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Final Environmental Impact Statement for the Mars Exploration Rover-2003 Project

FINAL ENVIRONMENTAL IMPACT STATEMENT FOR THE MARS EXPLORATION ROVER–2003 PROJECT

Office of Space Science
National Aeronautics and Space Administration
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ABSTRACT

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This Final Environmental Impact Statement addresses the potential environmental impacts associated with continuing the preparations for and implementing the National Aeronautics and Space Administration's (NASA's) Mars Exploration Rover–2003 (MER–2003) project. As proposed, this project would continue the long-term exploration of Mars as part of the United States' solar system exploration effort. The 2003 launch opportunity represents the best opportunity for a surface mission to Mars in the next twenty years.

The Proposed Action for the MER–2003 project consists of two missions to send two identical mobile science laboratories (rovers) to the surface of Mars. A Delta II 7925 would be used to launch the first spacecraft during May or June 2003 from Cape Canaveral Air Force Station (CCAFS), Florida, and inject it into an Earth-Mars trajectory with arrival at Mars in January 2004. A Delta II 7925 Heavy would be used to launch the second spacecraft in June or July 2003 from CCAFS, and inject it into an Earth-Mars trajectory with arrival at Mars in January 2004. Under the No Action Alternative NASA would cease preparations for and not implement the MER–2003 project.

The potential environmental impacts of implementing the Proposed Action and the No Action Alternative were evaluated. The environmental impacts of preparations for and launch of the MER–2003 spacecraft under the Proposed Action would be limited to those environmental impacts associated with the normal launch of other Delta II launches from CCAFS and have been addressed in prior NASA and U.S. Air Force environmental documentation. These impacts would be primarily associated with the

exhaust products resulting from the launch vehicles' solid rocket motors and main engines. Expected environmental effects would include short-term impacts to air quality, vegetation, and wildlife at and near the launch pads, and short-term impacts to stratospheric ozone. There would be no environmental impacts associated with the No Action Alternative.

Also considered is the potential for launch accidents that may result in release of some of the radioactive material onboard each of the MER–2003 rovers. Each rover would be equipped with up to 11 radioisotope heater units (as a source of heat for the onboard electronics and batteries), and two science instruments containing small quantities of radioactive sources. Under the No Action Alternative, there would be no MER–2003 launches.

The U.S. Department of Energy (DOE), the owner of the radioisotope heater units, participates as a cooperating agency. DOE has prepared a detailed nuclear risk assessment of potential launch accidents and radiological consequences to human health and the environment, as well as estimates of the risks associated with each phase of each mission. DOE's risk assessment for the MER–2003 project indicates that both the likelihood of an accident resulting in a release of radioactive material, and the expected impacts of released radioactive material on or near the launch area, and on a global basis, would be small.

Implementation of the Proposed Action would accomplish all of the scientific and technical goals and objectives set forth for the MER–2003 project, and substantially further NASA's program for the exploration and understanding of Mars. The No Action Alternative would result in loss of the 2003 mission opportunity and would adversely impact attainment of NASA's long-term science objectives for the exploration of Mars.

EXECUTIVE SUMMARY

This Final Environmental Impact Statement (FEIS) for the Mars Exploration Rover–2003 project has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321 *et seq.*); Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions"; the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR parts 1500-1508); and the National Aeronautics and Space Administration's (NASA's) policy and procedures (14 CFR subpart 1216.3). The purpose of this FEIS is to assist in the decisionmaking process concerning the Proposed Action and the No Action Alternative for the Mars Exploration Rover–2003 (MER–2003) project.

The MER–2003 project would consist of two missions to send two identical rovers to the surface of Mars to conduct mineralogy and geochemistry investigations and to characterize a diversity of rocks and soils which may hold clues about past water activity. Each rover would explore to a distance of at least 600 meters (1,968 feet) from its landing site, and surface operations would be expected to last at least 90 Martian days (sols[1]).

A Delta II 7925 with a Star 48B upper stage would be used to launch the first spacecraft (MER–A) during May or June 2003, and inject it into an Earth-Mars trajectory with arrival at Mars in January 2004. A Delta II 7925 Heavy (7925H) with a Star 48B upper stage would be used to launch the second spacecraft (MER–B) in June or July 2003, and inject it into an Earth-Mars trajectory with arrival at Mars in January 2004. NASA has not selected specific landing sites yet but is currently considering potential sites between 15° South and 5° North for the MER–A mission, and between 10° South and 10° North for the MER–B mission.

PURPOSE AND NEED FOR ACTION

For many years, Mars has been a primary focus for scientists due to its potential for past biological activity and for comparative studies with Earth. NASA continues to characterize the planet and its atmosphere, its geologic history, its climate and relationship to Earth's climate change process; to determine what resources Mars provides for future exploration; and to search for evidence of past or present life. The proposed MER–2003 missions would continue the exploration of Mars by enabling scientists to read the geologic record at each site, to investigate what role water played there, and to determine how suitable the conditions would have been for life. The scientific goal of each MER–2003 mission is to determine the aqueous, climatic, and geologic history of a site on Mars where conditions may have been favorable to the preservation of evidence of possible pre-biotic or biotic processes. The year 2003 represents a uniquely efficient launch opportunity for a surface mission to Mars in the next twenty years.

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[1] 1 sol = 1 Martian day = 24 hours, 37 minutes or 1.026 Earth days

The science instrument suite carried on each MER–2003 rover would conduct a series of investigations of the Martian surface which are designed to shed new light on the past environments, history and geology of the planet. The project would conduct fundamentally new observations of Mars geology, including the first small-scale studies of rock samples, and a detailed study of surface environments for the purpose of calibrating and validating orbital spectroscopic remote sensing.

ALTERNATIVES EVALUATED

The Proposed Action consists of continuing preparations for and implementing the MER–2003 project to Mars. The MER–2003 project involves two launches (the MER–A mission and MER–B mission) of identical spacecraft from Cape Canaveral Air Force Station (CCAFS), Florida, in 2003. The MER–A launch, aboard a Delta II 7925, would occur during May or June, 2003. The MER–B launch would occur during June or July, 2003, aboard a Delta II 7925H. Programmatic issues (*e.g.*, changes in NASA priorities or unforeseen circumstances) could necessitate modification to the mission objectives and timing. Such modifications could result in the need to launch one mission in 2003, and a second mission at a later launch opportunity or not at all. Under the No Action Alternative NASA would cease preparations for and not implement the MER–2003 project.

The following section discusses the potential environmental impacts associated with implementation of the Proposed Action and the No Action Alternative. Because the Proposed Action would employ radioactive material that could potentially be released in the event of a launch vehicle accident, a discussion on potential radiological impacts is provided. This Executive Summary concludes with a brief evaluation of the MER–2003 project's science return, including the missions' implications for NASA's longer-term efforts to characterize Mars and answer fundamental questions regarding the planet.

ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION AND THE NO ACTION ALTERNATIVE

Nonradiological Consequences of the Proposed Action and the No Action Alternative

For the MER–2003 project, the potentially affected environment includes the areas on and near the launch site at CCAFS in Florida. The potential environmental consequences of Delta II launch vehicles have been addressed in prior U.S. Air Force (USAF) and NASA NEPA documents, and are summarized below.

The environmental impacts of normal launches of the two missions for the Proposed Action would be associated principally with the exhaust emissions from each of the Delta II launch vehicles. These effects would include short-term impacts on air quality within the exhaust cloud at and near the launch pads, and the potential for acidic deposition on the vegetation and surface water bodies at and near each launch complex, particularly if rain occurs shortly after launch. Some short-term ozone degradation would occur along the flight paths as each launch vehicle passes through the stratosphere and deposits ozone-depleting chemicals from the solid rocket motors.

Accidents could occur during preparations for and launch of any launch vehicle. Only two types of nonradiological accidents would have potential off-site consequences: a liquid–propellant spill during fueling operations, and a launch failure. The most severe propellant spill accident scenario postulated involves release of the entire contents of the second stage nitrogen tetroxide (N_2O_4) tank during propellant transfer. Because N_2O_4 rapidly converts to nitrous oxides (NO_X) in the air, toxic effects of the release would be limited to the launch area.

A launch vehicle accident either on or near the launch pad within a few seconds of liftoff presents the greatest potential for impact to human health, principally to workers at the launch site. The potential short-term effects of an accident would include a localized fireball, falling fragments from explosion of the vehicle, release of uncombusted propellants and propellant combustion products, and for on-pad or very low altitude explosions, death or damage to nearby biota and brush fires near the launch pad.

There would be no environmental impacts associated with the No Action Alternative.

Radiological Consequences of Potential Launch Accidents for the Proposed Action and the No Action Alternative

Each MER–2003 rover could have up to 11 radioisotope heater units (RHUs), which use plutonium dioxide (consisting of mostly plutonium-238 (Pu-238)) to provide heat to prevent the electronics and batteries from freezing at night. The rover would also carry a small amount of radioactive sources (cobalt-57 (Co-57) and curium-244 (Cm-244)) in two of its science instruments. Depending on the sequence of events, some launch accidents could result in release of some of these materials.

NASA’s cooperating agency, the U.S. Department of Energy (DOE), as owner of the RHUs, has performed a nuclear safety risk assessment of potential accidents for the MER–2003 project. This assessment uses a methodology refined through applications to several previous missions and incorporates data from safety tests on the RHUs. The first step in the risk assessment is NASA's estimate of the probabilities of various launch system failures and the potential resulting accident environments that could threaten the RHUs and small-quantity radioactive sources onboard the spacecraft. Then, the response of the RHUs and small-quantity radioactive sources to these accident environments is assessed, and an estimate is made of the amount of radioactive material that could be released for each accident environment. Finally, the analysis determines the potential consequences of each release to the environment and to the population. Accidents are assessed over all launch phases, from pre-launch through orbit escape, and consequences are assessed for both the regional population near the launch site, and to the global population, in the event of an accident that results in a reentry from space.

DOE’s risk assessment for the MER–2003 project indicates that both the likelihood of an accident resulting in a release of radioactive material, and the expected impacts of released radioactive material on or near the launch area, and on a global basis, would be small.

The results of the NASA and DOE analyses indicate that the overall chance of an accident occurring during the launch of either of the MER–2003 spacecraft is about 1 in 30 (based upon launch vehicle history and additional analysis). Most potential accidents would not present a threat to the RHUs onboard the spacecraft because of the rugged design of the RHUs and the addition of an upper stage breakup system. For the MER–A launch, the chance of an accident in the launch area that releases any radioactivity is about 1 in 1,030. The overall chance of any accident that releases radioactive materials to the environment is about 1 in 230. The accident probabilities for a MER–B launch are similar.

The Cm-244 and Co-57 small-quantity radioactive sources and their mounting fixtures have relatively low melting temperatures compared to the plutonium in the RHUs, and their release in launch area accidents is assumed to be likely. Reentry conditions would also likely lead to the release of the small-quantity radioactive sources at high altitude. Safety testing and response analysis of the RHUs to accident environments indicate that only a very small fraction of early launch accidents could lead to potential releases of Pu-238. The RHUs are designed to survive reentry environments and subsequent surface impacts. The probability of an accident away from the launch area that could release small amounts of Cm-244 and Co-57, but not plutonium dioxide, is about 1 in 290.

The radiological consequences for each accident scenario were calculated in terms of (1) maximum individual dose; (2) potential for additional latent cancer fatalities (number of deaths due to cancer in excess of what the population would normally experience from other causes) due to a radiation release; and (3) land area contaminated at or above specified levels. Results are reported here for the MER–A mission. Results for the MER–B mission are similar.

If a launch-area accident resulting in the release of radioactive material were to occur, spectators and people offsite in the downwind direction could inhale small quantities of radionuclides, including Pu-238, Cm-244, and Co-57. In most cases, the amount of additional radiation exposure would be a very small fraction of the radiation exposure an individual receives from naturally occurring radiation in the Earth and from cosmic radiation. In the United States, the average annual radiation exposure is 300 millirem from natural background sources. Human-caused exposures such as medical diagnostic X-rays add an additional 60 millirem to this annual average. In the event of a launch accident with a release of radioactive materials, the person with the highest exposure would typically receive less than a few tens of millirem. No health consequences would be expected with this level of radiation exposure.

The total radiological exposure to the regional and global populations from an accidental release at high altitude would also be very small. With either launch-area or orbital reentry accidents, the releases are predicted to be so small that no additional cancers would be expected among the launch-area or worldwide population.

The airborne radioactive materials released in a launch-area accident would be deposited downwind from the accident location. Most of the material released in the accident scenarios considered would be very small particles. The results of the DOE analyses indicate that the land area contaminated at levels that might require further action, such as monitoring or cleanup, is expected to be less than 0.5 square kilometer (0.2 square mile) for postulated launch area accidents.

Under the No Action Alternative NASA would not complete preparations for and implement the MER–2003 project. The No Action Alternative would not entail any of the radiological risks associated with potential mission accidents.

SCIENCE COMPARISON

The Proposed Action would substantially further NASA's program for the exploration of Mars. The payload of instruments on each rover has been carefully selected to maximize collection of scientific data to meet MER–2003 project objectives. Scientists would be able to closely examine the physical, geological and chemical characteristics of the landing sites and determine their aqueous, climatic, and geologic histories. By reading the geologic record at each site, scientists would investigate the role water played there and determine how suitable the conditions might have been for life.

Operation of the rovers and their science instruments would also benefit the planning and design of future missions. Lessons learned during all phases of each MER–2003 mission (atmospheric entry, descent, and landing; initial deployment on the surface; real-time site traverse planning, execution and navigation; and science data collection) would provide valuable information for refining future mission designs and procedures.

Under the No Action Alternative none of the science planned for the MER–2003 missions would be obtained. The objectives of NASA's planned follow-on missions to Mars would be adversely affected without the data to be obtained by the MER–2003 missions.

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ABBREVIATIONS AND ACRONYMS

A

ac	acres
ADS	Automatic Destruct System
AEC	U.S. Atomic Energy Commission
AIC	accident initial condition
AOC	accident outcome condition
APXS	Alpha Particle X-ray Spectrometer
Al	aluminum
Al_2O_3	aluminum oxide

B

BUS	Breakup System (Star 48B)

C

^{o}C	degrees Celsius (centigrade)
CAA	Clean Air Act
CCAFS	Cape Canaveral Air Force Station
CDS	Command Destruct System
CFR	Code of Federal Regulations
Ci	curie(s)
Cl_2	chlorine
cm	centimeter(s)
Cm	curium
cm^2	square centimeters
Co	cobalt
CO	carbon monoxide
CO_2	carbon dioxide
COMPLEX	Committee on Planetary and Lunar Exploration

D

^{o}	degrees (temperature or angle)
dBA	decibels (A-weighted)
DEIS	Draft Environmental Impact Statement
DOC	U.S. Department of Commerce
DoD	U.S. Department of Defense

DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior

E

EA	environmental assessment
ECFRPC	East Central Florida Regional Planning Council
EDL	entry, descent and landing
EIS	environmental impact statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERPG	Emergency Response Planning Guidelines

F

^{o}F	degrees Fahrenheit
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FEIS	Final Environmental Impact Statement
FR	*Federal Register*
FSII	full stack intact impact
ft	feet
ft^2	square feet
ft^3	cubic feet
FTS	Flight Termination System
FWS	U.S. Fish and Wildlife Service

G

g	gram(s)
gal	gallon(s)
GEM	graphite-epoxy solid rocket motor
GIS	Geographic Information System
GOAA	Greater Orlando Aviation Authority

H

H_2	hydrogen
H_2O	water
ha	hectare(s)
HCl	hydrochloric acid (hydrogen chloride)
HTPB	hydroxyl-terminated polybutadiene

I

IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IDD	Instrument Deployment Device
in	inch(es)
in^2	square inch(es)
in^3	cubic inch(es)
INSRP	Interagency Nuclear Safety Review Panel
ISDS	Inadvertent Separation Destruct System

J

JPL	Jet Propulsion Laboratory, California Institute of Technology

K

K	degrees Kelvin
KeV	kilo electron volt(s)
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometer(s)
km/s	kilometers per second
KSC	Kennedy Space Center, NASA

L

lb	pound(s)
lbf	pound(s)-force
LDXL	Large Diameter Extra Long (GEM)
LOX	liquid oxygen

M

m	meter(s)
m^3	cubic meter(s)
mCi	millicurie(s)
MECO	main engine cutoff
MER–2003	Mars Exploration Rover–2003
MET	mission elapsed time
MFCO	Mission Flight Control Officer
MGS	Mars Global Surveyor

mi	mile(s)
mi^2	square mile(s)
MINWR	Merritt Island National Wildlife Refuge
mm	millimeter(s)
MMH	monomethyl hydrazine
mph	miles per hour
mt	metric ton(s)
µCi	microcurie(s)
$\mu Ci/m^2$	microcurie(s) per square meter
$\mu g/m^2$	microgram(s) per square meter
$\mu g/m^3$	microgram(s) per cubic meter

N

N_2	nitrogen
N_2H_4	hydrazine
N_2O	nitrous oxide
N_2O_4	nitrogen tetroxide (NTO)
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
nmi	nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NOI	notice of intent
NRC	U.S. Nuclear Regulatory Commission

O

O_2	oxygen
O_3	ozone
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
oz	ounce(s)

P

Pancam	Panoramic Camera
pfs	pounds per square foot
pH	measure of acidity
PLF	payload fairing
PMA	Pancam Mast Assembly
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
PM_{10}	particulate matter less than 10 microns in diameter
ppm	parts per million
Pu	plutonium
PuO_2	plutonium dioxide

R

REEDM	Rocket Exhaust Effluent Diffusion Model
rem	roentgen equivalent man
RHU	radioisotope heater unit
RP-1	rocket propellant–1
RTG	Radioisotope Thermoelectric Generator

S

s	second(s)
SECO	second-stage engine cutoff
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SLC	Space Launch Complex
SNAP	Systems for Nuclear Auxiliary Power
SO_2	sulfur dioxide
SPEGL	Short-Term Public Emergency Guidance Level
SR	State Route
SSB	Space Studies Board

T

T	time
TECO	Third-stage engine cutoff
TES	Thermal Emission Spectrometer

U

UDMH	unsymmetrical dimethylhydrazine
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USAF	U.S. Air Force
USBC	U.S. Bureau of the Census
U.S.C.	U.S. Code

W

WEB	warm electronics box

CONVERSION FACTORS

Length

1 centimeter (cm) = 0.3937 inch (in)	1 inch = 2.54 cm
1 centimeter = 0.0328 foot (ft)	1 foot = 30.48 cm
1 meter (m) = 3.2808 feet	1 ft = 0.3048 m
1 meter = 0.0006 mile (mi)	1 mi = 1609.3440 m
1 kilometer (km) = 0.6214 mile	1 mi = 1.6093 km
1 kilometer = 0.53996 nautical mile (nmi)	1 nmi = 1.8520 km
	1 mi = 0.87 nmi
	1 nmi = 1.15 mi

Area

1 square kilometer (km^2) = 0.3861 square mile (mi^2)	1 mi^2 = 2.5900 km^2
1 hectare (ha) = 2.4710 acres (ac)	1 ac = 0.4047 ha

Volume

1 liter = 0.2642 gallon (gal)	1 gal = 3.7854 l

Weight

1 gram (g) = 0.0353 ounce (oz)	1 oz = 28.3495 g
1 kilogram (kg) = 2.2046 pounds (lb)	1 lb = 0.4536 kg
1 metric ton (mt) = 1.1023 tons	1 ton = 0.9072 metric ton

1 PURPOSE AND NEED FOR ACTION

This Final Environmental Impact Statement (FEIS) has been prepared by the National Aeronautics and Space Administration (NASA) to assist in the decisionmaking process as required by the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321 *et seq.*); Executive Order (EO) 12114, "Environmental Effects Abroad of Major Federal Actions"; Council on Environmental Quality Regulations (40 CFR parts 1500–1508); and NASA policies and procedures at 14 CFR subpart 1216.3. This FEIS provides information associated with potential environmental impacts of continuing preparations for and implementing the proposed Mars Exploration Rover–2003 (MER–2003) project. The U.S. Department of Energy (DOE), as a cooperating agency, performed a nuclear safety risk assessment of potential accidents for the MER–2003 project. The MER–2003 project would conduct scientific investigations on the surface of Mars. The project would consist of two launches in 2003 of identical MER–2003 spacecraft (the MER–A mission and the MER–B mission) from Cape Canaveral Air Force Station (CCAFS), Florida. Chapter 2 of this FEIS evaluates the alternatives considered for the MER–2003 project.

1.1 BACKGROUND

The missions of the proposed MER–2003 project would be part of NASA's program for the exploration of the solar system. The goals of this program include understanding the nature and history of our solar system, and what makes Earth similar to and different from its planetary neighbors; understanding the origin and evolution of life on Earth; and understanding the external forces that affect life and the habitability of Earth. Interwoven with these goals is the search for and study of life elsewhere in the Universe. Over the past three decades NASA has addressed these goals with increasingly sophisticated robotic missions to the other planets and minor bodies of the solar system. The MER–2003 missions would continue the more detailed exploration of our nearest neighbor, the planet Mars.

Mars is a rocky planet like Earth but is substantially smaller with a thinner atmosphere and a cold, desert surface. As a result of previous space missions (the early Mariner Mars flybys and orbiter, the Viking orbiters and landers, the Mars Pathfinder lander and rover, and the Mars Global Surveyor (MGS) orbiter), much more has already been learned about Mars compared to any of the other planetary bodies except for the Moon. Meteorites that came from Mars have been found on Earth. Some of these meteorites are very young. One Mars meteorite, collected in Antarctica, is ancient, however, and has stimulated scientific controversy regarding possible evidence of fossil microbial life seen in the meteorite.

Mars has had a complicated history in which, among many geologic processes, liquid water may have played a major role in shaping the surface. Evidence of geologically recent volcanism has been observed, indicating that Mars may still be active. Mars is suspected to still have a significant quantity of subsurface water in the form of ground ice at and near the surface and in the liquid phase at greater depths. The early Martian surface environment may have been much more suitable for the evolution of life than would be supposed by observing the thin, dry atmosphere and the cold, unprotected (from solar ultra-violet radiation) surface of present-day Mars.

Many of the scientific questions regarding Mars ultimately involve the role and fate of the water that once flowed on its surface. Accordingly, NASA has developed an exploration strategy which can be summarized as "Follow the Water".

The reason for the intense interest in Martian water is simple: without water, life cannot exist as we know it. If it has been billions of years since liquid water was present on Mars, the chance of finding life there now is remote. But if water is present on Mars now, however well hidden, life may be holding on in some protected niche.

Based on what we have observed so far, Mars today is a frozen desert. The climate is too cold for liquid water to exist on the surface and it is too cold to rain. The planet's atmosphere is also too thin to permit any significant amount of snowfall. Even if some internal heat source warmed the planet enough for ice to melt, it would not yield liquid water. The Martian atmosphere is so thin that even if the temperature rose above freezing the ice would change directly to water vapor.

Despite these observations, there may have been abundant water in Mars' past. That is evident from the massive outflow channels that are found, mostly, in the northern lowlands of Mars. The intensity of the floods that carved these channels would have been tremendous. This evidence leads to several intriguing scientific questions, beginning with what caused these giant floods? Were the floods a result of a climate change, perhaps brought about by a change in the orbit of Mars, or was the planet's own internal heat responsible? Whatever the mechanism that caused the floods in the first place, where has all that water gone? Was it absorbed into the ground where it remains today, frozen? Or did it dissipate into the Martian atmosphere, where it was subsequently lost to space? No one knows for certain the answers to these questions.

1.2 PURPOSE OF THE ACTION

The purpose of the action addressed in this FEIS is to further the scientific objectives of NASA's program for solar system exploration by continuing the exploration and characterization of Mars. Specifically, the MER–2003 missions proposed for launch would continue the intensive and extensive study of two different local areas of the planet. These studies would involve geological investigations of two geologically different areas and characterize a diversity of rocks and soils which may hold clues to past water activity.

The scientific goal of each MER–2003 mission is to determine the aqueous, climatic, and geologic history of a site on Mars where conditions may have been favorable to the preservation of evidence of possible pre-biotic or biotic processes. Accordingly, the MER–2003 rovers would land on two pre-selected sites that show evidence of the action of liquid water. The broad scientific objectives for each mission are to:

- identify the hydrologic, hydrothermal, and other processes that have operated at the landing site and affected the materials there, using measurements of their mineralogy, elemental chemistry, and surface texture;

- identify and investigate Martian rocks and soils that have the highest possible chance of preserving evidence of ancient environmental conditions and possible pre-biotic or biotic activity; and,
- use the tools that were designed for the above objectives to respond to other discoveries associated with rover-based exploration.

The MER–2003 missions encompassed by the Proposed Action would continue the exploration of Mars by enabling scientists to read the geologic record at each site, to investigate what role water played there, and to determine how suitable the conditions would have been for life.

The proposed MER–2003 missions would also take advantage of one of the most efficient launch opportunities to place landers on the surface of Mars. During 2003, the planetary alignments are such that NASA has the opportunity to use smaller, less expensive launch vehicles to deliver a payload to the surface of Mars. NASA proposes to take advantage of this opportunity, within the limits of available resources, to launch two rovers to Mars. The Proposed Action would allow NASA to substantially advance its technological and operational capabilities on the surface of Mars. NASA established mission-level objectives including, but not limited to:

- demonstrate long range traverse capabilities by mobile science platforms to validate long-lived, long distance rover technologies;
- demonstrate complex science operations through the simultaneous use of multiple science-focused mobile laboratories; and
- validate the standards, protocols, and capabilities of the international Mars communications infrastructure.

1.3 NEED FOR THE ACTION

Following the water means looking for scientific evidence that water was present in the past or is present today on Mars, either below the surface or possibly in rare locations near small, hydrothermal vents. Previous and current Mars missions have returned views of the Martian surface that seem to show evidence of dry riverbeds, flood plains, rare gullies on Martian cliffs and crater walls, and sedimentary deposits that suggest the presence of water in the history of Mars.

A recent study by the Committee on Planetary and Lunar Exploration (COMPLEX) of the National Research Council's Space Studies Board (SSB) considered the scientific rationale for mobility in conducting planetary exploration (SSB 1999). In this study, COMPLEX concluded, in part, that "The pattern of planetary exploration to date has been to make basic observations of planetary surfaces from orbiters and to establish hypotheses for interpreting these observations. These hypotheses are then tested by more directed observations and measurements. Because the hypotheses are based on orbital images with a relatively low characteristic resolution, this suggests that long-range traverses are required to test the relevant hypotheses."

Regarding the need for mobility on the surface of Mars, COMPLEX further stated that "Although the global- and regional-scale surveys of mineralogic and elemental compositions that are a prerequisite for any assessment of Mars's potential as an abode of life can be determined from orbit, the detailed characterization of local sites of particular exobiological interest requires *in situ* (local) measurements. Most researchers do not expect that evidence for past or present life will be so abundant or widespread that it will be available in the immediate vicinity of landing sites. This is particularly true given that landings may occur up to tens of kilometers from the desired aim point. Without the mobility necessary to conduct *in situ* exploration, it may not be possible to identify a target location uniquely."

The MER–2003 missions encompassed by the Proposed Action would provide the capability for much greater mobility on the surface of Mars than ever before. Using a coordinated and complementary suite of scientific investigations, the MER–2003 rovers would explore broad areas around two diverse landing sites, searching for evidence of past or current water activity.

1.4 NEPA PLANNING AND SCOPING ACTIVITIES

On February 22, 2001, NASA published a Notice of Intent (NOI) in the *Federal Register* (66 FR 11184) to prepare an Environmental Impact Statement and conduct scoping for the Mars Exploration Rover–2003 Project. The scoping period ended April 9, 2001. Two scoping comments were received from private individuals expressing concerns about the use of plutonium in space missions, and were considered in development of the Draft Environmental Impact Statement (DEIS).

1.5 RESULTS OF PUBLIC REVIEW OF THE DRAFT EIS

NASA published its Notice of Availability for the DEIS for the Mars Exploration Rover–2003 Project on July 24, 2002 (67 FR 48490), and mailed copies to 79 Federal, State and local agencies, organizations, and individuals. In addition, the DEIS was publicly available in electronic format from a NASA server on the Internet. The U.S. Environmental Protection Agency published its Notice of Availability on July 26, 2002 (67 FR 48894), initiating the 45-day review and comment period.

The comment period for the DEIS closed on September 9, 2002. Responses were received from a total of four Federal and State entities (the State of Florida response consolidated the reviews of several State agencies), and two individuals. The comments included "no comment", requests to clarify specific points of discussion in the text, and an objection to the use of nuclear material in space. Minor clarifying revisions have been made as a result of the comments. All communications received during the DEIS public review period are found in Appendix C of this FEIS.

2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

The purpose of the Mars Exploration Rover–2003 (MER–2003) project would be to place two mobile science laboratories (rovers) on the surface of Mars to characterize rocks and soils that may hold clues to the possible presence of water on Mars.

This Final Environmental Impact Statement (FEIS) for the MER–2003 project evaluates the following alternatives:

- Proposed Action. NASA proposes to continue preparations for and to implement the MER–2003 project to Mars. The MER–2003 project involves two launches (the MER–A mission and MER–B mission) of identical spacecraft from Cape Canaveral Air Force Station (CCAFS), Florida, in 2003. The MER–A launch, aboard a Delta II 7925, would occur during May or June, 2003. The MER–B launch would occur during June or July, 2003, aboard a Delta II 7925 Heavy (7925H). The Proposed Action is described in Section 2.1.

- No Action. Under the No Action Alternative, NASA would discontinue preparations for and would not implement the MER–2003 project. The No Action Alternative is described in Section 2.2.

2.1 DESCRIPTION OF THE PROPOSED ACTION

NASA proposes to continue preparations for and to implement the MER–2003 project to Mars. The MER–2003 project would consist of two missions to send two identical rovers to two different sites on the surface of Mars to conduct *in situ* (local) mineralogy and geochemistry investigations and characterize a diversity of rocks and soils which may hold clues about past water activity. Each rover would explore to a distance of at least 600 meters (m) (1,968 feet (ft)) from its landing site (with a goal of one kilometer (km) (0.62 mile (mi))), and surface operations would be expected to last at least 90 Martian days (sols[1]). The rovers would investigate up to a total of eight separate locations in the vicinity of two diverse landing sites. The two rovers would operate simultaneously for at least 30 sols.

A Delta II 7925 with a Star 48B solid-rocket upper (third) stage would be used to inject the first spacecraft (MER–A) into an Earth-Mars trajectory during May or June 2003, with arrival at Mars in January 2004. A Delta II 7925H with a Star 48B third stage would be required to inject the second spacecraft (MER–B) into an Earth-Mars trajectory in June or July 2003 for arrival at Mars in January 2004. (Due to the later launch opportunity, the MER–B mission can only be achieved with the Delta II 7925H.) NASA has not selected specific landing sites yet but is currently considering potential sites between 15° South and 5° North for the MER–A mission, and between 10° South and 10° North for the MER–B mission.

Achieving all of the mission objectives would require launching two rovers as proposed. However, programmatic issues (*e.g.*, changes in NASA priorities or unforeseen

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[1] 1 sol = 1 Martian day = 24 hours, 37 minutes or 1.026 Earth days

circumstances) could necessitate modification to the mission objectives and timing. Such modifications could result in the need to launch one mission in 2003, and a second mission at a later launch opportunity or not at all. If any of these events were to occur, NASA would evaluate the need to prepare additional environmental documentation.

2.1.1 Spacecraft Description

The summary description of the MER–2003 spacecraft presented in this section is based upon the detailed design information available at the time of publication of this FEIS. This information, in the *Mars Exploration Rover Project Final Delta II 7925/7925H EIS Databook* (NASA 2001), is subject to further refinement as the design process proceeds.

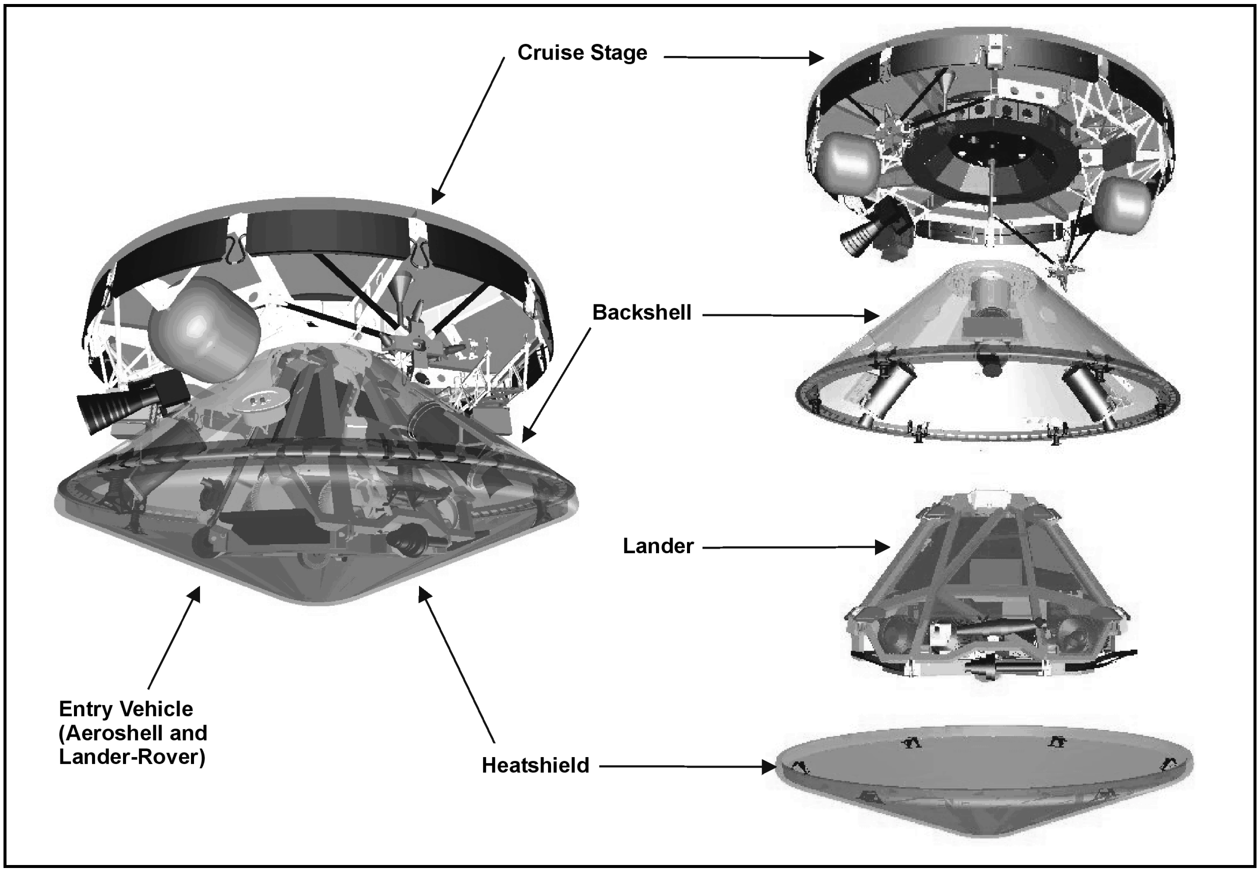
Each identical MER–2003 spacecraft (see Figure 2-1) would consist of a cruise stage and an entry, descent, and landing (EDL) stage, which would include an aeroshell, backshell, parachute, and airbags. A lander containing a large rover would be enclosed within the EDL stage. The primary function of the EDL stage would be to convey its lander-rover safely to the surface of the planet. Each rover would carry all science instruments and communications equipment for transmitting to and receiving data from Earth, either by using an existing Mars orbiting spacecraft or by communicating directly with Earth. The mass for each spacecraft is expected to be 1,063 kilograms (kg) (2,343 pounds (lb)).

After launch, each spacecraft would cruise to Mars for approximately seven to eight months. During final approach, the cruise stage would be jettisoned from the EDL stage, and the vehicle would enter the Martian atmosphere. The MER–2003 missions would employ a technique similar to that demonstrated by the 1996 Mars Pathfinder mission to ensure a safe landing on the surface of Mars. This technique would employ a heatshield, small solid retro-rockets, and a parachute to decelerate the lander as it passes through the Martian atmosphere. A system of airbags would then be used to cushion and protect the lander upon contact with the Martian surface. Once each lander comes to rest the airbags would deflate and the lander petals would unfold. Each rover would then drive off of its lander platform and begin exploring the landing site.

2.1.1.1 Cruise Stage

The cruise stage (see Figure 2-1) would contain the components that are used only during the cruise to Mars. It would provide the interface with the launch vehicle and upon command would separate from the launch vehicle upper stage. The cruise stage would provide the propulsion system for attitude control, trajectory correction maneuvers, and final Mars entry attitude alignment. It also would carry equipment for solar power generation during flight to Mars, and for telecommunications, attitude determination and navigation during cruise.

The cruise stage propulsion system would include two lightweight composite-wrapped aluminum-lined tanks, each designed to carry up to 35 kg (77 lb) of hydrazine (N_2H_4) propellant. Solar cells for electrical power generation would be fixed to the cruise stage along a disc-shaped substrate. A star tracker and sun-sensors would provide data for attitude determination. Telecommunications and navigation tracking would be provided by medium and low gain antennas.



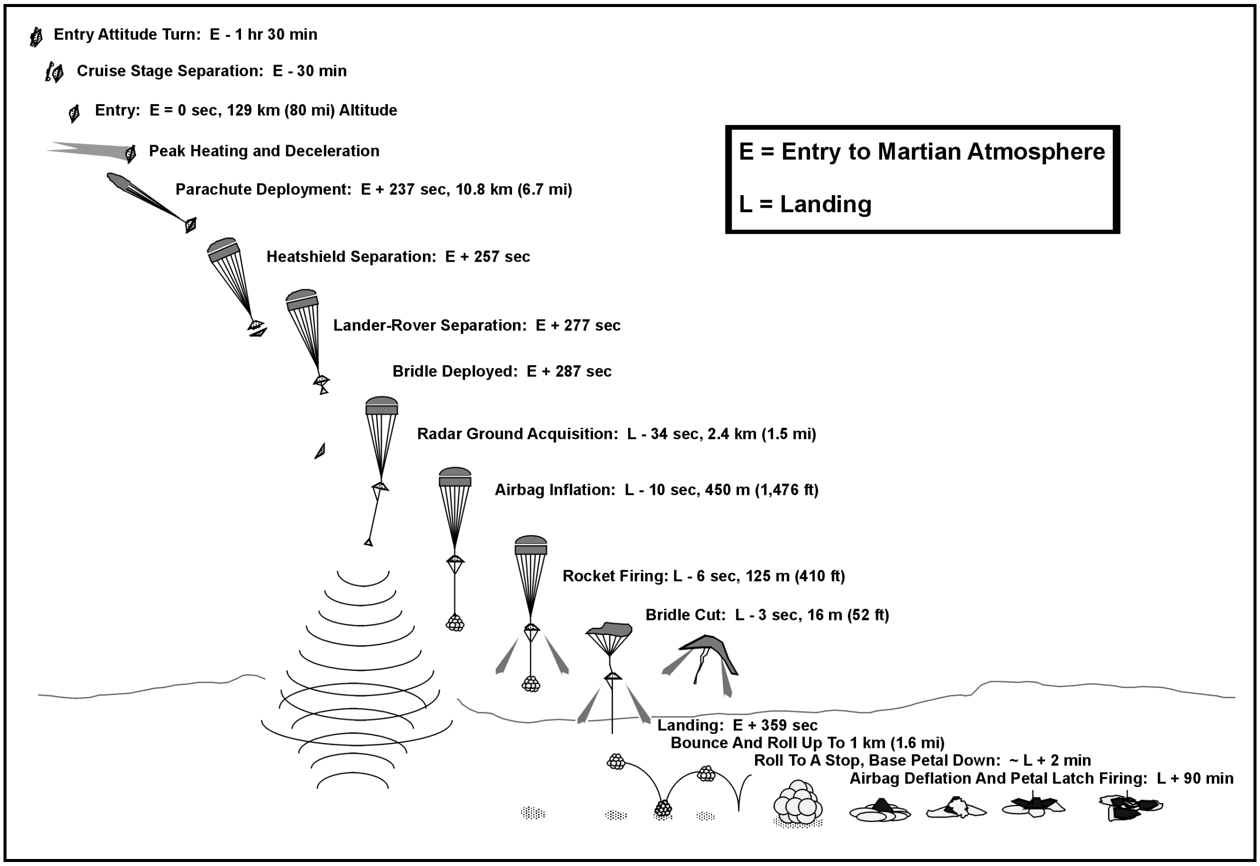
Source: Adapted from NASA 2001

Figure 2-1. Illustration of the MER–2003 Spacecraft

2.1.1.2 Entry Vehicle

The entry vehicle (see Figure 2-1) would contain the lander-rover vehicle in an aeroshell made up of a heatshield and a backshell. The entry vehicle would constitute the EDL stage of the MER–2003 spacecraft. The aeroshell would consist of the heatshield and backshell, a parachute, inflatable airbags, and small solid rocket motors. It would protect the lander-rover during entry through the Martian atmosphere via the thermal protection system on the heatshield. The heatshield would be shaped in a 70° half-cone, similar to that used for Mars Pathfinder.

The entry vehicle would separate from the cruise stage about 30 minutes prior to entering Mars' atmosphere. The vehicle would enter the atmosphere directly from its interplanetary trajectory without first being captured into an orbit about Mars. Between four and five minutes after entering Mars' atmosphere, the parachute would be deployed, the heatshield would be jettisoned, and the lander's radar altimeter would be turned on. The lander would descend on a tether suspended from the backshell. At approximately 450 m (1,476 ft) above the surface the airbags would be inflated. The small solid rocket motors would then fire at about 125 m (410 ft) above the surface. A few seconds after that the parachute bridle would be cut and the lander would descend in free-fall the remaining distance to the surface and bounce and roll to a stop. Figure 2-2 illustrates the landing sequence.



Source: Adapted from NASA 2001

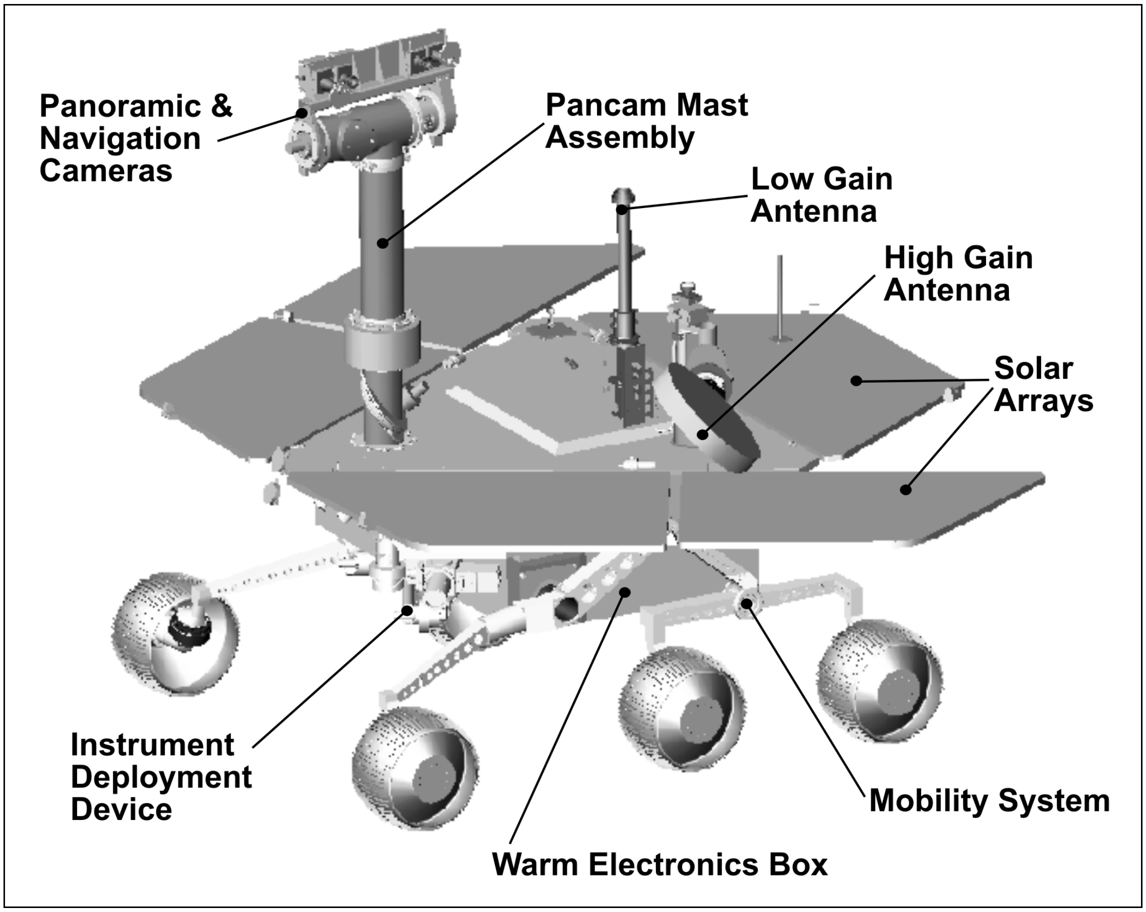
Figure 2-2. MER–2003 Entry, Descent and Landing Sequence

2.1.1.3 Lander

The lander (see Figure 2-1) would be a four-petal tetrahedron of composite structure with external aluminum sheet cladding for protection from rocks. The lander would carry the airbags and their associated inflation and retraction actuators, and the actuators that open the lander petals and right the lander. The lander would also carry the batteries to provide power through the first day of deployment activities, and electronics modules for pyrotechnic switching and primary battery control, and the lander radar altimeters. The base of the lander would contain the rover lift mechanism to support rover deployment after petal opening. Following entry, descent and landing, the lander would retract the airbags, deploy its petals, right itself if necessary, and erect the rover.

