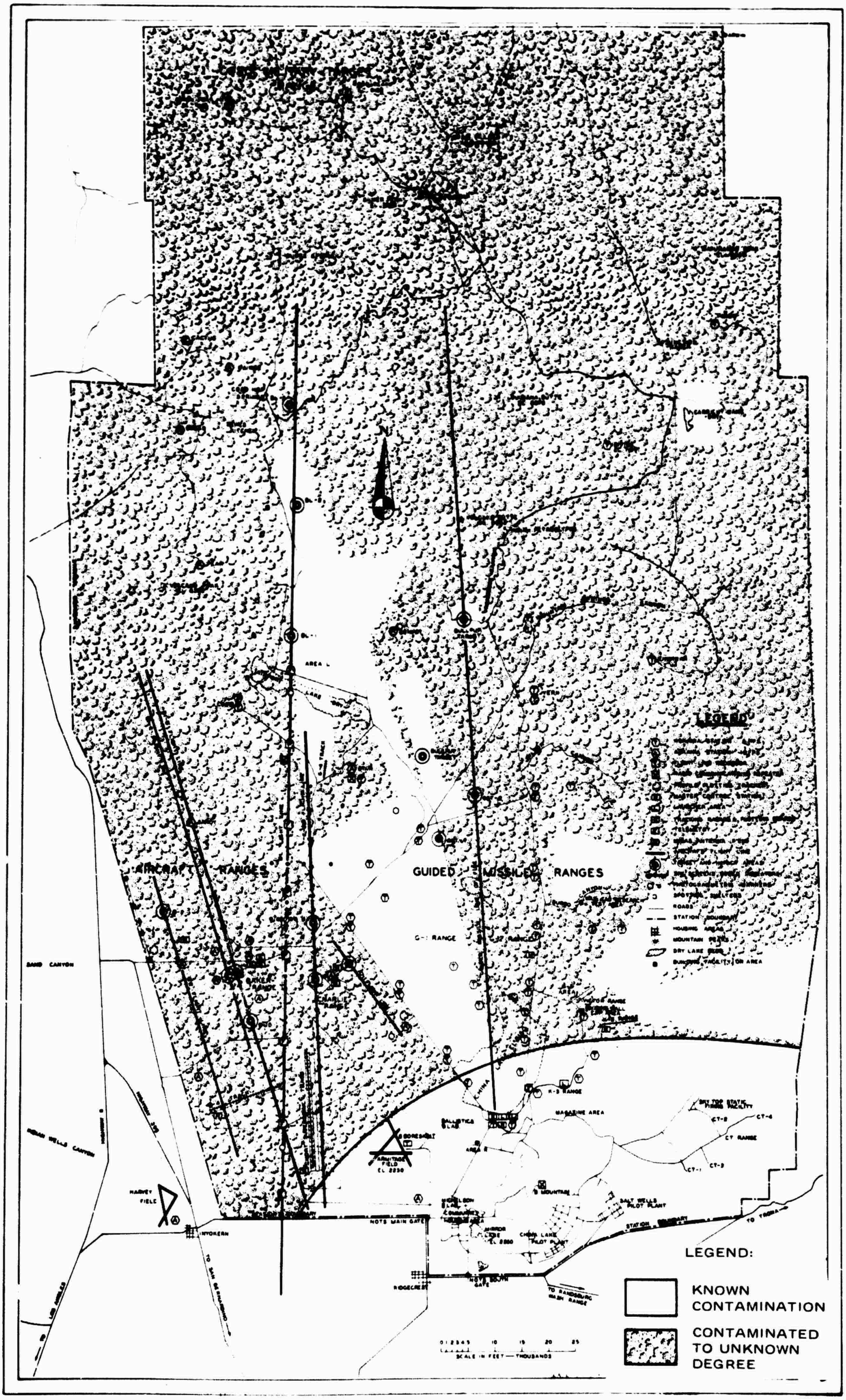

FIGURE 28. Areas Contaminated by Live Ordnance, China Lake Test Ranges, Naval Weapons Center.

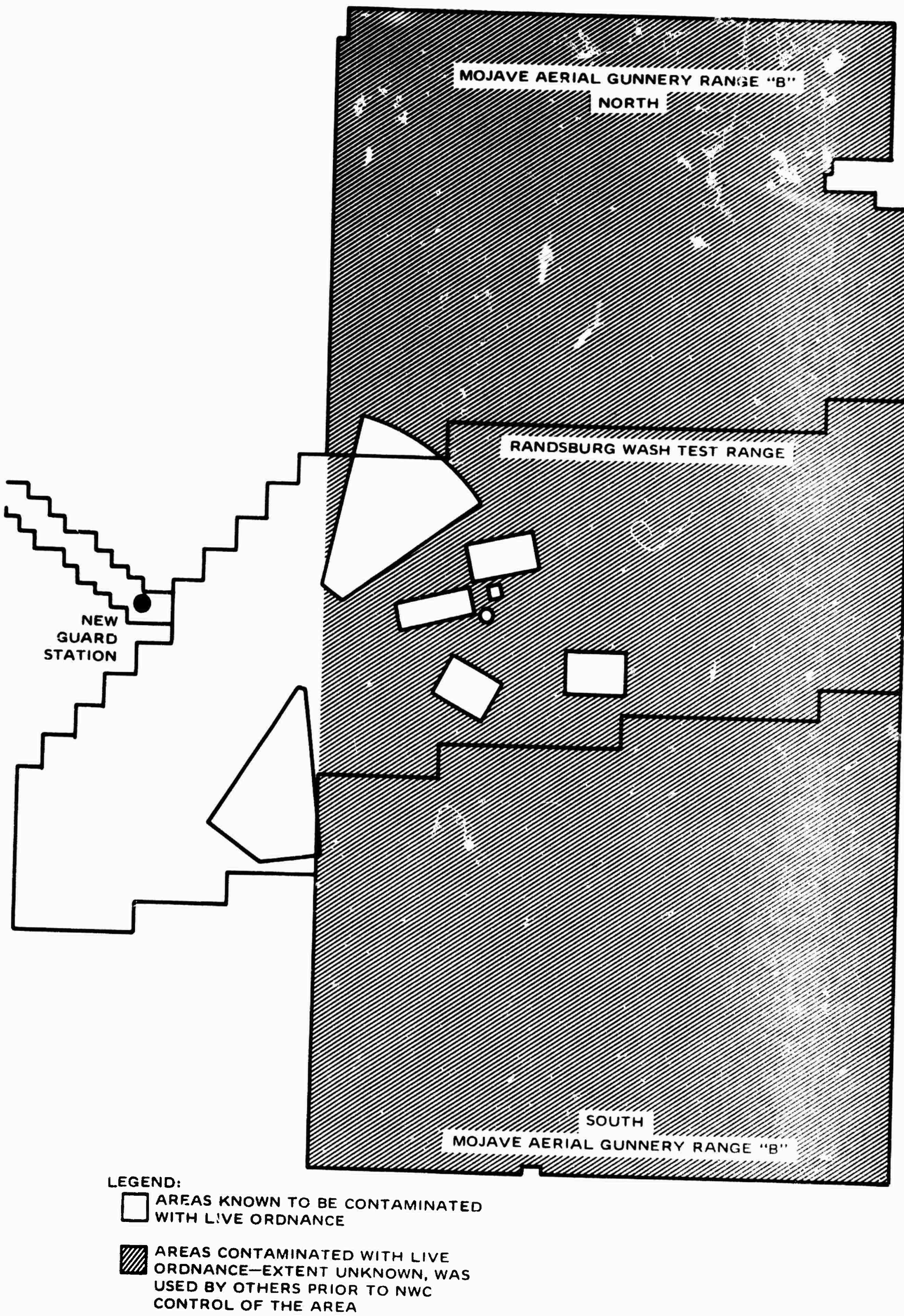

FIGURE 29. Areas Contaminated by Live Ordnance, Mojave "B"/Randsburg Wash Test Ranges, Naval Weapons Center.

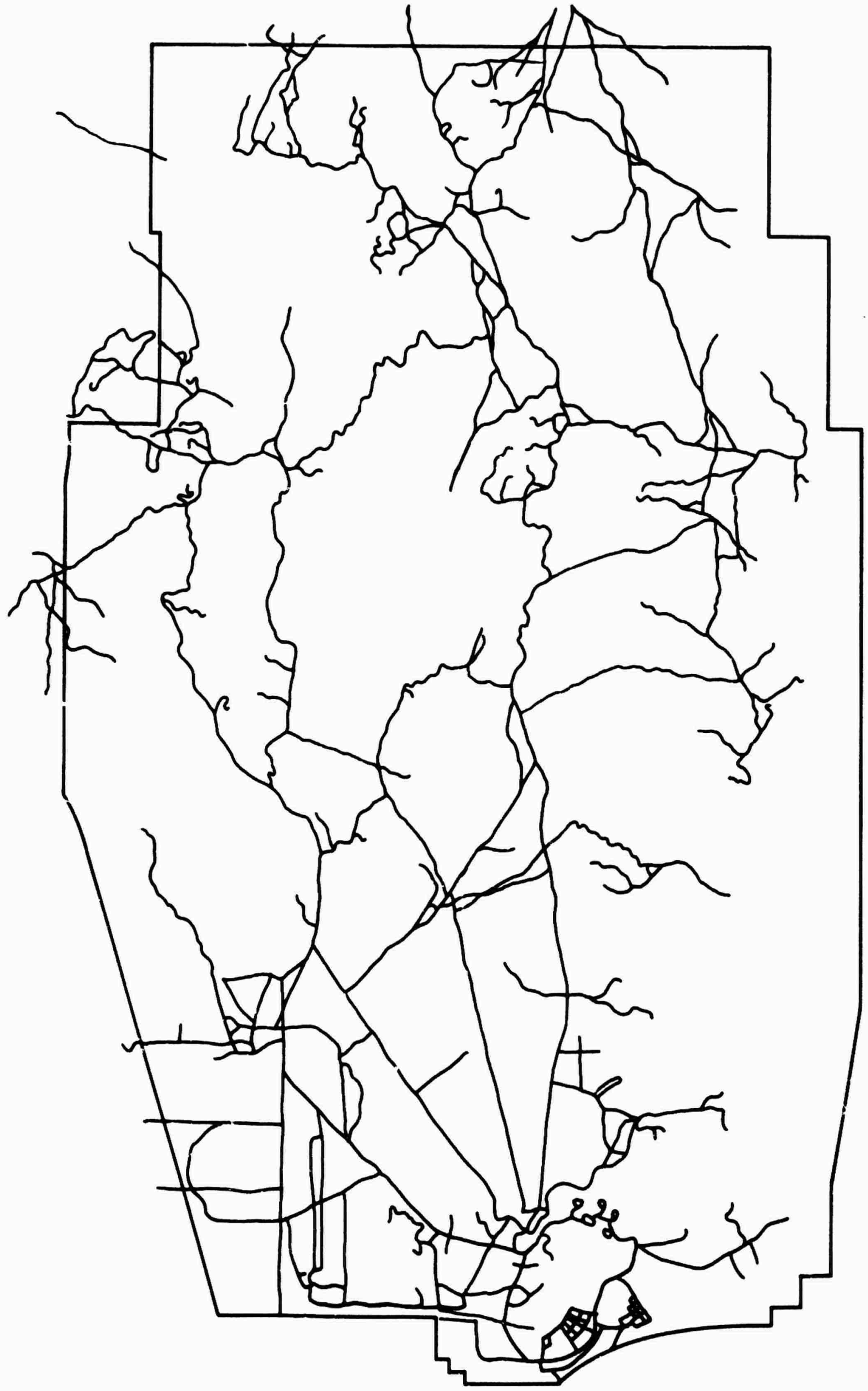

FIGURE 30. Improved and Unimproved Roads, China Lake Test Ranges, Naval Weapons Center.

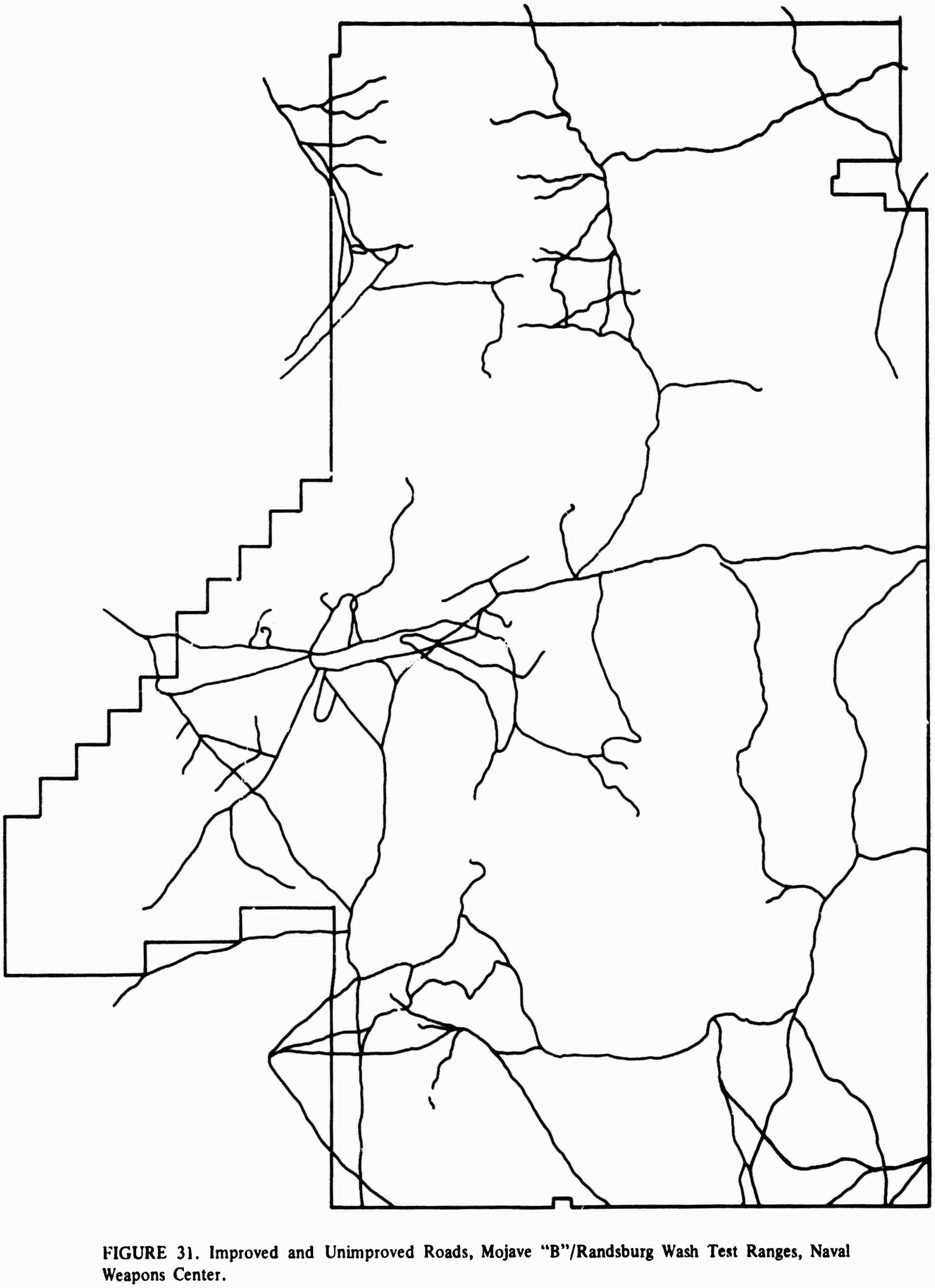

FIGURE 31. Improved and Unimproved Roads, Mojave "B"/Randsburg Wash Test Ranges, Naval Weapons Center.

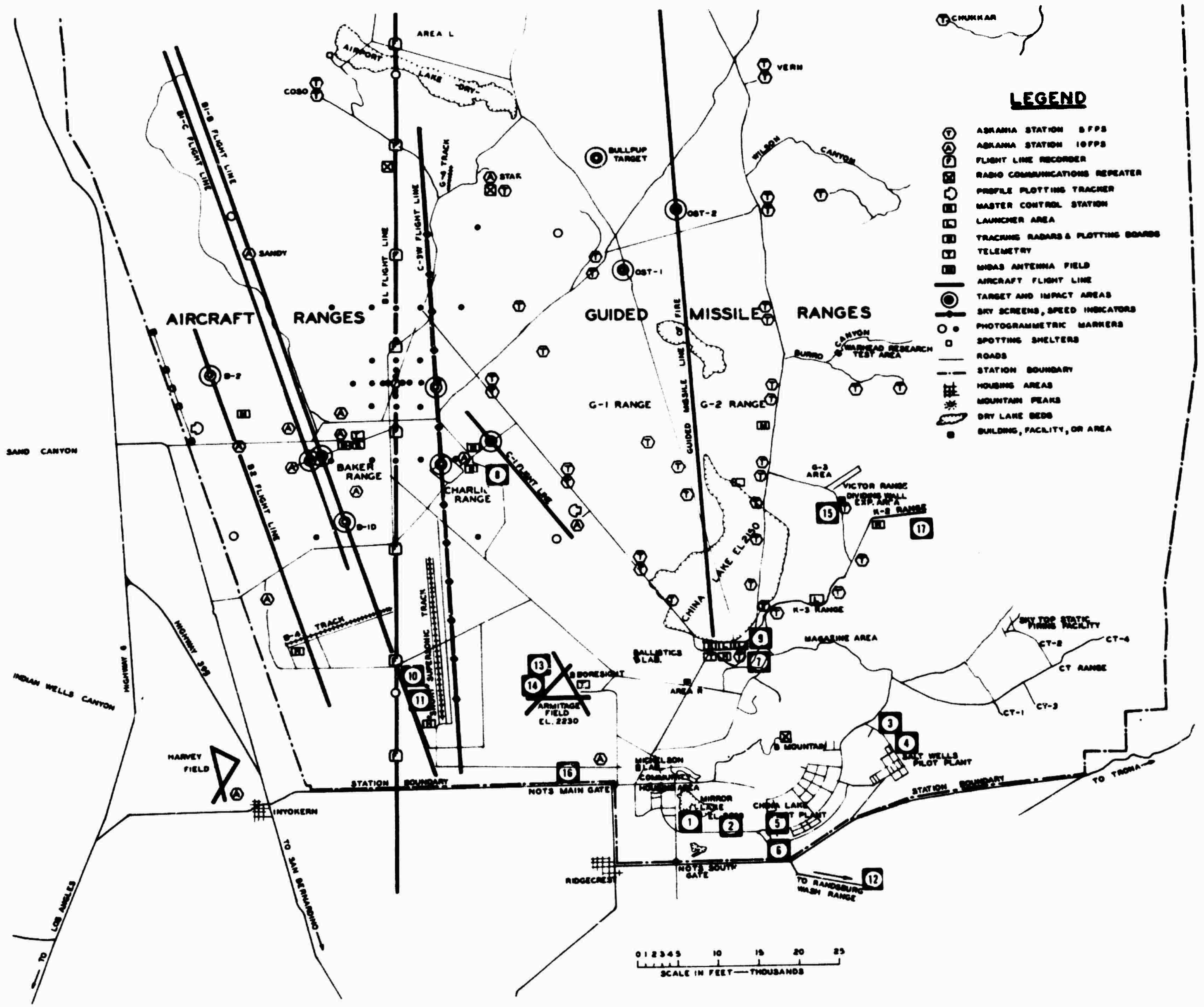

FIGURE 32. Disposal Locations, Naval Weapons Center.

5, 6: Two dumps in the China Lake Propulsion Laboratory area. These two adjacent dumps are used by range crews. No. 6 is for salvageable material, and No. 5 is for unsalvageable, dry refuse.

7: One dump on C-1 Range used by range crews. The refuse is unsalvageable.

8: C Range dump is used by range crews. Some of the material is salvageable.

9: B-1 Range dump has salvageable material.

10, 11: Two dumps at the SNORT Range. Both are limited burning operations and used by range crews.

12: One dump at Randsburg Wash for dry refuse.

13, 14: Two dump pits for dry refuse at the Naval Air Facility. Some of the refuse is salvageable.

15: One dump on the Victor Range for unsalvageable material.

16: C-2 Range has a dump for dry refuse and a small area for inert and contaminated materials.

17: K-2 Range has a dump pit for unsalvageable material.

18: An abandoned pit located northwest of the Center's main gate is used primarily for dry refuse. Public Works Department, contractors, and others have used this site intermittently over the past years.

The bulk of NWC-generated refuse originates from the housing and adjacent laboratory areas. Disposal is handled by a government contractor who hauls the refuse to a Kern County sanitary landfill located southwest of Ridgecrest in Indian Wells Valley.[3]

NOTES

1. Soil Conservation Division, State of California, 1971. Environmental Impact of Urbanization on the Foothill and Mountainous Lands of California. Resources Agency, State of California, Sacramento, Calif.

2. Flawn, P. T., 1970. Environmental Geology: Conservation, Land-Use Planning, and Resource Management. Harper and Row, New York. p. 119.

3. Stone, Ralph and Co., 1968. Kern County Solid Waste Master Plan, Final Report. Kern County Dept. of Public Works, Bakersfield, Calif.

ACTIVITIES AFFECTING CLIMATE

Precipitation Augmentation by Cloud Seeding

The Santa Barbara Project, performed by NWC, was initiated in 1967 to investigate the effects of cloud seeding with silver iodide (AgI) nuclei upon the rainfall output of winter frontal storms approaching the California coast. The primary effort is conducted over Santa Barbara and Western Ventura Counties.

Seeding accomplished during the first 3 years was conducted from the ground and by using a 3,500-foot elevation of the Santa Ynez Mountain ridge west-northwest of Santa Barbara. Aircraft seeding was added to the program during the 1970-71 season. The seeding target is a conductive band, a group of convective cells organized into band alignment, embedded in a general storm system. On the average about three such bands will be identified during a given storm.

Results to date indicate that about 50% more rain is generated from the seeded bands than from unseeded ones over an area of several hundred square miles. The total increase in seasonal rainfall in the area is estimated at about 10 to 15%. Seeding does not take place when heavy storms are forecast or when a condition of saturated watershed exists. This is to obviate any possibility of abetting a naturally occurring flood hazard.

Figure 33 depicts the relative changes in precipitation due to NWC cloud seeding from a ground seeding site in Santa Barbara County.[1] Specific areas in Kern and Ventura Counties received a substantial increase in rainfall.

Potential environmental effects of weather modification would be ". . . moderate shifts in rates of reproduction, growth, and mortality of weather-sensitive species of plants and animals."[2]

In addition to potential effects from precipitation change, there is the possibility of adding silver to the water from seeded storms. Silver in precipitation from non-seeded storms has been measured at levels up to 2×10^{-5} ppm. Silver concentrations in precipitation from seeded storms range from 1×10^{-6} ppm to 1.76×10^{-3} ppm. Typical values are 1 to 3×10^{-4} ppm. This is of the same order as the concentration of Ag in normal seawater--1.5 to 3.0×10^{-4} ppm.[3,4]

Radiation Balance and Cloud Formation

It has been suggested that aircraft operations have a potential for affecting the climate. In 1971 there were 29,088 jet takeoffs and landings from the Naval Air Facility, resulting in an estimated 4,000 hours of flying in Airspace R-2505 alone. Approximately 3,500 hours were spent above the inversion layer at 8,000 feet msl.

