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ANL/EAD/TM-63

Technical Documentation in Support of the Project-Specific Analysis for Construction and Operation of the National Ignition Facility

Environmental Assessment Division
Argonne National Laboratory

Operated by The University of Chicago,
under Contract W-31-109-Eng-38, for the
United States Department of Energy

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Technical Documentation in Support of the Project-Specific Analysis for Construction and Operation of the National Ignition Facility

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September 1996

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NOTATION

Abbreviations

AADT	average annual daily traffic
ABCAQCB	Albuquerque-Bernalillo County Air Quality Control Board
ACGIH	American Conference of Government Industrial Hygienists
BAAQMD	Bay Area Air Quality Management District
BEA	Bureau of Economic Analysis
CARB	California Environmental Protection Agency Air Resources Board
CFR	Code of Federal Regulations
CNR	composite noise rating
CO	carbon monoxide
DBHCC	District Board of Health of Clark County
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERPG-2	Emergency Response Planning Guideline-2
FWS	U.S. Fish and Wildlife Service
ICF	inertial confirment fusion
I-O	input-output
IP	Implementation Plan
ISCT	Industrial Source Complex Short Term Model
LANL	Los Alamos National Laboratory
L_{dn}	day-night sound level
LLNL	Lawrence Livermore National Laboratory
LPG	liquefied petroleum gas
MEI	maximally exposed individual
NAAQS	National Ambient Air Quality Standards
NDEP	Nevada Division of Environmental Protection
NEPA	National Environmental Policy Act
NIF	National Ignition Facility
NLVF	North Las Vegas Facility
NMEIB	New Mexico Environmental Improvement Board
NO_2	nitrogen oxide
NO_x	nitrogen oxides
NRC	U.S. Nuclear Regulatory Commission

NTS	Nevada Test Site
O_3	ozone
OSHA	Occupational Safety and Health Administration
Pb	lead
PEIS	programmatic environmental impact statement
PFIB	perfluoroisobutylene
PHA	Preliminary Hazards Analysis
PM_{10}	particulate matter with a diameter equal to or less than 10 micrometers
PSA	project-specific analysis
PSD	prevention of significant deterioration
RIMS	Regional Input-Output Modeling System
ROI	region of influence
SNL	Sandia National Laboratories
SO_2	sulfur dioxide
SSM	Stockpile Stewardship and Management
TLV	threshold limit value
TLV-TWA	threshold limit value, time-weighted average
TSR	tritium supply and recycling
UC	University of California
VKT	vehicle-kilometer(s) traveled
VOC	volatile organic compound
WBS	work breakdown structure

Units of Measure

°C	degrees Celsius	Hz	hertz
°F	degrees Fahrenheit	in.	inch(es)
Btu	British thermal unit(s)	kg	kilogram(s)
Ci	curie(s)	km	kilometer(s)
cm	centimeter(s)	L	liter(s)
d	day(s)	lb	pound(s)
dBA	decibel(s), A-weighted	m	meter(s)
ft	foot (feet)	m^2	square meter(s)
ft^2	square foot (feet)	m^3	cubic meter(s)
ft^3	cubic foot (feet)	mg	milligram(s)
gal	gallon(s)	mi	mile(s)
h	hour(s)	min	minute(s)
ha	hectare(s)	MJ	megajoule(s)

mm	millimeter(s)	s	second(s)
mo	month(s)	t	metric ton(s) (1,000 kilograms)
mph	mile(s) per hour		
MW	megawatt(s)	μg	microgram(s)
oz	ounce(s)	yd^2	square yard(s)
ppm	part(s) per million	yd^3	cubic yard(s)
ppmv	part(s) per million (by volume)	yr	year(s)

TECHNICAL DOCUMENTATION IN SUPPORT OF THE PROJECT-SPECIFIC ANALYSIS FOR CONSTRUCTION AND OPERATION OF THE NATIONAL IGNITION FACILITY

by

M.A. Lazaro, W. Vinikour, T. Allison, J. Arnish, T. Bingaman, B. Biwer, Y.S. Chang, K.-J. Hong, D. Kuhaneck, M.R. Monarch, E.D. Pentecost, A.J. Policastro, R. Seiden, and D.R. Wernette

1 INTRODUCTION

1.1 BACKGROUND

This document provides information that supports or supplements the data and impact analyses presented in the National Ignition Facility (NIF) Project-Specific Analysis (PSA). The NIF PSA constitutes Appendix I of the U.S. Department of Energy's (DOE's) *Programmatic Environmental Impact Statement (PEIS) for the Stockpile Stewardship and Management (SSM) Program* (DOE 1996). The purposes of NIF are to achieve fusion ignition in the laboratory for the first time with inertial confinement fusion (ICF) technology and to conduct high-energy-density experiments in support of national security and civilian applications. NIF is an important element in the DOE's science-based SSM Program, a key mission of which is to ensure the reliability of the nation's enduring stockpile of nuclear weapons. NIF would also advance the knowledge of basic and applied high-energy-density science and bring the nation a large step closer to developing fusion energy for civilian use.

The NIF PSA includes evaluations of the potential environmental impacts of constructing and operating the facility at one of five candidate sites and for two design options. The candidate sites include the Lawrence Livermore National Laboratory (LLNL) in Livermore, California (preferred site); Los Alamos National Laboratory (LANL) in Los Alamos, New Mexico; Nevada Test Site (NTS) near Mercury Base, Nevada; North Las Vegas Facility (NLVF) in North Las Vegas, Nevada; and Sandia National Laboratories (SNL) in Albuquerque, New Mexico. The design options evaluated are the Conceptual Design Option, which would use indirect drive deuterium-tritium fuel targets, and the Enhanced Option, which would use both indirect and direct drive deuterium-tritium fuel targets. The analyses conducted for the PSA indicate relatively small environmental impacts and very little difference in the impacts among the siting and operational alternatives (see Chapter I.4 of the PSA).

1.2 DOCUMENT ORGANIZATION

This document provides selected technical support information for the site-specific data, assessment methods, and regulatory framework for analyses conducted for air quality and acoustics, socioeconomics, radiation and hazardous chemicals, transportation impacts, and federal- and state-protected plant and animal species that could inhabit or visit the NIF candidate sites. These topical areas typically require evaluation of extensive databases or the use of modeling that is too comprehensive for extended discussion in the main text of an assessment document. Where appropriate, assumptions and rationale are provided in this document to support the methods selected.

Organization of this document is as follows: Section 1: Introduction, Section 2: Air Quality and Acoustics, Section 3: Socioeconomics, Section 4: Radiation and Hazardous Chemicals, and Section 5: Threatened, Endangered, and Rare Species. A synopsis of the technical information included in Sections 2 through 5 is provided below.

1.2.1 Section 2: Air Quality and Acoustics

Section 2 provides data on background (ambient baseline) concentrations of criteria air pollutants and NIF-related pollutant emissions for the five candidate sites. Air quality modeling used to predict emission concentrations resulting from site clearing and NIF operation is also discussed. Air quality analysis for NIF construction (both site-clearing and facility-construction phases) focused on fugitive particulate matter emissions from soil disturbance and on exhaust emissions from construction vehicles. Air quality modeling analysis for particulate matter emissions from site clearing at each candidate site is also discussed. Detailed information and assumptions used in the analysis are provided for air pollutant emission sources and levels, air pollutant emission factors, and source operating activity from NIF operations. Section 2 also provides data supporting the impact assessments for acoustics presented in the PSA. Included are description of the analytical methods used, discussion of assumptions used in the analyses, and presentation of the analysis results for each candidate site.

1.2.2 Section 3: Socioeconomics

Section 3 describes the methods, models, assumptions, and supporting data sources used to assess the potential socioeconomic impacts from constructing and operating NIF at each candidate site. The approach used for determining socioeconomic impacts of NIF was consistent with the overall approach used for the PEIS for the SSM Program. Because this approach is similar to that used in the Tritium Supply and Recycling PEIS (DOE 1995), only those aspects that differ from that PEIS are addressed in detail in this document. The potential socioeconomic impacts addressed

include regional economics, population in-migration, housing, public finance, public services, and local transportation. Also addressed under socioeconomics is environmental justice (i.e., potential disproportionate effects on minority and low-income communities). Section 3 of this document details the definitions, methods, and assumptions used to determine potential environmental justice effects from operation of NIF at each candidate site. The potential environmental justice impacts identified by the analysis for each site are also discussed.

1.2.3 Section 4: Radiation and Hazardous Chemicals

Section 4 presents the methods, data, and assumptions used to estimate radiological, hazardous chemical, and material transportation impacts that could result from operation of NIF at each candidate site. Information provided for the radiological impact assessment includes sources of radiation, assessment methods, model input (i.e., source term data, meteorological data, population data, and locations of maximally exposed individuals), and assumptions. This information was used to assess potential radiological impacts from normal NIF operations and from postulated accidents. The impact assessment is provided in Chapter I.4 of the PSA. Information provided for the hazardous chemical impact assessment includes a determination of potentially hazardous chemicals and descriptions of scenarios that could cause an accidental release of those chemicals. Section 4 also provides information required to calculate transportation impacts that could result from the shipment of tritium-filled targets from each of the target manufacturing facilities to each of the candidate NIF locations. The evaluation includes both radiological and nonradiological accident causes for both the Conceptual Design and Enhanced options. The discussion for the transportation accident assessment includes transportation routes, routine transportation risk, and transportation accident risk. Model input for the transportation assessment includes source terms and shipment configuration, accident severity categories, and material release fractions. Assumptions on release heights, population densities, and location of maximally exposed individuals are also provided. The section concludes with information on per-shipment risk factors and consequences to maximally exposed individuals.

1.2.4 Section 5: Threatened, Endangered, and Rare Species

Section 5 lists the federal- and state-listed plant and animal species that inhabit or could occur at each of the candidate sites. The species lists are for the entire candidate site, rather than being limited to the specific NIF location within the site. This information is presented in tabular form and includes the common and scientific names, status (federal and state), general habitat, and potential for each species to occur at the specific NIF location. Although the lists for some of the larger DOE sites are extensive, few protected species would actually occur at any of the proposed NIF locations within those sites. Furthermore, the potential for adverse impacts to any listed species is considered negligible.

1.3 REFERENCES FOR SECTION 1

U.S. Department of Energy, 1995, *Programmatic Environmental Impact Statement for Tritium Supply and Recycling*, Vols. I and II, DOE/EIS-0161, Office of Reconfiguration, Washington, D.C.

U.S. Department of Energy, 1996, *Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*, DOE/EIS-0236, Office of Reconfiguration, Washington, D.C.

2 AIR QUALITY AND ACOUSTICS

2.1 AIR QUALITY

This section provides data supporting air quality assessments presented in Chapter I.4 of the NIF PSA (DOE 1996, Appendix I). The data presented in this section include ambient baseline concentrations of criteria air pollutants and estimates of NIF-related pollutant emissions. Air quality modeling used to predict emission concentrations resulting from site clearing for NIF and operation of the facility is also discussed.

2.1.1 Affected Environment

Background information on air quality at the five candidate sites for NIF are provided here. National Ambient Air Quality Standards (NAAQS) exist for the criteria air pollutants ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur oxides (measured as sulfur dioxide [SO_2]), particulate matter equal to or less than 10 μm in diameter (PM_{10}), and lead (Pb) (Title 40, Code of Federal Regulations, Part 50 [40 CFR 50]). Most states have also established state ambient air quality standards (AAQS) for these and, in some cases, other pollutants. Federal Prevention of Significant Deterioration (PSD) regulations limit increases in criteria pollutant concentrations resulting from emissions from new sources above a baseline concentration. The allowable concentration increases (called increments) depend on the PSD classification of the area. The smallest increases are allowed in Class I areas, the largest in Class III areas. Table 2.1 lists the air quality standards applicable to each candidate site, and Table 2.2 lists maximum allowable PSD concentrations applicable to all candidate sites. Tables 2.3 through 2.8 provide air quality data for the individual candidate sites.

The NAAQS and California State and Bay Area Air Quality Management District (BAAQMD) ambient air quality standards applicable to LLNL are presented in Table 2.3. Table 2.4 summarizes 1993 air quality monitoring data for the single BAAQMD monitor near LLNL. NAAQS and Nevada state ambient air quality standards applicable to the NTS are presented in Table 2.5. NAAQS and Clark County ambient air quality standards applicable to the NLVF are presented in Table 2.6. Table 2.7 summarizes 1994 air quality monitoring data for the Clark County monitors near NLVF, and Table 2.8 summarizes 1993 air quality monitoring data from the New Mexico Environment Department monitors near SNL.

TABLE 2.1 Ambient Air Quality Standards Applicable to the National Ignition Facility Candidate Sites

Pollutant	Averaging Time	Unit	NAAQS		State Standards				
			Primary[a]	Secondary	California (LLNL)	Nevada (NTS)	Nevada (NLVF)	New Mexico (LANL)	New Mexico (SNL)
Criteria Pollutants									
Carbon monoxide	Annual	ppmv	—[b]	—	—	—	—	—	4
	8 hours	ppmv	9.0	—	9.0	9.0	9.0	8.7	8.7
	1 hour	ppmv	35	—	20	35	35	13.1	13.1[c]/13[d]
Lead	Calendar quarter	$\mu g/m^3$	1.5	1.5	—	1.5	1.5	—	—
	30 days	$\mu g/m^3$	—	—	1.5	—	—	—	3
Nitrogen dioxide	Annual	ppmv	0.053	0.053	—	0.05	0.05	0.05	0.05
	24 hours	ppmv	—	—	—	—	—	0.10	0.062
	1 hour	ppmv	—	—	0.25	—	—	—	—
Ozone	1 hour	ppmv	0.12	0.12	0.09	0.12	0.12	—	—
Particulate matter (PM_{10})	Annual	$\mu g/m^3$	50	50	30[e]	50	50	—	—
	24 hours	$\mu g/m^3$	150	150	50	150	150	—	—
Sulfur dioxide	Annual	$\mu g/m^3$	80	—	—	80	60	52	11
	24 hours	$\mu g/m^3$	365	—	105	365	260	260	92
	3 hours	$\mu g/m^3$	—	1,300	—	1,300	1,300	—	—
	1 hour	$\mu g/m^3$	—	—	655	—	—	—	—
Other Mandated Pollutants									
Arsenic, copper, and zinc	30 days	$\mu g/m^3$	—	—	—	—	—	—	10
Asbestos	30 days	$\mu g/m^3$	—	—	—	—	—	0.01	0.01
Beryllium	30 days	$\mu g/m^3$	—	—	0.01	—	—	0.01	0.01

TABLE 2.1 (Cont.)

Pollutant	Averaging Time	Unit	NAAQS		State Standards				
			Primary[a]	Secondary	California (LLNL)	Nevada (NTS)	Nevada (NLVF)	New Mexico (LANL)	New Mexico (SNL)
Heavy metals	30 days	$\mu g/m^3$	—	—	—	—	—	10	10
Hydrogen sulfide	1 hour	ppmv	—	—	0.03	0.08	0.08	0.01	0.003
Nonmethane hydrocarbons	3 hours	ppmv	—	—	—	—	—	0.19	0.19[c]/0.15[d]
Photochemical oxidants	1 hour	ppmv	—	—	—	—	—	0.06	0.01
Soiling index	—	cohs/ 1,000 linear ft of air	—	—	—	—	—	0.4	0.3
Suspended sulfates	24 hours	$\mu g/m^3$	—	—	25	—	—	—	—
Total reduced sulfur	30 minutes	ppmv	—	—	—	—	—	0.003	0.003
Total suspended particulates	Annual	$\mu g/m^3$	—	—	—	—	—	60	60
	30 days	$\mu g/m^3$	—	—	—	—	—	90	90
	7 days	$\mu g/m^3$	—	—	—	—	—	110	110
	24 hours	$\mu g/m^3$	—	—	—	—	—	150	150
Vinyl chloride	24 hours	ppmv	—	—	0.10	—	—	—	—
Visibility	—	—	—	—	—	—[f]	—	—	—
Visibility-reducing particles	8 hours	—	—	—	—[g]	—	—	—	—

See next page for footnotes.

TABLE 2.1 (Cont.)

[a] The NAAQS — other than those for ozone, particulate matter, and those based on annual averages — are not to be exceeded more than once per year. The ozone standard is attained when the expected number of days per year with maximum hourly average concentrations above the standard is less than or equal to 1. The 24-hour particulate matter standard is attained when the expected number of days with a 24-hour average concentration above the standard is less than or equal to 1. The annual arithmetic mean particulate matter standard is attained when the expected annual arithmetic mean concentration is less than or equal to the standard.

[b] — = There is no standard.

[c] State standard not to be exceeded.

[d] County standard not to be exceeded more than once per year.

[e] The California standard is the annual geometric mean; the other standards are the annual arithmetic means.

[f] Present in sufficient amount to produce an extinction coefficient of 0.23/km due to particles when the relative humidity is less than 70%.

[g] Present in sufficient amount to reduce the prevailing visibility to less than 50 km (30 mi) when humidity is less than 70%.

Sources: 40 CFR Part 50; CARB (1993); NDEP (1988-1992); DBHCC (1993); NMEIB (1981); ABCAQCB (1973).

TABLE 2.2 Maximum Allowable Prevention of Significant Deterioration (PSD) Concentration Increments

Pollutant	Averaging Time	PSD Increment ($\mu g/m^3$) Class I Area	Class II Area	Class III Area
Nitrogen dioxide	Annual	2.5	25	50
Particulate matter (PM_{10})	Annual	4	17	34
	24 hours[a]	8	30	60
Sulfur dioxide	Annual	2	20	40
	24 hours[a]	5	91	182
	3 hours[a]	25	512	700

[a] Short-term increments are not to be exceeded more than once per year.

Source: 40 CFR 52.21.

2.1.2 Environmental Impacts

The estimated air pollutant emissions resulting from NIF construction and operation are discussed in Sections 2.1.2.1 and 2.1.2.2, respectively. Construction emissions were evaluated separately for site-clearing and facility-construction phases. Site clearing would be the first phase of construction and would last, at most, about 2.5 months. Facility construction would follow site clearing and is expected to last a few years, depending on the site-specific construction requirements. Only the potential air quality impact of fugitive dust (PM_{10}) from site clearing was evaluated in detail. Although the magnitude of other construction pollutant emissions (from vehicle exhaust) and NIF operating emissions were estimated, the amounts of these other emissions were considered too low to warrant a modeling analysis. Air quality modeling analysis for PM_{10} emissions from site clearing is included in Section 2.1.2.1.3 under the construction emissions discussion.

2.1.2.1 Construction Air Pollutant Emissions

Construction activities would involve a number of separate dust-generating operations, including site clearing/grubbing, excavation, earthmoving, foundation treatment, building erection, electrical and mechanical installation, road construction, and landscaping. For the purpose of air pollutant emission estimation, construction was divided into two phases: site clearing and facility

TABLE 2.3 State of California and National Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards[a,b]	NAAQS[a,c]	
			Primary	Secondary
Ozone	1 hour	0.09 ppm (180 $\mu g/m^3$)	0.12 ppm (235 $\mu g/m^3$)	Same as primary standard
Carbon monoxide	8 hours	9.0 ppm (10 mg/m^3)	9.0 ppm (10 mg/m^3)	—[d]
	1 hour	20 ppm (23 mg/m^3)	35 ppm (40 mg/m^3)	—
Nitrogen dioxide	Annual average	—	0.053 ppm (100 $\mu g/m^3$)	Same as primary standard
	1 hour	0.25 ppm (470 $\mu g/m^3$)	—	—
Sulfur dioxide	Annual average	—	80 $\mu g/m^3$	—
	24 hours	0.04 ppm (105 $\mu g/m^3$)	365 $\mu g/m^3$ (0.14 ppm)	—
	3 hours	—	—	1,300 $\mu g/m^3$ (0.5 ppm)
	1 hour	0.25 ppm (655 $\mu g/m^3$)	—	—
Particulate matter (PM_{10})	Annual geometric mean	30 $\mu g/m^3$	—	—
	24 hours	50 $\mu g/m^3$	150 $\mu g/m^3$	Same as primary standard
	Annual arithmetic mean	—	50 $\mu g/m^3$	Same as primary standard
Sulfates	24 hours	25 $\mu g/m^3$	—	—
Lead	30 day average	1.5 $\mu g/m^3$	—	—
	Calendar quarter	—	1.5 $\mu g/m^3$	Same as primary standard
Hydrogen sulfide	1 hour	0.03 ppm (42 $\mu g/m^3$)	—	—
Vinyl chloride (chloroethene)	24 hours	0.10 ppm (26 $\mu g/m^3$)	—	—

TABLE 2.3 (Cont.)

Pollutant	Averaging Time	California Standards[a,b]	NAAQS[a,c]	
			Primary	Secondary
Visibility-reducing particles	8 hours (10 a.m. to 6 p.m., PST)	"In sufficient amount to produce an extinction coefficient of 0.23/km due to particles when the relative humidity is less than 70 percent. Measurement in accordance with ARB Method V."	—	—

[a] Concentration expressed first in units in which it was promulgated. Equivalent units given in parenthesis are based upon a reference temperature of 25°C and a reference pressure of 760 mm of mercury. All measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 mm of mercury; ppm in this table refers to ppm by volume or micromoles of pollutant per mole of gas.

[b] California standards for ozone, carbon monoxide, sulfur dioxide (1 hour and 24-hour), NO_2, PM_{10} particulate matter, and visibility-reducing particles are values that are not to be exceeded. The standards for sulfates, lead, hydrogen sulfide, and vinyl chloride are not to be equaled or exceeded.

[c] The NAAQS — other than ozone and those based on annual averages or annual arithmetic means — are not to be exceeded more than once a year. The ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the standard is equal to or less than 1.

[d] — = there is no standard.

Source: CARB (1993).

construction. As the first phase of construction, site clearing would involve removal and clearing of all surface structures and growth from the site and leveling of the terrain, followed by earthmoving, including excavation and placement of earth fill. Facility construction would involve all the construction phases after site clearing.

The number of days, types of equipment, and daily construction vehicle fuel consumption specified for site clearing at LLNL were used as the basis for estimating project-related site clearing air pollutant emissions (Foley 1995). These data based on daily site clearing activity at LLNL were also used to estimate the number of days to complete the site clearing for other candidate sites by using site-specific construction areas as a scaling factor. The time needed for site clearing and facility construction for the first year of construction and total construction area that would be disturbed at each site are summarized in Table 2.9. The estimated time to perform site clearing varies among sites from two weeks to nearly 2.5 months as a function of construction site area. Facility construction is estimated to take place over a five-year period (LLNL 1995b).

TABLE 2.4 Livermore Old First Street Ambient Air Monitoring Station Criteria Pollutant Monitoring Data for 1993

Pollutant	Averaging Time	Standard Exceeded	
		California	National
Ozone	1 hour	21 occurrences	1 occurrence
Carbon monoxide	8 hours	No occurrences	No occurrences
	1 hour	No occurrences	No occurrences
Nitrogen dioxide	Annual average	— [a]	No occurrences
	1 hour	No occurrences	—
Particulate matter (PM_{10})	Annual geometric mean	No occurrences	—
	24 hours	3 occurrences	No occurrences
	Annual arithmetic mean	—	No occurrences
Lead	30 day average	No occurrences	—
	Calendar quarter	—	No occurrences

[a] — = no ambient air quality standard.

Source: CARB (1993).

Air pollutant emissions that would be expected during the construction period include fugitive PM_{10} emissions from soil disturbance and, to a lesser degree, exhaust emissions from construction vehicles. Because of the high degree of soil disturbance, PM_{10} emission rates for site clearing would be much higher than those for facility construction. Therefore, annual emissions are estimated for the first year of construction, with separate analysis of site clearing and facility construction phases. Estimated total annual emissions from site clearing and facility construction stemming from vehicle exhaust and fugitive dust are summarized in Table 2.10 for each of the five NIF candidate sites. Air pollutant emission estimates from construction vehicle exhaust and PM_{10} fugitive dust are described in Sections 2.1.2.1.1 and 2.1.2.1.2, respectively. Subsequent years of construction would not involve site clearing, and annual emissions are estimated to be lower than those for the first year.

2.1.2.1.1 Construction Vehicle Exhaust Emissions

Site Clearing

The anticipated construction vehicle exhaust emissions for site clearing activities are summarized for each construction site in Table 2.11. Annual air pollutant emissions are summed for

TABLE 2.5 State of Nevada and National Ambient Air Quality Standards

Pollutant	Averaging Time	Nevada Standards[a,b,c]	National Standards[a,c]	
			Primary	Secondary
Ozone	1 hour	235 $\mu g/m^3$ (0.12 ppm)	0.12 ppm (235 $\mu g/m^3$)	Same as primary standard
Ozone — Lake Tahoe	1 hour	195 $\mu g/m^3$ (0.10 ppm)	0.12 ppm (235 $\mu g/m^3$)	Same as primary standard
Carbon monoxide less than 5,000 ft above mean sea level	8 hours	10,000 $\mu g/m^3$ (9.0 ppm)	9.0 ppm (10 mg/m^3)	—[d]
Carbon monoxide at or greater than 5,000 feet above mean sea level	8 hours	6,670 $\mu g/m^3$ (6.0 ppm)	9.0 ppm (10 mg/m^3)	—
Carbon monoxide at any elevation	1 hour	40,000 $\mu g/m^3$ (35 ppm)	40 mg/m^3 (35 ppm)	—
Nitrogen dioxide	Annual average	100 $\mu g/m^3$ (0.05 ppm)	100 $\mu g/m^3$ (0.05 ppm)	Same as primary standard
Sulfur dioxide	Annual average	80 $\mu g/m^3$ (0.03 ppm)	80 $\mu g/m^3$ (0.03 ppm)	—
	24 hours	365 $\mu g/m^3$ (0.14 ppm)	365 $\mu g/m^3$ (0.14 ppm)	—
	3 hours	1,300 $\mu g/m^3$ (0.5 ppm)	—	1,300 $\mu g/m^3$ (0.5 ppm)
Particulate matter (PM_{10})	Annual arithmetic mean	50 $\mu g/m^3$	50 $\mu g/m^3$	Same as primary standard
	24 hours	150 $\mu g/m^3$	150 $\mu g/m^3$	Same as primary standard
Lead	30 day average	1.5 $\mu g/m^3$	—	—
	Calendar quarter	—	1.5 $\mu g/m^3$	Same as primary standard
Hydrogen sulfide	1 hour	112 $\mu g/m^{3(e)}$ (0.08 ppm)		
Visibility-reducing particles	Observation	—[f]		

[a] Concentration expressed first in units in which it was promulgated. Equivalent units given in parenthesis are based upon a reference temperature of 25°C and a reference pressure of 760 mm of mercury. All measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 mm of mercury; ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.

[b] These standards must not be exceeded in areas where the general public has access.

[c] The AAQS — other than ozone and those based on annual averages or annual arithmetic means — are not to be exceeded more than once a year. The ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the standard is equal to or less than 1.

[d] — = there is no standard.

[e] The ambient air quality standard for hydrogen sulfide does not include naturally occurring background concentrations.

[f] Present in sufficient amount to reduce the prevailing visibility to less than 50 km when humidity is less than 70 percent. For the purposes of this section, prevailing visibility means the greatest visibility that is attained or surpassed around at least half of the horizon circle but not necessarily in continuous sectors.

Source: NDEP (1988-1992).

TABLE 2.6 Clark County, Nevada, and National Ambient Air Quality Standards

Pollutant	Averaging Time	Clark County Standards[a,b]	NAAQS[a,b] Primary	NAAQS[a,b] Secondary
Ozone	1 hour	235 $\mu g/m^3$ (0.12 ppm)	0.12 ppm (235 $\mu g/m^3$)	Same as primary standard
Carbon monoxide	8 hours	10 mg/m^3 (9.0 ppm)	9.0 ppm (10 mg/m^3)	—[c]
	1 hour	40 mg/m^3 (35 ppm)	35 ppm (40 mg/m^3)	—
Nitrogen dioxide	Annual average	100 $\mu g/m^3$ (0.053 ppm)	0.053 ppm (100 $\mu g/m^3$)	Same as primary standard
Sulfur dioxide	Annual average	60 $\mu g/m^3$ (0.02 ppm)	80 $\mu g/m^3$ (0.03 ppm)	—
	24 hours	260 $\mu g/m^3$ (0.1 ppm)	365 $\mu g/m^3$ (0.14 ppm)	—
	3 hours	1,300 $\mu g/m^3$ (0.5 ppm)	—	1,300 $\mu g/m^3$ (0.5 ppm)
Particulate matter (PM_{10})	Annual arithmetic mean	50 $\mu g/m^3$	50 $\mu g/m^3$	Same as primary standard
	24 hours	150 $\mu g/m^3$	150 $\mu g/m^3$	Same as primary standard
Lead	Calendar quarter	—	1.5 $\mu g/m^3$	Same as primary standard

[a] The AAQS — other than ozone and those based on annual averages or annual arithmetic means — are not to be exceeded more than once a year. The ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the standard is equal to or less than 1.

[b] Concentration expressed first in units in which it was promulgated. Equivalent units given in parenthesis are based upon a reference temperature of 25°C and a reference pressure of 760 mm of mercury. All measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 mm of mercury; ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.

[c] — = there is no standard.

Source: DBHCC (1993).

each site on the basis of the estimated time to complete site clearing. LLNL provided information on site-clearing equipment, diesel fuel consumption for each piece of construction equipment (Foley 1995), and time to complete site clearing. Vehicle exhaust emissions were computed on the basis of this information and use of EPA emission factors (see Table 2.12). These data were also used to compute air pollutant emissions for the other candidate sites. It was assumed that the daily site-clearing activity at the other candidate sites would be the same as at LLNL, but that the time to complete site clearing would vary depending on the size of the candidate site construction area relative to the size of the LLNL construction site area. (Table 2.9 lists the size of the construction site areas for each candidate site.)

TABLE 2.7 1994 Ambient Air Concentrations in Vicinity of North Las Vegas Facility

Monitoring Station	Distance from NLVF NIF Location (km)	Carbon Monoxide (ppmv)		Nitrogen Dioxide (ppmv), Annual	Ozone (ppmv), Highest 1-hour	PM_{10} ($\mu g/m^3$)	
		Highest 8-hour	Highest 1-hour			Annual	Highest 24-hour
McDaniel	1.9	—[a]	—	—	—	47[b]	117[b]
City Center Gaseous (West)	3.9	7.54[b]	11.75[b]	—	0.098	—	129[c]
City Center (Bonanza)	4	—	—	—	—	35	89
Bemis (Craig Rd.)	4.4	—	—	—	0.102	48	155
Health District (Shadow Ln.)	5.7	7.45	10.7	—	0.100	—	—
LV Fire Sta. 2	5.8	11.71	15.05	—	—	—	—
E. Charleston	5.8	10.92	15.29	0.028[b]	—	—	—
Maycliff	7.8	9.23	11.80	—	—	40	200
McMillan (Walt Lott)	9.4	—	—	—	—	28	66
Wengert	9.8	—	—	—	—	47	122
Flamingo	9.9	7.74	9.16	—	0.094	—	114[c]
Winterwood	10	8.35	9.98	—	0.103	—	—
Diskin (Ravenwood Dr.)	13.6	—	—	—	—	33	116
Paul Meyer	15.5	—	—	—	—	—	98[c]
Pittman	19.1	—	—	—	—	—	141[c]
Frias	21.2	—	—	—	—	21	46
Powerline	21.3	3.43	10.40	—	0.097	46	138
Burkholder	21.5	—	—	—	—	20	46
Boulder City	45	—	—	—	—	—	22[c]
Jean	60	—	—	—	—	—	32[c]

[a] — = no data available.

[b] Data from station nearest the NLVF NIF location.

[c] Less than a full year of data; highest concentration may be underestimated.

Source: Taipale (1995).

Facility Construction

Facility construction would involve all the construction phases after site clearing. Included would be such major activities as excavating foundations, pouring concrete, and erecting buildings. Facility construction is projected to take place over a five-year period. Fugitive dust (PM_{10}) emissions during facility construction are discussed in Section 2.1.2.1.2. Air pollutant emissions other than PM_{10} are expected to be primarily from use of construction equipment and vehicle exhaust. Annual vehicle exhaust emissions have been estimated by LLNL (LLNL 1995b) and are included in Table 2.13.

TABLE 2.8 1993 Ambient Air Concentrations in Vicinity of Sandia National Laboratories

State Station ID	Distance from NIF Location (km)	Carbon Monoxide (ppmv)			Nitrogen Dioxide (ppmv)		Ozone (ppmv)		Particulate Matter (PM_{10}) (μg/m)	
		Highest 8-hour	Highest 1-hour	2nd Highest 1-hour	Highest 24-hour	Annual	Highest 1-hour	2nd Highest 1-hour	2nd Highest 24-hour	Annual
2ZE	7.8	8.0[a]	10.0[a]	10.0[a]	—[b]	—	0.087[a]	0.084[a]	40[a]	17[a]
2ZK	8.8	9.0	12.0	12.0	—	—	—	—	53	27
2ZM	11	5.8	10.0	9.0	0.054[a]	0.024[a]	0.088	0.088	58	26
2ZO	11	—	—	—	—	—	—	—	65	28
2R	13	3.9	7.0	7.0	—	—	0.084	0.080	69	35
2G	15	—	—	—	—	—	—	—	38	21
2ZF	17	—	—	—	—	—	0.085	0.080	—	—
2ZH	18	—	—	—	—	—	0.085	0.080	86	25
2ZL	20	2.1	5.0	5.0	—	—	—	—	47	22
2ZN	20	5.1	9.0	9.0	—	—	—	—	36	19
2ZQ	25	2.0	5.7	4.1	—	—	0.090	0.086	—	—
2ZP	28	—	—	—	—	—	0.078	0.072	—	—
2U	29	—	—	—	—	—	—	—	63	28
2ZJ	29	—	—	—	—	—	0.082	0.080	—	—

[a] Data from station nearest the SNL NIF location.

[b] — = no data available.

Source: NMAQB (1994).

TABLE 2.9 Estimated Number of Months Required for Site Clearing and Facility Construction for the First Year

Site	Area (ha)	Estimated Duration (months)	
		Site Clearing	Facility Construction
LLNL[a]	7.5	1.0	11.0
LANL[b]	4.0	0.5	11.5
NTS[c]	18.2	2.4	9.6
NLVF[d]	3.3	0.4	11.6
SNL[e]	9.7	1.3	10.7

[a] LLNL (1994).

[b] Richardson (1995).

[c] White (1995a).

[d] Lazaroff (1995).

[e] Wheeler (1995).