2.1.1.4 Rover

The MER–2003 rover (see Figure 2-3) would be substantially larger and more capable than the *Sojourner* rover of the Mars Pathfinder mission. The MER–2003 rover would have a mass of nearly 185 kg (408 lb) and a range of up to 40 m (about 131 ft) per Martian day. The rover's wheel base would measure 1.4 m (4.6 ft) and it would have a track width of 1.06 m (3.5 ft). The total height of the rover would be 1.5 m (4.8 ft) and the ground clearance beneath the rover would be 0.29 m (11.2 inches (in)).



Source: Adapted from NASA 2001

Figure 2-3. Illustration of the MER–2003 Rover

Immediately after landing and system check-out, each rover would begin reconnaissance of its landing site by taking a 360° visible color and infrared panorama image. It would then drive off its lander to begin its exploration, and may drive to up to four different sites during its planned 90-sol mission. The rover would perform remote science, taking images with the Panoramic Camera (Pancam) mounted on the Pancam

Mast Assembly (PMA). The PMA also would serve as the optical path for infrared images collected by the Miniature Thermal Emission Spectrometer (Mini-TES). The rover would perform *in situ* science using available cameras, and, on selected targets, would use the Instrument Deployment Device (IDD) to position the *in situ* instrument suite. This would include the Alpha Particle X-Ray Spectrometer (APXS), the Mössbauer Spectrometer, the Rock Abrasion Tool, and the Microscopic Imager. Table 2-1 lists the science instruments proposed for each MER–2003 rover and summarizes their measurement objectives.

Table 2-1. MER–2003 Project Science Instruments And Objectives

Instrument	Objectives
Panoramic Camera (Pancam) [a]	• Provide high spatial resolution information on nearby rocks and local geologic features. • Provide information on the mineralogy of materials by using the multispectral imaging capability. • Observe the full Martian sky to provide information about atmospheric dust particles.
Miniature Thermal Emission Spectrometer (Mini-TES) [a]	• Detect the presence of salts containing silicates, carbonates, hydroxides, phosphates, sulfates, and oxides. • Provide high-resolution temperature profiles of the Martian atmosphere. • Determine the thermal inertia of Martian surface materials over diurnal cycles.
Alpha Particle X-ray Spectrometer (APXS) [b]	• Determine the elemental chemistry of rocks and soils.
Rock Abrasion Tool [b]	• Remove dust and weathered surfaces of selected rock specimens to reveal the underlying material.
Microscopic Imager [b]	• Provide detailed images of rocks and minerals. • Provide information about sedimentary rocks that may have been deposited during former wetter environments on Mars. • Observe small-scale features of rocks formed by volcanic activity or meteorite impacts.
Mössbauer Spectrometer [b]	• Determine the iron oxidation state of rock and soil samples. • Measure the magnetic phases of the soil samples.

a. Mounted on the Pancam Mast Assembly (PMA)

b. Mounted on the Instrument Deployment Device (IDD)

The Pancam is a high-resolution stereo color imager with 14 color filters and would provide panoramic images and information on geologic context, rock and soil texture, and detection of iron-bearing minerals. The Mini-TES is an infrared spectrometer and would be used to recognize carbonates, silicates, organic molecules, and minerals formed in water. In addition to determining mineral composition of Martian surface materials, the Mini-TES would be pointed upward to make the first ever high-resolution temperature profiles through the Martian atmosphere's boundary layer. The Pancam and Mini-TES would survey the scene around the rover and look for the most interesting rocks and soils for *in situ* analysis.

The Mössbauer Spectrometer would identify the mineralogy of all iron-bearing minerals and would also be capable of examining the magnetic properties of surface materials and identifying minerals formed in hot, watery environments. The APXS would perform elemental analyses of Martian rock or soil. Analyzing the elemental make-up of Martian surface materials would provide information about crust formation, weathering processes, and water activity on Mars.

The Rock Abrasion Tool is a surface preparation tool that would be used to expose fresh rock surface for study by the other sensors. The Microscopic Imager is a combination of a microscope and a camera that would produce extreme close-up views of rocks and soils examined by other instruments on the IDD, providing visual context for the interpretation of mineral and element composition data.

The rover would use a Navigational Camera, mounted on the PMA, to provide low-resolution black and white stereo images for traverse planning. Two pairs of Hazard Avoidance Cameras, mounted on the front and back of the rover's main body, would provide black and white range maps for obstacle avoidance during traverses.

Batteries and solar panels would be used to power the various electronics within the rover. Onboard systems would be used to manage the thermal environment for the rover's batteries. Lightweight radioisotope heater units (RHUs) would be used to help maintain the thermal environment requirements of the batteries, which have a relatively narrow operating temperature range (-20° Celsius (C) to +30° C (-4° Fahrenheit (F) to +86° F)), and to minimize the use of electrical heaters during the Martian night. The battery box would be isolated from the rover's equipment module. If RHUs were not used, the thermostatically-controlled battery heaters would draw excessive battery energy to the point of total discharge during the Martian night and consequently not be able to keep any of the electronics functioning properly. Initial thermal analyses for Mars surface operations indicated up to eleven (11) RHUs could be required for each rover. As the mission design matures, ongoing thermal analyses for surface operation of the rovers may indicate a requirement for fewer RHUs. The RHUs would be mounted in three locations inside each rover: within holders mounted at each end on top of the battery assembly in the rear of the thermally-insulated Warm Electronics Box, and within a holder mounted to the rear face of the rover electronics module.

2.1.1.5 Small-Quantity Radioactive Sources

Two of the science instruments on the rovers would use small quantities of radioactive material for instrument calibration or science experiments. The Mössbauer Spectrometer would contain two cobalt-57 (Co-57) sources, with a total activity that would not exceed 350 millicuries (mCi). The APXS would contain six curium-244 (Cm-244) sources with a total activity that would not exceed 50 mCi. Both the Mössbauer Spectrometer and the APXS detector heads would be located on the Science Instrument Turret, at the end of the IDD.

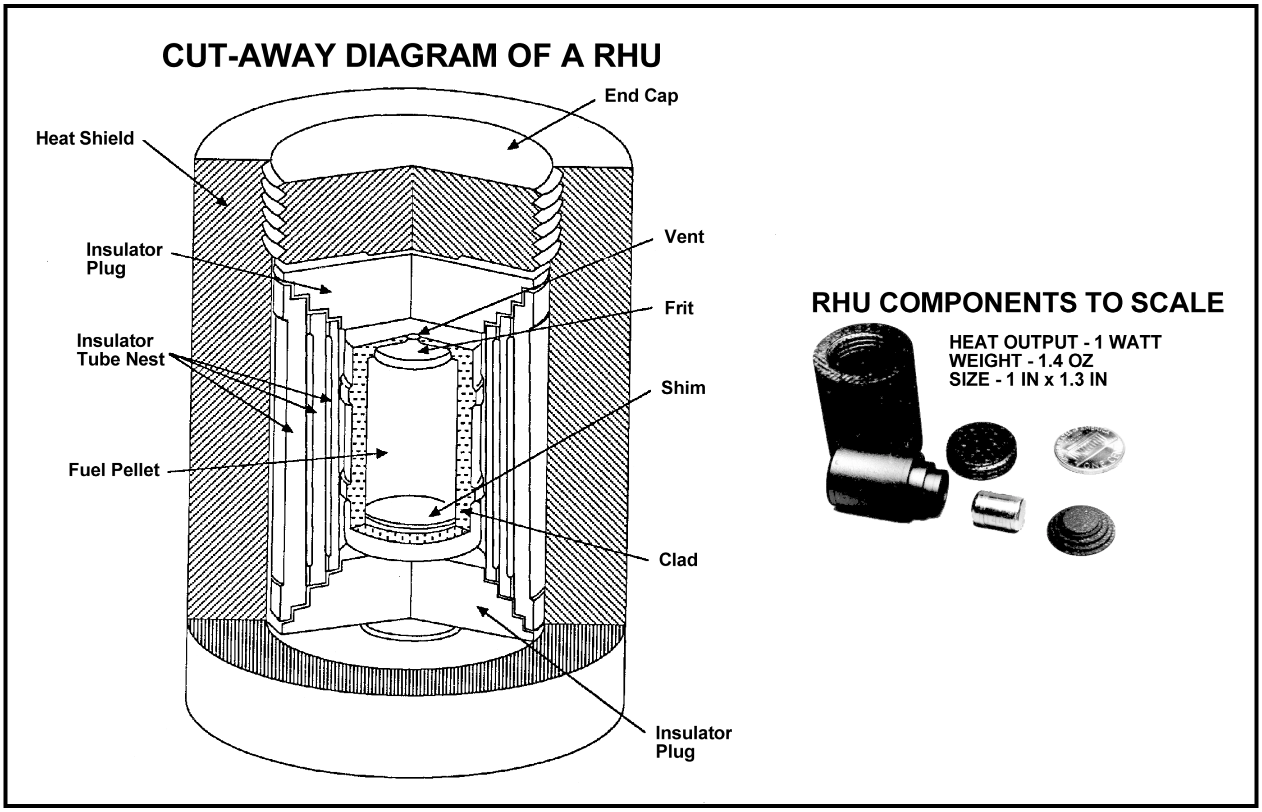
The Mössbauer Spectrometer is a unique analytical device which would identify the mineralogy of all iron-bearing minerals and would also be capable of examining the magnetic properties of surface materials and identifying minerals formed in hot, watery environments. No other instrument with similar mass and volume characteristics can determine *in situ* iron mineralogy with the same sensitivity. Analyzing iron mineralogy in a laboratory on Earth, if not done with a Mössbauer Spectrometer, can require multiple instruments, ranging from a saw and microscopes to create and observe thin sections of rock, to grinding tools and X-ray machines or concentrated acids for analytical wet chemistry. None of these methods have yet been made sufficiently compact or robust to be mounted on the end of a robotic arm and sent to Mars for analyzing rocks in place. While the Mini-TES instrument on the MER–2003 rover can determine the presence of some iron minerals, it cannot distinguish all iron minerals, and does not have the Mössbauer Spectrometer's ability to discriminate between minerals occurring at low concentrations. The Mössbauer Spectrometer is the best-suited instrument for conducting the iron mineralogy required for the project science objectives.

The APXS is also a unique instrument for analyzing the elemental composition of surface materials that would provide information about crust formation, weathering processes, and water activity on Mars. From its position on the IDD, the APXS would perform *in situ* analysis of both the light and heavy elemental composition of a substance (*e.g.*, soil, a rock, the calibration target). An active X-ray fluorescence instrument similar to that used on the 1975 Viking Landers could perform a similar elemental analysis. However, such analysis would be limited only to the heavy elements, and thus cannot provide the scientific insights most directly relevant to the understanding of processes involving water on Mars. In addition, such an instrument would also require the use of radioactive material (*e.g.*, iron-55 and cadmium-109) to provide a source of X-rays to carry out the measurements. Considering the project science objectives and mass and volume constraints imposed by the rovers, the APXS is the best-suited instrument for satisfying the mission objectives.

2.1.2 Radioisotope Heater Units

The MER–2003 rovers would use a combination of lightweight RHUs and electric heaters to maintain internal temperature during the Martian night. Each RHU (see Figure 2-4) would provide about 1 watt of heat derived from the radioactive decay of 2.7 grams (g) (0.095 ounce (oz)) of plutonium (mostly Pu-238) dioxide in ceramic form. Each RHU would contribute approximately 33.2 curies (Ci) for a total plutonium dioxide inventory of up to 365 Ci on each rover (based on the use of up to 11 RHUs). Table 2-2 provides the typical radionuclide composition of a RHU's fuel. The exterior dimensions of a RHU are 2.6 cm (1.03 in) in diameter by 3.2 cm (1.26 in) in length. Each RHU has a mass of about 40 g (1.4 oz).

RHUs are designed to contain the plutonium dioxide during normal operations and under a wide range of accident environments. The integrity and durability of RHUs have been well documented by the U.S. Department of Energy (DOE 2002). The plutonium dioxide ceramic is encapsulated in a 70% platinum and 30% rhodium alloy clad. Protection against high temperature accident environments is provided by a fine weave pierced fabric of carbon graphite used as a heatshield, and a series of concentric pyrolytic graphite sleeves and end plugs to thermally insulate the encapsulated radioactive material. The RHU's plutonium dioxide is principally protected from ground or debris impact by the alloy clad. The heatshield and inner pyrolytic graphite insulators provide additional protection.



Source: Adapted from DOE 2002

Figure 2-4. The Principle Features of a Radioisotope Heater Unit (RHU)

2.1.3 <u>Space Launch Complex 17</u>

Space Launch Complex 17 (SLC–17) is located in the southeastern section of CCAFS. SLC–17 consists of two launch pads (17A and 17B), a blockhouse, ready room, shops, mobile service towers, fixed umbilical towers, launch decks, exhaust flumes, fuel storage tanks, and other facilities that are needed to prepare, service, and launch Delta II vehicles. A Delta II 7925 could be launched from either Pad 17A or Pad 17B, whereas a Delta II 7925H can only be launched from Pad 17B.

Security at SLC–17 is ensured by a perimeter fence, guards, and restricted access. Since all operations in the launch complex would involve or would be conducted in the vicinity of liquid or solid propellants and explosive devices, the number of personnel permitted in the area, safety clothing to be worn, the type of activity permitted, and equipment allowed would be strictly regulated. The airspace over the launch complex would also be restricted as part of the overall security measures that will be in place for the launch.

Table 2-2. Typical Radionuclide Composition of a RHU's Fuel

Fuel Component	Weight Percent	Half-Life (Years)	Specific Activity (Ci/g Of Fuel Component) [a]	Total Activity (Ci)
Plutonium	85.735			
Pu–236	0.0000010	2.851	531.3	0.00001
Pu–238	70.810	87.7	17.12	32.7312
Pu–239	12.859	24,131	0.0620	0.02153
Pu–240	1.787	6,569	0.2267	0.01094
Pu–241	0.168	14.4	103.0	0.4672
Pu–242	0.111	375,800	0.00393	0.00001
Actinide Impurities	2.413	NA [b]	NA	NA
Oxygen	11.852	NA	NA	NA
Total	**100.00**	**NA**	**NA**	**33.231**

Source: DOE 2002

a. Ci/g = curies per gram
b. NA = Not Applicable

2.1.4 Payload Processing

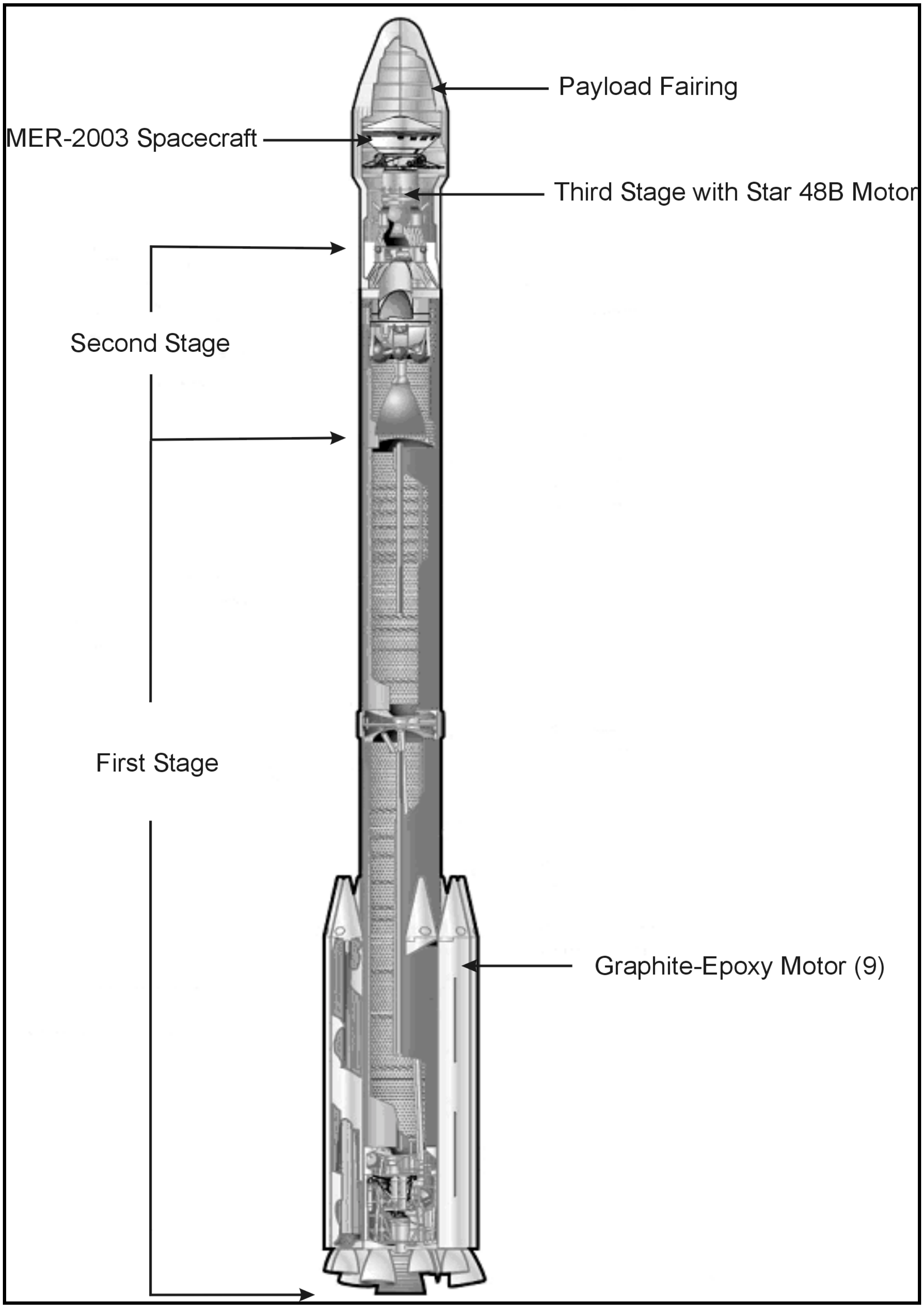
Industrial activities associated with integrating the MER–2003 spacecraft to the Delta II 7925 and the Delta II 7925H would involve receipt of components, inspection, storage, assembly, and testing at KSC, and transport to SLC–17 at CCAFS where the spacecraft would be mated to the Delta II vehicles. Spacecraft safety, security, and contamination control would be ensured by payload encapsulation within a special container prior to its transport to the launch pad. Transportation of the spacecraft within its container from KSC to the launch pad at CCAFS would be by truck, limited to a speed of 8 kilometers per hour (5 miles per hour). All effluents and wastes generated would be subject to Federal and State laws, regulations, and permits; CCAFS has permits and waste management programs in place. In addition, at KSC and CCAFS, all radiological safety controls and precautions relating to receipt, storage, handling, and installation of the RHUs and the small-quantity radioactive sources would be strictly followed.

2.1.5 The Delta II 7925 Launch Vehicle

The Delta II 7925 expendable launch vehicle main elements include a liquid-propellant first stage with nine graphite-epoxy solid rocket motors (called GEMs), a liquid-propellant second stage, a solid-propellant third stage, and a payload fairing (PLF) (see Figure 2-5). The Delta II 7925 stands more than 38 m (125 ft) in height at launch (NASA 2001).

2.1.5.1 First Stage and Solid Rocket Motors

The Delta II 7925 first stage is powered by a liquid-propellant RS-27A main engine. The first stage contains about 94,123 kg (207,504 lb) of propellant (NASA 2001). The fuel is rocket propellant-1 (RP-1), a thermally stable kerosene, and the oxidizer is liquid oxygen (LOX).



Source: Adapted from NASA 2001

Figure 2-5. Delta II 7925 Launch Vehicle with the MER–2003 Spacecraft

The nine externally attached GEMs provide thrust augmentation during the initial boost of the Delta II. The propellant case of each GEM is approximately 1 m (40 in) in diameter and 10 m (33 ft) long, and contains 11,740 kg (25,882 lb) of solid propellant (NASA 2001), consisting mostly of ammonium perchlorate with powdered aluminum additive and hydroxyl-terminated polybutadiene (HTPB) binder (Giles 2001). The total propellant load for the nine GEMs would be 105,660 kg (232,938 lb).

2.1.5.2 Second Stage

The Delta II 7925 second stage is powered by a liquid-propellant AJ10-118K engine. The propellant consists of Aerozine–50 (a 50:50 mix of N_2H_4 and unsymmetrical dimethylhydrazine (UDMH)) as fuel and nitrogen tetroxide (N_2O_4) as oxidizer. Approximately 6,052 kg (13,342 lb) of propellant is carried in the second stage (NASA 2001).

2.1.5.3 Third Stage

The Delta II 7925 third stage for the MER–A mission consists of a spin table assembly, a Star 48B solid rocket motor, and a payload attach fitting. The Star 48B is about 2 m (6.7 ft) in length and carries 2,009 kg (4,430 lb) of solid propellant, consisting mostly of ammonium perchlorate with powdered aluminum additive and HTPB binder (NASA 2001).

2.1.5.4 Payload Fairing

The Delta II 7925 PLF consists of two aluminum sections and is about 8.5 m (28 ft) tall and 2.9 m (9.5 ft) in diameter. The PLF protects the spacecraft from environmental, acoustic and aerodynamic forces during launch and ascent (NASA 2001).

2.1.5.5 Flight Termination System

Range Safety requires launch vehicles to be equipped with a Flight Termination System (FTS) capable of causing destruction of the launch vehicle in the event of a major vehicle malfunction. The FTS consists of both an Automatic Destruct System (ADS) and a Command Destruct System (CDS). As configured for this mission, the ADS and CDS would initiate destruct ordnance components that split open all first and second stage propellant tanks to disperse the liquid propellants and split all GEM cases to terminate solid motor thrusting. The Star 48B motor in the third stage would also be rendered non-propulsive. A Star 48B Breakup System (BUS) would be added for the MER-2003 missions. The BUS would add two conical shaped charges mounted above the motor and directed into its dome. The purpose of the BUS would be to break up the large propellant dome into fragments to preclude an intact dome and attached spacecraft falling to the ground, with potential for significant mechanical damage to the RHUs. The resulting fragments would be small enough to minimize the thermal threat to an intact RHU should it be exposed to a burning Star 48B propellant fragment. The BUS ordnance would be activated from either the CDS or the ADS and would not otherwise affect any of the normal CDS or ADS design functions (NASA 2001).

2.1.5.6 Launch Vehicle Processing

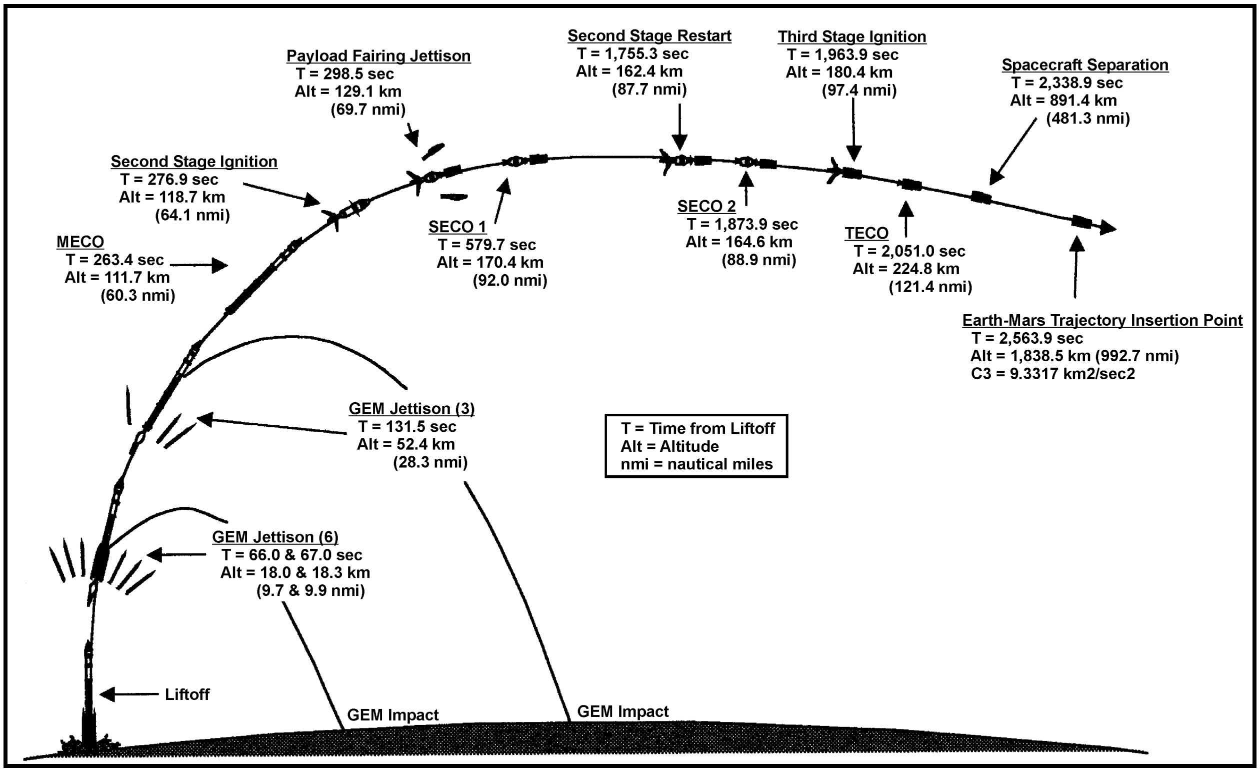
Delta launch vehicle preparation activities and procedures during and after launch have been well documented and standardized since Delta rockets began being launched from CCAFS over 30 years ago. These procedures and protocols are continuously being reviewed, and all NASA launches follow these standard operating procedures.

The Delta II 7925 launch vehicle components for the MER–A mission would be received, inspected, stored, and processed at appropriate facilities at CCAFS. Final integration, testing, and fueling would occur at SLC–17. The GEMs would be received and processed at the solid rocket motor facility before being transported to the launch pad and attached to the first stage (NASA 2001).

Because the Delta II 7925 for the MER–A mission would use processes and components similar to other Delta II vehicles, processing activities would be similar to those routinely practiced for other Delta II launches from CCAFS. Effluents and solid or hazardous wastes that may be generated by these activities are subject to Federal and State laws and regulations. CCAFS has the necessary permits and procedures in place to accomplish launch vehicle processing activities in an environmentally responsible manner (see Section 4.8 for details).

2.1.5.7 Launch Events for the MER–A Mission

A typical sequence of events for the Delta II 7925 launch of the MER–A mission is illustrated in Figure 2-6 for a launch on May 30, 2003, the opening of the mission's 18-day launch period (NASA 2001). The Delta II 7925 with the MER–A spacecraft would be launched from SLC–17 Pad A. The first stage main engine and six of the GEMs would be ignited at liftoff. After the six ground-lit GEMs burn out, the three remaining GEMs would be ignited in the air. The spent GEM casings would be jettisoned after burnout; the six ground-lit GEMs would be jettisoned first followed by the three air-lit GEMs after they completely burn out. Separation of the first and second stages would follow main engine cutoff (MECO). After separation, the second stage would be ignited and the PLF would be jettisoned. The jettisoned GEM casings, the first stage, and the PLF components would fall into the ocean. The second stage engine would be cut off (SECO 1) for a brief coast period and then restarted. The second and third stages would separate following SECO 2. The second stage would remain in orbit and would reenter the atmosphere within about two to three months (USAF 1996); the depleted second stage would typically burn up upon reentry. The third stage Star 48B motor would provide the final acceleration needed to inject the spacecraft onto the proper interplanetary trajectory. After third stage engine cutoff (TECO) the MER–A spacecraft would be separated and proceed toward Mars. The third stage would continue separately into interplanetary space.



Source: Adapted from NASA 2001

Figure 2-6. Delta II 7925 MER–A Mission Typical Launch Events Profile

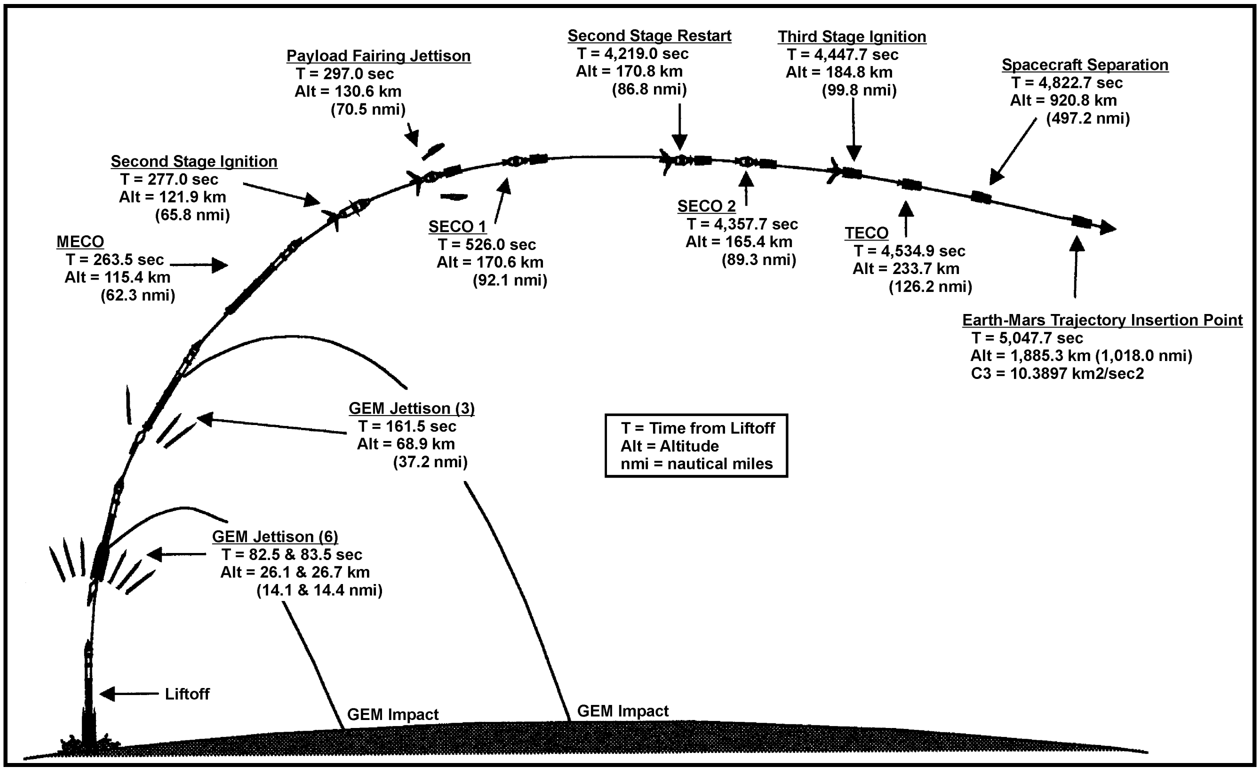
2.1.6 The Delta II 7925 Heavy Launch Vehicle

The Delta II 7925H expendable launch vehicle for the MER–B mission is essentially the same as the Delta II 7925 except that the nine standard GEMs are replaced with nine Large Diameter Extra Long (LDXL) GEMs for more thrust at liftoff and early ascent. Some structural and avionics modifications have been made to the Delta II core vehicle to accommodate these heavier, more powerful solid motors (NASA 2001).

Each LDXL GEM propellant case is approximately 0.2 m (6 in) larger in diameter and 1.2 m (4 ft) longer than the standard GEM. Each LDXL GEM contains 16,865 kg (37,180 lb) of the same solid propellant used in a standard GEM (NASA 2001). The total propellant load for the nine LDXL GEMs would be 151,785 kg (334,620 lb).

The first, second and third stages, the payload fairing, and processing of the Delta II 7925H launch vehicle for the MER–B mission would be essentially the same as those elements described in Section 2.1.5 for the Delta II 7925 launch vehicle for the MER–A mission. To meet Eastern Range safety requirements, the FTS for the Delta II 7925H includes an Inadvertent Separation Destruct System (ISDS). If a LDXL GEM inadvertently separates from the core vehicle due to mechanical failure, the ISDS would render the solid motor non-propulsive by activating ordnance charges that would split open the motor case.

A typical sequence of events for the Delta II 7925H launch of the MER–B mission is illustrated in Figure 2-7 for a launch on June 25, 2003, the opening of the mission's 18-day launch period (NASA 2001). The Delta II 7925H with the MER–B spacecraft would be launched from SLC–17 Pad B. The launch sequence for the Delta II 7925H would be similar to that described previously for the Delta II 7925.



Source: Adapted from NASA 2001

Figure 2-7. Delta II 7925H MER–B Mission Typical Launch Events Profile

2.1.7 Range Safety Considerations

CCAFS has implemented range safety programs, described in USAF 1997. For the MER–2003 missions, pre-determined flight safety limits would be established for the flight azimuth of each launch. Wind criteria, impacts from fragments that could be produced in a launch accident, dispersion and reaction (*e.g.*, toxic plumes, fire, etc.) of liquid and solid propellants, human reaction time, data delay time, and other pertinent data are considered when determining flight safety limits. The Mission Flight Control Officer (MFCO) would take any necessary actions, including vehicle destruction, if the vehicle trajectory indicates flight anomalies (*e.g.*, exceeding flight safety limits) (USAF 1997).

2.1.8 Electromagnetic Environment

Launch vehicles may be subject to electromagnetic conditions such as lightning, powerful electromagnetic transmissions (*e.g.*, radar, radio transmitters), and charging effects (*i.e.*, electrical charges generated by friction and the resultant electrostatic discharges). NASA and the USAF address such conditions with respect to the design of the launch vehicle, as well as with ordnance (explosives and explosive detonators/fuses), fuels, exposed surfaces of the vehicle, and critical electronic systems that must have highly reliable operations. A large body of technical literature exists on these subjects and has been used by NASA and the USAF in designing safeguards (NASA 1995).

2.2 DESCRIPTION OF THE NO ACTION ALTERNATIVE

Under the No Action Alternative, planning and preparations for the MER–2003 project would stop and neither the MER–A nor the MER–B spacecraft would be launched to Mars during the 2003 opportunity. None of the physical, geological, and chemical scientific investigations planned for the project (Table 2-1) would be achieved, and the objectives of NASA's planned follow-on missions to Mars would be adversely affected without the data to be obtained by the MER–2003 missions. Lessons expected to be learned during all phases of each mission (atmospheric entry, descent, and landing; initial deployment on the surface; real-time site traverse planning, execution and navigation; simultaneous operation of two rovers; and science data collection) would not be gained. NASA has no other Mars missions at a stage of development that could be substituted for the Proposed Action, and the efficient launch opportunity in 2003 would be lost to NASA’s overall Mars exploration effort.

2.3 ALTERNATIVES CONSIDERED BUT NOT EVALUATED FURTHER

This section discusses alternatives that were considered but were not evaluated further. These alternatives include a single mission and concepts studied for reducing or eliminating the plutonium heat sources onboard the MER–2003 rovers.

2.3.1 Single-Mission Alternative

As opposed to the Proposed Action, a single mission would not allow NASA to complete all mission objectives. Specifically, a single mission would not allow for:

- demonstrating complex science operations through the simultaneous use of multiple science-focused mobile laboratories (rovers), and
- exploration of two diverse landing sites.

In addition, a single mission would not allow for:

- taking full advantage of the uniquely efficient 2003 launch opportunity, and
- maximizing NASA's chances for successfully landing mobile laboratories on the surface of Mars.

For the above reasons, the single mission alternative was not evaluated further.

2.3.2 Reduction or Elimination of Plutonium Heat Sources

The MER–2003 rover batteries were qualified for survival and operation at temperatures as low as -30° C (-22° F) and the electronics were qualified for survival and operation down to -55° C (-67° F). Thermal data and modeling indicates that, over the potential range of landing sites (between 15° South and 10° North) for two rovers, the expected coldest night time Martian atmospheric temperature is approximately -105° C (-157° F). The baseline mission plan involves night-time operation of the APXS and Mössbauer Spectrometer to acquire measurements. Without the RHUs, the rover battery would then be required to provide power to these instruments and maintain the required rover thermal conditions throughout the Martian night.

Thermal analyses of expected landing site temperature conditions were conducted using landed thermal environment models based upon actual data obtained by the Viking and Mars Pathfinder missions for a 9° South latitude landing site. The thermal analyses indicated that, accounting for the combination of RHUs, waste heat from the electronics, insulation, and a battery energy of approximately 95 watt-hours, the rover battery temperatures inside the Warm Electronics Box (WEB) thermal enclosure would be expected to be between -15° C and +8° C (+5° F and +46° F). These analyses were performed assuming rover conditions at the end of the primary mission (*i.e.*, 90 sols). Also, the battery, electronics module, and mini-TES instrument have distinct electrical survival heaters that maintain this equipment to conditions no colder than -17° C (+1.4° F) for the battery, and -38° C (-36.4° F) for the electronics module and mini-TES. Therefore, internal rover temperature would always be maintained at the expense of rover battery energy. For this scenario, the total rover battery energy consumption for the survival heaters would be 542 watt-hours without RHUs, well over the current battery capacity of 392 watt-hours.

Reduction of Heat Loss in the WEB. The MER–2003 rover would be subject to stringent mass and volume limitations. The WEB design would include highly efficient Aerogel insulation. Heat loss from the wiring between external rover elements and the WEB electronics would be minimized by using flex print wiring. The WEB would be heated by waste heat from operation of the electronics and by heaters operated from the solar panels. Due to WEB volume limitations, there would not be room for additional insulation. There have been no additional options identified to further reduce heat loss from the WEB.

Operating Electric Heaters with the Rover Batteries. Plans call for electrical survival heaters to be used and powered by the rover batteries. If the electrical survival heaters were not supplemented by the RHUs, then the situation where all the RHUs were eliminated, discussed above, would apply. Even with a battery sized to accommodate electrical survival heaters, the battery itself would eventually fail due to extreme thermal cycling. It is estimated that the mission duration for a MER–2003 rover using only electrical heaters would last a maximum of 16 sols, considerably less than the 90-sol duration requirement for the MER–2003 project.

Operating Electric Heaters via a Lander Power Umbilical. A primary requirement for the MER–2003 project is that the rover explore to a distance of at least of 600 m (1,968 ft), with a goal of 1 km (0.62 mi). The use of an umbilical from the lander to provide supplemental power for electrical heaters would require additional mass to accommodate more than 1,000 m (3,281 ft) of power cable, the accompanying hardware to manage the cable mass, and the equipment necessary to convert and transmit power over that length of cable. Use of an umbilical would also significantly complicate rover navigation in order to avoid cable snags in the rock fields. These considerations cause this alternative to be precluded from further consideration.

2.4 COMPARISON OF PROJECT ALTERNATIVES INCLUDING THE PROPOSED ACTION

This section summarizes and compares the potential environmental impacts of the MER–2003 Project Proposed Action and the No Action Alternative. The anticipated impacts associated with nominal or normal implementation of the Proposed Action are considered first, followed by a summary and comparison of the potential radiological consequences and risks from an accident associated with the Proposed Action. Details summarized in this section can be found in Chapter 4 and in DOE 2002.

2.4.1 Environmental Impacts of Normal Implementation of the MER–2003 Project Proposed Action and No Action Alternative

Table 2-3 provides a summary comparison of the anticipated environmental impacts associated with normal implementation of the MER–2003 project Proposed Action and the No Action Alternative.

Proposed Action

The environmental impacts associated with implementing the Proposed Action would center largely on the exhaust products emitted from the Delta II launch vehicles' GEMs and the short-term impacts of those emissions. High concentrations of solid rocket motor exhaust products, principally aluminum oxide (Al_2O_3) particulates, carbon monoxide (CO), hydrogen chloride (HCl), nitrogen (N_2), and water (H_2O), would occur in the exhaust cloud that would form at the launch complex (CO would be quickly oxidized to CO_2 and N_2 may react with oxygen to form nitrogen oxides (NO_X)). Due to the relatively high gas temperatures, this exhaust cloud would be buoyant and would rise quickly and begin to disperse near the launch pad. The exhaust from a Delta II is relatively dry, thus high concentrations of HCl would not be expected, and damage to vegetation and prolonged acidification of nearby water bodies should not occur. No adverse impacts to air quality in offsite areas would be expected.

If rain were to occur shortly after launch, some short-term acidification of nearby water bodies could occur with the accompanying potential for some mortality of aquatic biota. Biota that happened to be in the path of the exhaust could be damaged or killed. Threatened or endangered species would not be jeopardized nor would critical habitats be affected at CCAFS. As the launch vehicles gain altitude, a portion of the solid rocket motor exhaust (specifically HCl, Al_2O_3, and NO_X) would be deposited in the stratosphere, resulting in a short-term reduction in ozone along each vehicle's flight path. Recovery, however, would be rapid.

Table 2-3. Summary Comparison of the MER–2003 Project Alternatives

Impact Category	Normal Implementation of the Proposed Action	No Action
Land Use	No adverse impact on non-launch-related land uses at CCAFS for either launch vehicle.	No change in baseline condition.
Air Quality	High levels of GEM combustion products within the exhaust cloud as it leaves the launch pad's flame trench; cloud would rise and begin to disperse near the launch complex. Exhaust product concentrations expected to drop rapidly with buoyant rise and mixing/dispersal of exhaust cloud. No adverse air quality impacts expected in offsite areas.	No change in baseline condition.
Noise and Sonic Boom	Short-term (5 sec) worker and public exposure to sound levels > 90 dBA; exposure levels within OSHA and EPA guidelines for affected workers and public.	No change in baseline condition.
Geology and Soils	Some particulate and HCl deposition near launch complexes. No impacts to underlying geology.	No change in baseline condition.
Hydrology and Water Quality	No substantial adverse long-term impacts to groundwater or surface water; potential short-term increase in the acidity of nearby surface waters.	No change in baseline condition.
Biological Resources	Biota in launch complex area could be damaged or killed during launch; possible acidification of nearby surface waters could cause some mortality of aquatic biota. No long-term adverse effects expected. No substantial short-term or long-term impact to threatened or endangered species.	No change in baseline condition.
Socioeconomics	No impact expected.	No change in baseline condition.
Cultural/Historical/ Archaeological Resources	No impact expected.	No change in baseline condition.
Global Environment	Not anticipated to adversely affect global climate. Temporary localized decrease in ozone along the flight paths with rapid recovery.	No change in baseline condition.

Noise and sonic booms would be associated with each launch. However, neither launch site workers nor the public would be adversely affected. No impacts to cultural, historical or archaeological resources would be expected from either launch. Neither MER–2003 mission launch would be expected to disproportionately impact either minority or low-income populations.

<u>No Action Alternative</u>

The No Action Alternative would not implement either launch associated with the Proposed Action. Thus, none of the anticipated impacts associated with either of the normal launches would occur.

2.4.2 Environmental Impacts of Nonradiological Accidents for the MER–2003 Project Proposed Action

A variety of nonradiological accidents could occur during preparation for and launch of the MER–2003 spacecraft at CCAFS. The potential nonradiological impacts from an accidental liquid fuel spill or a launch vehicle failure would be similar for the two launches of the Proposed Action. The No Action Alternative would not implement either launch associated with the Proposed Action. Thus, there would be no potential for such accidents to occur.

The potential for off-site consequences would be limited primarily to a liquid propellant (N_2O_4) spill during fueling operations of the Delta II second stage and a launch failure at or near the launch pad. USAF safety requirements (USAF 1997) specify detailed policies and procedures to be followed to ensure worker and public safety during liquid propellant (*e.g.*, RP-1, N_2H_4) fueling operations. If a spill were to occur, rapid oxidation of the N_2O_4 combined with activation of the deluge water system would limit the potential toxic effects of the propellant to the immediate vicinity of the launch pad. Workers performing propellant loading would be equipped with protective clothing and breathing apparatus and uninvolved workers would be excluded from the area during propellant loading. Propellant loading would occur only shortly before launch, further minimizing the potential for accidents.