The Massachusetts Institute of Technology sponsored the Study of Critical Environmental Problems (SCEP) that found that ". . . current commercial, subsonic jet aircraft flying in the upper troposphere, and occasionally in the lowest part of the stratosphere (below about 12 km, or 40,000 ft) . . ."[5] form condensation trails. These ". . . added con-

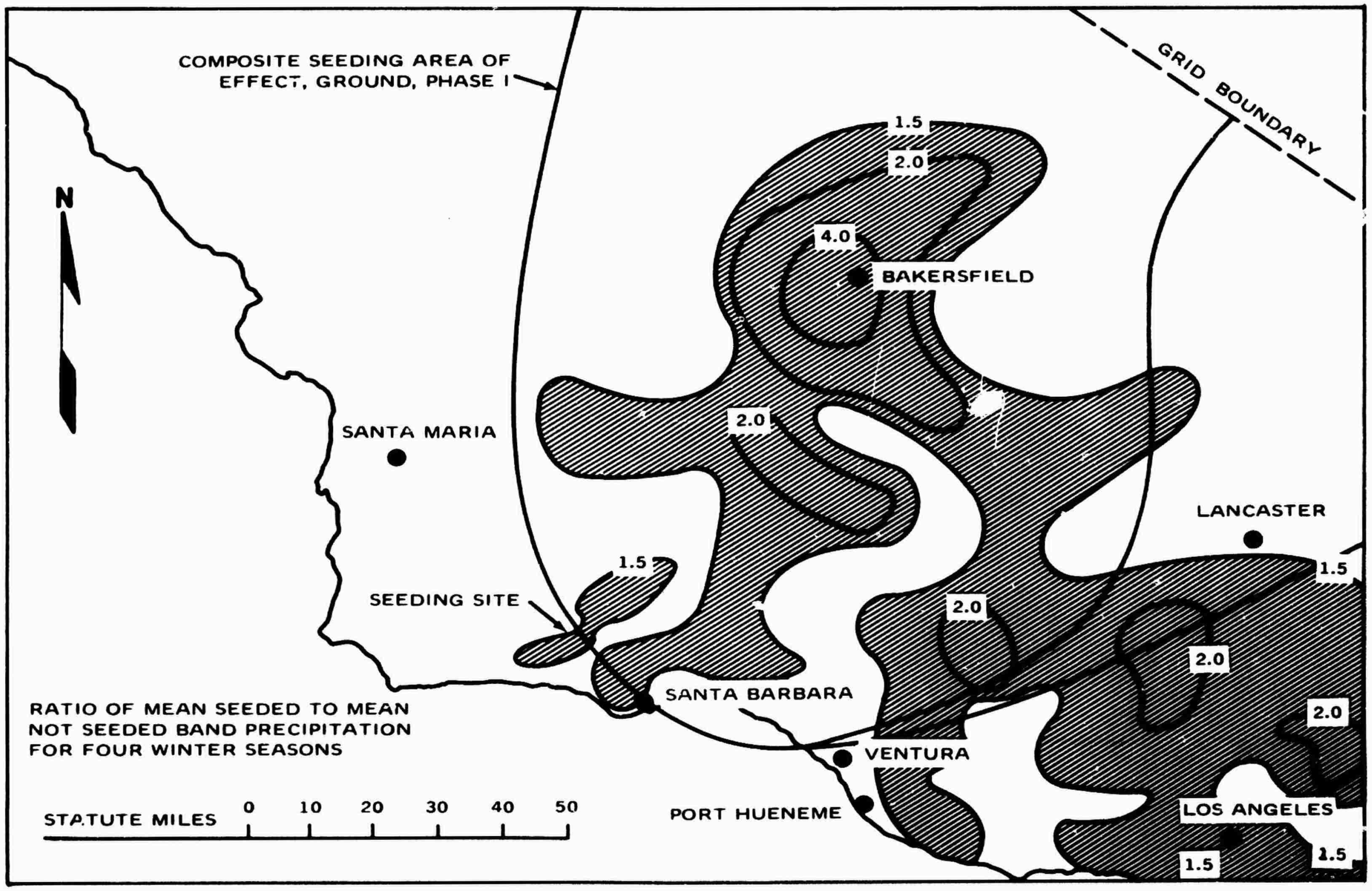

FIGURE 33. Seeding Site Vicinity Precipitation Change.

trails or cirrus clouds can affect the climate through both the heat balance and the nucleating role of falling ice crystals. . . . If an increase in cirrus cloudiness were to become significant as a result of jet activity in the upper atmosphere, the most important global effect would be an increase in the earth atmosphere albedo."[6]

The problem of releasing persistent gases and particles into the air does not appear to be nearly as great for NWC-type jets as for the envisioned supersonic transports (SST). SCEP notes, ". . . the stratosphere where SST's will fly at 20 km (65,000 ft) is a very rarefied region with little vertical mixing. Gases and particles produced by jet exhausts may remain for 1 to 3 years before disappearing."[7] Mixing is much better at the lower elevations flown by normal jets, so persistent air pollution would not pose the threat as would the SST.

Humidity Increase

Some desert communities have noticed that prolonged heavy use of evaporative water coolers has increased their summer humidity. NWC and Ridgecrest have the same potential for increasing average summer humidity in the Indian Wells Valley through the usage of residential coolers, cooling towers, and sewage evaporation ponds.

Assuming a 10% loss rate from NWC cooling towers, an estimated total of 7×10^7 gallons, or 210 acre-feet of water is annually released into the Indian Wells Valley. The sewage evaporation ponds release approximately 300 acre-feet of water annually to the atmosphere. NWC housing areas also release significant quantities of water to the atmosphere.

NOTES

1. Naval Weapons Center, 1972. Candidate Environmental Impact Statement, Santa Barbara Project (Phase II). Naval Weapons Center, China Lake, California.

2. Cooper, C. F., and W. C. Jolly, 1969. Ecological Effects of Weather Modification, A Problem Analysis. Sponsored by the U.S. Department of Interior, Bureau of Reclamation, Office of Atmospheric Water Resources, Denver, Col. p. 2.

3. Ibid. p. 65.

4. Standler, R. B., and B. Vonnegut, 1972. "Estimated Possible Effects of AgI Cloud Seeding on Human Health." Journal of Applied Meteorology 11:1388-1391.

5. Report of the Study of Critical Environmental Problems, 1970. Man's Impact on the Global Environment. MIT Press, Cambridge, Mass. p. 99.

6. Ibid. p. 99.

7. Ibid. p. 15.

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1. Grimes, A. E., 1972. An Annotated Bibliography on Weather Modification, 1960-1969. National Oceanic and Atmospheric Administration, Rockville, Maryland. NTIS No. COM-72-11287. 407 p.

2. Gutmanis, I., and R. J. Gillis, 1971. "Weather Modification: Programs and Prospects." Environment Reporter Monograph No. 8. Bureau of National Affairs, Inc.

ACTIVITIES AFFECTING DEPLETION OF NATURAL RESOURCES

Abiotic Physical Systems

Groundwater Resource. The source of water for all of NWC and Indian Wells Valley is groundwater. The groundwater resource is the result of runoff from the Sierras and Cosos; the annual yield is estimated to be between 9,850 and 12,000 acre-feet per year.[1,2] The U.S. Geological Survey estimates the underground water supply at over 750,000 acre-feet, with a total storage capacity of over 5 million acre-feet.[3,4]

Table 13 breaks down water usage by major user. In almost all categories there has been a substantial increase in usage.

TABLE 13. Estimated Water Pumpage Indian Wells Valley, Acre-Feet per Year.

Year	Total off Center	NWC	Total valley-wide
1946	2,076	931	3,007
1947	2,134	1,735	3,869
1948	2,042	2,186	4,228
1949	2,002	2,801	4,803
1950	1,963	3,297	5,260
1951	2,516	3,869	6,385
1952	2,751	4,158	6,909
1953	3,519	4,570	8,089
1954	3,412	4,922	8,334
1955	3,651	5,260	8,911
1956	3,707	5,600	9,307
1957	3,405	5,920	9,325
1958	3,595	5,800	9,395
1959	3,842	6,150	9,992
1960	4,306	6,250	10,556
1961	3,929	6,390	10,319
1962	4,215	6,830	11,045
1963	4,440	6,580	11,020
1964	4,446	7,110	11,556
1965	4,638	6,930	11,568
1966	5,174	7,234	12,408
1967	5,070	7,230	12,300
1968	5,512	7,518	13,030
1969	5,707	7,768	13,475
1970	5,843	8,184	14,027
1971	6,330	7,970	14,300
1972	7,130	8,070	15,200

Based on past data, the future Indian Wells Valley water usage has been projected. Two types of projections were used: a linear extrapolation and a damped exponential. The advantage to the linear (straight line) projection is that it is widely used and easily understood, while its chief disadvantage is that it is a functional form that never levels off. The advantage to the damped exponential is that it often corresponds more closely to real life by leveling off. Figure 34 is a graph of projected water usage; the curves are computer-generated best fit linear and damped exponential projections. The exponential is a better fit by 15% and comes closer to the data points than the linear curve. It shows a future leveling off at about 30,000 acre-ft/yr.

Although the projected values from Figure 34 are not reliable for greater than 20 years in the future, they can be used to roughly estimate how long the underground water resource may last. In modeling the resource lifetime, three different future trends were used: freezing usage at 1971 level; projecting usage linearly; and projecting it exponentially. In addition, because of the uncertainty about the size of the groundwater reserve, four different reservoir volumes were assumed. Using mathematical models to predict future use, Appendices 1 and 2, Table 14 was created:

TABLE 14. Lifetime of Indian Wells Valley Groundwater Resource Assumed Future Usage Trend.

Estimate of groundwater reserve, acre-feet	No change from 1971, no. yr.	Projected future use best fit exponential, no. yr.	Best fit linear, no. yr.
600,000	132	53	43
1,200,000	264	87	65
2,400,000	528	146	96
4,800,000	1,056	255	140

Figure 35 shows computer-generated water levels for 1986 as predicted by the U.S. Geological Service (1971).[5]

Energy and Fuel Resources. While not depleting any possible sources on NWC property, the Center does use significant amounts of electricity and fuel. Table 15 provides the amounts of these resources used in 1972.

TABLE 15. NWC Electricity and Fuel Usage, 1972.

Product	Amount
Electricity, kW-hr	121,152,340
No. 6 fuel oil, gal	250,425
Jet fuel (JP-5, JP-4, 115, 145), gal	6,028,156
Premium gas, gal	733,377
Diesel oil, gal	168,597
Propane, gal	1,302,688
Natural gas, ft^3	783,156,000

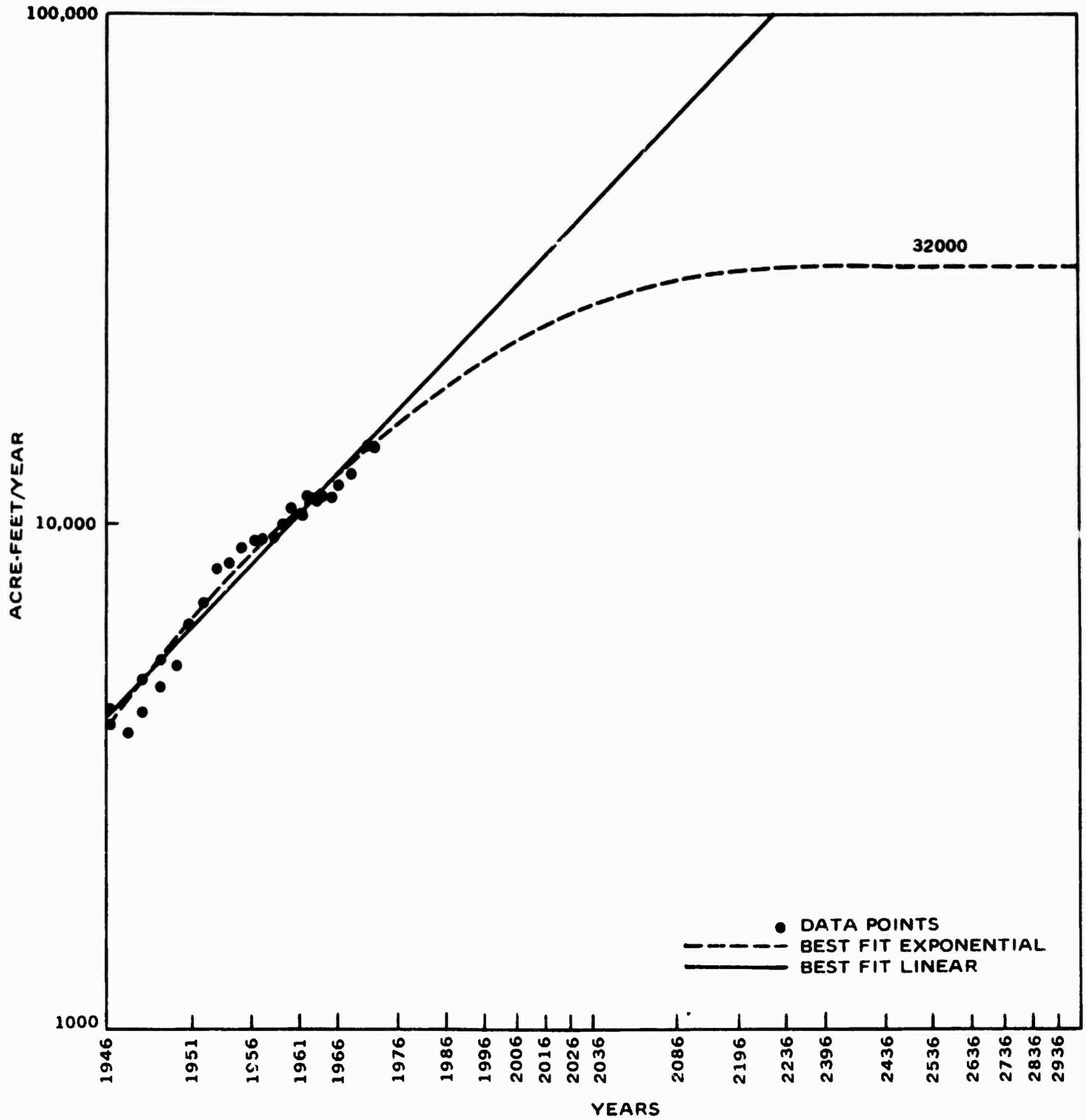

FIGURE 34. Projected Water Usage, Indian Wells Valley.

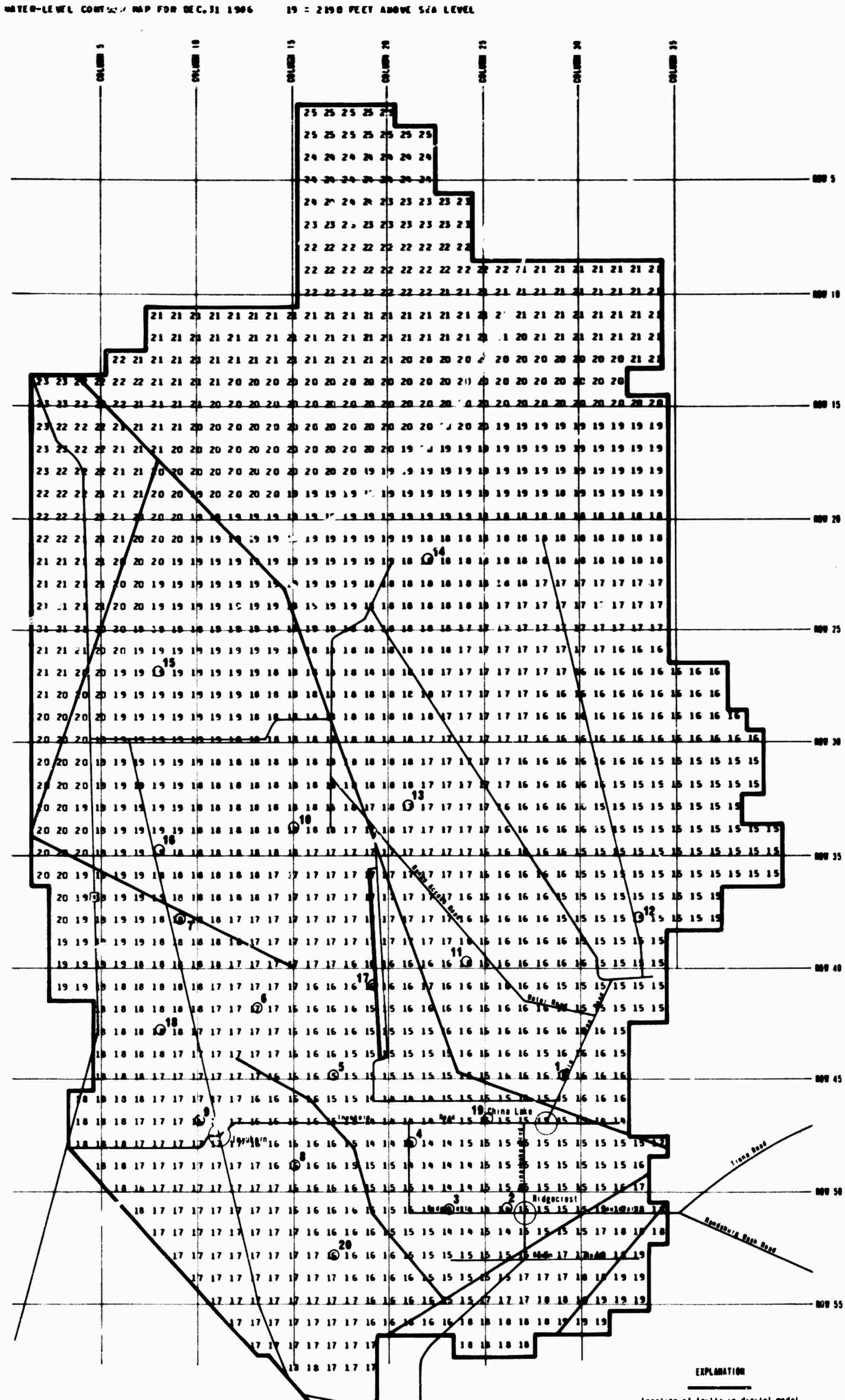

FIGURE 35. 1986 Projected Groundwater Levels, Indian Wells Valley.

Most of the electricity, propane, and natural gas is used for housing and administration areas on the Center. Using a national annual average home electricity usage figure of 7,380 kW-hr, NWC uses enough electricity to provide power to 16,500 homes.

Biotic Systems

There is a multitude of NWC actions which have the potential for affecting wildlife, habitat, and associated plant communities in the NWC vicinity. The living pattern and the recreation of the residents may affect wildlife in many different ways. It may be said that the very fact that we live here has a continuing influence on resident, migratory, and exotic wildlife.

Man's introduction of the burro to the California deserts vicinity, many years before establishment of NWC, affects native wildlife by providing additional competition for a number of species of plant foods and for water. Because burros and bighorn sheep are often incompatible, the burro has diminished the habitat which the bighorn once occupied.[6] Feral horses have not had the effect that burros have had, since they are more selective in their habitat at NWC, and do not provide as much competition.

Since the late 1800s cattle have been grazed on most of the China Lake Range. Since establishment of NWC two permittees run about 1,000 head of cattle from November through May on the northern one-third of the China Lake Range. The influence of cattle grazing on range wildlife is competition for food plants and for water.

Motor vehicle use of desert playas has a potential for affecting the desert fairy shrimp habitat. The impact of motorcycles on fairy shrimp on dry Mirror Lake has been heatedly debated by residents of China Lake. The results of scientific studies on Mirror Lake are presented in the section Evaluation of Environmental Impact of NWC Activities.

The pesticides used by NWC residents and for official use may not only exterminate undesirable insects and rodents, but may also be ingested directly or through the food chain by birds and non-target rodents. Although the food chain problem may diminish with the ban of persistent chlorinated hydrocarbons, such as DDT, indiscriminate use of any pesticide may affect wildlife.

The residential areas of NWC and Ridgecrest have removed or significantly modified roughly four square miles of former desert habitat. In addition, the areas have provided nesting sites for a variety of migratory and non-migratory birds that would not normally exist in Indian Wells Valley.

The sewage ponds from the sewage treatment plant have attracted a variety of migratory waterfowl. In this case NWC has had a beneficial effect on migratory waterfowl by providing water where it would not otherwise be in the desert.

The official business of NWC has the potential for influencing wildlife in two different ways. First, construction of roads and other sites may present corridors or obstructions to wildlife, or may create noise which would frighten some into other locations. Second, the strict security of the Center has provided a refuge for wildlife from the thousands of Californians who would normally use an area such as this for recreation.

The NWC natural resources management programs have a number of beneficial effects on wildlife:

1. Overall monitoring of range and habitat trends to identify potential problems and initiate preventive or remedial programs to maintain thriving biotic systems.

2. Habitat improvement by installation of artificial watering devices.

3. Providing refuges for rare and endangered desert fishes.

4. Providing protection for the desert tortoise, a diminishing species of desert wildlife.

5. Upland game bird management; brood count and live trapping for transplant into other areas; open hunting during plentiful years.

Superimposed Socioeconomic Systems

Archeological and Historical Resources. Official use of the ground ranges at NWC has the potential for disturbing archeological or historical sites. High explosives contamination has excluded some sites from investigation.

Recreational use of the China Lake Test Range has the potential for disturbing the sites. Although not widespread, there is evidence of vandalism at popular attractions. Since recreational use of the Mojave "B"/ Randsburg Wash Ranges is not permitted, there is less impact on those sites.

The natural resources management programs at NWC and the strict station security regulations have had beneficial effects on archeological and historical sites. Effective protection from off-road vehicles has been provided, while providing some conveniences at the sites which can tolerate use.

Wilderness and Scenic Resources. Official road-building on the ground ranges has the potential for reducing wilderness and scenic values. Much of NWC lands, because of the lack of roads can be considered de facto wilderness; however a road can reduce that value by its mere presence and create an irreversible scar.

Illegal entry onto NWC lands by off-road vehicles has the potential for destroying wilderness and scenic values. Off-road motorcycle use of the Mojave Desert has skyrocketed in the last 10 years. In addition, illegal trespassing by these vehicles onto Navy lands appears to be on the upswing. This appears to be a potentially greater problem in the Mojave "B"/Randsburg Wash Ranges, where illegal entry can be easily gained along existing poor roads on flat topography leading onto Navy property.

Approved and controlled recreation use of the China Lake Range creates the potential for diminishing scenic values by careless disposal of refuse, vandalism, or travel off of established roads.

NOTES

1. Kunkel, F., and G. Chase, 1969. Geology and Groundwater in Indian Wells Valley, California. U.S. Geological Survey open-file report.