TABLE 2.10 Estimated Construction Activity Air Pollutant Emission Summary for Candidate Sites

	Estimated Construction Activity Emissions (kg/yr)		
Pollutant	Site Clearing	Facility Construction	Total
LLNL			
PM_{10}	4,138	10,011	14,149
VOCs	406	32	438
CO	1,104	127	1,231
NO_2	3,719	35	3,754
SO_2	387	35	422
Lead	Negligible	Negligible	Negligible
LANL			
PM_{10}	2,171	5,656	7,827
VOCs	216	32	249
CO	589	127	716
NO_2	1,984	35	2,019
SO_2	206	35	241
Lead	Negligible	Negligible	Negligible
NTS			
PM_{10}	10,415	21,170	31,584
VOCs	988	32	1,020
CO	2,686	127	2,813
NO_2	9,052	35	9,087
SO_2	941	35	976
Lead	Negligible	Negligible	Negligible
NLVF			
PM_{10}	1,866	4,658	6,524
VOCs	176	32	208
CO	478	1,277	1,755
NO_2	1,611	35	1,648
SO_2	168	35	203
Lead	Negligible	Negligible	Negligible
SNL			
PM_{10}	5,235	12,642	17,876
VOCs	527	32	559
CO	1,435	127	1,562
NO_2	4,836	35	4,871
SO_2	502	35	537
Lead	Negligible	Negligible	Negligible

TABLE 2.11 Estimated Site-Clearing Construction Vehicle Exhaust Emissions for Each Candidate Site[a]

Site-Clearing Equipment Category	Diesel Fuel Consumption (L)	Pollutant Emissions[b] (kg/30 days)				
		PM_{10}	VOCs	CO	NO_2	SO_2
LLNL						
Water tankers	7,268	15	12	108	249	27
Bottom loaders/dump graders	54,510	191	282	645	2,098	204
Bulldozers	27,255	83	90	256	930	102
Graders	14,536	39	22	95	442	54
Totals	103,569	328	406	1,104	3,719	387
LANL						
Water tankers	3,876	8	6	57	133	15
Bottom loaders/dump graders	29,072	102	150	344	1,119	108
Bulldozers	14,536	44	48	137	496	54
Graders	7,752	21	12	51	236	29
Totals	55,237	175	216	589	1,984	206
NTS						
Water tankers	17,685	38	28	262	606	66
Bottom loaders/dump graders	132,640	466	686	1,568	5,106	496
Bulldozers	66,320	201	220	624	2,264	247
Graders	35,371	94	54	232	1,076	132
Totals	252,196	799	988	2,686	9,052	941
NLVF						
Water tankers	3,149	7	5	47	108	12
Bottom loaders/dump graders	23,621	83	122	279	909	88
Bulldozers	11,810	36	39	111	403	44
Graders	6,299	17	10	41	191	24
Totals	44,880	143	176	478	1,611	168
SNL						
Water tankers	9,448	20	15	140	324	35
Bottom loaders/dump graders	70,863	249	366	838	2,727	265
Bulldozers	35,431	108	117	333	1,210	132
Graders	18,897	50	29	124	575	70
Totals	134,639	427	527	1,435	4,836	502

[a] Based on site-clearing equipment daily fuel consumption (Foley 1995) and 30 days of site clearing for LLNL, 16 days for LANL, 73 days for NTS, 13 days for NLVF, and 39 days for SNL.

[b] Based on EPA construction vehicle emission factors (EPA 1985).

TABLE 2.12 Emission Factors for Site-Clearing Construction Equipment Exhaust

Equipment Category	Emission Factor ($kg/10^3$ L diesel fuel consumed)				
	PM_{10}	VOCs	CO	NO_2	SO_2
Water tanker	2.12	1.58	14.73	34.29	3.74
Bottom loader/dump grader	3.51	5.17	11.79	38.5	3.74
Bulldozer	3.03	3.31	9.4	34.16	3.73
Grader	2.66	1.53	6.55	30.41	3.73

Source: EPA (1985).

Vehicle Exhaust Emission Factors

The emission factors used to estimate pollutant discharges from the exhausts of site-clearing construction vehicles (Table 2.12) are based on EPA data for heavy-duty diesel-powered construction equipment (EPA 1985). The EPA emission factors are a function of construction vehicle type. The vehicle category descriptions in Table 2.12 were provided by LLNL (Foley 1995) but have slightly different category names in the EPA emission factor table. Water tankers, bottom loader/dump graders, bulldozers, and graders are referenced by EPA as off-highway trucks, wheeled loaders, track-type tractors, and motor graders, respectively.

TABLE 2.13 Estimated Facility Construction Air Pollutant Emissions

Pollutant	Emissions[a] (kg/yr)
PM_{10}	32
VOCs	32
CO	135
NO_2	35
SO_2	35

[a] Based on construction equipment and vehicle exhaust emissions.

Source: LLNL (1995b).

The EPA emission factors are established as a rate of air pollutant emission per unit of fuel consumed (that is, vehicle activity) for a specific manufacturer's model type of vehicle and fuel type. Identification of the vehicle and fuel category types expected to be used in site clearing for NIF was based on the site-clearing activity description provided by LLNL (Foley 1995).

2.1.2.1.2 Fugitive PM_{10} Emissions

Because of the high degree of soil disturbance, site clearing would cause the greatest volume of PM_{10} emissions during the construction phase. Thus, annual emissions were estimated for the first year of construction, and site clearing and facility construction were analyzed separately. Emission factors used to develop the PM_{10} emission rates were estimated from a standard reference source (EPA 1995a, hereinafter referred to as AP-42). In addition, some site-specific values for correction parameters (such as silt content of road surface material) used in the emission factor equation were not available, so appropriate mean values for which the emission factor in AP-42 was developed were used wherever possible. Data on the category types and number of construction vehicles were available (Foley 1995), but equipment specification data (such as vehicle model) needed to specifically apply air pollutant emissions factors were not. Therefore, vehicle specification data in the Caterpillar Performance Handbook (Caterpillar 1992) and data for Ford trucks (Nowinski 1993) were used to assign vehicle emission factors for site-clearing activities. Source activity information for facility construction after site clearing was not available, so a single-value fugitive PM_{10} emission factor was used to account for the entire construction activity.

In the first subsection below, PM_{10} emission factors for site clearing are based on specific equipment activity and general facility construction. The second subsection presents a discussion of source activities that are defined to estimate uncontrolled air pollutant emission rates. Finally, dust-control measures and estimates of controlled emission rates are discussed.

Emission Factors

The derivation of air pollutant emission factors for specific construction equipment activities during site clearing and for general facility construction is described in this section. Input parameters assumed in deriving emission factors are also discussed. The derived uncontrolled PM_{10} emission factors used to estimate construction emissions are summarized in Table 2.14.

Water Tankers. Two water tanker trucks would be operating to control fugitive dust on unpaved roads and in areas of earth disturbance and earthmoving. The predictive emission factor equation for travel on unpaved roads was taken from Section 13.2.2 of AP-42. This factor is affected by the silt content of unpaved road aggregate, the characteristics of the vehicle (e.g., speed, weight, number of wheels), and the number of dry days per year. For this analysis, a silt content of 12% (representative of a typical rural dirt road) was used in the emission factor algorithm. A 10-wheel truck with an average weight of 18.1 t (20 tons) was assumed to be operated at a speed of 8 km/h (5 mph). It was also assumed that the trucks could be represented by the Ford 7.6/9.2-m^3 (10/12-yd^3) dump truck (Nowinski 1993), which corresponds to a truck with a water tank capacity of about 22,700 L (6,000 gal). The number of days with at least 0.3 cm (0.01 in.) of

TABLE 2.14 Uncontrolled PM_{10} Emission Factors Used to Develop Construction Emission Estimates

Construction Phase	Equipment Category	Equipment Model[a]	Emission Factor	Emission Factor Unit	AP-42 Reference[b]
Site clearing	Water tanker	Ford 7.6/9.2 m^3 dump truck	0.50-0.56[c]	kg/VKT[d]	Section 13.2.2
	Grader	CAT 12G	0.43	kg/VKT	Section 11.9
	Bulldozer	CAT D8	1.09	kg/h	Section 11.9
	Bottom loader/ dump grader	CAT 980F	0.38-0.43[e]	kg/VKT	Section 13.2.2
Facility construction	Various[f]	Various[f]	0.97	t/ha-mo	Section 13.2.3

[a] Based on manufacturer's fuel requirement data for assumed equipment models (Foley 1995). CAT is a product of Caterpillar Company (Caterpillar 1992), and Ford is a product of Ford Motor Company (Nowinski 1993).

[b] EPA (1995a).

[c] Due to climatic correction factors (such as number of precipitation days per year), emission factor varies by site: 0.50 for LANL and SNL, 0.52 for LLNL, and 0.56 for NTS and NLVF.

[d] VKT = vehicle-kilometers traveled.

[e] Due to climatic correction factor (such as number of precipitation days per year), emission factor varies by site: 0.38 for LANL and SNL, 0.39 for LLNL, and 0.43 for NTS and NLVF.

[f] A number of different types of construction equipment would be involved in this phase.

precipitation per year was assumed to be 51 for LLNL, 26 for NTS and NLVF, and 61 for SNL and LANL (Bair 1992). The significance of this factor is that no PM_{10} emissions would occur on precipitation days.

Graders. Grading would be conducted to level the construction site and to maintain unpaved roads. The predictive emission factor algorithm for grading was taken from Section 11.9 of AP-42. The only variable for this emission factor is the mean grader speed. A value of 11.4 km/h (7.1 mph), a geometric mean value for which the emission factor was developed, was assumed for this analysis.

Bulldozers. Bulldozers would be used to excavate soils and to transfer materials to piles accessible to front-end loaders and trucks at the site. The predictive emission factor algorithm for bulldozer operations is contained in Section 11.9 of AP-42 and is dependent on the silt and moisture content of materials being handled. The average values for overburden silt and moisture content given in Section 11.9 of AP-42 are 6.9% and 7.9%, respectively. In addition, for exposed topsoil,

the average values for silt and moisture content are given as 15% and 3.4%, respectively, in Section 13.2.4 of AP-42. Because bulldozing disturbs both topsoil and subsurface material, the overall averages of 11% and 5.7% for silt and moisture contents of both soil types were used.

Bottom Loaders/Dump Graders. Because no emission factors specific for bottom loaders/dump graders were available, the assumption was made that the emissions from material-moving activities of those vehicles could, for purposes of this analysis, be represented by use of front-end loaders and that the predictive emission factor equation in Section 13.2.2 of AP-42 for travel on unpaved surfaces would be appropriate for these activities. To estimate emissions, four-wheeled front-end loaders with an average weight of 27.2 t (30 tons) were assumed to be operated on unpaved surfaces at a speed of 8 km/h (5 mph), which is the conventional operating speed for this type of vehicle in service. The silt content of the unpaved surfaces on which the vehicles would be working was assumed to be 11% (the same as for bulldozers).

Facility Construction. The quantity of fugitive dust emissions from construction operations would be proportional to the area being actively worked and to the level of construction activity. One particulate emission factor cited in Section 11.2.3 of AP-42 is 2.7 t of emissions per hectare (1.2 tons/acre) of construction per month of activity (based on a particle size of less than 30 μm Stokes' diameter [see the glossary of the PSA]). This value is most applicable to construction operations with (1) medium activity level, (2) moderate silt content, and (3) semiarid climate. The emission factor for PM_{10} is assumed to be 0.97 t/ha•mo (0.43 ton/acre•mo) on the basis of the ratio of 0.36 of PM_{10} to particles of less than 30 μm Stokes' diameter. This estimate is based on ratios of 0.36 for unpaved roads in Section 13.2.2 of AP-42 and 0.35 for aggregate handling and storage piles in Section 13.2.4 of AP-42.

Source Activities

The use of source activity data makes it possible to convert estimated emission factors to uncontrolled emission rates. Source activity for site clearing is based on maximum fuel consumption data (Foley 1995) and fuel consumption rates for heavy equipment models given in the *Caterpillar Performance Handbook* (Caterpillar 1992) and for Ford trucks given by Nowinski (1993). For this analysis, it was assumed that all the heavy equipment would operate 8 hours each day. Source activities for water tankers, graders, and bottom loaders/dump graders are expressed in terms of vehicle-kilometers traveled (VKT), while source activities for bulldozers are given in terms of hours of operation.

Source activity for facility construction is expressed as the product of the area being worked and months of activity. Total site areas cleared and number of months needed for site clearing and facility construction are listed in Table 2.9. It was conservatively assumed that only one-fourth of

each site's total construction area would be disturbed in any month during the facility construction period.

Dust-Control Measures

Measures to control fugitive dust emissions were evaluated to address compliance with air quality standards and regulations and to identify activities to which controls could be applied to minimize potential exposure of the off-site general public to respirable (PM_{10}) particulates. The conventional dust-control measure expected to be used at the NIF location during the construction period would be water spraying.

Use of dedicated trucks for spraying water twice daily as a conventional control measure at areas of active excavation and grading was assumed to provide a dust-control efficiency of 50% (EPA 1989). Control measures for unpaved roads are well documented. In this analysis, a 60% average control efficiency was assumed on the basis of a traffic volume of 20 vehicles per hour and a water spray application rate of 0.5 L/m^2 (0.11 gal/yd^2) every two hours.

Additional control measures could be implemented if a higher control efficiency were needed. Continuous spraying of an active work area with water containing a surfactant provides a conservative control efficiency of 75% (Muleski 1995). Along with water spraying, petroleum resin or calcium-based dust suppressants could also be applied to on-site roads and roads near the site boundary where heavy traffic is expected. Depending on the application intensity and frequency of water spray with calcium-based suppressants, a control efficiency of more than 90% could be achieved (Nalco Chemical Company 1987). The use of petroleum resin on unpaved roads provides a control efficiency of more than 90%, but that material is banned in ozone non-attainment and maintenance areas because of its VOC content.

Emission Inventories

Annual fugitive PM_{10} emissions were estimated for the first year of construction activities. Included were separate estimates for site clearing and post-site-clearing emissions from facility construction. Estimated annual PM_{10} fugitive dust emissions associated with construction activities at NIF candidate sites are presented in Table 2.15.

TABLE 2.15 Estimated Annual PM_{10} Fugitive Dust Emissions Associated with Construction Activities at National Ignition Facility Candidate Sites

Site	Construction Phase	Equipment Category	Uncontrolled Emission Factor	Activity[a]	Emissions (t/yr)	
					Uncontrolled	Controlled[b]
LLNL	Site clearing	Water tanker	0.52 kg/VKT[c]	3,862 km	2.0	0.8
		Grader	0.43 kg/VKT	5,488 km	2.4	1.2
		Bulldozer	1.09 kg/h	480 h	0.5	0.3
		Bottom loader/ dump grader	0.39 kg/VKT	7,725 km	3.1	1.5
		Subtotal			8.0	3.8
	Facility construction	—[d]	0.97 t/ha·mo	20.6 ha/mo	19.9	10.0
	Total				27.9	13.8
LANL	Site clearing	Water tanker	0.50 kg/VKT	2,060 km	1.0	0.4
		Grader	0.43 kg/VKT	2,929 km	1.3	0.6
		Bulldozer	1.09 kg/h	256 h	0.3	0.1
		Bottom loader/ dump grader	0.38 kg/VKT	4,120 km	1.6	0.8
		Subtotal			4.2	1.9
	Facility construction	—[d]	0.97 t/ha·mo	11.6 ha/mo	11.2	5.6
	Total				15.4	7.5
NTS	Site clearing	Water tanker	0.56 kg/VKT	9,399 km	5.3	2.1
		Grader	0.43 kg/VKT	13,341 km	5.8	2.9
		Bulldozer	1.09 kg/h	1,168 h	1.3	0.6
		Bottom loader/ dump grader	0.43 kg/VKT	18,797 km	8.0	4.0
		Subtotal			20.4	9.6
	Facility construction	—[d]	0.97 t/ha·mo	43.5 ha/mo	42.2	21.1
	Total				62.6	30.7
NLVF	Site clearing	Water tanker	0.56 kg/VKT	1,674 km	0.9	0.4
		Grader	0.43 kg/VKT	2,382 km	1.0	0.5
		Bulldozer	1.09 kg/h	208 h	0.2	0.1
		Bottom loader/ dump grader	0.43 kg/VKT	3,347 km	1.4	0.7
		Subtotal			3.5	1.7
	Facility construction	—[d]	0.97 t/ha·mo	9.5 ha/mo	9.2	4.6
	Total				12.7	6.3

TABLE 2.15 (Cont.)

Site	Construction Phase	Equipment Category	Uncontrolled Emission Factor	Activity[a]	Emissions (t/yr)	
					Uncontrolled	Controlled[b]
SNL	Site clearing	Water tanker	0.50 kg/VKT	5,021 km	2.5	1.0
		Grader	0.43 kg/VKT	7,129 km	3.1	1.5
		Bulldozer	1.09 kg/h	624 h	0.7	0.3
		Bottom loader/ dump grader	0.38 kg/VKT	10,042 km	3.8	1.9
		Subtotal			10.1	4.7
	Facility construction	—[d]	0.97 t/ha•mo	26.0 ha/mo	25.2	12.6
	Total				35.3	17.3

[a] Construction activities are assumed to occur 8 hours per day. The values for distance (km) traveled by equipment or hours of operation are for the total site clearing activity. It is also assumed that one-fourth of the site clearing area would be disturbed or remain disturbed in any month during the facility construction period.

[b] Conventional dust-control measures are assumed, such as 50% control for excavation area and 60% for traffic on unpaved road (see text).

[c] VKT = vehicle-kilometers traveled.

[d] A number of different types of construction equipment would be involved in this phase.

2.1.2.1.3 Air Quality Modeling Analysis for Site-Clearing Activities

Air Quality Model and Input Parameters

As shown in Table 2.15 and discussed in Section 2.1.2.1.2, PM_{10} emission rates for site clearing at LLNL were estimated to be 3.8 t/month (4.2 tons/month) and 1.7 t/month (1.9 tons/month) with conventional and additional dust control measures, respectively. The controlled emission rate for facility construction was estimated to be 0.9 t/month (1.0 ton/month). Emission rates during the relatively short site–clearing period, which would involve significant soil disturbance, would be much higher. Over the short term, unfavorable meteorological conditions (low wind speed, persistent wind direction, and/or stable atmosphere) could cause high PM_{10} concentrations at areas accessible to the general public. However, over the long term, winds shift in all directions, thus minimizing PM_{10} concentrations at any fixed receptor locations. Therefore, only short-term (24-hour) air quality impacts resulting from site clearing were analyzed.

Selection of an appropriate model to assess 24-hour air quality impacts from fugitive dust PM_{10} sources was based on U.S. Environmental Protection Agency (EPA) guidance (EPA 1993). For this analysis, the most appropriate EPA model meeting EPA criteria was determined to be the Industrial Source Complex Short Term Model (ISCST2) (EPA 1992a,b), a steady-state Gaussian plume dispersion model. The ISCST2 model is limited in its effectiveness for considering the effects

of uneven terrain; its application is restricted to areas of simple or flat terrain. In general, emissions from area sources are assumed to be of neutral buoyancy. Different from stack emission sources, plume phenomena such as downwash and impact on elevated terrain features are not considered relevant for modeling area sources. Moreover, ground-level, neutral-buoyant area sources follow terrain features along with the wind. For this modeling analysis, the following assumptions were made:

- All candidate sites are classified as being in a predominantly "rural" setting, except for the NLVF site, which is classified as "urban."
- Construction activities would occur during one daytime 8-hour shift each day.
- General areas between the construction site and receptor locations of interest are in flat terrain.
- Dust emissions would be released from the site-clearing area at a constant spatial and temporal emission rate.
- All PM_{10} particles are assumed to stay airborne in the modeling domain; that is, gravitational settling and removal by dry deposition are assumed negligible and not evaluated.
- Receptor locations are placed at the site boundaries or roads accessible to the general public.

Meteorological Data Summary

Meteorological conditions most representative of each candidate site were selected to model PM_{10} fugitive dust emissions from site clearing. For LLNL, 1994 on-site surface meteorological data were used, and a constant mixing height of 600 m (1,970 ft) was assumed throughout the year (LLNL 1995a). For LANL, 1994 on-site surface meteorological data were used, and seasonal average morning mixing height data for Albuquerque, New Mexico (Holzworth 1972), were assumed throughout the corresponding months (LANL 1995). For NTS, surface meteorological data and mixing height data from the nearby Desert Rock National Weather Service station for 1987-1991 were used (EPA 1995b). For NLVF, surface meteorological data from Las Vegas/McCarran International Airport and mixing height data from Desert Rock, Nevada, for 1987-1991 were used (EPA 1995b). For SNL, surface meteorological data and mixing height data from nearby Albuquerque International Airport for 1987-1991 were used (EPA 1995b).

Results and Discussion

Air quality modeling analysis was conducted to determine potential impacts on ambient air quality from site clearing. In the following subsections, the results are compared with ambient air quality standards for the five NIF candidate sites. More detailed site-specific air quality information is presented in Section 2.11 of this document and Chapter I.4 of the NIF PSA (Appendix I of DOE 1996).

Lawrence Livermore National Laboratory. The national and state 24-hour PM_{10} standards are 150 and 50 $\mu g/m^3$, respectively. The maximum 24-hour average PM_{10} background concentration of 84 $\mu g/m^3$ in the LLNL area is already above the state ambient air quality standard (SAAQS) of 50 $\mu g/m^3$. Accordingly, site clearing should be conducted so as to minimize further impacts on ambient air quality. With conventional dust control (water spray twice per day that results in a 50% control for excavation and water spray every two hours that results in a 60% control for traffic on unpaved roads), a maximum 24-hour average PM_{10} concentration of 104 $\mu g/m^3$ over background is predicted at the site boundary (about 350 m [1,150 ft] east of the proposed NIF location).

Operation with additional dust control measures that involve continuous water spraying and/or use of a chemical dust suppressant would reduce PM_{10} dust emissions from site clearing 75% and PM_{10} emissions from traffic on unpaved roads by 90%. These measures would bring maximum 24-hour PM_{10} concentrations down to 46 $\mu g/m^3$ over the background concentration. Including background concentration, maximum 24-hour concentrations would still be higher than the SAAQS for PM_{10}. Ambient air quality impacts associated with site clearing would be limited to the area just outside the site boundary, which the general public is expected to occupy infrequently. Site clearing at LLNL would be expected to last for only a month, so ambient air quality impacts associated with those activities would be local and temporary.

Determination of air quality impacts of construction fugitive dust (PM_{10}) emissions would normally not be required by BAAQMD as part of permitting process. Modeling estimates that predict violations of the SAAQS for PM_{10} would, under review by the BAAQMD, probably require that only dust control mitigation procedures be implemented during construction (DeBoisblance 1995).

Los Alamos National Laboratory. The maximum 24-hour average PM_{10} background concentration representative of the LANL site is 30 $\mu g/m^3$. With conventional dust control (water spray twice a day that results in 50% control for excavation and water spray every two hours that results in a 60% control for traffic on unpaved roads), maximum 24-hour average PM_{10} concentrations of 94 $\mu g/m^3$ over background are predicted at the public access road (West Jemez Road, which runs north of the NIF location at the closest site boundary distance of 460 m [1,500 ft]

from the proposed NIF location). The maximum PM_{10} concentration of 124 $\mu g/m^3$, including background concentration, would be below the 24-hour national standard of 150 $\mu g/m^3$ for PM_{10}. Site clearing at LANL would be expected to last for half a month, so ambient air quality impacts associated with site clearing would be minor, local, and temporary.

Nevada Test Site. The maximum 24-hour average PM_{10} background concentration representative of the NTS site is 173 $\mu g/m^3$, which exceeds the national and state standard of 150 $\mu g/m^3$. This situation is caused by arid soil conditions typical of the region. Therefore, site clearing should be carried out so as to minimize additional impacts on ambient air quality. With conventional dust control (water spray twice a day that results in 50% control for excavation and water spray every two hours that results in a 60% control for traffic on unpaved roads), maximum 24-hour average PM_{10} concentrations of 2 $\mu g/m^3$ over background are predicted at the site boundary. This value is very small because the site boundary would be a considerable distance from the site-clearing activity at the NIF location (approximately 4.5 km [2.8 mi] east of the proposed NIF location). The predicted maximum PM_{10} concentration increase of 2 $\mu g/m^3$ at the site boundary is only 1.1% and 1.3% of the background concentration and the national standard, respectively. Site clearing at NTS would be expected to last for two and a half months, so ambient air quality impacts associated with site clearing would be local and temporary.

North Las Vegas Facility. The maximum 24-hour average PM_{10} background concentration representative of the NLVF site is 114 $\mu g/m^3$, while both the national and state standards are 150 $\mu g/m^3$. This high ambient concentration is a result of arid soil conditions typical of the region. Accordingly, site clearing should be carried out so as to minimize the impact on ambient air quality. With conventional dust control, a predicted maximum 24-hour average PM_{10} concentration of 270 $\mu g/m^3$ (156 $\mu g/m^3$ over the maximum background level of 114 $\mu g/m^3$) would result at the site boundary (10 m [32 ft] north of the proposed NIF location). This concentration would be above the national and state standards for PM_{10}.

Operation with additional dust control measures that involve continuous water spray and/or use of chemical dust suppressant would reduce dust emissions from site clearing by 75% and from traffic on unpaved roads by 90%. These measures would bring the maximum 24-hour average concentrations down to 183 $\mu g/m^3$ (69 $\mu g/m^3$ over the background concentration). This concentration would still be higher than the national and state standard for PM_{10}. Thus, other approaches (such as reduction of activity or use of intensified dust control measures) would be needed to comply with the national and state standard for PM_{10}. For example, by reducing the workload by half (which would increase the site-clearing period to one month), the maximum PM_{10} concentration, including background concentration, would be 149 $\mu g/m^3$. This concentration would comply with the national and state 24-hour standard for PM_{10}. In either case, site clearing at NLVF would be expected to last

for a month or less, so ambient air quality impacts associated with site clearing would be local and temporary.

Sandia National Laboratories. The maximum 24-hour average PM_{10} background concentration representative of the SNL site is 40 $\mu g/m^3$. With conventional dust control, a maximum 24-hour average PM_{10} concentration of 52 $\mu g/m^3$ (12 $\mu g/m^3$ over background) is predicted at the closest site boundary (1.0 km [0.6 mi] north-northeast of the NIF location). This concentration would be considerably below the national standard of 150 $\mu g/m^3$ for PM_{10}. Site clearing at SNL would be expected to last over a month, so ambient air quality impacts associated with site clearing would be negligible, local, and temporary.

2.1.2.2 Operating Air Pollutant Emissions

2.1.2.2.1 Emission Sources and Levels

Air pollutant emissions from NIF operation would consist primarily of exhaust released during fossil fuel combustion and volatile organic compounds (VOCs) that, more significantly, would be emitted as vapors during use of solvents as cleaning agents. Ethanol would be the primary VOC solvent expected to be used (LLNL 1995b). Fossil fuel would be burned in external combustion equipment producing space heat and hot water for the buildings included in the NIF complex and in performing maintenance runs of stationary internal combustion engines used to power stand-by electric generators.

External combustion units, commonly referred to as boilers, are used to produce space heat and hot water. All candidate sites except the NTS would use natural gas as the fuel of choice to meet the space heat and hot water demands for the NIF complex (LLNL 1995b). NTS has reported that liquefied petroleum gas (LPG) would be used there (White 1995b). Stationary internal combustion engines used as prime-movers for stand-by electric generators would burn diesel fuel (LLNL 1995b).

The annual operating air pollutant emissions for each of the NIF candidate sites are summarized in Table 2.16 (see also DOE 1996, Appendix I, Sections I.4.1.2.2.1, I.4.2.2.2.1, I.4.3.2.2.1, I.4.4.2.2.1, and I.4.5.2.2.1). Air pollutant combustion emissions were estimated by application of EPA air pollutant emission factors to the design energy demand (LLNL 1995b) tailored to each specific site's proposal for new building construction for the NIF project. Aside from a small amount of fossil fuel combustion, VOC emission estimates are based on evaporative emissions (primarily ethanol — see Section 4, Tables 4.6 and 4.7) from estimated solvent use for component cleaning at the Laser and Target Area Building and the Optics Assembly Area. Estimated

TABLE 2.16 Total National Ignition Facility Estimated Operating Emissions at Candidate Sites[a]

Pollutant	Laser and Target Area Building Emissions (t/yr)		Support Facility Emissions (t/yr)		Total Emissions (t/yr)
	Combustion[b]	Other[c]	Combustion[b]	Other[c]	
LLNL					
PM_{10}	0.128	—[d]	0.035	—	0.163
VOCs	0.027	0.125	0.038	0.375	0.565
CO	0.327	—	0.111	—	0.438
NO_2	1.309	—	0.481	—	1.790
SO_2	0.007	—	0.027	—	0.034
Lead[e]	—	—	—	—	—
LANL					
PM_{10}	0.128	—	0.047	—	0.175
VOCs	0.027	0.125	0.041	0.375	0.568
CO	0.327	—	0.147	—	0.474
NO_2	1.309	—	0.604	—	1.913
SO_2	0.007	—	0.028	—	0.035
Lead[e]	—	—	—	—	—
NTS					
PM_{10}	0.065	—	0.011	—	0.076
VOCs	0.050	0.125	0.009	0.375	0.559
CO	0.318	—	0.056	—	0.374
NO_2	1.883	—	0.331	—	2.214
SO_2	0.004	—	<0.001	—	0.004
Lead[e]	—	—	—	—	—
NLVF					
PM_{10}	0.128	—	0.083	—	0.211
VOCs	0.027	0.125	0.047	0.375	0.574
CO	0.327	—	0.234	—	0.561
NO_2	1.309	—	0.973	—	2.282
SO_2	0.007	—	0.030	—	0.037
Lead[e]	—	—	—	—	—

TABLE 2.16 (Cont.)

Pollutant	Laser and Target Area Building Emissions (t/yr)		Support Facility Emissions (t/yr)		Total Emissions (t/yr)
	Combustion[b]	Other[c]	Combustion[b]	Other[c]	
SNL					
PM_{10}	0.128	—	0.070	—	0.198
VOCs	0.027	0.125	0.045	0.375	0.572
CO	0.327	—	0.201	—	0.528
NO_2	1.309	—	0.839	—	2.148
SO_2	0.007	—	0.029	—	0.036
Lead[e]	—	—	—	—	—

[a] Air pollutant emission estimates (metric tons [t] [1,000 kg] per year) based on design annual energy use requirements (LLNL 1995b), adjusted to reflect new support building construction energy demand only, using fuel-specific air pollutant emission factors (EPA 1995a).

[b] Emission factors selected to represent emissions from gas-fired external combustion units rated at from 10,560 to 105,600 MJ/h, assuming no pollutant controls and stationary internal combustion engines burning diesel fuel.

[c] VOC (primarily ethanol) emissions from solvent cleaning (LLNL 1995b).

[d] — = Not applicable.

[e] No emission factor cited; assumed negligible.

VOC emissions are 500 kg/yr (1,102 lb/yr) (125 kg/yr [276 lb/yr] at the Laser and Target Area Building and 375 kg/yr [827 lb/yr] at the Optics Assembly Area) (LLNL 1995b).

Table 2.16 summarizes air pollutant emissions from (1) combustion of fossil fuel for space heat and hot water energy demand and for operation of prime mover stand-by generators, and (2) release of VOCs from use of solvents. Air pollutant emissions are summarized separately for the Laser and Target Area Building, which would have to be constructed at all of the candidate sites, and for all other new buildings required to support NIF operations. Construction of the additional buildings to support NIF would vary among sites, since some existing buildings would be used to support NIF at all sites (see Section 2.1.2.2.3).

The annual operating air pollutant emissions listed in Table 2.16 for NIF are significantly below the annual emission levels that would require a determination that a federal action conforms

to a state implementation plan to attain and maintain air quality (40 CFR 6, 51, and 93). For federal actions, a conformity determination is required for each pollutant where the total of direct and indirect emissions in a non-attainment or maintenance area caused by a federal action would equal or exceed certain limits (40 CFR 51.853 or 93.153). The annual air pollutant emission limits that would initiate the need for ("trigger") a conformity analysis are listed in Tables 2.17 and 2.18 (see Appendix I, Section I.5.2, DOE 1996, for discussion).

The air pollutant emission triggering levels listed in Tables 2.17 and 2.18 indicate that the lowest annual emission level that triggers a conformity analysis is a federal action that causes an emission of 9 t/yr (10 tons/yr) of VOCs or NO_2 in an extreme non-attainment area (Table 2.17). All the other annual air pollutant triggering emission levels range from 23 to 91 t/yr (25 to 100 tons/yr). Comparison of summary operating emissions data in Table 2.16 with emission triggering levels in Tables 2.17 and 2.18 indicates that estimated NO_2 and VOC emissions for all sites are well below the 9-t/yr (10-ton/yr) triggering level, and none of the proposed NIF sites is in an extreme non-attainment area for O_3 (see Section 2.1 of this document and Sections I.4.1.1.2.2, I.4.2.1.2.2, I.4.3.1.2.2, I.4.4.1.2.2, and I.4.5.1.2.2 of Appendix I, DOE 1996). Among all sites, the maximum estimated NIF annual operating emission of any air pollutant is less than 3 t/yr (3.3 tons/yr), compared with the lowest air emission triggering level of 23 t/y (25 tons/yr) that could apply to any of the sites. Ambient air quality impacts of operating emissions were not analyzed by dispersion modeling because these estimated operating emissions are so low. Also, climate variations among sites that would affect space heat energy demand were not evaluated because operating emissions from heating equipment would be so low.

2.1.2.2.2 Operating Air Pollutant Emission Factors

No external or internal combustion source is 100% efficient. The incomplete combustion of fossil fuels to water vapor and carbon dioxide (CO_2) results in the emission of air pollutants. The EPA has developed an air pollutant emission factor manual that provides estimates of air pollutant emissions from a number of sources, including external and internal combustion units. That manual, commonly referred to as AP-42 (EPA 1995a), is often used by state and local regulatory agencies in the permitting process to determine source compliance with air pollutant regulations in lieu of requiring a stack test.

Annual air pollutant operating emissions from fossil fuel combustion depend on fuel types and quantities of fuel burned during the year. For this NIF analysis, the annual quantity of fuel expected to be burned to produce space heat and hot water was determined from the design energy demand or quantity of fuel required, as indicated in Table 2.19 for the NIF Laser and Target Area Building and Table 2.20 for site-specific new support building construction. The annual quantity of

TABLE 2.17 Non-Attainment Area Federal Facility Emission Limits Requiring Conformity Determination

Pollutant/Attainment Status	Emission Limit (tons/yr)[a]
Ozone (VOC and NO_2) serious non-attainment	50
Ozone (VOC and NO_2) severe non-attainment	25
Ozone (VOC and NO_2) extreme non-attainment	10
Other ozone non-attainment outside an ozone transport region	100
Marginal and moderate non-attainment inside an ozone transport region for VOCs	50
Marginal and moderate non-attainment inside an ozone transport region for nitrogen oxides (NO_x)	100
Marginal and moderate non-attainment inside an ozone transport region for VOCs	50
CO for all non-attainment areas	100
SO_2 or NO_2 for all non-attainment areas	100
PM_{10} for moderate non-attainment areas	100
PM_{10} for serious non-attainment areas	70
Lead for all non-attainment areas	25

[a] To determine metric tons per year (t/yr), multiply by 0.90718.

Source: 40 CFR 6, 51, and 93.

TABLE 2.18 Maintenance Area Federal Facility Emission Limits Requiring Conformity Determination

Pollutant/Attainment Status	Emission Limit (tons/yr)[a]
Ozone (NO_x, SO_2, or NO_2) for all maintenance areas	100
Ozone (VOCs) for maintenance areas inside an ozone transport region	50
Ozone (VOCs) for maintenance areas outside an ozone transport region	100
Carbon monoxide for all maintenance areas	100
PM_{10} for maintenance areas	100
Lead for all maintenance areas	25

[a] To determine metric tons per year (t/yr), multiply by 0.90718.

Source: 40 CFR 6, 51, and 93.

TABLE 2.19 Estimated Design Annual Energy Requirements for the National Ignition Facility

Facility	Use	Fuel Type	Annual Fuel Consumption
NIF Laser and Target Area Building	Space heat	Natural gas or LPG	21.075×10^6 MJ
	Domestic hot water	Natural gas or LPG	311×10^3 MJ
	Prime mover for stand-by electric generator	Diesel	320 L
NIF support facilities[a]	Space heat and hot water	Natural gas or LPG	19.5×10^6 MJ
	Prime mover for stand-by electric generator	Diesel	5,500 L

[a] Design energy demand estimate for full complement of NIF support building complex.

Sources: LLNL (1995b); White (1995b).