A launch vehicle failure on or near the launch area during the first few seconds of flight could result in the release of the propellants (solid and liquid) onboard the Delta II and the spacecraft. The resulting emissions would resemble those from a normal launch, consisting principally of CO, HCl, NO_X, and aluminum oxide particulates from the burning solid propellant. A launch vehicle failure would result in the prompt combustion of a portion of the liquid propellants, depending on the degree of mixing and ignition sources associated with the accident, and somewhat slower burning of the solid propellant fragments. Falling debris would be expected to land on or near the launch pad resulting in potential secondary ground-level explosions and localized fires. After the launch vehicle clears land, debris from an accident would be expected to fall over the ocean. Modeling of accident consequences with meteorological parameters that would result in the greatest concentrations of emissions over land areas indicates that the emissions would not reach levels threatening public health. Some uncombusted solid and liquid propellants could enter surface water bodies and the ocean. Uncombusted solid and liquid propellants entering surface water bodies could result in short-term, localized degradation of water quality and toxic conditions to aquatic life. Such chemicals entering the ocean would be rapidly dispersed and buffered, resulting in little long-term impact on water quality and resident biota.

2.4.3 Overview of the Nuclear Risk Assessment Process

This section presents a summary of the nuclear risk assessment performed for this FEIS. A more detailed presentation can be found in Sections 4.1.4 and 4.1.5. NASA, and DOE and its contractors have conducted safety assessments of launching and operating spacecraft using RHUs (*e.g.*, the Galileo mission in 1989, the Mars Pathfinder mission in 1996, the Cassini mission in 1997, and the proposed Mars Surveyor 2001 mission[2] in 1999). NASA and DOE, therefore, have built upon an extensive experience base that involves:

- testing and analysis of the RHUs under simulated launch accident environments;
- evaluating the probability of launch-related accidents based on evaluation of launch histories, including extensive studies of the January 1997 Delta II accident at CCAFS, and system designs; and
- estimating the outcomes of the RHU and small-quantity radioactive source responses to the launch accident environments.

The risk assessment for the MER–2003 missions began with NASA's identification of initial launch vehicle system failures and the subsequent chain of accident events that could ultimately lead to the accident conditions (*e.g.*, fire, fragments, explosive overpressures) that could threaten the RHUs and small-quantity radioactive sources onboard the MER–A and MER–B spacecraft. Based on Delta II system reliabilities and failure probabilities, accident initial conditions that could lead to failure of the launch vehicle were identified across all major mission phases[3].

NASA then identified the specific accident outcomes that threaten the RHUs and/or small-quantity radioactive sources and which could potentially lead to a release of radioactive material. DOE then determined the response of the RHUs and small-quantity radioactive sources to the accident conditions (DOE 2002). DOE utilized the results of modeling and data from its RHU tests conducted during the early 1980s in support of the Galileo mission and the mid 1990s in support of the Cassini mission to determine if a release of radioactive material from a RHU could potentially occur.

For the purpose of the analysis performed for this FEIS, the following inventory of radioactive materials was assumed to be onboard each rover.

- Pu-238: 33.2 Ci in each of up to 11 RHUs (an alpha emitter with a half-life of 87.7 years. The activity includes minor contributions from other related plutonium and actinide radionuclides);
- Cm-244: up to 0.05 Ci (an alpha emitter with an 18.1 year half-life); and
- Co-57: up to 0.35 Ci (a gamma emitter with a 271 day half-life).

Taking into consideration the characteristics of the release (release location, particle size, and weather conditions), modeling is used to predict how the released material would be dispersed in the environment. The amount potentially released for each accident scenario can then be used to determine the potential consequences of the release to the environment and to people. The approach used was similar to that used in the Galileo, Mars Pathfinder, Cassini, and Mars Surveyor 2001 risk assessments.

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[2] A risk assessment was being prepared for the Mars Surveyor 2001 lander-rover mission when that mission was cancelled.

[3] For the purpose of the risk assessment, the sequence of launch events for each mission was divided into five mission phases on the basis of the mission elapsed time (the time (T) in seconds (s) after liftoff).

The analysis conducted by DOE is described in Chapter 4, with results presented using mean and 99th percentile values. Chapter 2 presents the analysis in terms of the mean. The 99th percentile values are indicative of more severe accidents included in the mean values. However, none of the 99th percentile values for the MER–2003 missions result in any different conclusions about the safety of the missions.

2.4.3.1 Accident Scenarios and Probabilities

A range of potential Delta II launch vehicle accident scenarios that could occur during launch of the MER–2003 spacecraft were evaluated. These scenarios were developed based on launch vehicle reliability data updated to reflect actual flight history (NASA 2001). System-level failures that might lead to accidents include trajectory control malfunction, attitude control malfunction, propellant tank failure, catastrophic engine/motor failure, structural failure, inadvertent FTS activation or PLF separation, and staging failure. These failures were found to lead to several basic types of accident outcomes, including ground impact of the spacecraft still attached to all or portions of the rest of the launch vehicle (called intact impact), low altitude CDS or ADS activation, sub-orbital reentry, and orbital reentry. Details of the development of the accident scenarios, probabilities, and accident environments are presented in the EIS Databook (NASA 2001).

Using methodologies that combine both actual flight history with analytical failure rate predictions, the total probability of an accident occurring during the MER–A mission was estimated to be 1 in 31 and 1 in 34 during the MER–B mission. The probabilities that a launch accident would result in a release of radioactive material from either the MER–A or MER–B spacecraft are much lower, however.

2.4.3.2 Accident Environments

Each accident scenario was evaluated to determine the potential accident environments that could threaten the integrity of the RHUs and the small-quantity radioactive sources onboard the MER–A and MER–B spacecraft. These accident environments are summarized in the DOE risk assessment (DOE 2002), which is based on detailed analyses by NASA presented in the EIS Databook (NASA 2001). The launch area accident environments include: blast (explosion overpressure), fragments, fire (burning liquid propellant and/or solid propellant), and surface impacts of the launch vehicle and/or the Star 48B upper stage and the MER–2003 spacecraft on the launch pad and structures or the area near the launch pad. While explosions and fragments are unlikely to lead to a release from the RHUs, these environments could damage the graphite components such that the RHUs become more susceptible to other environments produced by burning solid rocket propellant. The most severe accident environments are associated with accidents in which part or all of the launch vehicle comes down with the spacecraft and subjects the spacecraft to high impact forces. This accident scenario has the potential to damage the graphite components and subject the exposed RHUs to high-temperature solid propellant fires.

Accidents during later launch phases could involve second stage, third stage, and spacecraft propellant explosion and fragments. Reentry from orbit would subject the spacecraft and/or the upper stage to aerodynamic stress and reentry heating. The risk analysis assumed that during reentry the spacecraft would break apart, releasing the RHUs, which would then impact the Earth's surface.

2.4.3.3 Potential Accident Source Terms

The assessment of the responses of the RHUs and small-quantity radioactive sources to the accident environments resulted in estimates of the likelihood of a release and the fraction of the inventory of RHUs and small-quantity radioactive sources that might become airborne. These potential releases are referred to as source terms. In developing these estimates, DOE used data developed in its safety tests and response analyses of RHUs over the almost 20-year period that RHUs have been used. This database includes explosion overpressure tests, tests with fragments and projectiles, impact testing of RHUs and bare clads onto aluminum and steel plates, exposure of RHUs to burning solid rocket propellant, and immersion testing in seawater (DOE 2002).

Safety testing and response analyses of the RHU to accident environments show that the protection provided by graphite components and the platinum-rhodium clad encapsulating the PuO_2 makes releases unlikely due to purely mechanical damage, including overpressures and fragments. The primary release mechanism is exposure to the high temperature of burning solid propellant. Should the graphite components be damaged or stripped and the clad exposed to this fire environment, some PuO_2 could be vaporized and released. If the graphite components remain intact, any vaporized PuO_2 release would be limited to that which permeates through the graphite components. Such a release would be a very small fraction (about 1/1000) of the release associated with a RHU with damaged graphite components. A very small percentage of early launch accidents could lead to intact impact of various spacecraft/launch vehicle configurations. The resulting impact could lead to mechanical damage of the graphite components, depending on the orientation and velocity at impact, and subsequent exposure to burning Star 48B solid propellant. This in turn could potentially lead to PuO_2 releases.

In later phases of the mission, accidents could lead to reentry heating and ground impact environments. The RHU is designed to survive these reentry environments and subsequent surface impacts.

The Cm-244 and Co-57 small-quantity radioactive sources and their mounting fixtures used in spacecraft instrumentation have relatively low melting temperatures compared to PuO_2, and their release in the thermal environment of launch area accidents is assumed to be likely. Reentry conditions would also likely lead to the release of the small-quantity radioactive sources at high altitudes.

A summary of the accident and source term probabilities by mission phase are presented in Table 2-4. The mission is divided into phases corresponding to potential accident environments that could occur during specific time periods. These do not directly correspond to the mission events discussed in Sections 2.1.5.7 and 2.1.6. A summary of radionuclide contributions to the estimated mean source terms (Pu-238, Cm-244, and Co-57) is presented in Table 2-5.

Table 2-4. Summary of Accident and Source Term Probabilities

Mission Phase	Initiating Accident Probability	Probability of Release Given an Accident [a]		Total Probability of a Radioactive Release [b]
		Pu-238	Cm-244 Co-57	
MER–A Mission				
0 (Pre-Launch)	1 in 8,600	1 in 1.8	1 in 1.8	1 in 16,000
1 (Early Launch)	1 in 210	1 in 34	1 in 5.2	1 in 1,100
2 (Late Launch)	1 in 41	-	1 in 31	1 in 1,300
3 (Pre-Orbit/Orbit)	1 in 3,000	-	1 in 2.0	1 in 6,000
4 (Orbit/Escape)	1 in 350	-	1 in 1.1	1 in 400
Overall Mission	**1 in 31**	**1 in 160**	**1 in 7.2**	**1 in 230**
MER–B Mission				
0 (Pre-Launch)	1 in 8,600	1 in 1.8	1 in 1.8	1 in 16,000
1 (Early Launch)	1 in 300	1 in 30	1 in 5.3	1 in 1,600
2 (Late Launch)	1 in 44	-	1 in 32	1 in 1,400
3 (Pre-Orbit/Orbit)	1 in 3,600	-	1 in 2.0	1 in 7,200
4 (Orbit/Escape)	1 in 340	-	1 in 1.1	1 in 380
Overall Mission	**1 in 34**	**1 in 170**	**1 in 6.8**	**1 in 240**

Source: Adapted from DOE 2002

a. Conditional probability of release given that the initiating accident occurs.

b. Total probability of a release, calculated as the product of the initiating accident probability times the larger of the Pu-238 or Cm-244/Co-57 conditional release probabilities. The values shown are rounded to two significant digits.

The essential results, in terms of the estimated means, are as follows for the MER–A mission. Results for the MER–B mission would be similar.

- Phase 0 (Pre-Launch, T < 0 s): Prior to launch vehicle liftoff, the chance of on-pad accidents that could result in a release is about 1 in 16,000. The mean source terms are estimated to be 0.033% of the Pu-238 inventory, about 55% of the Cm-244, and about 29% of the Co-57.

- Phase 1 (Early Launch, 0 ≤ T < 23 s): During Phase 1 from liftoff to 23 s, the chance of an accident with a release of the small-quantity radioactive sources is about 1 in 1,100. The probability of a release of Pu-238 is about 1 in 7,200. The mean source terms are estimated to be 0.13% of the Pu-238 inventory, about 18% of the Cm-244, and about 9.7% of the Co-57.

- Phase 2 (Late Launch, 23 s ≤ T < 297 s): In Phase 2, after which land impacts in the launch area are unlikely, most accidents lead to impact of debris in the Atlantic Ocean, and the at-altitude accident environments are not severe enough to lead to releases. Some accidents during Phase 2 could lead to a sub-orbital reentry or a subsequent orbital reentry at later times after Phase 2. Prior to achieving Earth orbit, those accidents could lead to sub-orbital reentry within minutes. Following spacecraft breakup during reentry, about 2% of sub-orbital reentries could result in impacts of RHUs along portions of the vehicle flight path over southern Africa, Madagascar, and western Australia. Accidents which might occur after reaching orbit could result in orbital reentries from minutes to years after the accident. Orbital reentries would lead to surface impacts between 28º South and 28º North latitudes.

Table 2-5. Summary of Mean Source Terms

Mission	Percent of Inventory Airborne in Accidents that Result in a Release [a]		
	Pu-238 (365 Ci)	**Cm-244 (0.05 Ci)**	**Co-57 (0.35 Ci)**
MER–A Mission			
0 (Pre-Launch)	0.033	55	29
1 (Early Launch)	0.13	18	9.7
2 (Late Launch)	-	50	25
3 (Pre-Orbit/Orbit)	-	50	25
4 (Orbit/Escape)	-	50	25
Overall Mission	**0.098**	**44**	**22**
MER–B Mission			
0 (Pre-Launch)	0.033	55	29
1 (Early Launch)	0.16	19	10
2 (Late Launch)	-	50	25
3 (Pre-Orbit/Orbit)	-	50	25
4 (Orbit/Escape)	-	50	25
Overall Mission	**0.11**	**46**	**23**

Source: Adapted from DOE 2002

a. Source terms for each radionuclide given a release of that radionuclide at the corresponding probabilities in Table 2-4.

The RHUs are designed to survive reentry environments resulting from sub-orbital or orbital reentries without release. Due to the lesser degree of protection and lower melting temperatures associated with the small-quantity radioactive sources, an estimated 50% of the Cm-244 and 25% of the Co-57 would be vaporized on average if subjected to reentry heating. During the Late Launch Phase, the estimated chance of an accident with a release is 1 in 1,300.

- Phase 3 (Pre-Orbit/Orbit, 297 s ≤ T < 640 s): Accidents during Phase 3 could lead to sub-orbital or orbital reentry conditions at a total probability of release for the small-quantity radioactive sources of 1 in 6,000. The source terms would be identical to those estimated for Phase 2. The characteristics of sub-orbital reentries in Phase 3 would be similar to those described in Phase 2.

- Phase 4 (Orbit/Escape, 640 s ≤ T < 2237 s): Accidents during Phase 4 could lead to immediate reentry conditions at a total probability of release for the small-quantity radioactive sources of 1 in 400. The source terms would be identical to those estimated for Phase 2. The characteristics of sub-orbital reentries in Phase 4 would be similar to those described in Phase 2.

The total probabilities of release, source term ranges, and release characteristics for the MER–B mission are very similar to those estimated for the MER–A mission, as is evident from Tables 2-4 and 2-5.

2.4.4 Potential Radiological Consequences and Risks of Accidents for the MER–2003 Project Proposed Action

The following paragraphs summarize the potential consequences of launch accidents that could result in release of radioactive material with implementation of the Proposed Action.

The radiological consequences for each accident scenario were calculated in terms of (1) maximum individual dose; (2) health effects; and (3) land area contaminated at or above specified levels. The maximum individual dose is used to estimate the potential impact on a representative individual within the exposed population. Health effect consequences were determined using methods described in Section 4.1.5. Health effects are an estimate of the potential radiological impacts on the regional or global population following an accident. The regional population, estimated to be approximately 2.4 million people, is considered to be all persons within 100 km (62 mi) of SLC–17 at the time of launch. The global population is the worldwide population at the time of launch. An estimate of the amount of land that could be contaminated above a level of concern is one measure of potential environmental impact.

Summaries of the mean radiological consequences by mission phase are provided in Table 2-6. The results, in terms of the estimated means, are as follows for the MER–A mission. The results for the MER–B mission would be similar.

- Phase 0 (Pre-Launch): The mean value of the maximum individual dose estimated for a Phase 0 accident is 11 millirem. This is the dose that would occur over a 50-year period following the release of radioactive material during a launch accident. For comparative purposes, this mean dose would be about 3% of the annual average dose to a person living in the U.S., from natural background radiation.

  The mean impacts on the potentially exposed population would be very small (see Table 2-6). No excess cancer fatalities would be expected as a result of a Phase 0 accident.

- Phase 1 (Early Launch): The mean maximum individual doses estimated for a Phase 1 accident would be 5.6 millirem (see Table 2-6). The doses to the potentially exposed regional population would be small and would not be expected to result in any excess cancer fatality over a 50-year period (see Table 2-6).

- Phases 2, 3, and 4 (Late-Launch, Pre-Orbit/Orbit and Orbit/Escape): Maximum individual doses would be a very small fraction of a millirem over a 50-year period. In all analyses, the dose to the potentially exposed global population would also be very small, and would not be expected to result in any excess cancer fatalities over the 50-year period following a release. The maximum individual doses in Phases 2 through 4 would be due to Co-57 and Cm-244 released as a vapor at high altitudes.

Table 2-6. Summary of Mean Radiological Consequences

Mission Phase	Maximum Individual Dose (millirem)	Population Health Effects [a]
MER–A Mission		
0 (Pre-Launch)	11	0.019
1 (Early Launch)	5.6	0.0098
2 (Late Launch)	0.0022	0.0013
3 (Pre-Orbit/Orbit)	0.0022	0.0013
4 (Orbit/Escape)	0.0022	0.0013
Overall Mission [b]	**1.3**	**0.0033**
MER–B Mission		
0 (Pre-Launch)	2.5	0.015
1 (Early Launch)	1.7	0.011
2 (Late Launch)	0.0022	0.0013
3 (Pre-Orbit/Orbit)	0.0022	0.0013
4 (Orbit/Escape)	0.0022	0.0013
Overall Mission [b]	**0.30**	**0.0030**

Source: Adapted from DOE 2002

a. Based on ICRP-60 health effects estimators of 4×10^{-4} health effects per person-rem for workers and 5×10^{-4} health effects per person-rem for the general population.

b. Overall mission values weighted by total probability of release for each mission phase.

2.4.4.1 Impacts on Individuals

If a launch-area accident occurs, spectators and people offsite in the downwind direction could inhale extremely small quantities of radionuclides, including Pu-238, Cm-244, and Co-57. The amount of additional radiation exposure would be a very small fraction of the annual radiation exposure from naturally occurring radiation in the Earth and from cosmic radiation. The person with the highest exposure would typically receive less than a few tens of millirem. In comparison, a person receives about 10 millirem from a single dental X-ray, and about 300 millirem/yr from natural sources.

2.4.4.2 Impacts on the Regional and Worldwide Populations

The total radiological exposures to the regional and worldwide populations from an accidental release were estimated. The amount of exposure to any individual is very small, as indicated above. In accordance with radiation health effects modeling accepted by the International Commission on Radiological Protection (ICRP 1990), any exposure is assumed to increase a person's chance of certain cancers. When this same model is applied to a large number of people, with each person getting a very, very small exposure, there is assumed to be a statistical increase in the incidence of cancer among the exposed population.

With either launch area or orbital/reentry accidents, the releases and resultant predicted average individual doses are so small that no additional cancers among the potentially exposed regional or global population would be expected.

2.4.4.3 Potential for Land Impacts

The airborne radioactive materials released in a launch area accident would be deposited downwind from the accident location. The results of the analysis indicated that the land area contaminated at levels exceeding 0.1 and 0.2 microcuries per square meter ($\mu Ci/m^2$) is expected to be less than 0.5 square kilometer (0.2 square mile) for any postulated pre-launch and launch phase accidents. In the past, the U.S. Environmental Protection Agency (EPA) used 0.2 $\mu Ci/m^2$ as a screening level to determine the need for further action, such as monitoring or cleanup.

The results indicated that under certain conditions dose-related land cleanup criteria, currently used by the EPA, could be exceeded during the first year following an accident, due primarily to resuspension. After the first year, these dose rates would fall well below these criteria levels. It is anticipated that no remedial action would be considered necessary on the basis of the dose rate criteria. Local remedial action at the accident site would be necessary to locate and recover the RHUs, small-quantity radioactive sources, and to clean up any residual radioactive materials and contamination (DOE 2002).

2.4.4.4 Mission Risks

To place the estimates of potential health effects (excess latent cancer fatalities) due to launch accidents for the proposed MER–2003 missions into a perspective that can be compared with other human undertakings and events, it is useful to use the concept of risk. Risk is defined by multiplying the total probability of a release by the health effects resulting from that release. The risks are estimated for the exposed population and individuals within the exposed population.

Phase 1 accidents represent 60% of the radiological risk for the MER–A mission and 55% of that for the MER–B mission. The relative contributions of Pu-238, Cm-244, and Co-57 to the total mission risks are estimated to be 57%, 43%, and 0.13%, respectively, for both missions combined.

<u>Population Risks</u>

For potential MER–2003 launch accidents resulting in a release of radioactive material, the total probability is obtained by multiplying the probability of the initiating accident by the conditional probability that a release will occur. For each mission phase, the risk to the potentially exposed population is then determined by multiplying this total probability of release by the associated health effects. Given the proposed MER–2003 missions, the risks calculated in this manner can be interpreted as the probability of one excess cancer fatality in the exposed population.

For the MER–A and MER–B missions, overall population health effects risks (*i.e.*, the probability of an excess latent cancer fatality as a result of the launches) are estimated to be 1 in 68,500 and 1 in 81,300, respectively. The combined risk for both missions is the sum of these two values, or 1 in 37,200. Considering both pre-launch and early launch accidents for both missions combined, the total probability of an excess latent cancer fatality within the regional population is about 1 in 106,000. Within the global population, the risk would be due to the potential for accidental release occurring from pre-launch through Mars trajectory insertion and was estimated by DOE to be about 1 in 57,500 (see Table 4-10).

<u>Individual Risks</u>

The risks of health effects to individuals within the potentially exposed regional and global populations due to the MER–A and MER–B missions were also estimated. The average individual risk, defined in this FEIS as the risk to the population divided by the number of persons exposed is estimated to be about 1 in 10 billion in the regional area and 1 in 170 trillion globally for both missions combined. This means, for example, that an individual within the launch area has about a 1 in 10 billion chance of incurring a fatal cancer associated with these missions.

While some individuals within the population, such as those very close to the launch area, would face higher risks, those risks are predicted to be very small. The risk to the maximum exposed individual within the regional population would be about 1 in 350 million for MER–A and about 1 in 1.6 billion for MER–B.

These risk estimates are very small relative to the other risks. For example, Table 2-7 presents information on annual individual fatality risks to U.S. residents due to various types of hazards. This data indicates that the average individual risk of accidental death in the U.S. is about 1 in 2,900 per year.

2.4.4.5 Radiological Emergency Response Planning

Prior to the launch of the MER–2003 missions with the RHUs and small-quantity radioactive sources onboard each rover, NASA, as the Lead Federal Agency, would develop a comprehensive plan in accordance with the Federal Radiological Emergency Response Plan. This plan would ensure that any accident could be met with a well-developed and tested response. The plan would be developed through the combined efforts of Federal agencies (*e.g.*, NASA, DOE, the U.S. Department of Defense (DoD), EPA, the Federal Emergency Management Agency, and others as appropriate), the State of Florida, and local organizations involved in local emergency response.

A Radiological Control Center would coordinate any emergency actions required during the pre-launch countdown or the early phases of the mission. In the event of an accident, a nearby offsite location would be established to conduct monitoring and surveillance in areas outside the launch site, assess the accumulated data, and coordinate further actions through the Radiological Control Center.

Table 2-7. Calculated Individual Risk of Fatality by Various Causes in the United States

Accident Type	Number of Fatalities [a]	Approximate Individual Risk Per Year [a]
Motor Vehicle	43,363	1 in 6,060
Suicide	31,300	1 in 8,400
Homicide and Legal Intervention (Executions)	22,900	1 in 11,500
Falls	13,986	1 in 18,800
Accidental Poisoning [b]	9,072	1 in 29,000
Drowning	3,790	1 in 69,400
Fires and Flames	3,761	1 in 69,900
Suffocation	2,095	1 in 129,000
Guns, Firearms, and Explosives	1,225	1 in 215,000
Air Travel	851	1 in 309,000
Water Transport	762	1 in 345,000
Manufacturing [c]	743	1 in 361,000
Railway	569	1 in 463,000
Electrocution	559	1 in 469,000
Lightning	85	1 in 3,100,000
Floods and Flash Floods	80	1 in 3,290,000
Tornadoes	30	1 in 8,770,000
Hurricanes	17	1 in 15,500,000
All Accidents	92,429	1 in 2,850
Diseases	2,164,600	1 in 122
All Causes	**2,392,217**	**1 in 110**

Sources: BLS 1998; NOAA 1995; USBC 1998

a. Based on 1995 statistics and a population of 263,039,000, except where noted.

b. Includes drugs, medicines, other solid and liquid substances, gases, and vapors.

c. Based on 1997 statistics and a population of 267,901,000.

The response to launch accidents would also depend on the geographical locations involved. Accident sites within the United States and U.S. Territories may be supported initially by the nearest Federal installation possessing a radiological contingency response capability. Personnel from all supporting installations would be alerted to this potential requirement prior to launch. Additional support would be dispatched from the launch site support personnel or from other support agencies, as needed. For accidents occurring outside the United States or its territorial jurisdictions, the U.S. Department of State and diplomatic channels would be employed in accordance with pre-arranged procedures and support elements would be dispatched as appropriate.

If an ocean or water impact occurs, the Federal agencies would undertake security measures, as appropriate, and search and retrieval operations. The recovery of the plutonium dioxide would be based on the technological feasibility, the health hazard presented to recovery personnel, the environmental impacts, and other pertinent factors.

2.4.5 Comparison of the Science Returns for the Project Alternatives

Proposed Action

The Proposed Action would have a substantial positive impact on NASA's program for the exploration of Mars. The payload of instruments on each rover has been carefully selected to maximize collection of scientific data to meet MER–2003 project objectives. Scientists would be able to closely examine the physical, geological and chemical characteristics of the landing sites and determine their aqueous, climatic, and geologic histories. By reading the geologic record at each site, scientists would investigate the role water played there and determine how suitable the conditions would have been for life.

Operation of the rovers and their science instruments would also benefit the planning and design of future missions. Lessons learned during all phases of each MER–2003 mission (atmospheric entry, descent, and landing; initial deployment on the surface; real-time site traverse planning, execution and navigation; and science data collection) would provide valuable information for refining future mission designs and procedures.

If programmatic issues (*e.g.*, changes in NASA priorities or unforeseen circumstances) were to necessitate modification of the mission objectives and timing, such issues could result in the need to launch one mission in 2003, and a second mission at a later launch opportunity or not at all. If such an event was to occur, the resulting mission would not allow NASA to complete all project objectives. Specifically, it would not allow NASA to achieve complex science operations through the simultaneous use of multiple science-focused mobile laboratories, and simultaneous exploration of two diverse landing sites. In addition, NASA would not be able to take full advantage of the uniquely efficient 2003 launch opportunity.

No Action Alternative

Under the No Action Alternative, planning and preparations for the MER–2003 project would cease and neither spacecraft would be launched during the 2003 launch opportunity to Mars. None of the science planned for the Proposed Action would be obtained and the objectives of NASA's planned follow-on missions to Mars would be adversely affected without the data to be obtained by the MER–2003 missions. NASA has no other missions at a stage of development that could be substituted for the Proposed Action and the launch opportunity for 2003 would be lost to NASA's overall Mars exploration effort.

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3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

This Chapter briefly describes the environment that could potentially be affected by the Proposed Action. The potentially affected environment is both local and global. Implementation of the Proposed Action could result in global and local environmental impacts. Global impacts could affect the global atmosphere and land mass. Local impacts could affect the environment at distances of 100 kilometers (km) (62 miles (mi)) or less from the launch site at Cape Canaveral Air Force Station (CCAFS), Florida. In this document the area enclosed by a circle of 100 km (62 mi) radius centered on the CCAFS launch site is referred to as the regional area of interest.

The potentially affected environment has been addressed in previous National Environmental Policy Act (NEPA) documentation and is summarized here. Principal sources for the following information include the National Aeronautics and Space Administration's (NASA) *Final Environmental Impact Statement for the Cassini Mission* (NASA 1995), NASA's *Final Supplemental Environmental Impact Statement for the Cassini Mission* (NASA 1997), the U.S. Air Force's (USAF) *Final Environmental Impact Statement for the Evolved Expendable Launch Vehicle Program* (USAF 1998), and the USAF's *Final Supplemental Environmental Impact Statement for the Evolved Expendable Launch Vehicle Program* (USAF 2000).

3.1 CCAFS AND THE REGIONAL AREA OF INTEREST

As shown in Figure 3-1, CCAFS is located on the Atlantic Seaboard of East Central Florida. The regional area of interest includes all or portions of nine counties in the State of Florida: Brevard, Indian River, Lake, Okeechobee, Orange, Osceola, Polk, Seminole, and Volusia. For this nine-county region, approximately 73% of the total population lives within 100 km (62 mi) of the launch site and could be affected by implementation of the Proposed Action. Relatively small portions of Lake, Okeechobee, and Polk Counties lie within the 100 km (62 mi) radius circle that defines the regional area of interest. Residents of the remaining six counties (Brevard, Indian River, Orange, Osceola, Seminole, and Volusia) comprise approximately 77% of the total population living within the nine-county region (USBC 2001). More than 99% of all persons living within 100 km (62 mi) of CCAFS reside within these six counties.

CCAFS is bounded by uninhabited marsh land and NASA's Kennedy Space Center (KSC) on the north, the Atlantic Ocean on the east, the City of Cape Canaveral approximately 6 km (4 mi) to the south, and the Banana River, KSC, and Merritt Island National Wildlife Refuge (MINWR) on the west. Figure 3-2 shows the location of CCAFS within the region.

3.1.1 Land Use

The six-county region (*i.e.*, Brevard, Indian River, Orange, Osceola, Seminole, and Volusia counties) covers approximately 1.5 million hectares (ha) (3.7 million acres (ac)). Nearly 17% of this area is urbanized or devoted to transportation and other rights-of-way. About 22% of the land in the region is agricultural. The three principal agricultural uses are crops (2.7%), citrus (3.9%), and pasturage (14.2%). The region also contains about 32 ha (80 ac) of historical and archaeological sites.

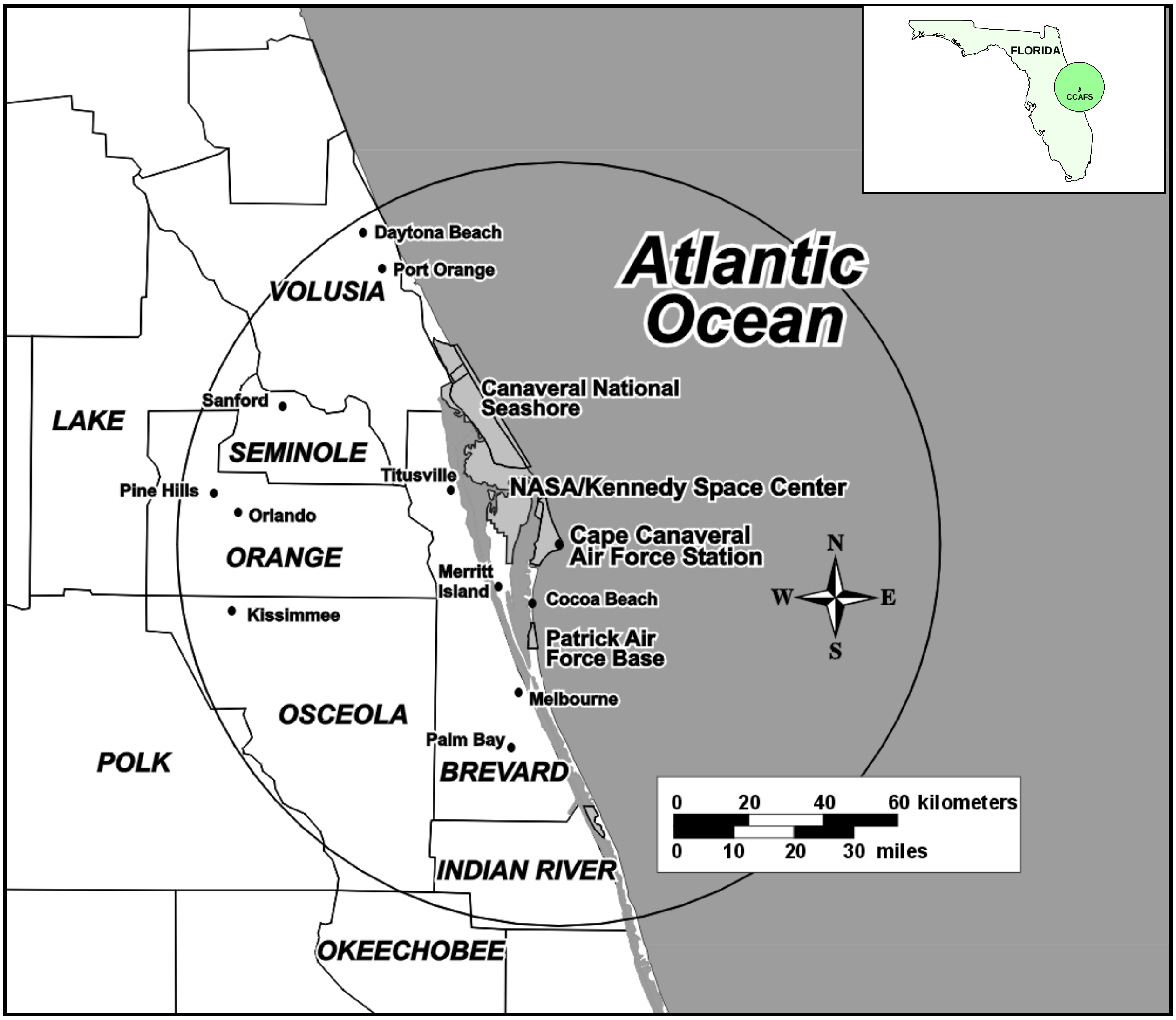


Figure 3-1. The Regional Area of Interest

KSC, immediately to the west of CCAFS, occupies about 57,000 ha (140,000 ac) of Merritt Island. Only about 4% (2,100 ha (5,300 ac)) of KSC is developed, and about 2,600 ha (6,500 ac) are used for NASA operations. About 40% of the KSC area (22,600 ha (55,800 ac)) is open water.

CCAFS occupies about 6,400 ha (15,800 ac) of the barrier island that also contains the City of Cape Canaveral. Major land uses at CCAFS include launch operations, launch support, airfield, port operations, station support areas, and open space. Approximately 1,900 ha (4,700 ac) or 30% of the station is developed, with over 40 space launch complexes (SLC) and support facilities, many of which have been deactivated. The remaining 70% (about 4,500 ha (11,100 ac)) is undeveloped land.

The Delta II Space Launch Complex 17 (SLC–17) is located in the southwestern portion of CCAFS.

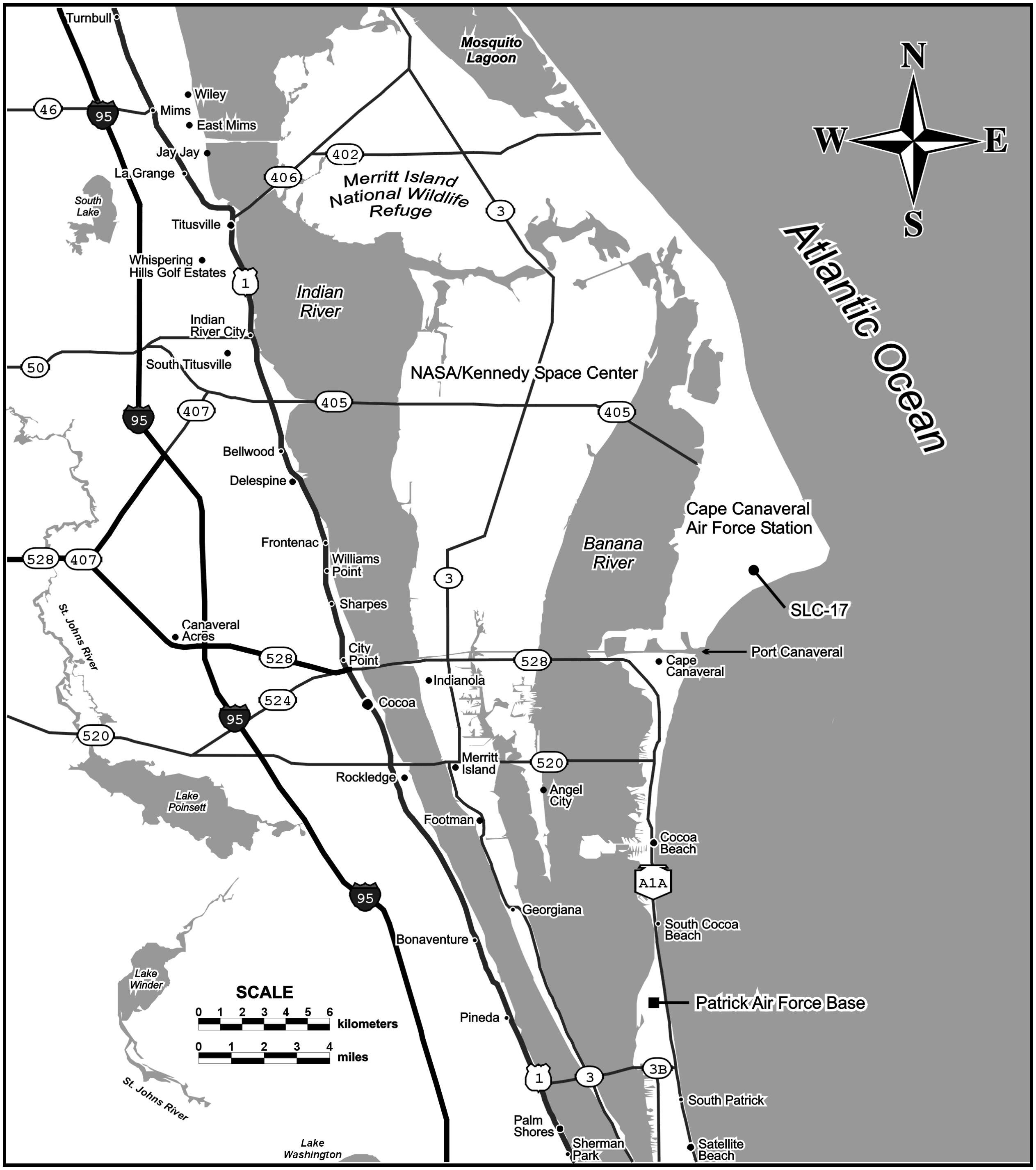


Figure 3-2. Location of CCAFS Relative to the Regional Area of Interest

3.1.2 Atmospheric Environment

3.1.2.1 Climate

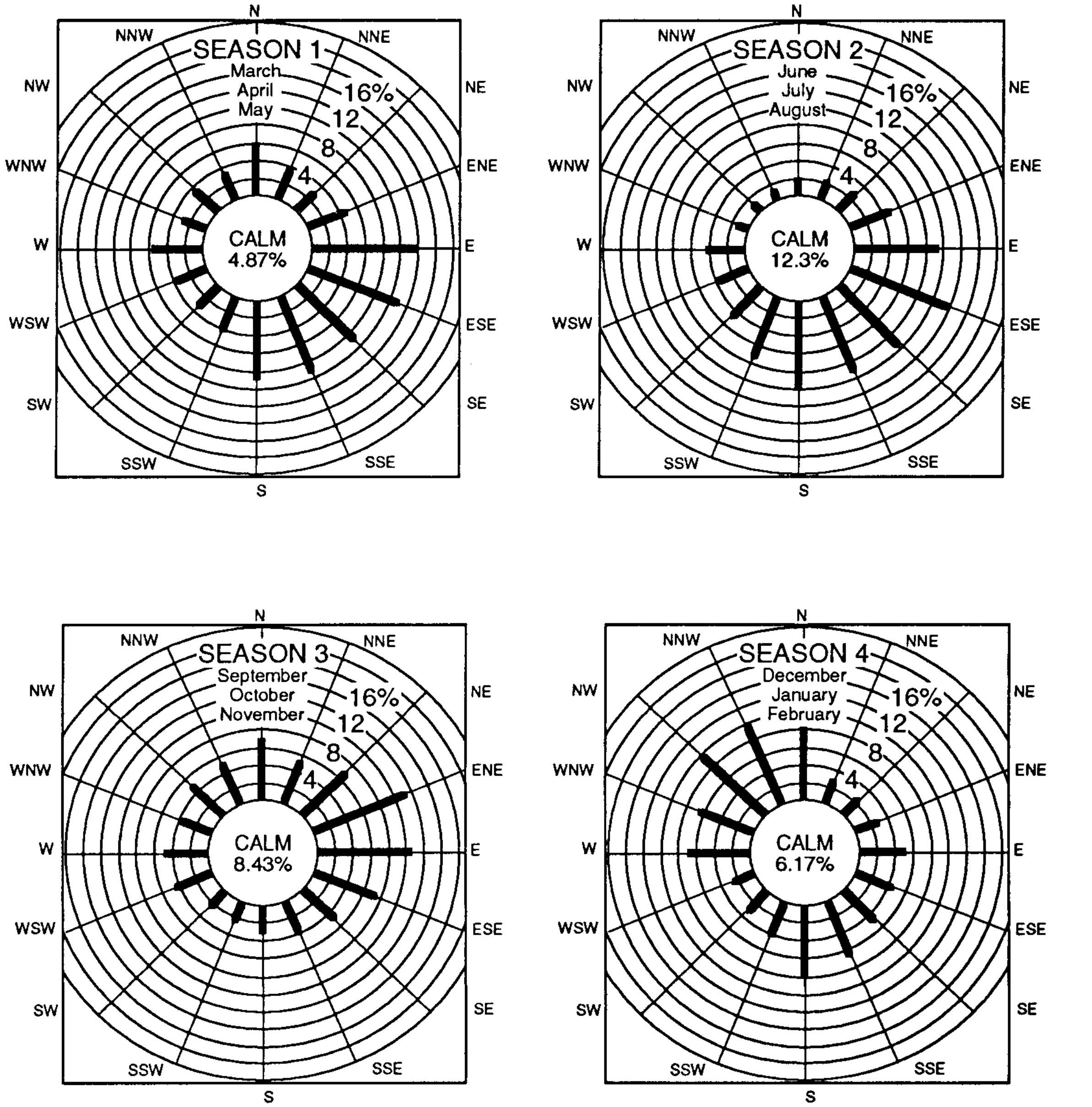
The climate of the region is subtropical with two definite seasons: long, warm, humid summers and short, mild, dry winters. Climatologic data from KSC indicate that winds from September through November occur predominantly from the east to north, shifting to the north and northwest from December through February (see Table 3-1). From March through May, the winds are predominantly from the east and shift east-southeast from June through August. Sea breezes (winds from the ocean towards land) and land breezes (winds from land towards the ocean) commonly occur during summer and fall. Sea breezes, with wind speeds of about 8 to 16 kilometers per hour (km/hr) (5 to 10 miles per hour (mph)) and air column depths of about 150 to 300 meters (m) (500 to 1,000 feet (ft)), occur at the surface during the day, with land breezes occurring at night. Thunderstorms bringing high winds and heavy rain typically occur from May through September. Surface mixing typically occurs during the winter to an altitude of about 700 to 900 m (2,300 to 3,000 ft) and during the summer to an altitude of about 1,200 to 1,400 m (3,900 to 4,600 ft). See Figure 3-3 for typical seasonal wind directions.

Table 3-1. Climatologic Data for Kennedy Space Center

	Surface Winds		Precipitation [a]		Fog	Thunderstorms
Month	Prevailing Direction	Mean Speed (km per hour (mph))	≥0.025 cm (≥0.01 in)	≥1.27 cm (≥0.5 in)	Visibility <3.2 km (<2 mi)	
			Mean Number of Days Occurrence			
January	NNW	13 (8)	7	2	9	1
February	N	13 (8)	7	2	7	2
March	SSE	13 (8)	8	2	7	3
April	E	14 (9)	5	1	4	3
May	E	13 (8)	8	2	3	8
June	E	11(7)	12	3	2	13
July	S	10 (6)	11	4	2	16
August	E	10 (6)	11	3	2	14
September	E	10 (6)	13	4	2	10
October	E	13 (8)	11	3	3	4
November	N	11 (7)	7	2	6	1
December	NW	13 (8)	8	1	7	1
Annual	E	11 (7)	108	29	54	76
Years of Record	10	10	26	26	26	26

Source: Adapted from USAF 1998

a. Snowfall has not occurred in over three decades.



NOTE: Bars denote the directions from which the winds occur.

Source: NASA 1995

Figure 3-3. Wind Roses Indicating Seasonal Wind Directions for Lower Atmospheric Conditions: Cape Canaveral/Merritt Island Land Mass

3.1.2.2 Air Quality

National ambient air quality is regulated through the National Ambient Air Quality Standards (NAAQS) promulgated under the Clean Air Act (CAA). NAAQS are the Federal primary and secondary air quality standards for criteria pollutants (ozone (O_3), nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), particulates (PM_{10} and $PM_{2.5}$)[1], and lead (Pb)). The value of the standards is based on human health and welfare. The primary standards address "levels of air quality necessary to protect the public health with an adequate margin of safety." The secondary standards address "protecting the public welfare from any known or anticipated adverse effects of a pollutant including economic values and personal comfort (*e.g.,* damage to soils, crops, wildlife, weather, climate, and personal comfort)" (40 CFR 50).

Air quality at CCAFS is considered good; Table 3-2 compares measured emission concentrations with current Federal and State standards. CCAFS is in attainment for NAAQS criteria pollutants[2]. Brevard County, including CCAFS, is considered by the Florida Department of Environmental Protection (FDEP) to be "in attainment" or "unclassifiable" with respect to criteria pollutants. Class I Areas are national parks or wilderness areas designated by the Prevention of Significant Deterioration Section of the CAA. There are no Class I areas within the regional area of interest. Under Section 176(c) of the CAA, the general conformity rules require a Federal action to conform to the applicable State Implementation Plan. Because the general conformity rules apply only to nonattainment and maintenance areas, these rules would not apply to the CCAFS region.