2. Bloyd, R. M., Jr., and S. G. Robson, 1971. Mathematical Groundwater model of the Indian Wells Valley, California. U.S. Geological Survey open-file report.

3. Fuhriman, D. K., and J. R. Barton, 1971. Ground Water Pollution in Arizona, California, Nevada, and Utah. Sponsored by the Office of Research and Monitoring, U.S. EPA, p. 36.

4. Bader, J. S. 1969. Ground-water Data as of 1967, South Lahontan Subregion, California. U.S. Geological Survey open-file report.

5. Bloyd and Robson, op. cit.

6. McKnight, T. L. 1958. "The Feral Burro in the United States: Distribution and Problems." Journal Wildlife Management 22(2): 163-179.

ACTIVITIES AFFECTING PUBLIC HEALTH

Hazardous and Toxic Materials Usage and Transportation

In conjunction with daily work at NWC, large amounts of hazardous material are used. The Supply Department at NWC has a list of over 3,000 different types. Table 16 provides a thematic breakdown of explosives, pyrotechnics, and chemicals handled for weapons purposes.

Liquid flammable materials on the Center are transported by the NWC Public Works Department, while the NWC Supply Department handles solid flammable, bulk-type powders, such as aluminum, magnesium, zirconium, and tungsten. Beryllium, due to its extreme health hazard, is no longer stocked at NWC.

A wide variety of solvents is used at NWC. Table 17 is a list of solvents including the annual demand for each solvent.

Toxic materials are handled chiefly by NWC in propellant formulations. Three major toxic compounds handled are

1. DDI 1410, a diisocyanate; slightly toxic
2. IPDI, an isocyanate; toxic
3. TDI, toluene diisocyanate; toxic

Necessary safeguards and precautions are spelled out in many Navy and U.S. Department of Transportation regulations.[1] In addition, for many exotic materials NWC Instructions exist. For hazardous materials handled at NWC, methods of transportation and handling are made explicit.

Potential environmental impact from hazardous materials can take a number of forms, depending upon the material and the circumstances. Death or injury to personnel is possible. From 1963-72, 16 injuries and 3 fatalities resulted from hazardous materials at NWC. Approximately 5% of all NWC injuries and deaths are due to handling of hazardous materials.

NWC explosives magazines are located sufficiently far away from residences so that potential harm is minimal. To this date, no residences have been affected by NWC's handling of hazardous materials.

Electromagnetic and Ionizing Radiation

The mission of NWC requires extensive use of a wide variety of electronic equipment. Much of the equipment used in research and development programs at NWC (such as radar and telemetry equipment) must operate in electronic "quiet zones," where electronic noise from other equipment is not present. Fortunately, the various ranges at NWC, where isolation is important because of weapons testing, are in relatively "quiet zones."[2]

Other programs, such as those conducted at Echo Range in the Mojave "B"/Randsburg Wash complex, require a higher degree of electronic quietness. The remoteness of these critical ranges enables NWC to maintain control and prevent the intrusion of outsiders who use equipment which would cause electronic interference. This combination of isolation and electronic quietness contributes significantly to the successful execution of RDT&E programs.

TABLE 16. Inventory of Hazardous Materials at NWC.

The following information relates to surface-type ammunition and missiles, air-to-air missiles, air-to-ground missiles, and underwater ordnance. This includes standard and experimental explosives.

1. Warheads

   a. High explosive loaded
   b. Exercise
   c. Inert

2. Rocket motors

   a. High explosive loaded
   b. Inert

3. Missile components

   a. Guidance and control units
   b. Target detecting devices
   c. Safe and arm devices
   d. Fuzes

4. Surface-type ammunition

   a. Demolition charges, high explosive loaded
   b. Gun ammunition, 22 caliber to 16-in. gun ammunition

5. Bombs, dispenser-type weapons, and related components

   a. Bombs, high explosive loaded
   b. Mark 80 series, loaded, practice, and inert types
   c. Fuzes; loaded and inert
   d. Boosters, loaded and inert
   e. Fins, inert
   f. Laser-related bombs and components
   g. Dispenser-type weapons, loaded, practice, and inert

6. Miscellaneous components for experimental purposes

   a. Detonators
   b. Squibs
   c. Primers
   d. Leads
   e. Initiators

7. Pyrotechnics

   a. Flares, various types
      (1) Hand signals
      (2) Surface-to-launch signals
      (3) Ships emergency identification signals
      (4) Aircraft-type pyrotechnics, such as tracking flares and parachute-type flares

8. Underwater-type materials and related components

   a. Mines, loaded, practice, and inert
   b. Torpedoes, loaded, practice, and inert

TABLE 16. (Contd.)

c. Warheads, loaded, practice, and inert
d. Fuzes, loaded, practice, and inert
e. Boosters, loaded, practice, and inert

9. Bulk high-explosive-type materials

a. TNT
b. Cyclotone
c. Comp-B
d. PBX-N
e. RDX
f. CH6
g. Amitol
h. Octol
i. Tetrol
j. TNETB
k. HMX
l. DATB

10. Bulk-type powders for gun and rocket use

a. Black powder
b. Ballistite, from 11 3/4 to 15 in.
c. Small arms bulk powder

11. Chemicals, military-type

a. CN-type
b. CS types
c. Smoke pots
d. Thickeners

TABLE 17. Annual Solvent Demand at NWC.

Name	Annual demand, gal
Cleaning compound	2,090
Cleaning compound	10
Cleaning compound	5
Cleaning compound	935
Stoddard solvent	213
Acetone	472
Acetone	1,760
Ethylalcohol	44
Methanol	1,925
Methanol	770
Naptha	50
Methylethylketone	147
Toluene	195
Trichloroethylene	1,430
Trichloroethylene	345
Xylene	10
Cleaning compound	160
Cleaning compound	75
Cleaning compound-solvent	395
Dry cleaning solvent	791
Dry cleaning solvent	41
Cleaning compound	7
Thinner dope and lacquer	1,778
Thinner dope and lacquer	6
Thinner, petroleum spirits	1,066
Thinner, enamel	56
Thinner, enamel	100
Turpentine	45
Corrosion preventive compound	990
Cleaner solvent	615
Antistatic spray	14
Cleaner	360
Cleaner	879
Film remover	15
Cleaner	127
Cleaner descaler	454
Total demand	18,673

Another important factor affecting the location and operation of NWC ranges is the possible hazard of radio frequency (RF) radiation to personnel. Equipment that produces high-energy RF radiation must be used in areas where access by personnel is closely controlled.

Similarly, the HERO (hazards of electromagnetic radiation to ordnance) effect also governs the location and use of electronic equipment. The NWC Electromagnetic Compatibility Group was organized in 1958 in the vanguard of the Navy HERO program. Its charter was to investigate the causes for accidents due to exposure of weapons to electromagnetic fields and to develop safety measures to prevent future accidents. With the establishment of the Navy HERO program under the Bureau of Ordnance at Naval Weapons Laboratory, Dahlgren, this group has continued an intensive research and development program. Contributions have been made to both the larger Navy program and to making NWC-developed weapons safe for use in the Fleet. Certain ordnance material used at NWC is classified as HERO UNSAFE because it is susceptible to detonation by RF radiation.

As the use of ordnance is a critical part of the mission of NWC, the placement of electronic equipment is carefully selected to meet HERO criteria. Isolation and controlled access to areas containing ordnance is extremely important. Here again, the remoteness of NWC ranges provides an important safety factor from the HERO standpoint.

Radio communications involve another important and widespread use of electronic equipment at NWC. Radio communication systems are used for air navigation and operational control of the ranges, and for support functions.

The Center has, at the present time, approximately 500 current frequency assignments for telemetry, video, microwave, radar, command control, and voice communication (range control, air/air/ground, internal security, industrial control, fire, ambulance, etc.). Approximately 130 radio frequencies are now assigned for voice communications. Tables 18 and 19 illustrate the extensive use of electronic equipment at NWC.

No comprehensive assessment has been made to evaluate safety hazards from all the radar sites. It is simply assumed that each presents a potential hazard, so appropriate precautions are taken to prevent burns.

NWC uses ionizing radiation in inside operations. All radiation is "closely held" under Atomic Energy Commission regulation. NWC activities are licensed and monitored by AEC; 11 licenses are held at NWC.

Pesticides Usage

A variety of insecticides, herbicides, and rodenticides is used by NWC. A significant percentage of pesticides is administered to NWC housing for insect abatement. Rodenticides are used in areas such as the golf course.

As shown in scientific literature,[3] pesticides can have great potential effect on non-target wildlife, either directly or through the food chain. The ban of persistent chlorinated hydrocarbons such as DDT has decreased the possibility of accumulated pesticide effects.

The greatest potential pesticide impact would be in the NWC housing

TABLE 18. Unclassified Radar Installations at NWC.[a]

System No.	Operating frequency, MHz[b]	Power, kW[b]	Radar use
Used at One Location			
1	9.3-9.4	10	Experimental tracking
2	8,500-9,600	150	Instrumentation
3	8,500-9,600	250	Drone tracking
4	2,700-2,900	250	Target
5	3,100-3,500	600	Surveillance
6	8,500-9,600	250	Experimental
7	2,700-2,900	250	Target
8	3,100-3,400	600	Air search
9	1,030	0.03	Weather research
10	1,220-1,350	500	Weather research
11	9,320-9,380	50	Weather surveillance
12	16-17 GHz	5.0	Tracking
13	8,500-10,500	120	Radar signal
14	2,700-2,900	800	Tracking
15	3,450-3,550	50 MW	R&D measure interference
16	2,700-3,100	450	Target
17	3,500-9,600	250	R&D
18	8,500-9,600	250	Space position tracking
19	10-10.25 GHz	0.2	Doppler
20	8,400-9,600	400	R&D
21	8,500-9,600	250	Weather research
22	10.26-10.46 GHz	1.0	Tracking
23	15,500-17,500	250	ECM training
24	2,700-3,100	240	Target
25	8,500-9,600	250	Aircraft
26	5,400-5,900	40	Experimental
27	8,100-12,100	0.01	R&D—measure radar
28	7,000-11,000	0.001	Interferometer
29	990-1,040	1.5	Interrogator
30	2,700-2,900	450	Target
31	3,100-3,300	1000	Drone acquisition
32	8,600-9,500	100	Experimental test-bed
33	8,500-9,600	250	Space position tracking
34	8,500-9,600	250	Space position tracking
35	8,500-9,600	250	Space position tracking
36	8,500-9,600	250	Space position tracking
37	8,500-9,600	400	Tracking
38	9.45-9.55 GHz	120	Experimental surveillance
39	9,500-9,600	250	Space position tracking
40	2,700-3,100	700	Target
41	8,500-9,600	250	ECM training
42	9.2-9.6	25	Passive target
43	4,900-5,100	200	Passive target
44	8,500-9,600	250	Aircraft
45	5,400-5,800	250	Tracking
46	8,500-9,600	250	Space position tracking
47	5,400-5,900	1 MW	Space position tracking

TABLE 18. (Contd.)

System no.	Operating frequency, MHz[b]	Power, kW[b]	Radar use
Used at Various Locations			
48, 49	150	150	Target
50, 51	720-3,100	350	Target
52-56	815-880	320-600	Target
57	820-880	400	Target
58	920-970	90-110	Target
59-70	2,700-3,100	250	Target
71-102	2,700-3,100	250	Target
103-107	2,740-2,960	200	Target
108	2,000-3,500	1,000	Target
109, 110	2,700-2,900	126-250	Target
111-116	4,900-5,100	200	Target
117-121	4,900-5,100	250	Target
122	4,900-5,100	200	Target
123	6,275-6,575	200	Target
124, 125	8,500-9,600	62	Target
126-135	8,600-9,500	250	Target

[a] Additional radar installations not listed because of their security classification.
[b] Except as indicated.

TABLE 19. Radio Communication Facilities.

NWC has a variety of radio communication systems which are used for operational control of 5 major test range complexes, and for industrial control, fire, ambulance, and internal security. These facilities provide ground-to-ground voice communications for the test ranges, laboratories, shop and housing areas, and consist of repeaters, base stations, and over 700 mobile and portable units. Major systems, with repeater locations and number of mobile units, are listed below:

1. SNORT Range Control Radio Repeater: collinear array antenna, 30 feet above ground, 2,350 feet msl; 15-mile operational radius; located 35° 40′ 19″ N. latitude, 117° 44′ 31″ W. longitude; 85 mobile units.

2. G Range Control Radio Repeater: collinear array antenna, 30 feet above ground, 2,750 feet msl; 30-mile operational radius; located 35° 40′ 47″ N. latitude, 117° 36′ 43″ W. longitude; 85 mobile units.

3. Echo Range Control Radio Repeater: collinear array antenna, 40 feet above ground, 2,460 feet msl; 30-mile operational radius; located 35° 31′ 18″ N. latitude, 117° 18′ 11″ W. longitude; 10 mobile units.

4. C Range Control Radio Repeater: collinear array antenna, 35 feet above ground, 2,203 feet msl; 20-mile operational radius; located 35° 46′ 10″ N. latitude, 117° 43′ 25″ W. longitude; 10 mobile units.

5. Survey Radio Repeaters: collinear array antenna, 20 feet above ground, 2,737 feet msl; 30-mile operational radius; located 35° 52′ 09″ N. latitude, 117° 42′ 44″ W. longitude; 8 mobile units.

6. Common Radio Repeater: collinear array antenna, 40 feet above ground, 4,493 feet msl; 60-mile operational radius; located 35° 28′ 48″ N. latitude, 117° 40′ 59″ W. longitude; 163 mobile units.

7. C Range Simplex System, Using Mobile Transceivers: 2,200 feet msl; 10-mile operational radius; 10 mobile units.

8. Echo Range Simplex System, Using Mobile Transceivers: 2,400-2,460 feet msl; 15-mile operational radius; 10 mobile units.

9. Survey Simplex System, Using Mobile Transceivers: 2,200-5,000 feet msl (used at various ranges); 10-mile operational radius; 8 mobile units.

10. B Range Simplex System, Using Mobile Transceivers: 2,300-2,400 msl; 15-mile operational radius; 25 mobile units.

11. B Range Control Radio Repeater: collinear array antenna; 30 feet above ground, 4,075 feet msl; 30-mile operational radius; repeater located 35° 55′ 41″ N. latitude, 117° 47′ 31″ W. longitude; 25 mobile units.

12. SNORT Range Control Simplex System: 2,160-2,200 feet msl; 15-mile operational radius; 30 mobile units.

13. G Range Control Simplex System: 2,160-2,260 feet msl; 15-mile operational radius; 85 mobile units.

14. Public Works Industrial Control Repeater: collinear array antenna 30 feet above ground, 3,370 feet msl; 30-mile operational radius; main repeater located 35° 39′ 58″ N. latitude, 117° 35′ 55″ W. longitude; 76 mobile units. (Spare repeater with same type antenna at 2,200 feet msl, located 35° 38′ 00″ N. latitude, 117° 39′ 00″ W. longitude.)

15. Internal Security Radio Repeater: collinear array antenna, 30 feet above ground, 3,370 feet msl; 30-mile operational radius; main repeater located 35° 39′ 58″ N. latitude, 117° 35′ 55″ W. longitude; 20 mobile units. (Spare repeater with same type antenna at 2,262 feet msl, located 35° 38′ 00″ N. latitude, 117° 40′ 00″ W. longitude.)

16. Fire/Ambulance/NAF Internal Security Base Stations (Three Base Stations): all using collinear array antennas, 30 feet above ground, 30-mile operational radius, located at:

TABLE 19. (Contd.)

a. 35° 39′ 58″ N. latitude, 117° 35′ 55″ W. longitude, 3,370 msl
b. 35° 32′ 25″ N. latitude, 117° 15′ 43″ W. longitude, 2,280 msl
c. 35° 41′ 00″ N. latitude, 117° 41′ 00″ W. longitude, 2,220 msl
32 mobile units.

17. Industrial Control (Taxi) Base Stations (Two Base Stations): all using collinear array antennas, 30 feet above ground; 30-mile operational radius, located at:

a. 35° 39′ 58″ N. latitude, 117° 35′ 55″ W. longitude, 3,370 msl
b. 35° 38′ 00″ N. latitude, 117° 39′ 00″ W. longitude, 2,220 msl
32 mobile units.

18. TACAN Site, NAF:

a. TACAN AN/URN-3A power output 5 Kw, effective range 200 miles.
b. Two UHF and three VHF transmitters. Power output approximately 20 watts. Normal range fixed station 15 miles. Maximum range varies with height and distance.
c. HOMER-AN/FRN-24

19. Tower, NAF:

a. Two UHF and Two VHF Transmitters: TED series; normal range 15 miles; maximum varies with height and distance.

20. Michelson Lab:

a. AN/FRC-70 power output 50 watts; effective range 100 miles.

21. Building 31427 (Ground Electronic):

a. Two FRT-17 HF. Power output 500 watts.
b. Two VHF and Two UHF. Normal range 15 miles; maximum range varies with height and distance.

and administration areas. Potential receptors would include birds which eat poisoned insects or vegetation; migratory waterfowl which could be affected if pesticides were to wash into the sewage ponds; and indigenous species of desert rodents such as Antelope, Mojave, and other ground squirrels which could fall prey to rodenticides.

Table 20 reports target pests and quantities and types of pesticides used by NWC; Table 21 provides a total annual inventory of NWC pesticide usage.

The Navy Applied Biology Program has for more than 5 years cooperated within guidelines established first by the Federal Committee on Pest Control and currently by the Working Group, Council on Environmental Quality. Annually this group has provided interfederal agency review of the Department of the Navy pesticide usage plans submitted by the Naval Facilities Engineering Command and has recommended changes, where appropriate, to protect the natural environment from unnecessary stresses resulting from persistent or hazardous pesticides. One of the features of the Navy program, which is coordinated with the program for the other services at DOD level through the Armed Forces Pest Control Board, is that routine Center operations are reviewed monthly at local levels within the same report system that provides Navy-wide program supervision. This frequent guidance by professional applied biologists ensures that pesticides are applied for control of specific pests and not used in a broad "shotgun" approach. Considerable concern is given to the fate of non-target organisms, both plant and animal, before a control program is instituted.

TABLE 20. NWC Pesticide Use by Pest and Concentration, 1972.

Name	Target pest	Annual pesticide amount, gal[a]	Concentration, %
Propoxur	Cockroaches	462	0.5
Diazinon	Cockroaches	1,669	0.5
Diazinon	Spiders	6	0.5
Chlordane	Cockroaches	23,925	0.5
Chlordane	Spiders	6,163	0.5
Chlordane	Leaf-chewing insects	400	0.5
Chlordane	Ants	100	0.5
Chlordane	Subterranean termites	5,850	1
Strychnine	Gophers	31	0.25
Dioxathion	Ticks	1,800	0.5
Atrazine	All weeds	1,000	2
Borate-Monuron mixture	All weeds	1,600 lb	
Calcium cyanide	Gophers	37 lb	42
Chlorate-borate mixture (25% sodium chlorate 73% disodium octaborate mixture)	Aquatic weeds	800 lb	98
	All weeds	12,236 lb	98
	Grass weeds	539 lb	98
Trifluralin	Mixed grass and broad-leaved weeds	100	2
Malathion	Biting flies	200	0.5
24 D	Grass weeds	120	0.5
24 D	All weeds	140	2
Mineral oils	Mosquitoes	1,250	100
Herbicidal oils	All weeds	2,025	100
Herbicidal oils	Grass weeds	500	
Dichlorvos	Filth flies	4,930	0.5
Cacodylic acid	Mixed grass and broad-leaved weeds	900	0.3
Araquat	Grass weeds	200	0.5
Maleic hydrazide	Grass	1,600	0.5

[a] Except as indicated.

TABLE 21. NWC Annual Pesticide Inventory, 1972.

Name	Annual usage, gal[a]
Propoxur	2.3
Diazinon	8.4
Chlordane	211.4
Dioxathion	9.0
Atrazine	20.0
Trifluralin	2.0
Malathion	1.0
24 D	3.4
Dichlorvos	24.6
Cacodylic acid	2.7
Paraquat	1.0
Maleic hydrazide	8.0
Calcium cyanide	15.5 lb
Borate-Monuron mixture	1,600 lb
Strychnine	0.8 lb
Chlorate-borate mixture	13,304 lb
Mineral oils	1,250
Herbicidal oils	2.525

[a] Except as indicated.

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EVALUATION OF ENVIRONMENTAL IMPACT OF NWC ACTIVITIES

IMPACT ON ABIOTIC NATURAL PHYSICAL SYSTEMS

Geological Systems

Seismological Implications of NWC Activities. Because NWC lies in a major earthquake intensity zone,[1] potential seismological impact of NWC explosives use must be examined. Literature cites both positive and negative potential impact of explosives use. Negative impact consists of unplanned, uncontrolled tectonic movements resulting from subsurface explosion or injection of fluids under high pressure. Positive impact consists of a planned action by which accumulated stress can be released gradually through controlled subsurface explosions or injections of fluids under high pressure.[2]

Since there are no NWC actions to purposefully relieve stress by explosives, any unplanned episode would therefore fall into the realm of negative environmental impact. As of this date, no explosive yield or subsurface depth criteria exist for man-made fault movement in the NWC vicinity. Since live warheads are seldom used at NWC, and because subsurface explosions almost never occur, it is predicted that the potential impact of NWC operations on seismological activity approaches zero. This is verified by the fact that no earthquakes or tremors have ever been found attributable to NWC actions.

Local Erosion Due to Roads Improvements. Roads and improvements promote local erosion by rerouting normal drainage patterns. This is particularly true on hillsides where two-dimensional laminar flow of water down the side may be transformed at the road to one or more one-dimensional flows. This alters the flow along certain drainage patterns so that it can increase by several orders of magnitude due to the road. Erosion and sedimentation are thereby enhanced. In addition, hillside slope instability can be caused by removal of part of the surface mass by excavation in order to build a road.

Local erosion and slope instability increase as a function of type of road, topographic gradient, and soil erodibility. In order to assess the environmental impact of roads at NWC, each of these factors must be examined. Table 22 displays the miles of road at NWC by type.

These figures are for locations outside the housing areas, where environmental impact would be felt the most. Total miles of maintained roads, including residential, is 410. The majority of roads at NWC are unimproved dirt which are not maintained. This is particularly true in the outlying mountain range areas.

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TABLE 22. NWC Road Mileage.

Area	Road classification	Mileage
China Lake complex (excl. residential)	Medium-duty	108
	Light-duty	252
	Unimproved dirt	267
Mojave "B"/Randsburg Wash	Medium-duty	18
	Light-duty	3
	Unimproved dirt	348

Figure 36 shows that for the majority of the mountain area on NWC the erodibility is classified as severe.[3] For the remainder of NWC the erodibility is classified as low. Thus the greatest impact of a road is in the outlying mountain areas of NWC, where erodibility is high. Because at least 90% of the road mileage in the outlying mountain area is unimproved dirt, there is a relatively low geological environmental impact due to roads.