TABLE 2.20 Site-Specific Energy Demand for New Support Buildings

Site	Total Area of New Support Building Construction (m^2)	Energy Demand Scale Factor[a] (dimensionless)	New Support Building Energy Demand (10^6 MJ/yr)
LLNL	1,858	0.07	1.37
LANL	4,645	0.174	3.39
NTS	5,341	0.201	3.91
NLVF	13,133	0.491	9.57
SNL	9,988	0.376	7.33

[a] The energy demand scale factor is the ratio of new construction building area size (m^2) to the sum of support building complex design area sizes (26,722 m^2) applied to the total support building complex design energy demand of 19,500,000 MJ/yr.

diesel fuel consumed by stand-by generators for both the NIF Laser and Target Area Building and support buildings is listed in Table 2.19. Quantities of annual air pollutant emissions were estimated by multiplying the air pollutant emission factors (EPA 1995a) by the amount of fuel expected to be burned. The EPA fossil fuel air pollutant emission factors are keyed to the amount of fuel used either in terms of fuel unit energy content or volume. The EPA emission factors used to compute fossil fuel combustion emissions in this analysis are identified in Table 2.21.

Table 2.21 lists air pollutant emission factors for external combustion units (boilers) burning natural gas. These emission factors are a function of boiler size, which is determined by the boiler rated heat input. The emission factors cited in Table 2.21 cover a very broad range of boiler sizes, from 10,560 MJ/h to 105,600 MJ/h (1×10^7 to 1×10^8 Btu/h). On the basis of the anticipated NIF space heat and hot water energy demand, this range should be sufficient to encompass the size

TABLE 2.21 Air Pollutant Emission Factors for External Combustion Units Burning Natural Gas or LPG and for Stationary Internal Combustion Engines

	Natural-Gas-Fired Boiler[a]		LPG (propane)-Fired Boiler[b]		Uncontrolled Stationary Diesel Internal Combustion Engines
Pollutant	Emission Factor ($kg/10^6 m^3$)	Emission Factor[c] (mg/MJ)	Emission Factor ($g/10^3$ L)	Emission Factor[d] (mg/MJ)	Emission Factor[e] (g/MJ)
PM_{10}	106.5[f]	2.85	70	2.67	0.135
VOCs	44.2	1.18	60	2.29	0.155[g]
CO	560	14.98	400	15.25	0.41
NO_2	2,240	59.91	2,300	8.77	1.896
SO_2	9.6	0.026	2[h]	0.763[h]	0.126

[a] Boilers with a rated heat input ranging from 10,560 to 105,600 MJ/h.

[b] Boilers with a rated heat input ranging from 3 to 29 MW using propane fuel.

[c] Based on an average natural gas higher heating value of 37.43 MJ/m^3.

[d] Based on an average propane heating value of 26.23 MJ/L (94,000 Btu/gal).

[e] Energy content of fuel input based on an average heat content of 38.23 MJ/L (137,000 Btu/gal).

[f] Includes both filterable and condensable PM_{10}.

[g] Includes exhaust, evaporative, crankcase, and refueling emissions.

[h] Based on 0.41 mg sulfur/m^3 (0.18 grain/100 ft^3).

Source: EPA (1995a).

range of boilers serving newly constructed NIF buildings. The natural gas emission factors are established as a mass (kg) of pollutant emitted per unit of gas volume (m^3). To apply the emission factor to the fuel combustion energy demand listed in Tables 2.19 and 2.20, a conversion factor is introduced to convert emissions from a fuel volume basis (m^3) to an energy basis (MJ). The conversion factor is an assumed heat content for gas of 37.43 MJ/m^3 (1,000 Btu/ft^3) (EPA 1995a). This heat content assumption is valid because natural gas (methane) contains little impurities and, therefore, has a fairly constant heat content throughout the United States. The inclusion of both filterable and condensable PM_{10} refers to the sampling procedure used by EPA to develop the PM_{10} factors that are reported separately as "dry" and "condensable" catch in the sampling train.

Table 2.21 lists air pollutant emission factors for external combustion units (boilers) burning LPG (propane). The emission factors are a function of boiler size. The emission factors cited in Table 2.21 cover a very broad boiler size range of from 3 to 29 MW. Again, this range should be sufficient to include any boilers expected to be used for newly constructed NIF buildings (see Tables 2.19 and 2.20). NTS is the only candidate site indicating that LPG would be used to meet NIF energy demands (White 1995a). The LPG emission factors (EPA 1995a) are established as a mass (g) of pollutant emission per unit of LPG (propane) volume (L).

To apply the LPG (propane) emission factor to the fuel combustion energy demand in Tables 2.19 and 2.20 for NTS, a conversion factor was used to convert emissions from a volume basis (L) to an energy basis (MJ). The conversion factor is an assumed heat content of 26.23 MJ/L (94,000 Btu/gal) (EPA 1995a). This factor is judged to be valid because propane contains little impurities and, therefore, has a fairly constant heat content throughout the United States. Emissions of sulfur dioxide (SO_2) are based on an assumed propane sulfur content of 0.41 mg/m^3 (0.18 grain sulfur/100 ft^3) (EPA 1995a).

Table 2.21 lists air pollutant emission factors (EPA 1995a) for stationary internal combustion engines of the size typically used for prime movers to drive standby electric generators. The emission factors cited are for the combustion of diesel fuel, as indicated in Table 2.19. The diesel engine emission factors are established as mass (g) of pollutant emission per unit of energy content (MJ) of diesel fuel input. To apply the air pollutant emission factor to diesel fuel usage (L) requirements in Table 2.19, a conversion factor was introduced to convert emissions from a fuel volume basis to an energy basis. The conversion factor is an assumed average heat content for diesel fuel of 38.23 MJ/L (137,000 Btu/gal) (EPA 1995a).

2.1.2.2.3 Source Operating Activity

Operating air pollutant emission factors are expressed per unit of source activity. NIF air pollutant emission sources would be external combustion (boilers) and stationary internal combustion engines burning fossil fuels. The operating source activity of interest is fulfilling the

energy demand that must be satisfied by burning fossil fuel. The estimates of NIF fossil fuel combustion operating emissions are based on design energy demand requirements for space heat, hot water, and maintenance operation of internal combustion engines used to drive standby electric generators. NIF design energy demand requirements are given in Table 2.19. As indicated in that table, slightly more than half the total space heat and hot water energy demand would be required for the Laser and Target Area Building, and the remainder would be required by the full complement of support buildings. Diesel fuel consumption for maintenance runs to drive standby electric generators reflects stand-by support for individual buildings.

All the facilities required to support NIF operations are identified in Table 2.22 (also see Section I.3.4 of the PSA [Appendix I of DOE 1996]). All sites would require construction of the Laser and Target Area Building; however, none of the sites would need to construct the full complement of support buildings. Only new construction would require additional fuel combustion for space heat and hot water. A conservative assumption is that the required energy demand of standby generators would be required for both existing buildings and new facilities.

Table 2.22 lists the area requirement for each support building. This information was used to adjust the total design support building complex energy demand of 19.5×10^6 MJ to the energy demand required only for the new support buildings that would be constructed at a specific site. For each site, the ratio of the area of new buildings to the sum of the areas for the total support building complex identified in Table 2.22 was used to compute energy demand for new construction at each candidate site. The sum of the design support building complex area in Table 2.22 is 26,722 m^2 (287,643 ft^2). Table 2.20 summarizes the information used to scale design support building energy demand to reflect only new building construction at each site.

At LLNL, for example, the area of new support building construction would be 1,858 m^2 (20,000 ft^2), compared with the design areas of all NIF support buildings of 26,722 m^2 (287,643 ft^2) (Table 2.20). The ratio of LLNL new support building construction area size to the sum of all support building area sizes is, thus, 1,858/26,722, or a scaling factor of 0.07. Multiplying that scaling factor times the total support building design energy demand of 19.5×10^6 MJ/yr (Table 2.19) results in a NIF support building energy demand of 1.37×10^6 MJ/yr for LLNL (Table 2.20). This approach was used for all candidate sites. The new construction support building space heat and hot water energy demand determined for each site, as listed in Table 2.20, was then used to compute air pollutant emissions. The annual energy demand (MJ/yr) was multiplied by the emission factor (grams of pollutant per megajoule) to arrive at projected annual air pollutant emissions.

Detailed site-specific NIF operating emissions based on site-specific energy demand are listed in Tables 2.23 through 2.25. Tables 2.23 and 2.24 show a breakdown of operating emissions for the NIF Laser and Target Area Building. This facility would have to be constructed to design specifications at whatever site was selected for NIF. Therefore, Tables 2.23 and 2.24 are based on the same fossil fuel energy demand indicated in Table 2.19. Table 2.23 lists emissions that would

TABLE 2.22 Facilities Required for National Ignition Facility Operations at Each Candidate Site

Required Facility	Size Required (m^2)	LLNL	LANL	NTS	NLVF	SNL
Laser and Target Area Bldg.	16,722	New facility	New facility TA-58	New facility	New facility	New facility
Target Receiving/Inspection	1,393	B298 ICF Target Development, Receiving, and Inspection	TA-35-213	New facility	C-3 High Intensity Source Laboratory	New facility
Optics Assembly Area	1,858	New facility and B391 High Bay	New facility TA-58	New facility	New facility	New facility
General Assembly Area	2,787	B166 ICF High Bay, B391 High Bay	New facility TA-58	6-800 Heavy Duty Shop (1,866 m^2) 6-624 Heavy Duty Shop (1,187 m^2)	A-1 High Bay	New facility
Optics Maintenance Area	3,716	B391 Nova, B321 Optics Fabrication, B329 ICF R&D and Storage Area, B432 High Bay and Optics Meteorology Area, new facility (same as Optics Assembly Area)	TA-3-287 (upgrade)	New facility	New facility	New facility
Optics Storage Area	2,090	B392, ICF R&D and storage area, B494-381 High Bay	TA-3-105 (upgrade)	New facility	New facility	New facility

TABLE 2.22 (Cont.)

Required Facility	Size Required (m^2)	LLNL	LANL	NTS	NLVF	SNL
Radiological Storage Area	127	B331 Tritium Facility	Existing Facility in TA-54	Building 610 about 3.2 km from NIF location	New facility	Existing facility in TA-III
Office Building	7,432	B481 ICF Office Building	TA-3-40 TA-3-287 TA-3-105 TA-3-100 New facility (1,860 m^2)	23-117 A&E Bldg. (2,104 m^2) 23-600 L.L. & Eng. (3,498 m^2) 23-113 REECo Trn. (962 m^2) 23-112 REECo Safety (889 m^2)	Conversion of B-1 or new facility	New facility and shared space (3,716 m^2) with Buildings 952 and 960 of TA-IV
Electrical and Mechanical Shops	1,115	B511 Maintenance Shop, B383 Machine Shop, B321 Machine Shop	TA-3-39	23-710 Crafts Bldg. (1,919 m^2)	A-1 Low Bay	Building 840 of TA-I
Warehouse	2,787	B041 Warehouse, B531 Warehouse and other on-site storage areas	TA-3-30 TA-3-142	23-W1, W2, W3, W3A (total 2,787 m^2) W4, W4A, W5	A-2 Warehouse	New facility
Shipping, Receiving, and Stores	1,300	B411 Central Stores	TA-3-30	23-W6 (1,300 m^2) W5A, W7	A-2 Warehouse	Building 857 of TA-I
Medical Facility	278	B663 Medical Services	TA-43	23-650 Medical Facility	C-1 Medical Facility	Building 831 of TA-I
Cafeteria	743	T4675 Central Cafeteria	TA-3-261	23-300 Cafeteria	C-1 Cafeteria	Building 861 of TA-I
Garage, Gas Station	223	B611 Garage	TA-3-36	23-750 Fleet Service	Not required on-site	Buildings 873, 874, 875, and 876 of TA-I

TABLE 2.22 (Cont.)

Required Facility	Size Required (m^2)	LLNL	LANL	NTS	NLVF	SNL
Fire Station	650	B323 Fire Station	TA-3-41	23-425 Mercury Fire Station (929 m^2)	Not required on-site	Existing facility at Kirtland Air Force Base
Security and Badge Office	223	B071 West Badge Office B271 Security	TA-3-490	23-1000 Badge Office	C-1 Administrative Security	Building 800 of TA-I

Source: Appendix I, Table 3.4-1, of DOE (1996).

TABLE 2.23 Laser and Target Area Building Estimated Annual Fuel Combustion Emissions with Natural Gas[a]

Pollutant	Natural Gas-Fired External Combustion Emissions[b] (t/yr)		Diesel-Fired Internal Combustion Stand-By-Power Emissions (t/yr)	Total Emissions (t/yr)
	Space Heat	Domestic Hot Water		
PM_{10}	0.124	0.002	0.002	0.128
VOCs	0.025	<0.001	0.002	0.152[c]
CO	0.317	0.005	0.005	0.327
NO_2	1.267	0.019	0.023	1.309
SO_2	0.005	<0.001	0.002	0.007
Lead[d]	Negligible	Negligible	Negligible	Negligible

[a] Air pollutant emission estimates based on siting document design annual energy use requirements (LLNL 1995b) and fuel-specific air pollution emission factors cited in AP-42 (EPA 1995a). Applicable to all sites burning natural gas (LLNL, LANL, NLVF, and SNL).

[b] Emission factors selected to represent emissions from external combustion units rated at from 10,560 to 105,600 MJ/h, assuming no pollutant controls.

[c] Includes 0.125 t/yr VOCs (primarily ethanol) from cleaning with solvents (LLNL 1995b).

[d] No emission factor cited, assumed negligible.

be applicable to all sites that would use natural gas as the fuel of choice for external combustion (boiler) air pollutant emissions (LLNL, LANL, NLVF, and SNL). Table 2.24 lists emissions that would be applicable to NTS, which specified that its fuel of choice for space heat and hot water, based on the Table 2.19 energy demand, is LPG (assumed to be propane) (White 1995b).

Detailed support building operating air pollutant emissions for each site are presented in Table 2.25. Emissions vary among sites on the basis of the number and size of new support buildings that would require space heat and hot water. All external combustion emissions are based on burning natural gas, except for those at NTS Area 22, where LPG would be used.

TABLE 2.24 Laser and Target Area Building Estimated Annual Fuel Combustion Emissions with LPG (Propane)[a]

Pollutant	LPG-Fired External Combustion Emissions (t/yr)		Diesel-Fired Internal Combustion Standby Power Emissions (t/yr)	Total Emissions (t/yr)
	Space Heat	Domestic Hot Water		
PM_{10}	0.058	0.005	0.002	0.065
VOCs	0.048	<0.001	0.002	0.175[b]
CO	0.308	0.005	0.005	0.318
NO_2	1.830	0.030	0.023	1.883
SO_2	0.002	<0.001	0.002	0.004
Lead[c]	Negligible	Negligible	Negligible	Negligible

[a] Air pollutant emission estimates based on siting document design annual energy use requirements (LLNL 1995b) and fuel-specific air pollution emission factors cited in AP-42 (EPA 1995a).

[b] Includes 0.125 t/yr VOCs (primarily ethanol) from cleaning with solvents (LLNL 1995b).

[c] No emission factors cited, assumed negligible.

TABLE 2.25 Estimated Fuel Combustion Emissions with Natural Gas for National Ignition Facility Support Facilities at LLNL, LANL, NLVF, and SNL

Pollutant	Natural Gas Space Heat and Hot Water Emissions[a] (t/yr)	Diesel Internal Combustion Standby Power Emissions (t/yr)	Total Emissions (t/yr)
LLNL[b]			
PM_{10}	0.008	0.027	0.035
VOCs	0.002	0.036	0.413[c]
CO	0.02	0.091	0.111
NO_2	0.082	0.399	0.481
SO_2	<0.001	0.027	0.027
Lead[d]	Negligible	Negligible	Negligible

TABLE 2.25 (Cont.)

Pollutant	Natural Gas Space Heat and Hot Water Emissions[a] (t/yr)	Diesel Internal Combustion Standby Power Emissions (t/yr)	Total Emissions (t/yr)
LANL[b]			
PM_{10}	0.02	0.027	0.047
VOCs	0.005	0.036	0.416[c]
CO	0.056	0.091	0.147
NO_2	0.205	0.399	0.604
SO_2	0.001	0.027	0.028
Lead[d]	Negligible	Negligible	Negligible
NLVF[b]			
PM_{10}	0.056	0.027	0.083
VOCs	0.011	0.036	0.424[c]
CO	0.144	0.091	0.235
NO_2	0.577	0.401	0.978
SO_2	0.003	0.027	0.03
Lead[d]	Negligible	Negligible	Negligible
SNL[b]			
PM_{10}	0.043	0.027	0.07
VOCs	0.009	0.036	0.420[c]
CO	0.110	0.091	0.201
NO_2	0.440	0.399	0.839
SO_2	0.002	0.027	0.029
Lead[d]	Negligible	Negligible	Negligible

[a] Emission factors selected to represent emissions from external combustion units rated from 10,560 to 105,600 MJ/h, assuming no pollutant controls.

[b] Air pollutant emission estimates based on siting document design annual energy use requirements (LLNL 1995b) adjusted to represent new support building construction energy demand for 1,858 m^2 new building area size for LLNL, 4,645 m^2 for LANL, 13,133 m^2 for NLVF, and 9,988 m^2 for SNL. Fuel-specific air pollution emission factors cited in AP-42 (EPA 1995a) were used to compute emissions.

[c] Includes 0.375 t/yr VOCs (primarily ethanol) from cleaning with solvents (LLNL 1995b).

[d] No emission factor cited, assumed negligible.

2.2 ANALYSIS OF ACOUSTICAL IMPACTS

This section provides data supporting impact assessments for acoustics presented in Chapter I.4 of the NIF PSA (Appendix I, DOE 1996). Included below are a description of the analytical methods used, discussion of assumptions used in the analyses, and summaries of the results for each of the candidate NIF sites.

2.2.1 Modified Composite Noise Rating

To evaluate the acoustical impacts from the construction equipment moving around a construction site, one conceptually places each piece of equipment at its most representative spot for a "worst day." Among all the metrics that have been used to represent noise impacts from fixed construction or operational sources, the Modified Composite Noise Rating (Modified CNR) has been commonly accepted by both industry and regulatory bodies (EEI 1984). The Modified CNR approach to noise impact evaluation has the following advantages:

- Provides a single value descriptor of impact;
- Considers the community's experience with noise;
- Considers community attitude toward the source;
- Accounts for existing background sound levels;
- Accounts for the frequency content of both the existing sound level and the added sound;
- Accounts for impulse, tonal, and low-frequency sound; and
- Accounts for duration, time of day, and time of year of the added sound.

The Modified CNR can be used with both short-term and long-term sound exposures, unlike other methods such as the annual average day-night sound level (L_{dn}).

Application of the Modified CNR requires the following information:

- Noise contribution of the new sound sources from the proposed action, as octave-band spectra,
- Octave-band spectra of baseline sound levels,

- Information on community noise experience, and
- Identification of receptors and locations.

Responses to the new noise sources at a given receptor location are evaluated on the basis of composite noise ratings of A through I, as part of the modified CNR method. Levels A through C imply no reaction, and levels higher than C lead to increasing expectation of noise impacts at a given receptor. The calculational model and evaluations are applied at each receptor location separately.

For greatest accuracy of the noise impact determination, it is preferable to use data from site measurements of baseline sound level; however, often such data are not available. Because appropriate data must be obtained over a long period and be representative of various times of day, days of the week, and seasons, they cannot be obtained by direct measurement in timely fashion. Alternative sources of baseline data include results of measurements at similar locations or analyses of databases containing results of measurements at many locations at various times.

For this analysis, measured data from representative noise sources were used. Selection of some baseline spectra was based on L_{dn} information from Tables 2.26 and 2.27. The appropriate spectrum was selected from various sources of measured data. The selection process consisted of choosing an L_{dn}, then selecting the most appropriate spectrum. The L_{dn} measure accounts for temporal difference in human response to noise, with nighttime noise considered more "annoying" than daytime noise of the same absolute magnitude. When the L_{dn} value is computed, a 10-dB "penalty" is added to the average nighttime noise level to account for this factor. Thus, in the case when the average nighttime sound level is 10 dB less than the average daytime level, the Ld_n value will be the average daytime level. For this analysis, if a spectrum was found that was appropriate from the standpoint of the type of environment represented, but was not consistent with the appropriate L_{dn} value, the spectrum was adjusted uniformly to correspond to the desired A-weighted level.

TABLE 2.26 Estimated Percentage of Urban Population[a] Residing in Areas with Various Day-Night Noise Levels (L_{dn})

Description	L_{dn} (dB) Typical Range	L_{dn} (dB) Average Estimated	Estimated Percentage of Urban Population	Average Census Tract Population (number/km^2)
Quiet suburban residential	48-52	50	12	243
Normal suburban	53-57	55	21	772
Urban residential	58-62	60	28	2,432
Noisy urban residential	63-67	65	19	7,720
Very noisy urban residential	68-72	70	7	24,318

[a] Total urban population is 134 million.

Source: EPA (1974).

TABLE 2.27 Typical Yearly Day-Night Average Sound Levels (L_{dn}) for Neighborhoods with No Well-Defined Source of Noise other than Usual Transportation Noise

Neighborhood Type	Population Density (people/km^2)	L_{dn} (dB)
Rural		
Undeveloped	8	35
Partially developed	23	40
Quiet suburban	77	45
Normal suburban	240	50
Urban	770	55
Noisy urban	2,300	60
Very noisy urban	7,700	65

Adapted from National Research Council (1971).

Octave-band spectra of the sound levels expected at various receptor locations were computed using the modified CNR method that incorporates evaluation of the dispersion of sound by propagation over distance and attenuation of sound by interaction with the air. Insufficient data were available to justify use of a more sophisticated model that would evaluate the effect of barriers, absorption of sound by the ground surface, and atmospheric effects. Omitting these factors is not expected to substantially change the comparative evaluation of the five candidate NIF sites.

Source terms used in the spreadsheet model include (1) sound power of equipment, (2) sound propagation path length based on representative location of equipment, and (3) location of identified receptors.

Data on equipment sound power levels were obtained from supporting documentation for assessment of alternative sites for a high-level nuclear waste repository (Liebich and Policastro 1986). The sound power data are shown in Table 2.28. The following assumptions were made in modeling noise expected from the construction of NIF:

1. The distance from the center of the proposed facility to each of the identified receptors was the same as the distance used in the analysis of radiological and other emissions.

TABLE 2.28 Sound Power Levels of Equipment Modeled for Analysis of Noise Impact during National Ignition Facility Construction Phase

	Octave Band Frequency (Hz) at Various Sound Power Levels (dB) (re: 1 pw)							
Item	32	63	125	500	1,000	2,000	4,000	8,000
Loader	107	108	109	109	109	106	101	97
Water truck	102	109	116	110	108	106	100	94
D8 Caterpillar tractor	124	130	125	122	113	108	102	98
Grader	100	104	114	111	108	106	101	97

2. Distances from individual equipment items to each receptor location were scaled from appropriate maps and drawings.

3. The activity creating the greatest amount of noise would be the clearing of the site and removal of spoil.

4. The following equipment would be used in the clearing and removal of spoil (excavating, hauling, and placing earth):

   a. Four diesel-powered bottom-load-and-dump haulers, used to excavate and haul earth,

   b. Two D-8 Caterpillar bulldozers used to move earth and push haulers during the loading operation,

   c. Two water trucks used to control dust during excavation and placement of spoil, and

   d. Two graders used to bring the site to grade following excavation.

5. Spoil would be stored on-site, or in off-site areas immediately adjacent to the boundary of the host facility, thus minimizing the length of the haul route.

6. In the model, the deployment of equipment is essentially the same for each site, with slight variations for site shape. Typically, two of the four haulers are deployed on the excavation site, one is en route between the excavation site and the spoil pile, and one is at the spoil pile. The two bulldozers are located proximal to the two haulers at the excavation area. One water tank truck is at the excavation and one is at the spoil pile. The two graders are in different

parts of the excavation area. Depending on the location of the receptor being modeled, the distance from each noise source to the receptor can differ substantially from the distance between the site center and the receptor.

For the Modified CNR analysis of noise effects, it was assumed that the site-clearing phase would occur during the summer. Since the summer is the time when more people are outdoors and doors and windows are more likely to be open, this season represents the greatest potential for noise impact.

The temperature and relative humidity values used in modeling air attenuation of sound were 15°C (59°F) and 70%, respectively. The values of attenuation (in dB/100 m [dB/328 ft]) used are shown in Table 2.29. The relative humidity may appear to be high, especially for locations like SNL and LANL; however, such conditions apply to times when sound-level impact may be the greatest and are within the range of accuracy established by the use of assumed values for baseline sound levels.

2.2.2 Assumptions and Results for Composite Noise Rating Analysis

The various adjustment criteria applied in the CNR analysis are summarized in Table 2.30. Community noise experience factors used to adjust the modified CNR results were based on the

TABLE 2.29 Sound Attenuation Rates for Molecular Absorption for "Standard Day" Conditions and for "Anomalous Excess Attenuation"

Octave Frequency Band (Hz)	Molecular Absorption at 59°F, 70% R.H. (dB/100 m)	Anomalous Excess Attenuation (dB/100 m)	Suggested Total Attenuation for Standard Day[a] (dB/100 m)
32	—	0.10	0.10
63	0.03	0.13	0.16
125	0.07	0.20	0.27
250	0.13	0.26	0.39
500	0.23	0.36	0.59
1,000	0.49	0.49	0.98
2,000	0.98	0.72	1.70
4,000	2.49	0.98	3.47
8,000	4.49	1.31	5.80

[a] Values obtained by adding columns 2 and 3.

assumption that in the case of each of the sites except NTS, community members have a strong association with, and thus a favorable attitude toward, the proposed action through their involvement with facilities presently at the site (such as various DOE laboratories). Since an assumption regarding previous experience with noise could not be made in the same manner, it was assumed that the residents of each of the urban communities has had some previous exposure to noise of the type expected. Because NTS does not appear to have a community structure nearby, the response adjustment factors for that analysis were considered to be neutral. Results of the Modified CNR evaluations for each candidate site are summarized in Tables 2.31 through 2.35.

Examination of the noise impact of site clearing in terms of annual noise exposure helps put the impact in perspective. Although site clearing would be the activity of highest noise emission that would occur at any of the candidate sites, the duration of this activity would be relatively short (on the order of four weeks). The temporary nature of high sound levels from this construction phase would mitigate the severity of any noise responses predicted by the Modified CNR process. The level of noise from other construction activities would be expected to be smaller in magnitude.

Noise resulting from operation of the facility is expected to consist of continuous low-level sound from heating, ventilation, and air conditioning equipment. A source of related noise is expected to be a nominal increase in traffic noise associated with the vehicles of commuting staff and from occasional delivery of materials.

TABLE 2.30 Normalizing Factors for Composite Noise Rating Results

Type and Description of Adjustment to Noise Rank	Factor[a]
Seasonal correction	
Summer or year-round operation	0
Winter-only operation	-1
Adjustment for outdoor baseline sound level	
Quiet suburban	+2
Normal suburban (no industrial activity)	+1
Urban residential (no high-traffic areas)	0
Noisy urban residential (nearby traffic)	-1
Very noisy urban residential	-2
Prior experience with noise and community attitude	
No prior experience with noise or some prior experience but poor community relations	+1
Some previous experience and good community relations	0
Considerable previous exposure and good community relations	-1
Noise character	
Low frequency present	+1
Tonal components present	+1
Impulsive sound present	+1
Intermittency of sound, percent of total time sound present	
100 - 57	0
56 - 18	-1
17 - 6	-2
5 - 1.8	-3
1.7 - 0.57	-4
0.56 - 0.01	-5

[a] Factors represent units on the modified CNR scale relating to human reaction.

TABLE 2.31 Summary of Modeling and Analysis — Lawrence Livermore National Laboratory

Parameter	Residential	Laboratory	MEI[a]
Background level			
Day-night level (dBA)	60	55	55
Daytime level (dBA)	61	55	55
Nighttime level (dBA)	48	45	45
CNR rank	-3	-2	-2
Construction contribution			
A-weighted level (dBA)	43	57	69
CNR rank before adjustment	C	F	G
Combined level at receptor	61	59	69
Increase in level (dBA)	1	4	14
Adjustments			
Background	-3	-2	-2
Temporal	-1	-1	-1
Seasonal	0	0	0
Intermittency	0	0	0
Low frequency	0	0	0
Tonal content	+1	+1	+1
Impulsive noise	0	0	0
Experience with noise	-0.5	-0.5	+0.5
Attitude toward project	-0.5	-0.5	+0.5
Total adjustment	-4	-4	-1
Results of CNR analysis			
Adjusted rank	A	B	F
Likelihood of complaints	None	None	Certain

[a] Maximally exposed individual east of Greenville Road, located 800 m east of Target Area.

TABLE 2.32 Summary of Modeling and Analysis — Los Alamos National Laboratory

Parameter	Laboratory	MEI[a]
Background level		
Day-night level (dBA)	40	40
Daytime level (dBA)	40	40
Nighttime level (dBA)	35	35
CNR rank	0	0
Construction contribution		
A-weighted level (dBA)	54	44
CNR rank before adjustment	E	C
Combined level at receptor	54	46
Increase in level (dBA)	14	6
Adjustments		
Background	0	+1
Temporal	0	0
Seasonal	0	0
Intermittency	0	0
Low frequency	0	0
Tonal content	0	0
Impulsive noise	0	0
Experience with noise	-0.5	-5
Attitude toward project	-0.5	-5
Total adjustment	0	0
Results of CNR analysis		
Adjusted rank	D	D
Likelihood of complaints	Sporadic	Sporadic

[a] Maximally exposed individual, located 1,670 m north-northeast of Target Area.

TABLE 2.33 Summary of Modeling and Analysis — Nevada Test Site

Parameter	Residential	Laboratory
Background level		
Day-night level (dBA)	28	28
Daytime level (dBA)	28	28
Nighttime level (dBA)	19	19
CNR rank	+2	+2
Construction contribution		
A-weighted level (dBA)	0	40
CNR rank before adjustment	NA	B
Combined level at receptor	28	40
Increase in level (dBA)	0	12
Adjustments		
Background	+2	+2
Temporal	0	0
Seasonal	0	0
Intermittency	0	0
Low frequency	0	0
Tonal content	0	0
Impulsive noise	0	0
Experience with noise	0	0
Attitude toward project	0	-1
Total adjustment	+2	+1
Results of CNR analysis		
Adjusted rank	NA	C
Likelihood of complaints	NA	Sporadic

TABLE 2.34 Summary of Modeling and Analysis — North Las Vegas Facility

Parameter	Closest Residential Area	Laboratory	Alternative Residential Area
Background Level			
Day-night level (dBA)	66	60	66
Daytime level (dBA)	66	60	66
Nighttime level (dBA)	56	50	56
CNR rank	-6	-5	-6
Construction contribution			
A-weighted level (dBA)	83	70	74
CNR rank before adjustment	J	H	H
Combined level at receptor	83	70	74
Increase in level (dBA)	17	10	8
Adjustments			
Background	-6	-5	-6
Temporal	-1	-1	-1
Seasonal	0	0	0
Intermittency	0	0	0
Low frequency	0	0	0
Tonal content	1	1	1
Impulsive noise	0	0	0
Experience with noise	-0.5	-0.5	-0.5
Attitude toward project	-0.5	-0.5	-0.5
Total adjustment	-7	-7	-7
Results of CNR analysis			
Adjusted rank	C	A	A
Likelihood of complaints	Sporadic	None	None

TABLE 2.35 Summary of Modeling and Analysis — Sandia National Laboratories

Parameter	Residential	Laboratory	MEI[a]
Background level			
Day-night level (dBA)	63	64	64
Daytime level (dBA)	63	64	64
Nighttime level (dBA)	53	54	54
CNR rank	-4	-4	-5
Construction contribution			
A-weighted level (dBA)	44	54	61
CNR rank before adjustment	D	E	G
Combined level at receptor	63	64	65
Increase in level (dBA)	0	0	1
Adjustments			
Background	-4	-5	-5
Temporal	0	0	0
Seasonal	0	0	0
Intermittency	0	0	0
Low frequency	0	0	0
Tonal content	0	0	0
Impulsive noise	0	0	0
Experience with noise	-0.5	-0.5	-0.5
Attitude toward project	-0.5	-0.5	-0.5
Total adjustment	-5	-6	-6
Results of CNR analysis			
Adjusted rank	A	A	A
Likelihood of complaints	None	None	None

[a] Maximally exposed individual, located 1,864 m north of Target Area.

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3 SOCIOECONOMICS

3.1 INTRODUCTION

The socioeconomic analysis conducted for the NIF PSA (Appendix I, DOE 1996) involved three principal steps: (1) characterization and projection of existing social, economic, and infrastructure conditions around each candidate site (that is, the reference baseline or affected environment); (2) evaluation of potential changes in socioeconomic conditions that could result from the construction and operation of NIF in the regions addressed (NIF alternative); and (3) evaluation of potential changes in socioeconomic conditions that could result from not constructing NIF (that is, the No Action Alternative). Under the No Action Alternative, NIF would not be constructed at any of the DOE candidate sites, resulting directly in the loss of approximately 100 full-time-equivalent employees at LLNL and 20 each at LANL and SNL.

The following sections describe the methods, models, assumptions, and supporting data sources used in assessing the potential socioeconomic impacts of NIF. The NIF PSA uses some supporting data sources presented in the *Stockpile Stewardship and Management Environmental Impact Statement (SSM PEIS)* (DOE 1996). This section only addresses those methods, models, assumptions, and supporting data sources that vary from the SSM PEIS. The socioeconomics technical appendix (Appendix D) of the SSM PEIS can be referenced for a description of the general approach and supporting data sources used in conducting the assessment of socioeconomic impacts presented in the NIF PSA.

3.2 METHODS AND MODELS

To estimate the potential socioeconomic impacts of the No Action and NIF alternatives, this evaluation examined potential impacts for two larger geographic regions — an economic study area and a region of influence — for each of the five candidate sites. An economic study area was used to estimate the primary economic impact of NIF on earnings and jobs. Each economic study area is coincident with economic areas defined by the U.S. Department of Commerce's Bureau of Economic Analysis (BEA). Each area includes the most important intraregional interactions in broad labor and product markets, trade among and between the most important regional industrial and service sectors, and the most important economic linkages among the communities located in the region. These linkages determine the nature and magnitude of multiplier effects of economic activity at each candidate site. Table 3.1 shows the counties included in the economic study area for each candidate site.

TABLE 3.1 Economic Study Regions

Lawrence Livermore National Laboratory[a]		Los Alamos National Laboratory[b]	Nevada Test Site	North Las Vegas Facility	Sandia National Laboratories
Merced County	Santa Clara County	Guadalupe County	**Arizona**	**Arizona**	**Arizona**
Mariposa County	Santa Cruz County	Mora County	Mohave County	Mohave County	Apache County
Stanislaus County	Sonoma County	Taos County	**Nevada**	**Nevada**	**New Mexico**
Tuolumne County	Lake County	San Miguel County	Nye County	Nye County	Socorro County
Contra Costa County	Humboldt County	Los Alamos County	Clark County	Clark County	Valencia County
Alameda County	Mendocino County	Santa Fe County	Esmerelda County	Esmeralda County	Catron County
Monterey County	Trinity County	Rio Arriba Country	Lincoln County	Lincoln County	Cibola County
San Mateo County	San Joaquin County		Mineral County	Mineral County	McKinley County
Marin County	Calaveras County		**Utah**	**Utah**	Sandoval County
San Francisco County	Napa County		Piute County	Piute County	Torrance County
San Benito County	Solano County		Beaver County	Beaver County	Bernalillo County
			Garfield County	Garfield County	
			Iron County	Iron County	
			Washington County	Washington County	

[a] All counties are in California.