On July 18, 1997, the U.S. Environmental Protection Agency (EPA) promulgated a new standard for $PM_{2.5}$ particulate matter. The EPA cannot start implementing the 1997 fine particle standards until the EPA and the States collect three years of monitoring data to determine which areas are not attaining the standards. The fine particle monitoring network was completed in 2000. In most cases, areas would not be designated "attainment" or "nonattainment" for fine particles until 2004-2005. Given that States would need to modify their State Implementation Plan following a determination of non-compliance, and there would be a period of time following such modification before controls would be required, it is unlikely that $PM_{2.5}$ emission restrictions would apply prior to 2005 or 2006. In addition, the EPA promulgated a new ozone standard and is determining the approach and schedule for moving forward with its implementation. The EPA will be conferring with States and other interested parties to that end.

3.1.3 <u>Ambient Noise</u>

Ambient noise levels at CCAFS have not been monitored. The ambient noise levels at KSC, where similar industrial activities occur, range from about 60 A-weighted decibels (dBA) to 80 dBA, similar to levels found in many industrial settings. Noise levels at

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[1] PM_{10} = Particulate matter equal to or less than 10 microns in diameter
$PM_{2.5}$ = Particulate matter equal to or less than 2.5 microns in diameter

[2] Currently, six pollutants are regulated by NAAQS: carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particulate matter equal to or less than 10 microns in diameter.

resorts and on the beaches near Cape Canaveral probably range from 45 to 55 dBA (USAF 1998).

Table 3-2. Summary Air Quality Data Near CCAFS for 2000

Criteria Pollutant	Averaging Time	Federal Primary Standard [a, b] ($\mu g/m^3$ (ppm))	Florida State Standard [a] ($\mu g/m^3$ (ppm))	2000 Ambient Concentrations Near CCAFS ($\mu g/m^3$ (ppm))
Ozone (O_3)	1 hour [c]	235 (0.12) [d]	235 (0.12)	(0.095)
	8 hours [e]	(0.08)	(0.08)	(0.08)
Sulfur Dioxide (SO_2)	Annual [f]	80 (0.03)	60 (0.02)	(0.002)
	24 hours [g]	365 (0.14)	260 (0.10)	(0.008)
	3 hours [g]	no standard	1,300 (0.5) [h]	(0.033)
Particulate Matter (PM_{10})	Annual [i, j]	50 [d]	50	17
	24 hours [e]	150 [d]	150	46
Lead (Pb)	Quarterly	1.5	1.5	no data [k]
	Hourly	no standard	no standard	0.0 [k]
Nitrogen Dioxide (NO_2)	Annual [i, j]	100 (0.053) [d]	100 (0.053)	(0.012)
Carbon Monoxide (CO)	1 hour [g]	40,000 (35)	40,000 (35)	(5)
	8 hours [g]	10,000 (9)	10,000 (9)	(4)

Source: Adapted from USAF 1998; FDEP 2000

a. Federal and State standards are identical except for SO_2.
b. Federal Primary Standards are levels of air quality necessary, with an adequate margin of safety, to protect the public health.
c. Daily maximum one-hour concentration not to be exceeded an average of more than once per year averaged over three consecutive years.
d. Federal Secondary Standards, which protect the public welfare from any known or anticipated adverse effects of a pollutant, are the same as the Federal Primary Standard.
e. Not to exceed the three-year average of the fourth highest daily maximum.
f. Arithmetic mean.
g. Not to be exceeded more than once per year, averaged over three years.
h. Florida standard is same as Federal secondary standard.
i. Calculated as annual arithmetic mean, averaged over three consecutive years.
j. Cannot be exceeded.
k. Pb data reported in USAF 1998 is from a weather station in Orange County; the State Pb monitoring sites nearest to CCAFS are in Palm Beach and Tampa.

$\mu g/m^3$ = micrograms per cubic meter
ppm = parts per million

3.1.4 Geology and Soils

CCAFS lies on a barrier island composed of relict beach ridges. The barrier island, 7.2 km (4.5 mi) at its widest point, has an average land surface elevation of approximately 3 m (10 ft) above mean sea level (USAF 1998).

There are four stratigraphic units at the site: surficial sands, Caloosahatchee Marl, Hawthorn Formation, and the limestone formations of the Floridan Aquifer. The Upper

Floridan Aquifer is under artesian pressure in the vicinity of CCAFS and is about 110 m (360 ft) thick at a depth of about 80 m (260 ft). The Hawthorn Formation separates the Floridan Aquifer from the shallower aquifers in the area. CCAFS is not in an active sinkhole area. It lies in a Seismic Hazard Zone 0 (very low risk of seismic events) (USAF 1998).

Soils in the CCAFS area include five major associations. The three most prominent soil types are contained in the Canaveral-Palm Beach-Welaka Association. These soils are highly permeable and allow water to quickly percolate into the ground. Soils in and around SLC–17 are not considered suitable for commercial agriculture. There are no prime or unique farmland soils at CCAFS (USAF 1998).

3.1.5 Hydrology and Water Quality

3.1.5.1 Surface Waters

The major surface water resources in the region include the upper St. Johns River basin, the Indian River, the Banana River, the Mosquito Lagoon (see Figure 3-2), and a portion of the Kissimmee River on the western border of Osceola County. Except for the portions that are part of the Intercoastal Waterway between Jacksonville and Miami, these water bodies are shallow, estuarine lagoons with average water depths of 0.6 to 0.9 m (2 to 3 ft). The Indian and Banana Rivers join at Port Canaveral. The combined Indian and Banana River watersheds cover 218,500 ha (540,000 ac) and have a combined surface area in Brevard County of 60,000 ha (150,000 ac). Surface drainage at CCAFS is generally westward toward the Banana River (adapted from USAF 1998).

On CCAFS, the 100-year floodplain extends 2 m (7 ft) above mean sea level on the Atlantic Ocean side, and 1.2 m (4 ft) above mean sea level on the Banana River side (USAF 1998). SLC–17 does not lie within the 100-year floodplain.

3.1.5.2 Surface Water Quality

The St. Johns River, from Lake Washington south, and its tributaries are classified by the State of Florida as Class I surface waters (potable water supply) and serve as the source of potable water for Melbourne and for much of the surrounding population. Near CCAFS, the Mosquito Lagoon and portions of the Indian River have been designated as Class II waters (shellfish propagation and harvesting) (see Figure 3-4). The remaining surface waters in the vicinity (the Banana Creek, the Banana River, and portions of the Indian River south of Titusville) have been designated as Class III waters (recreation, fish and wildlife management).

Under Florida's Aquatic Preserve Act of 1975, the following areas located near CCAFS have been designated as Aquatic Preserves (FAC 62-302.700): the Banana River Aquatic Preserve, the Indian River Aquatic Preserve, and the Mosquito Lagoon Aquatic Preserve (see Figure 3-5). Aquatic Preserves have exceptional biological, aesthetic, and scientific values and have substantial restrictions placed on activities like oil and gas drilling and effluent discharges.

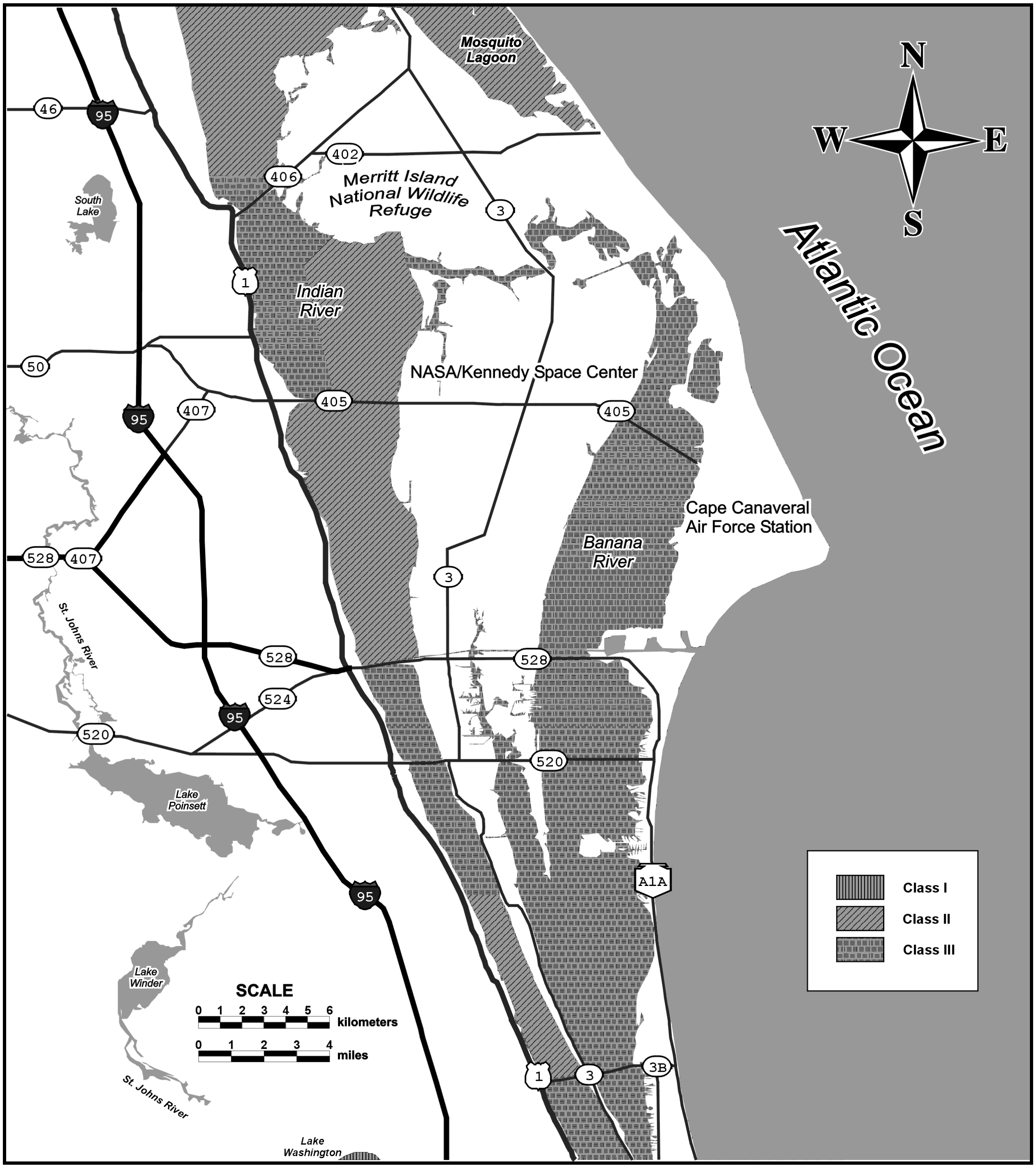


Figure 3-4. Surface Water Classifications Near CCAFS

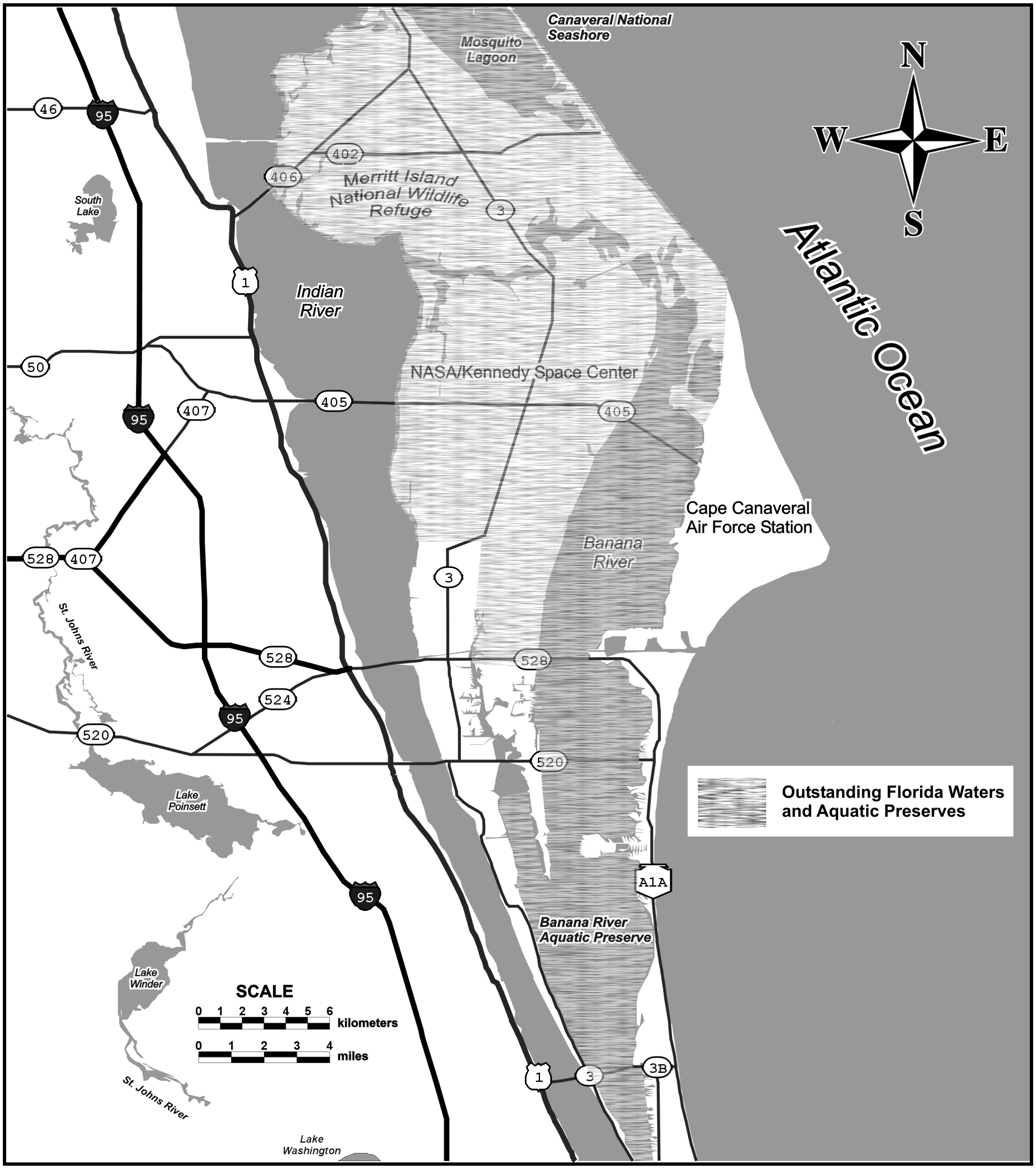


Figure 3-5. Outstanding Florida Waters and Aquatic Preserves Near CCAFS

Surface waters within the following areas located near CCAFS have been designated as Outstanding Florida Waters and as such are afforded the highest protection by the State of Florida (FAC 62-302.700): the Merritt Island National Wildlife Refuge, the Canaveral National Seashore, the Banana River Aquatic Preserve (see Figure 3-5). The Mosquito Lagoon Aquatic Preserve, the Archie Carr National Wildlife Refuge, the Pelican Island National Wildlife Refuge, the Sebastian Inlet State Recreation Area, the Indian River Aquatic Preserve – Malabar to Vero Beach, and the Indian River North Beach Program Area are also in the vicinity of CCAFS but outside the area of Figure 3-5. The State established this special designation for surface waters that demonstrate recreational or ecological significance. In addition, the Indian River Lagoon System, which includes the Mosquito Lagoon, has been selected as an Estuary of National Significance by the EPA's National Estuary Program. The goal of that program is to balance conflicting uses of the Nation's estuaries while restoring or maintaining their natural character. There are no designated wild or scenic rivers located on or near CCAFS.

Surface water quality near CCAFS is monitored at 11 long-term stations. These stations are located in the Mosquito Lagoon, the Banana River, the Banana Creek, the Indian River, and other locations on or near KSC. Other water quality monitoring stations in the area are maintained by Brevard County, the State of Florida, and the U.S. Fish and Wildlife Service (FWS). Surface water quality has been characterized as generally good, with best areas of water quality adjacent to undeveloped areas of the lagoon, *i.e.*, the North Banana River, the Mosquito Lagoon, and the northern-most point of the Indian River. The waters tend to be basic, with an average pH of 8.3, and have good buffering capacity, with alkalinities generally averaging 163 parts per million (ppm). Dissolved oxygen levels are generally above 6.0 ppm (NASA 1997).

Certain parameters—phenols and silver—generally exceed State water quality criteria, with pH, iron, and aluminum occasionally exceeding criteria. A similar pattern has been found in recent water quality data from the northern segment of the Banana River (NASA 1997).

3.1.5.3 Groundwater Sources

Groundwater underlying CCAFS occurs in three aquifer systems: the surficial aquifer, a secondary semi-confined aquifer, and the Floridan Aquifer. The surficial aquifer is unconfined and extends from just below the ground surface to a depth of about 21 m (70 ft). Recharge of the surficial aquifer is largely by percolation of rainfall and runoff. Near CCAFS, wells that tap this aquifer are used primarily for non-potable uses; however, Mims and Titusville, located about 16 km (10 mi) northwest of CCAFS, and Palm Bay, located about 64 km (40 mi) south of CCAFS, use the surficial aquifer for public water supply. The secondary, semi-confined aquifers are found below confining layers, but above and within the Hawthorn Formation. Recharge is minor and depends on leakage through surrounding lower permeability soils (NASA 1997). A confining layer of clays, sands, and limestone, ranging from 24 to 37 m (80 to 120 ft) thick, restricts exchange between the surficial aquifer and the deeper Floridan Aquifer. The Floridan Aquifer is the primary source of potable water in central Florida. The Floridan Aquifer underlying CCAFS is highly mineralized. CCAFS receives its potable water from the City of Cocoa, which draws its water from a non-brackish area of the Floridan Aquifer (USAF 1998).

3.1.5.4 Groundwater Quality

In the vicinity of CCAFS, groundwater from the Floridan Aquifer is highly mineralized (primarily by chlorides) because of entrapment of seawater in the aquifer, lateral intrusion caused by inland pumping, and lack of flushing because of distant freshwater recharge areas (NASA 1997). Water samples exceeded national drinking water criteria for sodium, chloride, and total dissolved solids (NASA 1998b).

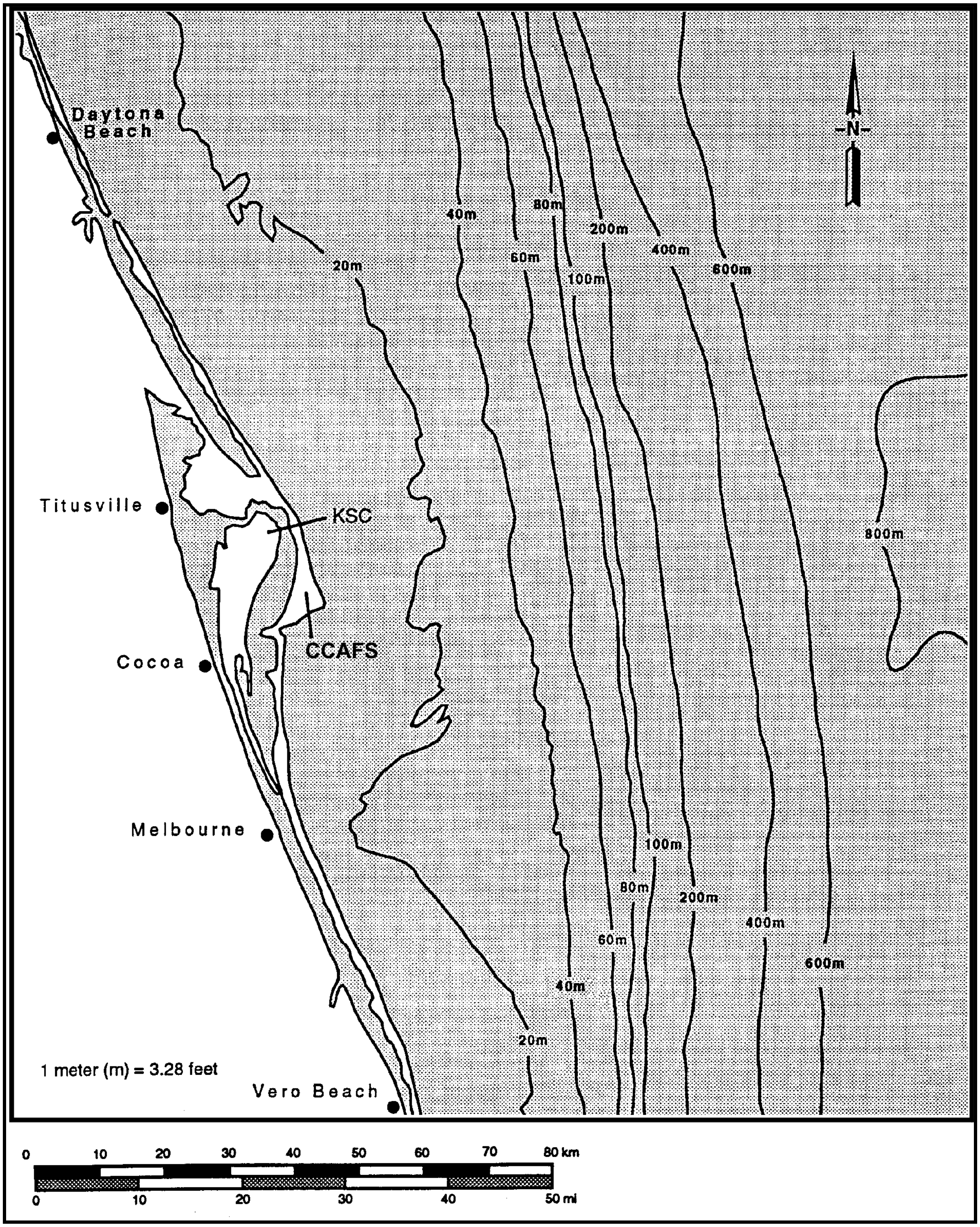
The secondary semi-confined aquifer lies between the surficial aquifer and the Floridan Aquifer and is contained within the relatively thin Hawthorn Formation. Groundwater recharge is by upward leakage from the Floridan system as well as lateral intrusion from the Atlantic Ocean. Water quality varies from moderately brackish to brackish (NASA 1997).

Groundwater in the surficial aquifer system at CCAFS remains good quality because of immediate recharge, active flushing, and a lack of development (NASA 1997). Groundwater from the surficial aquifer meets Florida's criteria for potable water (Class G-II, total dissolved solids less than 10,000 milligrams per liter (10,000 ppm)) and national drinking water criteria for all parameters other than iron and total dissolved solids.

3.1.5.5 Offshore Environment

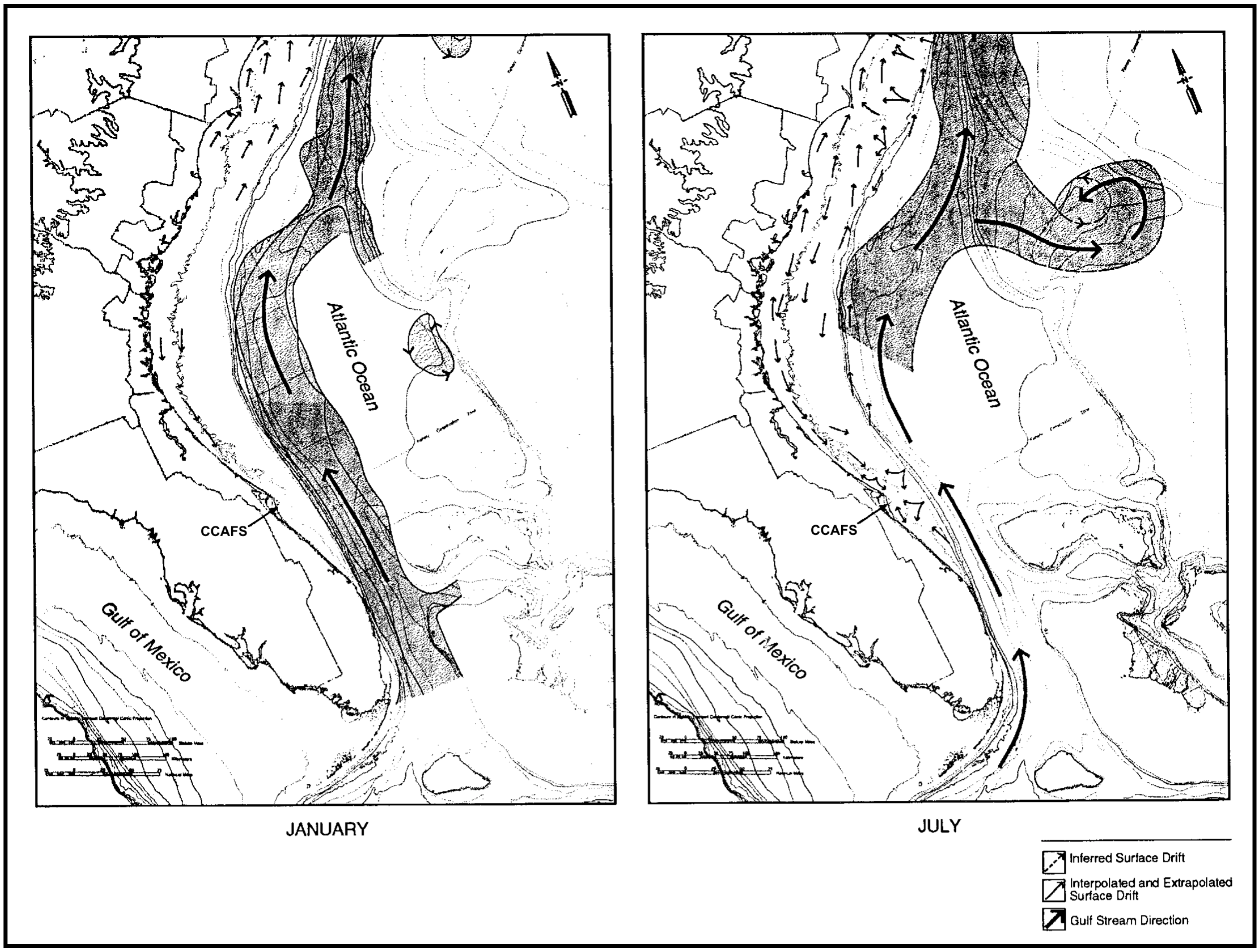
The Atlantic Ocean near CCAFS can be characterized by its bottom topography and circulation. Out to depths of about 18 m (60 ft), sandy shoals dominate the underwater topography. The sea floor continues to deepen out to about 100 km (62 mi) from the coast, where the bank slopes down to depths of 700 to 900 m (2,400 to 3,000 ft) to the Blake Plateau. The Blake Plateau extends out to about 370 km (230 mi). Figure 3-6 depicts the depths of the offshore waters.

Offshore currents usually reflect the general northern flow of the Gulf Stream, as illustrated in Figure 3-7 (NOAA 1980). Studies of water movements in the area indicate a surface-to-bottom shoreward current out to depths of 18 m (60 ft) (about 33 km (20.5 mi) offshore) at speeds of several kilometers per day, although wind generally determines current flow at the surface. Southeast winds occur from May to October, creating a wet season, and travel clockwise around the Bermuda High. These warm, moisture-laden winds produce thundershowers during this period, which account for about 70% of the yearly rainfall (NASA 1997). In general, during the MER–2003 launch opportunities (May/June/July), prevailing winds would occur from the east in May and then would shift from the south. The prevailing winds transport surface waters toward shore, with an offshore component in shallow bottom waters that diminishes rapidly with distance offshore. The net effect is that material suspended in the water column tends to be confined to the area near the coast, and heavier material (*e.g.*, sand) is deposited in this area. The occasional northward winds result in a net movement of surface waters offshore, with an onshore movement of higher density bottom waters. Materials suspended in surface waters are transported offshore, and heavier bottom materials move onshore.



Source: Adapted from DOE 1989

Figure 3-6. Offshore Water Depth Near the CCAFS/KSC Region



Source: Adapted from NOAA 1980

Figure 3-7. Ocean Currents and Water Masses Offshore of CCAFS/KSC for January and July

In the region out to the sloping bank (100 km (62 mi)), flow is slightly to the north and tends to move eastward when the wind blows to the south. Water over the Blake Plateau mostly flows to the north and is known as the Florida current, a component of the Gulf Stream.

3.1.6 Biological Resources

As noted in Section 3.1.5.2, the region has several terrestrial and aquatic conservation and special designation areas (*e.g.*, wildlife management areas and aquatic preserves). These areas serve as wildlife habitat and occupy about 25% (about 405,000 ha (1 million ac)) of the total land and water acreage within the region.

3.1.6.1 Terrestrial Resources

Table 3-3 provides an overview of the eight general land use-land cover categories in the six-county region. The data presented in Table 3-3 was extracted from recent geographic information system (GIS) data from two Florida Water Management

Districts. Brevard, Indian River, Seminole, and Volusia counties are entirely within the St. Johns River Water Management District (SJRWMD); Orange and Osceola counties are partly in the SJRWMD and partly in the South Florida Water Management District (SFWMD). Approximately 22% of the region is rangeland and forests of various types, while nearly 13% is open water. Over 26% is classified as wetlands (SJRWMD 1998; SFWMD 1995). The FWS National Wetlands Inventory conducted in 1994 identified a total of 905 ha (2,235 ac) of wetlands on CCAFS (USAF 1998).

Table 3-3. Major Land Cover Types by County in the CCAFS Region

Major Land Use - Land Cover Classification	Brevard (Acres[a] (%))	Indian River (Acres (%))	Orange (Acres (%))	Osceola (Acres (%))	Seminole (Acres (%))	Volusia (Acres (%))	Six-County Region Total (Acres (%))
Urban and Built-up	126,620 (15.5)	29,113 (9.3)	158,157 (24.6)	48,055 (5.0)	73,692 (33.3)	119,045 (14.9)	554,682 (14.8)
Agriculture	115,727 (14.2)	137,469 (44.0)	92,127 (14.3)	402,628 (41.7)	22,366 (10.1)	52,498 (6.6)	822,815 (21.9)
Rangeland	61,409 (7.5)	19,080 (6.1)	50,953 (7.9)	62,365 (6.5)	7,473 (3.4)	33,590 (4.2)	234,870 (6.3)
Upland Forests	96,279 (11.8)	28,249 (9.0)	109,020 (16.9)	98,685 (10.2)	26,583 (12.0)	226,072 (28.3)	584,888 (15.6)
Water	176,113 (21.6)	18,302 (5.9)	68,013 (10.6)	84,180 (8.7)	25,748 (11.6)	100,799 (12.6)	473,155 (12.6)
Wetlands	218,196 (26.8)	73,703 (23.6)	136,675 (21.2)	257,333 (26.6)	58,590 (26.5)	252,220 (31.6)	996,717 (26.5)
Barren Land	5,348 (0.7)	2,964 (0.9)	4,620 (0.7)	4,496 (0.5)	1,156 0.5)	3,149 (0.4)	21,733 (0.6)
Transportation, Communication and Utilities	15,086 (1.9)	3,648 (1.2)	24,094 (3.7)	8,192 (0.8)	5,615 (2.5)	10,989 (1.4)	67,624 (1.8)
Total	**814,778 (100.0)**	**312,528 (100.0)**	**643,659 (100.0)**	**965,934 (100.0)**	**221,223 (100.0)**	**798,362 (100.0)**	**3,756,484 (100.0)**

Source: Extracted from SJRWMD 1998 and SFWMD 1995

a. One acre equals 0.4047 hectares

Note: The data for this table were compiled directly from the referenced computer databases. The level of precision implied by the numbers is an artifact of the computer compilation process; therefore, data should be viewed only as approximations.

The majority of the land at and near CCAFS, including KSC/MINWR and the Mosquito Lagoon/Cape Canaveral National Seashore, is undeveloped and in a near-natural state. These areas host a variety of plant communities, ranging from mangrove swamps and salt marshes to freshwater wetlands, coastal dunes, and beaches.

Approximately 70% (4,400 ha (11,100 ac)) of the land at CCAFS is undeveloped. Three principal plant communities dominate this undeveloped land. The coastal dune community is the smallest (320 ha (800 ac)) and extends from the high tide line of the Atlantic Ocean across the beach into the dunes along the coastal perimeter of CCAFS

(USAF 1990). The coastal strand community, covering about 920 ha (2,300 ac), lies inland of the coastal dune community. The coastal scrub community, the largest of the three (3,760 ha (9,400 ac)), lies further inland. Three other ecologically important, but smaller, communities exist at CCAFS: mangrove swamp (180 ha (450 ac)), salt marsh (56 ha (140 ac)), and freshwater wetland (80 ha (200 ac)).

Coastal dune communities are inhospitable to many plants because of the constantly shifting substrate, salt deposition, abrasion from wind-blown sand, and effects of storm waves (USAF 1998). Vegetation on the dunes is dominated by sea oats. Other grasses, such as slender cordgrass and beach grass, also occur. Shrubs, such as beach berry and marsh elder, occur in the dune community, along with herbs such as beach sunflower and camphorweed. The beach areas, while largely unvegetated, still provide significant wildlife resources.

Coastal strand occurs between the coastal scrub community and the salt spray zone of the dune system. Strand vegetation has a low profile that is maintained by nearly constant winds. Plants that tolerate strand conditions are saw palmetto, wax myrtle, tough buckthorn, cabbage palm, partridge pea, prickly pear, and various grasses.

White-tailed deer, raccoons, mice, 14 species of birds (*e.g.*, red-tailed hawk and red-headed woodpecker), and two reptile species (gopher tortoise and eastern diamondback rattlesnake), among others, use this community (USAF 1990). The coastal scrub association is characterized by xeric tree species, including scrub oak, live oak, sand live oak, and myrtle oak.

The scrub community is in a harsh environment with low soil moisture. Herbaceous and shrub vegetation is sparse, but includes wire grass, saw palmetto, tar flower, lantana, wax myrtle, greenbriar, prickly pear, gopher apple, and others. Ten species of mammals, including white-tailed deer, armadillo, feral hogs, and bobcat use this habitat type at CCAFS. In addition, 14 species of birds (similar to those inhabiting the coastal strand) and 5 species of reptiles use the scrub community (USAF 1990).

Overall, 68 reptile and amphibian species, more than 300 bird species, and more than 25 mammal species use communities at CCAFS (adapted from NASA 1997). There are eight to nine bird rookeries in the area. Terrestrial wildlife in the region include migratory and native waterfowl (*e.g.*, ringneck, pintail, and baldpate ducks), as well as turkey, squirrel, white-tailed deer, wild hogs, and black bear. Seven State wildlife management areas, primarily in the St. Johns River basin, are hunted for small game, turkey, hogs, and deer.

3.1.6.2 Aquatic Resources

The coastline from Daytona to Melbourne seaward to a depth of 180 m (600 ft) is one of the most productive marine fishery areas along the southern Atlantic coast. Inshore waters support a sea trout and redfish sport fishery. The tidal zone supports an abundance of several species of marine invertebrates, as well as small fish that are food for many shore birds. Several species of gulls, terns, sandpipers, and other birds use the beaches of the Cape Canaveral area. In addition, these beaches are important to nesting sea turtles (USAF 1998).

The lagoons and rivers support limited commercial fishing. At least 141 species of freshwater, estuarine, and marine fish occur in the northern portions of the Indian River Lagoon near CCAFS (ECFRPC 1988). Of these, 65 species are exploited commercially, and 85 are sport fish that may also be commercially fished.

Fishing for crabs, clams, scallops, oysters, and shrimp is an important component of the commercial and recreational fishing effort, particularly in Brevard and Volusia counties. In 1997, 90% (700,933 kg (1,545,292 lb)) of Florida landings of Calico Scallops were produced in Brevard County. Further, Brevard County landings of clams accounted for over 80% (198,065 kg (436,658 lb)) of the Florida east coast clam harvest. Volusia County accounted for over 6% (15,377 kg (33,902 lb)) of clam landings off the Florida east coast (FDEP 1998).

Commercial fishing is an important economic asset to the region. Brevard County and Volusia County ranked first and fourth respectively, among the 12 east coast Florida counties in terms of 1997 finfish landings. Among the 12 east coast Florida counties, Brevard ranked first in invertebrate landings (*e.g.*, crab, clams, and oysters) and shrimp landings, with Volusia sixth and third, respectively, in these categories (FDEP 1998). Mosquito Lagoon is considered among the best oyster and clam harvesting areas on the east coast.

3.1.6.3 Endangered and Threatened Species

The Federal Government's Threatened or Endangered Species List, prepared by the FWS under the Endangered Species Act, currently recognizes 111 endangered or threatened species in the state of Florida. Another 14 species, including 13 plants, are listed as candidate species and are being reviewed for possible Federal listing in the state of Florida (FWS 2002). The State of Florida considers 470 species of plants and animals as endangered or threatened (FFWCC 1997). Roughly half of all the endangered and threatened species occur in wetlands, principally estuarine environments; the other half depends largely on upland habitat (ECFRPC 1991).

Table 3-4 lists 34 Federal and State endangered and threatened species, and species of special concern, known to occur at CCAFS (USAF 1998, FWS 2002, FFWCC 1997). No Federally listed threatened or endangered flora exists at CCAFS, although State-listed species, such as coastal vervain, are located on both CCAFS and KSC.

About 15% of the U.S. population of West Indian Manatee occurs near CCAFS. The following areas have been designated as critical habitat for manatee by the FWS: the entire inland section of the Indian River; the entire inland section of the Banana River; and all the waterways between the Indian and Banana Rivers (exclusive of those existing human-made structures or settlements that are not necessary to the normal needs and survival of the species). On March 11, 1990, the FWS established the waters of the Banana River from State Road 528 north to the NASA Parkway East causeway as a manatee refuge. On January 7, 2002, the FWS declared the Barge Canal, to the immediate south of CCAFS, and Sykes Creek in Brevard County as additional manatee refuge areas.

Table 3-4. Threatened, Endangered, and Species of Special Concern Occurring at or Near CCAFS

Common Name	Scientific Name	Federal Status	State Status
Plants			
Curtiss' milkweed	*Asclepias curtissii*	---	E
Satin-leaf	*Chrysophyllum oliviforme*	---	E
Coastal vervain	*Verbena maritima*	---	E
Nodding pinweed	*Lechea cernua*	---	T
Hand fern	*Ophioglossum palmaturn*	---	E
Beach-star	*Remirea maritima*	---	E
Giant Leatherfern	*Acrostichum danaeifolium*	---	C
Reptiles and Amphibians			
Gopher frog	*Rana capito*	---	SSC
Gopher tortoise	*Gopherus polyphemus*	---	SSC
American alligator	*Alligator mississippiensis*	T(S/A)	SSC
Eastern Indigo snake	*Drymarchon corais couperi*	T	T
Atlantic green sea turtle	*Chelonia mydas*	E	E
Atlantic loggerhead sea turtle	*Caretta caretta*	T	T
Leatherback sea turtle	*Dermochelys coriacea*	E	E
Atlantic (Kemp's) Ridley sea turtle	*Lepidochelys kempii*	E	E
Atlantic hawksbill sea turtle	*Eretmochelys imbriccata imbratica*	E	E
Birds			
Wood stork	*Mycteria americana*	E	E
Bald eagle	*Haliaeetus leucocephalus*	T	T
Little blue heron	*Egretta caerulea*	---	SSC
Florida scrub jay	*Aphelocoma coerulescens*	T	T
Piping plover	*Charadrius melodus*	T	T
Least tern	*Sterna antillarum*	---	T
Roseate tern	*Sterna dougallii dougallii*	T	T
Roseate spoonbill	*Ajaia ajaja*	---	SSC
Brown pelican [a]	*Pelicanus occidentalis*	E	SSC
Southeastern American kestrel	*Falco sparverius paulus*	---	T
Arctic Peregrine falcon	*Falco peregrinus tundrius*	---	E
Mammals			
West Indian manatee	*Trichechus manatus*	E	E
Southeastern beach mouse	*Peromyscus polionotus niveiventris*	T	T
Finback whale	*Balaenoptera physalus*	E	E
Humpback whale	*Megaptera novaeangliae*	E	E
Northern right whale	*Balaena glacialis*	E	E
Sei whale	*Balaenoptera borealis*	E	E
Sperm whale	*Physeter catodon*	E	E

Source: Based on FFWCC 1997, USAF 1998, and FWS 2002

a. The Brown Pelican is endangered by Federal Status in the U.S., but the Federal status does not encompass the Brown Pelican population in Florida as listed in the special reprint of 50CFR17.11 and 50CFR17.12 on December 31, 1999.

E = endangered; T = threatened; SSC = state special concern species; C = commercially exploited

(S/A) = listed by similarity of appearance to a listed species

One rare species, while not on the Federal or State threatened or endangered lists, is known to inhabit the Indian River. The rainwater killifish has been listed by the Florida Committee on Rare and Endangered Plants and Animals as a "species of special concern."

SLC–17 is within several hundred meters of sea turtle nesting beaches. Loggerhead, green, and leatherback sea turtles use the beaches at CCAFS as nesting habitat. Nesting typically occurs between May and October. The launch complex uses exterior lighting for safety and security reasons. Sea turtle adults and hatchlings are sensitive to artificial lighting near their nesting beaches. Extensive research has demonstrated that artificial lighting deters adult female turtles from emerging from the water and nesting. After emerging from the nests, the hatchlings use moonlight and starlight reflected off the ocean as a guide to finding the ocean. If the inland lighting is brighter than the reflected light, the hatchlings may get disoriented and never reach the ocean. CCAFS's lighting plan minimizes light impacts on sea turtle nesting beaches (USAF 2000; USAF 2001).

Populations of the southeastern beach mouse are high at CCAFS largely because of the amount of coastal dune and strand habitat at the station. Southeastern beach mouse populations have been found at CCAFS launch sites where open grassland habitat is maintained. Coastal grasslands and strand provide the highest population densities at CCAFS.

Peregrine falcons, recently removed from the Endangered Species list but subject to continued monitoring by the FWS, are typically tolerant of humans and use the dune habitat for overwintering. Wood storks are year-around residents of the Cape Canaveral area, nesting in treetops of mangrove swamps and near water impoundments. Florida scrub jays use the oak scrub habitat in the Cape Canaveral-MINWR. The total estimated population in Florida is between 7,000 to 11,000 birds (66 FR 21999). There are about 20 historically used bald eagle nest sites on KSC, but eagles are not known to breed at CCAFS. In 1993, a total of four out of five recently used nests were occupied on KSC, and seven eaglets were fledged (NASA 1997). Least terns typically nest between May and June and use sandy or gravelly beaches and gravel rooftops in an industrial area at CCAFS from April to October. Least terns are sensitive to disturbance during nesting.

Five endangered whale species (finback, humpback, Northern right, sei, and sperm) occur in the coastal waters near CCAFS. The National Marine Fisheries Service (NMFS) has designated critical habitat for the Northern right whale pursuant to the Endangered Species Act. The designated habitat involves marine waters adjacent to the coast of Georgia and Florida, including the Cape Canaveral area (NMFS 1994).

3.1.7 Socioeconomics

Socioeconomic resources in the area surrounding CCAFS include its population; economy; transportation system; public and emergency services; and recreation opportunities. These resources are described below.

3.1.7.1 Population

Implementation of the Proposed Action could result in potential environmental impacts to residents surrounding the launch site at CCAFS. This population includes all persons residing within 100 km (62 mi) of the launch site. This area is referred to as the regional area of interest, and persons living within it are collectively called the potentially affected population.

Figure 3-8 highlights the population centers located within the regional area of interest. The largest of these include the Daytona Beach/Port Orange area to the north, the Kissimmee/Orlando/Sanford area and Titusville to the west, and the Melbourne/Palm Bay area to the south. Table 3-5 shows populations by county based on data from the census conducted in 2000 (USBC 2001).