Surface Settling Due to Groundwater Extraction. There are a number of recorded incidents where extraction of large volumes of water or oil has caused settling of the ground surface. As an example, subsidence at Long Beach, California, as a result of withdrawals from the Wilmington Oil field caused extensive damage.[4,5] In addition, it is a problem in Houston "where withdrawals of large amounts of water from the poorly consolidated sediments of the Gulf Coast Aquifer have resulted in subsidence of several feet in some areas, with damage to buildings, pavement, and flood control systems."[6] At Lancaster, California, 2.8 feet of subsidence was recorded between 1926 and 1955 as a result of groundwater extraction.[7,8]

Although the amount of subsidence is proportional to the decline in water table, it varies widely with the area. In some areas of the San Joaquin Valley there was as much as 1 foot subsidence for each 20 to 25 feet of water table decline.[9,10]

Water-level contours for Indian Wells Valley for years 1920 and 1968 show a decline in water table between 5 and 35 feet in that time.[11] If Antelope Valley and San Joaquin Valley results can be used as guides, subsidence of up to a foot in two locations in Indian Wells Valley might be predicted. Because no subsidence has been noted to date, the environmental impact on surface settling is judged to be low up to this point. There is a small future possibility of local subsidence if current pumping practices are continued.

Soil Alteration. In arid climates where there are significant amounts of irrigation, vegetation and chemical salts may build up and alter the composition of the soil.[12] In the residential areas of Indian Wells Valley, soil composition change is a desired result, in consonance with the desire by a large majority of residents to have an "oasis environment in the desert."

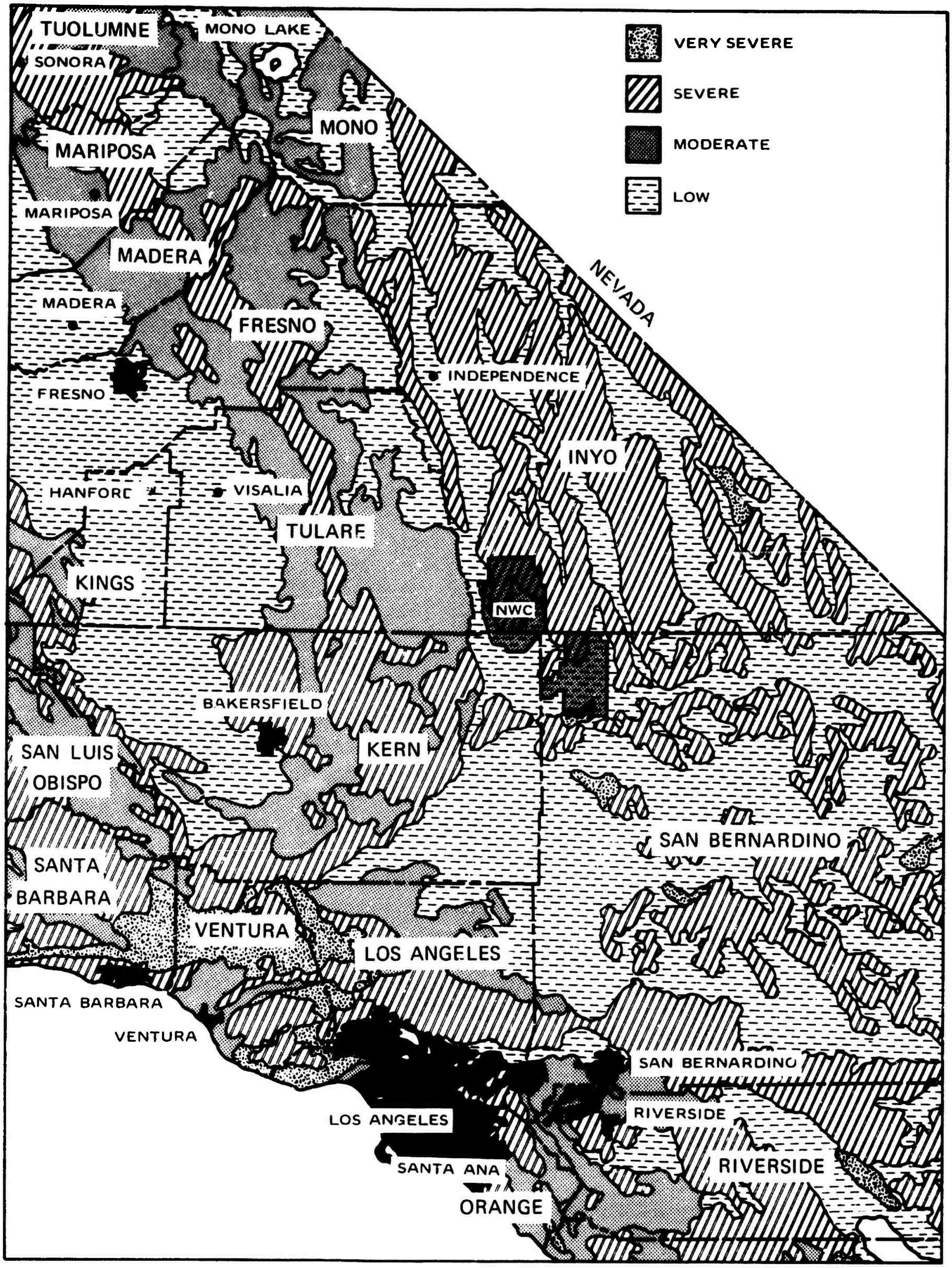

FIGURE 36. Soil Erodibility, Naval Weapons Center and Vicinity.

In the residential areas at NWC, there has been soil alteration, but because of the people's perception of environmental quality, it could be considered a positive environmental impact. Trees, shrubs, and grass are considered by most residents to be important amenities, even though there is little harmony with the native desert flora.

Climatological Systems

Humidity Change in Indian Wells Valley. Some arid western cities have experienced a significant increase in summer humidity due to the usage of large amounts of water for irrigation, water coolers, and other uses. The Indian Wells Valley has climatological characteristics conducive to large-scale humidity change. It is a closed valley, it is extremely hot in the summer with low humidity, and a significant amount of water is released to the air per unit time.

Data on NWC water usage and inflow to the sewage treatment plant (Tables 10 and 13) indicate that only 20 to 40% of the water used is returned as sewage. The remainder is used for gross productivity for plants and lost through evaporation. In addition, roughly 25% of the sewage influent is ultimately lost to evaporation. Assuming an upper limit of 25% of NWC water used for gross plant productivity, it is estimated that at least 50% of all NWC water used is ultimately lost to evaporation. At NWC, roughly 4,000 acre-feet of water is then evaporated each year. If this can be extrapolated to other Indian Wells Valley users, a total of roughly 6,000 acre-feet or 2 billion gallons of water is evaporated within the valley each year. Data on yearly usage show that well over half of this figure occurs within the four summer months, June through September. It can be concluded that enough water is evaporated that the possibility of valley-wide summer humidity change should be investigated.

In order to test the assumption that humidity has changed, data on summer humidity were gathered for the 1952 to 1972 summer months. The year 1952 was considered a sufficient baseline since the valley water usage that year was between 40 and 50% of present usage. The humidity-measuring site is the Naval Air Facility, which is sufficiently removed from the local housing effects to give a true valley-wide value.

The statistical tool commonly used to discern significant variation in time-series data is called the student t-regression analysis. The method is given in Appendix 3. In essence, the method computes a t-statistic which increases as the humidity increases continuously from one year to the next. One then compares this number with another statistic to see if any significant change has occurred. Table 23 gives the t-statistics for summer months humidity.

If /t/ were to exceed the critical value $t_{.025,18} = 2.101$, then one could conclude that at the 5% significance level there has been true change in humidity.

TABLE 23. T-Statistics for NWC Summer Humidity.

Month	t-Statistic, /t/
t - June	0.010
t - July	0.728
t - August	0.357
t - September	0.390

For all months the t-statistics are much less than the critical value of 2.101; so, it can be concluded that NWC and the adjacent residential development has had no impact on average summer humidity in the Indian Wells Valley.

Cirrus Cloud Formation and Radiation Balance Change Due to Jet Contrails. Recent studies[13] related to future environmental impact of the proposed supersonic transport (SST) suggest the possibility of climate modification due to cirrus clouds created by jet contrails. Because NWC jet aircraft occasionally create contrails, the environmental impact is examined.

Studies show[14] that contrails are caused by flight in the upper troposphere and occasionally in the lowest part of the stratosphere (below 40,000 feet). NWC jets logged approximately 3,500 hours in 1971 above the inversion layer (8,000 feet msl) in Airspace R-2505. Although no data are available on number of hours spent in flight in the upper troposphere and lower stratosphere, the number could not exceed 3,500 hours.

Because the jet contrail studies are currently inconclusive, there are no criteria or guidelines to follow in order to quantitatively assess this aspect of environmental impact due to NWC jets. The only alternative is to rely upon observations of cloudiness in the NWC area. Because all contrails in the NWC area never cover more than 0.001 of the sky, the environmental impact of NWC jet contrails on clouds and radiation balance is preliminarily judged to be extremely low.

Rainfall Augmentation by Cloud Seeding. NWC has been conducting a cloud seeding program in Santa Barbara and Ventura Counties since 1967. Results to date show a total increase of about 10 to 15% in seasonal rainfall over an area of several hundred square miles. Seeding does not take place when heavy storms are forecast, or when a condition of saturated watershed exists.

Previous data in this report show that certain small areas in the seeding areas received two to three times their average rainfall. It is in these areas where significant rainfall change has been induced.

Ecological research on rain augmentation predicts,

> *An increase of 10% in mean annual precipitation will inevitably lead to an adjustment in community structure over a period of time. . . . This adjustment will normally take*

place more slowly in a region of highly variable weather than in one of relatively uniform weather from year to year. Likewise, sensitivity to deliberate precipitation change is likely to be greatest in semiarid climates, least in humid climates, and intermediate in truly arid regions.[15]

The semiarid Santa Barbara region would therefore be sensitive to precipitation change, although plant community structure change would take place slowly since it is an area of sporadic changes in rainfall from one year to the next.

If the Santa Barbara project is continued for another decade, significant plant community and productivity change could occur in selected areas. The hot dry period from May to November with frequent fires, coupled with a mild winter, favors a chaparral plant community over much of the area. It is possible that a foothill woodland community could succeed chaparral in areas of a significant increase in precipitation.

Assuming the Santa Barbara seeding program has the effect of generating an additional one inch of rain per year average over a 500-square mile area, then approximately 25,000 additional acre-feet of water are created. If 20% were to reach domestic water sources, an additional 5,000 acre-feet of water would be made available to the Santa Barbara Project area. In the absence of floods, this could be termed a beneficial environmental impact in Southern California.

In summary, the Santa Barbara seeding project has significant climatic impact, not only in augmenting current water supplies, but also in providing the potential for plant community change over an extended period of time in local areas of Southern California.

Hydrological Systems

Groundwater Table Change. Because the water users of Indian Wells Valley are currently pumping groundwater faster than it is being replenished, the groundwater table is dropping. Data and figures from previous sections of this report show that between 1920 and 1968 there was a 5- to 35-foot drop in water table in Indian Wells Valley, and that by 1983 another 5- to 20-foot drop is predicted if current trends continue.[16] The effect will be greatest 2 miles west of Ridgecrest and at Inyokern, where levels between 1920 and 1983 are predicted to drop 40 to 55 feet.

Direction of flow was altered in the Ridgecrest area such a degree that, "By 1968 pumpage in the deep aquifer had caused a reversal in the groundwater gradient south of China Lake. . . ."[17] Because of this there is a possibility of brackish water flow from beneath the China Lake playa to the good water of the Ridgecrest pumping area some time in the future. The probability of this happening within the next 40 years is undetermined by the U.S. Geological Survey.[18]

The U.S. Geological Survey has termed the water level decline over much of the Indian Wells Valley deep aquifer as "small." Combining this assessment with the larger water table drops predicted in Inyokern and Ridgecrest areas by 1983, it is judged that the environmental impact of NWC water usage or groundwater table change is low to moderate.

Impact on Springs and Seeps. Springs and seeps are indispensable water sources for almost all wildlife inhabiting the NWC ranges. Certain springs on NWC are also used as municipal water supply for the town of Darwin.

Through the natural resources management programs at NWC a number of springs and seeps have been restored and improved after destruction or fouling due to feral animals and other causes. In addition, in order to distribute game birds and small mammals over a wider area of the range, watering devices (guzzlers) are located on slopes where rainwater and snowmelt can be conserved. Even during extremely dry years the guzzlers have held sufficient water for use by wildlife.

Because NWC has improved wildlife water sources on the Center while not destroying others, the net environmental impact is judged to be significantly beneficial.

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IMPACT ON NATURAL BIOTIC SYSTEMS

Habitat Alteration

Facilities. NWC facilities that affect animal habitat consist of buildings, landscaping, roads, overhead utility lines, sewage ponds and lagoons, and dumps. In certain discrete areas, the natural creosote bush scrub plant community has been replaced by a man-made habitat which often attracts migratory or exotic species and alters the population and spatial distribution of others. In the case of the industrial and residential community in China Lake and Ridgecrest, rodent and reptile populations have been significantly reduced due to destruction of habitat. However, migratory songbirds such as warblers and wrens have been attracted, and others, such as the mockingbird, are now residents.

Sewage ponds and lagoons serving the main sewage plant have attracted a variety of migratory waterfowl. The attraction of the lagoons is probably greater than if Owens Lake to the north had not dried up as a result of providing water to the Los Angeles metropolitan area. The principal effect of the NWC dumps has not been to alter species composition, but to localize and increase populations of desert rodents and their predators, such as the desert kit fox. The total estimated area affected is 10 square miles. This is roughly 2% of the Indian Wells Valley and less than 1% of NWC total area.

NWC Tests. The fragility of the desert scrub plant communities has been well documented in the ecological and botanical literature. Complete regeneration of plant growth after destruction can approach 40 to 100 years. The primary effect of NWC operations on habitat has been to destroy vegetation in certain small areas. Small spotting charges dropped into normal drop zones in north Indian Wells Valley have little effect due to the sparsity of the creosote bush-atriplex association. Infrequent magazine explosion tests conducted in the Randsburg Wash Range have greater impact due to the intensity of the blast. The amount of land affected due to the facilities preparation and explosion is from 2 to 5 acres.

Shields, et al.[1] assessed most of the recovery of vegetation at Mojave Desert sites in Nevada after nuclear detonations and provides some quantitative data on desert recovery time after denuding vegetation. In this study they noted that damage was due to three major effects: blast and shock, heat, and ionizing radiation. They noted recovery after the first year by a number of annuals, ranging in coverage from 12 to 47% at 16 control plots in Yucca Flat. Recovery in the second, third, and fourth years decreased, associated with a decrease in precipitation. After 4 years, recovery of several perennials, such as *Larrea divaricata*, was evident.

If the Shields, et al.,[2] study can be used as a guide, then one could expect regeneration of desert annuals and perennials in those areas denuded by blasts or grading within 5 to 10 years, depending upon precipitation. Although, as stated in Wells (1961),[3] the time necessary to return to the original climax condition could exceed 33 years.

Unofficial Recreational Use of Off-Road Motor Vehicles. Although a by-product of the official function of NWC, the use of motorcycles and other off-road vehicles has a significant impact on wildlife habitat.[4]

As of October 1972, NWC Security Department records show 300 off-street, unregistered, two-wheeled vehicles which had been issued identifying numbers for use on the Center. At the same time, 1,100 registered street-use, two-wheeled motor vehicles permitted on NWC streets were listed in Security Department records. Extending this intensity of usage to the entire Indian Wells Valley gives approximately 2,000 motorcycles, about 1 per 10 people in the valley. Nationwide there is about 1 motorcycle per 100 people.[5]

The impact of motorcycles on NWC lands has been investigated. Impact on soils in the Mirror Lake playa vicinity is provided by this extraction from the NWC Draft Environmental Impact Statement, *Off-Road Vehicle Use of Mirror Lake, Naval Weapons Center*, July 1973:[6]

The impact of continued recreational uses on the playa surface appears to result from two phenomena related to such use. The first of these is deflation - the second is armoring due to sand encroachment.

Obvious deflation occurs during periods of high wind, especially after a long, dry calm period. As a visual estimate, in the present time frame, some 75 percent of the dust blown from Mirror Lake playa should be considered the result of recreational usage of the playa surface. The 25 percent that is natural is the result of desiccation fracturing and temperature cycling phenomena. That blowing dust is natural is readily observed on such playas as Airport Lake, the southeast side of Searles Valley, etc. The dusts from Owens Lake should be considered man-made, however.

The second phenomenon related to the recreational use is the increased encroachment of sand from the loose alluvium along the west side (Richmond Road) of the playa. This sand-silt mixture is a significant source of windblown dust and sand. The sand fraction is gradually spreading onto the western margin of the playa. This reduces the quantity of playa-derived dust and modifies the playa surface, but is of no detriment per se.

A significant portion of the playa surface is stabilized by a desert pavement, i.e., is covered by a monolayer of pebbles. Examination of the "pavement" areas shows that, due to the high dry bearing strength of the playa surface and to the bonding ability of the calcareous micaceous silts, vehicular traffic has not caused significant damage or modification to the dust-preventive nature of this stabilizing cover.

The silty playa surface, when dry is too strong to break up under either two-wheeled or larger vehicles. Thus, local blowouts do not form as the result of the traffic-caused breakdown of a surface crust of layer. However, traffic does cause a loosening of the uppermost surface layer of *particles (scuffing) and traffic also breaks the edges of individual desiccation cracks. These two effects result in dust which can become airborne, both during periods of high wind (generally out of the southwest) and during the passage of "dust devils".*

A study was conducted by the Bureau of Land Management (1968) "to determine the effects of unregulated vehicle use on the vegetation, soil, and watersheds."[7] Some of the conclusions were as follows:

1. Hill climb areas where use is continued over a period of five years show more adverse effect than any other use sites. This is due to steep slopes (up to 50 percent) and a more concentrated use as compared to a cross country course. Soils are compacted more severely, often inhibiting germination of seeds, thereby preventing revegetation. Existing vegetation is usually wholly eliminated from the hill climb slope as a result of continued use. The erosion hazard is increased from a slight classification to severe. Once erosion occurs, major portions or all of the climb areas can be lost to future use by either vehicle or vegetation. Since climb areas are elevated and easily seen from a distance, aesthetic loss is greatly magnified.

2. Areas experiencing the least effects are those of the "one time only", cross country trail rides. Where they are laid out and take place on a level to slightly sloping terrain with only occasional low hills, damage to both soil and vegetation are minimal. In the Barstow [California] *course, for instance, tracks were discernible only occasionally, annual plants having germinated during the growing period following the cross country race. On the other hand, the Johnson Valley* [California] *course exhibited loss of annual vegetation since the race was held during the growing period. Presumably, new annual vegetation will fill the "one time" tracks following the next growing period.*

3. Continuous or intermittent use by cycles or four wheel drive vehicles on cross country trails results in considerable damage to the vegetation. Unrestricted use of large expanses of easily-accessible terrain results in a crisscross and spider web of trails. Individually, trails do not result in high rates of plant loss but, collectively, plant reduction is significant. Because slopes in this type of use are usually more gentle than those of hill climb areas, soil movement is categorized as displaced rather than lost. Exceptions to this will, of course, occur in the event of a secondary movement by wind or water of the now unprotected soil.

4. Use of the dune areas by dune buggies showed that, in general, adverse effects on the soil are negligible. Since a large percentage of the dunes support no vegetation, plant losses were not a problem. However, in localized sites where conditions are favorable, some rather rare or aesthetically valuable plants do survive and propagate on the dunes and these can be damaged by vehicles.

5. Observation of old and recent training maneuver areas reveals that tracks are more easily discernible from the air than on the ground. Undoubtedly much of the woody vegetation consisting chiefly of creosote bush and burro brush was destroyed by the heavy tracks, but there has since been some recovery by new seedlings and replacement by annual forbs and grasses. Time for the study did not permit a detailed count of plant damage or soil movement in this area.

6. The most apparent and easily-measured effect on vegetation and soil is that occurring in parking and camping areas, starting points and overlooks. The protective vegetation present is easily damaged or destroyed by the wheels of many vehicles or by use for fuel in camping areas. Continued use of this area will result in 100 percent denuding of the site. Intermittent use may or may not provide suitable protection for annual plants. Measurements on a one-acre plot were taken at a parking area and starting point for a cross country trail where 900 vehicles were gathered. The plot showed that 53 percent of the woody vegetation was destroyed or irreparably damaged. The slow rate of growth of one particular species, creosote bush, which is present on approximately 78 percent of the desert, precludes it from becoming a dominant wind or water control device for at least 10 years.

7. A further observation of soil compaction on use areas appears to have validity. Soils having a clay content of 25 percent or higher can produce compaction problems resulting in prevention of seed germination and water infiltration or concentration of surface water flows. Since most of the soils observed in the desert area are of coarse texture with low clay content, this problem is not as acute as in other regions.

8. It was not possible to measure effects of vehicle use on the quality and quantity of water at the time of the study due to lack of precipitation and resultant non-existent surface water flow.

9. A projection of future trends on increased use suggests that even the minimum amount of existing damage to the soil and vegetation on a single cross country trail in the creosote vegetative type could become very serious.

Lands most affected by motorcycles do not lie on NWC, since all but a very small fraction of land adjacent to the housing area is closed to their use. Public domain lands in the El Paso, Rademacher, and Spangler hills to the south of Indian Wells Valley appear to sustain the principal environmental impact.

Introduction of Non-Native Species

Cattle. On the China Lake Test Ranges since 1959, seasonal cattle grazing has been administered under a Memorandum of Understanding between the Bureau of Land Management (BLM) and the Center. Grazing area covers abcut the northern one-third of the China Lake Ranges shown in Figure 13. About 1,000 head of cattle are run from November through May by two permittees, who maintain the certain water troughs and berm reservoirs for the cattle under joint supervision of the BLM and NWC.

The effect of cattle grazing is to provide competition for water and forage plants. The degree of competition is dependent upon the plant primary productivity and intensity of grazing. Walter (1954)[8] showed that the primary productivity was roughly a linear function of rainfall. Extrapolating from his data, the cattle grazing site should produce 1,000 to 1,700 kg/ha-yr from the 5 to 8 inches annual rainfall. Odum, using data based on a 9-year study at Cottonwood, South Dakota, reported by Johnson et al. (1951),[9] states "the light intensity use, in which about a third of the net production is removed by grazing is the optimum use since the quality of range and animal is improved and the probability of severe damage during periodic droughts is greatly reduced."[10] This would amount to a grazing level in the China Lake Ranges of less than 400 to 600 kg/ha-yr by domestic cattle.

Through the NWC natural resources management programs, the effects of cattle grazing as well as uses by other large ungulates are continually monitored to ensure that domestic use of water and plants does not severely conflict with wildlife use. In many locations, fenced exclosures have been installed to provide water sources for birds and small mammals where an area of undisturbed vegetative cover gives them a retreat from predators.