[b] All counties are in New Mexico.

A second geographical area around each site, referred to as the region of influence (ROI), was used to estimate the potential impacts of the No Action and NIF alternatives on population and housing, public finances and local public service infrastructure, and local transportation. The ROI was defined as the area surrounding each site in which approximately 90% of the current DOE workforce resides, and counties in which at least 5% of the DOE workforce lives. The residential distribution information is consistent with data sets presented in Appendix D of the SSM PEIS. Table 3.2 lists the counties and cities included in the ROI for each candidate site.

3.2.1 Regional Economics

3.2.1.1 Existing and Future Baseline

The reference baseline was established from regional economic projections to the year 2045 developed by BEA (1996). Current employment levels at four of the candidate sites (excluding NLVF, 1,030 employees in 1995 [White 1995]) are presented in Appendix D of the SSM PEIS. The regional baseline for employment in the affected regional economies is presented in Table 3.3. Adjusted baseline projections account for the increase in regional economic activity resulting from construction and operation of NIF. Effects on regional growth rates are presented under the "Growth Rate" column.

3.2.1.2 Potential Project Effects

General Approach and Methodology

Final demand multipliers obtained for each region from the U.S. Department of Commerce, BEA Regional Input-Output Modeling System (RIMS II) (BEA 1995) were used in an economic model developed to evaluate socioeconomic impacts of the loss of the ICF program (No Action) and of constructing and operating the NIF. The RIMS II code is based on an accounting framework called an input-output (I-O) table. An I-O table shows, for each industry, industrial distributions of inputs purchased and outputs sold. A typical I-O table in RIMS II derives mainly from two data sources: (1) BEA's national I-O tables, which show the input and output structure (production and consumption of commodities) of nearly 600 U.S. industries; and (2) BEA's four-digit Standard Industrial Classification (SIC) county wage and salary data, which can be used to adjust the national I-O table to show a region's industrial structure and trading patterns (BEA 1992; Repice 1996). Final demand multipliers from RIMS II were used to estimate the impacts of NIF project expenditures by industry on earnings (the sum of wages and salaries, proprietors' income, and other labor income,

TABLE 3.2 Regions of Influence

Lawrence Livermore National Laboratory	Los Alamos National Laboratory	Nevada Test Site	North Las Vegas Facility	Sandia National Laboratories
Alameda County	Los Alamos County	Clark County	Clark County	Bernalillo County
Contra Costa County	Rio Arriba County	Nye County	Nye County	Valencia County
San Joaquin County	Santa Fe County	City of Henderson	City of Henderson	Sandoval County
City of Livermore	City of Santa Fe	City of Las Vegas	City of Las Vegas	City of Albuquerque
City of Pleasanton	City of Espanola	City of North Las Vegas	City of North Las Vegas	
City of Manteca				
City of Tracy				

TABLE 3.3 Regional Economic Impact Analysis Comparison — Baseline and NIF Alternative Employment Forecasts[a]

BEA Economic Area (NIF Site)	Number Employed										Growth Rate (%)
	1980	1995	1996	1997	1998	1999	2000	2001	2002	2003	
San Francisco-Oakland-San Jose, CA (LLNL)											
Baseline	3,752,900	4,888,941	4,976,984	5,066,613	5,157,856	5,250,741	5,345,300	5,428,001	5,511,982	5,597,262	1.706
w/NIF		4,888,941	4,977,404	5,067,792	5,160,716	5,253,422	5,347,098	5,429,205	5,512,416	5,598,156	1.708
Growth Rate Increase											0.002
Santa Fe, NM (LANL)											
Baseline	78,500	132,988	136,464	140,031	143,691	147,446	151,300	154,225	157,206	160,245	2.358
w/NIF		132,988	136,561	140,385	144,810	148,295	151,627	154,436	157,267	160,840	2.405
Growth Rate Increase											0.047
Las Vegas, NV-AZ-UT (NTS and NLVF)											
Baseline	320,400	653,026	676,440	700,694	725,818	751,842	778,800	799,185	820,103	841,568	3.221
w/NIF		653,026	676,594	701,174	727,438	753,059	779,218	799,448	820,182	842,184	3.231
Growth Rate Increase											0.009
Albuquerque, NM-AZ (SNL)											
Baseline	290,100	450,282	460,565	471,083	481,841	492,845	504,100	512,963	521,981	531,159	2.086
w/NIF		450,282	460,720	471,594	483,493	494,149	504,619	513,282	522,066	531,829	2.102
Growth Rate Increase											0.016

[a] Forecasts are based on BEA (1996).

less employer contributions to private pension and welfare funds), and employment (number of jobs).

NIF cost data were obtained from the *NIF Conceptual Design Report* (LLNL 1994) and were translated from work breakdown structure (WBS) categories to RIMS II industries. These cost data were then converted to final demand estimates and were applied to the appropriate RIMS II multipliers to project regional economic impacts. Final demand estimates reflect expenditures in the regional economy and were calculated by estimating regional purchase coefficients on the basis of historical procurement data (Paisner 1995). Figure 3.1 shows the major industrial sectors impacted by NIF construction.

Comparison of Regional Economic and Demographic Impacts

Figure 3.2 illustrates the relative regional economic impact on projected baseline employment levels for each of the affected regional economies. The percentage increase along the vertical axis reflects the increase of the projected NIF impact over the reference baseline presented in Table 3.3. Although the graph ends at year 2003, the level of impact in 2003 is expected to remain relatively constant for the projected operational period.

Figures 3.3 through 3.6 show the breakdown of economic effects resulting from regional NIF spending and investment at each site. Figures 3.7 through 3.10 show direct (at the NIF site), indirect (resulting from the multiplier effect), and total (direct plus indirect) job creation in the regional economies presented in Table 3.1, as well as in-migration for the affected regions of influence. Assumptions used to calculate in-migration occurring at each site with NIF are shown in Table 3.4. A summary of projected employment impacts in each regional economy for each construction year and for the first year of operation is provided in Table 3.5. The table also includes the residual U.S. employment impact resulting from extra-regional leakage at each candidate site.

Impacts on the U.S. Economy

The approach used to model the impacts of NIF spending on the U.S. economy is similar to that described for the regional economic impact analysis, except that RIMS II multipliers for the U.S. economy were used in place of the regional multipliers. Also, it was assumed that all final demand changes resulting from NIF procurement would occur within the U.S. economy (i.e., no leakage to foreign markets for importing goods or services). The results of this analysis are presented in Table 3.5. The values for the United States indicate the total employment effect of constructing and operating NIF.

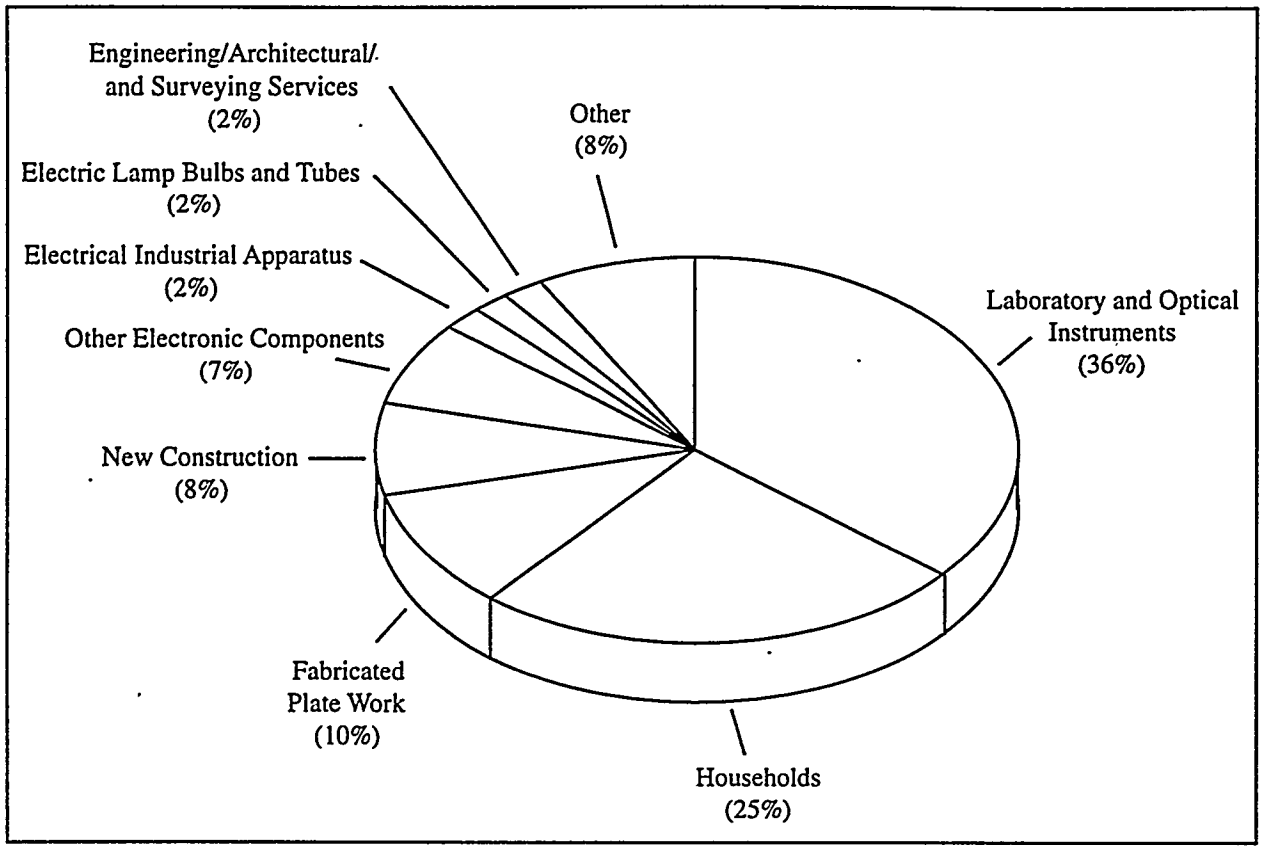

FIGURE 3.1 Industry Share of Total NIF Construction Cost

3.2.2 Population In-Migration

Changes in regional and local economic activity affect regional and local demographics. To project potential population changes resulting from construction and operation of NIF, population in-migration scenarios were developed for each candidate site. Estimated direct and indirect jobs created as a result of constructing and operating NIF are the basis for the assessment of population in-migration impacts. Some of these jobs would be supplied by local labor markets; however, others would be supplied by workers migrating into the region as a result of the marginal increase in economic opportunity from constructing and operating NIF. Additional population would have the potential to burden public infrastructure and create additional demand in local housing markets.

Different assumptions related to the proportion of direct and indirect jobs supplied by the local labor force were applied to each job (direct or indirect). These assumptions were based on a comparison of the industrial composition of each regional economy (that is, presence of NIF-related industries) and the size of the unemployed labor force for each economic study area. A relative ranking scheme was used for those industrial sectors substantially affected by local NIF

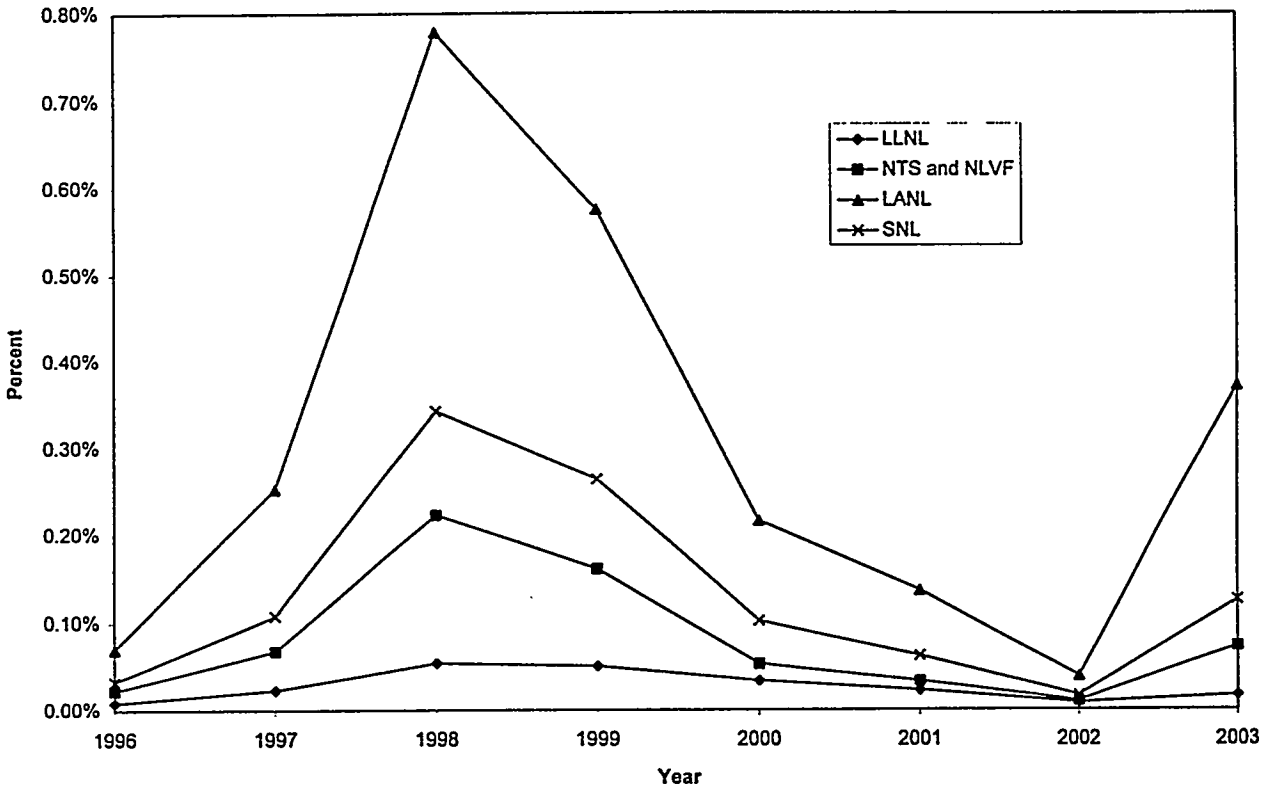

FIGURE 3.2 Relative Regional Economic Impact Comparison

procurement. A percentage factor was applied to each job to calculate those jobs supplied by the local labor force. The highest ranking economic sector was assigned the lowest migration rate; while the lowest sector was assigned the highest migration rate.

The residual, those jobs created in economic sectors (industries) not substantially affected, was assigned a migration rate relative to the unemployed labor force in each of the economic study areas. These labor markets were ranked according to size, and an assumed percentage of each job supplied by the local labor market was applied on the basis of the ranking scheme. The lowest assumed proportion was applied to the largest labor pool; while the highest assumed proportion was applied to the smallest labor pool.

The total population in-migration in any given year was calculated as the sum of direct and indirect in-migration (based on the previously described methodology) multiplied by an average household size (based on an empirical study of migration from region to region). In-migration rate assumptions for each candidate site are listed in Table 3.4. The approach provides a reasonable relative comparison of impacts related to constructing and operating NIF at each candidate site.

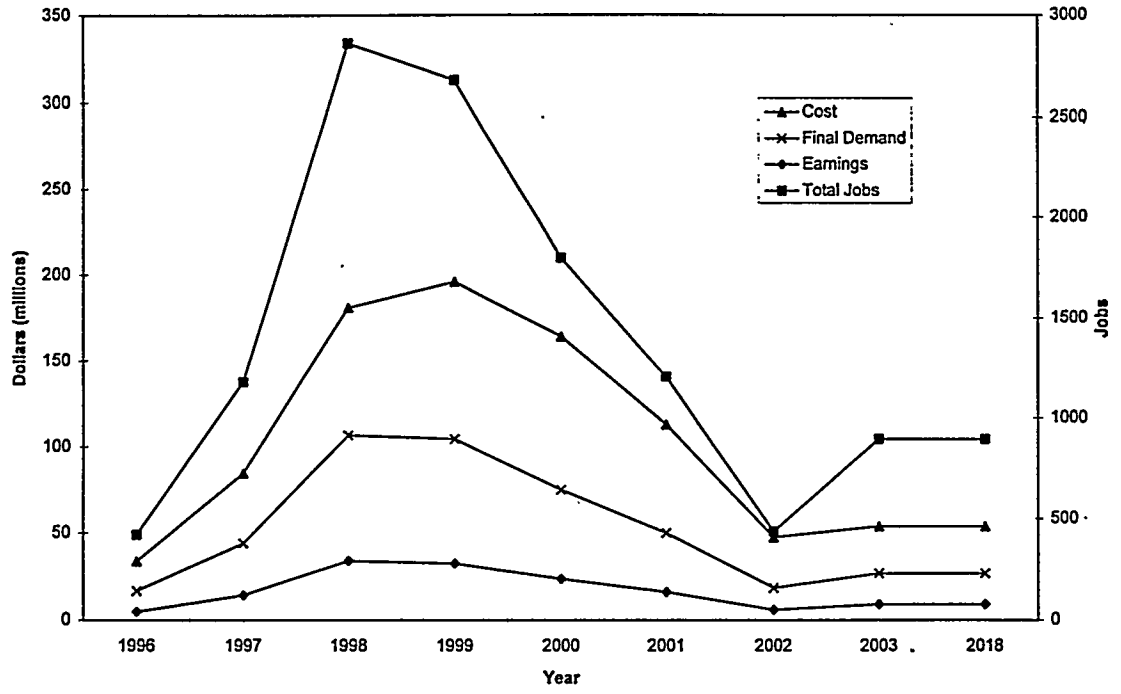

FIGURE 3.3 Impacts of NIF Spending on the LLNL Regional Economy

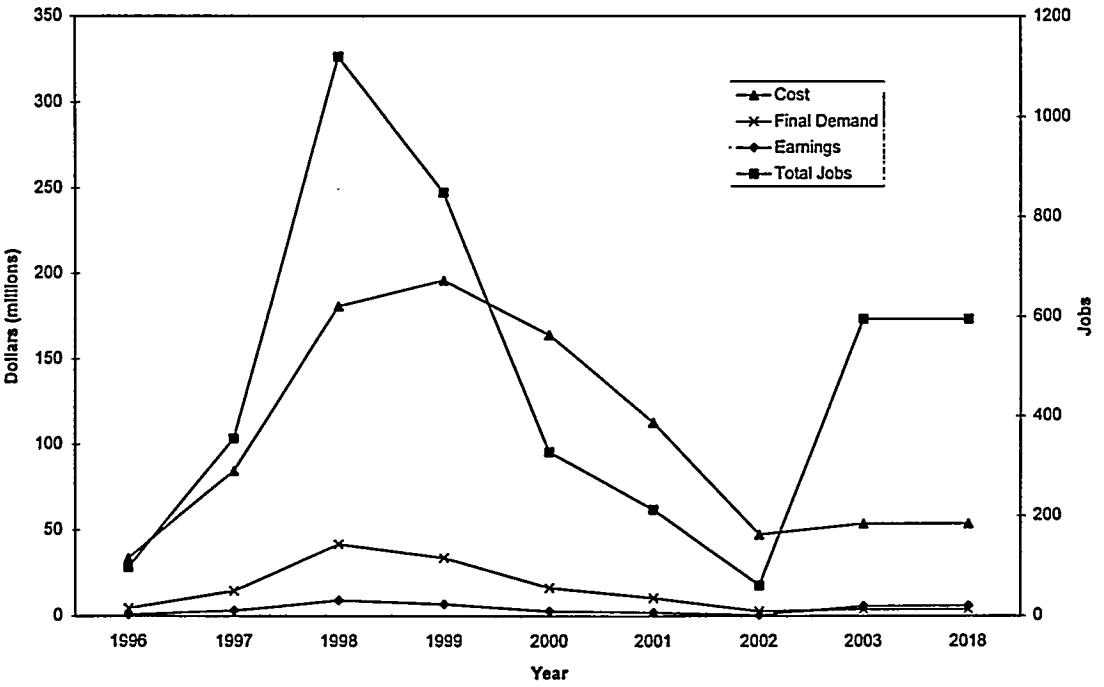

FIGURE 3.4 Impacts of NIF Spending on the LANL Regional Economy

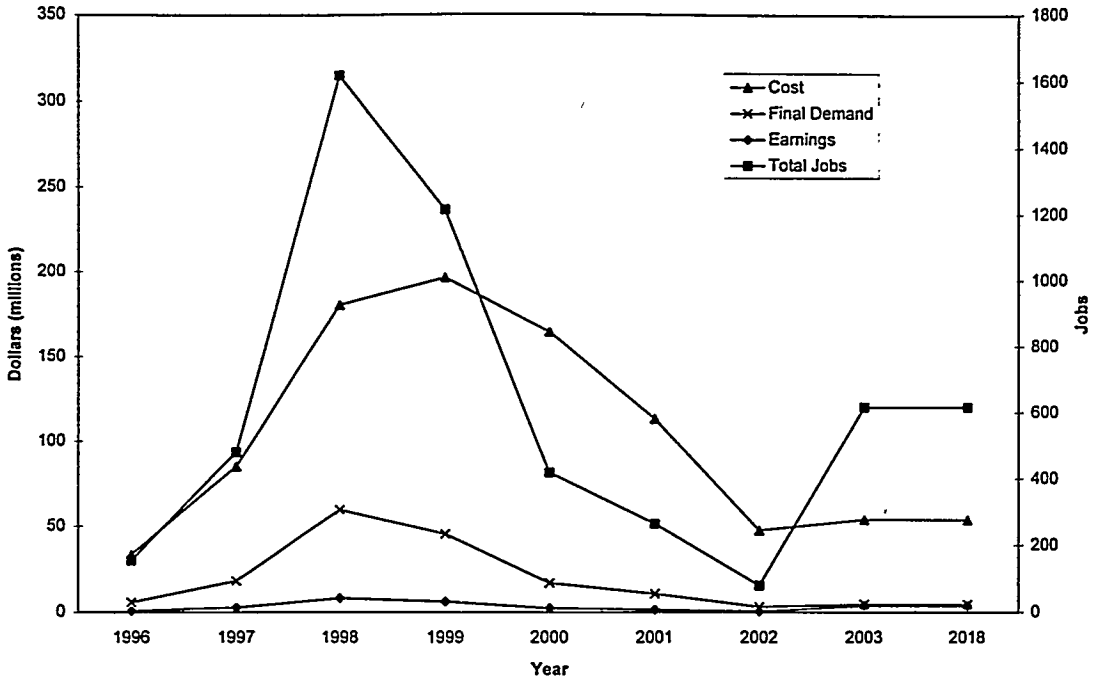

FIGURE 3.5 Impacts of NIF Spending on the NTS/NLVF Regional Economy

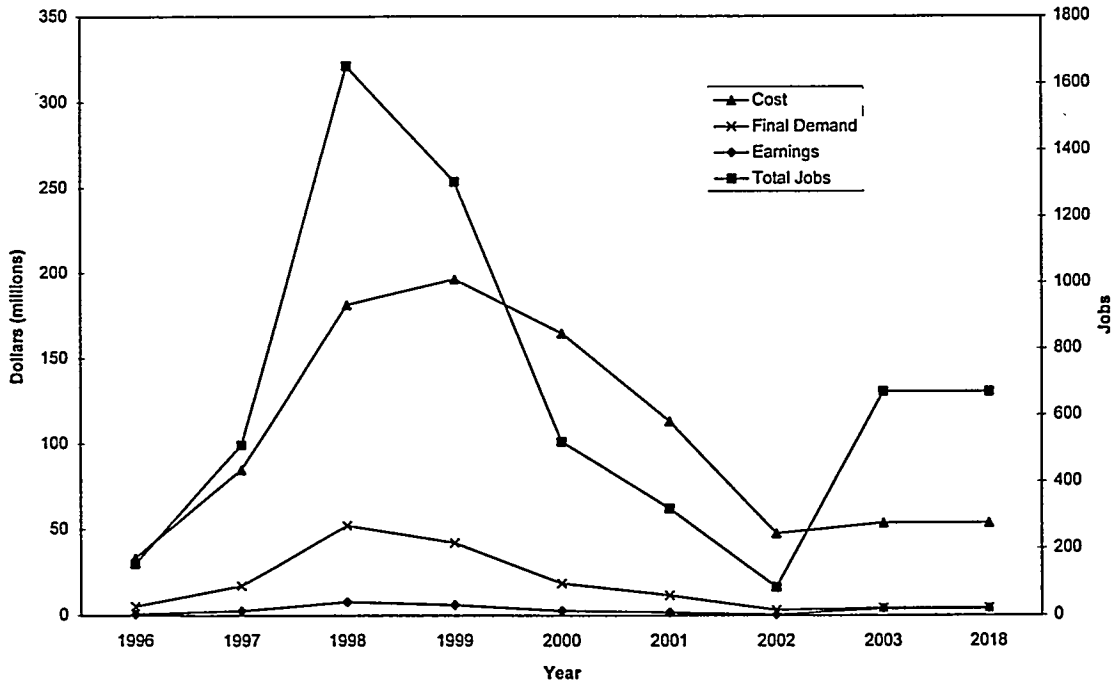

FIGURE 3.6 Impacts of NIF Spending on the SNL Regional Economy

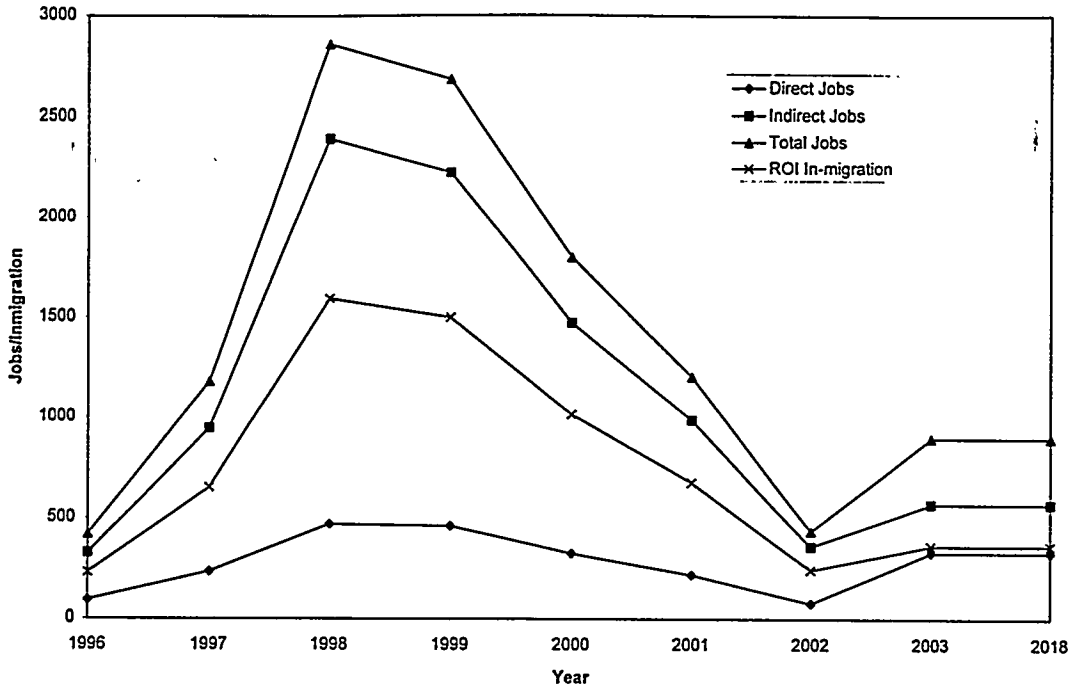

FIGURE 3.7 Economic and Demographic Impacts at LLNL

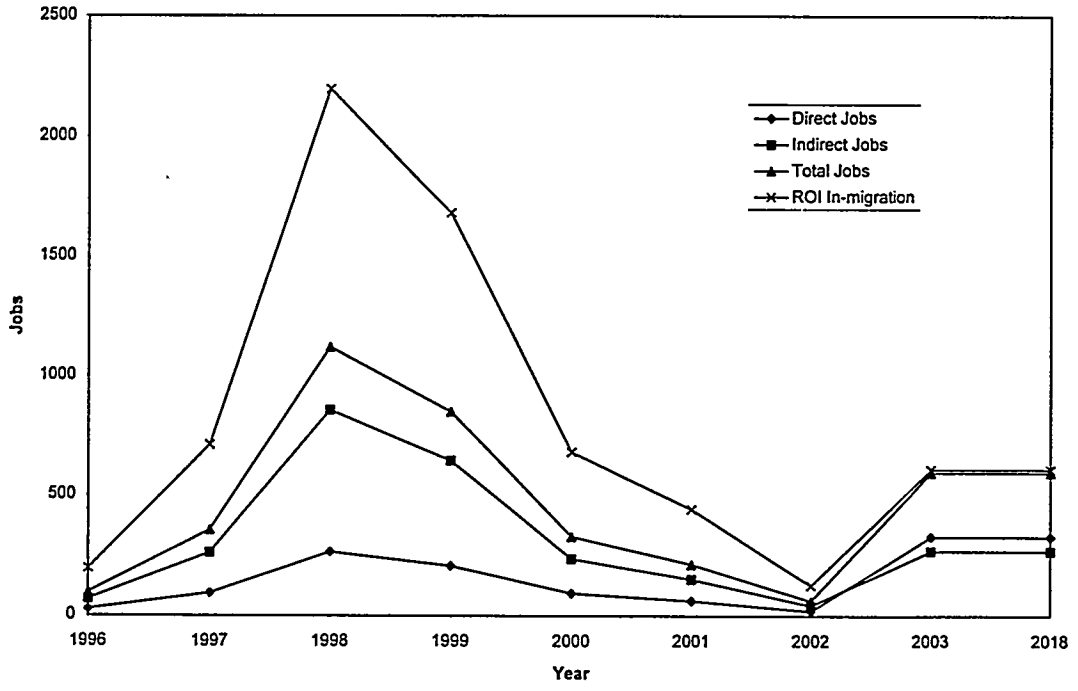

FIGURE 3.8 Economic and Demographic Impacts at LANL

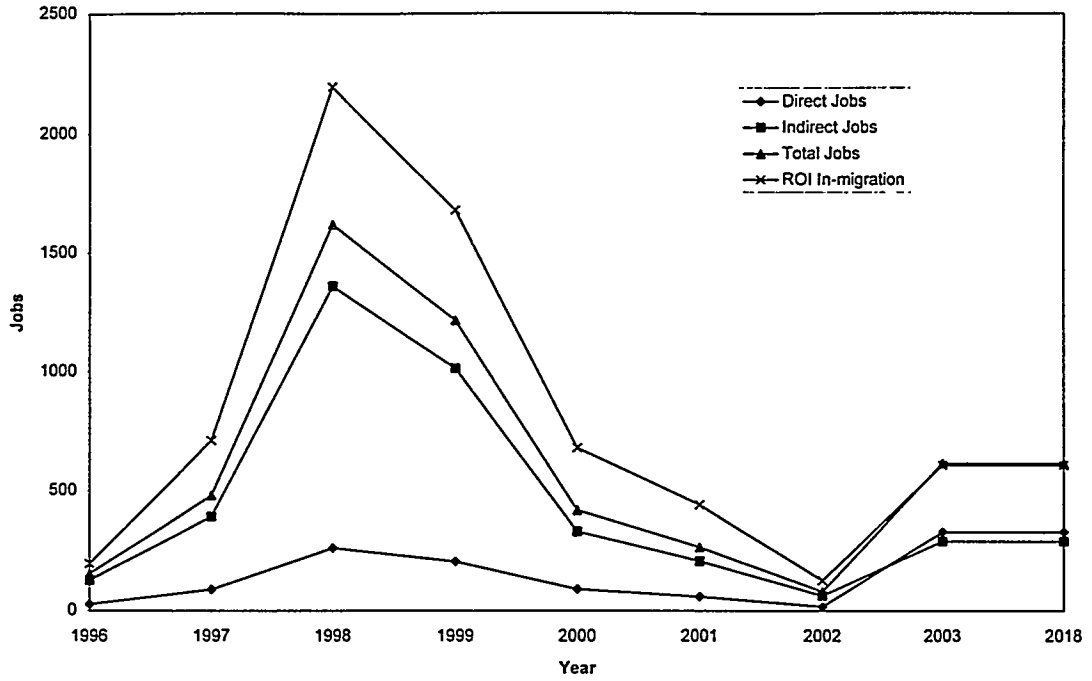

FIGURE 3.9 Economic and Demographic Impacts at NTS/NLVF

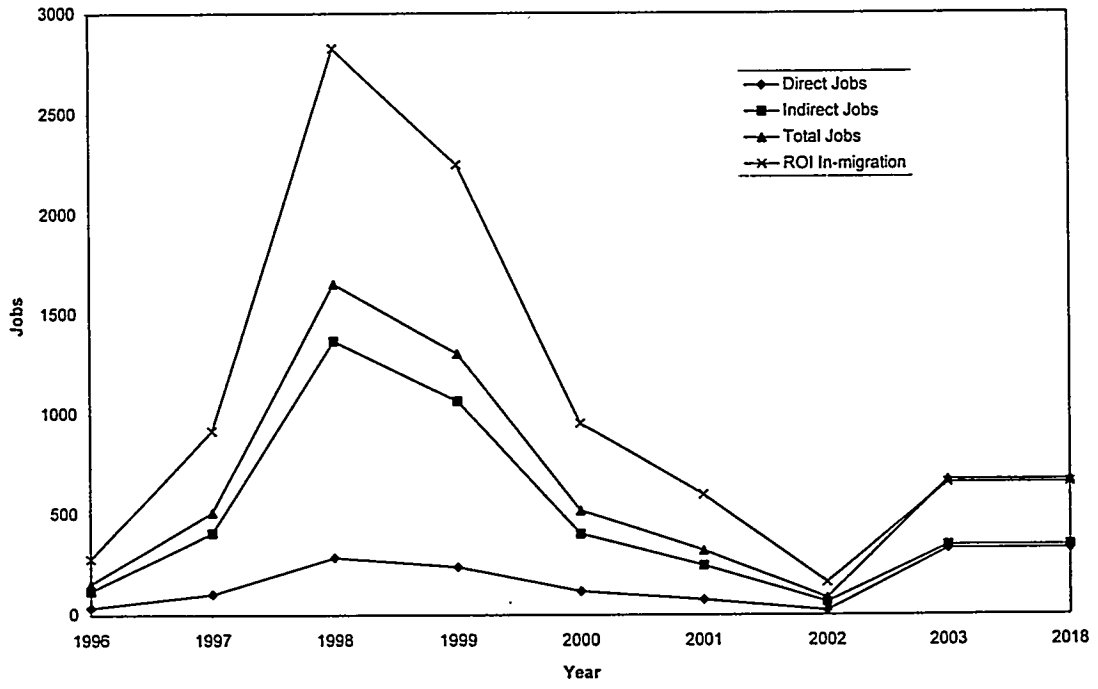

FIGURE 3.10 Economic and Demographic Impacts at SNL

TABLE 3.4 Site-Specific In-Migration Rate Assumptions

	In-Migration Rate,[a] by Year							
Regional Labor Market	1996	1997	1998	1999	2000	2001	2002	2003
LLNL								
Direct In-Migration Rate	0.096	0.086	0.058	0.073	0.092	0.090	0.075	0
Indirect In-Migration Rate	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
LANL								
Direct In-Migration Rate	0.575	0.478	0.276	0.333	0.656	0.697	0.687	0.250
Indirect In-Migration Rate	0.945	0.952	0.976	0.973	0.937	0.927	0.928	0.939
NTS and NLVF								
Direct In-Migration Rate	0.550	0.474	0.305	0.348	0.660	0.715	0.714	0.250
Indirect In-Migration Rate	0.724	0.623	0.584	0.596	0.664	0.739	0.861	0.573
SNL								
Direct In-Migration Rate	0.565	0.482	0.288	0.354	0.605	0.642	0.655	0.250
Indirect In-Migration Rate	0.707	0.723	0.716	0.713	0.713	0.720	0.731	0.717

[a] Percentage of in-migrants from outside of the regional economic study area.