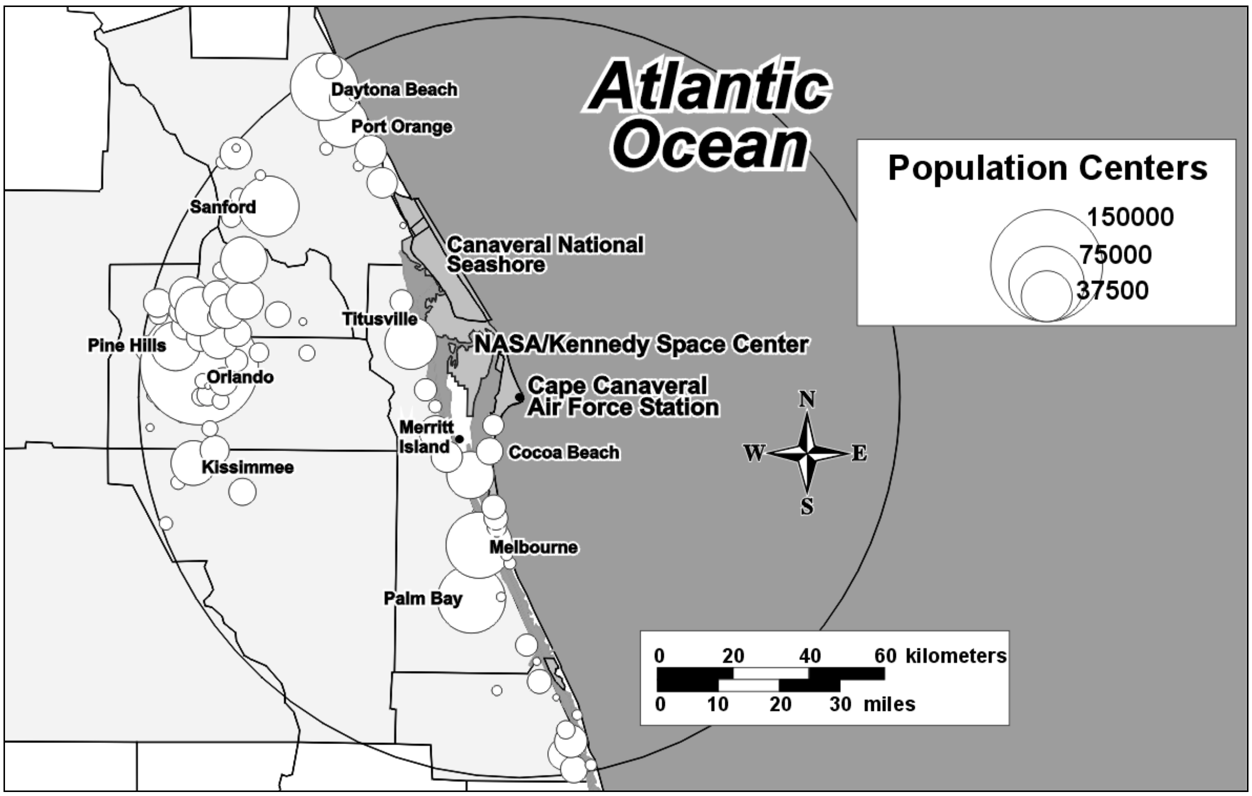


Figure 3-8. Population Centers in the Regional Area of Interest.

Figure 3-9 shows population groups residing within the regional area of interest surrounding CCAFS in 1990 and 2000. The regional population grew at a faster rate than the State's from 1990 to 2000. The six-county region grew by 27.6% (1,932,646 to 2,466,553) whereas the State's population grew by 23.5% (12,937,926 to 15,982,378). The population in Brevard County grew by 19.4% (398,978 to 476,230), a lower rate than both the State and region (USBC 2001). Minorities comprised 19% of the total resident population in 1990. Between 1990 and 2000, the minority population in the regional area of interest nearly doubled, and by 2000, minority persons comprised nearly 30% of the residents in the area. "Hispanic or Latino" and "Black or African American" groups comprised approximately 86% of the potentially affected minority population in 2000 (see Appendix B).

Table 3-5. Population of the Regional Area of Interest

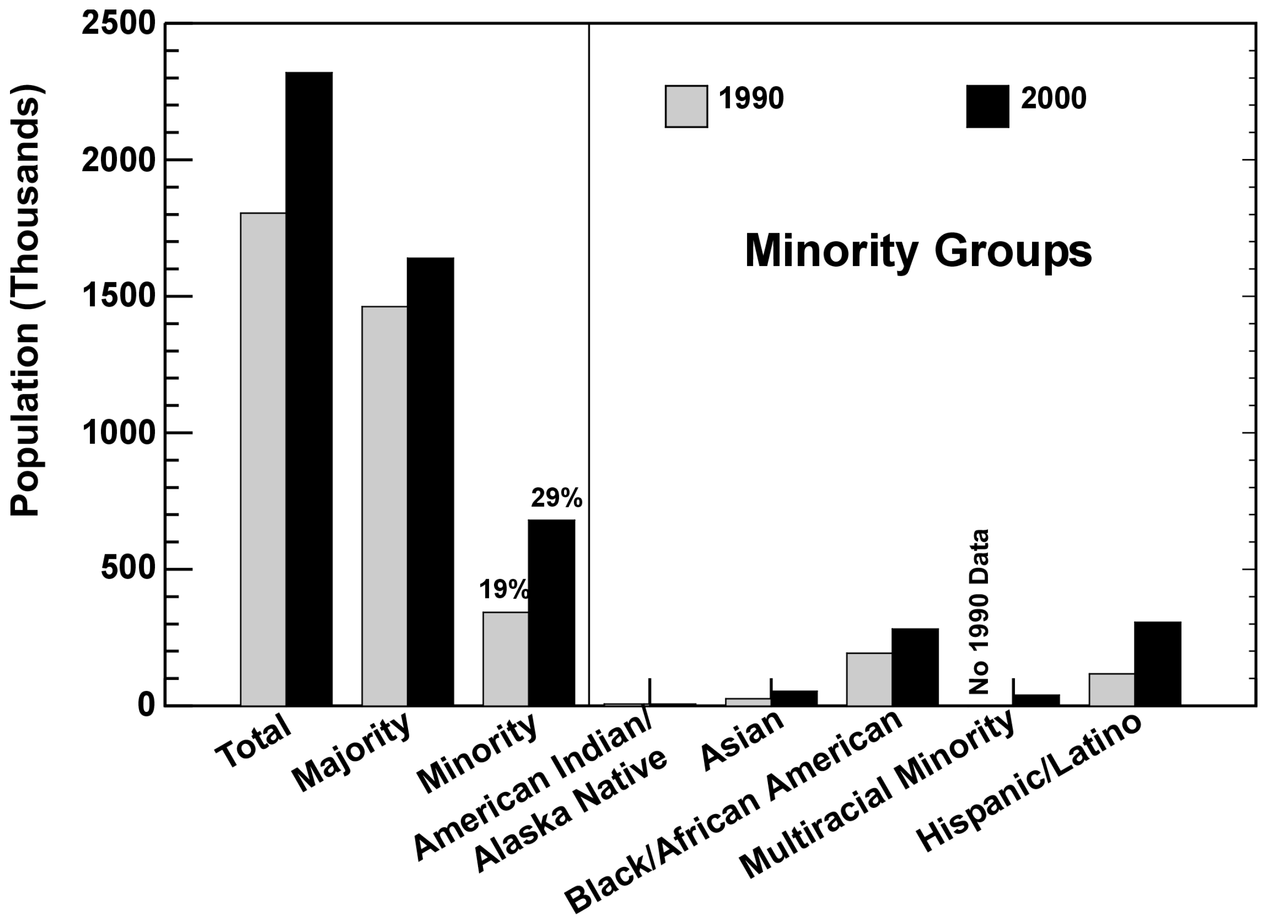
County	2000 Census Population	2003 Projected Population	Estimated Percent of Population Within 100 km of CCAFS	Potentially Affected Population [a] in 2003
Brevard	476,230	497,184	100.0	497,184
Indian River	112,947	119,385	95.2	113,654
Orange	896,344	960,881	95.1	913,798
Osceola	172,493	190,087	97.2	184,764
Seminole	365,196	387,108	100.0	387,108
Volusia	443,343	463,737	78.1	362,178
Six-County Region	**2,466,553**	**2,618,382**	**93.9**	**2,458,686**
Lake	210,528	226,739	0.5	1,134
Okeechobee	35,910	38,675	0.3	116
Polk	483,924	521,186	0.9	4,691
Nine-County Region	3,196,915	3,404,982	72.6	2,464,627

Source: Adapted from USBC 2001

a. Those persons living within 100 km (62 mi) of the launch site at CCAFS.

All counties are expected to have population increases through 2003. The U.S. Bureau of the Census' (USBC's) projected population estimates for 2005 were interpolated to estimate populations in 2003 (see Table 3-5). Orange County is expected to remain the most populated and is projected to grow to 960,881, and Brevard County is expected to increase to 497,184. During the decade from 1990 to 2000, the potentially affected population within 100 km (62 mi) of CCAFS increased from approximately 1.8 million persons to 2.3 million persons. The potentially affected population within the regional area of interest is expected to exceed 2.4 million persons by the year 2003. More than 99% (2,458,686) of the projected potentially affected population in 2003 will reside in the six counties of Brevard, Indian River, Orange, Osceola, Seminole, and Volusia, and less than 0.3% of the potentially affected population will reside in the remaining three counties (Lake, Okeechobee, and Polk).

In 2000, approximately 56,500 people lived within 20 km (12 mi) of the launch site, and about 3,900 lived within a distance of 10 km (6 mi). By 2003 the population residing within 20 km (12 mi) of the launch site is expected to approach 59,000, while the population living within 10 km (6 mi) is projected to exceed 4,000.



Note that a direct comparison of 1990 Census data and 2000 Census data for minority groups is not possible. During the 2000 Census, the USBC modified its enumeration methodology to include multiracial responses and added a separate racial category, "Native Hawaiian or Other Pacific Islander". Persons in the "Native Hawaiian or Other Pacific Islander " group were included in the "Asian or Pacific Islander " group in the 1990 Census data. For the purposes of comparison, the data for the Asian Group shown in Figure 3-9 includes persons self-designated as "Hawaiian or Other Pacific Islander" during the 2000 Census (approximately 1,135 persons). As indicated in Figure 3-9, no data for multiracial persons were gathered during the 1990 Census.

Figure 3-9. Potentially Affected Populations Surrounding CCAFS in 1990 and 2000

In 1990, about 10% of the potentially affected population reported incomes that were below the 1990 poverty threshold (see Appendix B). Persons whose income is less than the poverty threshold are designated as low-income persons by the Council on Environmental Quality (CEQ 1997). Low-income persons comprised approximately 8% of the population residing within 20 km (12 mi) of the launch complex, and approximately 11% of the population residing within 10 km (6 mi) of the launch complex.

3.1.7.2 Economy

The region's economic base is tourism and manufacturing. Regional tourism attracts more than 20 million visitors annually. Walt Disney World®, Sea World®, and Universal Studios Florida®, along with KSC, are among the most popular tourist attractions in the state. Several cruise lines anchor at Port Canaveral, immediately to the south of CCAFS.

As shown in Table 3-6, industrial sectors in Brevard County providing significant employment in 2000 were services, with 61,921 employees (34.2% of total private industry employment); wholesale and retail trade, with 44,125 employees (24.3%); government, with 25,885 employees (14.3%), manufacturing, with 25,085 employees (13.8%); construction, with 10,737 employees (5.9%); finance and real estate, with 6,024 employees (3.3%); transportation and public utilities, with 5,130 employees (2.8%); and agriculture, forestry, and fishing, with 1,975 employees (1.1%) (BEBR 2001).

Table 3-6. Industry Employment Estimates for Brevard County

Standard Industrial Classification [a]	Average Employment		Percent Change
	1999	2000	
Agriculture, Forestry, and Fishing	2,087	1,975	-5.4
Construction	9,906	10,737	8.3
Manufacturing	25,836	25,085	-2.9
Transportation, Communications, and Public Utilities	5,254	5,130	-2.4
Wholesale Trade	5,924	6,581	11.1
Retail Trade	38,111	37,544	-1.5
Finance, Insurance, and Real Estate	6,138	6,024	-1.8
Services	57,889	61,921	7.0
Unassigned Industries	395	381	-1.5
Government [b]	25,057	25,885	3.3
Total	**176,597**	**181,263**	**2.6**

Source: BEBR 2001

a. Includes all employers covered by Federal and State unemployment compensation laws; excludes proprietors, the self-employed, unpaid volunteers, family workers, domestic workers in households, military personnel, and employees of some Federal agencies.
b. Includes Federal, State and local civilian employees for all Standard Industrial Classification codes.

An estimated 1,071,361 people were employed in the regional area of interest in 2000. The unemployment rate for the region in 2000 was estimated at 2.9%. Brevard County had an estimated 200,686 people employed in 2000 with an estimated unemployment rate of 3.4% (BEBR 2001).

The employment pool at CCAFS involves about 10,000 military and civilian personnel, all associated with the USAF. Military personnel are attached to the 45th Space Wing at Patrick Air Force Base (PAFB), approximately 24 km (15 mi) away from the duties they perform at CCAFS. Most people employed by the base are contractor personnel from companies associated with missile testing and launch vehicle operations.

3.1.7.3 Transportation

The region’s road network includes five major limited access highways: Interstate 4, Interstate 95, Florida's Turnpike, the Spessard L. Holland East-West Expressway, and the Martin L. Andersen Beeline Expressway. In addition, numerous Federal, State, and county roads are located in the region. Primary highways serving CCAFS include Interstate 95, US Route 1, State Route (SR)-A1A, and SR-520. CCAFS is linked to the highway system by the south gate via SR-A1A, NASA Causeway, and General Samuel C. Phillips Parkway.

Rail service for freight is available in all six counties, although passenger service is limited. Rail transportation in the CCAFS/KSC area is provided by Florida East Coast Railway. A mainline traverses the cities of Titusville, Cocoa, and Melbourne.

The region has three major airports: Orlando International, which served over 30 million passengers in 2000 (GOAA 2001); Daytona Beach International, which served over 800,000 passengers in 1996; and Melbourne International, which served almost 600,000 passengers in 1996 (ECFRPC 1997). Melbourne International Airport, the closest air transportation facility of the three, is located 48 km (30 mi) south of CCAFS (see Figure 3-1). CCAFS contains a skid strip for Government aircraft and delivery of launch vehicle components. Air freight associated with the operation of CCAFS launch complexes arrives at the CCAFS skid strip.

Port Canaveral, the nearest navigable seaport, has approximately 480 m (1,600 ft) of dockage. With six cruise terminals and two more planned, Port Canaveral became the busiest cruise port in the Western Hemisphere during 2000, with a record $3.8 million revenue cruise passengers (Port Canaveral 2001).

3.1.7.4 Public and Emergency Services

A mutual agreement exists among the City of Cape Canaveral, KSC, and the range contractor at CCAFS for reciprocal support in the event of an emergency or disaster (USAF 1990). Further, CCAFS range operations and the Brevard County Office of Emergency Management have agreements for communications, product dissemination, and early warning in the event of a launch accident.

Health care in the region is provided at 28 general hospitals (6,600 beds), three psychiatric hospitals, and two specialized hospitals. Medical services for CCAFS are provided primarily at the Air Force Space Command Hospital at PAFB and at nearby public hospitals located outside of CCAFS.

Nearly 90% of the people in the six-county region rely on public systems for potable water. CCAFS obtains its potable water under contract from the City of Cocoa water system and uses 3.8 million liters (1 million gallons (gal)) per day (USAF 1998). The

Cocoa water system draws its supplies from the Floridan Aquifer. The onsite water distribution system is sized to accommodate the short-term high-volume flows required by the launch deluge system.

3.1.7.5 Recreation

There is an abundance of public recreational opportunities in the six-county region. Recreational activities focus primarily on coastal beaches, inland waterways (*e.g.*, Indian, Banana, and St. Johns Rivers), and freshwater lakes scattered throughout the region (USAF 1998). The Canaveral National Seashore lies to the north of CCAFS, and MINWR, which comprises the bulk of KSC, lies immediately to the west. Within the confines of CCAFS, fishing by CCAFS personnel and their guests is permitted at SLC–34, SLC–16, and two other onsite locations.

Recreational facilities at CCAFS, which are for base personnel only, are located in the industrial and port areas. These include a fitness center, softball field, picnic pavilion, a U.S. Navy service club, and a naval recreation facility. Cultural facilities on station include the Air Force Space and Missile Museum and the original NASA mission control, all located at the southern portion of the base. Off-base military and civilian personnel use recreational and cultural facilities available in local communities. No public school facilities are present on CCAFS (USAF 1990).

3.1.8 Cultural/Historic/Archaeological Resources

There are 81 sites in the region listed on the National Register of Historic Places (DOI 1991), two on the National Registry of Historic Landmarks, and one (Emeralda Marsh) on the National Registry of Natural Landmarks.

Archeological investigations at CCAFS indicate that human occupation of the area first occurred approximately 4,000 years ago. Surveys of CCAFS recorded 56 prehistoric and historic archaeological sites, with 19 identified as eligible for listing on the National Register of Historic Places. Historic building and structure surveys reported 14 properties as listed or eligible for listing on the National Register. Launch Pads 5/6, 13, 14, 19, 26, 34, and the original Mission Control Center at CCAFS are listed and form a National Historic Landmark District. Launch Complexes 1/2, 3/4, 17, 21/22, 25, 31/32, and the Cape Canaveral Lighthouse are considered as eligible for listing on the National Register (USAF 1998).

A 1978 survey of MINWR identified four historic sites: Sugar Mill ruins, Fort Ann, Dummett Homestead, and the Old Haulover Canal. Of the four sites, only the Old Haulover Canal is listed on the National Register of Historic Places (DOI 1991).

3.2 THE GLOBAL ENVIRONMENT

In accordance with Executive Order 12114, this section provides a general overview of the global environment. It includes basic descriptions of the troposphere and stratosphere, general climate characteristics, the distribution of land surface types, and global population distribution and density. It also briefly discusses the global atmospheric inventory of plutonium.

3.2.1 Troposphere

The troposphere is the atmospheric layer closest to the Earth's surface. All life exists and virtually all weather occurs within this layer. Additionally, this layer accounts for more than 80% of the mass and essentially all of the water vapor, clouds, and precipitation contained in the Earth's atmosphere. The height of the troposphere ranges from an altitude of 10 km (6 mi) at the poles to 15 km (9 mi) at the equator (see Figure 3-10).

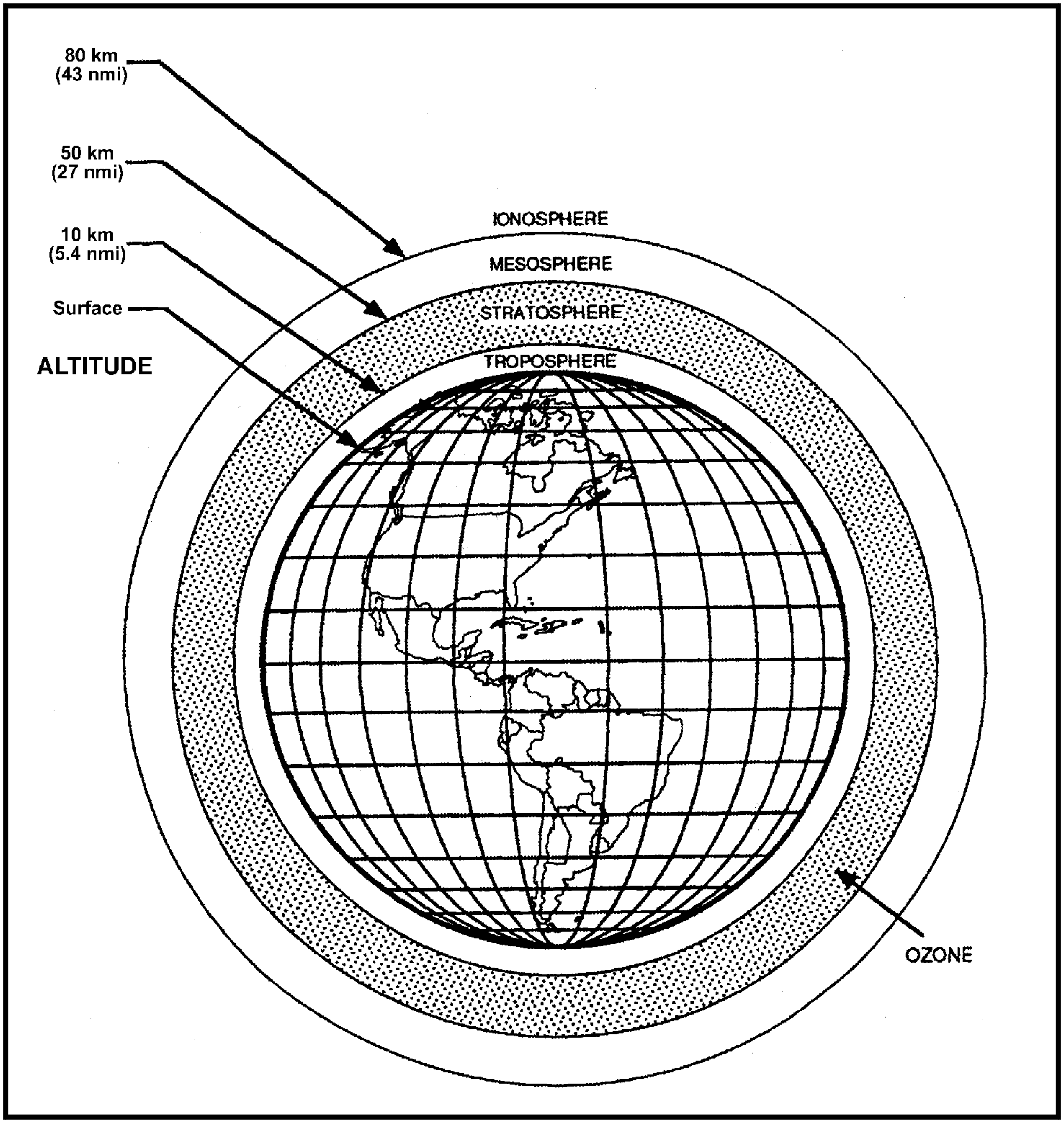


Figure 3-10. Atmospheric Layers and Their Estimated Altitudes

In this layer, temperature decreases with height at a nominal rate of approximately 6.5º Celsius (C) per km (about 3.6º Fahrenheit (F) per 1,000 ft). The troposphere is generally well mixed, but occasionally stagnates. As a result of mixing and scavenging by precipitation, the mean residence time for tropospheric aerosols is short (ranging from a few days to a few weeks). A narrow region called the tropopause separates the troposphere and the stratosphere.

The USAF estimated total annual emissions emitted to the troposphere from a total of 23 Atlas, Delta, and Titan launches from CCAFS in 1995 and 23 launches in 1996. The total estimated annual input to the troposphere was 445 metric tons per year (491 tons per year) of particulate matter, 18 metric tons per year (19.4 tons per year) each of NO_x and CO, and 225 metric tons per year (248 tons per year) of chlorine compounds. Removal of most of these emissions from the troposphere occurs over a period of less than one week, preventing a buildup of these products on a global level (USAF 1998).

3.2.2 Stratosphere

The stratosphere extends from the tropopause up to an altitude of approximately 50 km (31 mi) (see Figure 3-10). In general, vertical mixing is limited within the stratosphere, providing little transport between the layers above and below. Thus, the relatively dry, ozone-rich stratospheric air does not easily mix with the lower, moist ozone-poor tropospheric air. In addition, the lack of vertical mixing and exchange between atmospheric layers provides for extremely long residence times, causing the stratosphere to act as a “reservoir” for certain types of atmospheric pollution. The temperature is relatively constant in the lower stratosphere and gradually increases with altitude, reaching approximately 3° C (37.5° F) at the top of the layer. The temperature increase is caused primarily by the adsorption of short-wave radiation by ozone molecules. Recent measurements indicate that stratospheric chlorine levels are decreasing, consistent with expected declines resulting from the Montreal Protocols. The USAF estimated the total annual input of rocket exhaust products to the stratosphere from a total of 23 Atlas, Delta, and Titan launches from CCAFS in 1995 and 23 launches again in 1996. The total estimated annual input to the stratosphere averaged about 376 metric tons per year (414 tons per year) of particulate matter, 1.4 metric tons per year (1.5 tons per year) of NO_x, 725 metric tons per year (799 tons per year) of CO, and 188 metric tons per year (208 tons per year) of chlorine compounds (USAF 1998).

3.2.3 Population Distribution and Density

The information used for global demographics was adapted from *World Demographic Update Through 1990 for Space Nuclear System Safety Analysis*, prepared for the U.S. Department of Energy (DOE) by Halliburton NUS Environmental Corp. (HNUS 1992). This document used world-wide population statistics and other information distributed among 720 cells of equal size. The cells were derived by dividing the Earth from pole to pole into 20 latitude bands of equal area. Each latitude band was then segmented into 36 equal size cells, for a total of 720 cells. Each of the cells covered an area of 708,438 square kilometers (km^2) (273,528 square miles (mi^2)). The 1990 population estimates in the document were increased by a growth factor of 1.28 to provide population estimates for 2003 (Firstenberg 2002).

Table 3-7 lists the distribution of the Earth's 2003 projected population across each of the 20 equal-area latitude bands. Figure 3-11 illustrates the land-adjusted population densities within the latitude bands. These exhibits show that, with the exception of the six southernmost latitude bands, the population of the bands varies by about one order of magnitude. The greatest population densities occur in a relatively narrow grouping of the four northern bands between latitudes 44º North and 17º North (bands 4 through 7).

Table 3-7. Latitude Band Populations and Surface Characteristics

Latitude Band	Band 2003 Population Estimate	Population Density [a] (persons/km^2 (persons/mi^2))	Band Surface Fractions			
			Water	Land	Land Rock Fraction	Land Soil Fraction
1	7.77×10^7	11.4 (29.6)	0.7332	0.2668	1.0 [b]	0.0 [b]
2	2.58×10^8	17.1 (44.3)	0.4085	0.5915	1.0 [b]	0.0 [b]
3	6.87×10^8	48.6 (126.0)	0.4456	0.5544	0.251 [b]	0.749 [b]
4	1.02×10^9	89.3 (231.0)	0.5522	0.4478	0.251	0.749
5	1.07×10^9	98.0 (254.0)	0.5718	0.4282	0.153	0.847
6	1.13×10^9	113.0 (292.0)	0.6064	0.3936	0.088	0.912
7	8.10×10^8	96.5 (250.0)	0.6710	0.3290	0.076	0.924
8	4.61×10^8	72.7 (188.0)	0.7514	0.2486	0.058	0.924
9	4.24×10^8	69.0 (179.0)	0.7592	0.2408	0.077	0.923
10	2.55×10^8	46.6 (121.0)	0.7854	0.2146	0.084	0.916
11	2.55×10^8	42.2 (109.0)	0.7630	0.2370	0.044	0.956
12	1.57×10^8	28.2 (73.0)	0.7815	0.2185	0.055	0.945
13	1.04×10^8	18.5 (48.0)	0.7799	0.2201	0.085	0.915
14	1.09×10^8	17.6 (45.6)	0.7574	0.2426	0.089	0.911
15	6.91×10^7	12.3 (31.8)	0.7796	0.2204	0.092	0.980
16	7.37×10^7	21.3 (55.3)	0.8646	0.1354	0.112	0.888
17	1.32×10^7	11.2 (29.0)	0.9538	0.0462	0.296	0.704
18	5.91×10^6	10.7 (27.8)	0.9784	0.0216	0.296 [b]	0.704 [b]
19	9.53×10^5	5.3 (13.8)	0.9930	0.0070	1.0 [b]	0.0 [b]
20	$<10^4$	<0.001 (<0.002)	0.3863	0.6137	1.0 [b]	0.0 [b]

Source: Adapted from HNUS 1992

a. Population density on land fraction.
b. Assumed values.

3.2.4 Climate

Worldwide climate types range from the perpetual frost of the polar regions to arid desert.

3.2.5 Surface Types

The worldwide distribution of surface types is an important characteristic in considering the potential consequences of accident scenarios. Table 3-7 provides a breakdown of the total land fraction for each of the 20 latitude bands. The total land fraction was further subdivided by the fraction consisting of soil or rock cover. For the most densely populated bands (bands 4 through 7), the land fraction varies from about 33% (band 7) to about 45% (band 4), with the soil fraction dominating (75% in band 4 to 92% in band 7).

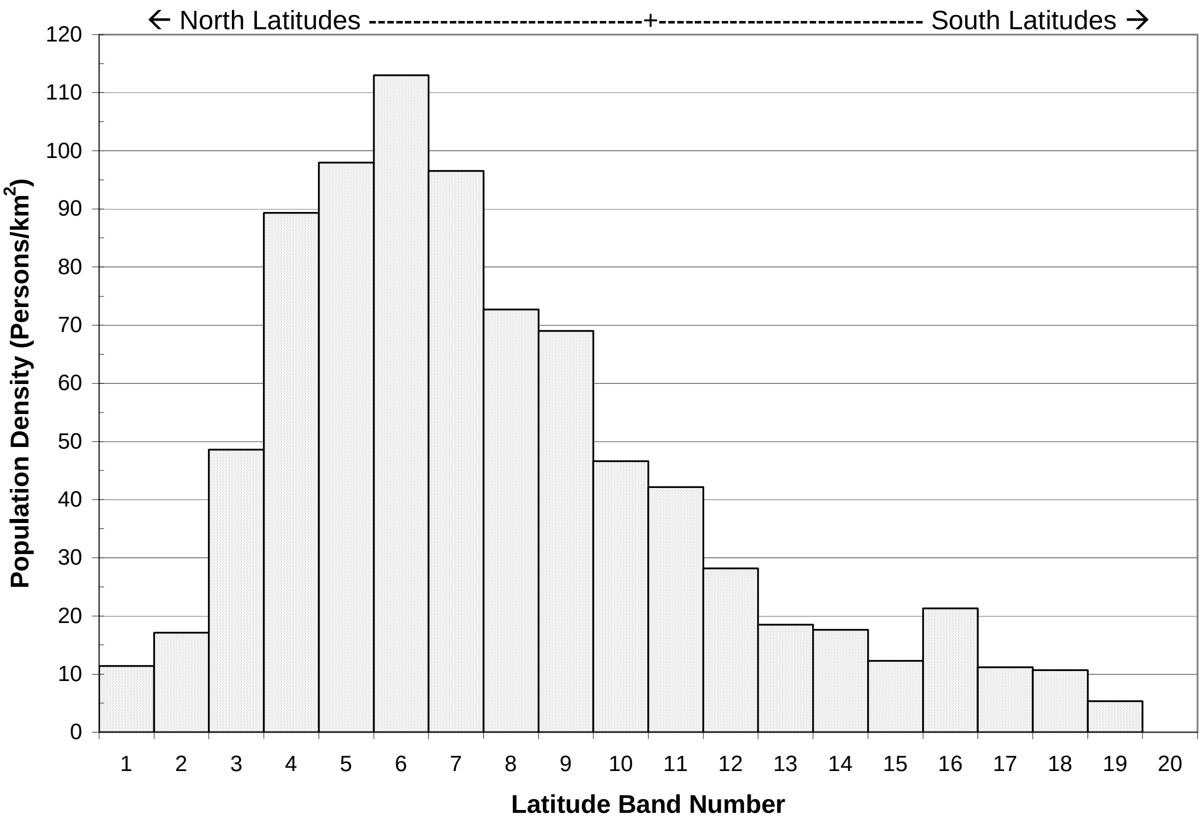


Figure 3-11. Estimated World Population Density by Latitude Bands for 2003

3.2.6 <u>Worldwide Plutonium Levels</u>

Plutonium-238 (Pu-238), used in the RHUs for the MER–2003 rovers, already exists in the environment as a result of atmospheric testing of nuclear weapons and a 1964 launch accident. The following paragraphs describe the worldwide levels of Pu in the environment. This information provides a perspective against which to compare the scope of postulated incremental releases of Pu from potential mission accidents.

Between 1945 and 1974, aboveground nuclear weapons tests released about 440,000 curies (Ci) of Pu to the environment (EPA 1977; AEC 1974). About 97% (about 430,000 Ci) of this plutonium was Pu-239 and Pu-240, essentially identical isotopes with respect to chemical behavior and radiological emission energies. The remainder (about 10,000 Ci) consists primarily of about 9,000 Ci of Pu-238, along with much smaller amounts of Pu-241 and Pu-242. (Some of the Pu-238 and Pu-241 has decayed since the time of release.)

Table 3-8 indicates that the Pu-238 in the atmosphere from weapons tests (about 9,000 Ci) was increased by the 1964 reentry and burnup of a Systems for Nuclear Auxiliary Power (SNAP)-9A radioisotope thermoelectric generator (RTG), which released 17,000 Ci. This release into the atmosphere was consistent with the RTG design philosophy of the time. Since 1964, essentially all of the SNAP-9A release has been deposited on the Earth's surface (AEC 1974). About 25% (approximately 4,000 Ci) of that release was deposited in the northern hemisphere, with the remaining 75% settling in the southern hemisphere. In April 1986, approximately 100,000,000 Ci of various radioisotopes were released to the environment from the Chernobyl accident (NRC 1987). Approximately 810 Ci were Pu-238.

The total plutonium released to the ocean environment by overseas nuclear reprocessing plants between 1967 and 1987 is approximately 20,000 Ci (IAEA 1976; NCRP 1987; UNSCEAR 1988). Assuming that 15% of the total was Pu-238 (based upon the 1980-85 fraction in Great Britain's Sellafield releases), about 3,000 Ci of Pu-238 have been added from these sources, bringing the total of Pu-238 dispersed into the environment up to about 29,810 Ci.

Table 3-8. Major Sources and Approximate Amounts of Plutonium-238 Distributed Worldwide

Source	curies
Atmospheric Testing, 1945-1974	9,000
Space Nuclear Power – SNAP-9A, 1964	17,000
Overseas Nuclear Reprocessing Plants, 1967-1987	3,000
Chernobyl Nuclear Power Station, 1986	810
Total	**29,810**

Source: NASA 1995

4 ENVIRONMENTAL CONSEQUENCES OF ALTERNATIVES

This Chapter of the Final Environmental Impact Statement (FEIS) for the Mars Exploration Rover–2003 (MER–2003) project presents information on the potential environmental impacts of a Delta II 7925 and a Delta II 7925 Heavy (7925H) launch with the MER–2003 spacecraft payload. The impacts are examined for two areas: (1) the region within 100 kilometers (km) (62 miles (mi)) of Cape Canaveral Air Force Station (CCAFS), Florida (called the regional area of interest), and (2) the global environment.

4.1 ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION

NASA proposes to continue preparations for and to implement the MER–2003 project. The MER–2003 project involves two launches in 2003 (the MER–A mission and MER–B mission) of identical spacecraft from Space Launch Complex 17 (SLC–17) at CCAFS. The MER–A launch, aboard a Delta II 7925, would occur during May or June, 2003. The MER–B launch would occur during June or July, 2003, aboard a Delta II 7925H. The project would send two identical rovers to separate locations on the surface of Mars to conduct *in situ* mineralogy and geochemistry investigations and characterize a diversity of rocks and soils which may hold clues about past water activity.

Each rover's science payload would include two instruments that contain small quantities of radioactive material used for instrument calibration or science experiments. The Mössbauer Spectrometer would contain two cobalt-57 sources, with a total activity that would not exceed 350 millicuries (mCi). The Alpha Particle X-Ray Spectrometer (APXS) would contain a curium-244 source that would not exceed 50 mCi. Initial thermal analyses for Mars surface operations indicated up to eleven (11) radioisotope heater units (RHUs) could be required for each rover. As the mission design matures, ongoing thermal analyses for surface operation of the rovers may indicate a requirement for fewer RHUs. Each RHU would provide about 1 watt of heat derived from the radioactive decay of 2.7 grams (g) (0.095 ounce (oz)) of plutonium (mostly Pu-238) dioxide (PuO_2) in ceramic form. Each RHU would contribute approximately 33.2 curies (Ci) to the total plutonium dioxide inventory of 365 Ci on each rover, based on the current maximum requirement of 11 RHUs.

4.1.1 Environmental Consequences of Preparing for the MER–2003 Launches

Launch vehicle and payload processing at CCAFS typically involves the use of hazardous materials and generates hazardous, solid, and liquid wastes and air emissions. Processing of a Delta II 7925 or Delta II 7925H launch vehicle would entail activities common to all Delta II launches at CCAFS.

Hazardous materials management, hazardous waste management, and pollution prevention programs are in place at CCAFS. Airborne emissions from liquid propellant loading and off-loading of the spacecraft and the launch vehicle are closely monitored using vapor detectors. Systems for loading hypergolic fuels (which ignite spontaneously when mixed together) use air emission controls (scrubbers, oxidizers, and closed loop designs) (USAF 1998). Thus, processing the launch vehicles and payloads would not cause substantial environmental impacts.

4.1.2 Environmental Impacts of Normal MER–2003 Launches

The primary environmental impacts of a normal launch would be associated with airborne emissions, particularly from the nine strap-on graphite-epoxy solid rocket motors (called GEMs) used on the Delta II 7925 launch vehicle or the nine Large Diameter Extra Long (LDXL) GEMs used on the Delta II 7925H . Air emissions from the liquid propellant engines on the Delta II core vehicle, although large in magnitude, would be relatively inconsequential in terms of environmental effects. This is discussed further in Sections 4.1.2.2 and 4.1.2.3.

4.1.2.1 Land Use

Land areas on and around SLC–17 are currently within the launch operations land use category (USAF 1998). The general plans of Brevard County and the City of Cape Canaveral designate compatible land uses around Cape Canaveral. At CCAFS, launch of a Delta II vehicle would be consistent with the designated land use of the facility.

4.1.2.2 Air Quality

The USAF's Rocket Exhaust Effluent Diffusion Model (REEDM) has been used at CCAFS to predict exhaust emission concentrations from a variety of launch vehicles. This model has been used in previous USAF and NASA environmental documentation to evaluate the emission concentrations from both a normal launch and from accident conditions for various Delta II launch vehicle configurations (USAF 1998, NASA 1998a, NASA 1998b, and NASA 2002).

The REEDM analyses performed for the *New Millennium Program Final Programmatic Environmental Assessment* (NASA 1998a) and the *Space Infrared Telescope Facility Environmental Assessment* (NASA 2002) were examined and are assumed to be typical. These two documents, respectively, address the Delta II 7925 (the MER–A launch vehicle) and the Delta II 7925H (the MER–B launch vehicle). The REEDM analyses prepared for both documents assumed meteorological conditions that would be acceptable for launch but which could result in the highest exhaust product concentrations in populated areas near CCAFS. None of these analyses predicted substantial adverse impacts to the air quality in populated areas near CCAFS due to the launches under consideration.

A normal launch would result in combustion emissions from first stage main engines and the six ground-lit solid rocket motors. The first stage of the Delta II core vehicle, fueled by rocket propellant-1 (RP-1) and liquid oxygen (LOX), would primarily produce carbon monoxide (CO), carbon dioxide (CO_2), and water (H_2O) as combustion products. The emission products of the GEMs on the Delta II 7925 and the LDXL GEMs on the Delta II 7925H would consist primarily of aluminum oxide (Al_2O_3) particulates, CO, hydrogen chloride (HCl), nitrogen (N_2), and H_2O. Under the high temperatures of the GEMs' exhaust the CO would be quickly oxidized to CO_2 and the N_2 may react with ambient oxygen to form nitrogen oxides (NO_X), but such afterburning would diminish quickly as the plume expands and cools (Zittel 1995).

Emissions from a typical Delta II launch would form a cloud of about 100 m (328 ft) in diameter at the launch pad during the first few seconds after ignition and liftoff. This high-temperature cloud would be buoyant and would rise to a height ranging from about 670 to 1,340 m (about 2,200 to 4,400 ft) near the launch area. The cloud would then dissipate through mixing with the atmosphere. Exhaust products would also be distributed along the vehicle's flight path, but emissions per unit length of trajectory would decrease as the vehicle accelerates. An area of about 80 m (262 ft) in the vicinity of the launch pad would be directly impacted by the exhaust flames.

The results of REEDM analyses are typically compared to the following recommended guidelines. The Emergency Response Planning Guidelines (ERPG), developed by the American Industrial Hygiene Association, represent the maximum airborne concentration levels below which it is believed nearly all individuals could be exposed for up to one hour without (1) experiencing adverse health effects; (2) perceiving clearly defined objectionable odor; or (3) experiencing or developing life-threatening health effects. The Short-term Public Emergency Guidance Level (SPEGL) is an advisory recommendation from the National Research Council for single, short-term, emergency exposures of the general population, and consider members of sensitive populations, such as children, the aged, and persons with serious, debilitating diseases. National Ambient Air Quality Standards (NAAQS), established by the U.S. Environmental Protection Agency (EPA) to allow "an adequate margin of safety ... to protect public health" (42 U.S.C. §7409(b)), apply only to stationary sources, but are also considered for comparison purposes.

Based upon the REEDM analyses performed for previous USAF and NASA environmental documentation (USAF 1998, NASA 1998a, NASA 1998b, and NASA 2002), and the assumption that they are representative of the MER–2003 launches, emissions from normal launch of the MER–2003 missions would not exceed any of the standards or guidelines, and would not create adverse impacts to air quality in the region.

4.1.2.3 Global Environment

Upper Atmosphere. Launch of a Delta II 7925 or a Delta II 7925H would result in the deposition of ozone-depleting chemicals from the combustion products released along the launch vehicle's trajectory through the stratosphere. NASA has examined the potential impact of a Delta II 7925 emissions in the stratosphere. The principal ozone-depleting chemicals in exhaust emissions would be HCl, NO_X, and Al_2O_3 particulates. Because of uncertainties about the current loading of ozone-depleting chemicals in the atmosphere, the effects of a single launch can more accurately be calculated as a percentage increase in the rate of ozone depletion relative to the No Action Alternative. The rate of increase in ozone depletion has been calculated to be 3.1×10^{-5}% of the annual average global ozone depletion rate per metric ton (mt) (2.8×10^{-5}% per ton) of HCl emissions, 1.8×10^{-6}% per mt (1.6×10^{-6}% per ton) of NO_X, and 8.3×10^{-6}% per mt (7.5×10^{-6}% per ton) of Al_2O_3 (Jackman *et al.* 1998).

Using these ozone depletion rates and the total mass of each of these combustion products emitted by a Delta II 7925, an estimate of ozone depletion was developed. This estimate is conservative because it assumes that the entire mass of these exhaust products would migrate to the stratosphere (Jackman *et al.* 1998), even though the majority of emissions occur in the lower atmosphere and would mostly not reach the stratosphere.

A Delta II 7925 would emit a total of about 22,289 kilograms (kg) (49,139 pounds (lb)) of HCl, about 37,902 kg (83,558 lb) of Al_2O_3, about 8,792 kg (19,382 lb) of NO_x, and about 299 kg (658 lb) of chlorine during launch (Kelley 2002, NASA 2001). Applying the ozone depletion rates estimated for each of these exhaust products, the stratospheric ozone depletion rate associated with a Delta II 7925 launch would be approximately 0.001% of the annual average global ozone depletion rate that would occur under the No Action Alternative.

Using the ozone depletion rates stated above and the total mass of each of the combustion products emitted by a Delta II 7925H, an estimate of ozone depletion was developed. Emissions would generally be higher for a Delta II 7925H than for a Delta II 7925 because of the larger amount of solid propellant in the LDXL GEMs. The estimate for the Delta II 7925H is conservative because it assumes that the entire mass of these exhaust products would migrate to the stratosphere, even though the majority of emissions occur in the lower atmosphere.

Based on these assumptions, a Delta II 7925H would emit a total of about 31,634 kg (69,740 lb) of HCl, about 54,447 kg (120,033 lb) of Al_2O_3, about 12,458 kg (27,466 lb) of NO_x, and about 343 kg (756 lb) of chlorine during launch (Kelley 2002, NASA 2001). Applying the ozone depletion rates estimated for each of these exhaust products, the stratospheric ozone depletion rate associated with a Delta II 7925H launch would be less than 0.0015% of the annual average global ozone depletion rate that would occur under the No Action Alternative.

Ozone depletion would occur along the trajectory of each launch vehicle, but it has been estimated that the depletion “trail” from a launch vehicle is largely temporary and would be self-healing within a few hours of passage (AIAA 1991). Cumulative impacts are discussed in Section 4.3.

Global Warming. Launch of a Delta II 7925 or a Delta II 7925H would result in the emission of global warming gasses. These would primarily be CO_2, though there may be trace emissions of nitrous oxide (N_2O) emitted by the solid rocket motors. Both the core and the solid rocket motors would also emit carbon monoxide (CO) which would quickly react with oxygen in the atmosphere to form CO_2. The Delta II core vehicle would emit 27,973 kg (61,670 lb) of CO_2 and 40,266 kg (88,770 lb) of CO. The nine GEMs on the Delta II 7925 combined are calculated to emit 2,706 kg (5,966 lb) of CO_2, and 22,463 kg (49,522 lb) of CO, yielding a combined total emission of 30,679 kg (67,636 lb) of CO_2 and 62,729 kg (138,292 lb) of CO for the Delta II 7925 (Kelley 2002). The nine LDXL GEMs on the Delta II 7925H are calculated to emit 3,122 kg (6,884 lb) of CO_2 and 35,809 kg (78,945 lb) of CO, yielding a combined total emission of 31,096 kg, (68,554 lb) of CO_2 and 76,076 kg (167,715 lb) of CO for the Delta II 7925H (Kelley 2002). For comparison, the U.S. emitted 5.8×10^{12} kg (12.8×10^{12} lb) of CO_2 during 2000, with total greenhouse gas emissions (including substances such as methane, nitrous oxide, and hydrocarbons) equivalent to 7.0×10^{12} kg (15.4×10^{12} lb) of CO_2 (EPA 2002). Cumulative impacts are discussed in Section 4.3.