Year-around cattle grazing leases have been issued in the past by the Riverside District of BLM for a portion of the south Mojave "B" Aerial Gunnery Range. In 1972, NWC requested reclassification of this grazing range in order to prevent continued overgrazing of the region. The BLM has informed NWC that the renewal of the lease has classified the range as "ephemeral" and restricts its use to allow recovery of the scanty vegetation on the grazing area.

Feral Horses. The California Department of Fish and Game estimates there are between 150 and 200 head of feral horses on NWC lands. They seem to prefer to range over higher elevations in the Coso Mountains and high volcanic tablelands of the Argus Range. Quality of the animals is outstanding and except during prolonged drought, their condition appears to be consistently good. Numbers of colts observed fluctuate with the cycles of drought and normal rainfall to which this area is subject.

The subject of wild horses in the western United States has been a matter of violent and highly emotional controversy during the past 5 or 6 years. Some of the largest herds in the State of California exist on NWC's China Lake Test Ranges.

Although the wild free-roaming horses do not appear to compete critically with other wildlife at NWC, in other areas this does not appear to be the case. In the State of Oregon's response to the Department of the Interior's Draft Environmental Impact Statement, Proposed Wild Free Roaming Horse and Burro Management Regulations, it is asserted that "horses are extremely aggressive and competitive, and when left unchecked could, more than likely, completely dominate many sites." It is also asserted that "unrestricted horses probably reproduce at the rate of 25% per year."[11]

It appears that the cold arid sites chosen by the horses on NWC have prevented them from rapid reproduction and subsequent ecological domination of the area. In fact, it appears from population counts over the last number of years at NWC that the population is stable. A recent 2-year investigation of wild horses in western Nevada found that band sizes were stabilized within the observed herd by limited colt production.[12]

The horses do not appear to dominate any former desert bighorn habitat. The competition for annuals and perennials in the sagebrush scrub and pinyon-juniper woodland plant communities where forage productivity is higher is not nearly as great as could be found in the lower elevations where creosote-atriplex communities exist.

Feral Burros. Wildlife biologists of the California Department of Fish and Game estimate 250 wild free-roaming burros on the China Lake Test Ranges and estimate 200 in the Mojave "B"/Randsburg Wash Ranges. Recent estimates by NWC have put the number in the Mojave "B"/Randsburg Wash Ranges as high as 500. Although not native to the area, feral burros have proved to be highly adaptable, establishing themselves in extremely arid areas.

Feral burros constitute a severe management problem on Center lands, on both the China Lake Ranges and the Mojave "B"/Randsburg Wash Test Ranges. Burros are far less selective in their choice of habitat than the horses, and range seasonally over all elevations on NWC lands.

Burros can be seen within 2 or 3 miles of the central area of the Center during winter months when they move down from the higher elevations. In summer, they range to the upper elevations of the Coso and Argus Mountains. Most wildlife managers consider them destructive to springs and water sources where they trample and foul large areas.[13,14,15,16] It is fairly well established that burros are highly competitive to bighorn sheep where the animals share the same habitat.[17,18,19,20] With no natural enemies other than man,[21] the herds are considered detrimental to areas where they exist in great numbers.

Use of low production habitat by burros, domestic cattle, and feral horses as well as mule deer and desert bighorn sheep in some areas puts five large ungulates in competition on the China Lake Ranges of the Center.

On the Mojave "B"/Randsburg Wash Test Ranges, sparse distribution of water makes the feral burro problem critical. Herds are concentrated in the Slate Range where vegetation is suffering very evident damage from their overgrazing. At water holes protected by steel fence posts with four-strand barbed wire for use of game birds and small animals, the burros destroy fences during the dry season to get to water. In this area, they tend to congregate around the water holes, with resulting denudation of vegetative cover from browsing and trampling.

The effects of burros can be more quantitatively seen using existing data on energy flow through the creosote bush plant community. Chew and Chew (1965)[22] estimated the net annual production of an Arizona Sonoran

Larrea community to be 1,400 kg/ha, giving an estimated net primary productivity of 6,100 Mcal/ha-yr. In a subsequent study, Chew and Chew (1970)[23] found that for an average biomass of mammals of 1.13 kg/ha in the community, the average energy flow of mammals was 105.95 Mcal/ha. They concluded "since the mammals dissipated only 1.95% of the net annual above ground plant production, their importance must be in their controlling actions on the community rather than in their energy turnover."[24]

If one assumes 200 burros to 50,000 acres in the Slate Range, it results in an average burro biomass density of 2.69 kg/ha, or over twice the natural mammal density existing already in Chew and Chew's site. Because burros concentrate around water holes, it is reasonable to assume that in some areas the burro biomass density would be more than 20 times the normal density. Only two permanent water sources are available to burros during the summer months.

If burros were as efficient as the small mammals in eating, one would expect them to consume 20 x 1.95 = 40% of the net annual above ground plant production. Their waste has already been documented; therefore, it is conceivable that the estimated 200 burros in the Slates could eat, literally, all the net annual above ground plant production in certain areas. Studies at NWC over the last 3 years have verified this.

In summary, the burros severely compete with native wildlife for available plant productivity at NWC, particularly in the Slate Mountains of the Mojave "B" Test Range.

Trailing and terracing of the highly erosible soils of the Slate Range by burros is very evident. It is reasonable to assume that movement of the feral burro herds in this remote area ranges from NWC lands into Death Valley. Mutual cooperation between the personnel of the Death Valley National Monument and the Center is planned in establishing management units, with burro herd numbers balanced to the ability of the habitat to support these animals and native wildlife.

To determine optimum numbers of burros on the ranges for the benefit of vegetation and other wildlife, a management program is under preparation. Based on definite geographical management units, all resources within a unit and the competition between species can be evaluated. From this unit plan, a reduction program can be undertaken in critical areas with a fair degree of expectation for permanent improvement.

Chukar Partridge *(Alectoris graeca)*. In the early 1940s the California Department of Fish and Game introduced Indian red-legged partridges *(Alectoris graeca)* to the upland desert areas of the state. This exotic game bird, popularly called chukar, successfully established itself in about 10 years. It occupies an ecological niche in the desert biotic community that is not considered significantly competitive with native gallinaceous birds such as Gambel's quail by the Department of Fish and Game.

The lands of NWC have proved to be nearly ideal habitat for chukar partridge. The species is managed under a Cooperative Wildlife Management Agreement between the California Department of Fish and Game, the U.S.

Fish and Wildlife Service of the Department of the Interior, and the Center.

Since 1954, the trapping program on the Center has supplied 11,724 chukar and 1,696 quail to the State for transplant. So successful has the live-trapping of chukar been that the State of California discontinued pen-raising chukar at its game farm for transplant. Wild birds supplied by NWC's lands have proven hardier and adapt better to transplant than pen-raised chukar.

Since 1963, a program offering special hunts on designated weekends during the regular statewide upland game bird season has been carried out. Approximately 320 square miles are included in the hunting area on the China Lake Test Ranges. Typically, the first 3 weeks of the season are open to the general public and Center personnel for hunting of chukar, quail, and rabbits. In years when prospects for chukar and quail are good, about 1,500 hunters enter the Center on opening weekend, in addition to several hundred NWC personnel. In years when drought severely decreases the number of birds, the hunting program is suspended.

The effect of the hunting policy is apparently to prevent wide fluctuations of bird populations about their long-term average.

Although about 3,000 hunter days are spent in the upland areas of the Center during special hunting weekends, little adverse effect on vegetation or non-huntable species of wildlife has been observed.

Other Exotic Game Birds. Experimental introduction of two additional species of game birds was made by the Department of Fish and Game in 1968-69. Both the crested tinamou and the seesee partridge were expected to use more arid habitats than either the introduced chukar or native quail.

Although a few credible reports on these species have been received, their success or failure in this environment has not been verified.

Rare and Endangered Desert Fishes. In July 1971, approximately 400 Mojave chub (*gila mojavensis bicolor)* were introduced into a seep, between China Lake playa and the NWC sewage lagoon. Although it is too early to evaluate the success of this program, it is felt that they may fill an ecological niche in the man-made seep. In the absence of excessive predation and contamination, their survivability is enhanced because they are eurythermal and euryhaline, tolerating temperatures between 10 and 40°C and salinities ranging from fresh water to that greater than seawater.[25,26]

Animal Health

Air Pollution. Many raptors such as eagles rely upon great visibility to spot prey. When the visibility is obscured due to air pollution (primarily particulates), the raptor may not be an efficient predator and could suffer.

The national secondary standards for air pollutants are designed to reduce effects on plants, animals, and human aesthetics. Previous data in this report show that NWC did not surpass the national secondary standard for particulates in 1972 and 1973. Additional air pollution inventory data earlier in this report showed that the possibility of surpassing the standards for other pollutants appears to be small. The State of California, in its implementation plan for the Clean Air Act, assumed that standards in the NWC area were not surpassed. Therefore, it appears that the biotic resources are not significantly affected at NWC by air pollution.

Water Pollution. A number of leaching fields exist in the NWC industrial area, carrying wastes from propellant fabrication, little-treated sewage, propellant washdown from casing reclaiming, and an acid drain from a photo laboratory.[27] The areas affected are specific locations in the Salt Wells, Explosive Ordnance Supply, and Michelson Laboratory areas of NWC. Although these sources provide the potential for chemical contamination of wildlife, NWC records do not show such an occurrence ever happening. On the contrary, they are used as water sources by birds and mammals. Evidently, due to the flushing of clean water through the system, the concentrations of chemicals do not reach unhealthy proportions. For example, the concentrations of silver in the acid drain do not appear to be high enough to cause problems for local animals. The nitrogen in propellant fabrication wastes has acted as a fertilizer, increasing growth of many water-loving plants. In summary, although there are a number of contaminated water sources at NWC, continuous monitoring has not detected any negative impact on wildlife. On the contrary, they appear to be beneficially used.

Noise. The effects of noise on animals have not been investigated as much as on people. However, the effects of low altitude supersonic flights on condors, pelicans, terns, and other birds have been documented.[28,29,30,31] The effects can be nest abandonment, hatching failure, and egg destruction. Memphis State University (1971)[32] predicts that other possible effects could be alteration of the predator-prey situation, increased infant mortality, and decreased reproduction efficiency. Based on the review of the research,[33] it tentatively appears that among the animals, the birds would be most affected by man-made noise from aircraft and motor vehicles in the NWC vicinity.

Fortunately, NWC conducts no low altitude supersonic flights, and the level of motor vehicle and aircraft activity in the remote areas on NWC is very low. Off-road vehicles are not permitted. Preliminary data suggest that the day-night average sound level, L_{dn}, in the remote ranges is less than 40 dB. This is judged to be very quiet, and the effects on wildlife appear to be minimal.

Pesticides. The fact that many pesticides may have adverse impact on wildlife is well-documented.[34] Previous data in this report show that about 2,400 pounds of pesticides were used by NWC in 1972. Virtually all were used in the residential and industrial areas, leaving 95 to 99% of NWC free of application. Smithsonian Institution (1972)[35] found that higher trophic level species, particularly birds, were the best indicators of contamination through pesticides. Thus it appears that wildlife most likely to be affected would be the seasonal and permanent birds around the housing area. In addition, there exists the possibility of poisoning native rodents near the golf course.

At NWC, the majority of pesticides are used on household pests such as ants, cockroaches, and black widow spiders, which are not prey for birds in the housing area. However, rodents which could be poisoned at the golf course could be preyed upon by hawks and other raptors, thereby moving through the food chain. Monitoring of the rodent and bird populations has not resulted in finding any such poisonings. Based on these historical data, it appears that the effect of NWC pesticides on non-target species is small.

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IMPACT ON SUPERIMPOSED SOCIOECONOMIC SYSTEMS

Land Use

General Land Use. Before the establishment of NWC, seasonal livestock grazing, marginal dry farming, and small or individually operated mines occupied the area from Mojave to Lone Pine. It is obvious that the general land use of the NWC vicinity has changed since then.

Land values of inhabited, non-Navy property in the Indian Wells Valley have skyrocketed. In the early 1940s unimproved land at what is now the intersection of China Lake and Ridgecrest Boulevards sold for $1.30 per acre. The same land, still undeveloped, was sold in 1970 by the General Services Administration to a private developer for over 5,000 times that value. Grazing land on the western perimeter of the Center sold for $1.10 per acre in 1949. Land in the same region, still unimproved, is today selling for 400 to 600 times the amount 23 years ago. Presence of NWC is directly responsible for current high land values.

NWC's impact on general land use in the vicinity, therefore, has been to substitute range firing and testing for marginal grazing and mining on NWC land, and to substitute higher-density residential areas with correspondingly higher land values for undeveloped land in the areas where private ownership is possible.

Transportation Systems. The establishment of NWC has led to the development of two airports, the Naval Air Facility and Inyokern Airport. State Route 178 has brought about access to highways, State 14 and U.S. 395, for China Lake and Ridgecrest residents, and bus service to Los Angeles and Reno, Nevada. Major trucking and van lines now serve Indian Wells Valley.

In addition to public roads, approximately 1,000 miles of NWC official roads are in use. The majority of these are located in remote areas and are unimproved dirt.

The effect of NWC on transportation systems has been to provide impetus for upgrading some systems while providing completely new facilities for others. The impact has been significant.

Recreational Resources. NWC operates an extensive recreation program for the benefit of the military personnel and civilian populace employed at NWC. In addition to employee recreation facilities, NWC provides for limited recreational use of the north China Lake Range area for public weekend use by permit when testing is not in operation. In certain attractive areas tables and shelters have been installed. The policy of the Center in admitting visitors under controlled conditions to sites of interest on weekends and holidays is administration of the lands under the same rules and regulations that apply to national parks and monuments.

The impact of NWC on recreational use of the China Lake Ranges has been to severely limit the use that it would otherwise get if it were public domain. In addition, recreational use of motorcycles has been completely curtailed since they are not allowed on the upper ranges at all.

The impact of NWC on recreational use of the Mojave "B"/Randsburg Wash Test areas is also great since the nature of tests being conducted made it necessary several years ago to close this area to all access not directly concerned with the mission of the Center. This closure will probably remain in effect indefinitely.

The final impact that NWC has had on recreational resources in the vicinity has been to provide a population of over 20,000 people to use neighboring public forests, canyons, and playa areas much more heavily than if NWC were not here.

Wilderness Resources. NWC has affected wilderness in the vicinity in a number of ways. First, it has introduced over 20,000 people and over 2,000 off-road vehicles to a fragile desert. Scarring of some areas and subsequent removal as wilderness has occurred as a result of some Indian Wells Valley residents' off-road recreation.

Secondly, NWC in its official operations has created roads and structures in areas which formerly had none, therefore removing some areas of de facto wilderness which existed on NWC property. In the remote areas the roads are usually unimproved dirt and the structures temporary, having a low to moderate impact on wilderness.

Lastly, because NWC strictly controls recreational usage on the China Lake Ranges by permit only, and does not permit any recreational usage on the Mojave "B"/Randsburg Wash Ranges, NWC has had a significant beneficial impact by preventing encroachment from off-road vehicles. Other parcels of public land in Southern California have been removed as de facto wilderness due to off-road use. This has not occurred on NWC property.

Archeological and Historic Resources. The establishment of NWC has had two effects on archeological and historical resources. Most paleontological study is done in the Indian Wells Valley from elevation 2,240 msl to the lowest elevation of the China Lake bed. Because much of this area is contaminated by high explosives, a number of possible sites are excluded from investigation. Because it is believed that the fragmented remains of mineralized bone are uniformly distributed throughout this area of the valley, there still exists enough uncontaminated land to provide significant samples.

Because of the strict security measures governing NWC test range usage, the archeological sites are protected from human intrusion much more than if the lands were public domain. Historical sites in the NWC test ranges are similarly protected. This beneficial impact of NWC is particularly felt by users of the academic community whose former study areas have become constricted by human encroachment.

Population

Demographic Characteristics. The demographic characteristics of the Indian Wells Valley have changed radically since the inception of NWC in

1943. Population count, employment status, type of work, income, and housing characteristics have all changed. It must be noted that demographic parameters for the State of California as a whole have changed so dramatically since 1943 that to attribute all Indian Wells Valley change to NWC would be presumptuous.

Population in the Indian Wells Valley has increased from an estimated 100 to 200 in 1943 to approximately 24,000 in 1973. Employment status has changed. As contrasted with previous marginal mining and farming, 60% of all workers in the Indian Wells Valley now are employed by the government. The 1969 mean Indian Wells Valley family income of over $13,000 was 60 to 100% higher than in some neighboring desert census tracts. There are now over 7,500 housing units in Indian Wells Valley, at least 100 times the 1943 figure. The inhabited Indian Wells Valley, approximately 350 square miles, has grown from a density of approximately 0.3 to 0.5 persons per square mile in 1943 to 60 persons per square mile today. The 1,700-square-mile NWC property is now uninhabited except for the China Lake community.

Public Health and Aesthetics. The routine business of NWC creates air, water, and noise emissions. Some lands are contaminated while hazardous and toxic materials, electromagnetic and ionizing radiation, and pesticides are used. Each of the above parameters, if carried to an extreme, could become a public nuisance or even a public health hazard. Carried to the other extreme of no emissions, etc., there would be no Naval Weapons Center. The question is, therefore, if NWC falls between these two extremes, what net environmental impact results on the people in the NWC vicinity?

Each of the emissions and public health parameters listed above will be examined for human environmental impact. Specific background and inventory data have been provided in earlier sections of this report. These data will be analyzed to provide an objective appraisal of impact.

Air Pollution. The State of California and the federal government have adopted standard ambient air pollutant concentrations for a number of pollutants. The federal primary standards are designed to protect public health while the secondary standards are designed to protect aesthetics, crop loss, and materials. The state and federal standards are listed in Table 24.

Pursuant to the federal Clean Air Act of 1970, all states have adopted the federal standards and have provided an implementation plan to achieve the standards by 1975. All states have been divided into Federal Air Quality Control Regions (AQCRs)[1] that are internally homogeneous with respect to air pollution history and demography. The controls necessary to achieve clean air are then adopted by unit of AQCR so that a clean region does not have to adopt controls as extensive as a polluted area to achieve the same standard of air quality. Figure 37 shows the AQCRs applicable to the NWC vicinity. Figure 37 displays the

TABLE 24. Ambient Air Quality Standards Applicable in California.

Pollutant	Averaging time	California standards	Federal standards[a]	
		Concentration	Primary[b]	Secondary[c]
Photochemical oxidants (corrected for NO_2)	1 hr	0.10 ppm	0.08 ppm	Same as primary standards
Carbon monoxide	12 hr	10 ppm	...	Same as primary standards
	8 hr	...	9 ppm	
	1 hr	40 ppm	35 ppm	
Nitrogen dioxide	Annual average	...	0.05 ppm	Same as primary standards
	1 hr	0.25 ppm	...	
Sulfur dioxide	Annual average	...	0.03 ppm	0.02 ppm
	24 hr	0.04 ppm	0.14 ppm	0.10 ppm
	3 hr	...	...	0.5 ppm
	1 hr	0.5 ppm	...	...
Suspended particulate matter	Annual geometric mean	60 $\mu g/m^3$	75 $\mu g/m^3$	60 $\mu g/m^3$
	24 hr	100 $\mu g/m^3$	260 $\mu g/m^3$	150 $\mu g/m^3$
Lead (particulate)	30-day average	1.5 $\mu g/m^3$	...	...
Hydrogen sulfide	1 hr	0.03 ppm	...	...
Hydrocarbons (corrected for methane)	3 hrs (6-9 a.m.)	...	0.24 ppm	Same as primary standards
Visibility reducing particles	1 observation	Visibility to 10 miles when the relative humidity is less than 70%	...	...

[a] Federal standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once per year.

[b] National primary standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than three years after that state's implementation plan is approved by the Environmental Protection Agency (EPA).

[c] National secondary standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after implementation plan is approved by the EPA.

SOURCE: State Air Resources Board.

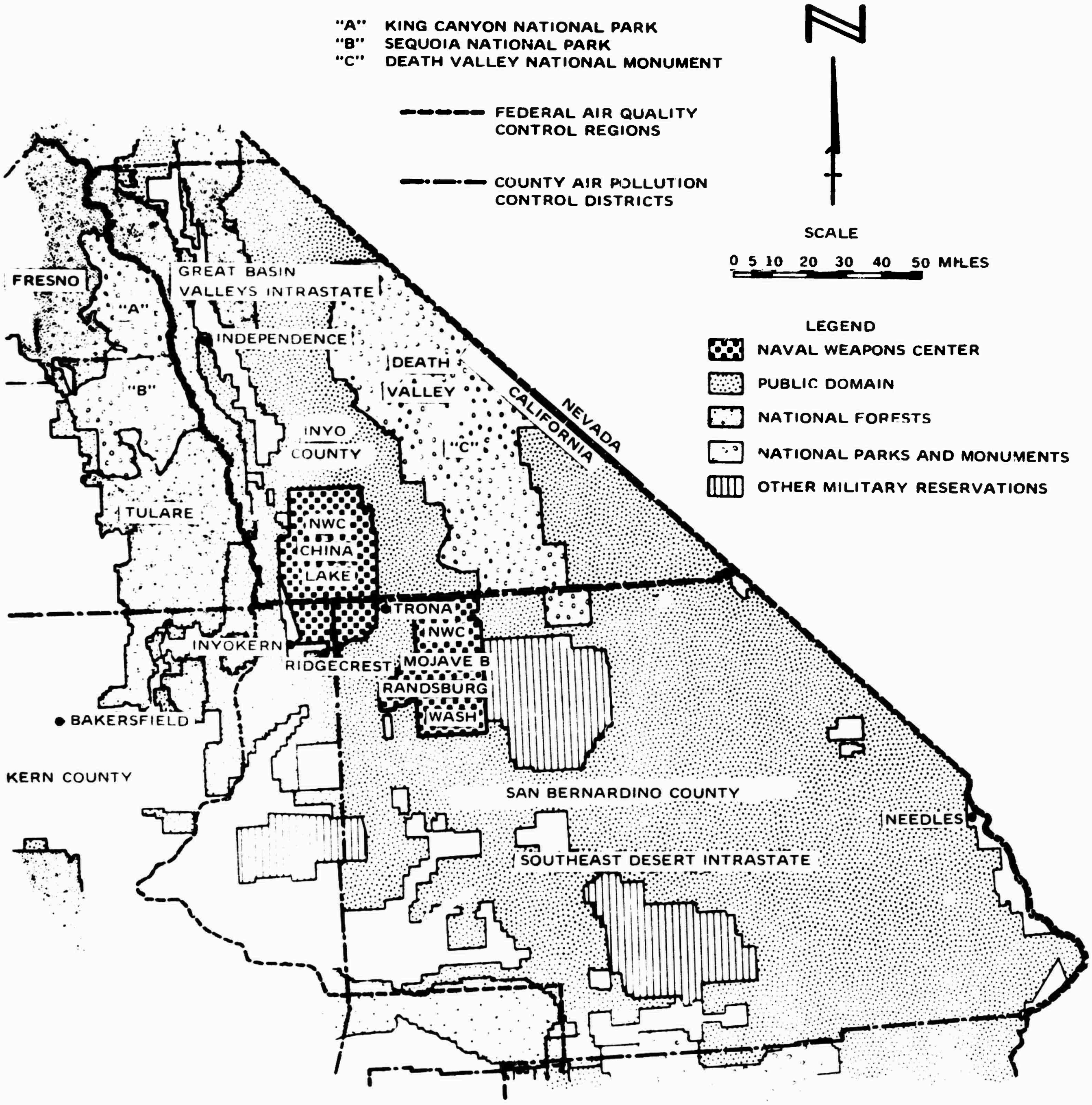

FIGURE 37. Federal Air Quality Control Regions and County Air Pollution Control Districts, Naval Weapons Center and Vicinity.

three counties in which NWC is located; each county has air pollution regulations.[2,3,4]

As in any other area, the air quality in the Indian Wells Valley is a function of pollution generated within the valley plus net migration from other areas. PEDCO--Environmental Specialists, Inc. (1973)[5] found the natural background particulate levels for the valley area to be 25 to 30 $\mu g/m^3$ which "probably results almost entirely from wind action across arid land."[6] In three-dimensional air sampling work conducted by NWC in the Indian Wells Valley, the following background concentrations were found: O_3, 0.02 ppm; NO, 0.01 ppm; and CO, 1 ppm. These background levels may be considered to be a baseline above which the effects of man can be measured.