3.2.3 Housing

Population and employment changes associated with NIF could potentially affect housing supply in the project area. Projected housing needs were developed from several data sets. The first data set used for this study was population projections provided by the BEA (1995). These data were used to project baseline population for the life of NIF.

The second data set used for this analysis was the *1990 Census of Population and Housing* (U.S. Bureau of the Census 1991). These data were used to establish the total number of housing units (owner and renter) for each ROI in 1990. An average annual growth rate for housing units was established for the years between 1980 and 1990. This rate was applied to the project construction and operation years to establish the estimated number of housing units in an ROI for those years. By holding the ratio of owner to renter units constant, the approximate number of vacant owner and renter units was projected for the project construction and operation years. A household size-to-population ratio was then applied to the estimated future population trends to obtain the number of housing units needed to accommodate the projected population for a future reference baseline.

TABLE 3.5 Employment Impact Summary — U.S. and Regional Economies

Component	Construction/Assembly Phase and Other Project Activities							Average Annual	Operations
	1996	1997	1998	1999	2000	2001	2002	1996 to 2002	2003 to 2018
LLNL Region									
Direct	93	234	467	458	323	218	76	267	327
Indirect	327	945	2,393	2,223	1,474	986	358	1,244	568
Total	420	1,179	2,860	2,681	1,798	1,204	434	1,511	895
U.S. Residual									
Direct	78	23	30	39	34	22	6	33	0
Indirect	526	1,359	3,042	3,446	2,974	2,034	900	2,040	650
Total	604	1,382	3,072	3,484	3,007	2,056	907	2,073	650
LANL Region									
Direct	28	93	264	206	92	61	19	109	327
Indirect	69	261	855	643	235	150	42	322	268
Total	97	355	1,119	848	327	212	61	431	595
U.S. Residual									
Direct	143	164	234	291	265	179	64	191	0
Indirect	784	2,042	4,580	5,026	4,213	2,870	1,216	2,962	950
Total	927	2,206	4,814	5,317	4,478	3,048	1,280	3,153	950

TABLE 3.5 (Cont.)

Component	Construction/Assembly Phase and Other Project Activities							Average Annual	Operations
	1996	1997	1998	1999	2000	2001	2002	1996 to 2002	2003 to 2018
SNL Region									
Direct	35	103	284	238	117	75	21	125	327
Indirect	119	407	1,368	1,066	402	245	63	524	344
Total	154	511	1,652	1,304	519	319	84	649	671
U.S. Residual									
Direct	136	154	214	258	240	165	61	176	0
Indirect	733	1,896	4,067	4,603	4,046	2,775	1,195	2,759	874
Total	869	2,050	4,281	4,861	4,286	2,940	1,257	2,935	874
NTS/NLVF Region									
Direct	27	88	260	203	89	58	17	106	327
Indirect	127	392	1,360	1,013	329	206	62	498	289
Total	154	480	1,620	1,216	418	264	79	604	616
U.S. Residual									
Direct	144	169	238	293	268	182	65	194	0
Indirect	725	1,912	4,075	4,656	4,119	2,814	1,196	2,785	929
Total	870	2,081	4,313	4,949	4,387	2,996	1,261	2,980	929
U.S. Economy (Total Effect)									
Direct	171	257	498	496	357	240	83	300	327
Indirect	853	2,303	5,435	5,669	4,448	3,020	1,258	3,284	1,218
Total	1,024	2,561	5,933	6,165	4,805	3,260	1,341	3,584	1,545

Housing needs for the NIF construction and operation workforce, which were estimated on the basis of data in the economic and in-migration section of this study, were then compared with the number of vacant units projected to be present in each ROI. This comparison was made for the largest in-migrating workforce and their families and was used as a conservative scenario to assess potential impacts on housing supply in a particular ROI.

Housing need projections for each of the five candidate sites were developed in the same manner as the estimates for the reference baseline. Employment projections were used to estimate the size of the in-migrating workforce required for NIF construction and operation. Housing needs for the NIF construction and operation workforce were then estimated by adding the in-migrating workforce to the future reference baseline.

3.2.4 Public Finance

Finances of the ROI local jurisdictions were evaluated on the basis of historic revenue and expenditure levels. These historic fiscal characteristics were obtained from comprehensive annual financial reports supplied by each jurisdiction. The analysis focused on each jurisdiction's governmental funds, including general fund, special revenue funds, and, as applicable, capital projects, debt service, and expendable trust funds. The analysis of local jurisdictions' public finances focused upon fiscal balances (revenue and expenditure) because no reasonable assumptions could be made for some projected fund balances (such as capital expenditures) so far into the future. Estimated changes in population as a result of the proposed actions were used to project changes in total revenue and expenditures for each jurisdiction.

3.2.5 Public Services

Potential effects on the public services provided by the local jurisdictions caused by changes in demand associated with the proposed action were determined for each region. The levels of general public service were determined by the ratios of employees (for example, sworn officers, professional firefighters) to service populations. Existing level-of-services ratios were determined for each jurisdiction individually. Those ratios were adjusted to account for economies and diseconomies of scale. The adjusted ratios were then used to estimate jurisdiction-specific future requirements for services on the basis of the projected population growth in the ROI.

3.2.6 Local Transportation

Population and employment changes associated with NIF would have the potential to affect transportation conditions in the project area. Traffic impacts were modeled with a proprietary

transportation model developed in accordance with the Highway Capacity Manual's methodology for freeways, multi-lane roads, and two-lane roads (Transportation Research Board 1985). Average annual daily traffic (AADT) volumes were projected for 1995 and the impact year for no-action population projections, which represent the population expected to live in an ROI if no action was taken (no projects were constructed). The AADT data in the impact years (the year with the highest number of construction workers or the year with the highest number of operation workers) for each candidate site were projected on the basis of the no-action population projections. This AADT projection was used to develop the future baseline traffic conditions.

The future baseline year is the year that the maximum impacts are expected; however, traffic conditions reflect future traffic without project construction and operation workers. Moreover, the future baseline year reflects future traffic conditions in an ROI without NIF.

The AADT information for impacts beyond the future baseline was calculated on the basis of the direct employment and direct in-migrating population associated with each alternative. Only roads in the vicinity of a site on which at least 5% of new workers travel were modeled for 1995, the future baseline year, and the future impact year. The assumption was made that the additional workers would use the same roads as now used by the current workforce.

Service flow also was calculated for the road segments for 1995, the future baseline year, and the future impact year. Service flow is the maximum hourly rate at which vehicles can reasonably be expected to cross a point of a lane during a given time period under current roadway and traffic conditions. Service flow rates are discrete values, while level of service represents a range of conditions. Various adjustment factors were assumed or calculated. Capacity of the road segments was calculated from the number of lanes and capacity per lane. The service flow equation was solved for the volume-to-capacity ratio. This ratio was used to find 1995, future baseline, and future impact levels of service.

Level of service is a qualitative measure describing operational conditions within a traffic stream. A level of service definition generally describes these conditions in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety. The level of service scale ranges form A to F, with each level defined by a range of volume-to-capacity ratios. Levels of service A, B, and C are considered good operating conditions where minor or tolerable delays are experienced by motorists. Level of service D represents below-average conditions. Level of service E corresponds to the maximum capacity of the roadway, a jammed condition. The level of service designations are defined in Table 3.6. These levels are based primarily on a report by the Transportation Research Board (1985).

TABLE 3.6 Roadway Level-of-Service Letter Designations and Definitions

Letter Designation	Operating Conditions	Definition
A	Good	A condition of free flow, accompanied by low volumes and high speeds.
B	Good	This level occurs in a zone of stable flow, with operating speeds beginning to be restricted somewhat by traffic conditions.
C	Good	This level is still in a zone of stable flow, but speeds and maneuverability are more closely controlled by the higher volumes.
D	Below Average	This level of service approaches unstable flow, with tolerable operating speeds being maintained, though considerably affected by changes in operating conditions.
E	Maximum Capacity	This level cannot be described by speed alone, but represents operations at lower operating speeds, typically, but not always, in the neighborhood of 30 mph, with volumes at or near the capacity of the highway.
F	Traffic Jam	This level describes a forced-flow operation at low speeds, where volumes are below capacity

Source: Transportation Research Board (1985).

3.2.7 Environmental Justice

3.2.7.1 Introduction

On February 11, 1994, President Clinton issued Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629). This Executive Order, with the accompanying cover memo, calls on Federal agencies to incorporate environmental justice as part of their missions, including decisions made in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 USC 4321 et seq.). Specifically, the President's cover memo to the Environmental Justice Executive Order mentions NEPA in the following context:

> Each Federal agency shall analyze the environmental effects, including human health, economic, and social effects, of Federal actions, including effects on minority communities and low-income communities, when such analysis is required by the *National Environmental Policy Act* of 1969 (NEPA), 42 U.S.C.

> Section 4321 et seq. Mitigation measures outlined or analyzed in an environmental assessment, environmental impact statement, or record of decision, whenever feasible, should address significant and adverse environmental effects of proposed Federal actions on minority communities and low-income communities.

In addition, Executive Order 12898 establishes an Interagency Working Group, one function of which is to provide guidance on the implementation of the Executive Order. At the time of this writing, no final guidance has been issued by the Working Group. However, the Working Group has issued draft working definitions, which are the basis for much of the approach employed in this analysis.

The analysis presented here is a partial response to the requirements of Executive Order 12898 and is intended to assess the potential for high and adverse environmental and/or human health impacts associated with the NIF project to disproportionately affect minority or low-income populations.

In addition to the analyses presented here, Executive Order 12898 and its cover memo also require that: "Each Federal agency shall provide opportunities for community input in the NEPA process, including identifying potential effects and mitigation measures in consultation with affected communities and improving the accessibility of meetings, crucial documents, and notices." Section 1.8 of the SSM PEIS (DOE 1996) describes the scoping process employed for the PEIS, including the PSA. The scoping process and the comments recorded during it are also described in the Draft Implementation Plan (IP) for the SSM PEIS. Scoping comments on environmental justice stipulated that "thorough investigations of the following should be conducted: proximity of proposed facilities to culturally important areas such as ancient burial grounds; transportation, storage, and disposal of nuclear waste on Native American lands; and cleanup of testing sites" (Draft IP, p. E-5, issue code 12.1). In addition, one comment asked that DOE involve Native Americans in the NEPA process and honor agreements with Native Americans. A number of representatives of American Indian tribes participated in the scoping process. Additional information has also been provided, as appropriate, in response to public comments on the Draft SSM PEIS. The public response process also provided the opportunity for "consultation with affected communities" in "identifying potential effects of mitigation measures."

This analysis is limited to identifying the relevant population characteristics around the candidate NIF sites and does not include an analysis of the waste streams from NIF operations. This approach is taken because wastes would be either stored on the site or "sent off site to a permitted treatment, storage, and disposal facility" (see Section I.3.6.8 of the PSA [DOE 1996, Appendix I]). It is assumed that the permitting process ensures that no high and adverse environmental or human health impacts would be caused by the treatment, storage, and disposal of such wastes.

Methods, assumptions, and data sources are discussed in Section 3.2.7.2; results are discussed in Section 3.2.7.3.

3.2.7.2 Definitions, Methods, and Assumptions

Data on the minority and low-income characteristics of the populations potentially affected by the operation of NIF were taken from the *1990 U.S. Census of Population and Housing* Summary Tape File 3-A on CD-ROM. Consequently, the definitions of minority and low-income correspond to the U.S. Bureau of the Census definitions employed in compiling those data. Specifically, "minority populations" include individuals who report themselves as belonging to any of the following racial groups: Black (reported their race as "Black or Negro," or reported entries such as "African American, Afro-American, Black Puerto Rican, Jamaican, Nigerian, West Indian, or Haitian"); American Indian, Eskimo, or Aleut; Asian or Pacific Islander; or "Other Race." In addition, individuals identifying themselves as of Hispanic origin are also included in the minority category. Hispanics can be of any race, however. To avoid double-counting minority Hispanic individuals, only white Hispanics were included in the number of racially based minorities in a tabulation, since nonwhite Hispanics had already been counted under the appropriate minority racial classifications.

"Low-income" status is based on census data definitions of individuals below the poverty line. For the 1990 census, for example, that included individuals in four-person families with 1989 incomes at or below $12,674. Other poverty thresholds are provided by the Census Bureau for larger and smaller family sizes (U.S. Bureau of the Census 1994).

Interagency Working Group draft definitions exist for the phrases: "disproportionately high and adverse human health effects" and "substantially affect human health." Disproportionately high and adverse human health effects are those effects, including cumulative and/or synergistic effects, that exceed generally accepted levels of risk and fall disproportionately on minority or low-income populations. To substantially affect human health is to increase the measurable incidence of any specific illness, disease, or disorder to a level significantly higher than the national average. Both of these draft definitions may be changed in the final guidelines, which could occasion a revision of the findings reported here.

This section addresses the issue of the potential for impacts from NIF falling disproportionately on minorities or low-income populations. Two measures are employed to determine disproportionality: disproportionality of numbers of individuals at potential risk and disproportionality in the levels of potential impacts. The measure of disproportionality in numbers at risk involves comparing the population in the zone of potential impact with a reference population. For this purpose, the proportions or percentages of the potentially impacted populations (those

residing within 80 km [50 mi] of the potential NIF locations) who are minority or low-income are compared to the corresponding states' populations who are minority or low-income.

The second measure of disproportionality, which focuses on the level of potential impacts, examines the characteristics of the populations within the zone of potential impact at various distances from the risk source. Distance from the risk source frequently means lower potential impacts or lower probability of impacts, especially with airborne pollutants or risk elements. This issue of relative concentrations of the two subpopulations of interest (minorities and low-income persons) within the zone of potential impact is addressed with the measure of distance of the block groups from the candidate NIF locations. Specifically, data exist for each block group concerning the distance from its centroid to the potential NIF location, and the percentages of the block group population consisting of minorities and low-income persons.

Correlation coefficients show both the direction, strength, and statistical significance of the relationships between the distance measure and the demographic characteristics of the block groups. Correlation coefficients can vary from -1 to +1. A positive coefficient between distance and the percent minority or low-income population within a block group indicates that the farther the block group is away from the site, the higher is the percentage of minority or low-income persons within the block group. In that case, the minorities or low-income population would be less likely to be affected by impacts that decline with distance to the site, compared with the non-minority or non-low-income population. A negative coefficient indicates the reverse — that minorities or low-income persons are disproportionately closer to the site compared with their non-minority or non-low-income counterparts and, thus, are more likely to be adversely affected by impacts from the site, assuming such impacts are greater the closer the distance to the site. A coefficient that is statistically insignificant indicates that minorities or low-income persons are neither more nor less concentrated close to the candidate NIF locations relative to their non-minority or non-low-income counterparts.

3.2.7.3 Findings and Discussion

As noted above, two measures of potential disproportionality of impacts on minority or low-income populations are employed in this study. The first measure focuses on the percentages of minority and low-income populations living within the 80-km (50-mi) zone of potential impact compared with the percentages of minority and low-income populations in the state as a whole within which the zone of potential impact is located. Table 3.7 presents the appropriate percentages for comparisons for the five candidate NIF sites. On the basis of this measure, potential environmental justice impacts exist only for minority populations in the 80-km (50-mi) zones around the candidate NIF locations at LANL and NLVF. In each of these cases, minorities are over-represented in the population within the 80-km (50-mi) zone compared with the corresponding state percentages. Low-income populations, in contrast, are not over-represented among the populations within 80 km (50 mi) of any of the five candidate NIF locations.

TABLE 3.7 Percentages of Populations within 80 km (50 mi) of National Ignition Facility Candidate Sites and of States in Which Those Sites Are Located, by Minority and Low-Income Status

	Percent Minority		Percent Low Income	
Site	NIF Site[a]	State	NIF Site[a]	State
LLNL	41	43	7	12
LANL	52	49	14	21
NTS	14	21	10	10
NLVF	25	21	10	10
SNL	45	49	15	21

[a] As measured from the population living within 80 km (50 mi) of the potential NIF site, based on populations living in census tracts with centroids within 80 km (50 mi) of the candidate site.

Source: U.S. Bureau of the Census (1991).

The second measure of potential disproportionality of impacts focuses on the relative concentrations of minority and low-income populations close to the candidate NIF sites, compared with non-minority or non-low-income populations. Specifically, within the 80-km (50-mi) zone of potential impact, are minorities or low-income persons located closer to the NIF site, on average, than are non-minorities or non-low-income persons? If so, then the assumption is made that a potential exists for disproportionate impacts because risks often increase with spatial proximity to the risk source. On the basis of this measure, the potential exists for disproportionate impacts on minorities around the candidate NIF locations at LLNL and NLVF, as shown by statistically negative correlation (-0.064 and -0.410) coefficients for percent minority for these sites (Table 3.8). No such disproportionate concentrations of minorities occur close to any of the other three candidate NIF locations, as shown by the non-significant correlation coefficients in Table 3.8. Likewise, low-income populations are not located disproportionately close to any of the candidate NIF locations, compared with non-low-income populations. The locations of block groups with above state average percentages of minority or low-income persons are shown in Figures 3.11 through 3.20. These maps graphically illustrate the findings discussed above.

As noted, the NLVF site is of particular concern for environmental justice, given that it has negative correlation coefficients between distance from the NIF location and both percentage

TABLE 3.8 Correlation Coefficients for Distance to National Ignition Facility Candidate Sites and Percentage Minority or Percentage Low-Income Populations[a]

Site	Percent Minority	Percent Low Income	Number
LLNL	-0.064*	+0.058*	5,161
LANL	-0.151	+0.023	235
NTS	-0.395	-0.366	26
NLVF	-0.410*	-0.029	333
SNL	+0.036	+0.017	607

[a] An asterisk indicates correlation is statistically significant at or beyond the 0.001 significance level.

Source: U.S. Bureau of the Census (1991).

minority and percentage low income (see Table 3.7). Thus, both minorities and low-income individuals are disproportionately close to the NLVF location. The individual at risk to maximum exposure to radionuclides is located 210 m (689 ft) west of the NLVF location (Table 4.4). The maximum threat zone for heavy gas and other releases from this location is between 75 and 239 m (246 and 784 ft) (Tables 4.8 through 4.11). In all cases, these maximum threat zones are within 1.6 km (1.0 mi) of the potential NIF location, or within the first circular zone for the NLVF site (Figures 3.21 and 3.22). As shown in these figures, the populations in these zones are both disproportionately minority and low-income, compared with the Nevada state averages. Consequently, potential environmental justice impacts are present at the NLVF site for both minority and low-income populations, on the basis of the findings presented here and in Tables 4.4 and 4.8 through 4.11.

In summary, for both measures of assessment, the potential exists for disproportionate impacts on minorities at the NLVF location. The potential also exists for disproportionate impacts on minorities at LLNL, but only because minorities are disproportionately concentrated close to the potential site.

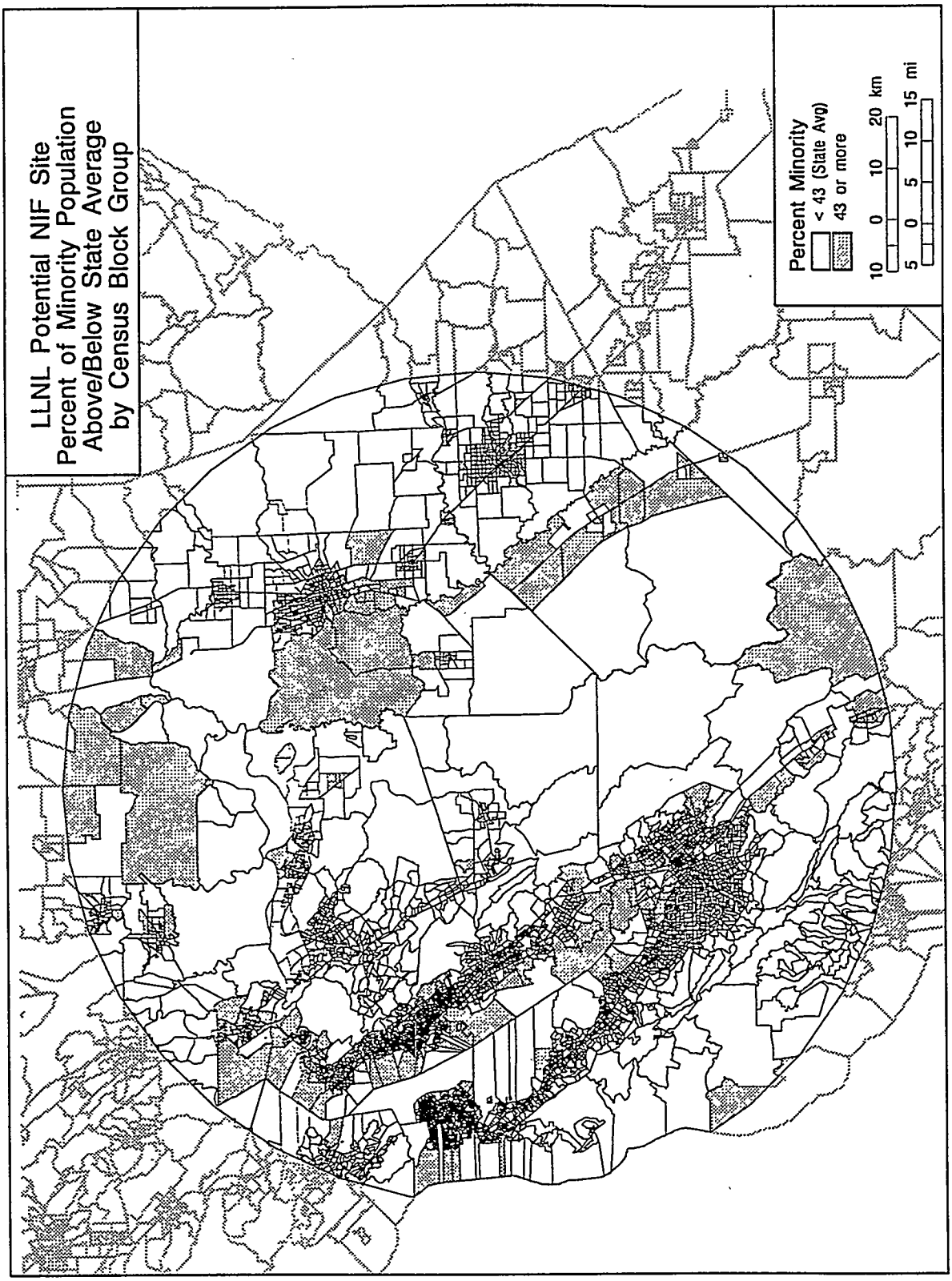

FIGURE 3.11 LLNL Potential NIF Site Percentage of Minority Population Above/Below State Average by Census Block Group

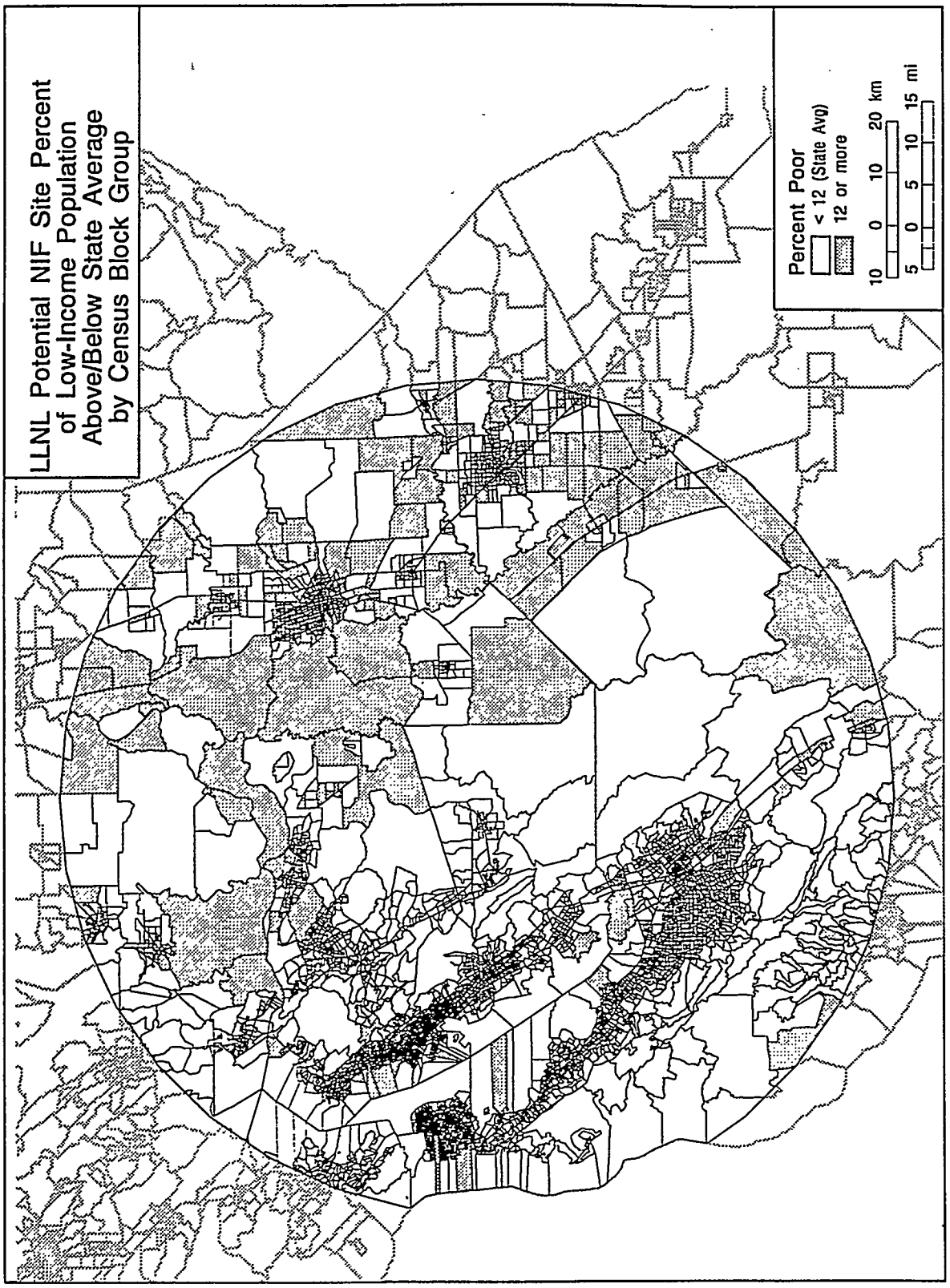

FIGURE 3.12 LLNL Potential NIF Site Percentage of Low-Income Population Above/Below State Average by Census Block Group

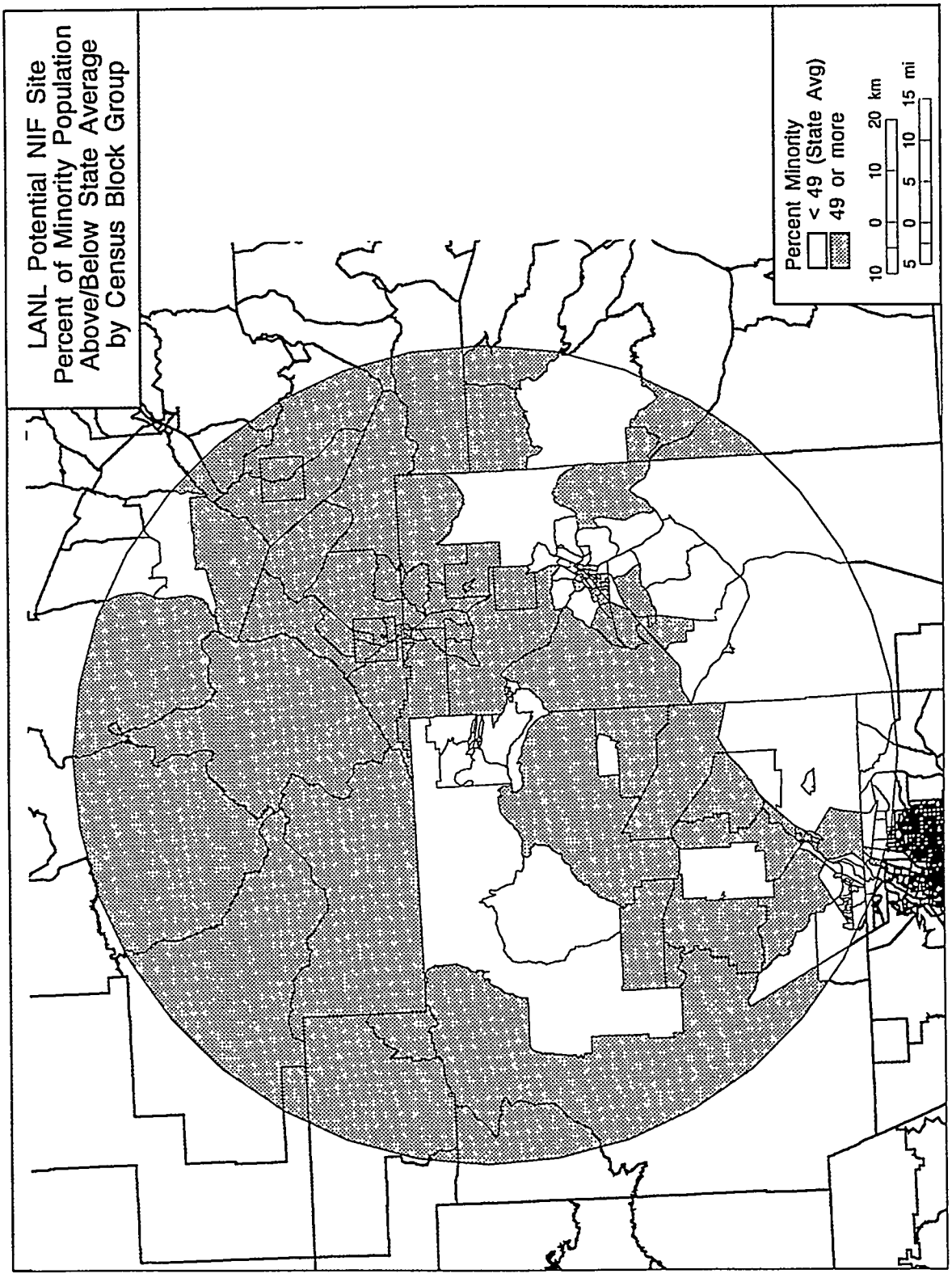

FIGURE 3.13 LANL Potential NIF Site Percentage of Minority Population Above/Below State Average by Census Block Group

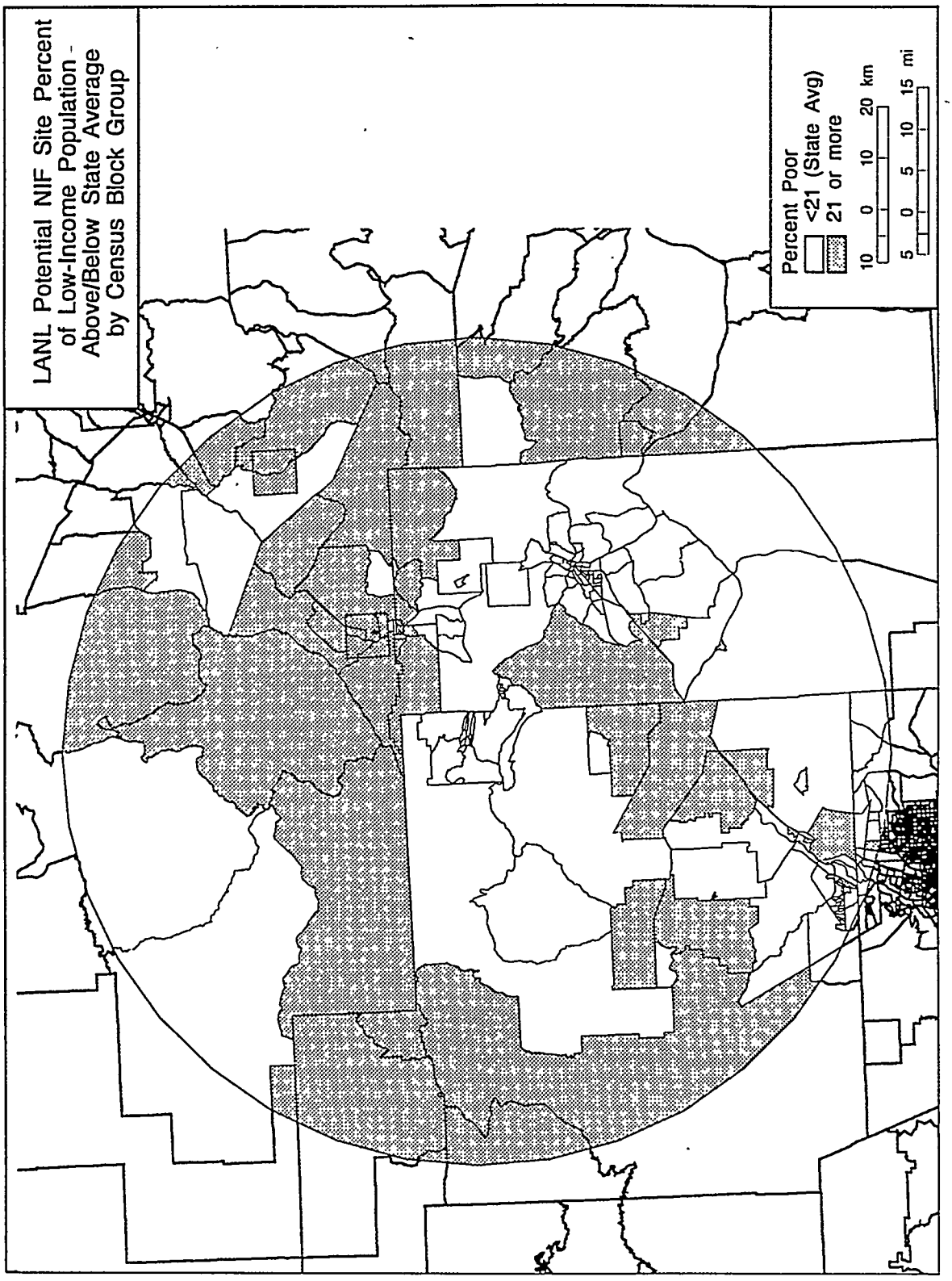

FIGURE 3.14 LANL Potential NIF Site Percentage of Low-Income Population Above/Below State Average by Census Block Group