4.1.2.4 Noise

Space vehicle launches generate intense noise levels over short periods of time at the launch pad and are relatively infrequent (tens of events per year). The highest noise levels for a space vehicle launch (160 A-weighted decibels (dBA)) have been recorded at the launch pad and supporting facilities during a Space Shuttle launch. Noise measurements for a Delta II launch vehicle were recorded in 1992 at distances of about 450 meters (m), 600 m, and 900 m (1,500 feet (ft), 2,000 ft, and 3,000 ft) from SLC–17 (see Figure 4-1). The noise pressure levels varied from about 120 dBA at 450 m (1,500 ft) to 115 dBA at 900 m (3,000 ft). These levels would occur for less than two minutes during the launch, and diminish rapidly as the launch vehicle gains altitude and moves downrange over the Atlantic Ocean (USAF 1998). Launch site workers would be a minimum of 2,000 m (6,500 ft) away from the launch pad at SLC–17 at the time of the Delta II launch. They would be exposed to noise levels well below Occupational Safety and Health Administration regulations for unprotected workers (140 dBA maximum, 115 dBA 15-minute average).

While some area residents may experience momentary annoyance, the noise levels outside the CCAFS property boundary would not exceed the EPA's maximum 24-hour average exposure level of 70 dBA and would present no health hazard (NASA 1998a). By comparison, vehicular traffic noise levels range from about 85 dBA for an automobile to 110 dBA for a motorcycle.

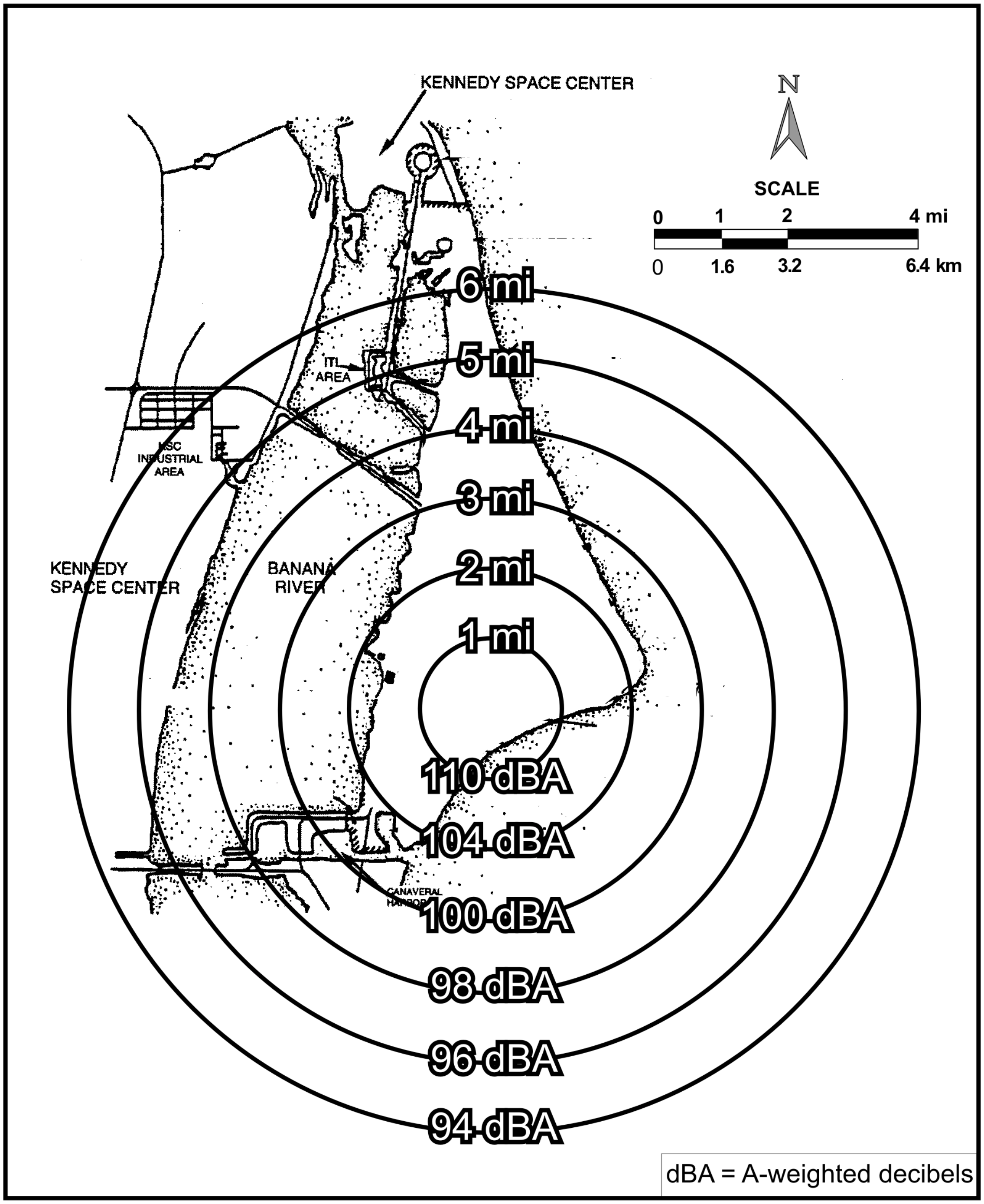
Noise generated from a launch of a Delta II 7925H is expected to be slightly higher than for a Delta II 7925 launch (see Figure 4-1), but less than for a Space Shuttle or Titan IV launch. SLC–17 Pad B has been modified to use water for noise suppression, so noise levels away from CCAFS should be comparable to those of a Delta II 7925 (NASA 2002).

The short-term elevation of noise levels generated by the launch of either launch vehicle would probably disturb terrestrial biota near the launch complex, but is not expected to result in long-term adverse impacts (USAF 1996).

Sonic booms are associated with normal launches of any vehicles, but occur over the ocean, downrange of populated areas (NASA 1998a; NASA 1998b; USAF 1996). No adverse impact to human populations would be expected. Ships and other vessels in the area potentially affected would be warned in advance of launch events and are not expected to be adversely affected.

4.1.2.5 Geology and Soils

No impacts to geology would be expected. A Delta II 7925 or 7925H launch would result in deposition of solid rocket exhaust products (primarily Al_2O_3 and HCl) onto soils. Deposition of particulate Al_2O_3 would occur primarily in the vicinity of the launch complex, but depending on the particle size distribution and winds, appreciable deposition could also occur downwind. Wet deposition of HCl could occur as exhaust chlorides mix with entrained deluge water and with water contained in the exhaust of the first stage engine, but the majority of HCl is swept into the flame trench. Wet deposition of chlorides would be limited to within a few hundred meters of the launch pad. If rain passed through the exhaust ground cloud shortly after launch, wet HCl deposition could occur at further distances from the launch complex. The soils at CCAFS have relatively high buffering capacities and are not expected to be adversely affected (NASA 1998b; USAF 1998).



Source: Adapted from NASA 1998a

Figure 4-1. Peak Noise Generated by a Delta II 7925 Launch from CCAFS SLC–17

4.1.2.6 Hydrology and Water Quality

There are two principal sources of potential launch area impacts to groundwater and surface water resources associated with a normal launch: disposal of spent deluge water collected at the SLC–17 launch pads, and the deposition of launch exhaust products from the exhaust cloud into nearby surface water bodies. For a Delta II 7925 launch, about 111,600 liters (29,500 gallons (gal)) of water would be utilized for deluge, fire suppression, and washdown at Pad A (USAF 1994) and about 143,054 liters (37,800 gal) for a Delta II 7925H launch at Pad B (Giles 2001). The water would be supplied from local municipal sources and no groundwater would be withdrawn.

Exhaust from the Delta II 7925 GEMs and Delta II 7925H LDXL GEMs would cause the primary water impacts. No impacts would be expected from exhaust from the liquid rocket engines.

Groundwater. At CCAFS, the deluge, fire suppression, and washdown water collected in the catch basins of launch complexes would be monitored for water quality (NASA 1998a; NASA 1998b; USAF 1996). The water would be held and treated, if necessary, to reduce contaminant levels (or adjust pH) prior to release to grade in accordance with a Florida Department of Environmental Protection wastewater discharge permit. The water discharged to grade would percolate through soil to the groundwater table and flow west towards the Banana River (Schmalzer *et al.* 1998). The water would be further neutralized during its passage through the soil, such that some of the contaminants that would not be removed during treatment would also be removed. It is not expected that groundwater quality would be substantially affected by the discharge of deluge, fire suppression, and washdown water.

Surface Water. Surface water runoff from SLC–17 flows west towards the Banana River (Schmalzer *et al.* 1998). Depending on wind conditions, the launch exhaust cloud could drift over the Atlantic Ocean or the Banana River near CCAFS. Surface waters in the area of the exhaust cloud might acidify from deposition of HCl. The large volumes of the water bodies in the vicinity of CCAFS, combined with their natural buffering capacity, suggest that the reduced pH caused by acidic deposition would return to normal levels within a few hours (USAF 1996). Al_2O_3 particles would also settle from the exhaust cloud. Al_2O_3 is relatively insoluble at the pH of the local surface waters and particles would settle down to sediments. Long-term elevation of aluminum levels in the water is not expected.

4.1.2.7 Offshore Environment

The solid rocket motor casings, the first stage, and the payload fairing (PLF) of each Delta II launch vehicle would be jettisoned and land in deep ocean areas where the metal parts would eventually corrode. Toxic concentrations of metals would be unlikely because of slow corrosion rates and the large volume of ocean water available for dilution (USAF 1996). Launch vehicle missions are nominally designed such that all first stage fuel is depleted at the time of main engine cut-off. Any residual propellant in spent stages would be released to the water column. RP-1 fuel in the Delta II first stage is weakly soluble and any residual amounts would be expected to migrate to the ocean surface where it would evaporate. Any small amounts of residual propellants in either the GEMs or the LDXL GEMs would be released slowly and should not reach toxic concentrations except in the immediate vicinity of the motors.

4.1.2.8 Biological Resources

Terrestrial and Aquatic Biota. Terrestrial fauna and flora at CCAFS would be largely unaffected by the launch except near the launch pad (NASA 2002). High temperatures would damage or kill biota within the launch cloud. However, damage would occur primarily in the immediate vicinity of the launch complex, and long-term population effects on terrestrial biota are not expected. Acid deposition is unlikely to harm terrestrial biota.

The exhaust clouds from the Delta II 7925 and the Delta II 7925H should not significantly affect aquatic biota in nearby water bodies (USAF 1996). There has been no evidence of fish kills in either the Banana River or the Atlantic Ocean from a launch at CCAFS (NASA 1998a; NASA 1998b).

Threatened or Endangered Species. At CCAFS, no scrub jay mortality is expected based on studies during and following Titan IV launches in 1990. Fire caused by a launch in 1990 caused extended scrub jay scolding behavior, however, the jays avoided the burned area for about one month (USAF 1998). Other bird species, such as wood storks and bald eagles, may be temporarily disturbed, but no long-term effects would be expected.

Sea turtles are sensitive to lighting near nesting beaches. If lighting inland is brighter than reflected light of the moon and stars on the ocean, hatchlings may become confused, head the wrong way, and never reach the water. A light management plan is in force at SLC–17.

The short-term elevation of noise levels generated by the launch of either launch vehicle would probably disturb terrestrial biota near the launch complex but is not expected to result in long-term adverse impacts (USAF 1996).

4.1.2.9 Socioeconomics

Launch of a Delta II 7925 and a Delta II 7925H from CCAFS for the MER–2003 missions would be part of the normal complement of launches at the facility. These launches would result in negligible impacts to socioeconomic factors such as demography, employment, transportation, public or emergency services.

4.1.2.10 Environmental Justice

Neither of the MER–2003 launches would result in disproportionate adverse impacts on low income or minority populations. See Appendix B for further details.

4.1.2.11 Cultural Resources

CCAFS SLC–17 is an active launch complex and is eligible for listing on the National Register of Historic Places because of its significance as the longest continually active launch site in the United States and its association with events that have made a significant contribution to history (USAF 1996). The USAF has requested guidance from the State Historic Preservation Officer on how to best preserve the historical significance of SLC–17 while it continues to serve the Nation's space program. Launch of the MER–2003 Delta II vehicles would not affect its status, so no impacts are expected.

4.1.3 Environmental Impacts of Potential MER–2003 Project Nonradiological Accidents

The potential environmental impacts associated with Delta II accidents have been discussed in previous USAF and NASA NEPA documentation and are summarized here.

A variety of accidents could occur during preparations for and launch of any launch vehicle. Only two types of nonradiological accidents would have potential consequences: a liquid propellant spill during fueling operations and a launch failure. The potential consequences of these accidents are presented below.

4.1.3.1 Liquid Propellant Spill

The Delta II core vehicle uses RP-1 (a thermally stable kerosene) and LOX in the first stage, and Aerozine–50 (a 50:50 mix of hydrazine and unsymmetrical dimethylhydrazine) and nitrogen tetroxide (N_2O_4) in the second stage. Standard practices such as closed-loop fueling are maintained during loading operations. Standard procedures for loading hypergolic fuels include sealed transfer systems, wet scrubbing, and oxidation, and only very small fugitive emissions (on the order of grams) are expected (USAF 1998). The most severe propellant spill accident scenario postulated involves release of the entire contents of the second stage N_2O_4 tank during propellant transfer (NASA 1998a). Because N_2O_4 rapidly converts to NO_X in the air, toxic effects of the release would be limited to the immediate vicinity of SLC–17. Using REEDM modeling results for a similar spill postulated for a Titan launch vehicle and scaled for a Delta II propellant load, airborne levels of NO_X would reduce to 5 parts per million (ppm) within about 150 m (500 ft) of the spill and to 1 ppm within about 300 m (984 ft) (NASA 1998b). Activating the launch pad water deluge system would substantially reduce the evaporation rate of spilled propellant, limit potential exposures in the vicinity of the spill, and in turn reduce the amount of propellant dispersed downwind. During fueling operations, propellant transfer personnel are equipped with protective clothing and breathing apparatus, and uninvolved personnel are excluded from the area. USAF safety requirements specify that plans and procedures be in place to protect the workforce and the public during fueling operations (USAF 1997).

4.1.3.2 Launch Failures

A launch vehicle accident either on or near the launch pad presents the greatest potential for nonradiological impacts to human health, principally to workers at the launch site. Range Safety requirements mandate a flight termination system on the Delta II (see Section 2.1.5.5). In the event of either a command or an automatic destruct event, the propellant tanks and solid motor casings on the Delta II would be ruptured, and the launch vehicle would be destroyed. The potential short-term effects of an accident would include a localized fireball, falling fragments from explosion of the vehicle, release of uncombusted propellants and propellant combustion products; and, for on-pad or very low altitude explosions, death or damage to nearby biota and brush fires near the launch pad.

The USAF modeled postulated accidents at CCAFS involving combustion of Delta II 7925 and Delta II 7925H propellants. Results of these analyses have been reported in previous NASA environmental documents (NASA 1998a and NASA 2002, respectively). Typical unfavorable meteorological conditions were used for the REEDM analyses to model transport of the exhaust cloud. Release and combustion of both liquid and solid propellants were assumed to be involved. For these modeled accidents, the principal constituents resulting from burning propellant were estimated to be CO, Al_2O_3, and HCl. Although Al_2O_3 would be deposited from the explosion cloud as it was carried downwind, little wet deposition of HCl would be expected unless rain falls through the explosion cloud. The estimated concentrations of combustion products resulting from these postulated accidents were found to be well within prescribed guidelines and standards. Based upon these REEDM analyses and the assumption that they are representative of the MER–2003 launches, emissions resulting from accidents during either of the MER–2003 launches would not exceed any of the recommended guidelines and standards, and would not create adverse impacts to air quality in the region.

Parts of the exploded vehicle would fall back to earth. Except for on-pad or very near-pad accidents, most of the fragments would fall into the ocean, where the metal parts would eventually corrode. Toxic concentrations of metals would be unlikely because of slow corrosion rates and the large volume of ocean water available for dilution (USAF 1996).

Uncombusted solid rocket propellant would dissolve slowly and should pose no long-term threat since ocean systems would only temporarily be impacted and would recover rapidly through dispersion. There would probably be no impact to aquatic biota except in the immediate vicinity of the solid rocket motors. Residual RP-1 fuel is weakly soluble, would spread over the surface of the water, and should evaporate within a few hours resulting in only a short-term impact to aquatic biota. Hypergolic fuels would either be consumed or disperse in the atmosphere without entering the ocean.

On January 17, 1997 a Delta II 7925 launch vehicle failed when one of the GEMs failed structurally 7.2 seconds after liftoff from SLC–17. The Automatic Destruct System was activated by the initial GEM failure, followed by a Command Destruct System activation issued by the Range Control Officer (now called the Mission Flight Control Officer (MFCO)), preventing hazard to the public. The vast bulk of the plume that resulted occurred over the Atlantic Ocean, with localized maximum ground concentrations of HCl and NO_2 at levels of 1 to 2 ppm, respectively. A high altitude, visible plume also extended over large parts of Brevard and Indian River counties. While ground concentrations from this plume were not hazardous, the general public was not immediately notified that the accident had occurred. To ensure that the public would be notified of any accident in a timely manner, CCAFS now has a Brevard County Emergency Management Center representative at the launch console beginning two hours before launch. This representative has direct audio and video communications links to the Center in Rockledge, Florida. The USAF has also installed a direct emergency phone line to the Florida State Emergency Response Center (NASA1998b).

4.1.4 Radiological Accident Assessment

This section is summarized from the U.S. Department of Energy's (DOE) *Nuclear Risk Assessment for 2003 Mars Exploration Rover Project Environmental Impact Statement* (DOE 2002). NASA, and DOE and its contractors have conducted safety assessments of launching and operating spacecraft using RHUs (*e.g.*, the Galileo mission in 1989, the Mars Pathfinder mission in 1996, the Cassini mission in 1997, and the proposed Mars Surveyor 2001 mission[1] in 1999). NASA and DOE, therefore, have built upon an extensive experience base that involves:

- testing and analysis of the RHUs under simulated launch accident environments;
- evaluating the probability of launch-related accidents based on evaluation of launch histories, including extensive studies of the January 1997 Delta II accident at CCAFS, and system designs; and
- estimating the outcomes of the RHU and small-quantity radioactive source responses to the launch accident environments.

The risk assessment for the MER–2003 missions began with identification of initial launch vehicle system failures and the subsequent chain of accident events that could ultimately lead to the accident conditions (*e.g.*, explosive overpressures, fragments, fire) that could threaten the RHUs and small-quantity radioactive sources onboard the MER–A and MER–B spacecraft. Based on Delta II system reliabilities and failure probabilities, accident initial conditions that could lead to failure of the launch vehicle were identified across all major mission phases.

NASA then identified the specific accident outcome environments that could potentially threaten the RHUs and small-quantity radioactive sources. DOE determined the response of the sources to these accident environments and estimated the amount of radioactive material that could potentially be released. DOE utilized the results of modeling and data from its RHU testing and analyses during the early 1980s in support of the Galileo mission and the mid 1990s in support of the Cassini mission to determine if a release of radioactive material from a RHU could potentially occur.

The nuclear risk assessment for the MER–2003 Project considers 1) potential accident scenarios associated with the launch of the MER–A and MER–B mission spacecraft, and their probabilities and accident environments; 2) the response of the RHUs and small-quantity radioactive sources to such accidents in terms of release source terms and their probabilities; and 3) the radiological consequences and mission risks associated with such potential releases. This section addresses the first two items and Section 4.1.5 addresses the third item. For the purpose of the analysis performed for this FEIS, the following inventory of radioactive materials was assumed to be onboard each rover.

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[1] A risk assessment was being prepared for the Mars Surveyor 2001 lander-rover mission when that mission was cancelled.

- Plutonium-238 (Pu-238): 33.2 curies (Ci) in each of up to 11 RHUs (an alpha emitter with a half-life of 87.7 years; the activity includes minor contributions from other related plutonium and actinide radionuclides);
- Curium-244 (Cm-244): 0.05 Ci (an alpha emitter with a half-life of 18.1 years); and
- Cobalt-57 (Co-57): 0.35 Ci (a gamma emitter with a half-life of 271 days).

The amount released for each accident scenario was used to determine the potential consequences of the release to the environment and to people. The approach used was similar to that used in the Galileo, Mars Pathfinder, Cassini, and Mars Surveyor 2001 risk assessments.

For the purpose of the risk assessment, the MER–A mission on the Delta II 7925 launch vehicle was divided into five mission phases on the basis of the mission elapsed time (the time (T) in seconds (s) after liftoff) of principal events as follows:

- Phase 0 (Pre-Launch, T < 0 s);
- Phase 1 (Early Launch, 0 s ≤ T < 23 s, after which most debris and intact vehicle configurations resulting from an accident would impact water);
- Phase 2 (Late Launch, 23 s ≤ T < 297 s, at payload fairing (PLF) separation following first and second stage separation);
- Phase 3 (Pre-Orbit/Orbit, 297 s ≤ T < 640 s, when the Command Destruct System (CDS) is disabled); and
- Phase 4 (Orbit/Escape, 640 s ≤ T < 2237 s, at MER–2003 spacecraft escape).

Differences between the Delta II 7925 and Delta II 7925H vehicle trajectories and mission profiles for the MER–A and MER–B missions result in slight differences in the mission phase timing for the MER–B mission. For MER–B, Phase 3 ends at 589 s and Phase 4 ends at 3434 s.

4.1.4.1 Accident Scenarios, Probabilities and Environments

Accident scenarios, probabilities and environments are developed in detail in the EIS Databook (NASA 2001). Accident scenarios and probabilities are developed in terms of Accident Initial Conditions (AICs), defined as the first system-level indication of a launch vehicle failure that could lead to loss of the launch vehicle or to mission failure. An example of an AIC would be a trajectory control malfunction resulting in a launch vehicle deviation from its planned trajectory. The accident progression after the AIC leads to a range of possible accident outcomes in which the RHUs (and/or small-quantity radioactive sources) might first experience a potentially damaging environment. An example of an outcome would be the ground impact of various intact spacecraft/launch vehicle configurations (termed intact impact).

The accident outcomes are determined to a large degree by the Flight Termination System (FTS) actions (see Section 2.1.5.5) that occur or do not occur during the accident. If the MFCO does not respond in time and the Automatic Destruct System (ADS) does not activate, ground impact would result.

The Pre-Launch AICs generally involve conditions leading to failure of propellant tanks, drop accidents involving the Star 48B/spacecraft during stacking operations, inadvertent GEM ignition, or inadvertent FTS activation. These AICs along with their probabilities are summarized in Table 4-1, which indicates a total AIC probability of 1.16 x 10^{-4} (1 in 8,600). The Pre-Launch AICs lead to one of four outcomes defined in terms of intact impact configurations: spacecraft only, Star 48B/spacecraft, and second stage/Star 48B/spacecraft/payload fairing (PLF). The Pre-Launch probabilities are identical for both the Delta II 7925 and Delta II 7925H.

Table 4-1. Pre-Launch AIC Probabilities

AIC	Probability
SLC–17 Propellant Containment Failures	6.00×10^{-5}
First Stage LOX Tank Overpressure	1.20×10^{-5}
Star 48B/Spacecraft Stacking Failure	2.40×10^{-5}
Second Stage Common Bulkhead Failure	1.80×10^{-5}
Inadvertent FTS Activation	1.20×10^{-6}
Premature GEM Ignition	1.20×10^{-6}
Total	**1.16×10^{-4}**

Source: DOE 2002

The Post Lift-Off (T > 0) AICs, covering those associated with Phases 1 to 4, were developed in NASA 2001 based on Delta II launch vehicle reliability data and updated to reflect actual flight history. The types of AICs identified include:

- Trajectory control malfunction,
- Attitude control malfunction,
- Propellant tank failures,
- Catastrophic engine/motor failure,
- Structural failure,
- Inadvertent FTS activation or PLF separation, and
- Staging failure.

The specific Post Lift-Off AICs and their probabilities by mission phase are presented in Table 4-2 for the Delta II 7925. The total probability of all Post Lift-Off AICs is 3.20 x 10^{-2} (about 1 in 30). These AICs can lead to one of the following:

- Impact configurations near the launch pad or over water: spacecraft only, Star 48B/spacecraft, second stage/Star 48B/spacecraft/PLF, and full stack (entire launch vehicle including spacecraft) intact impact (FSII);
- Sub-orbital reentry; or
- Orbital reentry.

The Post Lift-Off AICs and their probabilities for the Delta II 7925H are similarly presented in Table 4-3.

Table 4-2. Post Lift-Off AIC Probabilities by Time Intervals for the Delta II 7925

AIC	AIC Probability by Mission Phase				
	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**	**Total**
	0 – 23 s	**23 – 297 s**	**297 – 640 s**	**640 – 2237 s**	**0 – 2237 s**
Trajectory Control Malfunction	$1.87x10^{-4}$	$7.44x10^{-3}$	$3.24x10^{-5}$	$7.59x10^{-5}$	$7.74x10^{-3}$
Attitude Control Malfunction	$5.56x10^{-4}$	$6.15x10^{-3}$	$7.07x10^{-5}$	$2.45x10^{-4}$	$7.02x10^{-3}$
First Stage Failures [a]	$5.48x10^{-4}$	$3.07x10^{-3}$	-	-	$3.62x10^{-3}$
GEM Failures [a]	$3.39x10^{-3}$	$7.35x10^{-3}$	-	-	$1.07x10^{-2}$
PLF Failures	$1.20x10^{-5}$	$9.50x10^{-5}$	-	-	$1.07x10^{-4}$
Second Stage Failures [a]	$5.38x10^{-7}$	$3.26x10^{-5}$	$2.00x10^{-4}$	$8.79x10^{-5}$	$3.21x10^{-4}$
Third Stage Failures [a]	$5.14x10^{-8}$	$4.07x10^{-7}$	$2.53x10^{-8}$	$1.81x10^{-3}$	$1.81x10^{-3}$
Spacecraft Failures	$9.58x10^{-8}$	$8.00x10^{-7}$	$1.95x10^{-7}$	$9.10x10^{-7}$	$2.00x10^{-6}$
Staging Failures	-	$9.14x10^{-5}$	-	$6.32x10^{-4}$	$7.23x10^{-4}$
Inadvertent CDS Activation	$2.16x10^{-6}$	$2.57x10^{-5}$	$3.22x10^{-5}$	-	$6.01x10^{-5}$
Total	**$4.69x10^{-3}$**	**$2.42x10^{-2}$**	**$3.35x10^{-4}$**	**$2.85x10^{-3}$**	**$3.21x10^{-2}$**

Source: DOE 2002

a. Includes failures other than ones leading to trajectory or attitude control malfunctions.

Table 4-3. Post Lift-Off AIC Probabilities by Time Intervals for the Delta II 7925H

AIC	AIC Probability by Mission Phase				
	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**	**Total**
	0 – 23 s	**23 – 297 s**	**297 – 589 s**	**589 – 3434 s**	**0 – 3434 s**
Trajectory Control Malfunction	$8.71x10^{-6}$	$6.65x10^{-3}$	$2.45x10^{-5}$	$8.49x10^{-5}$	$6.77x10^{-3}$
Attitude Control Malfunction	$5.55x10^{-4}$	$6.13x10^{-3}$	$5.33x10^{-5}$	$2.83x10^{-4}$	$7.02x10^{-3}$
First Stage Failures [a]	$5.48x10^{-4}$	$3.07x10^{-3}$	-	-	$3.62x10^{-3}$
GEM Failures [a]	$2.17x10^{-3}$	$6.42x10^{-3}$	-	-	$8.59x10^{-3}$
PLF Failures	$1.17x10^{-5}$	$9.53x10^{-5}$	-	-	$1.07x10^{-4}$
Second Stage Failures [a]	$4.91x10^{-7}$	$3.36x10^{-5}$	$1.71x10^{-4}$	$1.16x10^{-4}$	$3.21x10^{-4}$
Third Stage Failures [a]	$4.72x10^{-8}$	$3.85x10^{-7}$	$1.57x10^{-8}$	$1.81x10^{-3}$	$1.81x10^{-3}$
Spacecraft Failures	$8.52x10^{-8}$	$7.20x10^{-7}$	$1.11x10^{-7}$	$1.08x10^{-6}$	$2.00x10^{-6}$
Staging Failures	-	$9.14x10^{-5}$	-	$6.32x10^{-4}$	$7.23x10^{-4}$
Inadvertent CDS Activation	$2.34x10^{-6}$	$2.80x10^{-5}$	$2.98x10^{-5}$	-	$6.01x10^{-5}$
Total	**$3.29x10^{-3}$**	**$2.25x10^{-2}$**	**$2.79x10^{-4}$**	**$2.93x10^{-3}$**	**$2.90x10^{-2}$**

Source: DOE 2002

a. Includes failures other than ones leading to trajectory or attitude control malfunctions.

4.1.4.2 Accident Source Terms and Probabilities

The potential accident environments associated with launch area accident scenarios include blast (explosion overpressure), fragment, fire (burning liquid propellant and/or solid propellant), and surface impact. The accident environments for each scenario would be a function of the time of occurrence. Details of the accident environments are presented in NASA 2001 and are summarized, together with the potential response of the RHUs, in Table 4-4.

Table 4-4. Summary of RHU Responses to Accident Environments

Accident Environment	Accident Environment Severity [a, b, c, d]	RHU Response [e]
Explosion (Delta II First Stage Liquids)	0.38 to 2.8 MPa overpressure and 4.4 to 19.5 kPa-s impulse	No release
Explosion (Delta II Second Stage Liquids)	0.38 to 0.76 MPa overpressure and 0.55 to 4.2 kPa-s impulse	No release
Explosive Burn (Star 48B/GEMs)	0.53 to 2.0 MPa overpressure and 17.0 kPa-s impulse	No release
Explosion (Spacecraft Hydrazine Tanks)	0.91 to 1.3 MPa overpressure	No release
Liquid Propellant Fires	2450 K initial, decreasing to 2120 K at fireball stem lift-off (6.6 s)	No release
Solid Propellant Fires	2600 K to 3100 K for up to 500 s	Vapor release possible
Fragments	Star 48B: 2.8 mm thick Ti at ≤ 200 m/s	No release [f]
	Spacecraft Hydrazine Tank: 1 mm Al at 69 m/s without attenuation	No release
Impact	Spacecraft: < 49 m/s	No release
	Star 48B/Spacecraft: < 131 m/s	No release [f]
	Stage 2/Star 48B/Spacecraft/PLF: < 122 m/s	No release [f]
	Full Stack Intact Impact: < 212 m/s	No release [f]
Reentry	< 11 km/s @ 122 km altitude	No release

Source: DOE 2002

a. A MegaPascal (MPa) is a unit of pressure; a kiloPascal-second (kPa-s) is a unit of impulse; 1 Pascal is a unit of pressure equal to a force of 1 newton per meter squared or 0.0208 pound per square foot.
b. Kelvin (K) is a unit of absolute temperature; 0 K = –273.15° C = –459.67° F.
c. mm = millimeters; m/s = meters per second; Ti = Titanium; Al = Aluminum.
d. km/s = kilometers per second.
e. The Cm-244 and Co-57 in the science instruments would be released in liquid and solid propellant fires and during reentry.
f. Failure of graphite components possible.

Safety testing and response analyses of the RHUs to accident environments indicate that the protection provided by the graphite components and the platinum-rhodium clad encapsulating the PuO_2 (see Section 2.1.2) makes releases unlikely due to purely mechanical damage from spacecraft ground impacts, propellant blast overpressures, and debris fragments. The primary release mechanism is exposure to high-temperature burning solid propellant, which could lead to clad melting and partial vaporization of the PuO_2. Should the graphite components be damaged or stripped, some PuO_2 could be vaporized. If the graphite components remain intact, any vaporized fuel release would be limited to that which permeates through the graphite components. A release which permeates through the graphite components would be a very small fraction (about 1/1000) of that potentially vaporized fuel associated with a bare clad. A small fraction of early launch accidents could lead to intact impact of various spacecraft/launch vehicle configurations, as described above. The resulting impact could lead to mechanical damage of the RHU graphite components, depending on the orientation and velocity at impact, and subsequent exposure to burning Star 48B solid propellant, which could potentially lead to PuO_2 releases.

In later phases of the mission, accidents could lead to reentry heating and ground impact environments. However, the RHU would survive these potential reentry environments and subsequent surface impacts.

The Cm-244 and Co-57 small-quantity radioactive sources used in spacecraft instrumentation have relatively low melting temperatures compared to PuO_2. Due to their functional requirements for use in the science instruments, these sources cannot be contained and their release in the thermal environment of launch area accidents would be likely. Reentry conditions would also likely lead to the release of the small-quantity radioactive sources at high altitudes.

A summary of the accident and source term probabilities by mission phase are presented in Table 4-5. A summary of the radionuclide contributions to the source terms (Pu-238, Cm-244, and Co-57) are presented in Table 4-6 in terms of the mean and 99th percentile values. The 99th percentile source term is the value predicted to be exceeded only one percent of the time (1 in 100), given the release of the respective radionuclide in an accident. Essential features of the results for the MER–A mission are summarized below.

- Phase 0 (Pre-Launch): During the pre-launch period and prior to launch vehicle liftoff, on-pad accidents could result in a release at a total probability of 6.3×10^{-5} (1 in 16,000). The source terms (mean and 99th percentile) are estimated to be 0.12 and 0.31 Ci for Pu-238; 0.028 and 0.028 Ci for Cm-244; and 0.10 and 0.10 Ci for Co-57.
- Phase 1 (Early Launch): During Phase 1 from liftoff to 23 s, after which land impacts in the launch area are unlikely, the total probability of a release of any radioactive material is 9.0×10^{-4} (1 in 1,100). The source terms (mean and 99th percentile) are estimated to be 0.47 and 1.6 Ci for Pu-238 (at a lower total probability of 1.4×10^{-4} (1 in 7,200)); 0.009 and 0.027 for Cm-244; and 0.034 and 0.099 Ci for Co-57.
- Phase 2 (Late Launch): In Phase 2, most accidents lead to impact of debris in the Atlantic Ocean, and at-altitude environments are not severe enough to lead to releases. Some AICs during Phase 2 could lead to degraded launch vehicle performance, causing a sub-orbital reentry or a subsequent orbital reentry at later times after Phase 2. Prior to achieving Earth orbit, those accidents could lead to

sub-orbital reentry within minutes. Following spacecraft breakup during reentry, about 2% of sub-orbital reentries could result in impacts of RHUs along portions of the vehicle flight path over southern Africa, Madagascar, and western Australia. Accidents which might occur after reaching orbit could result in orbital reentries from minutes to years after the accident. Orbital reentries would lead to surface impacts between 28º South and 28º North latitudes. The reentry heating conditions lead to the high-altitude release of the small-quantity radioactive sources with a total probability of 7.8×10^{-4} (1 in 1,300). The source terms (mean and 99th percentile) are estimated to be 0.025 and 0.049 Ci for Cm-244; and 0.088 and 0.18 Ci for Co-57.

- Phase 3 (Pre-Orbit/Orbit): Accidents during Phase 3 could lead to sub-orbital or orbital reentry conditions with a total probability of release for the small-quantity radioactive sources of 1.7×10^{-4} (1 in 5,900). The source terms would be identical to those estimated for Phase 2.
- Phase 4 (Orbit/Escape): Accidents during Phase 4 could lead to orbital reentry conditions with a total probability of release for the small-quantity radioactive sources of 2.5×10^{-3} (1 in 400). The source term ranges would be identical to those estimated for Phase 2.

Table 4-5. Accident and Source Term Probability Summary

Mission Phase	AIC Probability	Conditional Probability [a]		Total Probability [b]
		Pu-238	Cm-244/Co-57	
MER–A Mission				
0 (Pre-Launch)	$1.16x10^{-4}$	$5.42x10^{-1}$	$5.42x10^{-1}$	$6.29x10^{-5}$
1 (Early Launch)	$4.69x10^{-3}$	$2.96x10^{-2}$	$1.92x10^{-1}$	$9.01x10^{-4}$
2 (Late Launch)	$2.42x10^{-2}$	-	$3.23x10^{-2}$	$7.82x10^{-4}$
3 (Pre-Orbit/Orbit)	$3.35x10^{-4}$	-	$5.00x10^{-1}$	$1.67x10^{-4}$
4 (Orbit/Escape)	$2.85x10^{-3}$	-	$8.88x10^{-1}$	$2.53x10^{-3}$
Overall Mission	**$3.22x10^{-2}$**	**$6.27x10^{-3}$**	**$1.38x10^{-1}$**	**$4.44x10^{-3}$**
MER–B Mission				
0 (Pre-Launch)	$1.16x10^{-4}$	$5.42x10^{-1}$	$5.42x10^{-1}$	$6.29x10^{-5}$
1 (Early Launch)	$3.29x10^{-3}$	$3.31x10^{-2}$	$1.87x10^{-1}$	$6.15x10^{-4}$
2 (Late Launch)	$2.25x10^{-2}$	-	$3.11x10^{-2}$	$7.00x10^{-4}$
3 (Pre-Orbit/Orbit)	$2.79x10^{-4}$	-	$5.00x10^{-1}$	$1.39x10^{-4}$
4 (Orbit/Escape)	$2.93x10^{-3}$	-	$8.90x10^{-1}$	$2.61x10^{-3}$
Overall Mission	**$2.91x10^{-2}$**	**$5.90x10^{-3}$**	**$1.48x10^{-1}$**	**$4.13x10^{-3}$**

Source: DOE 2002

a. Conditional probability of release given the AIC probability.
b. Total probability of a release, calculated as the product of the AIC probability times the larger of the Pu-238 or Cm-244/Co-57 conditional release probabilities.

Table 4-6. Source Term Summary

Mission Phase	Source Term[a] (curies) Pu-238 Mean	Pu-238 99th Percentile	Cm-244 Mean	Cm-244 99th Percentile	Co-57 Mean	Co-57 99th Percentile
MER–A Mission						
0 (Pre-Launch)	$1.19x10^{-1}$	$3.06x10^{-1}$	$2.76x10^{-2}$	$2.81x10^{-2}$	$1.03x10^{-1}$	$1.05x10^{-1}$
1 (Early Launch)	$4.66x10^{-1}$	$1.55x10^{0}$	$9.05x10^{-3}$	$2.71x10^{-2}$	$3.41x10^{-2}$	$9.94x10^{-2}$
2 (Late Launch)	-	-	$2.50x10^{-2}$	$4.90x10^{-2}$	$8.80x10^{-2}$	$1.75x10^{-1}$
3 (Pre-Orbit/Orbit)	-	-	$2.50x10^{-2}$	$4.90x10^{-2}$	$8.80x10^{-2}$	$1.75x10^{-1}$
4 (Orbit/Escape)	-	-	$2.50x10^{-2}$	$4.90x10^{-2}$	$8.80x10^{-2}$	$1.75x10^{-1}$
Overall Mission	**$3.58x10^{-1}$**	**$1.16x10^{0}$**	**$2.18x10^{-2}$**	**$4.43x10^{-2}$**	**$7.73x10^{-2}$**	**$1.50x10^{-1}$**
MER–B Mission						
0 (Pre-Launch)	$1.19x10^{-1}$	$3.06x10^{-1}$	$2.76x10^{-2}$	$2.81x10^{-2}$	$1.03x10^{-1}$	$1.05x10^{-1}$
1 (Early Launch)	$5.78x10^{-1}$	$1.55x10^{0}$	$9.73x10^{-3}$	$2.68x10^{-2}$	$3.66x10^{-2}$	$9.76x10^{-2}$
2 (Late Launch)	-	-	$2.50x10^{-2}$	$4.90x10^{-2}$	$8.80x10^{-2}$	$1.75x10^{-1}$
3 (Pre-Orbit/Orbit)	-	-	$2.50x10^{-2}$	$4.90x10^{-2}$	$8.80x10^{-2}$	$1.75x10^{-1}$
4 (Orbit/Escape)	-	-	$2.50x10^{-2}$	$4.90x10^{-2}$	$8.80x10^{-2}$	$1.75x10^{-1}$
Overall Mission	**$4.10x10^{-1}$**	**$1.09x10^{0}$**	**$2.28x10^{-2}$**	**$4.54x10^{-2}$**	**$8.06x10^{-2}$**	**$1.62x10^{-1}$**

Source: DOE 2002

a. Source terms for each radionuclide given a release of that radionuclide at the corresponding conditional probabilities in Table 4-5.

The total probabilities of release, source term ranges, and release characteristics for the MER–B mission are very similar to those estimated for the MER–A mission, as evident from Tables 4-5 and 4-6.

4.1.5 Environmental Consequences and Risks of Potential MER–2003 Project Radiological Accidents

This section is summarized from the DOE's *Nuclear Risk Assessment for 2003 Mars Exploration Rover Project Environmental Impact Statement* (DOE 2002). Health effect consequences stemming from potential PuO_2 and small-quantity radioactive source releases have been determined from atmospheric transport and dispersion simulations incorporating both launch-site specific and worldwide meteorological and population data. Biological effects models, based on methods prescribed by the National Council on Radiation Protection and Measurements (NCRP) and the International Commission on Radiological Protection (ICRP), were applied to predict the number of excess latent cancer fatalities (health effects) induced in a 50-year period following a MER–2003 launch accident that results in a release of radioactive material.

4.1.5.1 Radiological Consequences

The radiological consequences of a given accident scenario that results in a radiological release have been estimated by DOE in terms of (1) maximum individual dose, (2) collective dose, (3) health effects, and (4) land area contaminated at or above specified levels.

The maximum individual dose is the dose that the person with the highest exposure would receive for a specific accident. Collective dose is the sum of the radiation dose received by all individuals exposed to radiation from a given release in units of "person-rem." The health effects represent excess latent cancer fatalities induced by releases, determined using ICRP estimators of 5×10^{-4} fatalities per person-rem for the general population and 4×10^{-4} for workers (ICRP 1990). It is recognized that another measure of radiological consequence is total detriment. Total detriment, as defined by ICRP, includes consideration of fatal cancers, non-fatal cancers, and hereditary effects in the exposed population, encompassing consideration of all age groups, including children. It is determined using total detriment estimators of 7.3×10^{-4} effects per person-rem for the general population and 5.6×10^{-4} for workers. Further details on total detriment can be found in DOE's risk assessment (DOE 2002).

Health effects estimators, which relate health effects to effective dose, are based on the assumption that the health effects vary directly with dose (*i.e.*, a linear, non-threshold model). This means that the contribution to health effects decreases linearly as the dose decreases to zero.

A summary of the radiological consequences by mission phase is presented in Table 4-7 in terms of the mean and 99th percentile values. The 99th percentile radiological consequence is the value predicted to be exceeded only one percent of the time (1 in 100) given an accident with a release. Essential features of the results for the MER–A mission, given a radiological release, are summarized below.

- <u>Phase 0 (Pre-Launch)</u>: The radiological consequences (mean and 99th percentile) are estimated to be: maximum individual dose, 0.011 and 0.39 rem; collective dose, 39 and 207 person-rem; and health effects, 0.019 and 0.10.
- <u>Phase 1 (Early Launch)</u>: The radiological consequences (mean and 99th percentile) are estimated to be: maximum individual dose, 0.006 and 0.085 rem; collective dose, 20 and 332 person-rem; and health effects, 0.010 and 0.16.
- <u>Phase 2 (Late Launch)</u>: The radiological consequences (mean and 99th percentile) are estimated to be: maximum individual dose, 2.2×10^{-6} and 6.3×10^{-6} rem; collective dose, 2.6 and 7.5 person-rem; and health effects, 0.0013 and 0.0038.
- <u>Phases 3 (Sub-Orbit/Orbit) and 4 (Orbit/Escape)</u>: The radiological consequences for Phases 3 and 4 are identical to those for Phase 2.

The ranges in the various types of radiological consequences for the MER–B mission are very similar to those estimated for the MER–A mission, as evident from Table 4-7.