Air pollution is a total Southern California problem. Table 25 shows EPA classifications[7,8] of the AQCRs. The federal standard for photochemical oxidants was surpassed in the NWC-vicinity Mojave Desert communities of Lancaster, Victorville, and Barstow.[9,10] However, the EPA notes that

> *Significant data support the hypothesis that air pollution from the Metropolitan Los Angeles Intrastate Region is transported to and contributes substantially to high oxidant levels in the desert areas east of Los Angeles. . . . Because of the dependence of air quality in the Southeast Desert Region upon that in the Los Angeles Region, and because of the very small impact that emissions in the Southeast Desert Region have upon air quality there, no transportation controls are promulgated for this region at present.*[11]

Because air pollution migration has been documented in the communities south of NWC it is assumed that NWC may at times also be affected.

Since ambient air quality is also affected by local Indian Wells Valley sources, these must be examined. Table 6 provides an annual inventory of NWC-related sources. In order to predict ambient air pollutant concentrations resulting from a given activity, the major activities were categorized by temporal and spatial characteristics as follows:

Activity	Source type
NAF aircraft	Continuous area source
Ridgecrest-China Lake autos	Continuous area source
C Range jet run-ins	Instantaneous line source
Highways 395 and 14 autos	Continuous line source
Boiler plants	Continuous point source
JP-5 cook-offs	Instantaneous point source

TABLE 25. Classification of NWC Vicinity Air Quality Control Regions (AQCRs) by the Environmental Protection Agency.

Note classifications in (a) based on known or estimated air quality in area of maximum pollutant concentration by the criteria given in (b).

AQCR	Pollutant				
	Partic-ulates	Sulfur oxides	Nitrogen dioxide	Carbon monoxide	Photochemical oxidants
Southeast Desert Intrastate	I	III	III	III	I
Great Basin Valley Intrastate	III	III	III	III	III
Metropolitan Los Angeles Intrastate	I	II	I	I	I

(a)

Pollutant	Priority		
	I	II	III
Sulfur oxides:			
Annual arithmetic mean	>0.04 ppm	0.02-0.04 ppm	<0.02 ppm
24-hr max.	>0.17 ppm	0.10-0.17 ppm	<0.10 ppm
3-hr max.	...	≥0.50 ppm	<0.50 ppm
Particulate matter:			
Annual geometric mean	>95 μg/m³	60-95 μg/m³	<60 μg/m³
24-hr max.	>325 μg/m³	150-325 μg/m³	<150 μg/m³
Carbon monoxide:			
1-hr max.	≥48 ppm	...	<48 ppm
8-hr max.	≥12 ppm	...	<12 ppm
Nitrogen dioxide:			
Annual arithmetic mean	≥0.06 ppm	...	<0.06 ppm
Photochemical oxidants:			
1-hr max.	≥0.10 ppm	...	<0.10 ppm

(b)

As shown in Appendix 4, the appropriate mathematical dispersion models differ by source type.[12] Each source type was modeled, and the resultant ground-level air pollutant concentrations as a function of location were then provided by computer printout. Some of the results are

1. Although Highways 14 and 395 annually contribute a significant mass of pollutants to the Indian Wells Valley relative to other sources, Appendix 4 shows that the ambient concentrations that result are at most one-thousandth the value of the federal air quality standards for all pollutants. Thus it has no significant impact.

2. According to Appendix 4, C Range jet run-ins create no ground-level concentrations greater than one-thousandth the value of federal air quality standards for all pollutants.

3. Computer printouts were made for the ground-level particulate concentrations that occur due to JP-5 cook-off (Appendix 4). Results show that particulate standards were not even remotely approached at ground level.

4. Appendix 4 shows that the following upper 10-percentile city-wide average concentrations[13] would occur due to local autos:

Pollutant	Upper 10% $\bar{C}$	Median $\bar{C}$
NO_2	0.0098 ppm	0.0025 ppm
CO	0.120 ppm	0.035 ppm
Hydrocarbons	0.012 ppm	0.0035 ppm
Particulates	1.8 $\mu g/m^3$	0.46 $\mu g/m^3$

Thus, although local autos account for approximately one-half of the pollutants generated in Indian Wells Valley, the air pollution concentrations that result in the city never exceed one-tenth the federal standards. Outside of the Ridgecrest-China Lake urban area, the resultant concentrations that occur on a stagnant day are given in Figure 38. Outlying area concentrations are lower than the urban area.

5. Appendix 4 shows that the following upper 10-percentile airport-wide concentrations[14] would occur due to aircraft pollutants:

Pollutant	Upper 10% $\bar{C}$	Median $\bar{C}$
NO_4	1.4×10^{-3} ppm	5.5×10^{-4} ppm
CO	6.0×10^{-4} ppm	2.3×10^{-4} ppm
Hydrocarbons	8.5×10^{-5} ppm	3.3×10^{-5} ppm
Particulates	0.75 $\mu g/m^3$	0.29 $\mu g/m^3$

None exceed one-hundredth the federal standards. The resultant concentrations that occur on a stagnant day outside of the Naval Air Facility area are given in Figure 39.

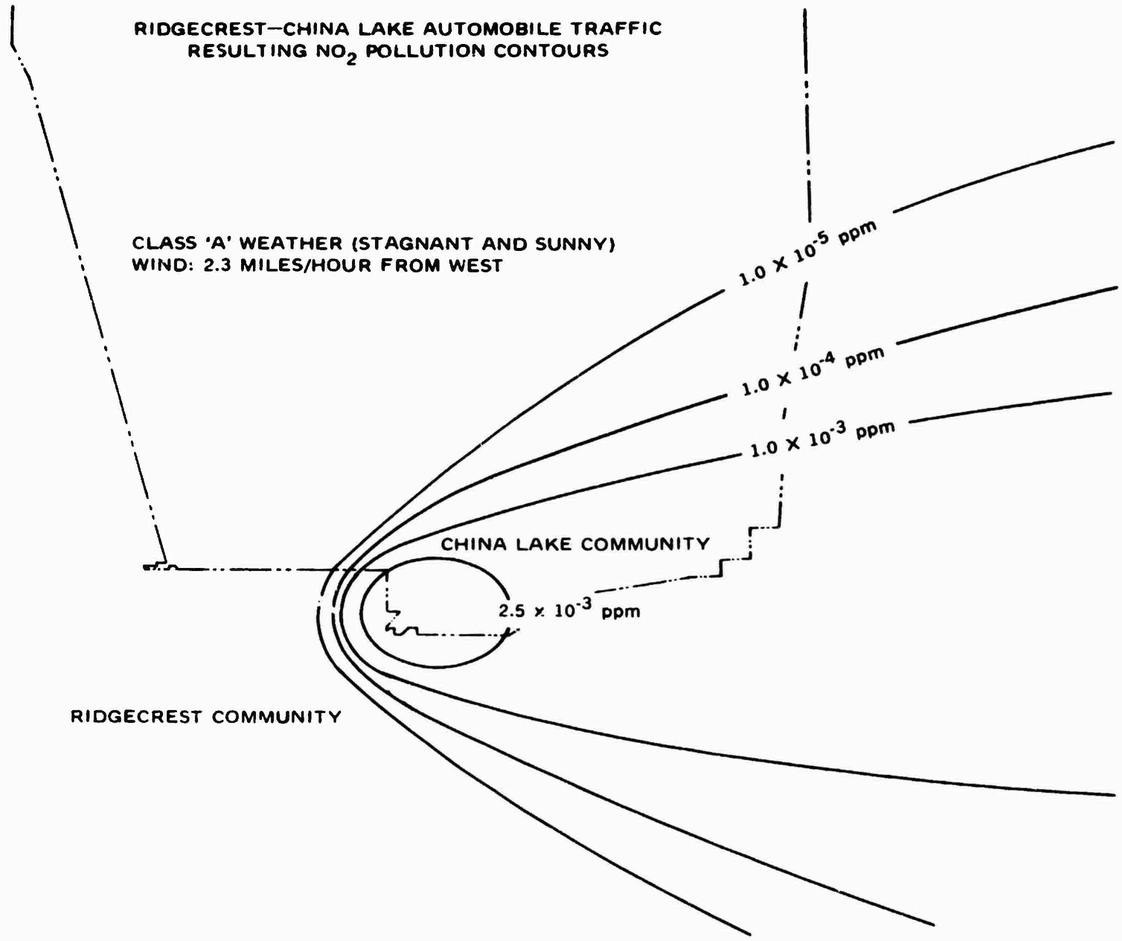

FIGURE 38. Computed Ambient NO_2 Levels Generated by Ridgecrest and China Lake Automobile Traffic.

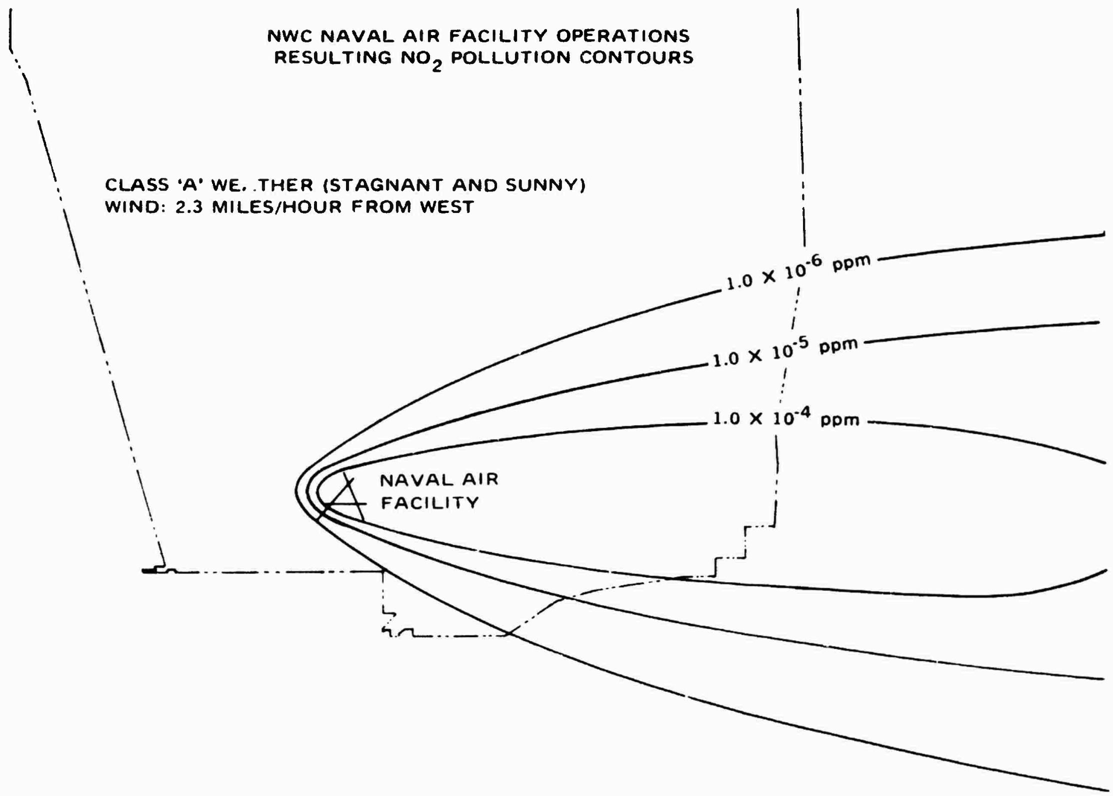

FIGURE 39. Computed Ambient NO_2 Levels Generated by Naval Air Facility.

Study of air pollution annual inventory and Appendix 4 suggests that official NWC activities have a low environmental impact on public health due to air pollution. Although non-official automobile usage provides the bulk of Indian Wells Valley pollutants, its environmental impact is also rated low. Continuous monitoring of particles partially verifies these results. Figure 40 compares Indian Wells Valley particulate levels for 1972 and 1973 with federal air quality standards. It shows that Indian Wells Valley levels are much below the standards, and only slightly above the desert background of 25 to 30 $\mu g/m^3$. Aside from the higher levels created in March and December from windblown dust, the higher levels occur in the summer months. Using the data on pollution migration from the Los Angeles air basin to the Mojave Desert, it is judged that its impact on Indian Wells Valley air quality during the summer surpasses NWC operations.

Water Pollution. Because there are no surface waters on NWC, the only water pollution effects on public health would be contamination of groundwater. Water quality standards for domestic water supply have been established by the National Technical Advisory Committee on Water Quality Criteria,[15] and the U.S. Public Health Service.[16] They are listed in Tables 26A and 26B.

NWC pumps groundwater for drinking from eight wells located between China Lake and Inyokern. Water quality data for these wells are given in Table 27. Table 28 provides trace toxic element concentration data[17,18] on a number of wells in the Indian Wells Valley. Wells 12A, 19, and 27 are pumped by NWC for drinking water. Comparisons of Table 26 with Tables 27 and 28 show that no health standards or criteria are surpassed.

In order to assess NWC's impact on groundwater quality over the last 20 years, a study was done to determine if there has been any significant change in water quality parameters over time. A student t- regression analysis was performed for Well 29, which had been randomly chosen from the eight wells that are pumped by NWC for drinking water. The statistical technique is the same as in Appendix 3. The results are as follows:

Constituent	$/t/$	$/t_{0.05}/$
PO_4	0.498	1.796
NO_3	1.50	1.782
Total dissolved solids .	0.213	1.746
Conductivity.	1.78	1.895
pH	1.71	1.753
Detergents	0.189	1.753

Because $/t/ < /t_{0.05}/$ for all constituents, there has been no change over the last 20 years at the 5% significance level. Thus, for these parameters water quality at Well 29 has not changed.

The groundwater quality data and the statistical analysis on change over a 20-year time for one well indicate that NWC has probably had a negligible effect on public health as indicated by water pollution.

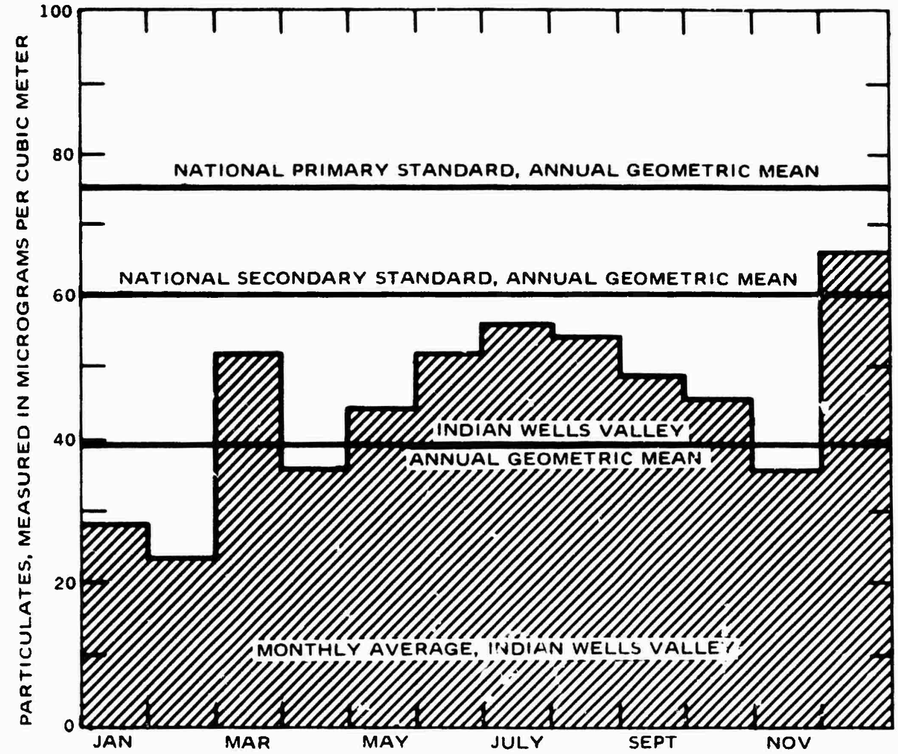

FIGURE 40. Comparison of Indian Wells Valley Particulate Levels, 1972 and 1973 Average, With Federal Air Quality Standards.

TABLE 26A. Surface Water Criteria for Public Water Supplies.

Constituent or characteristic	Permissible[a] criteria	Desirable[b] criteria
Physical:		
Color, color units	75	<10
Microbiological, per 100 ml:		
Coliform organisms	10,000[c]	<100[c]
Fecal coliforms	2,000[c]	<20[c]
Inorganic chemicals, mg/l:		
Ammonia	0.5 (as N)	<0.01
Arsenic	0.05	Absent
Barium	1.0	Absent
Boron	1.0	Absent
Cadmium	0.01	Absent
Chloride	250	<25
Chromium, hexavalent	0.05	Absent
Copper	1.0	Virtually absent
Dissolved oxygen	4 (monthly mean) 3 (indiv. sample)	Near saturation
Iron (filterable)	0.3	Virtually absent
Lead	0.05	Absent
Manganese (filterable)	0.05	Absent
Nitrates plus nitrites	10 (as N)	Virtually absent
pH (range)	6.0 to 8.5	Variable
Selenium	0.01	Absent
Silver	0.05	Absent
Sulfate	250	<50
Total dissolved solids (filterable residue)	500	<200
Uranyl ion	5	Absent
Zinc	5	Virtually absent
Organic chemicals, mg/l:		
Carbon chloroform extract (CCE)	0.15	<0.04
Cyanide	0.20	Absent
Methylene blue active substances	0.5	Virtually absent
Oil and grease	Virtually absent	Absent
Pesticides:		
Aldrin	0.017	Absent
Chlordane	0.003	Absent
DDT	0.042	Absent
Dieldrin	0.017	Absent
Endrin	0.001	Absent
Heptachlor	0.018	Absent
Heptachlor epoxide	0.018	Absent
Lindane	0.056	Absent
Methoxychlor	0.035	Absent

TABLE 26A. (Contd.)

Constituent or characteristic	Permissible[a] criteria	Desirable[b] criteria
Organic phosphates plus carbamates	0.1[d]	Absent
Toxaphene	0.005	Absent
Herbicides, mg/l:		
2, 4-D plus 2, 4, 5-T plus 2, 4, 5 TP	0.1	Absent
Phenols	0.001	Absent
Radioactivity, pc/l:		
Gross beta	1,000	<100
Radium-226	3	<1
Strontium-90	10	<2

[a] Permissible criteria—Those characteristics and concentrations of substances in raw surface waters which will allow the production of a safe, clear, potable, aesthetically pleasing, and acceptable public water supply which meets the limits of Drinking Water Standards after treatment.

[b] Desirable criteria—Those characteristics and concentrations of substances in the raw surface waters which represent high-quality water in all respects for use as public water supplies. Water meeting these criteria can be treated in the defined plants with greater factors of safety or at less cost than is possible with waters meeting permissible criteria.

[c] Microbiological limits are monthly arithmetic averages based upon an adequate number of samples. Total coliform limit may be relaxed if fecal concentration does not exceed the specified limit.

[d] Expressed as parathion in cholinesterase inhibition. It may be necessary to resort to even lower concentrations for some compounds or mixtures.

TABLE 26B. Chemical Standards of Drinking Water.

Category A: Maximum Allowable Concentrations Where Other More Suitable Supplies Are, or Can Be Made Available.

Substance	Concentration, mg/l
Alkyl benzene sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250
Copper (Cu)	1
Carbon chloroform extract (CCE)	0.2
Cyanide (CN)	0.01
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)[a]	45
Phenols	0.001
Sulfate (SO_4)	250
Total dissolved solids (TDS)	500
Zinc (Zn)	5

Category B: Maximum Concentrations Which Shall Constitute Grounds for Outright Rejection of the Supply.

Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Hexavalent) (Cr^{+6})	0.05
Cyanide (CN)	0.2
Fluoride (F)	0.6 to 1.7[b]
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

[a] In areas in which the nitrate content of water is known to be in excess of the listed concentration, the public should be warned of the potential dangers of using the water for infant feeding.

[b] Varies with water temperature.

TABLE 27. Water Quality Data for NWC Wells, October 1971, ppm.

Constituents	Well 12A	Well 15	Well 16A	Well 27	Well 28	Well 29	Well 18A	Well 19
Calcium (Ca)	49	36	34	80	31	20	16	38
Magnesium (Mg)	5.8	6.8	3.9	13	6.3	4.4	1.5	9.8
Sodium (Na)	65	63	64	68	36	44	57	60
Potassium (K)	3.0	2.1	2.4	3.4	3.2	2.6	2.2	5.4
Carbonate (CO_3)	...	...	...	...	...	...	...	...
Bicarbonate (HCO_3)	105	117	112	73	119	117	129	115
Hydroxide (OH)	...	...	...	...	...	...	...	...
Sulphate (SO_4)	62	81	67	85	37	23	27	68
Chloride (Cl)	98	48	52	176	30	24	22	70
Nitrate (NO_3)	4.6	11.1	10.6	6.6	10.2	8.3	10.6	12.4
Total hardness (as $CaCO_3$)	146	118	100	252	104	68	46	134
Calcium hardness (as $CaCO_3$)	122	90	84	200	78	50	40	34
Magnesium hardness (as $CaCO_3$)	24	28	16	52	26	18	6	40
Alkalinity P/M (as $CaCO_3$) M. orange	86	96	92	60	98	96	106	34
Total dissolved solids	466	342	350	589	256	223	242	331
Silica (as SiO_2)	34	26	28	29	30	27	26	39
Fluoride (F)	0.70	0.39	0.40	0.65	0.65	0.68	0.66	0.43
Boron (B)	0.1	0.2	0.5	0.6	0.3	1.0	0.5	0.4
Iron (Fe)	0.0	0.02	0.0	0.02	0.05	0.02	0.0	0.02
Hydrogen-ion concentration	7.6	7.3	7.0	7.4	6.9	7.7	8.0	7.1
Specific conductivity	665	488	500	842	365	319	345	558
Detergents (apparent ABS)	0.04	0.01	0.048	0.058	0.038	0.045	0.032	0.056
Phosphate PO_4	0.0	0.0	0.2	0.0	0.05	0.00	4.2	0.0
Manganese (Mn)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 28. Single-Sweep Polarographic Analyses of Some Trace Elements in Well Waters in the Mojave Desert, ppm.