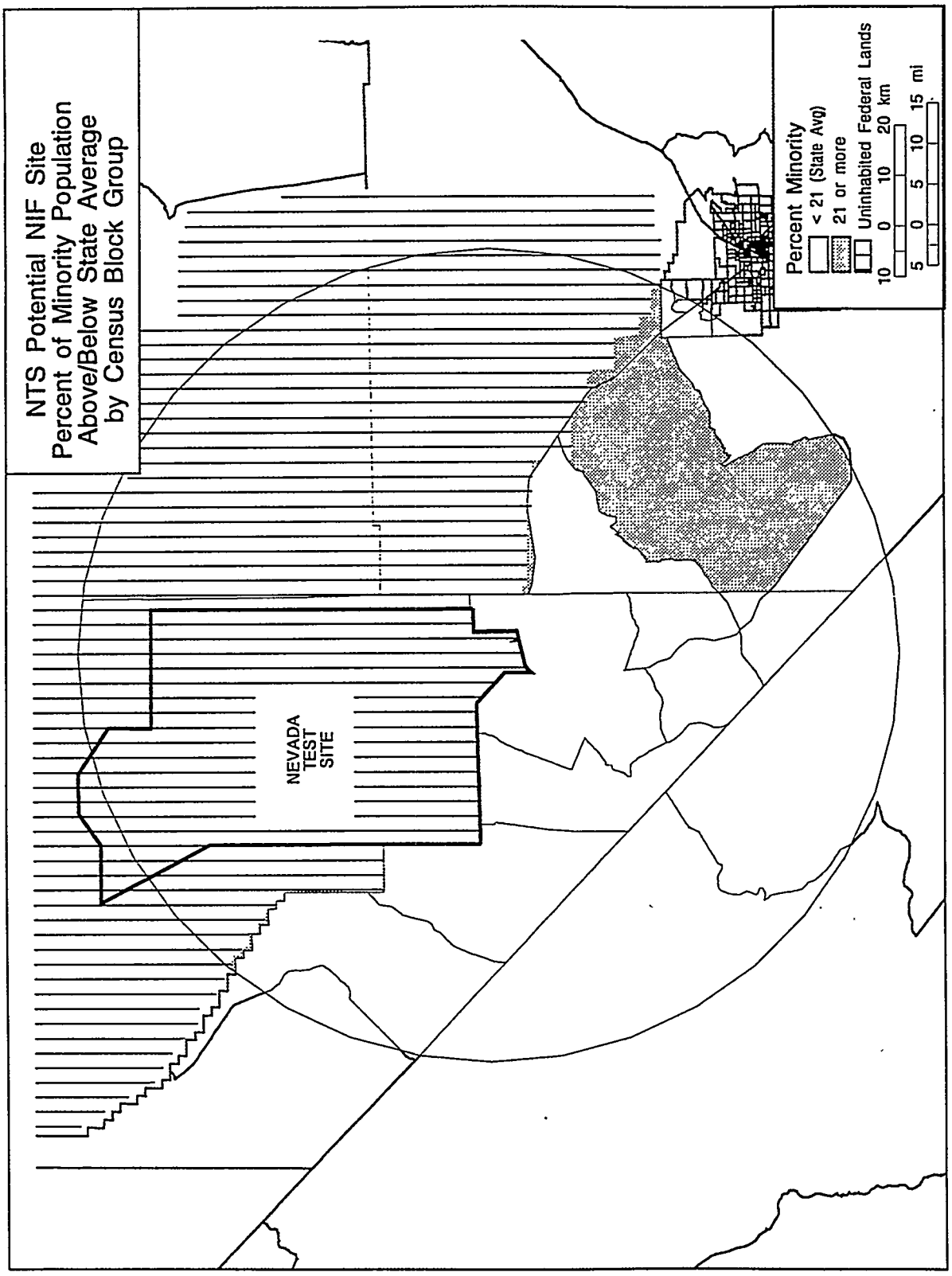

FIGURE 3.15 NTS Potential NIF Site Percentage of Minority Population Above/Below State Average by Census Block Group

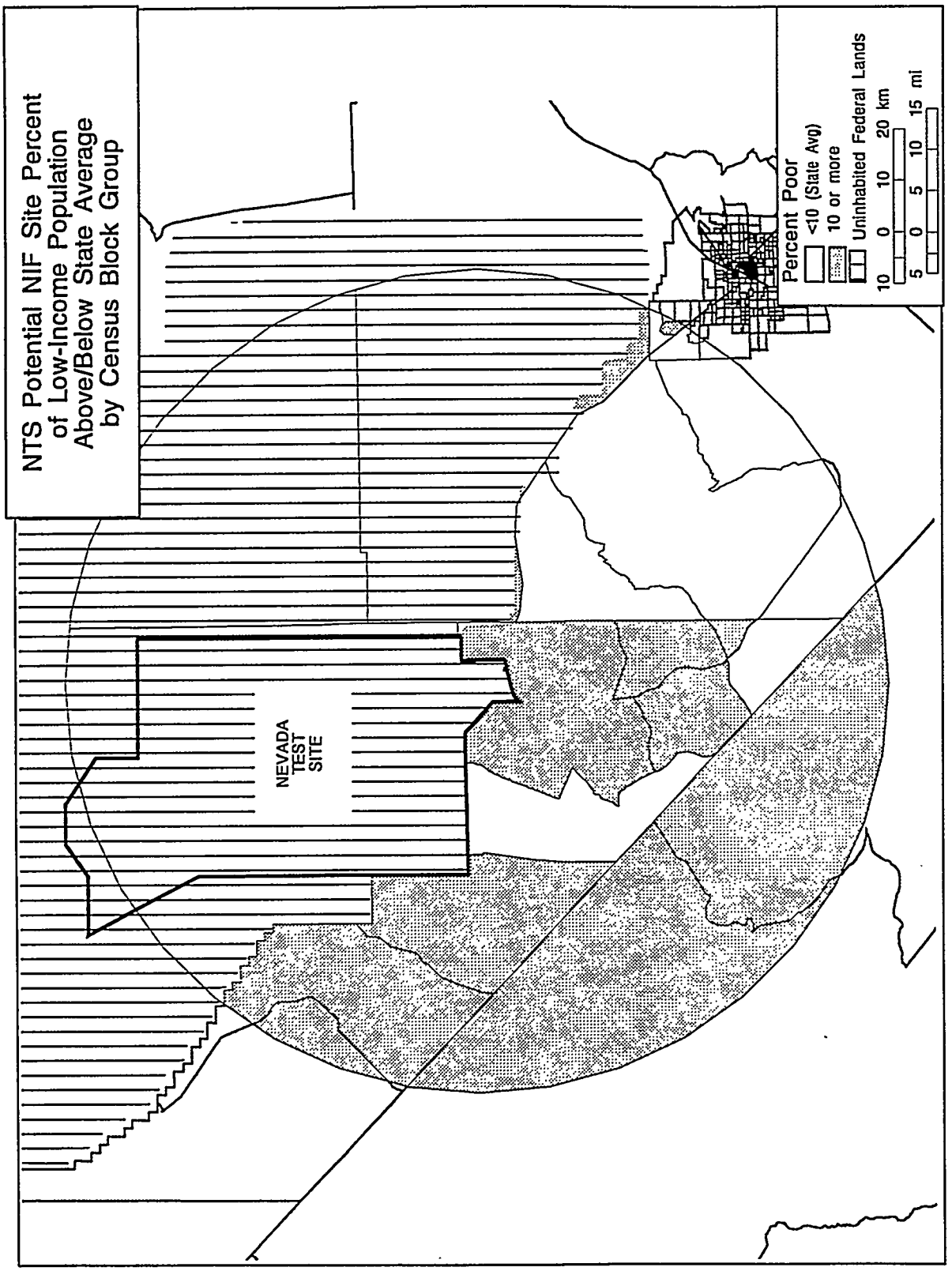

FIGURE 3.16 NTS Potential NIF Site Percentage of Low-Income Population Above/Below State Average by Census Block Group

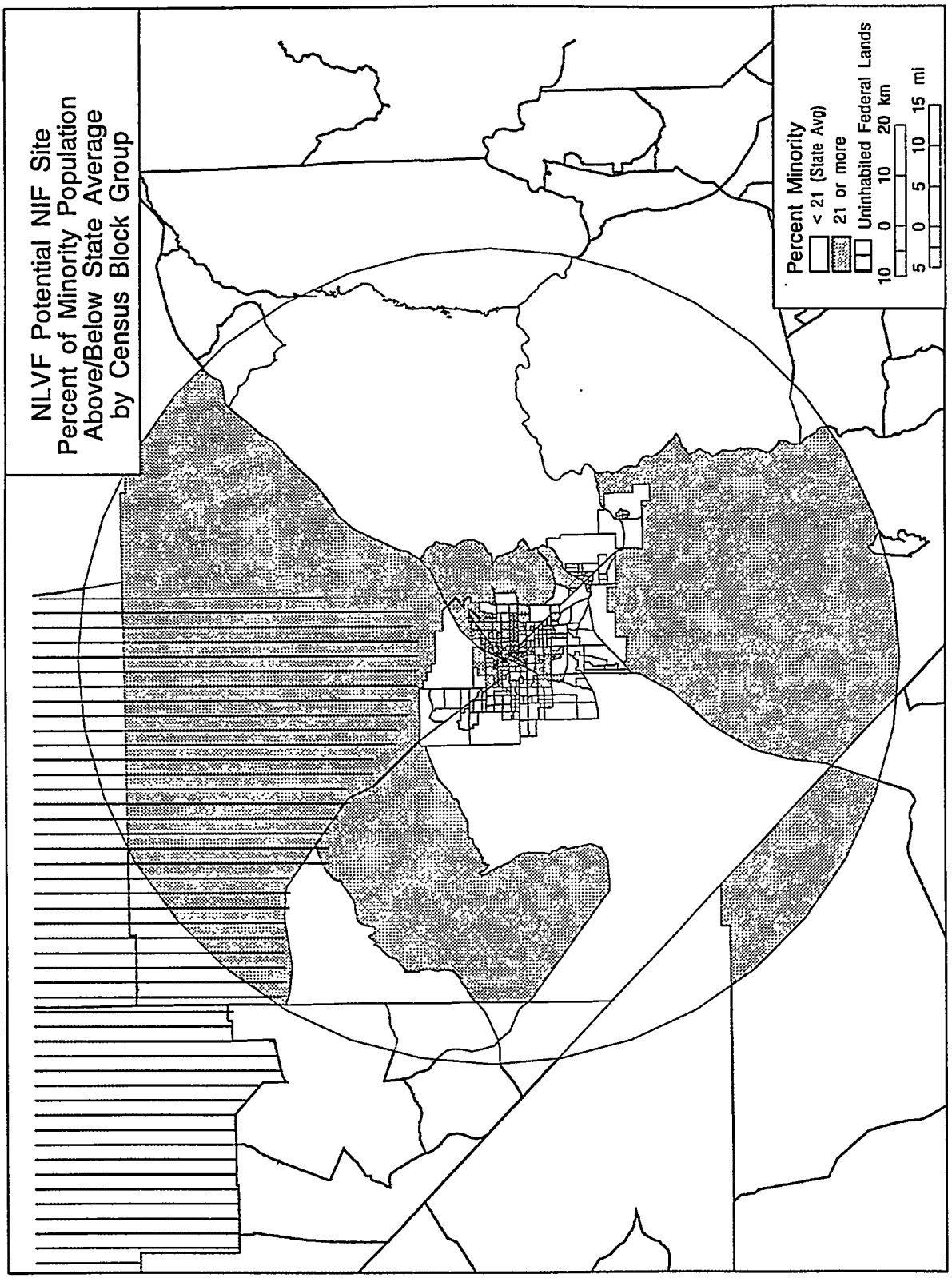

FIGURE 3.17 NLVF Potential NIF Site Percentage of Minority Population Above/Below State Average by Census Block Group

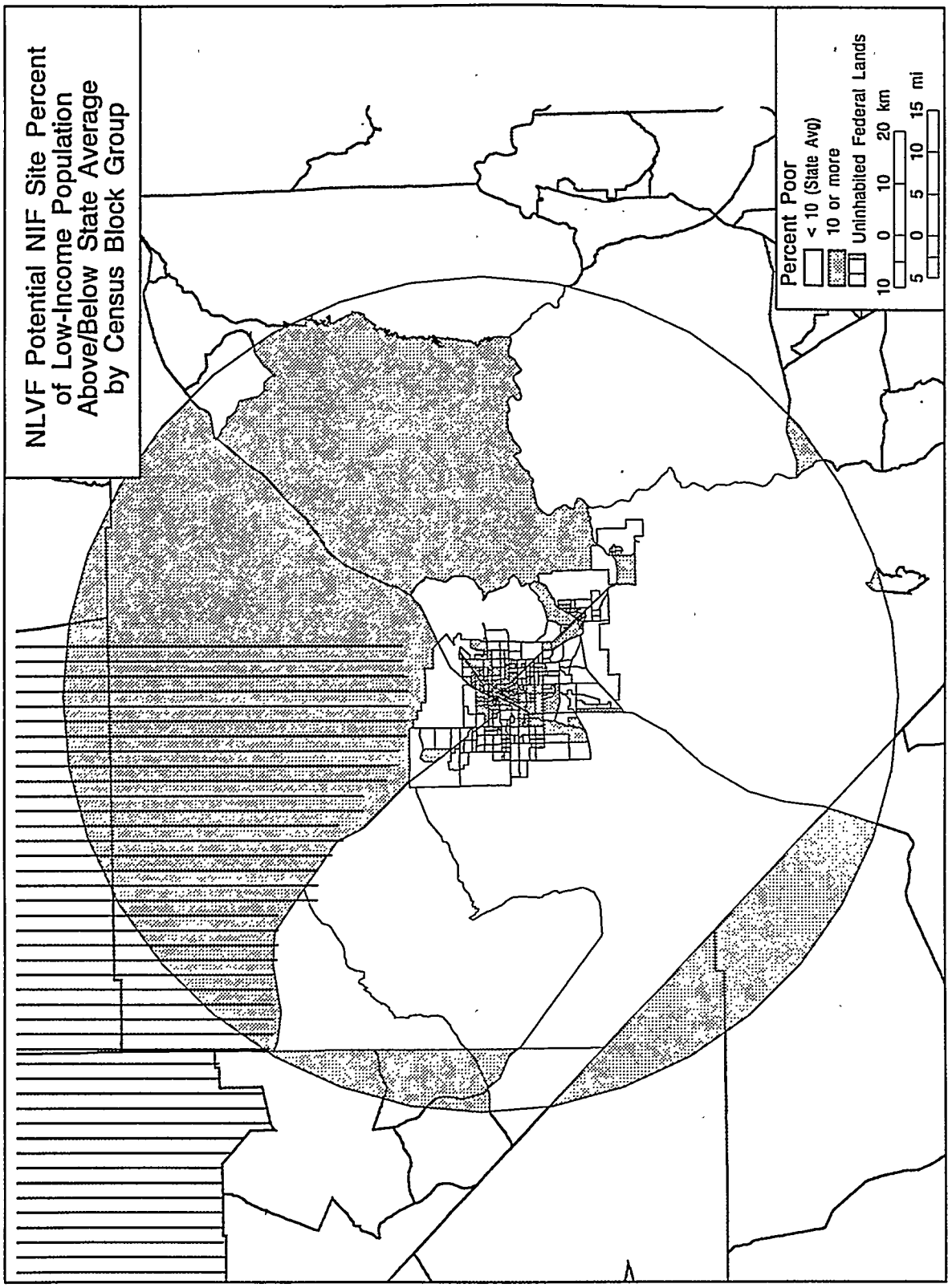

FIGURE 3.18 NLVF Potential NIF Site Percentage of Low-Income Population Above/Below State Average by Census Block Group

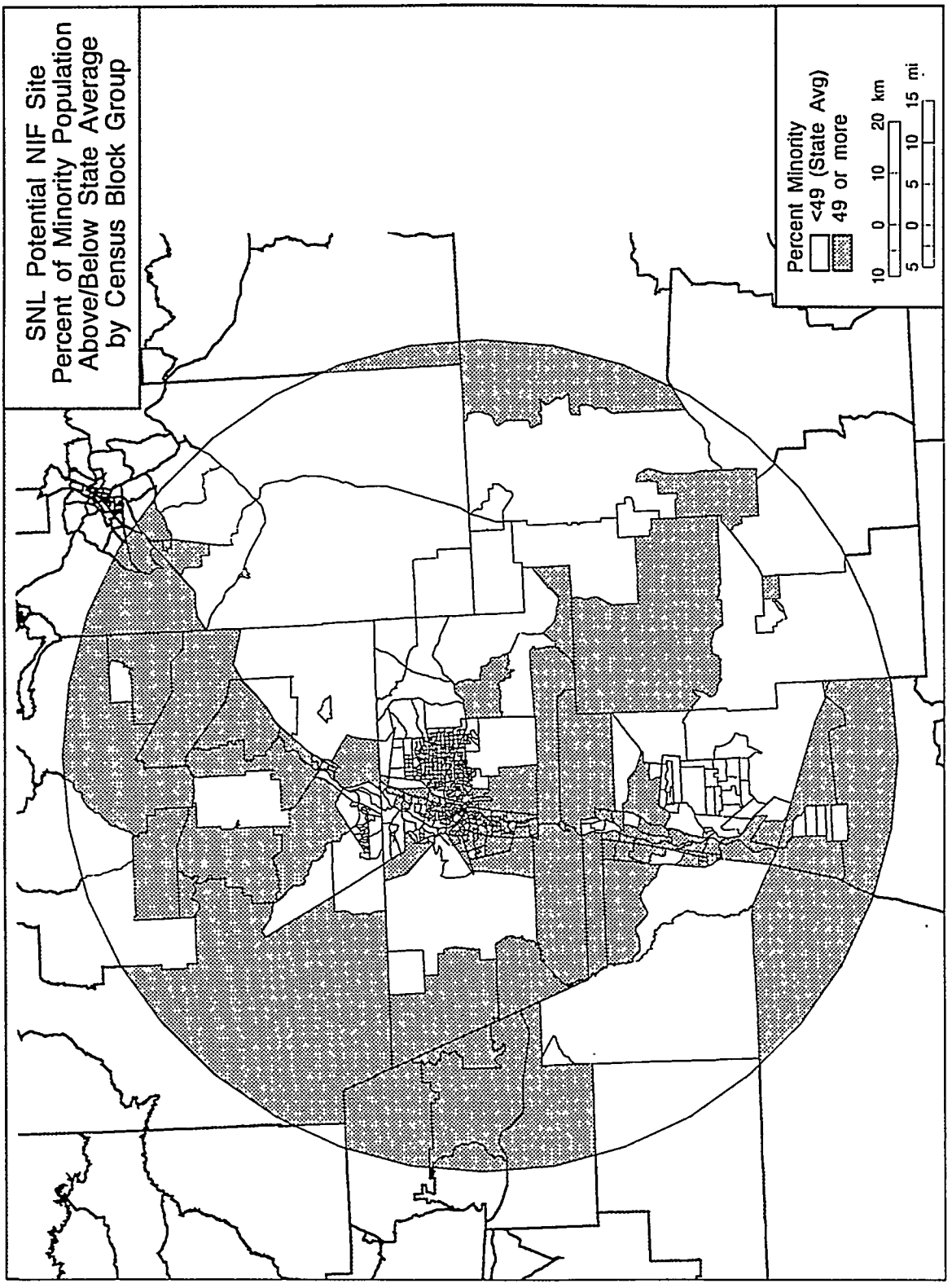

FIGURE 3.19 SNL Potential NIF Site Percentage of Minority Population Above/Below State Average by Census Block Group

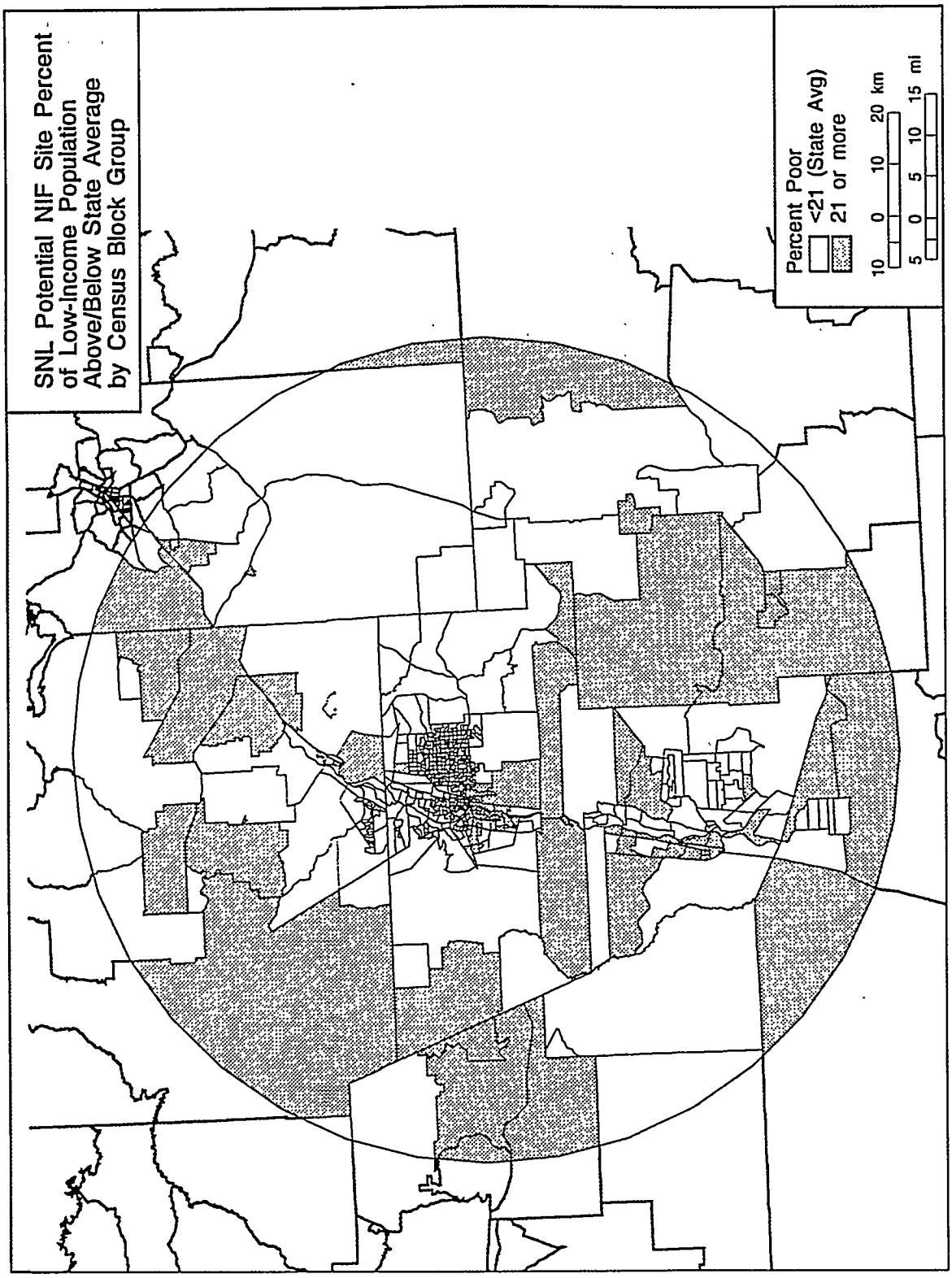

FIGURE 3.20 SNL Potential NIF Site Percentage of Low-Income Population Above/Below State Average by Census Block Group

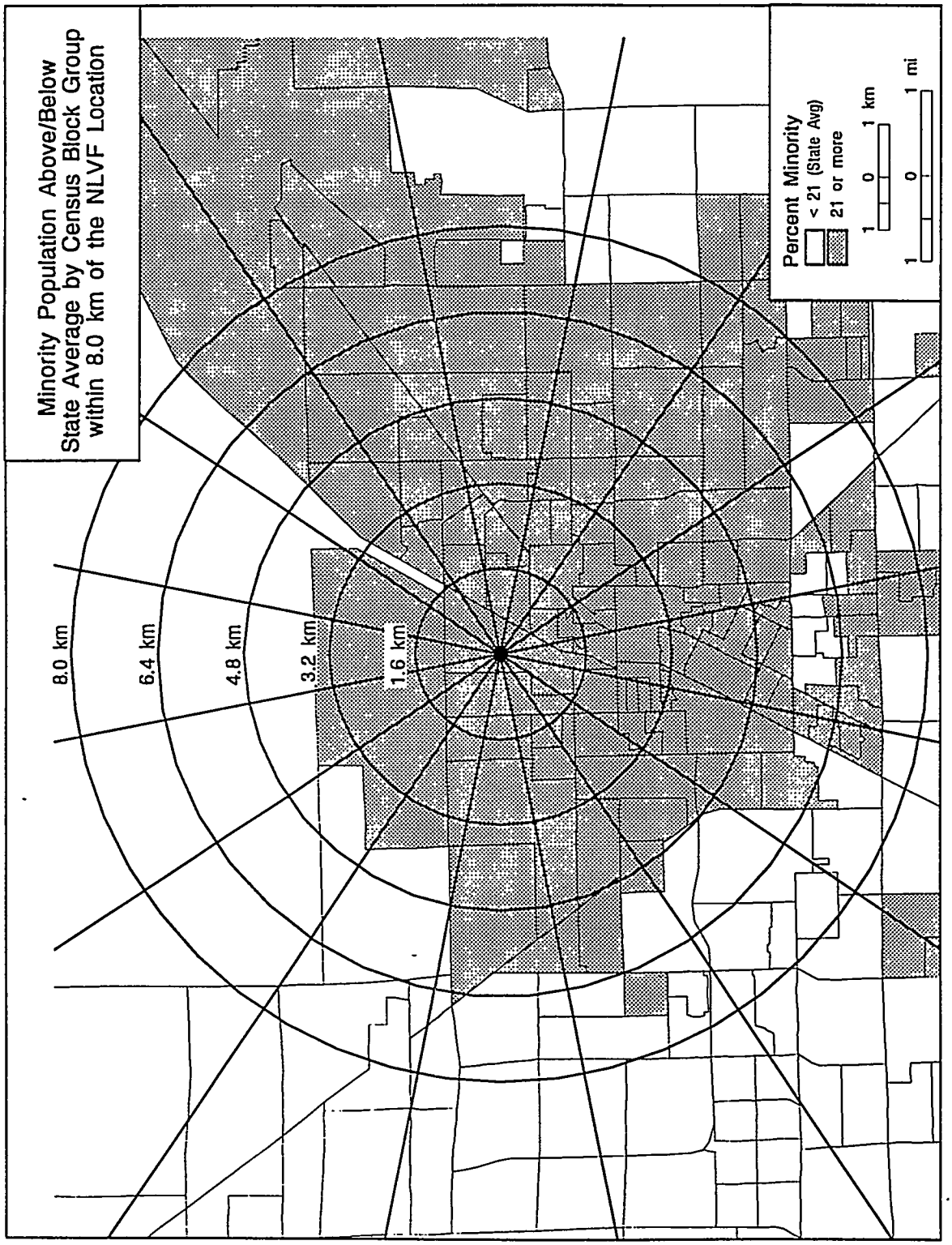

FIGURE 3.21 Minority Population Above/Below State Average by Census Block Group within 8 km (5 mi) of the NLVF Site

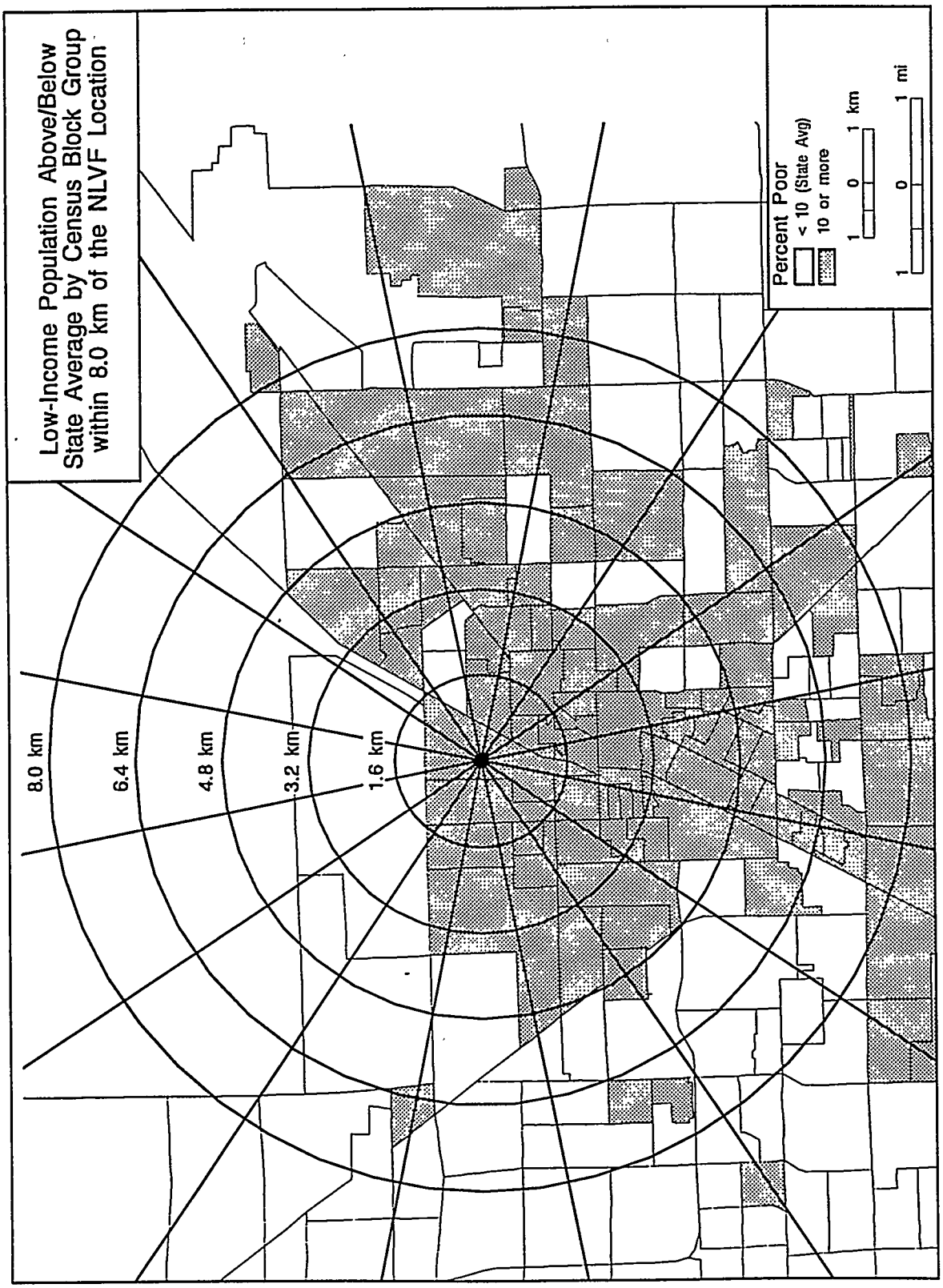

FIGURE 3.22 Low-Income Population Above/Below State Average by Census Block Group within 8 km (5 mi) of the NLVF Site

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4 RADIATION AND HAZARDOUS CHEMICALS

This section describes the methods, data, and assumptions used to estimate radiological, hazardous chemical, and material transportation impacts that could result from the operation of NIF at the five alternative locations analyzed in the PSA (Appendix I, DOE 1996).

4.1 RADIOLOGICAL IMPACT ASSESSMENT

4.1.1 Sources of Radiation

NIF would house a powerful multi-beamline laser. During a fusion experiment, each beam of light would be focused and directed onto a target containing fusion fuel (a deuterium-tritium mixture). The fusion experiment would emit neutrons, energetic particles, debris, and x-rays. The energetic particles, debris, and x-rays would be confined by the 5-m (16-ft) inner-radius aluminum alloy target chamber. The 0.1-m (0.3-ft) -thick target chamber would be housed in a cylindrical (30.5-m [100-ft] -diameter by 29.3-m [96-ft] -tall), reinforced-concrete building. The target chamber would be surrounded by a 0.4-m (1.3-ft) -thick concrete shield. Most neutrons would travel through the target chamber and local shielding structure before being stopped by concrete walls. Some neutrons would activate the target chamber, gases in the air, and concrete and reinforcing bars (rebars) in the walls. The cylindrical Target Area Building would have a 1.83-m (6.0-ft) -thick concrete wall and a 1.22-m (4.0-ft) -thick concrete roof to shield direct radiation of neutrons and their induced gamma rays. The switchyard building would have a 1.22-m (4.0-ft) -thick concrete wall and a 0.61-m (2.0-ft) -thick concrete roof. With such shielding design, direct radiation exposure to the general public would be negligibly small (Singh et al. 1995). Most of the unburned tritium would be exhausted to the tritium processing system, while a small amount would be adsorbed onto the target chamber wall.

During normal NIF operations, up to 1,200 fusion experiments (with 25% involving tritium) would be conducted each year. These experiments would result in chronic atmospheric releases of small quantities of tritium and some radionuclides produced from activation of gases in the air.

For impact analysis, a bounding accident was postulated on the basis of a preliminary hazard analysis. The bounding accident assumed that a severe earthquake occurs during a maximum-credible-yield fusion experiment. With a small number of maximum-yield experiments projected for each year of NIF operation, the frequency of the accident would be less than 2×10^{-8}/yr (Brereton 1995). It was assumed that beamlines leading into the target chamber and building structures other than the Target Area Building would fail during the postulated earthquake. The collapsed beamlines

and building structures would provide a pathway for acute atmospheric releases of tritium in the tritium processing system, activated gases in the air, and activated material in the target chamber.

Although radiological impacts from the postulated accident described above would bound all other potential accidents, a brief discussion of a possible light aircraft crash event is warranted. The likelihood of that event's occurring at the Target Area Building was estimated to be approximately 4×10^{-5}/yr (Kimura 1996). The thick, reinforced concrete structure of this building would withstand the impact of a direct aircraft hit. Thus, no release of radioactive material would be expected. However, the NIF Diagnostics Building, which would have a metal frame with steel siding, could be severely damaged if it were to be hit by an aircraft. As a result, a total of up to 75 Ci of tritium in the target handling area could be released. The impact from this tritium release would be bounded by the postulated bounding accident already analyzed in this study.

The released radionuclides would be dispersed and transported through air in patterns determined by meteorological conditions and would reach downwind humans directly or through the foods they eat. Potential routes through which radiation can enter the human body include external exposure to, inhalation of, or ingestion of radionuclides.

4.1.2 Assessment Methods

Radiological impacts were estimated in terms of potential radiation doses received by a human body and the resulting risk of cancer fatalities. The cancer fatality statistics referred to in this study are latent cancer fatalities, which are of deaths from cancer that occur within 30 years following exposure to radiation.

The GENII computer program (Napier et al. 1988) was used to model chronic and acute releases of radionuclides and to calculate radiation doses to the surrounding public and workers at the five candidate sites during normal operations and under postulated accident conditions at the NIF location. The GENII program models atmospheric dispersion of radionuclides with a straight-line Gaussian-plume model. Radiation doses calculated with GENII were converted into health effects on the basis of the *1990 Recommendations of the International Commission on Radiological Protection* (Publication 60) (ICRP 1991). The conversion factors are 5×10^{-4} cancer fatality per person-rem for the public and 4×10^{-4} for workers.

4.1.3 Model Input

4.1.3.1 Source Term Data

Tables 4.1 and 4.2 list the source terms, or the quantities of radionuclides released to the environment over a period of time, for both the Conceptual Design Option and the Enhanced Option. These source terms were used to estimate the impacts of normal operations and a postulated accident.

4.1.3.2 Meteorological Data

Table 4.3 lists available site-specific meteorological data used in atmospheric dispersion calculations for releases from NIF at the five candidate sites.

4.1.3.3 Population Data

Data from the 1990 census (U.S. Bureau of the Census 1991) were used to derive population distributions around the sites, and current workforce information was used to estimate

TABLE 4.1 Radiological Source Terms from Normal National Ignition Facility Operations

		Quantity Released (Ci/yr)	
Radionuclide	Half-Life	Conceptual Design Option	Enhanced Option
Tritium	12 yr	10	30
Nitrogen-13	10 min	21	86
Nitrogen-16	7.1 s	41	170
Sulfur-37	5.0 min	0.3	1.4
Chlorine-40	1.4 min	0.3	1.4
Argon-41	1.8 h	17	54
Carbon-14	5,700 yr	4.5×10^{-4}	1.5×10^{-3}

Source: Singh et al. (1995).