Table 4-7. Radiological Consequences Summary

Mission Phase	Maximum Individual Dose (rem)		Collective Dose (person-rem)		Health Effects [a]	
	Mean	99th Percentile	Mean	99th Percentile	Mean	99th Percentile
MER–A Mission						
0 (Pre-Launch)	$1.11x10^{-2}$	$3.92x10^{-1}$	$3.87x10^{1}$	$2.07x10^{2}$	$1.89x10^{-2}$	$1.03x10^{-1}$
1 (Early Launch)	$5.56x10^{-3}$	$8.54x10^{-2}$	$2.00x10^{1}$	$3.32x10^{2}$	$9.80x10^{-3}$	$1.58x10^{-1}$
2 (Late Launch)	$2.16x10^{-6}$	$6.34x10^{-6}$	$2.62x10^{0}$	$7.54x10^{0}$	$1.31x10^{-3}$	$3.77x10^{-3}$
3 (Pre-Orbit/Orbit)	$2.16x10^{-6}$	$6.34x10^{-6}$	$2.62x10^{0}$	$7.54x10^{0}$	$1.31x10^{-3}$	$3.77x10^{-3}$
4 (Orbit/Escape)	$2.16x10^{-6}$	$6.34x10^{-6}$	$2.62x10^{0}$	$7.54x10^{0}$	$1.31x10^{-3}$	$3.77x10^{-3}$
Overall Mission [b]	**$1.29x10^{-3}$**	**$2.29x10^{-2}$**	**$6.66x10^{0}$**	**$7.62x10^{1}$**	**$3.29x10^{-3}$**	**$3.65x10^{-2}$**
MER–B Mission						
0 (Pre-Launch)	$2.46x10^{-3}$	$3.38x10^{-2}$	$3.11x10^{1}$	$2.29x10^{2}$	$1.54x10^{-2}$	$1.14x10^{-1}$
1 (Early Launch)	$1.73x10^{-3}$	$2.42x10^{-2}$	$2.23x10^{1}$	$2.40x10^{2}$	$1.10x10^{-2}$	$1.19x10^{-1}$
2 (Late Launch)	$2.16x10^{-6}$	$6.34x10^{-6}$	$2.62x10^{0}$	$7.54x10^{0}$	$1.31x10^{-3}$	$3.77x10^{-3}$
3 (Pre-Orbit/Orbit)	$2.16x10^{-6}$	$6.34x10^{-6}$	$2.62x10^{0}$	$7.54x10^{0}$	$1.31x10^{-3}$	$3.77x10^{-3}$
4 (Orbit/Escape)	$2.16x10^{-6}$	$6.34x10^{-6}$	$2.62x10^{0}$	$7.54x10^{0}$	$1.31x10^{-3}$	$3.77x10^{-3}$
Overall Mission [b]	**$2.97x10^{-4}$**	**$4.13x10^{-3}$**	**$5.99x10^{0}$**	**$4.56x10^{1}$**	**$2.98x10^{-3}$**	**$2.26x10^{-2}$**

Source: DOE 2002

a. Based on ICRP health effects estimators of 4×10^{-4} health effects per person-rem for workers and 5×10^{-4} health effects per person-rem for the general population (ICRP 1990).
b. Overall mission values are weighted by total probability of release for each mission phase (see Table 4-5).

Potential land contamination was evaluated in terms of 1) areas exceeding various screening levels (0.1 and 0.2 microcuries per square meter (μCi/m^2)), and 2) dose-rate related criteria (15, 25, and 100 millirem/yr) considered by the EPA, the Nuclear Regulatory Commission (NRC), and DOE in evaluating the need for land cleanup following radioactive contamination. The results indicated that mean values of land area contaminated at levels exceeding 0.1 and 0.2 μCi/m^2 (the latter being an EPA screening level used in the past to determine the need for further action, such as monitoring or cleanup, and considered in the risk analyses of previous missions) was less than 0.5 square kilometer (0.2 square mile) for all postulated pre-launch and launch phase accidents, and less than 1.0 square kilometer (0.4 square mile) at the 99th percentile level. The results indicated that dose-related criteria (15, 25, and 100 millirem/yr) developed using a risk-based approach could be exceeded during the first year, due primarily to resuspension, but dose rates would fall well below these levels after the first year. Dose rates after the first year would be well below the dose-rate criteria for remedial action, which in any case would require several years to implement following detailed evaluation and monitoring. When considered with respect to the lifetime risk levels associated with these annual dose rates, the lifetime risks would be well below the EPA lifetime-risk criterion from which the average annual dose rate criterion of 15 millirem/yr was derived. It is anticipated that no remedial action would be considered necessary on the basis of the dose rate criterion. Local remedial action at the accident site would be necessary to locate and recover the RHUs, small quantity sources, and cleanup any residual radioactive materials and contamination.

4.1.5.2 Mission Risks

A summary of the mission risks is presented in Table 4-8. For the purpose of this FEIS, risk is defined as the expectation of health effects in a statistical sense (*i.e.*, the product of total probability of release multiplied by the health effects resulting from a release, and then summed over all conditions leading to a release). The risk is determined for each mission phase and the overall mission. Since the potential health effects resulting from a release are the sum of each individual's probability of a health effect in the exposed population, risk can also be interpreted as the total probability of one health effect given a launch accident resulting in a release during the mission. The overall risks for the MER–A and MER–B missions is estimated to be 1.5 x 10^{-5} and 1.2 x 10^{-5}, respectively. The combined risk for both missions is the sum of these two values, or 2.7 x 10^{-5}.

Table 4-8. Mission Risk Summary

Mission Phase	AIC Probability	Conditional Probability	Total Probability	Mean Health Effects	Mission Risks
MER–A Mission					
0 (Pre-Launch)	$1.16x10^{-4}$	$5.42x10^{-1}$	$6.29x10^{-5}$	$1.89x10^{-2}$	$1.19x10^{-6}$
1 (Early Launch)	$4.69x10^{-3}$	$1.92x10^{-1}$	$9.01x10^{-4}$	$9.80x10^{-3}$	$8.83x10^{-6}$
2 (Late Launch)	$2.42x10^{-2}$	$3.23x10^{-2}$	$7.82x10^{-4}$	$1.31x10^{-3}$	$1.02x10^{-6}$
3 (Pre-Orbit/Orbit)	$3.35x10^{-4}$	$5.00x10^{-1}$	$1.67x10^{-4}$	$1.31x10^{-3}$	$2.19x10^{-7}$
4 (Orbit/Escape)	$2.85x10^{-3}$	$8.88x10^{-1}$	$2.53x10^{-3}$	$1.31x10^{-3}$	$3.31x10^{-6}$
Overall Mission	$\mathbf{3.22x10^{-2}}$	$\mathbf{1.38x10^{-1}}$	$\mathbf{4.44x10^{-3}}$	$\mathbf{3.29x10^{-3}}$	$\mathbf{1.46x10^{-5}}$
MER–B Mission					
0 (Pre-Launch)	$1.16x10^{-4}$	$5.42x10^{-1}$	$6.29x10^{-5}$	$1.54x10^{-2}$	$9.68x10^{-7}$
1 (Early Launch)	$3.29x10^{-3}$	$1.87x10^{-1}$	$6.15x10^{-4}$	$1.10x10^{-2}$	$6.77x10^{-6}$
2 (Late Launch)	$2.25x10^{-2}$	$3.11x10^{-2}$	$7.00x10^{-4}$	$1.31x10^{-3}$	$9.16x10^{-7}$
3 (Pre-Orbit/Orbit)	$2.79x10^{-4}$	$5.00x10^{-1}$	$1.39x10^{-4}$	$1.31x10^{-3}$	$1.83x10^{-7}$
4 (Orbit/Escape)	$2.93x10^{-3}$	$8.90x10^{-1}$	$2.61x10^{-3}$	$1.31x10^{-3}$	$3.41x10^{-6}$
Overall Mission	$\mathbf{2.91x10^{-2}}$	$\mathbf{1.48x10^{-1}}$	$\mathbf{4.13x10^{-3}}$	$\mathbf{2.98x10^{-3}}$	$\mathbf{1.23x10^{-5}}$

Source: DOE 2002

Phase 1 accidents represent 60% of the radiological risk for the MER–A mission and 55% of that for the MER–B mission. FSIIs followed by second stage/Star 48B/spacecraft/PLF impacts are the primary contributors to the Phase 1 risk.

The relative contributions of Pu-238, Cm-244, and Co-57 to the mission risks, summarized in Table 4-9, are estimated to be 57%, 43%, and 0.13%, respectively, for both missions combined.

Table 4-9. Mission Risk Contributions by Radionuclide

Mission	Overall Mission Risk			
	Pu-238	Cm-244	Co-57	Total
MER–A	8.54×10^{-6}	6.03×10^{-6}	1.82×10^{-8}	1.46×10^{-5}
MER–B	6.74×10^{-6}	5.51×10^{-6}	1.76×10^{-8}	1.23×10^{-5}
Both Missions	$\mathbf{1.53 \times 10^{-5}}$	$\mathbf{1.15 \times 10^{-5}}$	$\mathbf{3.58 \times 10^{-8}}$	$\mathbf{2.69 \times 10^{-5}}$

Source: DOE 2002

The relative contributions of risks in the launch area (*i.e.*, the regional area of interest within 100 km (62 mi) of SLC–17) and on a global scale, summarized in Table 4-10, are estimated to be 35% and 65% respectively, for both missions combined. Estimated launch area risks are based on accidents that occur during Phases 0 and 1. The risks beyond the launch area are due to accidents in all mission phases with Phase 1 the primary contributor due to long range transport of releases beyond 100 km (62 mi) from SLC–17.

Table 4-10. Mission Risk Contributions by Affected Region

Mission	Overall Mission Risk		
	Launch Area [a]	Global [b]	Total
MER–A	5.55×10^{-6}	9.02×10^{-6}	1.46×10^{-5}
MER–B	3.88×10^{-6}	8.37×10^{-6}	1.23×10^{-5}
Both Missions	$\mathbf{9.43 \times 10^{-6}}$	$\mathbf{1.74 \times 10^{-5}}$	$\mathbf{2.69 \times 10^{-5}}$

Source: DOE 2002

a. The regional area of interest within 100 km (62 mi) from the launch site for Phases 0 and 1.
b. Beyond 100 km (62 mi) from the launch site for Phases 0 and 1, and worldwide for Phases 2 to 4.

Another descriptor used in characterizing risk is the average individual risk (see Table 4-11), defined in this FEIS as the risk divided by the number of persons exposed. The average individual risk, interpreted as an individual's average incremental probability of incurring a health effect given the mission, is estimated to be 9.4×10^{-11} in the launch area (within 100 km (62 mi) of SLC–17) and 5.8×10^{-15} on a global scale for both missions combined. The primary contributors to the average individual risk are Phase 1 accidents.

Some individuals within the exposed population, such as those very close to the launch area, would face higher risks. The risk to the maximally exposed individual is defined in this FEIS as the total probability of a release multiplied by the risk of a latent cancer fatality to that individual. Table 4-11 summarizes these risks. The risk to the potentially maximally exposed individual within the launch area population is about 2.9×10^{-9} (1 in 350 million) for the MER–A mission and about 6.1×10^{-10} (1 in 1.6 billion) for the MER–B mission.

Table 4-11. Individual Risk Contributions by Affected Region

Mission	Average Individual Risk [a]		Maximum Individual Risk [d]	
	Launch Area [b]	Global [c]	Launch Area	Global
MER–A	$5.55x10^{-11}$	$3.01x10^{-15}$	$2.85x10^{-9}$	$3.76x10^{-12}$
MER–B	$3.88x10^{-11}$	$2.79x10^{-15}$	$6.09x10^{-10}$	$3.72x10^{-12}$
Both Missions	**$9.43x10^{-11}$**	**$5.80x10^{-15}$**	**$3.46x10^{-9}$**	**$7.48x10^{-12}$**

Source: Adapted from DOE 2002

a. Mission risk contribution in the affected area divided by the number of persons exposed.
b. The regional area of interest within 100 km (62 mi) of the launch site for Phases 0 and 1. Based on an exposed population on the order of 10^5 persons.
c. Beyond 100 km (62 mi) from the launch site for Phases 0 and 1, and worldwide for Phases 2 to 4. Based on an exposed population on the order of 3×10^9 persons.
d. Within 100 km (62 mi) of the launch site, the maximum individual risks are summed over Phases 0 and 1. Beyond 100 km (62 mi) from the launch site, the maximum individual risks are summed over Phases 2 through 4.

These risk estimates are clearly very small relative to other risks. For example, Table 2-7 presents information on annual individual fatality risk to U.S. residents due to various types of hazards. This table indicates that the average individual risk of accidental death in the U.S. is about 3.5×10^{-4} (1 in 2,900) per year.

4.1.5.3 Uncertainty

A detailed uncertainty analysis has not been performed as part of the risk assessment prepared for this FEIS. Based on uncertainty analyses performed for previous mission risk assessments (*e.g.*, NASA 1997), parameter and model uncertainties associated with estimating radiological consequences could result in risk estimates that vary from one to two orders of magnitude higher (at the 95% confidence level) or lower (at the 5% confidence level) relative to the estimates presented in Sections 4.1.5.1 and 4.1.5.2.

4.1.6 Radiological Emergency Response Planning

Prior to the launch of the MER–2003 missions with the RHUs and small quantity radioactive sources onboard each rover, NASA, as the Lead Federal Agency, would develop a comprehensive plan in accordance with the Federal Radiological Emergency Response Plan. This plan would ensure that any accident would be met with a well-developed and tested response. The plan would be developed through the combined efforts of Federal agencies (*e.g.*, NASA, DOE, the U.S. Department of Defense (DoD), EPA, the Federal Emergency Management Agency, and others as appropriate), the State of Florida, and local organizations involved in local emergency response.

A Radiological Control Center would coordinate any emergency actions required during the pre-launch countdown or the early phases of the mission. In the event of an accident, a nearby offsite location would be established to conduct monitoring and surveillance in areas outside the launch site, assess the accumulated data, and coordinate further actions through the Radiological Control Center.

The response to launch accidents would also depend on the geographical locations involved. Accident sites within the United States and U.S. Territories may be supported initially by the nearest Federal installation possessing a radiological contingency response capability. Personnel from all supporting installations would be alerted to this potential requirement prior to launch. Additional support would be dispatched from the launch site support personnel or from other support agencies, as needed. For accidents occurring outside the United States or its territorial jurisdictions, the U.S. Department of State and diplomatic channels would be employed in accordance with pre-arranged procedures and support elements would be dispatched as appropriate.

If an ocean or water impact occurs, the Federal agencies would undertake security measures, as appropriate, and search and retrieval operations. The recovery of the plutonium dioxide would be based on the technological feasibility, the health hazard presented to recovery personnel, the environmental impacts, and other pertinent factors.

4.2 ENVIRONMENTAL IMPACTS OF THE NO ACTION ALTERNATIVE

Under the No Action Alternative, preparations for the MER–2003 project would be discontinued, and the MER–2003 missions would not be implemented. None of the physical, geological, and chemical scientific investigations planned for the proposed MER–2003 missions would be achieved. Furthermore, lessons expected to be learned during all phases of each mission (atmospheric entry, descent, and landing; initial deployment on the surface; real-time site traverse planning, execution and navigation; simultaneous operation of two rovers; and science data collection) would not be gained. Canceling this project would thus lead to a significant gap in NASA's scientific objectives for exploring Mars and would adversely affect NASA's plans for future missions to Mars. There would be neither adverse environmental impacts nor beneficial effects with the No Action Alternative.

4.3 CUMULATIVE IMPACTS

Within the CCAFS regional area, cumulative impacts of exhaust emissions from the MER–2003 launch vehicles would not substantially affect long-term air quality, water quality, and biotic resources. Launching the MER–2003 missions also would not cause any changes in land use at or in the vicinity of CCAFS.

From a cumulative environmental impact perspective, launch of the MER–2003 missions from CCAFS would principally contribute to exhaust emissions impacts on and near the launch pads. Over the period between May 1995 and January 1998, NASA monitored 46 Atlas, Delta II, and Titan IV launches from CCAFS (USAF 1998). Within 70 to 100 m (230 to 330 ft) of the flame trenches, vegetation was scorched and trees were partially or completely defoliated. Deposition of large particulates was found in this area out to about 200 m (660 ft) from the flame trench of the Titan IV launch complex, with small particulate deposition and evidence of low-concentration acidic deposition found between 250 and 830 m (820 and 2,720 ft) from the Delta II launch complex. While these impacts may persist with continued use of a launch site, and the MER–2003 launches would contribute to these conditions, they are probably not irreversible. NASA (Schmalzer *et al.* 1998) found that vegetation reestablished itself after cessation of launches in similarly affected areas near the Space Shuttle launch pads.

On a short-term basis, the two MER–2003 launches would contribute to the addition of ozone depleting substances (about 0.02 kg (0.05 lb)) to the stratosphere. The total contribution of the two launches to the average annual depletion of ozone would be extremely small (about 0.0025% for both launches on a global annual average basis). See Section 4.1.2.3 for further discussion.

4.4 ENVIRONMENTAL IMPACTS THAT CANNOT BE AVOIDED

During a normal launch of both the Delta II 7925 (NASA 1998a) and the Delta II 7925H, the Delta II main engine and ground-lit GEMs would be ignited shortly prior to lift-off and would produce an exhaust cloud. This exhaust cloud, consisting of Al_2O_3, CO, HCl, and relatively smaller amounts of CO_2, H_2, H_2O, N_2, Cl and NO_X, would be concentrated near the launch pad during the first moments of launch. Thereafter, the exhaust cloud would be transported downwind and upward, and would dissipate. Aluminum oxide (Al_2O_3) particulates would also be deposited at the launch site as the exhaust cloud travels downwind.

Biota in the immediate vicinity of the launch pad could be damaged or killed by the intense heat and HCl deposition from the exhaust cloud. No long-term adverse effects to biota would be anticipated at either launch pad of SLC–17 (USAF 1996; NASA 1998a; NASA 1998b; NASA 2002).

4.5 INCOMPLETE OR UNAVAILABLE INFORMATION

The primary areas of either incomplete or unavailable information for the MER–2003 project include the following items.

This FEIS evaluates launch accident scenarios that could potentially result in a release from the RHUs and small quantity radioactive sources onboard the MER–2003 rovers. NASA and DOE are continuing to evaluate factors potentially affecting mission safety and risks. Should any of the ongoing evaluations result in risk estimates greater than those presented in this FEIS, NASA will consider the new information, and determine the need for additional NEPA documentation.

A detailed uncertainty analysis has not been performed as part of the risk assessment prepared for this FEIS. Based on uncertainty assessments performed for previous mission safety analyses (*e.g.*, NASA 1997), parameter and model uncertainties associated with estimating radiological consequences could result in risk estimates that vary from one to two orders of magnitude at the 5% and 95% confidence levels.

4.6 RELATIONSHIP BETWEEN SHORT-TERM USES OF THE HUMAN ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

4.6.1 Short-Term Uses

The MER–2003 missions would be launched from CCAFS. The short-term affected environment would include this launch site and surrounding areas. At CCAFS, short-term uses include NASA and USAF operations, urban communities, a fish and wildlife refuge, citrus groves, residential communities, and recreational areas (NASA 1995). The MER–2003 mission would be conducted in accordance with past and ongoing NASA and USAF procedures for operations at a CCAFS launch site. Should an accident occur at CCAFS causing a radiological release, short-term uses of contaminated areas could be curtailed, pending mitigation.

4.6.2 Long-Term Productivity

No changes to land use at CCAFS or the surrounding region would be anticipated because of the two MER–2003 launches from SLC–17. The region would continue to support human habitation and activities, wildlife habitats, citrus groves, and grazing/agricultural land. No long-term effects on these uses would be anticipated because of the MER–2003 missions. However, should an accident occur at CCAFS causing a radiological release, the long-term productivity of contaminated land areas could be impacted.

The successful completion of the MER–2003 missions would benefit the U.S. space program, which is important to the economic stability of the area surrounding the launch site. In addition to the localized economic benefits, implementing the MER–2003 missions has broader socioeconomic benefits. These include technology spin-offs to industry and other space missions, maintaining the unique capability of the U.S. to conduct complex planetary missions by scientists and engineers, and supporting the continued scientific development of graduate students at universities and colleges. Furthermore, real-time data and images acquired by the MER–2003 rovers would be made available to the general public, schools, and other institutions via a broad variety of media, including the Internet.

4.7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

An irretrievable resource commitment results when a spent resource cannot be replaced within a reasonable period of time. For the Proposed Action, quantities of various resources, including energy, fuels, and other materials, would be irreversibly and irretrievably committed. The use of these resources would be associated with the fabrication, launch, and operation of the MER–2003 project.

4.7.1 Energy and Fuels

The fabrication processes for the MER–2003 spacecraft and launch vehicles would use electrical and fossil fuel energy. This use constitutes an irretrievable commitment of resources but would not impose any significant energy impacts. The launch and operation of the spacecraft would consume solid and liquid propellants. The solid propellant ingredients, primarily in the Star 48B motors and GEMs, would be ammonium perchlorate, aluminum powder, and HTPB binder. The liquid propellants would include RP-1, LOX, Aerozine–50, and N_2O_4 in the Delta II core vehicles and hydrazine in the MER–2003 cruise stages. The quantities that would be used for the MER–2003 missions are discussed in Sections 2.1.1, 2.1.5 and 2.1.6.

4.7.2 Other Materials

The total quantities of other materials used in the MER–2003 missions that would be irreversibly and irretrievable committed are relatively minor. Typically, these materials include steel, aluminum, titanium, iron, molybdenum, plastic, glass, nickel, chromium, lead, zinc, and copper. Less common materials may include small quantities of silver, mercury, gold, rhodium, gallium, germanium, hafnium, niobium, platinum, plutonium, and tantalum.

4.8 ENVIRONMENTAL COMPLIANCE AT CCAFS

This section presents an overview of the environmental reviews and consultation requirements for CCAFS, which include permits, licenses, and approvals.

Air Resources

Air quality in Florida, and consequently at CCAFS, is managed by the Florida Department of Environmental Protection (FDEP) through a Federal, State, and local regulatory framework.

Air permits are required for activities having the potential to release air pollutants. CCAFS is required to have necessary air permits and currently operates under Title V (40 CFR 70) of the Clean Air Act (CAA) as a single facility (USAF 1998).

Air permits are not required for emissions from mobile sources such as motor vehicles, aircraft, and space launch vehicles, but are required for support activities such as launch vehicle preparation, assembly, and propellant loading which are considered stationary sources. Since existing equipment and services would be used for the proposed MER–2003 project and there would be no new construction of stationary sources, there would be no requirement to obtain new air permits or modify the existing Title V permit.

The Delta II oxidizer and fuel vapor air pollution control devices at CCAFS comply with NAAQS and FDEP regulations. The citric acid scrubber for Delta II propellants is probably one level of control beyond that required by FDEP (NASA 2002).

Water Resources

Wastewater discharge from CCAFS is regulated by the FDEP through a permitting program which places limitations on the amount of pollutants discharged to the receiving waterways. Permits are also required for construction activities that involve areas greater than 2 hectares (5 acres) in extent for storm water management (USAF 1998).

Because the proposed MER–2003 project would be within the normal contingent of Delta II launches no new permits would be required for discharge of sanitary and industrial wastewater. Deluge and wash down water would be collected in the flame trench prior to discharge. The water would be tested and if regulatory requirements were met, would be discharged to grade under a FDEP discharge permit. If regulatory requirements cannot be met and the water cannot be released to grade, the wastewater would be treated and disposed by a certified contractor in accordance with applicable Federal, State, and local regulations (USAF 1998).

Floodplains and Wetlands

SLC–17 does not lie on a floodplain and is not located on a wetland. New permits would not be required since there would be no new construction or dredge and fill activities associated with the proposed MER–2003 project. The MER–2003 launches from SLC–17 would not add substantial impacts beyond those normally associated with any launch of a Delta II.

Hazardous Material Management

The USAF provides guidance for managing hazardous materials through Instruction AFI 32-7086, *Hazardous Material Management*. CCAFS hazardous material management is administered from Patrick Air Force Base through a hazardous material pharmacy distribution system (HazMart). Under the HazMart system, less toxic alternatives are examined prior to procuring the requisitioned item with distribution controls (USAF 1998). The proposed MER–2003 project would follow recommended guidelines for hazardous material management.

Hazardous Waste Management

Hazardous wastes generated during the preparation, processing, and launch operations of the proposed MER–2003 project at CCAFS would be managed as either Boeing commercial hazardous waste or as NASA hazardous waste in accordance with the 45th Space Wing's *Petroleum Products and Hazardous Waste Management Plan* (OPlan19-14) and under USAF Guidance AFI 32-7042, *Solid and Hazardous Waste Compliance* (USAF 1998). Any hazardous waste generated at the launch pad (usually negligible) would be returned to the spacecraft processing facility at KSC and disposed properly by Boeing in accordance with the Launch Site Support Plan and in compliance with applicable Federal, State, and local regulations.

Pollution Prevention

Pollution prevention guidelines at CCAFS are provided by DoD Directive 4210.15; USAF Policy Directive AFPD 32-70, *Environmental Quality*; USAF Instruction AFI 32-7080, *Pollution Prevention Program*; and the 45th Space Wing's *Pollution Prevention Program Guide and Pollution Prevention Management Action Plan* (USAF 1996). NASA also participates in a partnership with the military services, called the Joint Group on Pollution Prevention (JG-PP), to reduce or eliminate hazardous material or processes. The proposed MER–2003 project activities would follow appropriate guidelines.

Spill Prevention

CCAFS has a Spill Prevention, Control, and Countermeasures Plan which is developed with and integrated to the 45th Space Wing's *Hazardous Materials Response Plan* (OPlan 32-3). When a Federally listed oil or petroleum spill occurs, as per the 45th Space Wing's *Hazardous Substance Pollution Contingency Plan* (OPlan 19-4), the substance will be collected and removed for disposal by a certified contractor. In addition, per OPlan 32-3, all spill or releases would be reported (USAF 1996). The proposed MER–2003 project activities would follow appropriate guidelines.

Biological Resources

The region surrounding CCAFS is host to diverse species of fauna and flora, some of which are listed in the endangered and threatened category, including sensitive habitats. Biological resources at CCAFS are impacted by spacecraft launches (*e.g.*, from noise, the exhaust cloud) and other activities associated with launches. The proposed MER–2003 project would observe procedures which minimize impacting these resources, such as the lighting management plan used to minimize impacts to sea turtle nesting beaches.

Coastal Zone Management

The mandate to preserve the Nation's coastal zones is provided by the Federal Coastal Zone Management Act of 1972, which has established a national policy to preserve, protect, develop, restore, and/or enhance the resources of the nation's coastal zone. Management of Florida's coastal zones is delegated to the State. Federal activities that directly affect coastal zones are required to be consistent to the maximum extent practicable with the Florida Coastal Management Program. In Brevard County, a no-development zone has been established 23 m (75 ft) inland from the mean high water level. CCAFS has additional siting requirements extending to 46 m (150 ft) inland from the mean high water level (USAF 1998). The proposed MER–2003 project would not add substantial impacts beyond those normally associated with a Delta II launch, and therefore would be consistent with applicable regulations.

Cultural Resources

Section 106 of the National Historic Preservation Act of 1966, as amended, requires Federal agencies to consult with the State Historic Preservation Officer and the Federal Advisory Council on Historic Preservation if a proposed action has the potential to impact cultural resources. Implementation of the proposed MER-2003 project is not expected to adversely impact cultural resources within CCAFS. The Environmental Office at CCAFS will assure conformity with the regulations of the National Historic Preservation Act of 1966 (36 CFR part 800).

Noise

The Occupational Safety and Health Administration (OSHA) and the National Institute of Occupational Safety and Health provide guidelines for worker exposure to noise. The proposed MER–2003 project would follow prescribed guidelines.

Worker and Public Safety and Health

Worker safety and health guidelines including public health and safety guidelines provided by OSHA would be followed by the proposed MER–2003 project with respect to protection from noise, exposure to hazardous materials and hazardous wastes, and ingestion of toxic fumes such as from fueling operations. The 45th Space Wing has the responsibility to follow range safety guidelines as outlined in EWR 127-1, *Eastern and Western Range Safety Requirements* (USAF 1998).

5 CONTRIBUTORS TO THE EIS

This Final Environmental Impact Statement (FEIS) for the Mars Exploration Rover–2003 (MER–2003) Project was prepared by the Office of Space Science, National Aeronautics and Space Administration. As a cooperating agency, the U.S. Department of Energy (DOE) has contributed expertise in the preparation of this DEIS. The organizations and individuals listed below contributed to the overall effort in the preparation of this document.

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Table 5-1. Contributors to the EIS

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6 AGENCIES AND INDIVIDUALS CONSULTED

This Final Environmental Impact Statement (FEIS) for the Mars Exploration Rover–2003 (MER–2003) project was preceded by a Draft EIS (DEIS), which was made available for review and comment by Federal, State, and local agencies and the public on July 24, 2002. The public review and comment period closed on September 9, 2003. Comments were considered during the preparation of the FEIS.

In preparing this EIS, NASA has actively solicited input from a broad range of interested parties. In addition to publication in the *Federal Register* of a Notice of Intent (NOI) (66 FR 11184) and a Notice of Availability (67 FR 48490) for the DEIS, NASA mailed copies of the DEIS directly to agencies, organizations, and individuals who may have interest in environmental impacts and alternatives associated with the MER–2003 project. In addition, the DEIS was publicly available in electronic format from a NASA server on the Internet.

Comments on the DEIS were solicited or received from the following:

Federal Agencies

Council on Environmental Quality
Federal Emergency Management Agency
National Science Foundation
Office of Management and Budget
U.S. Department of Agriculture
U.S. Department of the Air Force
U.S. Department of Commerce
    National Oceanic and Atmospheric Administration
U.S. Department of Health and Human Services
    Centers for Disease Control and Prevention
    National Cancer Institute
U.S. Department of the Interior
    Fish and Wildlife Service
    National Park Service
U.S. Department of State
U.S. Department of Transportation
    Federal Aviation Administration
    Research and Special Programs Administration
    U.S. Coast Guard
U.S. Environmental Protection Agency
U.S. Nuclear Regulatory Commission

State of Florida

State of Florida, Office of Governor
Florida State Clearinghouse
East Central Florida Regional Planning Council

County Agencies

Brevard County
- Board of Commissioners
- Comprehensive Planning Commission
- Natural Resources Management Office
- Office of Emergency Management
- Planning and Zoning Office
- Public Safety Department

Lake County
Orange County
Osceola County
Seminole County
Volusia County

Local Agencies

Canaveral Port Authority
City of Cape Canaveral
City of Cocoa
City of Cocoa Beach
City of Kissimmee
City of Melbourne
City of Merritt Island
City of New Smyrna Beach
City of Orlando
City of West Melbourne
City of St. Cloud
City of Titusville

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The American Association for the Advancement of Science
American Astronomical Society
American Institute of Aeronautics and Astronautics
American Society of Mechanical Engineers
Audubon of Florida
Economic Development Commission of Florida's Space Coast
Environmental Defense Fund
Federation of American Scientists
Friends of the Earth
Global Network Against Weapons and Nuclear Power in Space
Greenpeace
Indian River Audubon Society
National Space Society
National Wildlife Federation
Natural Resources Defense Council
The Planetary Society
Sierra Club
Union of Concerned Scientists

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APPENDIX A

GLOSSARY OF TERMS

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APPENDIX A

GLOSSARY OF TERMS

accident environment—Conditions resulting from an accident scenario, such as blast overpressures, fragments, and fire.

accident initial condition—First launch vehicle system-level event that results in a catastrophic accident.

aeroshell—The protective shell that encapsulates a spacecraft intended to enter a planet's atmosphere.

affected environment—A description of the existing environment that could be affected by the Proposed Action.

ambient air—The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. (It is not the air in the immediate proximity of the emission source.)

background radiation—Ionizing radiation that is present in the environment from cosmic rays and natural sources in the Earth; background radiation varies considerably with location.

backshell—The protective shell on the back half of a spacecraft aeroshell.

biotic—Of or relating to life; caused or produced by living beings.

conditional probability—Within the context of this document, the probability that a release of radioactive material could occur given an initiating accident (*i.e.*, the accident has occurred).

convection—Atmospheric motions that are predominately vertical, resulting in vertical transport and mixing of atmospheric properties.

criteria pollutants—The Clean Air Act required the U.S. Environmental Protection Agency to set air quality standards for common and widespread pollutants after preparing “criteria documents” summarizing scientific knowledge on their health effects. Currently, there are standards in effect for six “criteria pollutants”: sulfur dioxide, carbon monoxide, particulate matter equal to or less than 10 microns in diameter, nitrogen dioxide, ozone, and lead.

cruise stage—The system used in the cruise phase of a spacecraft's interplanetary trajectory.

cultural resources—The prehistoric and historic districts, sites, buildings, objects, or any other physical activity considered important to a culture, subculture, or a community for scientific, traditional, religious, or any other reason.

cumulative impact—The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes other such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

curie (Ci)—A measure of the radioactivity level of a substance (*i.e.*, the number of unstable nuclei that are undergoing transformation in the process of radioactive decay); one curie equals the disintegration of 3.70×10^{10} (37 billion) nuclei per second and is approximately equal to the radioactivity of one gram of radium-226.

decibel (dBA)—A measurement unit that describes a particular sound pressure quantity to a standard reference value (A-weighted).

Delta—A family of launch vehicles manufactured by The Boeing Aerospace Company.

entry vehicle—The spacecraft system that consists of the elements needed to protect a payload during atmospheric entry, and the payload which it encapsulates.

equatorial landing location—A landing site close to the equator (on Mars).

evaporite—A sedimentary rock that originates by evaporation of water in an enclosed basin.

exposure to radiation—The incidence of radiation from either external or internal sources on living or inanimate material.

first stage—The launch vehicle stage that provides initial thrust at lift-off.

full stack intact impact (FSII)—For the purpose of this document, a postulated accident scenario in which the entire launch vehicle (*i.e.*, all stages, other elements, and the payload) impacts the ground in an intact configuration due to a malfunction at or very shortly after liftoff.

geology—The study or science of the Earth (or any solid celestial body), its history, and its life as recorded in the rocks.

graphite epoxy motor (GEM)—A family of solid rocket motors with graphite-epoxy wound casings containing solid fuel that augment the launch vehicle first stage thrust capabilities.

heatshield (spacecraft)—The forward component of the aeroshell that protects a spacecraft from heat during atmospheric entry.

heatshield (RHU)— The components composed of carbon-graphite fine weave pierced fabric designed to protect a radioisotope heater unit during reentry and to provide mechanical impact protection.

health effects—Within the context of this document, health effects are defined as the number of additional, or excess, latent fatal cancers (above and beyond those that would normally be expected in the exposed population over a 50-year period).

hydrazine (N_2H_4)—A toxic, colorless liquid fuel that is hypergolic (*i.e.*, can burn spontaneously on contact) when mixed with an oxidizer such as nitrogen tetroxide (N_2O_4). Vapors may form explosive mixtures with air.

in situ—From the Latin for *in the original place*; used in planetary exploration to describe those science investigations conducted close to or within the phenomena being observed or measured.

infrared radiation—Electromagnetic radiation of wavelengths that lie in the range from 0.75 micron (the long-wavelength limit of visible red light) to 1,000 microns (the shortest microwaves).

initiating probability—The probability that an identified accident scenario and associated adverse conditions (accident environment) will occur.

interplanetary trajectory—A spacecraft's path around the sun from one planet to another.

isotopes—Forms of the same chemical element that differ only by the number of neutrons in their nucleus. Most elements have more than one naturally occurring isotope. Many isotopes have been produced in reactors and scientific laboratories.

lander—A spacecraft that is designed to land on a planet's surface.

maximally exposed individual—A hypothetical person that would receive the maximum predicted dose.

mean—The outcome (source term; dose; health effects; land contamination) that would be anticipated if an accident were to occur which released radioactive material; the mean is a statistical expression of probability-weighted consequences.

mesosphere—The atmosphere layer between 44-55 kilometers and 80-95 kilometers, extending from the top of the stratosphere to the mesopause; characterized by a temperature change that generally decreases with altitude.

meteorology—The scientific study of atmospheric phenomenon.

micron—A unit of length equal to one-millionth of a meter; also called a micrometer.

mineralogy—The scientific study of minerals, their crystallography, physical and chemical properties, and classification.

morphology—A branch of biology that deals with structure and form of an organism at any state of its life history.

National Ambient Air Quality Standards (NAAQS)—Section 109 of the Clean Air Act requires the U.S. Environmental Protection Agency to set nationwide standards, the NAAQS, for widespread air pollutants. Currently, six pollutants are regulated by primary and secondary NAAQS: carbon monoxide, lead, nitrogen dioxide, ozone, and particulate matter equal to or less than 10 microns in diameter, and sulfur dioxide.

99th percentile case—A statistical expression of an outcome that would occur not more than 1% of the time; the 99th percentile case is derived from the distribution of outcomes on which the mean value is based; *i.e.*, 1% of the outcomes were greater than the 99th percentile level.

nitrogen oxides (NO_X)—Gases formed primarily by fuel combustion, which contribute to the formation of acid rain. Hydrocarbons and nitrogen oxides combine in the presence of sunlight to form ozone, a major constituent of smog.

nitrogen tetroxide (N_2O_4)—A liquid oxidizer that can cause spontaneous ignition with many common materials such as, paper, leather, or wood. It also forms strong acids in combination with water, and contact can cause severe chemical burns. It is a yellow-brown liquid which is easily frozen or vaporized.

offsite—The area outside the property boundaries of Cape Canaveral Air Force Station (CCAFS) and Kennedy Space Center (KSC).

onsite—The area within the property boundaries of CCAFS and KSC.

payload—The element(s) that a launch vehicle or spacecraft carries over and above what is necessary for the operation of the vehicle. For a launch vehicle, the spacecraft being launched is the payload; for a scientific spacecraft, the suite of science instruments is the payload.

payload fairing (PLF)—The protective shell on a launch vehicle that encapsulates the spacecraft through atmospheric ascent.

peak concentration/mean concentration—The peak concentration is the highest reading in a series of samples; the mean concentration is the average of readings in a series of samples over a specified period of time.

radiation—The emitted particles (alpha, beta, neutron) or photons (gamma, X-ray) from the nuclei of unstable (radioactive) atoms as a result of radioactive decay. Some elements are naturally radioactive; others are induced to become radioactive by bombardment in a nuclear reactor or other particle accelerator.

radiation dose—The amount of energy from ionizing radiation deposited within tissues of the body; it is a time-integrated measure of potential damage to tissues from exposure to radiation and as such is related to health-based consequences.

radioactive half-life—The time required for one half the atoms in a radioactive substance to decay.

radioisotope heater unit (RHU)—A passive heating device that uses the radioactive decay of plutonium-238 dioxide to produce heat.

Relationship of Short-Term Uses and Long-Term Productivity—The balance or trade-off between short-term uses and long-term productivity need to be defined in relation to the Proposed Action.

rem—The unit dose representing the amount of ionizing radiation needed to produce the same biological effects as one roentgen of high-penetration X-rays (about 200 kilo electron volts (Kev)).

rover—A vehicle that can move freely on a planet's surface.

second stage—The launch vehicle stage that provides thrust during ascent, but not at liftoff.

source term—The quantities of materials released during an accident to air or water pathways and the characteristics of the releases (*e.g.*, particle size distribution, release height and duration); used for determining accident consequences.

sol—One day on a planet other than Earth (*i.e.*, the time it takes the planet to rotate 360º on its polar axis); on Mars, one sol is equal to 24 hours, 37 minutes or 1.026 Earth days.

stratopause—The boundary between the stratosphere and the mesosphere.

stratosphere—An upper portion of the atmosphere above the troposphere reaching a maximum height of 50 kilometers above the Earth’s surface. The temperature is relatively constant in the lower stratosphere and gradually increases with altitude. The stratosphere is Earth’s main ozone producing region.

thermal protection system—A combination of systems that protect a spacecraft from potential heat sources; heatshield.

third stage—The launch vehicle stage that provides the final thrust required to place a launch vehicle's payload into its proper trajectory or orbit.

trajectory—The flight path that a spacecraft will take during a mission.

tropopause—The boundary between the troposphere and stratosphere, usually characterized by an abrupt change of lapse rate; the change is in the direction of increased atmospheric stability from regions below to regions above the tropopause; its height varies from 15 kilometers in the tropics to about 10 kilometers in polar regions.

troposphere—The portion of the atmosphere next to the Earth’s surface in which the temperature rapidly decreases with altitude, clouds form, and convection is active. The troposphere begins at ground level and extends to an altitude of 10 to 12 kilometers above the Earth’s surface.

unavoidable adverse effects—Effects that can not be avoided due to constraints in alternatives. These effects must be disclosed, discussed and mitigated, if practicable.

upper stage—The launch vehicle stage that provides thrust required to insert a spacecraft into an interplanetary trajectory.

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APPENDIX B

ENVIRONMENTAL JUSTICE ANALYSIS

TABLE OF CONTENTS FOR APPENDIX B

ENVIRONMENTAL JUSTICE ANALYSIS

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APPENDIX B

ENVIRONMENTAL JUSTICE ANALYSIS

B.1 INTRODUCTION

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs Federal agencies to identify and address, as appropriate, the disproportionately high and adverse health or environmental effects of their programs, policies, and activities on minority populations and low-income populations.

The Council on Environmental Quality (CEQ) has oversight responsibility for documentation prepared in compliance with the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321 *et seq.*). In December 1997, the CEQ released its guidance on environmental justice (CEQ 1997). The CEQ's guidance was adopted as the basis for the information provided in this Draft Environmental Impact Statement (DEIS).

This appendix provides data necessary to assess the potential for disproportionately high and adverse human health or environmental effects that may be associated with implementation of the Mars Exploration Rover–2003 (MER–2003) project. The potentially affected area examined in this DEIS is encompassed by a circle of 100 kilometers (km) (62 miles (mi)) radius centered at the launch site at Cape Canaveral Air Force Station (CCAFS), Florida.

B.2 DEFINITIONS AND APPROACH

B.2.1 Minority Populations

During the Census of 2000, the U.S. Bureau of the Census (USBC) collected population data in compliance with guidance adopted by the Office of Management and Budget (OMB) (62 FR 58782-58790). The OMB published its guidelines on aggregation of multiple race data in March 2000 (OMB 2000). Modifications to the definitions of minority individuals in the CEQ's original definition were made in this analysis to comply with the OMB's guidelines issued in March 2000. The following definitions of minority individuals and population are used in this analysis of environmental justice:

Minority Individuals: Persons who are members of any of the following population groups: Hispanic or Latino of any race, American Indian or Alaska Native, Asian, Black or African-American, Native Hawaiian or Other Pacific Islander, or Multiracial (and at least one race which is a minority race under CEQ guidance (CEQ 1997)).

Minority Population: The total number of minority individuals residing within a potentially affected area.

Persons self-designated as Hispanic or Latino are included in the Hispanic or Latino population regardless of race. For example, Asians self-designated as Hispanic or Latino are included in the Hispanic or Latino population and not in the Asian Population.

Data used to characterize minority populations in the year 2000 were extracted from Table P4 of Standard File 3 published by the USBC on their Internet web site (www.census.gov). Data used for the projection of minority populations in Florida for the year 2003 were extracted from the USBC's Internet web site at:

http://www.census.gov/population/www/projections/stproj.html

Since projections using Census 2000 data are not yet available, 1990 Census data and the USBC's projections following the 1990 Census were used to project population data to the year 2003.

B.2.2 Low-Income Populations

Poverty thresholds are used to identify "low-income" individuals and populations (CEQ 1997). The following definitions of low-income individuals and population are used in this analysis:

Low-Income Individuals: Persons whose self-reported income is less than the poverty threshold.

Low-Income Population: The total number of low-income individuals residing within a potentially affected area.

Low-income data from Census 2000 is scheduled for publication in mid-2002. Therefore, low-income data from the 1990 Census was used in this analysis. These data were extracted from Table P121 of Standard Tape File 3 (DOC 1992).

B.2.3 Disproportionately High And Adverse Human Health Effects

Disproportionately high and adverse health effects are those that are significant (as employed by NEPA at 40 CFR Part 1580 Subpart 1508.27) or above generally accepted norms, and for which the risk of adverse impacts to minority populations or low-income populations appreciably exceeds the risk to the general population.

B.2.4 Disproportionately High And Adverse Environmental Effects

Disproportionately high and adverse environmental effects are those that are significant (as employed by NEPA), and that would adversely impact minority populations or low-income populations appreciably more than the general population.

B.3 METHODOLOGY

B.3.1 Spatial Resolution

For the purposes of enumeration and analysis, the USBC has defined a variety of areal units (DOC 1992). Areal units of concern in this document include (in order of increasing spatial resolution) states, counties, census tracts, block groups, and blocks. The block is the smallest of these entities and offers the finest spatial resolution. This term refers to a relatively small geographical area bounded on all sides by visible features such as streets and streams or by invisible boundaries such as city limits and property lines. During the 1990 census, the USBC subdivided the United States and its territories into 7,017,425 blocks. For comparison, the 1990 census used 3,248 counties, 62,276 census tracts, and 229,192 block groups. In the analysis below, block-level spatial resolution is used in the analysis of minority impacts.

B.3.2 Projections of Populations

Population estimates used in this DEIS were projected to 2003. Projections of the total population for individual states are available from both the USBC and various state agencies (Campbell 1996). The USBC also projects state populations by age, sex, race, and Hispanic origin for the years from 1995 to 2025. In order to project minority populations in potentially affected areas, minority populations determined from the 1990 census data were taken as a baseline. Then it was assumed that percentage changes in the minority population of each block group for a given year (compared to the 1990 baseline data) will be the same as percentage changes in the state minority population projected for the same year. An advantage to this assumption is that the projected populations are obtained with consistent method regardless of the state and associated block group involved in the calculation. A disadvantage is that the method is insensitive to localized demographic changes that could alter projections in a specific area.

The USBC uses the cohort-component method to estimate future populations for each state (Campbell 1996). The set of cohorts is comprised of (1) age groups from 1 year or less to 85 years or more, (2) male and female populations in each age group, and (3) racial and ethnic groups in each age group and sex (Hispanic, Asian, Black, Native American, and White). Components of the population change used in the demographic accounting system are births, deaths, net state-to-state migration, and net international migration. If P(t) denotes the number of individuals in a given cohort at time “t”, then:

$$P(t) = P(t_0) + B - D + DIM - DOM + IIM - IOM \qquad \text{(Eq. 1)}$$

where:

$P(t_0)$	=	Cohort population at time $t_0 \leq t$ (for this analysis, t_0 denotes the year 1990);
B	=	Births expected during the period from t_0 to t;
D	=	Deaths expected during the period from t_0 to t;
DIM	=	Domestic migration expected into the state during the period from t_0 to t;
DOM	=	Domestic migration expected out of the state during the period from t_0 to t;
IIM	=	International migration expected into the state during the period from t_0 to t; and
IOM	=	International migration expected out of the state during the period from t_0 to t.