Well no.	Cu^{2+}	Mn^{2+}	Zn^{2+}	Au^{3+}	As^{3+}	NO_3^-	IO_3^-
20	0.050	0.030	0.040	0.087	0.016	6.5	0.004
21	0.050	0.076	0.040	0.240	0.013	5.2	0.008
22	0.100	0.050	0.040	0.200	<0.010	4.8	0.060
7	<0.010	<0.010	...	0.120	<0.010	...	0.013
19	0.100	<0.010	0.040	<0.010	0.015	10.9	0.015
12A	0.050	...	0.100	<0.010	0.036	12.1	0.020
14	0.050	...	0.040	0.075	0.016	6.9	0.013
27	0.050	0.050	0.060	<0.010	0.029	1.7	0.015
23	0.050	0.057	0.040	0.025	0.027	3.5	0.005

Noise. Because of differing criteria which presently exist, noise at NWC is measured in two units: aircraft noise is measured in units of PNdB to create composite noise rating (CNR) zones;[19] non-aircraft noise is measured in units of dBa to create the average day-night noise level, L_{dn}.[20] These two units will be used to identify areas where NWC has environmental impact.

In support of public health and welfare criteria for noise,[21] Task Group No. 3 of the EPA Aircraft/Airport Noise Study concluded

> *. . . the 'energy' equivalent, or average, A-weighted sound level, taken over a 24 hour period, with a 10-decibel penalty applied to nighttime sound levels, is the simplest noise measure that provides high correlation with annoyance, complaint behavior, and overt community reaction.*[22] *This measure was named 'day-night average sound level.'*[23]

A summary of the relationship between L_{dn} and community response is shown in Figure 41.[24] Task Group 3 recommended that a "yearly day-night average sound level of 60 dB or below should be the long range limit of the EPA for environmental noise quality in residential areas with respect to health and welfare."[25]

To assess cumulative impact from NWC aircraft, weapons disposal and testing, and motor vehicles, community noise data for NWC residential areas are given in the following table:

Site	L_{dn}
Lower density residential site on minor arterial	50
Higher density residential site on major arterial	57
Site adjacent to Mirror Lake off-road vehicle recreational area	48, 47, 50

All residential sites are below the 60-dB recommended limit. A comparison of these sites with other U.S. outdoor locations is given in Figure 42.[26,27] Using the 60-dB criterion level and the comparison in Figure 42, the impact of noise on the public health of the NWC residential community is judged to be low to moderate.

NWC aircraft have their greatest residential noise impact on areas outside of NWC because of operational requirements. The impact is measured by CNR zones, generated by PNdB, or dBD + 7, contours. The areas primarily affected are west of the City of Ridgecrest in rural Indian Wells Valley. A summary of the relationship between PNdB, CNR zones, and community response is shown in Figure 43.[28] L_{dn} is approximately equal to CNR-35 (dB).[29]

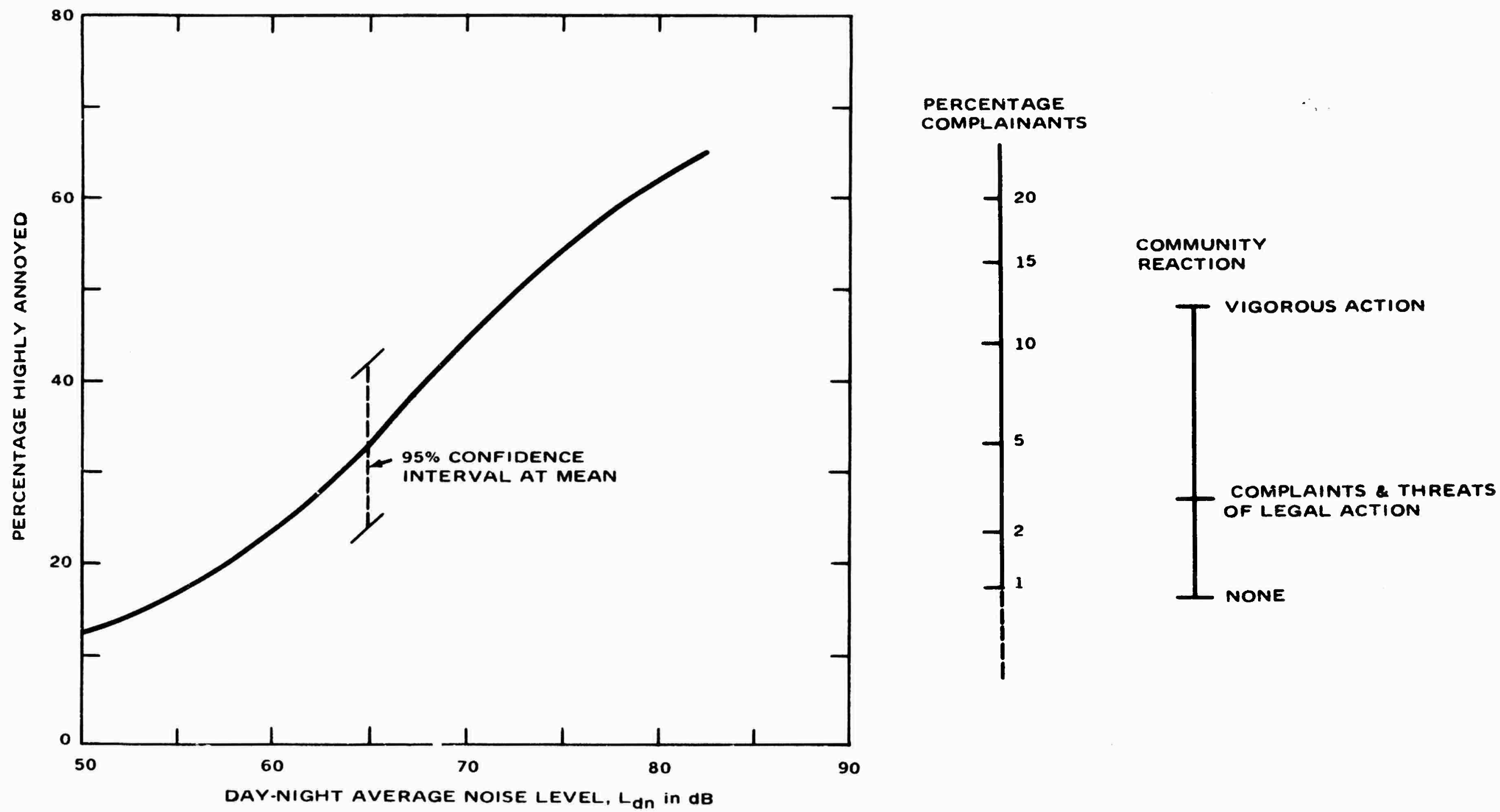

FIGURE 41 Intercomparison of Various Measures of Individual Annoyance and Community Reaction as a Function of the Day-Night Average Noise Level, L_{dn}.

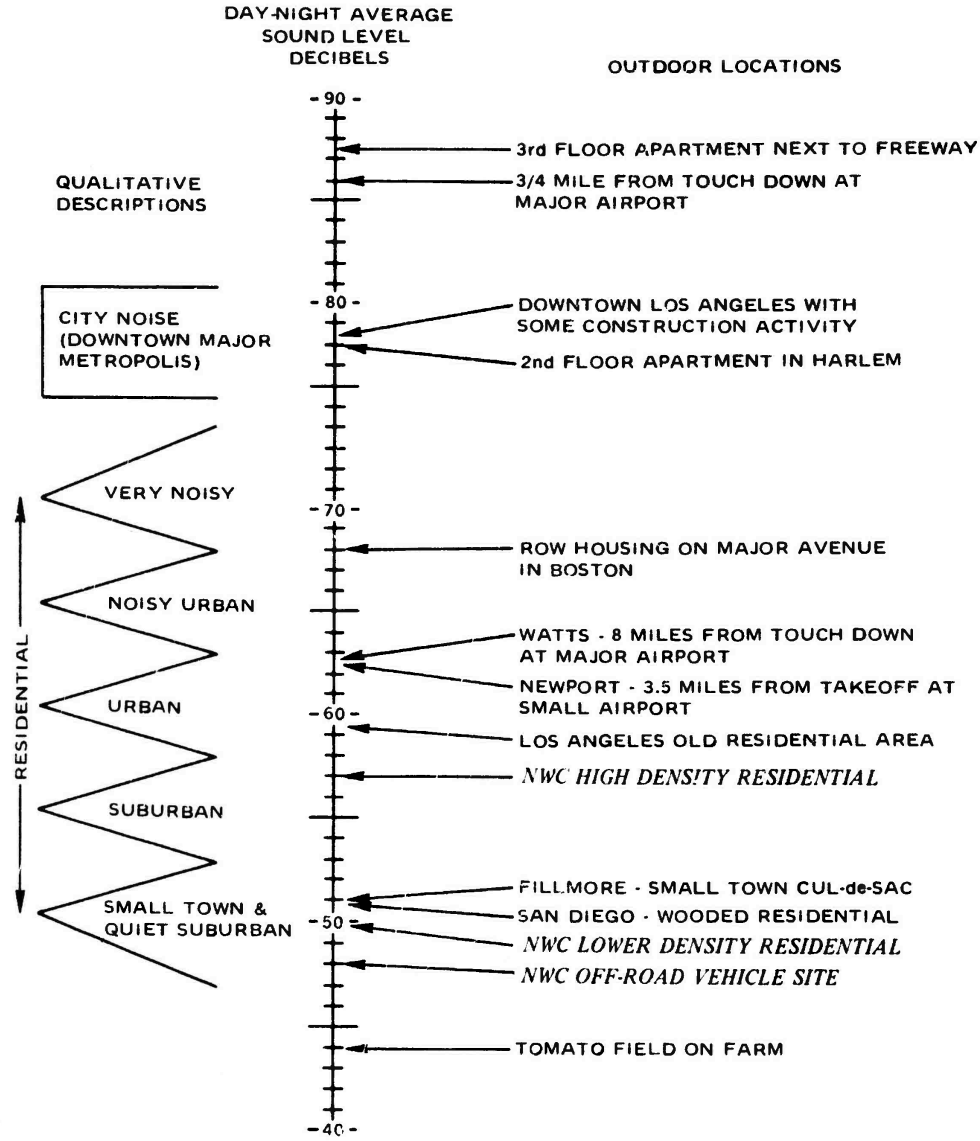

FIGURE 42. Outdoor Day-Night Average Sound Level at Various U.S. Locations Compared to Naval Weapons Center Residential Sites.

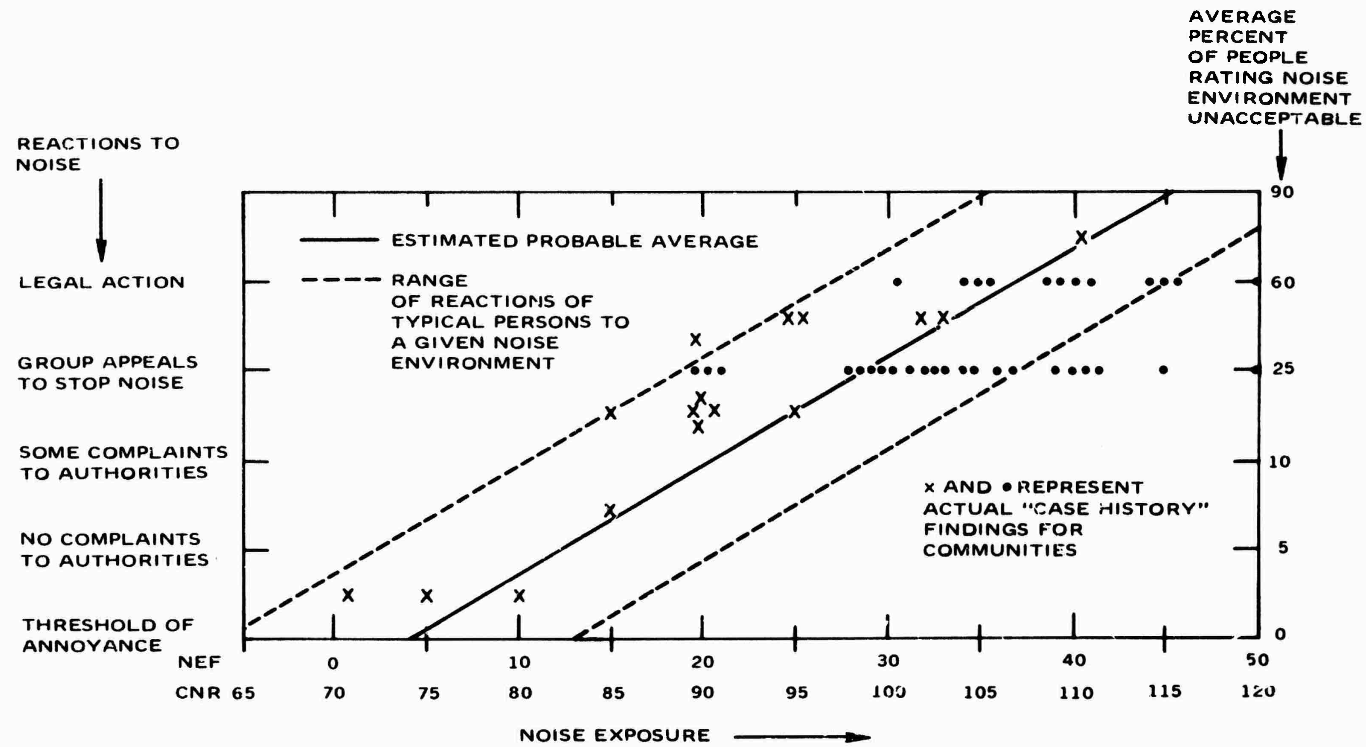

FIGURE 43. Relations Between Noise Exposure Measured in CNR, Community Reaction, and Judgments of Unacceptability.

Using data provided in the noise inventory section of this report, Figure 44 is created.[30] It divides the Naval Air Facility vicinity into CNR zones. It shows that the noise impact on people in Ridgecrest and China Lake is low, but that there is moderate impact on the area south of Inyokern Road in Zone 2. The area has only seven dwellings,[31] so the number of people affected is very low.

Figure 45 shows the CNR zones which result from NWC use of the high-speed approach corridor in Airspace R-2506.[32] It shows high noise environmental impact in area west of Ridgecrest and south of Inyokern Road. However, moderate impact is felt in a much larger portion of rural Indian Wells Valley. Fortunately, a large majority of this land is uninhabited public domain land. The remainder is either uninhabited or sparsely populated. NWC is proposing to purchase the private holdings in Zone 3 and part of Zone 2 in order to reduce public health impact on the area.[33]

Land Degradation. As discussed in an earlier section, Activities Affecting Land Quality, a number of areas on NWC have become contaminated due to the presence of live ordnance, residual ionized radiation, or hazardous materials. Access to these areas for non-official usage is controlled and warnings of contamination are posted at the sites. These controls, in addition to the fact that no injuries or deaths have been caused due to contaminated land, indicate that the impact of contaminated land on public health is low.

The 18 dumps on NWC may affect public health by transmission of vectors from rodent and other pests. The State of California notes,

> *The most prominent health factor associated with solid wastes is domestic flies. Flies are carriers of many disease agents and evidence exists that they are significant vectors of shigellosis and other enteric infections . . . Other disease vectors whose populations are enhanced by the presence of solid wastes include rats, cockroaches, and mosquitos. Their numbers may become excessive and spill over into suburban and urban areas in situations where inadequate solid waste storage and disposal methods are employed. The threat of plague, a disease enzootic in certain of California's sylvatic rodent populations, is increased by poor solid waste management.*[34]

The majority of NWC solid waste is generated in the NWC residential and administrative areas, and is taken to a sanitary landfill operated by Kern County. The NWC dumps are used by personnel in outlying areas. As noted by the data in the section Activities Affecting Land Quality, the dumps contain few moist organics which could breed flies. However, because rodents have environmental needs which are usually not as stringent as those for flies, many of these dumps are likely rodent habitats. The State of California states,

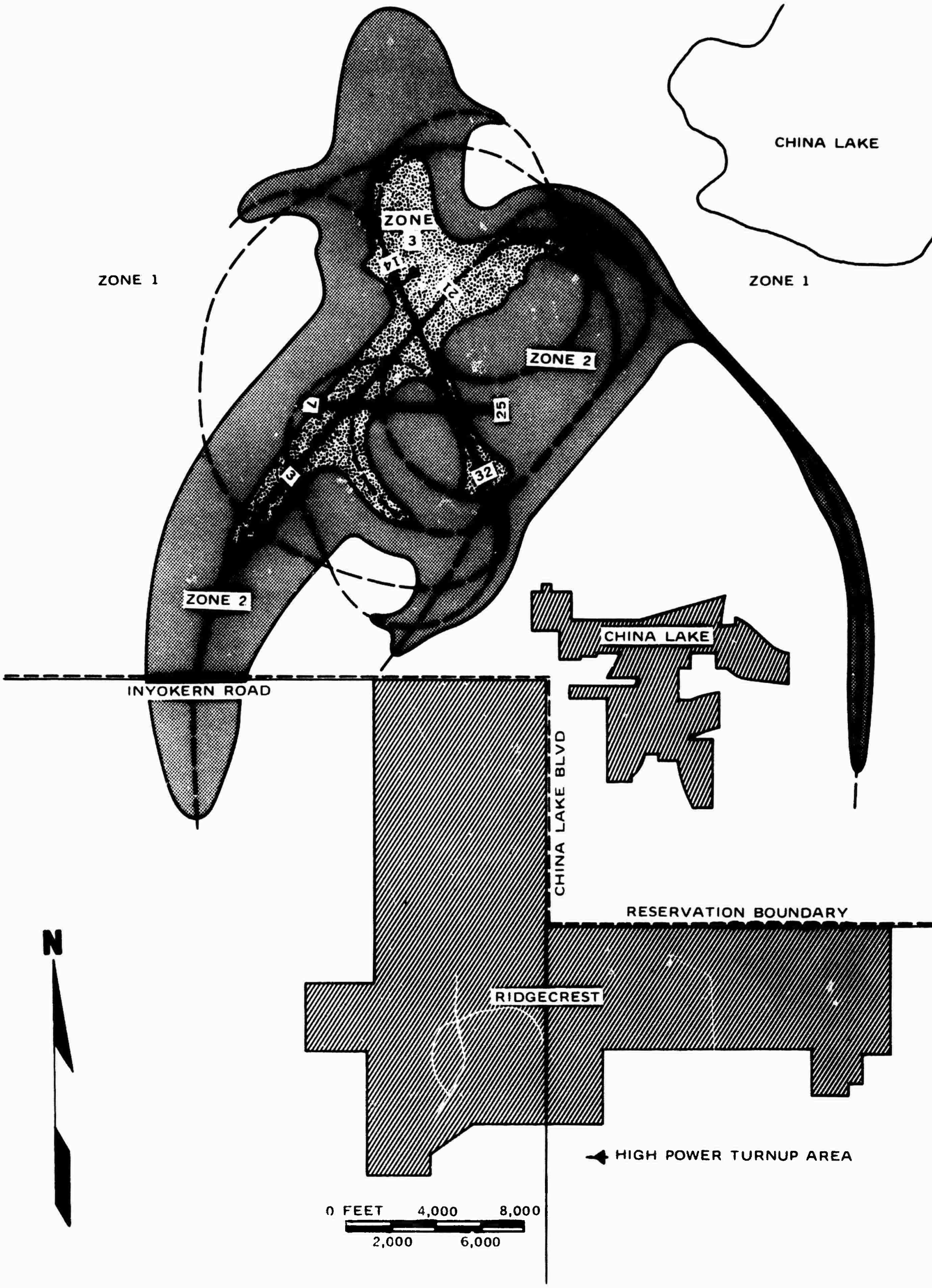

FIGURE 44. Composite Noise Rating Zones, Naval Air Facility and Vicinity.

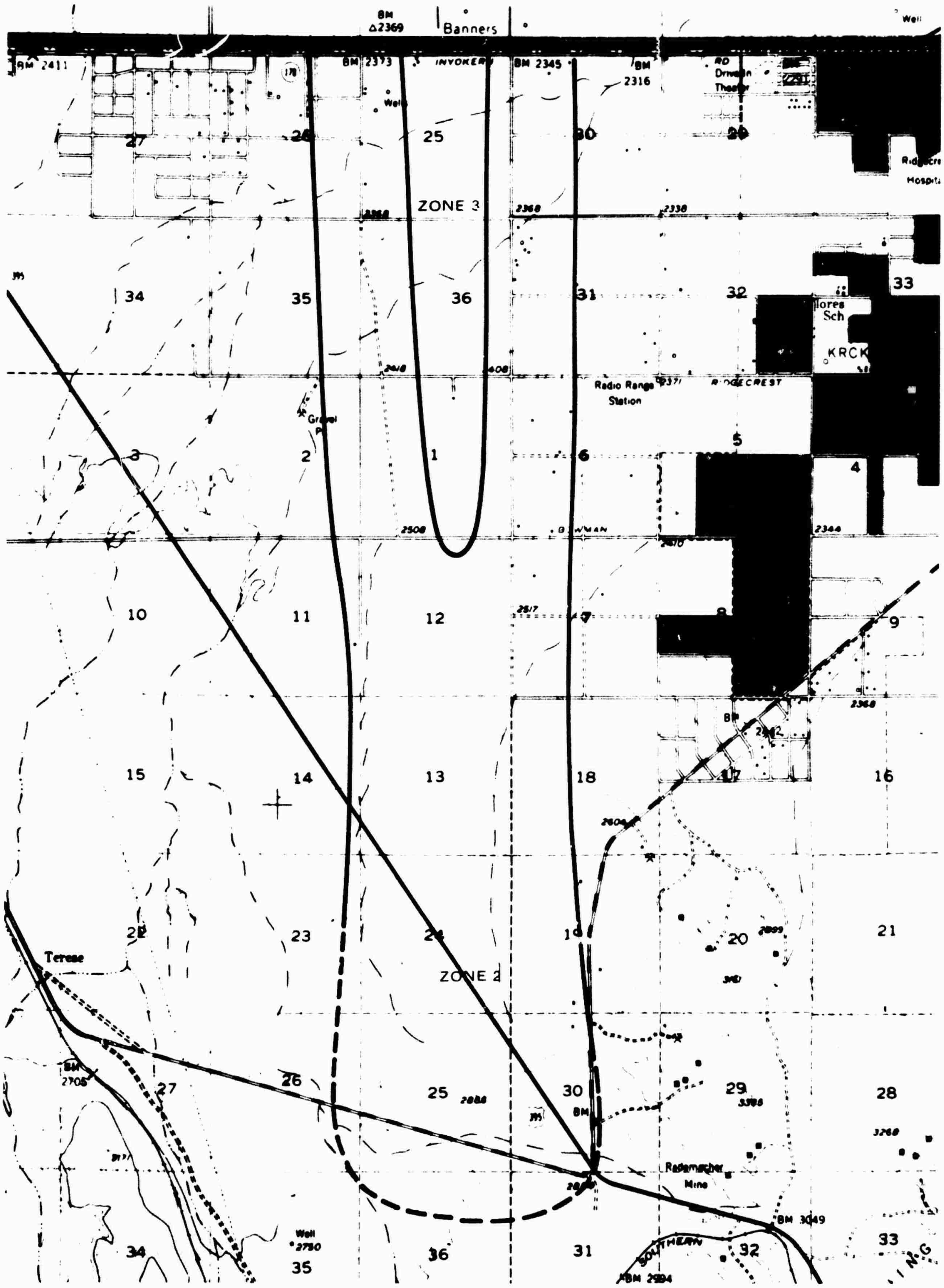

FIGURE 45. Composite Noise Rating Zones, Airspace R-2506 in Indian Wells Valley.