TABLE 4.2 Radiological Source Terms for a Postulated Accident at the National Ignition Facility

		Quantity Released (Ci)	
Radionuclide	Half-Life	Conceptual Design Option	Enhanced Option
Tritium	12 yr	300	500
Nitrogen-13	10 min	7.9	24
Nitrogen-16	7.1 s	150	570
Sulfur-37	5.0 min	2.0×10^{-1}	6.0×10^{-1}
Chlorine-40	1.4 min	6.0×10^{-1}	1.7
Argon-41	1.8 h	1.4	3.3
Carbon-14	5,700 yr	2.4×10^{-5}	5.5×10^{-5}
Sodium-24	15 h	4.8×10^{-5}	4.8×10^{-4}
Magnesium-27	9.4 min	3.0×10^{-3}	3.0×10^{-2}
Aluminum-28	2.2 min	4.0×10^{-3}	3.0×10^{-2}
Aluminum-29	6.5 min	2.5×10^{-6}	2.5×10^{-5}
Vanadium-52	3.8 min	5.0×10^{-3}	1.0×10^{-2}
Chromium-51	28 d	1.0×10^{-6}	8.5×10^{-6}
Chromium-55	3.5 min	2.0×10^{-3}	5.0×10^{-3}
Manganese-54	310 d	5.5×10^{-7}	5.5×10^{-5}
Manganese-56	2.6 h	7.0×10^{-4}	2.0×10^{-3}
Cobalt-58	71 d	1.3×10^{-8}	2.5×10^{-7}
Cobalt-60	5.2 yr	2.4×10^{-8}	1.1×10^{-5}
Cobalt-60m	10 min	9.0×10^{-3}	2.0×10^{-2}
Cobalt-62m	14 min	1.0×10^{-3}	2.0×10^{-3}
Nickel-57	36 h	7.5×10^{-8}	1.7×10^{-7}
Copper-62	9.7 min	2.1×10^{-1}	4.8×10^{-1}
Copper-64	13 h	3.0×10^{-3}	6.0×10^{-3}
Copper-66	5.1 min	5.9×10^{-4}	1.0×10^{-3}
Zinc-63	38 min	3.6×10^{-7}	3.6×10^{-6}
Platinum-197	18 h	3.1×10^{-6}	7.0×10^{-6}
Gold-196	6.2 d	4.5×10^{-4}	2.0×10^{-3}
Gold-198	2.7 d	5.0×10^{-6}	1.3×10^{-5}

Source: Brereton (1995).

TABLE 4.3 Site-Specific Meteorological Data

Site	Tower Location	Data Period
LLNL	On-site	1990–1994
LANL	TA-6, on-site	1990–1994
NTS	MEDA DRA, on-site	1978–1988
NLVF	Las Vegas Int'l. Airport	1987–1991
SNL	On-site	1994

worker distribution at the sites. The population was spatially distributed on a circular grid with 16 directions and 10 radial distances up to 80 km (50 mi). The grid was centered on the proposed NIF location at each candidate site.

4.1.3.4 Locations of Maximally Exposed Individual

Table 4.4 lists the distance and direction of the maximally exposed individual (MEI) relative to the proposed NIF location at the five candidate sites. The MEI is a hypothetical nearby individual who would receive the highest radiation dose of all the surrounding general population.

4.1.4 Assumptions

Key assumptions used in estimating the radiological impacts were as follows:

- The release of radionuclides is at 27 m (89 ft) above ground during normal NIF operations, and at ground level under accident conditions.
- All tritium releases are in the form of tritiated water.
- The absolute humidity is 0.009 L/m^3 (0.002 gal/yd^3) for LLNL and 0.005 L/m^3 (0.001 gal/yd^3) for other sites.
- Radionuclides of either small quantity or short half-life are not included in GENII calculations. The radiation dose that they contribute to the surrounding public is negligible (Brereton 1995).

- The accident occurs immediately before the annual crop harvest.
- Radiation dose from resuspension of particulates after deposition is negligible.
- No prior deposition of radionuclides on ground surfaces has occurred.

TABLE 4.4 Location of Maximally Exposed Individual[a]

Site	Distance (m)	Direction
LLNL	400	E
LANL	1,620	NNE
NTS	20,000	SSW
NLVF	210	W
SNL	1,864	N

[a] Distance and direction relative to proposed NIF location.

4.2 HAZARDOUS CHEMICAL IMPACT ASSESSMENT

4.2.1 Assessment Procedure

The normal operation of NIF would require the use of numerous chemicals. The assessment of potential impacts of those chemicals began by first determining which are potentially hazardous because of toxicity or other harmful effects, such as asphyxiation. The next step was to identify scenarios that could cause an accidental release of those chemicals. Release scenarios were identified and evaluated for both Conceptual Design and Enhanced options for each of the five candidate NIF sites.

Five bounding chemical release accidents were developed for evaluation. These events were derived from the Preliminary Hazards Analysis (PHA) (Brereton 1993). They were derived from general considerations of the NIF design and are, therefore, applicable to any of the five candidate NIF sites. In addition, an accidental propane gas release was evaluated for the NTS (exclusively) as a sixth scenario. The large propane storage tanks are unique to the NTS and are independent of NIF itself.

Estimated inventories of chemicals for the Conceptual Design and Enhanced options are provided in Tables 4.5 and 4.6, respectively. The inventories include agents for cleaning, electrical equipment use, optics treatment, and fire wall protection. The inventories were examined to determine which chemicals have hazardous or exposure criteria thresholds. The criteria were weighted against release amounts to determine which chemicals could possibly present risk. Generally, NIF would maintain relatively higher inventories of materials with lower toxicity. Most chemicals can be conservatively eliminated from consideration by jointly weighting these two factors. On the basis of these combined factors, five materials were identified as potential sources of concern under four accident scenarios. These materials and scenarios apply generally to NIF wherever its location. Parameters for the Conceptual Design and Enhanced release scenarios are summarized in Table 4.7.

TABLE 4.5 Estimated Chemical Inventories for the National Ignition Facility Conceptual Design Option

Chemical	Source	Quantity
Acetone	Solvent for cleaning	38 L (30 kg)
Alumina (aluminum oxide)	Particulates from first wall	6.7 kg
Ammonium hydroxide (50% wt)	Optics treatment	38 L (~38 kg ammonia-equivalent)
Copper	Particulates from cryostat	<0.5 kg
Ethanol	Solvent for cleaning and optics treatment	1,514 L[a] (~1,200 kg)
Fluorinert[b]	Optics treatment	151 L
Fused silica[c]	Particulates from ablated debris shield	2.1 kg
	Lenses, windows, debris shields, deformable mirrors	96.5 kg[d]
Gold	Particulates from hohlraum	<1 kg
Hafnium oxide	Optics coating	0.07 kg[e]
Hydrofluoric acid (151 L at 1% wt, 1.9 L at 52% wt)	Optics treatment	208 L (~22 kg hydrogen fluoride)
KDP (potassium dihydrogen phosphate)	Frequency conversion crystals	
KH_2PO_4		3.2 kg
$KD_{1.2}H_{0.8}PO_4$ (deuterated)		7.6 kg
Mercury	Ignitrons[f]	450 L (~6,200 kg[g])

TABLE 4.5 (Cont.)

Chemical	Source	Quantity
Sodium hydroxide (189 L at 3% wt, 76 L at 50% wt, or solid pellets)	Cleaner for debris shields	265 L (~82 kg sodium hydroxide)
Stainless steel	Particulates from target positioner	<0.2 kg
Teflon[h]	Optics treatment	3 kg
Tetraethylorthosilicate[i]	Optics treatment	379 L (353 kg)
Zirconium oxide	Optics coating	0.003 kg

[a] Single-container inventories will not exceed 189 L.

[b] Consists of perfluoro compounds (C5-18); actual composition is proprietary. The hazards associated with the vapors of fluorinert are low, but decomposition products, including hydrogen fluoride and perfluoroisobutylene (PFIB), may be produced at elevated temperatures (>100°C). The threshold limit value (TLV) (ceiling) for PFIB is 0.082 mg/m^3.

[c] In addition to fused silica, borosilicate and laser glass are used for optics components. They are not listed here because they are solids, and no release mechanism has been identified.

[d] Total quantity per beamline, consisting of 3.6-kg debris shield, 15.3-kg final focusing lens, two 10.9-kg transfer spatial filter lenses, two 10.4-kg cavity spatial filter lenses, 5.6-kg gas box window, two 11.2-kg switch windows, and 7.1-kg deformable mirror.

[e] Total quantity per beamline.

[f] Ignitrons are high-current switches used to discharge energy storage capacitors, which are used to fire laser flashlamps.

[g] Single ignitron inventories are approximately 6.5 kg (0.47 L).

[h] Polytetrafluoroethylene. Decomposition products, such as PFIB, may be formed at elevated temperatures (>450°C).

[i] Tetraethylorthosilicate can potentially form silicon dioxide, which has a TLV of 2 mg/m^3.

TABLE 4.6 Estimated Chemical Inventories for the National Ignition Facility Enhanced Option

Chemical	Source	Quantity
Acetone	Solvent for cleaning	38 L (30 kg)
Alumina (aluminum oxide)	Particulates from first wall	29.6 kg
Ammonium hydroxide (50% wt)	Optics treatment	38 L (~38 kg ammonia-equivalent)
Copper	Particulates from cryostat	<0.9 kg
Ethanol	Solvent for cleaning and optics treatment	1,514 L[a] (~1,200 kg)
Fluorinert[b]	Optics treatment	151 L
Fused silica[c]	Particulates from ablated debris shield	4.4 kg
	Lenses, windows, debris shields, deformable mirrors	96.5 kg[d]
Gold	Particulates from hohlraum	<1.7 kg
Hafnium oxide	Optics coating	0.07 kg[e]
Hydrofluoric acid (40 gal at 1% wt, 0.5 gal at 52% wt)	Optics treatment	208 L (~22 kg hydrogen fluoride)
KDP (potassium dihydrogen phosphate)	Frequency conversion crystals	
KH_2PO_4		3.2 kg
$KD_{1.2}H_{0.8}PO_4$ (deuterated)		7.6 kg
Mercury	Ignitrons[f]	450 L (~6,200 kg[g])

TABLE 4.6 (Cont.)

Chemical	Source	Quantity
Sodium hydroxide (50 gal at 3% wt, 20 gal at 50% wt, or solid pellets)	Cleaner for debris shields	265 L (~82 kg sodium hydroxide)
Stainless steel	Particulates from target positioner	<0.6 kg
Teflon[h]	Optics treatment	3 kg
Tetraethylorthosilicate[i]	Optics treatment	379 L (353 kg)
Zirconium oxide	Optics coating	0.003 kg

[a] Single-container inventories will not exceed 189 L.

[b] Consists of perfluoro compounds (C5-18); actual composition is proprietary. The hazards associated with the vapors of fluorinert are low, but decomposition products, including hydrogen fluoride and perfluoroisobutylene (PFIB), may be produced at elevated temperatures (>100°C). The TLV (ceiling) for PFIB is 0.082 mg/m^3.

[c] In addition to fused silica, borosilicate and laser glass are used for optics components. They are not listed here because they are solids, and no release mechanism has been identified.

[d] Total quantity per beamline, consists of 3.6-kg debris shield, 15.3-kg final focusing lens, two 10.9-kg transfer spatial filter lenses, two 10.4-kg cavity spatial filter lenses, 5.6-kg gas box window, two 11.2-kg switch windows, and 7.1-kg deformable mirror.

[e] Total quantity per beamline.

[f] Ignitrons are high-current switches used to discharge energy storage capacitors, which are used to fire laser flashlamps.

[g] Single ignitron inventories are approximately 6.5 kg (0.47 L).

[h] Polytetrafluoroethylene. Decomposition products, such as PFIB, may be formed at elevated temperatures (>450°C).

[i] Tetraethylorthosilicate can potentially form silicon dioxide, which has a TLV of 2 mg/m^3.

TABLE 4.7 Summary of Chemical Accident Release Scenarios for the National Ignition Facility[a]

Release Scenario	Vulnerable Inventory (kg)	Release Fraction	Total Quantity Released (g)	Release Duration	Release Height
Mercury					
Equipment Failure	6.5	1.0×10^{-2}	65	30 min	17 m
Aircraft Accident	51.5	1.0	51,500	10 min	Ground level
Alumina (earthquake)	6.7 (29.6)	1.0×10^{-3}	6.7 (29.6)	7.6 min[b]	Ground level
Silica (earthquake)	2.1 (4.4)	1.0×10^{-3}	2.1 (4.4)	7.6 min[b]	Ground level
Hydrogen fluoride (overheating)	273 fluorinert (151 L)	1.0×10^{-4}	27.3	1 h	Ground level
	3 kg Teflon	3.8×10^{-1}	1,145		
Carbonyl fluoride (overheating)	3 kg Teflon	6.3×10^{-1}	1,890	1 h	Ground level
Propane[c] (leak)	56,780 L	1.0	56,780 L	1 h	Ground level

[a] Values are the same for conceptual design and enhanced options except for vulnerable inventory and total quantity released for alumina and silica. Values in parentheses for those two materials are for the enhanced option.

[b] Corresponds to a wind speed of 1 m/s. See text for release durations corresponding to other wind speeds.

[c] Propane is present only at NTS. Modeling was not performed for propane at the other candidate sites.

4.2.2 Mercury Release Scenarios and Results

4.2.2.1 Switch Rupture

Mercury was identified as a concern because of its low threshold limit value of 0.025 mg/m^3 (American Conference of Government Industrial Hygienists [ACGIH 1994]) and ceiling of 0.1 mg/m^3 (Occupational Safety and Health Administration [OSHA]) (ACGIH 1994). It

would be used in the ignitron switches[1] in the capacitor bank bays of NIF. Approximately 200 switches would be used in the bays, and each would contain 0.473 L (0.125 gal) of mercury. Given the low toxic threshold for mercury, a single switch rupture would potentially present a chemical hazard. The Conceptual Design and Enhanced options have identical power supply requirements, so a mercury release resulting from equipment failure would be the same in either case.

This first accident scenario for a mercury release results from the failure of a water-cooled tube due to repeated electrical arcing with the eccentric anode. When this happened, water vapor might possibly fill the ignitron tube. The resulting pressurization could then produce a spray release of mercury. Such a failure is estimated to have a probable frequency of between 10^{-4} and 10^{-6} per year. A release fraction of 10^{-2} is estimated for the 0.473 L (0.125 gal) of mercury in the ignitron (Mishima 1993). This assumption yields a conservative estimate of 65 grams (2.29 oz) of mercury released over a period of 30 minutes; a longer release time would imply lower concentration levels of longer duration. The time period is chosen to be conservatively small since the ventilation rate is not known. The release mass includes vapor and droplets having diameters of 50 μm or less.

The second accident scenario for a mercury release results from the crash of a light aircraft and the resulting fire. Such an accident at the NIF Laser and Target Area Building was found to be a credible event (Kimura 1996), with the capacitor bays being the primary area of concern for a mercury release. Most of the mass of an airplane is associated with the engine. Given that the engine of a light aircraft is much smaller than a single capacitor bay module, it was assumed that no more than two equivalent capacitor bay modules would be damaged under this accident scenario. Each capacitor bay module contains 20 capacitors and 4 switches; therefore, a total of 40 capacitors and 8 switches are assumed to be severely damaged as a result of the accident and associated fire. The vulnerable inventory of mercury is 51.5 kg. The total energy available from the resulting fire was determined to be sufficient to release the entire inventory of mercury over a 10-minute fire duration.

The threshold limit value, time-weighted averages (TLV-TWAs) for hazardous chemicals are typically used by the ACGIH as limits for repeated exposure over time, such as a 40-hour work week over many years. The limits are overly conservative in the context of a single event, such as the accident scenarios analyzed here for NIF. Exposure criteria for chemicals such as mercury are set low for repeated exposure because of the high toxicities. Mercury tends to accumulate in the human body, so any permissible long-term exposure must be low. Since the accident for NIF is assumed to occur only once (leading to a single acute impact), the TLV-TWA was multiplied by five to arrive at an effective Emergency Response Planning Guideline-2 (ERPG-2) (American Industrial Hygiene Association 1988) exposure criterion of 0.125 mg/m^3.

Five of the six accident scenario analyses were carried out with the ALOHA model (Reynolds 1992), a model that is commonly used for emergency response planning. The sixth accident scenario, the aircraft accident and resulting fire, was modeled with the FIREPLUME model

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[1] Ignitron switches are high-current switches used to discharge energy storage capacitors, which are used to fire laser flashlamps.

(Brown 1996). The ALOHA model uses several source models to compute the release rate as a function of time. It then uses either a neutrally buoyant or heavy gas model to treat downwind dispersion. Finally, it predicts the edge of the hazard zone of the plume on the basis of health criteria values used as input to the model as appropriate for the chemical or chemicals emitted.

Like the ALOHA model, the FIREPLUME model consists of two components. The first component is a Monte Carlo model that estimates the dispersion of both buoyant and nonbuoyant chemical releases in the atmospheric boundary layer. The second component is a puff dispersion model that is based in part on a Monte Carlo model. The FIREPLUME model is used to predict ground-level concentrations resulting from the release of a hazardous material within an instantaneously discharged thermal (i.e., a fireball), a fire, or a smoldering fire before it is fully extinguished.

The health criteria used in this study is the ERPG-2 or its surrogate if an ERPG-2 value has not yet been determined. The ERPG-2 refers to the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action. Individuals who experience higher concentrations than those limits generally suffer respiratory distress of various kinds.

The equipment failure accident scenario for mercury was simulated with the ALOHA model for each of the five candidate sites. ALOHA defaulted to the heavy gas model by virtue of the molecular weight of mercury. The manual override feature was used to select the neutrally buoyant model to determine which of the two model options was most conservative. Although the source elevation was taken at 17 m (56 ft) above ground level for the mercury release, the heavy gas model defaults to ground level. Probably for this reason, the heavy gas model produced the more conservative results. Table 4.8 summarizes the results.

Except for the NLVF site, no point of public access is threatened in the mercury scenario. The concern would be for workers in the immediate vicinity of the spill who are either outdoors or in the NIF area when the release occurred. The indoor concentrations predicted by ALOHA depend on the specific building ventilation. Details of each building within each threat zone would be necessary for quantitative evaluation. Typically, single-storied structures show concentrations of a factor of five or more below the outdoor levels. At the NLVF, the predicted maximum threat zone extends just slightly to the edge of public access.

The situation at LLNL warrants careful study because a veterinary hospital located across Greenville Road east-northeast of the proposed NIF location was identified as a sensitive location. The hospital is the nearest point of public access to NIF. In the mercury release scenario, the source would be in the capacitor switchbank about 245 m (804 ft) from the hospital. Predicted mercury concentrations just fall just within the level of concern at that location.

TABLE 4.8 Summary of Mercury Release Scenario Predictions at the Five National Ignition Facility Candidate Sites[a]

Site	Nearest Public Access	Dispersion Type[b]	Outdoor/Indoor Concentration[c] (mg/m^3)	Maximum Threat Zone (m)
LLNL	245 m ENE	Heavy gas	0.124/0.025	237
NTS	20,000 m SSW	Heavy gas	Negligible	237
NLVF	210 m W	Heavy gas	0.165/0.033	239
LANL	1,620 m NNE	Heavy gas	Negligible	237
SNL	1,864 m N	Heavy gas	0.0204/0.0035	237

[a] Results are the same for the Conceptual Design and Enhanced options.

[b] The ALOHA model chooses either a neutrally buoyant or a heavy gas treatment for dispersion, depending on which approach is most appropriate.

[c] Predicted concentrations at nearest point of public access.

Although the mercury scenario would pose no concern to the public at LLNL, personnel within NIF and immediately outside could be affected. Here again, the only potential hazard would be to workers in the immediate location of the spill and those outdoors within the maximum threat zone who are otherwise unprotected. Inside neighboring trailers 5983, 5984, 5985, and 5927, the concentrations would probably remain below the level of concern, depending upon the building ventilation.

Table 4.8 presents the results of the modeling for the mercury release resulting from an aircraft accident and associated fire scenario at each of the five NIF candidate sites. Outdoor concentrations of mercury are predicted with the FIREPLUME model. Model results indicate negligible mercury concentrations for all distances from the site of the aircraft accident and associated fire. Predicted concentrations of mercury are significantly less than its ERPG-2 value, 0.125 mg/m^3.

4.2.2.2 Aircraft Crash

The occurrence of a light aircraft crash at the NIF location is a credible event (Kimura 1996). The probability of such an event is approximately 4×10^{-5}/year. The capacitor bays are an area of specific concern because impact to the ignitron switches could result in the release of mercury. Given that an aircraft engine is much smaller than a single capacitor bay module, it is estimated that no more than the equivalent of two capacitor modules (i.e., 40 capacitors and

8 switches) would be damaged by the incoming aircraft (LLNL 1996). Because the capacitors contain dielectric fluid, which is combustible, it is assumed that the spilled material would become involved in a fire resulting from ignition of spilled aircraft fuel. The temperature of the fire is expected to be in excess of the boiling point of mercury (356°C), thus a substantial amount of mercury vapor would be generated.

Modeling of this accident scenario was conducted at LLNL using the ALOHA model with values determined for the plume rise, effective release height, and the source term (LLNL 1996). The modeling results indicate a maximum off-site mercury concentration of 0.16 mg/m^3 (7.4×10^{-6} oz/yd^3) at a distance of 4.2 km (2.6 mi) downwind. Although the concentration calculated at this location exceeds the ERPG-2-equivalent, the total mercury exposure from this event is calculated to be less than that corresponding to the ERPG-2-equivalent value because this condition would exist for only 10 minutes. Consequently, no human health effects are predicted in terms of the ERPG-2 emergency response metric.

Additional modeling of this accident scenario was conducted with the FIREPLUME model (Brown et al. 1996). The FIREPLUME model consists of two components. The first component is a Monte Carlo model used to estimate the dispersion of both buoyant and non-buoyant chemical releases in the atmospheric boundary layer. The second component is a puff dispersion model based in part on a Monte Carlo model. The FIREPLUME model is used to predict the ground-level concentration resulting from the release of a hazardous material within an instantaneously discharged thermal event (a fireball), a fire, or a smoldering fire before it is fully extinguished.

For the small aircraft crash accident scenario, the assumption was made that the volatile portion of the aircraft fuel and the capacitor dielectric fluid was consumed during the fire, and that no volatile component remained at the start of the cooldown period. Values used for the effective diameter of the burning surface, the temperature of the fire, and meteorological conditions were based on the methodology previously discussed. Modeling was completed for stability classes A, D, and F.

On the basis of FIREPLUME modeling results, the maximum off-site consequence for this accident scenario is below the ERPG-2-equivalent for mercury (i.e., below 0.25 mg/m^3 [1.16×10^{-5} oz/yd^3]). For stability class A, a maximum mercury concentration of 3.37×10^{-3} mg/m^3 (1.56×10^{-7} oz/yd^3) was predicted at a distance of 11,600 m (38,058 ft). For D class stability, a maximum mercury concentration of 1.87×10^{-4} mg/m^3 (8.68×10^{-9} oz/yd^3) was predicted at a distance of 80,000 m (262,467 ft). No impacts above ERPG-2 threshold levels occurred for F stability computer runs as well. The FIREPLUME model results support the LLNL modeling results of this accident scenario. Therefore, the small aircraft crash accident scenario would not represent a threat to the general public from plume rise and dispersion effects. Should the assumption that there be no volatile component at the start of the cooldown period prove to be incorrect, then the FIREPLUME modeling results would change. Additional modeling with the FIREPLUME

model would be required because impacts at the ground from the cooldown period releases could lead to concentrations above threshold.

4.2.3 Alumina and Silica Release Scenarios and Results

Alumina and silica particulates were identified as a potential health concern for the second accident scenario. These materials are not normally considered hazardous for short-term exposure; the concern would be accumulation of dust in the lungs after repeated exposure. The TLV-TWA for alumina is 10 mg/m^3 (ACGIH). For silica, the TLV-TWA is 0.1 mg/m^3. The single-event exposure criterion was obtained by multiplying these values by a factor of 5 to obtain an effective ERPG-2.

The alumina/silica accident scenario involves particulates that would be released as a result of an earthquake. The scenario considered a severe earthquake. Although the target chamber is not expected to fail, failure of the beam tubes would expose the chamber to airflow. In that event, alumina, silica, and other particulate matter in the chamber could be blown out of the target area and dispersed into the environment. The timing of an earthquake must be considered, because the amounts of particulates present would be a function of facility operation. The event is assumed to occur after the last experiment of the year; more specifically, when the buildup had resided in the chamber for one week after the last experiment. The joint frequency of these combined events is estimated to be 1×10^{-8} per year for the Conceptual Design Option, and 2×10^{-8} per year for the Enhanced Option.

Alumina particulates would be created from ablation of first wall material. The amount of particulate matter in the chamber would depend on the experiment accumulation and cleanup frequency. These factors cannot be known with certainty at present, but a conservative estimate of 6.7 kg (14.8 lb) for the Conceptual Design Option and 29.6 kg (65.3 lb) for the Enhanced Option can be derived on the basis of the total accumulation over one full year. The silica particulates would be created from ablated debris shield material. The vulnerable inventory is estimated to be 2.1 kg (4.6 lb). Under the earthquake accident scenario, the alumina and silica particulates would be released together in a combined mixture.

The exit outflow area was estimated for the collapse of 24 beam tubes and the switchyard, yielding 40.8 m^2 (439 ft^2). A conservative mass fraction of 10^{-3} was used for the amount actually removed by the outflow (DOE 1992). This fraction implies a release of 6.7 g (0.24 oz) of alumina and 2.1 g (0.07 oz) of silica in 7.6 minutes for the Conceptual Design Option and 29.6 g (1.04 oz) of alumina and 4.4 g (0.16 oz) of silica for the Enhanced Option.

Release durations were computed from the volumetric displacement for a given wind speed, with adjustment for mixing. With a l-m/s (3.3-ft/s) wind, the computed duration is 7.6 minutes for both the Conceptual Design and Enhanced options. The most conservative source height, ground

level, was assumed. These conditions were modeled as an instantaneous release with the ALOHA code, which yielded higher peak concentrations and is therefore conservative. Since both compounds would be released simultaneously and their biological effects are similar, their toxicities must be weighted additively for this scenario.

The dispersion of the airborne particulates would depend upon wind and atmospheric stability. Higher wind speeds cause greater dispersion because of increased turbulence, but the rate of release also increases accordingly. The duration of the release, therefore, decreases as wind speed increases. These competing factors tend to offset each other, making wind speed less critical than atmospheric stability. All other factors being equal, the largest particulate concentrations would occur under the most stable atmospheric conditions, as characterized by class F stability. Therefore, a wind speed of 1.0 m/s (3.3 ft/s) with class F stability was proposed as a conservative concentration scenario.

For LLNL, the alumina/silica release from the target chamber was modeled by taking the source to be 400 m (1,312 ft) from the veterinary hospital. Predictions indicate no impact to the public at any site. The only potential hazard would be to workers in the immediate location of the release and people outdoors within the maximum threat zone who are otherwise unprotected. Inside neighboring trailers 5983, 5984, 5985, and 5927, the concentrations would probably remain below the level of concern, depending upon the building ventilation. Indoor concentrations were computed for a single-story building in the model scenario. Table 4.9 summarizes the predictions for the alumina/silica release scenarios for the Conceptual Design and Enhanced options at the five candidate sites.

4.2.4 Carbonyl Fluoride and Hydrogen Fluoride Release Scenarios and Results

Optical maintenance operations involve the use of Teflon® dissolved in a fluorinert solution to treat optics. Hydrogen fluoride and carbonyl fluoride can be released if these materials are heated sufficiently. Hydrogen fluoride can pose a hazard because it is acidic and can cause severe burns to eyes and internal tissue and can cause kidney or liver damage. The worst case would be for a heat source to decompose the Teflon. The fourth and fifth release accident scenarios can then be postulated for these two fluoride compounds. The 3.0 kg (6.6 lb) of Teflon in the inventory could potentially give a fractional carbonyl fluoride release of 0.63, resulting in a release of 1,890 g (66.7 oz) for the fifth accident scenario. The ERPG-2 for carbonyl fluoride is 27.5 mg/m^3.

ALOHA selected the heavy gas model for these calculations. The Conceptual Design and Enhanced options are the same for this chemical. For LLNL, the release was modeled as a continuous source at Building B392, 120 m (394 ft) from the veterinary hospital. The predicted

TABLE 4.9 Summary of Alumina/Silicate Release Scenario Predictions at the Five National Ignition Facility Candidate Sites for Conceptual Design and Enhanced Options

Site	Nearest Public Access	Dispersion Type[a]	Outdoor/Indoor Concentration[b] (mg/m^3)	Maximum Threat Zone[c,d] (m)
Conceptual Design Option				
LLNL	800 m E	Neutrally buoyant	0.0509/0.0001	171
NTS	20,000 m SSW	Neutrally buoyant	Negligible	171
NLVF	210 m W	Neutrally buoyant	0.296/0.002	171
LANL	1,620 m NNE	Neutrally buoyant	Negligible	171
SNL	1,864 m N	Neutrally buoyant	0.0123/0.0001	174
Enhanced Option				
LLNL	800 m E	Neutrally buoyant	0.11/0.0017	231
NTS	20,000 m SSW	Neutrally buoyant	Negligible	231
NLVF	210 m W	Neutrally buoyant	Negligible	231
LANL	1,620 m NNE	Neutrally buoyant	Negligible	231
SNL	1,864 m N	Neutrally buoyant	0.0268/0.0001	234

[a] The ALOHA model chooses either a neutrally buoyant or heavy gas treatment for dispersion, depending on which approach is most appropriate.

[b] Predicted concentrations at nearest point of public access.

[c] Differences in predictions among the various sites (171 m vs. 174 m or 231 m vs. 234 m) are not important and are due to the atmospheric differences (elevation) among the sites.

[d] The maximum threat zone corresponds to the distance from the source beyond which outdoor concentrations are below the ERPG-2 value.

maximum threat zone was 99 m (325 ft); therefore, the concentrations would pose no immediate threat to the public. As in the other analyses, personnel in the immediate vicinity could be adversely affected at each site (Table 4.10).

It is also possible that the carbonyl fluoride could react to form hydrogen fluoride (Table 4.11). The estimated release fraction for such a reaction is 0.38, corresponding to 1,145 g (40.4 oz) of hydrogen fluoride released in the fourth accident scenario. This amount would be added to the 27.3 g (1.0 oz) released directly from the fluorinert solution, making a total of 1,172.3 g (41.4 oz) of hydrogen fluoride. The ERPG-2 for hydrogen fluoride is 16.4 mg/ m^3. The releases for the fourth and fifth scenarios are both likely to continue over a period of one hour.

TABLE 4.10 Summary of Carbonyl Fluoride Release Scenario Predictions at the Five National Ignition Facility Candidate Sites for Conceptual Design and Enhanced Options[a]

Site	Nearest Public Access	Dispersion Type[b]	Outdoor/Indoor Concentration[c] (mg/m^3)	Maximum Threat Zone[d] (m)
LLNL	120 m ENE	Heavy gas	18.9/4.14	99
NTS	20,000 m SSW	Heavy gas	Negligible	75
NLVF	210 m W	Heavy gas	4.83/1.02	75
LANL	1,620 m NNE	Heavy gas	0.198/0.0324	70
SNL	1,864 m N	Heavy gas	0.608/0.114	70

[a] Conceptual Design and Enhanced options have the identical accidents proposed, so no differences exist between these options.

[b] The ALOHA model chooses either a neutrally buoyant or heavy gas treatment for dispersion, depending on which approach is most appropriate.

[c] Predicted concentrations at nearest point of public access.

[d] The maximum threat zone corresponds to the distance from the source beyond which outdoor concentrations are below the ERPG-2 value.

The carbonyl fluoride and hydrogen fluoride releases are considered at LLNL because of optics maintenance in three buildings, B391, B392, and B321. For these two scenarios, the nearest point of public access would be the industrial park to the east. For both the carbonyl and hydrogen fluoride scenarios, the nearest potential source to the industrial park would be Building B392, which is 120 m (394 ft) away.

4.2.5 Propane Gas Release Scenario and Results

The sixth accident scenario considered (for NTS only) was a propane gas leak from the storage tanks at NTS. Four large tanks are present at NTS, and the two largest ones, which hold 28,390 L (7,500 gal) of propane each, are positioned side by side. The worst-case scenario assumes that both tanks simultaneously leak from a 5.08-cm (2.0-in.) diameter hole located 0.3 m (1.0 ft) from the bottom of the tank as a continuous release over one hour. The level (concentration) of concern is the estimated ERPG-2, again taken to be five times the OSHA permissible exposure limit of 1,800 mg/m^3, giving a level of concern of 9,000 mg/m^3. This concentration would occur out to a distance of 755 m (2,477 ft) from the source, and this area would constitute the maximum threat zone.

TABLE 4.11 Summary of Hydrogen Fluoride Release Scenario Predictions at the Five National Ignition Facility Candidate Sites for Conceptual Design and Enhanced Options[a]

Site	Nearest Public Access	Dispersion Type[b]	Outdoor/Indoor Concentration[c] (mg/m^3)	Maximum Threat Zone[d] (m)
LLNL	120 m ENE	Neutrally buoyant	11.2/4.66	99
NTS	20,000 m SSW	Neutrally buoyant	$<10^{-2}/10^{-2}$	75
NLVF	210 m W	Neutrally buoyant	3.78/1.54	75
LANL	1,620 m NNE	Neutrally buoyant	0.005/0.077	70
SNL	1,864 m N	Neutrally buoyant	0.076/0.020	70

[a] Conceptual Design and Enhanced options have the identical accidents proposed, so no differences exist between these options.

[b] The ALOHA chooses either a neutrally buoyant or heavy gas treatment for dispersion, depending on which approach is most appropriate.

[c] Predicted concentrations at nearest point of public access.

[d] The maximum threat zone corresponds to the distance from the source beyond which outdoor concentrations are below the ERPG-2 value.

4.3 TRANSPORTATION IMPACT ASSESSMENT

Transportation impacts for both radiological and nonradiological causes resulting from the shipment of cryogenic tritium-filled targets were calculated from each of the tritium target manufacturing facilities to each of the candidate NIF locations. For each candidate location, five target manufacturing sites were assumed: the University of Rochester Laboratory of Laser Energetics (New York), LANL, General Atomics (San Diego, California), the Savannah River Site (South Carolina), and LLNL. For the transportation analysis, each of the manufacturing sites was assumed to ship 100% of the yearly supply of tritium to each of the five candidate NIF sites, although in practice the cryogenic tritium-filled targets might be shipped from several manufacturing sites.

Potential radiological (cargo-related) risks involved in the transportation of tritium targets would result from a release of tritium to the environment following a transportation accident sufficiently severe to breach the transportation package. Because tritium is a low-energy beta emitter with no associated gamma radiation, no radiological risks would result from routine (incident-free) transportation operations.

Nonradiological (vehicle-related) risks were calculated for both routine and accident conditions. Nonradiological risks result from potential exposure to increased vehicular exhaust emissions in urban areas. Nonradiological accident risks result in fatalities from the physical trauma of a transportation accident and are independent of the cargo being transported.

For the Conceptual Design Option, risks resulting from transportation operations were estimated for two separate cases to establish the bounding impacts (Tobin and Brereton 1995). Case 1 involved 145 tritium shipments per year of 1.5 Ci each, while case 2 involved 29 shipments per year of 7.5 Ci each. Because each of the two cases for the Conceptual Design Option would result in the same amount of tritium being shipped annually, the radiological risks associated with the shipment of cryogenic tritium targets would be identical. However, the nonradiological risks would be proportional to the distance of shipment; therefore, case 1 would yield the largest nonradiological risks. Also, single-accident consequences would be proportional to the amount of tritium shipped; therefore, the maximum consequence accident impacts would be larger in case 2.