A factor of major public health concern arises from the fact that a refuse dump affords a meeting place for field and domestic rodents. Field rodents, such as ground squirrels and chipmunks, are the primary reservoirs of bubonic plague [Pasteurella pestis] *infection in this state. The refuse dump becomes important if it provides a point of transfer of infected fleas from wild to domestic rodents, thereby increasing the potential for human exposure within the urban population.*[35]

However, NWC has had no recorded vector episodes associated with dumps. Because of this, and because the dumps are dispersed throughout NWC at distances usually greater than 2 miles from residences, the net impact on public health is judged to be low.

Hazardous and Toxic Materials Usage. As discussed in the inventory section of this report, large amounts of hazardous material are used in the day-to-day work at NWC. The safeguards and precautions are made explicit in many Navy and U.S. Department of Transportation regulations. From 1963 to 1972 there were 16 injuries and 3 fatalities that resulted from personnel handling hazardous materials. Approximately 5% of all NWC injuries and deaths are due to handling of hazardous materials. The public health impact on some NWC personnel is therefore judged to be significant.

NWC explosives magazines are located sufficiently far away from residences so that potential harm is minimal. To this date, no residences have been affected by NWC's handling of hazardous materials. The public health impact on residential areas is therefore judged to be low.

Electromagnetic and Ionizing Radiation. NWC makes extensive use of a wide variety of electromagnetic radiation sources. There are currently 148 radar installations, with powers ranging from 1 watt to 50 megawatts. No comprehensive assessment has been made to evaluate safety hazards from the radar sites. It is simply assumed that each presents a potential hazard, so that appropriate precautions are taken to prevent burns. Since no deaths and very few injuries have resulted from electromagnetic radiation operations, it is judged that its public health impact on personnel has been low. Impact on residences is insignificant.

NWC uses ionizing radiation in inside operations. All radiation is "closely held" under Atomic Energy Commission regulations. NWC activities are licensed and monitored by AEC. Because of no past episodes, the impact on public health has been insignificant.

Pesticides Usage. Data on NWC pesticides usage in the inventory section of this report indicate that a variety of insecticides, herbicides, and rodenticides are used. In addition, personal residential use of pesticide adds another increment to the total. NWC does not monitor pesticide concentrations in water or wildlife. However, one of the features of the Navy Applied Biology Program, which is coordinated with the other services through the Armed Forces Pest Control Board, is that routine station operations are reviewed monthly at local levels. The Navy program is reviewed in turn by the President's Council on Environmental Quality. Thus, it is assumed that the federal review plus monthly guidance by professional applied biologists assures that public health impact is minimized by the proper application of pesticides. No significant non-target pesticide poisoning episodes are known to have occurred at NWC. In the absence of monitoring data and related studies on long-term effects, it is assumed that the public health impact due to official NWC pesticides usage is low.

Economic Base

Direct Employment and Payroll. Expansion of economic base has probably been the greatest impact that NWC has had on the Indian Wells Valley and vicinity. NWC employs roughly 1,000 military personnel and 4,500 civilians, providing an annual payroll of $71 million. Since the valley was almost uninhabited before the establishment of NWC, the result has been to create a huge demand for goods and services in the valley.

Secondary Employment Benefits. Basic-nonbasic employment ratios for American cities of 10,000 to 20,000 population vary from 1:.8 to 1:.9.[36] That is, for every 1,000 basic workers who bring money into the community, there would be 800 to 900 nonbasic workers whose goods and services are consumed within the confines of the urban area. China Lake provides approximately 5,500 basic employees to the Indian Wells Valley, while the number of nonbasic employees in the valley is approximately 3,650. Thus the basic:nonbasic employment ratio for the valley is approximately 1:.65, which is lower than the average. The fact that Ridgecrest does not reap as much of the secondary employment benefits is partially because NWC itself provides some goods and services to the employees and residents. Nevertheless, by providing an additional estimated 3,650 jobs to the valley, NWC has had a significant impact on secondary employment.

Retail Sales and Building Permits. Data in the background section in this report show that building permits for over $6 million were issued for the City of Ridgecrest in 1970. Taxable retail sales in 1970 exceeded $22 million. These are a result of goods and services supplied to the NWC employees and those who provide services. The impact of NWC has therefore been significant.

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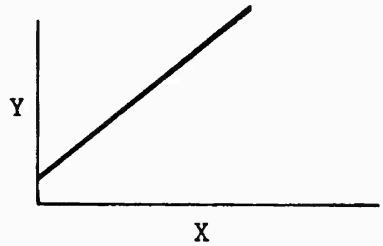
APPENDIXES

Appendix 1

RESOURCE DEPLETION BASED ON STRAIGHT LINE PROJECTION

Assume overdraft given by $Y_i = AX_i + b$



A, b = constants

Y_i = amount of overdraft in year i

X_i = year i

If there is a given total amount that can be used, say 1,000,000 acre-feet, then one must find an n such that:

$$\sum_{i}^{n} Y_i = \text{TOTAL} = 1{,}000{,}000 \text{ acre-ft} \qquad (1)$$

$$\Rightarrow \sum_{i}^{n} (AX_i + b) = \text{TOTAL}$$

Let

$$X_i = X_0 + i$$

Then

$$\sum_{i}^{n} (AX_i + b) = \sum_{i}^{n} [A(X_0 + i) + b] = \sum_{i}^{n} (AX_0 + b) + \sum_{i}^{n} i$$

$$= (AX_0 + b)n + \frac{n(n+1)}{2}$$

Thus

$$n^2 + \left[1 + 2\left(X_0 + \frac{b}{A}\right)\right] n - \frac{2(\text{TOTAL})}{A} = 0 \qquad (2)$$

Solving for n,

$$n = \frac{-b' + \sqrt{b'^2 - 4C}}{2} \qquad (3)$$

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where

$$b' = 1 + 2\ (X_0 + b/A)$$

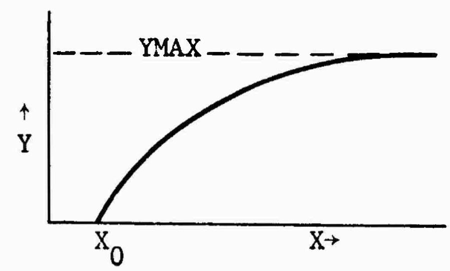
$$C = \frac{2(\text{TOTAL})}{A}$$

n is then the resource lifetime.

Appendix 2

RESOURCE DEPLETION ASSUMING NONLINEAR RESOURCE USE

Assume the overdraft of the groundwater resource can be given by the following form:



$$Y_i = YMAX \left\{1 - \exp[-\sigma(X_i - X_0)]\right\} \quad (1)$$

where

$YMAX, \sigma, X_0$ = constants

Y_i = the amount of overdraft in year i

X_i = year i

This assumes that the water usage levels off at some constant amount at a given future year.

If there is a given total amount that can be used, say 1,000,000 acre-feet, then one must find an n such that:

$$\sum_{i=1}^{n} Y_i = TOTAL = 1,000,000 \text{ acre-ft} \quad (2)$$

$$\Rightarrow \Sigma YMAX \left\{1 - \exp[-\sigma(X_i - X_0)]\right\} = TOTAL$$

Let

$$X_i = X_1 + i$$

Then

$$\sum^{n} YMAX \left\{ 1 - \exp[-\sigma(X_i - X_0)] \right\} = \sum^{n} YMAX \left\{ 1 - \exp[-\sigma(X_i - X_0 + 1)] \right\}$$

$$= \left\{ YMAX \sum_{i=1}^{n} 1 \right\} - \left\{ YMAX \sum^{n} \exp[-\sigma(X_1 - X_0)] \exp(-\sigma i) \right\}$$

$$= (YMAX)(n) - \left\{ (YMAX) \exp[-\sigma(X_1 - X_0)] \right\} \sum_{i=1}^{n} \exp(-\sigma i)$$

Thus

$$YMAX \left\{ n - \exp[-\sigma(X_1 - X_0)] \sum_{i=1}^{n} \exp(-\sigma i) \right\} = TOTAL \qquad (3)$$

To find an n that satisfies this relation, one notes the following:

$$\exp[-\sigma(X_1 - X_0)] \sum_{i=1}^{n} \exp)(-\sigma i) > 0$$

$$\Rightarrow n > \left\{ n - \exp[-\sigma(X_1 - X_0)] \sum^{n} \exp(-\sigma i) \right\}$$

If one picks an n_0 such that $(YMAX)(n_0) = TOTAL$, then

$$TOTAL > YMAX \left\{ n_0 - \exp[-\sigma(X_1 - X_0)] \sum^{n_0} \exp(-\sigma i) \right\} \qquad (4)$$

At some point, however, as n is increased from n_0 to some critical n, n_c, Eq. 4 becomes an equality. Thus, to find the n_c that satisfies Eq. 3, one starts with $n = n_0$ and then increases n until Eq. 3 is satisfied. Then, Eq. 2 will also be satisfied. The critical n_c will tell how many years the groundwater resource will last.

Appendix 3

STUDENT T-REGRESSION ANALYSIS

Let $H_i(t)$ = average humidity for month i in year t

Assume $H_i(t) = \alpha_i + \beta_i t + e$

Least squares will give $x = a + bt$

To test the null hypothesis that the slope β of the true regression line has a slope of 0, compute (Reference 1, p. 160)

$$t = \frac{b}{S_b}$$

where

$$b = \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2} \quad \text{(Reference 1, p. 152)}$$

$$S_b{}^2 \equiv \frac{S^2{}_{y/x}}{S_{x^2}(n-1)}; \qquad S^2{}_{y/x} \equiv \frac{n-1}{n-2}(S_{y^2} - b^2 S_{x^2});$$

$$S_{x^2} \equiv \frac{1}{n(n-1)}[n\Sigma x^2 - (\Sigma x)^2];$$

$$S_{y^2} \equiv \frac{1}{n(n-1)}[n\Sigma y^2 - (\Sigma y)^2] \quad \text{(Reference 1, p. 157)}$$

Rearranging gives

$$t^2 = \frac{n-2}{\frac{1}{b^2}\frac{S_{y^2}}{S_{x^2}} - 1}, \Rightarrow t^2 = \frac{n-2}{\frac{AB}{C} - 1}$$

where

$$A = n\Sigma x^2 - (\Sigma x)^2$$
$$B = n\Sigma y^2 - (\Sigma y)^2$$
$$C = [n\Sigma xy - \Sigma x \Sigma y]^2$$

We reject the null hypothesis at the significance level γ if $|t|$ exceeds the critical value $t_{\gamma/2,n-2}$ given in Reference 1, Appendix Table 3, for $P(t) = \frac{\gamma}{2}$ and $f = n-2$ degrees of freedom. For a 5% level of significance[1] and $(n-2) = 18$, $t_{0.025,18} = 2.101$.

Thus, the t's from the time series data for humidity have to exceed this value for there to be a significant relationship between humidity and time. However, the following data results:

$$t_{June} = 0.010$$

$$t_{July} = 0.728$$

$$t_{Aug} = 0.357$$

$$t_{Sept} = 0.390$$

Thus, the average summer humidity has not changed significantly over the last 20 years.

The same technique is used to determine changes in water quality in Well 29. In this case, the degrees of freedom vary from that used in the summer humidity analysis.

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[1] 5% sig. level =>≈1/20 chance of picking null hypothesis (no relationship between humidity and time) when in fact it is not. 5% is the conventional sig. level.

Appendix 4

AIR POLLUTION DISPERSION MODELS FOR NWC SOURCES

I. Model of Continuously Emitting Area Source

Given the jet emissions from the Naval Air Facility (NAF) area source postulated, it is desirable to estimate to what degree the air quality in the surrounding areas is altered. Following the theory in Reference 1, the area source can be approximated as a point source having an initial standard deviation σ_{yo}, which is a function of the side length of the area source and meteorological conditions. Assuming a side length of 3 miles, the following results are obtained:

Meteorological stability class	σ_{yo}, km	$X_o(\sigma_{yo})$, km
Class A	1.1	6.6
Class B	1.1	9.2
Class C	1.1	14.0

Then

$$\frac{C(X,Y,0;H)}{Q_T} = \left(\frac{1}{\Pi\sigma_y(X + X_o)\sigma_z(X)U}\right) \exp\left\{-\frac{1}{2}\left[\left(\frac{Y}{\sigma_y(X + Y_o)}\right)^2 + \left(\frac{H}{\sigma_z}\right)^2\right]\right\} \quad (1)$$

where

$C(X,Y,0;H)$ = concentration in gm/m^3 at point $(X,Y,Z) = (X,Y,0)$

Q_T = emission per unit time for total area, gm/sec

U = wind speed, m/sec

H = average height of pollutant generator σ_y, σ_z, X, Y, H, meters

Empirical data for σ_y and σ_z show that they are functions of meteorological stability class and downwind distance from the source, X.

Because of the predominance of an inversion layer above the valley, it must be accommodated into the model. Using the method generated in Reference 1, the following equation results for $X \geq 3$ miles:

$$\frac{C(X,Y,0)}{Q_T} = \left(\frac{1}{\sqrt{2\Pi}\ \sigma_y(X_0 + X)LU}\right)\exp\left[-\frac{1}{2}\left(\frac{Y}{\sigma_y(X_0 + X)}\right)^2\right] \tag{2}$$

where

L = inversion height

Since this is independent of the source height, H, it can be used for the Ridgecrest-China Lake automobile traffic and for the NAF aircraft traffic. σ_y is given empirically as follows:

Stability class	$\sigma_y(X)$
A	$0.210X^{.874}$
B	$0.160X^{.874}$
C	$0.105X^{.874}$

Eq. 2 can be used only for concentrations outside the area source. From Reference 2, the average concentration in the area can be given as follows:

$$\frac{\overline{C}}{Q} = 0.3994 \left(\frac{S}{U}\right)^{.115} \tag{3}$$

where

S = length of area side, meters
U = wind speed, m/sec
Q = emissions per unit time per unit area, $\frac{gm}{m^2\text{-sec}}$

Reference 2 gives the following data on $\frac{\overline{C}}{Q}$:

	Upper decile $\frac{\overline{C}}{Q}$	Median $\frac{\overline{C}}{Q}$
Annual morning	50	15
Annual afternoon	13	10

To determine the steady-state value of Q for aircraft, one computes the total emissions per unit time over the area. Using the data on the Airspace 2505 below 3,000 feet, the following results are obtained:

Pollutant	Q_T, gm/sec	Q, gm/m^2-sec	Upper 10% $\bar{C}$, gm/m^3	Median $\bar{C}$, gm/m^3
NO_x	1.3	55×10^{-9}	2.8×10^{-6}	7.2×10^{-7}
CO	0.40	17×10^{-9}	8.5×10^{-7}	2.2×10^{-7}
Total hydrocarbons	0.056	2.4×10^{-9}	1.2×10^{-7}	3.1×10^{-8}
Reactive hydrocarbons . . .	0.019	0.81×10^{-9}	4.1×10^{-8}	1.0×10^{-8}
Particulates	0.35	15×10^{-9}	7.5×10^{-7}	2.0×10^{-7}

Using the same model as for NAF, the average concentrations of pollutants inside the Ridgecrest-China Lake 9-square-mile area due to private automobiles, are obtained:

Pollutant	Q_T, gm/sec	Q, gm/m^2-sec	Upper 10% $\bar{C}$	Median $\bar{C}$,
NO_x	7.9	4.0×10^{-7}	0.0098 ppm	0.0025 ppm
CO	79.0	3.4×10^{-6}	0.120 ppm	0.035 ppm
Hydrocarbons	9.3	3.4×10^{-7}	0.012 ppm	0.0035 ppm
Particulates	0.81	3.5×10^{-8}	1.8 $\mu gm/m^3$	0.46 $\mu gm/m^3$

II. Continuous Line Source Model for Highways 395 and 14

To compute the effect on the valley, Reference 1 is used to model a continuous line source under an inversion layer. The following equations would apply:

For $0 < X < X_L$,

$$\frac{C(X,Y,0;H)}{Q} = \frac{\sqrt{2}}{\sqrt{\Pi}\ \sigma_z(X)U} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z(X)}\right)\right]^2 \qquad (1)$$

for $2X_L < X$, integrate above from Z = 0 to L which gives:

$$\frac{C(X,Y,0;H)}{Q} = \left(\sqrt{\frac{\Pi}{2}}\ \frac{\sigma_z}{L}\right)\left(\frac{\sqrt{2}}{\sqrt{\Pi}\ \sigma_z U}\right) = \frac{1}{LU} \qquad (2)$$

For $X_L < X < 2X_L$, assume a linear approximation based on results at $X = X_L$ and $X = 2X_L$ from Eq. 1 and 2 above. Then:

$$\frac{C}{Q} = 1.2 \times 10^{-3} \left(1 - \frac{X}{3.5X_L}\right) \text{ for Class A stability} \qquad (3a)$$

$$\frac{C}{Q} = 2.9 \times 10^{-4} \left(1 - \frac{X}{3.5X_L}\right) \text{ for Class B stability} \qquad (3b)$$

For the equations above,

$C(X,Y,0)$ = concentration in gm/m^3 at $(X,Y,Z) = (X,Y,0)$
Q = line emission, gm/m-sec
U = wind speed, m/sec
L = inversion height, 2,000 meters
H = line height, 150 meters X,Y,Z,σ_z, meters
X_L = 1.4 km for Class A stability; X_L = 8.2 km for Class B;
X_L = 20 km for Class C

For stagnant conditions, Eq. 2 would hold throughout most of the valley. This would create the following background concentrations throughout the valley for L = 2,000 m and U = 2.24 mi/hr:

Pollutant	Concentration
NO_x	2.4×10^{-5} ppm
CO	3.4×10^{-4} ppm
HC	1.1×10^{-5} ppm
Particulates	4.3×10^{-3} $\mu gm/m^3$

Thus, although Highways 14 and 395 annually contribute a significant mass of pollutants, the ambient concentrations of pollutants that result are extremely small.

III. Instantaneous Line Source Model for Aircraft Run-In

In order to determine how the air quality in the Indian Wells Valley is affected by the run-ins for C range over Airspace 2506, one approximates the run-in as an instantaneous line source. Because the run-in takes place at 450-550 mi/hr, the pollutants will be deposited in a line before the atmosphere has time to disperse them.

The model for an instantaneous line source can be obtained by using the form for the instantaneous point source (Reference 1) and integrating Y from $-\infty$ to $+\infty$. What results is the following form:

$$\frac{C(X,Y,0)}{Q} = \left(\frac{1}{\Pi\sigma_x(X)\sigma_z(X)\sin\phi}\right) \tag{1}$$

$$\exp\left\{-\frac{1}{2}\left[\left(\frac{X-UT}{\sigma_x(X)}\right)^2 + \left(\frac{H}{\sigma_z(X)}\right)^2\right]\right\}$$

where

$C(X,Y,0)$ = concentration in gm/m^3 at $(X,Y,Z) = (X,Y,0)$
Q = emission per unit length, gm/m
ϕ = angle between wind and line source = 45 deg
U = wind speed, m/sec
T = time, seconds
H = height of line source, in meters = 150 m
X, Y, σ_x, σ_z, meters

Data from page 41 and pages 8-9, Reference 1, were extrapolated to give the following equations for σ_x and σ_z for different stability classes:

Class	$\sigma_x(X)$	$\sigma_z(X)$
A	$0.085X^{.874}$	$0.078X^{.72}$
B	$0.034X^{.874}$	$0.027X^{.76}$
C	$0.010X^{.874}$	$0.003X^{.60}$

The validity of these equations for $X \geq 5$ miles is open to question. However, for $X \leq 2$ miles they should be reasonably accurate (p. 41, Reference 1).

To calculate Q, assume the run-in takes place for 10 miles over the valley at 500 mi/hr. Using the jet test cell data and the data on operation mode, then the following results are obtained.

Pollutant	lb/hr	gm/m
NO_x	180	1.0×10^{-1}
CO	36	2.0×10^{-2}
Total HC	2.0	1.1×10^{-3}
Reactive HC	0.52	2.9×10^{-4}
Particulate	55	3.1×10^{-2}

Using Eq. 1 and the data above, a typical run-in was simulated on the computer to monitor the change in pollution concentration over time and space after the run-in. The computer printout shows that at no time is any area exposed to adverse pollution, and under average weather conditions pollution disperses very rapidly. Pollution concentrations at ground level never exceed one-thousandth the federal air quality standard.

IV. Instantaneous Point Source Model for Explosions and Quick Burns

Many of NWC's test and disposal operations are burns or explosions which take place in a confined locale for a short period of time. These can be approximated as instantaneous point sources.

Using the procedure described on page 41 of Reference 1, the following equation would apply:

$$\frac{C(X,Y,0,t;H)}{Q_T} = \left(\frac{2}{(2\Pi)^{3/2}\sigma_x(X)\sigma_y(X)\sigma_z(X)}\right) \exp\left\{-\frac{1}{2}\left[\left(\frac{X-Ut}{\sigma_x(X)}\right)^2 + \left(\frac{H}{\sigma_z(X)}\right)^2 + \left(\frac{Y}{\sigma_y(X)}\right)^2\right]\right\} \quad (1)$$

where

$C(X,Y,0,t;H)$ = concentration in gm/m^3 at time t at point $(X,Y,Z) = (X,Y,0)$
Q_T = total amount of pollutant released, grams
t = time, seconds
U = wind speed, m/sec
H = plume height, meters
σ_x, σ_y, σ_z, X, Y, Z, meters

In this model, $\sigma_x = \sigma_y$ for horizontal dispersion. The same values for σ_y and σ_z were used as for an instantaneous line source, with the attendant limitations for large downwind distances.

The instantaneous point source model was used to estimate ground level pollutants resulting from JP-5 fuel and ordnance burns. Application of the model indicated that even under stagnant conditions, ambient standards were not surpassed.

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