For the Enhanced Option, risks resulting from transportation operations were again estimated for two separate cases. Case 1 involved 335 tritium shipments per year, 90 of which would contain one direct-drive target of 15 Ci, while the remaining 245 shipments would each have a single indirect-drive target of 1.5 Ci. Case 2 involved shipping 5 targets per shipment or 67 shipments per year, 18 shipments with 75 Ci of target material and 49 shipments with 7.5 Ci of target material. Because each of the two cases for the Enhanced Option would result in the same amount of tritium being shipped annually, the radiological risks associated with the shipment of cryogenic tritium targets would be identical. However, the nonradiological risks would be proportional to the distance of shipment; therefore, case 1 would yield the largest nonradiological risks. Also, single-accident consequences would be proportional to the amount of tritium shipped; therefore, maximum consequence accident impacts would be larger in case 2.

Transportation impacts were estimated for ground transport from the manufacturing site to the nearest major airport, air transport to the nearest major airport to the NIF site, and ground transport from the airport to the NIF site.[2] For cases when the source was manufactured at the NIF site, any intrasite transfers were considered to be insignificant compared with the off-site transport because of the short distances involved.

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[2] Ground transport was assumed between LANL and SNL.

4.3.1 Methods

4.3.1.1 Transportation Routes

Truck routes from each of the tritium target manufacturing facilities to the nearest major airport were calculated with the HIGHWAY 3.1 computer code (Johnson et al. 1993). HIGHWAY 3.1 was also used to calculate truck routes between each candidate NIF location and the nearest major airport. Distances between the major airports were calculated with an arc distance formula using the latitude and longitude coordinates of the airports.

4.3.1.2 Routine Transportation Risk

Tritium is a pure beta emitter with no associated gamma rays and is transported in a container that does not release tritium to the environment under incident-free (normal) conditions. Therefore, no radiological risks would be associated with routine transportation operations involving tritium targets.

Nonradiological risks associated with vehicular exhaust emissions were calculated for ground transportation operations. A risk factor generated by Rao et al. (1982) for latent mortality from pollution inhalation is 1×10^{-7}/km (1.6×10^{-7}/mi) for truck travel in an urban area. This risk factor is based on regression analysis of the effect on mortality from sulfur dioxide and particulate releases from diesel exhaust. Excess latent mortality is assumed to be equivalent to cancer fatalities. Nonradiological risks from routine transportation operations were calculated by multiplying the total distance of truck travel in urban areas by the risk factor. Similar risk factors are not available for rural and suburban areas.

4.3.1.3 Transportation Accident Risk

Transportation accident risk assessment is treated probabilistically in RADTRAN 4 (Neuhauser and Kanipe 1993) because accident occurrences are statistical. The accident risk is defined as the product of the accident consequence (dose) and the probability of the accident's occurring. In this respect, the RADTRAN 4 computer code estimates the collective accident risk to populations by considering a wide range of possible accidents, including low-probability, high-consequence and high-probability, low-consequence accidents.

For accidents that involve a release of radioactive material into the environment, RADTRAN 4 assumes that the material is dispersed according to standard Gaussian diffusion

models. Default data for atmospheric dispersion were used in this analysis to represent an instantaneous ground-level release and a small-diameter source cloud (Neuhauser and Kanipe 1993).

As a complement to the RADTRAN risk calculations, the RISKIND computer code (Yuan et al. 1993) was used to estimate scenario-specific doses to MEIs and the collective population under accident conditions. The RISKIND calculations were conducted to supplement the results for collective risk calculated with RADTRAN 4. While the results for collective risk provide a measure of the overall risks of each case, the RISKIND calculations are meant to address areas of specific concern to individuals and subgroups of population.

The RISKIND accident consequence assessment for the NIF analysis focused on accidents that would result in the largest releases of radioactive material into the environment. For each scenario, accident consequences were calculated for a shipment of tritium targets that represented the highest potential radiological risk if an accident occurred. This worst-case accident assumed a complete release of the tritium cargo into the environment.

Nonradiological risks from transportation activities would result from the physical trauma of the accident itself. Nonradiological risks were calculated for round-trip shipping distances and only for the ground transport of the tritium targets. State-specific fatality rates were used for both urban and rural travel (Saricks and Kvitek 1994); urban fatality rates were conservatively assigned for suburban travel.

4.3.2 Model Input

4.3.2.1 Source Terms and Shipment Configuration

The radioactive source terms used for the transportation risk and consequence assessment were assumed to be cryogenic tritium-filled targets. The Conceptual Design Option assumes a total of 220 Ci of tritium would be shipped from the target manufacturing facilities to NIF each year. The Enhanced Option increases tritium shipments to 1,720 Ci of tritium per year. Tritium is a low-energy beta emitter with no associated gamma ray emission and has a 12.3-year half-life. For assessment purposes, released tritium was conservatively assumed to be in the oxide form (tritiated water). Because of biological uptake, tritium in this form is 10,000 times more hazardous than in its form in the targets. Conversion to the oxide form is expected only for a portion of the tritium as a result of fire following an accident. However, fire would be associated only with a small percentage of accidents.

The cryogenic tritium-filled targets for NIF were assumed to be transported in Type A packaging in accordance with 49 CFR Part 173. Type A packaging must withstand the conditions

of normal transportation without loss or dispersal of the radioactive contents. ("Normal" transportation refers to all transportation conditions except those resulting from accidents or sabotage.) The Type A packaging would be required only if the curie content was greater than 20 Ci. A NIF tritium target would contain a maximum of 15 Ci of tritium.

4.3.2.2 Accident Severity Categories

Methodology developed by the U.S. Nuclear Regulatory Commission (NRC) was used to characterize the potential severity of transportation-related accidents (NRC 1977). This method divides the range of transportation accidents into eight categories of progressive severity. Severity is described as a function of the magnitude of the mechanical forces (impact) and thermal forces (fire) to which a package may be subjected during an accident. The severity category assigned to an accident is independent of the specific accident sequence.

The accident classification scheme is designed to take into account all credible accidents, from low-probability, high-consequence events to high-probability, low-consequence events. A conditional probability of occurrence is assigned to each severity category using information from NUREG-0170 (NRC 1977). These probabilities are presented by population density zones in Table 4.12. Category I accidents are the least severe but most frequent, while Category VIII accidents are very severe but infrequent. To determine the expected frequency of an accident of a given severity, the conditional probability in the category is multiplied by the baseline accident rate. Although only one baseline accident rate is used for air transport (NRC 1977), truck shipments of radioactive materials are assigned different baseline accident rates for each population density zone for every state (Saricks and Kvitek 1994).

4.3.2.3 Release Fractions

Radiological risks are calculated by assigning package release fractions to each accident severity category using values from NUREG-0170 (NRC 1977). Release fractions vary according to the package type and the physical form of the material being transported and take into account all mechanisms necessary to create release of radioactive material from a damaged package to the environment.

Package release fractions for accidents of each severity category for type A packages are given in Table 4.13. The values for release fractions were obtained from NUREG-0170 (NRC 1977). Tritium remains in elemental form unless subject to fire or excessive heat. For all transportation accidents that result in a release of tritium into the environment, it is conservatively assumed that the tritium inside the targets would be completely oxidized into tritium water vapor at the moment of release. The aerosolized fraction (required for code input) can be directly related to the fraction

TABLE 4.12 Conditional Probabilities of Transportation Accidents by Severity Category and Population Density Zone

Severity Category	Conditional Probability[a]	Probability by Population Density Zone		
		Rural	Suburban	Urban
Truck				
I	0.55	0.1	0.1	0.8
II	0.36	0.1	0.1	0.8
III	0.07	0.3	0.4	0.3
IV	0.016	0.3	0.4	0.3
V	0.0028	0.5	0.3	0.2
VI	0.0011	0.7	0.2	0.1
VII	8.5×10^{-5}	0.8	0.1	0.1
VIII	1.5×10^{-5}	0.9	0.05	0.05
Aircraft				
I	0.57	0.05	0.9	0.05
II	0.16	0.05	0.9	0.05
III	0.09	0.1	0.8	0.1
IV	0.05	0.1	0.8	0.1
V	0.03	0.3	0.6	0.1
VI	0.03	0.3	0.6	0.1
VII	0.04	0.98	0.01	0.01
VIII	0.03	0.98	0.01	0.01

[a] The conditional probability is defined as the probability that an accident is of a given severity given that an accident has occurred. Severity increases from Category I to Category VIII.

Source: NRC (1977).

TABLE 4.13 Release, Aerosolized, and Respirable Fractions for Type A Packages Filled with Tritium Targets

Severity Category	Release Fraction	Aerosolized Fraction	Respirable Fraction
I	0	0	0
II	0.01	1.0	1.0
III	0.1	1.0	1.0
IV	1.0	1.0	1.0
V	1.0	1.0	1.0
VI	1.0	1.0	1.0
VII	1.0	1.0	1.0
VIII	1.0	1.0	1.0

Sources: NRC (1977); Neuhauser and Kanipe (1993).

4.3.3 Assumptions

4.3.3.1 Release Heights

Because the most severe accidents normally involve fire, it was assumed that the tritium inside the targets would be released and oxidized. Fire tends to elevate the plume height; hence, the effective release height for the plume was assumed to be at 10 m (33 ft).

4.3.3.2 Population Densities

Route-specific population densities obtained from HIGHWAY 3.1 were used to calculate potential risks associated with the ground transport of the tritium targets. For the air shipments of the tritium-filled targets, the national average population densities along the route were obtained from NUREG-0170 (NRC 1977) and were assumed to be 6 persons/km^2 (15.5 persons/mi^2) rural, 719 persons/km^2 (1,863 persons/mi^2) suburban, and 3,861 persons/km^2 (10,003 persons/mi^2) urban.

4.3.3.3 Locations of Maximally Exposed Individuals

In the scenario evaluations, the maximally exposed individual in a maximum-consequence accident was placed where the dose to that individual would be at a maximum: 380 m (1,250 ft) from the site of the accident. Atmospheric stability class F (stable weather conditions with a wind speed of 1 m/s [3.3 ft/s]) was used to estimate the maximum dose following a hypothetical transportation accident.

4.3.4 Per-Shipment Risk Factors and MEI Consequences

The transportation risk assessment calculated risks associated with the shipment of tritium targets from the manufacturing sites to the proposed NIF locations. Each manufacturing site was assumed to produce 100% of the tritium targets. In practice, however, several sites might be shipping tritium targets to NIF. Table 4.14 presents the per-shipment risk factors used to calculate the associated risks when shipping tritium targets from the manufacturing sites to the candidate NIF sites. The risk factors are given on a per-shipment-per-curie basis and consider both air and ground transport. Table 4.15 presents the nonradiological risk factors associated with vehicular emissions and transportation accidents. These risk factors are given on a per-shipment basis.

Single-accident consequences are proportional to the amount of tritium shipped and the exposed population. Hence, shipments that contained larger amounts of tritium would result in larger radiological risks for a given population density than a similar accident involving a smaller amount of the same type of target material. Since it is difficult to predict the exact location of a transportation accident, maximum consequence accidents are presented in Table 4.16 for each population density and shipment configuration. The radiological risks were calculated with the RISKIND computer code using the shipping configuration and assumptions provided in Section 4.3.3.

TABLE 4.14 Radiological Per-Shipment Risk Factors

	Risk Factors (fatalities per shipment per curie), by Site				
Source	LLNL	LANL	NTS	NLVF	SNL
General Atomics	2×10^{-12}	5×10^{-12}	3×10^{-12}	3×10^{-12}	3×10^{-12}
Lawrence Livermore	0	5×10^{-12}	3×10^{-12}	3×10^{-12}	3×10^{-12}
Los Alamos	5×10^{-12}	0	5×10^{-12}	5×10^{-12}	4×10^{-12}
Savannah River	4×10^{-12}	6×10^{-12}	5×10^{-12}	5×10^{-12}	3×10^{-12}
University of Rochester	4×10^{-12}	6×10^{-12}	5×10^{-12}	5×10^{-12}	4×10^{-12}

TABLE 4.15 Nonradiological Vehicular Per-Shipment Risk Factors

	Vehicular Emissions Risk Factors (fatalities/shipment), by Site				
Source	LLNL	LANL	NTS	NLVF	SNL
General Atomics	6.7×10^{-6}	5.3×10^{-6}	6×10^{-6}	5.6×10^{-6}	5.5×10^{-6}
Lawrence Livermore	0	2.6×10^{-6}	3×10^{-6}	2.9×10^{-6}	2.8×10^{-6}
Los Alamos	2.6×10^{-6}	0	1×10^{-6}	1.5×10^{-6}	1.4×10^{-6}
Savannah River	2.6×10^{-6}	1.2×10^{-6}	1×10^{-6}	1.5 × 10-6	1.4×10^{-6}
University of Rochester	2.6×10^{-6}	1.2×10^{-6}	1×10^{-6}	1.5×10^{-6}	1.4×10^{-6}
	Transportation Accident Risk Factors (fatalities/shipment), by Site				
Source	LLNL	LANL	NTS	NLVF	SNL
General Atomics	3.8×10^{-6}	1.2×10^{-5}	7.8×10^{-6}	5.7×10^{-6}	3.4×10^{-6}
Lawrence Livermore	0	1.3×10^{-5}	8.3×10^{-6}	6.1×10^{-6}	3.9×10^{-6}
Los Alamos	1.3×10^{-5}	0	1.7×10^{-5}	1.5×10^{-5}	1.2×10^{-5}
Savannah River	4.0×10^{-6}	1.3×10^{-5}	8.0×10^{-6}	5.9×10^{-6}	3.6×10^{-6}
University of Rochester	2.4×10^{-6}	1.1×10^{-5}	6.4×10^{-6}	4.3×10^{-6}	2.0×10^{-6}

TABLE 4.16 Radiological Impacts Resulting from a Severity Category VIII Accident for Each Shipment Configuration of Tritium Targets

	Impact per Shipment Configuration			
Parameter	1.5 Ci	7.5 Ci	15 Ci	75 Ci
Impact at accident location (person-rem)				
Rural	1.0×10^{-4}	5.2×10^{-4}	1.0×10^{-3}	5.2×10^{-3}
Suburban	1.2×10^{-2}	6.2×10^{-2}	1.2×10^{-1}	6.2×10^{-1}
Urban	6.7×10^{-2}	3.3×10^{-1}	6.7×10^{-1}	3.3
Impact to maximally exposed individual (rem)	2.4×10^{-5}	1.2×10^{-4}	2.4×10^{-4}	1.2×10^{-3}

of the tritium that is oxidized. Table 4.13 presents the release, aerosolized (oxidized), and respirable fractions used to conduct this transportation risk assessment.

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5 THREATENED, ENDANGERED, AND RARE SPECIES

This section includes tabular information on federal- and state-protected species that inhabit or could occur at the candidate NIF sites. Protected species are listed in Table 5.1 for LLNL, Table 5.2 for LANL, Table 5.3 for the NTS, Table 5.4 for the NLVF, and Table 5.5 for SNL. Each table provides information on common and scientific names, protection status, habitat, and potential to occur at the candidate NIF locations.

The classification system for federally protected species is based on definitions set forth in the *Endangered Species Act* of 1973 and subsequent amendments. Federal status terms reported in the tables are:

- Endangered (E): Any species in danger of extinction throughout all or a significant part of its range.
- Threatened (T): Any species likely to become an endangered species throughout all or a significant part of its range.
- Candidate 1 (C1): Species for which the U.S. Fish and Wildlife Service (FWS) has sufficient information on hand to support the biological appropriateness of its being listed as endangered or threatened.
- Candidate 2 (C2): Species for which information now in the possession of the FWS indicates the probable appropriateness of listing it being listed as endangered or threatened.

The terminology used by the various states in classifying protected species is specific to each state and is defined in a footnote to each table.

TABLE 5.1 Threatened, Endangered, and Rare Species Potentially Present at Lawrence Livermore National Laboratory

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
Hairless popcorn flower	*Plagiobothrys glaber*	C2	–	Coastal salt marshes, wet alkaline soils	Unlikey
Hispid bird's beak	*Cordylanthus mollis hispidus*	C2	R	Saline marshes, flats	Unlikely
Palmate bird's beak	*Cordylanthus palmatus*	E	E	Saline to alkaline soils; in alkali sink scrub vegetation or relatively undisturbed, seasonally flooded lowland sites	Unlikely
San Joaquin saltbush	*Atriplex joaquiniana*	C2	–	Alkaline soils	Unlikely
California linderiella	*Linderiella occidentalis*	C2	–	Aquatic	None
Callippe silverspot butterfly	*Speyeria callippe callippe*	C2	–	Violets (food plant)	Low
Consevancy fairy shrimp	*Branchinecta conservatio*	C2	–	Aquatic	None
Curved-foot hygrotus diving beetle	*Hygrotus curvipes*	C2	–	Aquatic	None
Longhorned fairy shrimp	*Branchinecta longiantenna*	C2	–	Aquatic	None
Molestan blister beetle	*Lytta molesta*	C2	–	Flowers	Low
Ricksecker's water scavenger beetle	*Hydrochara rickseckeri*	C2	–	Aquatic	None
Vernal pool fairy shrimp	*Branchinecta lynchi*	C2	–	Aquatic	None
California red-legged frog	*Rana aurora draytoni*	C2	SC	Marshes; slow portions of streams, lakes, reservoirs, ponds. Most common in wooded areas of lowlands and foothills	Unlikely
California tiger salamander	*Ambystoma tigrinum californiense*	C2	SC	Open woodlands and grasslands; requires aquatic habitats for breeding.	Unlikely
Alameda whipsnake	*Masticophis lateralis euryxanthus*	C2	T	Associated with chaparral, but can also occur in grasslands, open woods, rocky slopes, open streams, arroyos	Low
California horned lizard	*Phrynosoma coronatum frontale*	C2	SC	Brushland, coniferous forests, and broadleaf woodlands. Most common in lowlands along sandy washes with scattered low bushes	Unlikely
Bald eagle	*Haliaeetus leucocephalus*	T	E	Lakes, reservoirs, rivers, coastlines	None

TABLE 5.1 (Cont.)

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
White-tailed kite	*Elanus caeruleus*	–	R	Open groves, river valleys, marshes, grasslands	Low
Burrowing owl	*Athene cunicularia*	C2	SC	Open grasslands, prairies, farmland, airfields	Low
Cooper's hawk	*Accipiter cooperi*	–	SC	Mature forests, open woodlands, wood edges, river groves	Unlikely
Golden eagle	*Aquila chrysaetos*	–	SC	Open mountains, foothills, plains, open country	Unlikely
Northern harrier	*Circus cyaneus*	–	SC	Fields, marshes, prairies	Low
Peregrine falcon	*Falco peregrinus*	E	E	Wetlands, woodlands, forest, cities, agricultural areas, cliff faces, coastal habitats	None
Prairie falcon	*Falco mexicanus*	–	SC	Mountainous grasslands, open hills, plains, prairies	Unlikely
Sharp-shinned hawk	*Accipiter striatus*	–	SC	Open deciduous woodlands, mixed or coniferous forests, thickets, edges	Unlikely
Short-eared owl	*Asio flammeus*	–	SC	Prairies, marshes, dunes, tundra	Unlikely
Swainson's hawk	*Buteo swainsoni*	–	T	Nests peripherally to riparian areas or in lone trees or tree groves in agricultural fields; requires large open grasslands for foraging	Unlikely
Tricolored blackbird	*Agelaius tricolor*	C2	–	Cattail and tule marshes; forages in fields and farms	Low
Badger	*Taxidea taxus*	–	SC	Grasslands, forest edges	Low

TABLE 5.1 (Cont.)

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
San Joaquin kit fox	*Vulpes mocrotis mutica*	E	T	Open, level, sandy ground; low desert vegetation, junipers, grasslands	Low
Greater western mastiff bat	*Eumops perotis californicus*	C2	SC	Buildings, cliff crevices, trees, tunnels	Unlikely
Pacific western big-eared bat	*Plecotus townsendii townsendii*	C2	SC	Caves, mine tunnels, buildings	Unlikely
Pallid bat	*Antrozous pallidus*	–	SC	Rocky outcrops and crevices, buildings, caves, mines, hollow trees	Unlikely
Riparian woodrat	*Neotoma fuscipes riparia*	C2	SC	Heavy chaparral, streamside thickets, deciduous or mixed woods	Unlikely
San Joaquin pocket mouse	*Perognathus inornatus inornatus*	C2	–	Dry, open, grassy or weedy areas; fine-textured soil	Low

[a] Federal status definitions: E = endangered, T = threatened, C2 = candidate 2 (see text for details); state status definitions: E = endangered, T = threatened, R = rare, SC = species of special concern. A dash (–) indicates not listed.

Sources: Burt and Grossenheider (1976); California Department of Fish and Game (1991); DOE and UC (1992); Jones et al. (1985); Peterson (1990); Stebbins (1966).

TABLE 5.2 Threatened, Endangered, and Rare Species Potentially Present at Los Alamos National Laboratory

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
Grama grass cactus	*Pediocactus papyracanthus*	C2	–	Grasslands, pinyon-juniper woodlands (1,525 to 2,225 m)	Low
Sandia alumroot	*Heuchera pulchella*	–	RS	Rock crevices	Low
Paper-spined cactus	*Epipactis gigantea*	C2	E	Pinyon-juniper	Low
Santa Fe cholla	*Opuntia viridiflora*	–	E	Pinyon-juniper (2,200 to 2,440 m)	Low
Wood lily	*Lilium philadelphicum*	–	E	Ponderosa to mixed conifer cliffs (1,800 to 3,050 m)	Unlikely
Wright's fishhook cactus	*Mammillaria wrightii*	–	E	Desert grassland to pinyon-juniper (915 to 2,135 m)	Low
Say's pond snail	*Lymnaea captera*	–	E	Aquatic	None
Flathead chub	*Platygobio gracilis*	C2	–	Sandy runs of small to large turbid rivers	None
Jemez Mountain salamander	*Plethodon neomexicanus*	C2	E	Densely wooded, shady canyons	None
Northern goshawk	*Accipiter gentilis*	C2	–	Ponderosa; dense, mature, or old-growth coniferous forest	Moderate
Ferruginous hawk	*Buteo regalis*	C2	–	Grasslands	Unlikely
Common black hawk	*Buteogallus anthracinus*	–	E	Riparian areas with cottonwoods	Unlikely
Broad-billed hummingbird	*Cynanthus latirostris*	–	T	Riparian woodlands	Unlikely
Southwestern willow flycatcher	*Empidonax traillii extimus*	E	T	Willows, thickets, brushy pastures, old orchards	Low
Peregrine falcon	*Falco peregrinus*	E	E	Ponderosa-pinyon, streams, lakes	Unlikely
Whooping crane	*Grus americana*	E	E	Prairie ponds, marshes	None
Bald eagle	*Haliaeetus leucocephalus*	T	T	Riparian areas near streams and lakes	None
Mississippi kite	*Ictinia mississippiensis*	–	E	Riparian areas and shelterbelts	Unlikely
Loggerhead shrike	*Lanius ludovicianus*	C2	–	Grasslands, open woodlands	Moderate
White-faced ibis	*Plegadis chihi*	C2	–	Streams, marshes, ponds	None
Gray vireo	*Vireo vicinior*	–	T	Brushy mountain slopes, mesas, open chaparral, scrub oaks, junipers	Moderate

TABLE 5.2 (Cont.)

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
Mexican spotted owl	*Strix occidentalis lucida*	T	–	Mixed conifer; mountains and canyons, uneven-aged, multi-storied forest with closed canopy	Unlikely
Spotted bat	*Euderma maculatum*	C2	E	Ponderosa, pinyon-juniper, cliffs and rock crevices	Moderate
Occult little brown bat	*Myotis lucifugus occultus*	C2	–	Mountains, caves, hollow trees	Low
Long-legged myotis	*Myotis volans interior*	C2	–	Buildings, small pockets and crevices in rock ledges	Unlikely
Big free-tailed bat	*Nyctinomops macrotus*	C2	–	Rough, rocky country; crevices in rocks are preferred roost sites	Unlikely
Cave myotis	*Myotis velifer*	C2	–	Rough, rocky country; caves or building for nesting	Unlikely
Long-eared myotis	*Myotis evotis*	C2	–	Open forest areas	Unlikely
Pale Townsend's big-eared bat	*Plecotus townsendii paleseans*	C2	–	Caves or buildings	Unlikely
Yuma myotis	*Myotis yumanensis*	C2	–	Caves, tunnels	Unlikely
Small-footed myotis	*Myotis ciliolabrum*	C2	–	Rock crevices, caves in forested areas	Unlikely
Goat peak pika	*Ochotona princeps nigrescens*	C2	–	Lava boulders, talus slopes, rockslides; usually near timberline in mountains	Unlikely
New Mexican jumping mouse	*Zapus hudsonius luteus*	C2	E	Prefers low meadows for feeding, but occurs in various land habitats; not restricted	Low

[a] Federal status definitions: E = endangered, T = threatened, C2 = candidate 2 (see text for details); state status definitions: E = endangered, T = threatened, RS = rare and sensitive plant species. A dash (–) indicates not listed.

Sources: Burt and Grossenheider (1976); DOE (1995a-b); Jones et al. (1985); LANL (1993); New Mexico Department of Game and Fish (1995); Page and Burr (1991); Peterson (1990).

TABLE 5.3 Threatened, Endangered, and Rare Species Potentially Present at Nevada Test Site

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
Beatley milkvetch	*Astragalus beatleyae*	C1	CE	Shallow gravelly soil in open volcanic bedrock	None
Beatley phacelia	*Phacelia beatleyae*	C2	–	Gravel/volcanic tuff, canyon washes, steep barren slopes	None
Black wooly-pod	*Astragalus funereus*	C2	–	Unstable, steep gravelly slopes of volcanic tuff	None
Amargosa penstemon	*Penstemon fruticiformis* var. *amargosae*	C2	–	Along washes	None
Beardtongue	*Penstemon pahutensis*	C2	–	Mesas, slopes	None
Cane spring suncup	*Camissonia megalantha*	C2	–	Shad scale, disturbed soil	Unlikely
Sanicle biscuitroot	*Cymopterus ripleyi* var. *saniculoides*	C2	–	Sandy soils	Unlikely
Green-gentian	*Frasera pahutensis*	C2	–	Gravelly slopes, valley bottoms	None
Kingston bedstraw	*Galium hilendiae kingstonense*	C2	–	Ravines, gulleys	None
Mojave fishhook cactus	*Sclerocactus polyancistrus*	–	CY	Yucca Mountain area	Unlikely
White bear desert-poppy	*Arctomecon merriamii*	C2	–	Shallow gravelly soil, limestone outcrop	Unlikely
Devil's Hole pupfish	*Cyprinodon diabolis*	E	E	Deep limestone pool, Devil's Hole	None
Chuckwalla	*Sauromalus obesus*	C2	–	Rock dweller (lava flows, rocky hillsides, outcrops); feeds on creosote bush	Low
Desert tortoise	*Gopherus agassizii*	T	T	Washes, rocky hillsides, and flat desert having sandy and gravelly soil; bushes, cacti, etc, required for cover	Moderate
Bald eagle	*Haliaeetus leucocephalus*	T	E	Lakes, reservoirs, rivers, coastlines	None
Ferruginous hawk	*Buteo regalis*	C2	–	Woodlands, grasslands	Unlikely
Loggerhead shrike	*Lanius ludovicianus*	C2	–	Most habitats	Low
Mountain plover	*Charadrius montanus*	C2	–	Semi-arid plains, grasslands, plateaus	Unlikely
Peregrine falcon	*Falco peregrinus*	E	E	Open country, cliffs	Unlikely

TABLE 5.3 (Cont.)

Common Name	Scientific Name	Status[a] Federal	Status[a] State	Habitat	Potential to Occur at NIF Location
Western least bittern	*Ixobrychus exilis hesperis*	C2	–	Marshes, weedy ponds	None
Western snowy plover	*Charadrius alexandrinus nivosus*	C2	–	Sand flats, beaches	None
White-faced ibis	*Plegadis chihi*	C2	–	Marshes, irrigated lands, tules	None
Fringed myotis	*Myotis thysanodes*	C2	–	Caves and buildings	Unlikely
Long-eared myotis	*Myotis evotis*	C2	–	Open forest areas	Unlikely
Long-legged myotis	*Myotis volans*	C2	–	Buildings, small pockets and crevices in rock ledges	Unlikely
Pacific Townsend's big-eared bat	*Plecotus townsendii townsendii*	C2	–	Caves or buildings	Unlikely
Small-footed myotis	*Myotis ciliolabrum*	C2	–	Rock crevices, caves in forested areas	Unlikely
Spotted bat	*Euderma maculatum*	C2	–	Arid country, occasionally buildings and caves	Unlikely
Yuma myotis	*Myotis yumanensis*	C2	–	Caves, tunnels	Unlikely

[a] Federal status definitions: E = endangered, T = threatened, C1 = candidate 1, C2 = candidate 2 (see text for details); state status definitions: CE = critically endangered, E = endangered, T = threatened, CY = protected by authority of Nevada Cacti and Yucca Law. A dash (–) indicates not listed.

Sources: DOE (1995c); Peterson (1990); Stebbins (1966).

TABLE 5.4 Threatened, Endangered, and Rare Species Potentially Present at North Las Vegas Facility

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
Desert tortoise	*Gopherus agassizii*	T	T	Washes, rocky hillsides, and flat deserts having sandy and gravelly soil; bushes, cacti, etc. required for cover	Unlikely

[a] Federal status definition: T = threatened (see text for details); state status definition: T = threatened.

Source: Stebbins (1966).

TABLE 5.5 Threatened, Endangered, and Rare Species Potentially Present at Sandia National Laboratories

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
Club cholla	*Opuntia clavata*	–	SP1	Grasslands	Low
Cyanic milkvetch	*Astragalus cyaneus*	–	T	Grasslands, arroyos	Unlikely
Grama grass cactus	*Pediocactus papyracanthus*	C2	E	Grasslands	Unlikely
Great Plains lady tresses	*Spiranthes magnicamporum*	–	E	Grasslands	Unlikely
Plank's catchfly	*Silene plankii*	–	T	Grasslands	Unlikely
Santa Fe milkvetch	*Astragalus feensis*	–	T	Grasslands, arroyos	Unlikely
Simpson's cactus	*Pediocactus simpsonii*	–	E	Grasslands	Unlikely
Strong prickly pear	*Opuntia valida*	–	UR	Grasslands, woodlands	Unlikely
White visnagita	*Neolloydia intertexta*	–	E	Open woodlands	None
Wright's pincushion	*Mammillaria wrightii*	–	E	Open woodlands	None
Millipede	*Toltecus chihuanus*	C2	–	Grasslands	Unlikely
Rio Grande silvery minnow	*Hybognathus amarus*	E	T	Pools and backwaters of Rio Grande	None
Flathead chub	*Platygobio gracilis*	C2	–	Sandy runs of small to large turbid rivers	None
Texas horned lizard	*Phrynosoma cornutum*	C2	–	Arid and semi-arid open country with sparse plant growth; requires loose soil and bushes, burrows, or rocks for shelter	Unlikely
Northern goshawk	*Accipiter gentilis*	C2	–	Forests (especially in mountains), forest edges; winters in lowlands	Unlikely
Baird's sparrow	*Ammodramus bairdii*	C2	E	Native tallgrass prairies	Unlikely
Ferruginous hawk	*Buteo regalis*	C2	–	Plains, prairies	Unlikely
Common black-hawk	*Buteogallus anthracinus anthracinus*	–	T	Wooded stream bottoms	None
Northern beardless-tyrannulet	*Camptostoma imberbe ridgwayi*	–	E	Low woods, mesquite, stream thickets, lower canyons	None
Mountain plover	*Charadrius montanus*	C2	–	Semi-arid plains, grasslands, plateaus	Unlikely
Black tern	*Chlidonias niger surinamensis*	C2	–	Marshes, lakes, coastal waters	None

TABLE 5.5 (Cont.)

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
Southwestern willow flycatcher	*Empidonax traillii extrimus*	E	T	Willow, thickets, brushy pastures, old orchards	Unlikely
Peregrine falcon	*Falco peregrinus*	E	E	Wetlands, woodlands, forest, cities, agricultural areas, cliff faces, coastal habitats	None
Gray vireo	*Vireo vicinior*	–	E	Brushy mountain slopes, mesas, open chaparral, scrub oaks, junipers	Unlikely
Swainson's hawk	*Buteo swainsoni*	C2	–	Plains, ranges, open hills, sparse trees	Unlikely
Whooping crane	*Grus americana*	E	E	Prairie pools, marshes	None
Bald eagle	*Haliaeetus leucocephalus*	T	T	Lakes, reservoirs, rivers, coastlines	None
Least bittern	*Ixobrychus exilis exilis*	C2	–	Marshes, reedy ponds	None
White-faced ibis	*Plegadis chihi*	C2	–	Streams, marshes, ponds	None
Burrowing owl	*Speotyto cunicularia hypugaea*	C2	–	Open grassland, prairies, farmlands, airfields	Unlikely
Mexican spotted owl	*Strix occidentalis lucida*	T	–	Mature old-growth forests, conifers, wooded canyons	None
Bell's vireo	*Vireo bellii*	–	T	Willows, streamsides	Unlikely
Arizona black-tailed prairie dog	*Cynomys ludovicianus arizonensis*	C2	–	Semi-arid prairies; thrives on overgrazed rangelands; avoids tall grass	Unlikely
Spotted bat	*Euderma maculatum*	C2	E	Arid country; occasionally enters buildings and caves	Unlikely
Great western mastiff bat	*Eumops perotis californicus*	C2	–	Buildings, crevices, trees, tunnels	Unlikely
Western small-footed myotis	*Myotis ciliolabrum melanorhinus*	C2	–	Caves, rock crevices	None
Occult little brown myotis	*Myotis lucifugus occultus*	C2	–	Mountains, caves, hollow trees	None
Fringed myotis	*Myotis thysanodes thysanodes*	C2	–	Caves, attics	Unlikely
Long-legged myotis	*Myotis volans interior*	C2	–	Buildings, small pockets and crevices in rock ledges	Unlikely
Yuma myotis	*Myotis yumanensis yumanensis*	C2	–	Caves, tunnels, or buildings; arid areas	Unlikely
Big free-tailed bat	*Nyctinomops macrotis*	C2	–	Rough, rocky country; crevices in rocks	None
Pecos River muskrat	*Ondatra zibethicus ripensis*	C2	–	Marshes and other shallow water where emergent vegetation is abundant	None

TABLE 5.5 (Cont.)

Common Name	Scientific Name	Status[a]		Habitat	Potential to Occur at NIF Location
		Federal	State		
Townsend's big-eared bat	*Plecotus townsendii pallescens*	C2	–	Caves, mine tunnels, buildings	Unlikely
Colorado chipmunk	*Eutamias quadrivitatus australis*	C2	T	Coniferous forests, rocky slopes, ridges	Low
New Mexican jumping mouse	*Zapus hudsonius luteus*	C2	–	Prefers low meadows for feeding, but occurs in various land habitats; not restricted	Low

[a] Federal status definitions: E = endangered, T = threatened, C2 = candidate 2 (see text for details); state status definitions: E = endangered, SP1 = state priority 1, T = threatened species endemic to New Mexico or of restricted and decreasing abundance, UR = under review by New Mexico Forestry and Resource Conservation Division. A dash (–) indicates not listed.

Sources: Burt and Grossenheider (1976); IT Corporation et al. (1992); Jones et al. (1985); New Mexico Department of Game and Fish (1995); Page and Burr (1991); Peterson (1990); Stebbins (1966); Wheeler (1995).

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