Estimated values for the components shown on the right side of Equation 1 are based on past data and various assumptions regarding changes in the rates for birth, mortality, and migration (Campbell 1996). It should be noted that the USBC does not project populations of individuals who identified themselves as “Other Race” (and non-Hispanic). This population group is less than 2% of the total population in each of the states. However, in order to project total populations in the environmental justice analysis, population projections for the “Other Race” group were made under the assumption that the growth rate for the “Other Race” population will be identical to the growth rate for the combined minority and White populations.

B.3.3 Environmental Justice Assessment

The purpose of this analysis is to (1) identify minority populations and low-income populations residing in the area that would be potentially affected by implementation of the Proposed Action or alternatives, and (2) determine if implementation of the Proposed Action or alternatives would result in disproportionately high and adverse effects on these populations. Figure B-1 shows the potentially affected area within a radius of 100 km (62 mi) of the CCAFS launch site in Florida.

B.4 CHARACTERIZATION OF POTENTIALLY AFFECTED POPULATIONS

Figure B-2 shows majority and minority populations residing in the potentially affected area surrounding CCAFS during the decennial census of 2000. For further detail, Figure B-3 shows similar information for majority and minority populations residing within 30 km (19 mi) of the launch site. As indicated in Figure B-2, both the majority and minority populations begin to increase noticeably at the outskirts of the City of Orlando. The City of Merritt Island is the population center closest to the launch site. As seen in Figure B-3, both majority and minority populations show significant increases at the outskirts of Merritt Island. Figures B-4 and B-5 show analogous information for majority and minority populations expressed as a percentage of the total minority and majority populations, respectively. As indicated in Figure B-4, 10% of the minority population in the potentially affected area reside within approximately 50 km (31 mi) of the launch site, while one-half of the minority population resides within 85 km (53 mi) of CCAFS. Figure B-5 presents the same information as Figure B-4 to a finer scale. Less than 5% of the minority population resides within 30 km (19 mi) of the launch facility.

Figures B-6 and B-7 show resident minority populations residing within 100 km (62 mi) and 30 km (19 mi) of the launch facility, respectively. In addition to the minority groups shown in these figures, approximately 1,300 residents in the potentially affected area designated themselves as Native Hawaiian or Other Pacific Islander during the 2000 Census. As indicated in the figures, Hispanic or Latino and Black or African-American American populations comprise most of the minority population residing within the potentially affected area. Figures B-6 and B-7 show that as the distance from the launch facility, Blacks or African-Americans are the most numerous resident minority until approximately the outskirts of the City of Orlando. Due to the relatively large concentration of Hispanics or Latinos in Orlando, Hispanics or Latinos comprise the largest group of minority residents in the potentially affected area. Minorities comprised approximately 29% of the resident population in the potentially affected area in 2000. By the year 2003, it is reasonable to expect that the minority population would exceed 30% of the resident population.

During the 1990 Census, 10.1% of the residents within 100 km (62 mi) of CCAFS reported incomes below the 1990 poverty threshold. By comparison, the corresponding percentage for the State of Florida was 12.6%. Within 20 km (12 mi) about 8% of the population reported income below the 1990 poverty threshold, and within 10 km (6 mi) about 12.5% of the population was below the 1990 threshold.

B.5 IMPACTS ON MINORITY AND LOW-INCOME POPULATIONS

As discussed in Chapter 4 of this DEIS, accidents during the MER–A or MER–B missions could result in human exposure to radioactive and other hazardous materials. Plutonium-238, cobalt-57 and curium-244 are the primary radioactive materials of concern. Potential radiological releases could affect populations residing both within and beyond 100 km (62 mi) of the launch site. As shown in Table 4-7 of Chapter 4, if the Proposed Action were implemented, and if an accidental release of radioactive material were to occur during any mission phase, no latent cancer facilities or other health impacts would be expected to occur. The largest potential radiological consequences estimated to occur during pre-launch and early launch mission phases are 0.16 latent cancer fatality (99th percentile) for the MER–A mission and 0.12 latent cancer fatality (99th percentile) for the MER–B mission. Potential radiological consequences for the later mission phases are less than 0.004 latent cancer fatality for each mission.

Mission risks (consequences that would occur in the event of a radioactive release multiplied by the probability of a release) are also small. As shown in Table 2-4 of Chapter 2, the likelihood of an accident resulting in a release of radioactive material during pre-launch is approximately 1 in 16,000 and no more than approximately 1 in 1,100 during early launch. The corresponding risk to the local population (persons residing within 100 km (62 mi) of the launch facilities at CCAFS) of a latent cancer fatality resulting from an accident in pre-launch or early launch is approximately 1 in 106,000 (see Section 2.4.4.4). The risk to the global population of a latent cancer fatality resulting from an accident during the MER–A and MER–B missions is approximately 1 in 37,000 (see Section 2.4.4.4).

As discussed in Section 4.1.3, non-radiological accidents also pose no significant risks to the public. Prevailing winds during the MER–A and MER–B launch opportunities would generally be from the east and east-southeast (see Section 3.1.2.1). However, toxic effects that could result from a liquid propellant spill during fueling operations would not extend beyond the immediate vicinity of the launch pad. Members of the public are excluded from the area at risk during fueling operations. A fuel explosion on the launch pad or during the first few seconds of flight could temporarily increase carbon monoxide, hydrochloric acid, and aluminum oxide levels near the CCAFS boundary. One-hour average concentrations of hazardous emissions from such an explosion are less than the emergency response guidelines recommended by the American Industrial Hygiene Association and the National Research Council for the Department of Defense.

Thus, implementation of the Proposed Action would pose no significant radiological or non-radiological risks to the public, including minority and low-income groups within the total potentially affected population.

B.6 REFERENCES FOR APPENDIX B

Campbell, P. R. 1996. *Population Projections for States by Age, Sex, Race, and Hispanic Origin: 1995-2025.* U.S. Bureau of the Census , Population Division, PPL-47. October 1996.

CEQ 1997. Council on Environmental Quality. *Environmental Guidance under the National Environmental Policy Act.* Executive Office of the President, Washington, DC. Available at <http://www.Whitehouse.gov/CEQ/>. December 10, 1997.

DOC 1992. U.S. Department of Commerce. *1990 Census of Population and Housing, Summary Tape File 3 on CD-ROM.* U.S. Bureau of the Census. Washington, DC. May 1992.

OMB 2000. Office of Management and Budget. *Guidance on Aggregation and Allocation of Data on Race for Use in Civil Rights Monitoring and Enforcement.* OMB Bulletin No. 00-02, Available at <http://www.whitehouse.gov/omb/bulletins/b00-02.html>. March 9, 2000.

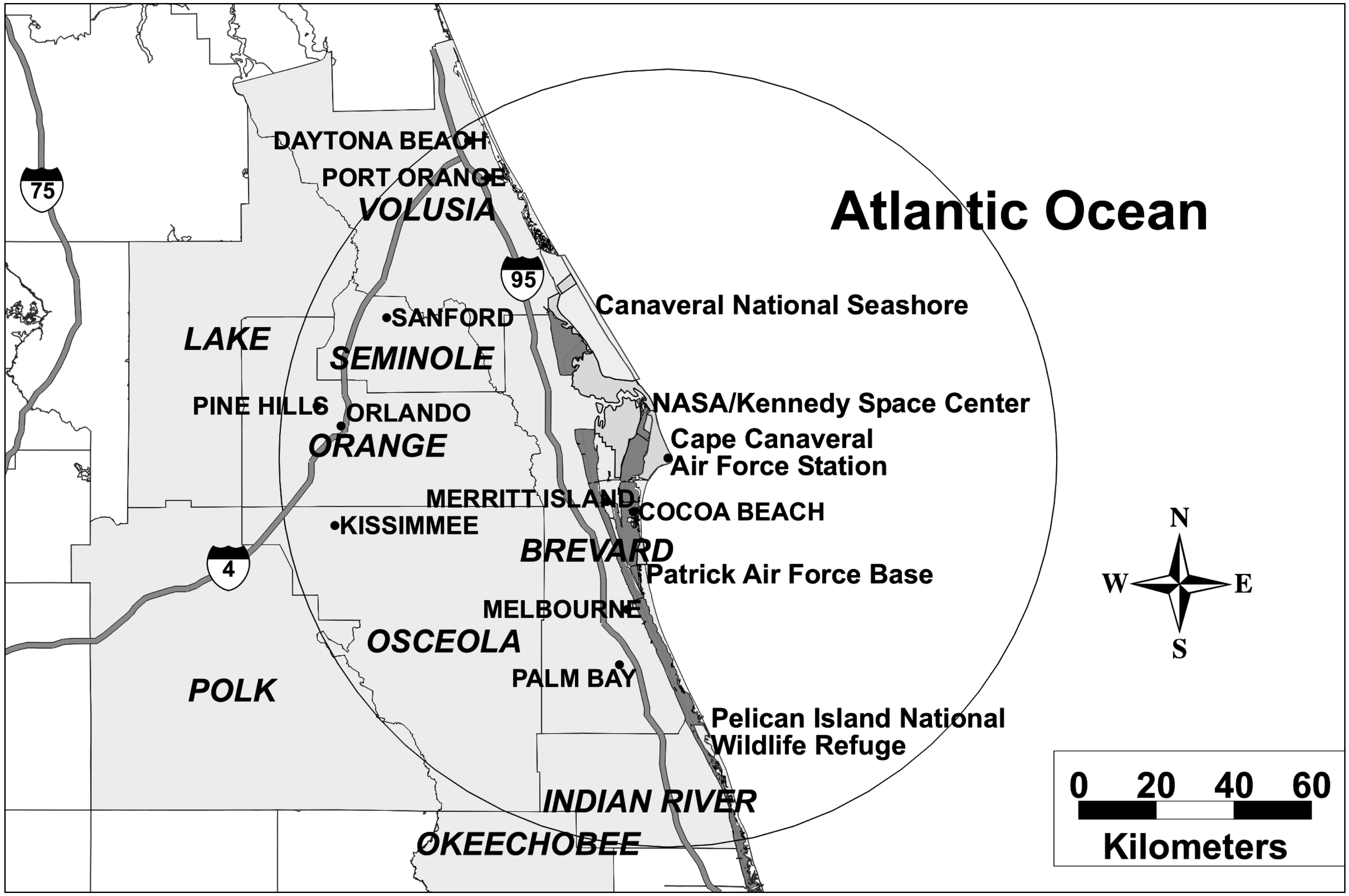

Figure B-1. Potentially Affected Area Surrounding Cape Canaveral Air Force Station

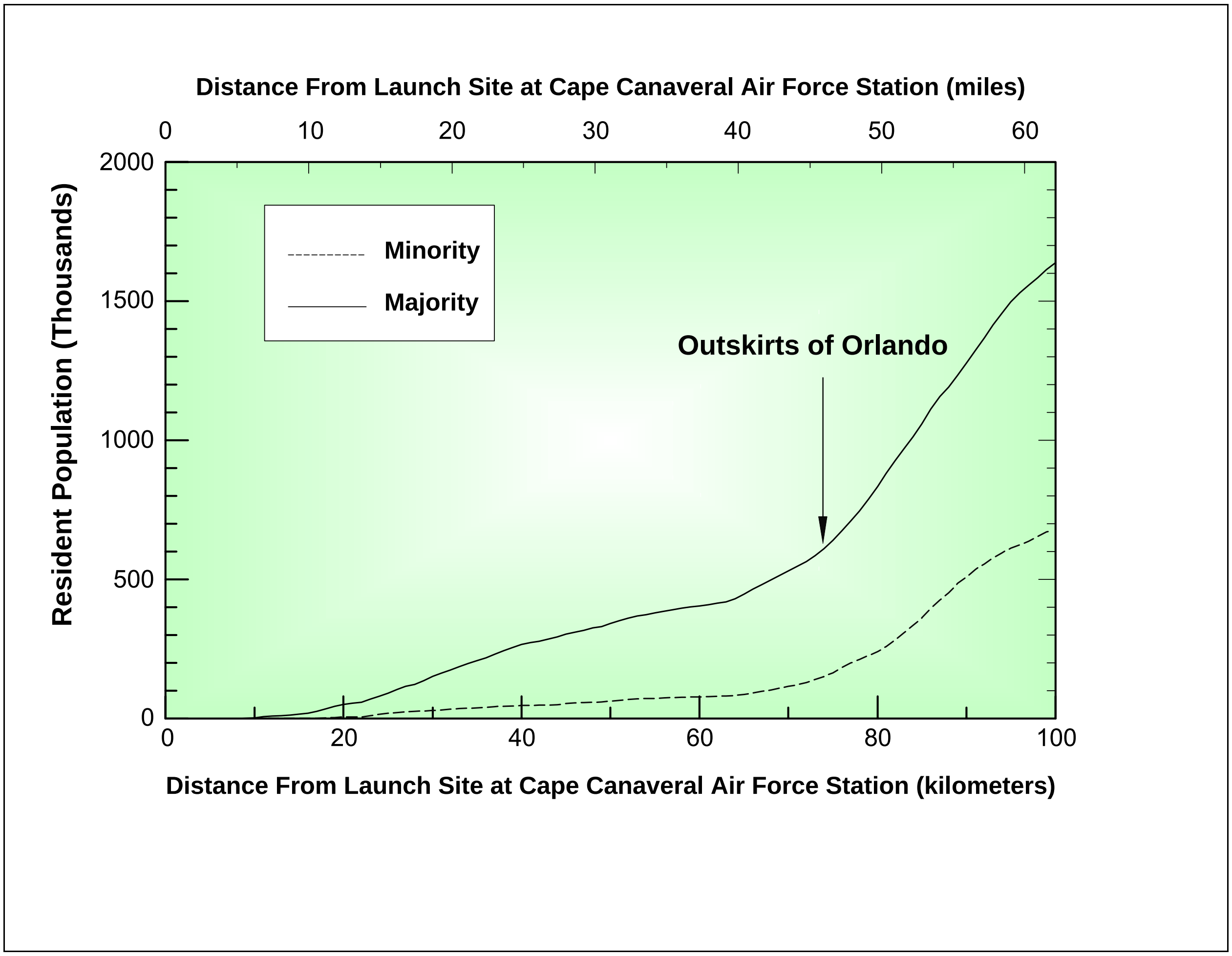

Figure B-2. Majority and Minority Populations Residing Within the Potentially Affected Area in 2000

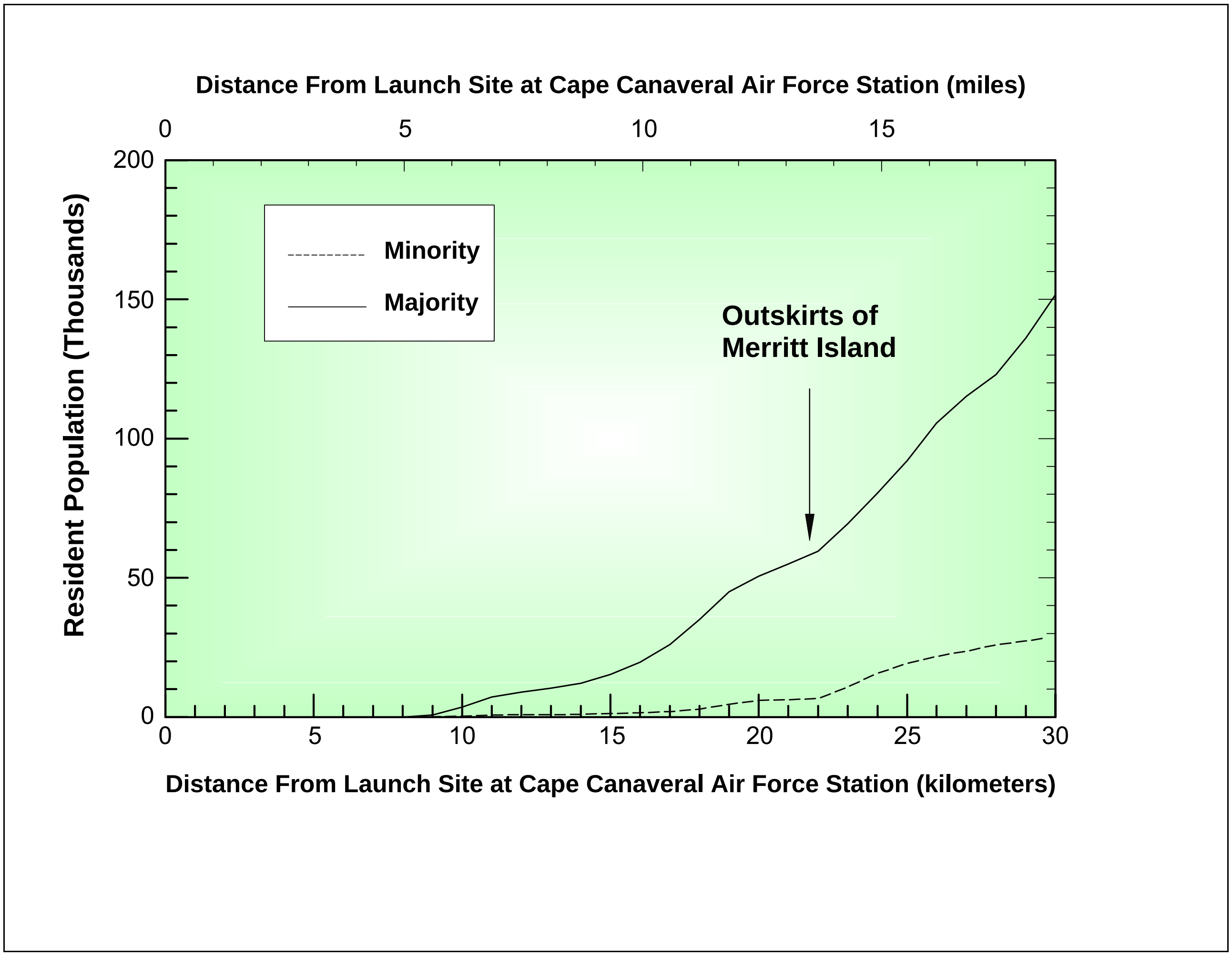

Figure B-3. Majority and Minority Populations Residing Within 30 Kilometers (19 Miles) of CCAFS in 2000

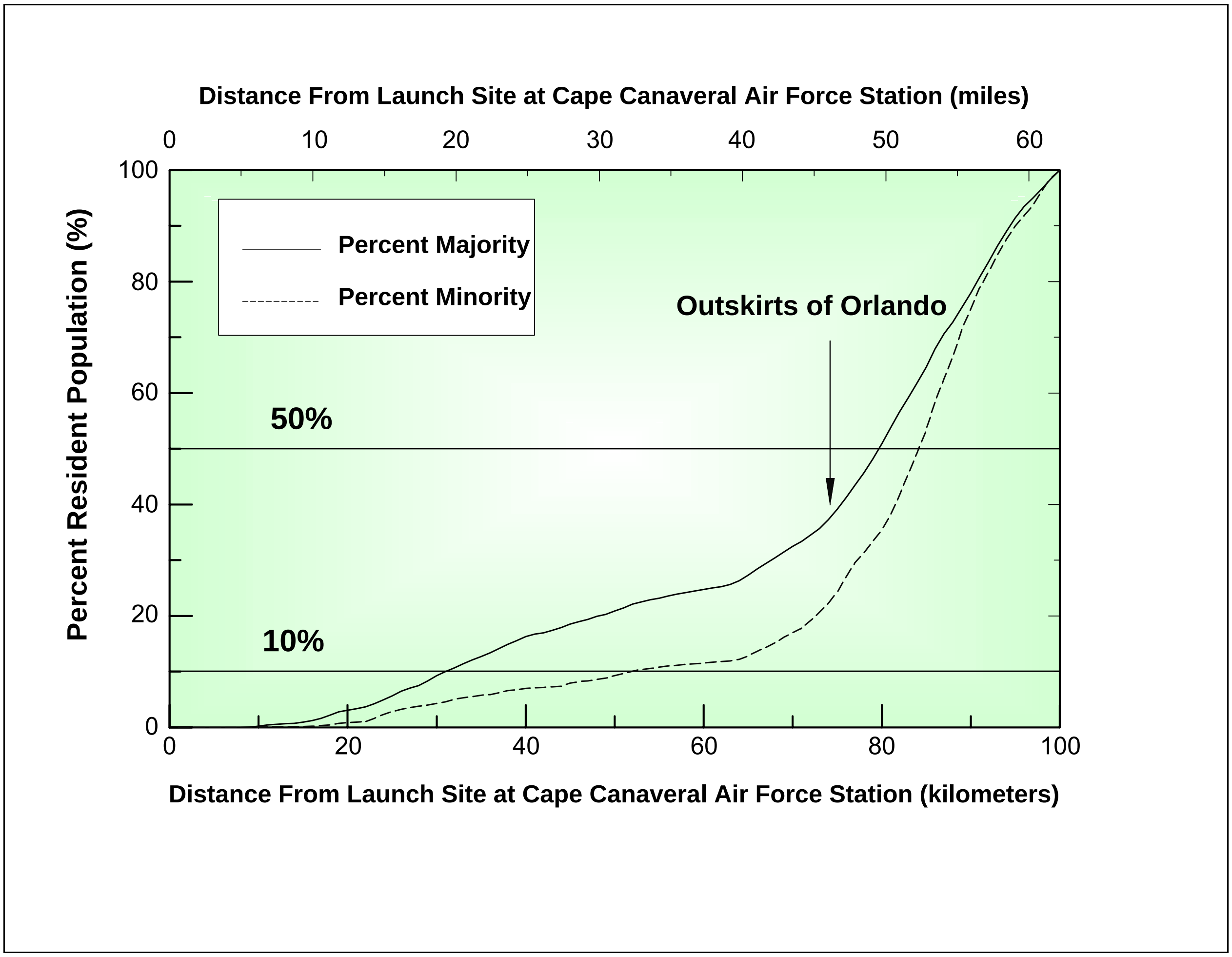

Figure B-4. Percent Majority and Minority Populations Residing Within the Potentially Affected Area in 2000

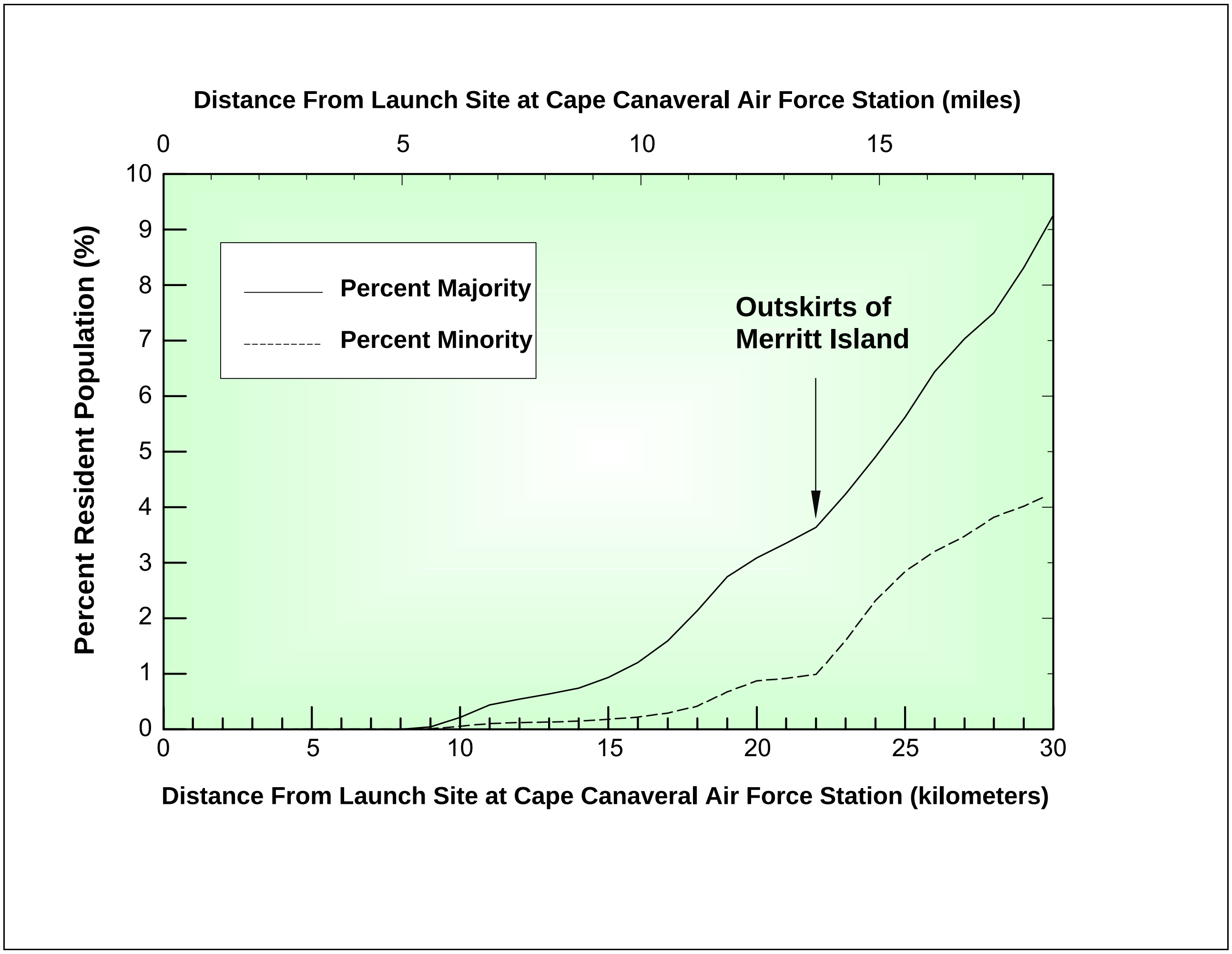

Figure B-5. Percentage of Majority and Minority Populations Residing Within 30 Kilometers (19 Miles) of CCAFS in 2000

Table B-1. Projected Racial and Ethnic Composition of the Population at Varying Distances from CCAFS for 2001 and 2005

	100 km (62 mi)			20 km (12 mi)			10 km (6 mi)		
Population	**1990**	**2001**	**2005**	**1990**	**2001**	**2005**	**1990**	**2001**	**2005**
Asian	26,298	44,444	50,229	572	967	1,093	6	10	11
Black	191,118	246,543	263,743	1,940	2,502	2,667	101	131	140
Native American	5,982	7,179	7,538	305	365	384	47	57	59
Hispanic	116,100	183,438	210,141	1,558	2,462	2,820	140	221	253
Other Race	1,168	1,390	1,471	55	65	69	0	0	0
White	1,448,678	1,608,033	1,651,493	44,136	48,991	50,315	2,492	2,767	2,841
Minority	339,498	481,604	531,651	4,375	6,296	6,964	294	419	463
Total	1,789,344	2,091,027	2,184,615	48,566	55,352	57,348	2,786	3,186	3,304
Percent Minority	19.0%	23.0%	24.3%	9.0%	11.4%	12.1%	10.6%	13.2%	14.0%
Percent Low Income	10.1%	—	—	8.3%	—	—	12.5%	—	—

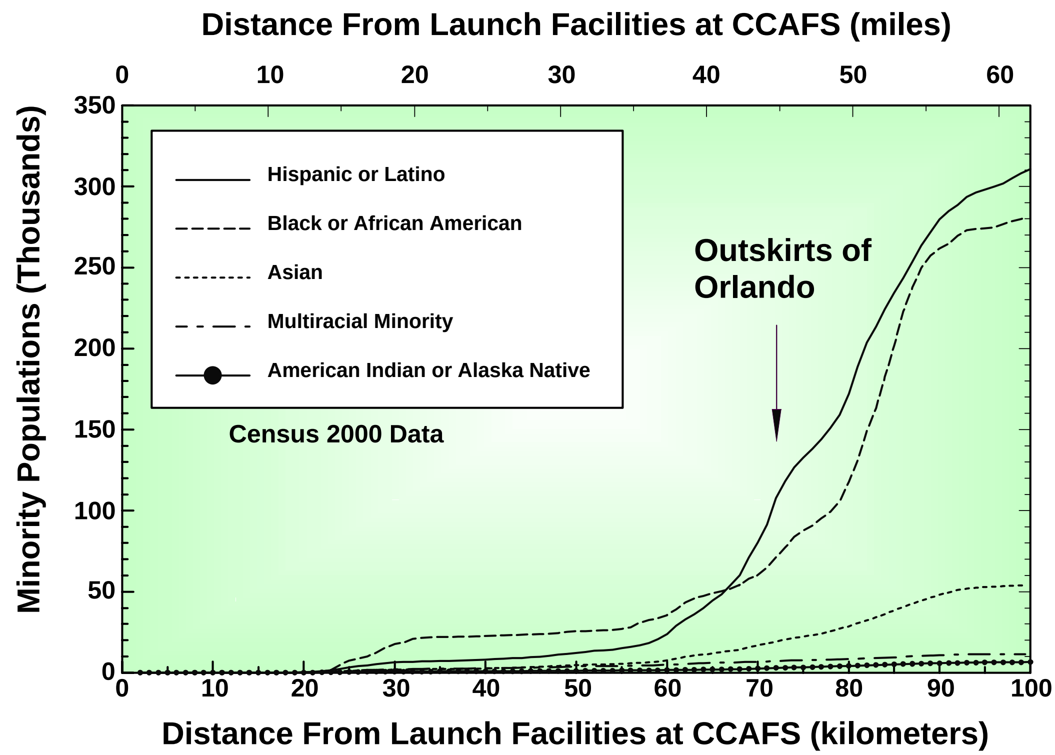

Figure B-6. Minority Populations Residing Within the Potentially Affected Area in 2000

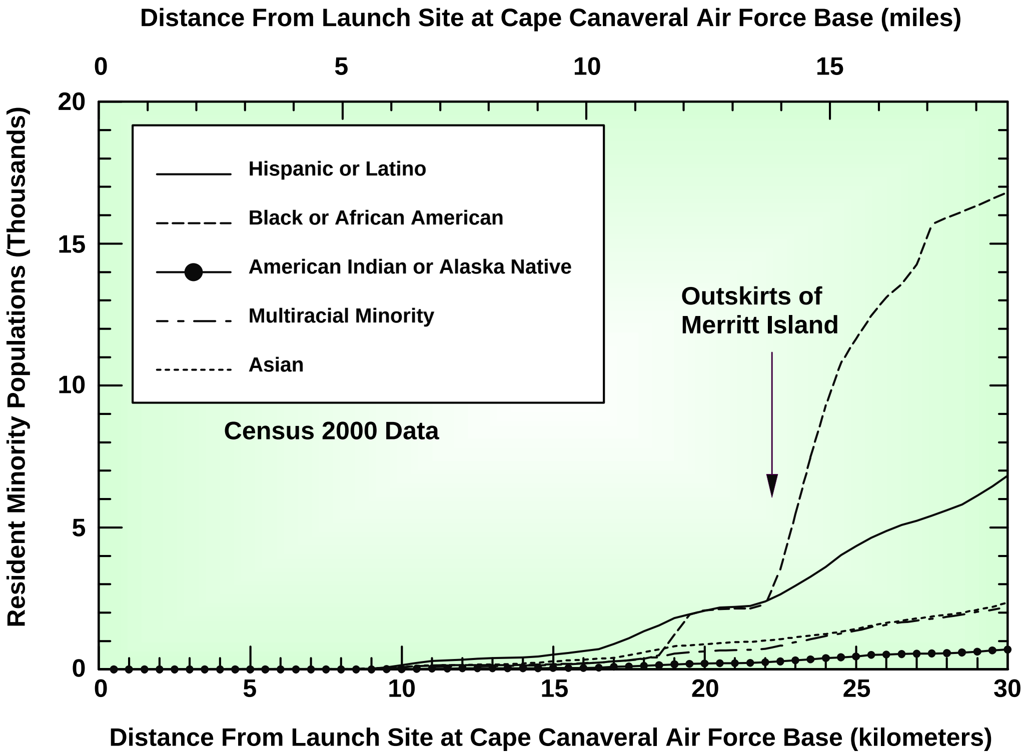

Figure B-7. Minority Population Residing Within 30 Kilometers (19 Miles) of CCAFS in 2000

APPENDIX C

RESPONSES TO PUBLIC REVIEW COMMENTS

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APPENDIX C

RESPONSES TO PUBLIC REVIEW COMMENTS

The U.S. Environmental Protection Agency (EPA) published a Notice of Availability (NOA) for the Draft Environmental Impact (DEIS) for the Mars Exploration Rover–2003 Project in the *Federal Register* on July 26, 2002 (67 FR 48894). The DEIS was mailed by NASA to 79 potentially interested Federal, State and local agencies, organizations and individuals. In addition, the DEIS was publicly available in electronic format from a NASA server on the Internet. The public review and comment period closed on September 9, 2002. A total of six comment letters were received: three from Federal agencies, one from the State of Florida (which consolidated the reviews of several State agencies), and two, via electronic mail, from individuals.

This appendix provides specific responses to the comments received from the agencies and individuals listed in Table C-1. Copies of each letter, including attachments, are presented in the following pages. The relevant comments in each letter are marked and numbered for identification. The comments received included "no comment", requests to clarify specific points of discussion in the text, and an objection to the use of nuclear material in space. NASA's response to each identified comment is presented in Table C-2, which follows the letters.

Table C-1. Agencies and Individuals Providing Comments

Commentor Number	Organization	Individual Presenting Comment
1	U.S. Environmental Protection Agency	Anne Norton Miller
2	Federal Aviation Administration	Patricia Grace Smith
3	United States Air Force	Angy Chambers
4	State of Florida	Sally B. Mann
5	–	Norma J. F. Harrison
6	–	Kev

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

SEP - 9 2002

Mr. David Lavery
Mars Exploration Program Office
Office of Space Science (Mail Code SM)
National Aeronautics and Space Administration
Washington, DC 20546-0001

Dear Mr. Lavery:

In accordance with National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act, the Environmental Protection Agency (EPA) has reviewed the National Aeronautics and Space Administration's (NASA) draft environmental impact statement (EIS) for the Mars Exploration Rover-2003 Project.

The proposed action would consist of two missions to send two identical mobile science laboratories (rovers) to two different sites on the surface of Mars. The first spacecraft would be launched during May or June 2003, with arrival at Mars in January 2004. The second spacecraft wold be launched during June or July 2003, with arrival at Mars in January 2004.

EPA believes that this EIS provides an adequate discussion of the potential environmental impacts of these particular Mars missions. Therefore, EPA has no objection to the proposed actions as discussed in this draft EIS. **|– 1-1**

We appreciate the opportunity to review this draft EIS. The staff contact for this review is Ken Mittelholtz (202-564-7156).

Sincerely,

Anne Norton Miller
Director
Office of Federal Activities

Internet Address (URL) • http://www.epa.gov
Recycled/Recyclable • Printed with Vegetable Oil Based Inks on Recycled Paper (Minimum 25% Postconsumer)

Comment Letter #1: U.S. Environmental Protection Agency

U.S. Department of Transportation
Federal Aviation Administration

800 Independence Ave., S.W.
Washington, D.C. 20591

SEP 9 2002

Mr. David Lavery
Mars Exploration Program Office
Office of Space Science
NASA Headquarters
Washington, DC 20546

Dear Mr. Lavery:

Thank you for the opportunity to comment on the Draft Environmental Impact Statement for the Mars Exploration Rover-2003 Project. I am pleased to submit the following comments for your consideration.

Section 2.1.3. It may also be useful to add that the airspace over SLC-17 would be restricted and would therefore be part of the security measures that are in place for each launch. |– 2-1

Section 2.1.5.7. Given the recent concerns with security surrounding launch events and publication of the actual launch dates and times, it may be appropriate to mention that the launch dates listed in the Draft EIS (i.e., May 30, 2003 and June 25, 2003) represent only the opening of the launch window and not necessarily the actual planned date of the launch. The actual dates would be released when appropriate to notify relevant agencies and the public of the planned launch event. |– 2-2

Section 2.3.1. As explained in the Draft EIS, a single mission would not allow NASA to meet all mission objectives; however, please clarify what would happen if a spacecraft is lost or if a launch window is missed. In either of these scenarios would NASA propose to continue the project with only one spacecraft or would other arrangements be made? |– 2-3

Sections 4.1.4 and 4.1.5. It may be helpful to compare the risk characterized in these sections to risks that people are exposed to every day to provide a context for the reader. |– 2-3

Please feel free to contact Michon Washington of my office at (202) 267-9305 if you have any questions.

Sincerely,

Patricia Grace Smith
Associate Administrator for
Commercial Space Transportation

Comment Letter #2: Federal Aviation Administration

ENGINEERING REVIEW COMMENTS			1. DATE: 27-Aug-02
2. Project: Draft Environmental Impact Statement for the Mars Exploration Rover – 2003 Project			
3. Office Symbol of Reviewer: 45 CES/CEV		4. Name and Phone number of Reviewer Multiple Reviewers POC Angy Chambers	
5. ITEM NUMBER	6. DRAWING OR PARAGRAPH NUMBER	7. COMMENTS	
1	Abstract, Paragraph 3, Page iii/iv	Suggest changing second to last sentence to read, "Expected environmental effects would include short-term impacts to air quality, vegetation, wildlife and stratospheric ozone."	3-1
2	Page 2-10, Payload Processing	Although processing of the payload is discussed, a short discussion on transportation of the payload over NASA and AF lands should be included.	3-2
3	Page 2-16, Section 2.3	What about the alternative of launching both rovers on one Delta?	3-3
4	Page 3-17, Section 3.1.6.3, Paragraph 2	Suggest re-wording last sentence of paragraph. Although coastal vervain is a state-listed species and is located on CCAFS/KSC, there are other state-listed species located on both properties, as well.	3-4
5	Page 3-19, Paragraph 1	Removing the sentence that begins "Nighttime lighting near nesting beaches can sometimes result.." This is not entirely accurate. Nest site selection is most heavily influenced by nonvisual cues. It is rare for a nest on CCAFS/KSC to be deposited in the intertidal zone because of lighting. Replace sentence with "Extensive research has demonstrated that artificial lighting deters adult female turtles from emerging from the water and nesting."	3-5
6	Page 3-24, Section 3.1.7.4, Paragraph 2	Cape Canaveral Hospital is located closer to CCAFS/KSC than Wuesthoff; therefore, wouldn't this be another option?	3-6
7	Page 4-28, Paragraph 4	Reword to state that hazardous waste generated in support of this mission will be disposed under either Boeing's or NASA's EPA identification number (depending on agreements between the two organizations). The waste will not be disposed by the Air Force.	3-7
8	Page 4-29, Paragraph 2	What are the established standard practices mentioned here?	3-8
9	General	Measures should be taken to safeguard the payload in case of controlled burns or wildfires on KSC/CCAFS. A pro-active vegetative fuel reduction and habitat restoration program takes place on both KSC and CCAFS. It is recommended that proper filtration systems be at hand to protect the payloads to prevent impacts to these programs.	3-9

Comment Letter #3: United States Air Force

Department of Environmental Protection

Jeb Bush
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard, MS 47
Tallahassee, Florida 32399-3000

David B. Struhs
Secretary

September 3, 2002

Mr. David Lavery
Office of Space Science
Code SM
NASA Headquarters
Washington, DC 20546-0001

RE: National Aeronautics and Space Administration - Draft Environmental Impact Statement For Mars Exploration Rover – 2003 Project (MER-2003) – Cape Canaveral, Brevard County, Florida
SAI: FL200207242467C

Dear Mr. Lavery:

The Florida State Clearinghouse, pursuant to Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, has coordinated the review of the above-referenced Draft Environmental Impact Statement (DEIS).

Based on the information contained in the above-referenced DEIS and the enclosed comments provided by our reviewing agencies, the state has determined that the proposed project is consistent with the Florida Coastal Management Program (FCMP). Thank you for the opportunity to review this project. If you have any questions regarding this letter, please contact Ms. Rosalyn Kilcollins at (850) 922-5438. |– 4-1

Sincerely,

Sally B. Mann, Director
Office of Intergovernmental Programs

SBM/rk

Enclosures

"More Protection, Less Process"

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Comment Letter #4: State of Florida

DIVISIONS OF FLORIDA DEPARTMENT OF STATE
Office of the Secretary
Office of International Relations
Division of Elections
Division of Corporations
Division of Cultural Affairs
Division of Historical Resources
Division of Library and Information Services
Division of Licensing
Division of Administrative Services

MEMBER OF THE FLORIDA CABINET
State Board of Education
Trustees of the Internal Improvement Trust Fund
Administration Commission
Florida Land and Water Adjudicatory Commission
Siting Board
Division of Bond Finance
Department of Revenue
Department of Law Enforcement
Department of Highway Safety and Motor Vehicles
Department of Veterans' Affairs

FLORIDA DEPARTMENT OF STATE
Jim Smith
Secretary of State
DIVISION OF HISTORICAL RESOURCES

Ms. Cindy Cranick
Florida State Clearinghouse Coordinator
Florida Department of Environmental Protection
3900 Commonwealth Boulevard, Mail Station 47
Tallahassee, Florida 32399-3000

August 15, 2002

RECEIVED
AUG 21 2002
OIP/OLGA

RE: DHR No. 2002-07550 / Received by DHR: August 1, 2002
SAI #: 200207242467C
Draft Environmental Impact Statement for the Mars Exploration Rover – 2003 Project
Cape Canaveral, Brevard County

Dear Ms. Cranick:

Our office received and reviewed the above referenced project in accordance with Section 106 of the *National Historic Preservation Act of 1966* (Public Law 89-665), as amended in 1992, and *36 C.F.R., Part 800: Protection of Historic Properties*. The State Historic Preservation Officer is to advise Federal agencies when identifying historic properties (listed or eligible for listing, in the *National Register of Historic Places*), assessing effects upon them, and considering alternatives to avoid or minimize adverse effects.

We have reviewed sections 3.1.8 and 4.1.2.11, both dealing with Cultural Resources, of the referenced environmental impact statement. Based on the information provided, it is the opinion of this office that the proposed undertaking will have no effect on historic properties.

If there are any questions concerning our comments or recommendations, please contact Sarah Jalving, Historic Sites Specialist, by electronic mail at sjalving@mail.dos.state.fl.us or at 850-245-6333 or SunCom 205-6333. Thank you for your interest in protecting Florida's historic properties.

Sincerely,

Frederick P. Gaske, Deputy SHPO
for Janet Snyder Matthews, Ph.D., Director, and
State Historic Preservation Officer

500 S. Bronough Street • Tallahassee, FL 32399-0250 • http://www.flheritage.com

☐ Director's Office (850) 245-6300 • FAX: 245-6435
☐ Archaeological Research (850) 245-6444 • FAX: 245-6436
☑ Historic Preservation (850) 245-6333 • FAX: 245-6437
☐ Historical Museums (850) 245-6400 • FAX: 245-6433
☐ Palm Beach Regional Office (561) 279-1475 • FAX: 279-1476
☐ St. Augustine Regional Office (904) 825-5045 • FAX: 825-5044
☐ Tampa Regional Office (813) 272-3843 • FAX: 272-2340

Comment Letter #4 Attachment #1

Lauren

COUNTY: BREVARD

Message:

DATE: 7/24/2002
COMMENTS DUE DATE: 8/23/2002
CLEARANCE DUE DATE: 9/5/2002
SAI#: FL200207242467C

STATE AGENCIES	WATER MNGMNT. DISTRICTS	OPB POLICY UNITS
AGRICULTURE OTTED COMMUNITY AFFAIRS FISH and WILDLIFE COMMISSION STATE TRANSPORTATION X ENVIRONMENTAL PROTECTION	ST. JOHNS RIVER WMD	ENVIRONMENTAL POLICY UNIT

RECEIVED
JUL 30 2002
OIP/OLGA

To: **Florida State Clearinghouse**
AGENCY CONTACT AND COORDINATOR (SCH)
2555 SHUMARD OAK BLVD
TALLAHASSEE, FLORIDA 32399-2100
(850) 414-6580 (SC 994-6580)
(850) 414-0479

EO. 12372/NEPA

- ☐ No Comment
- ☐ Comment Attached
- ☐ Not Applicable

Federal Consistency

- ☑ No Comment/Consistent
- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

From:
Division/Bureau: OS/OIP
Reviewer: R. Kilwlling / McMigan
Date: 8/30/02

Comment Letter #4 Attachment #2

COUNTY: BREVARD

Message:

DATE: 7/24/2002
COMMENTS DUE DATE: 8/23/2002
CLEARANCE DUE DATE: 9/5/2002
SAI#: FL200207242467C

STATE AGENCIES	WATER MNGMNT. DISTRICTS	OPB POLICY UNITS
AGRICULTURE OTTED COMMUNITY AFFAIRS X FISH and WILDLIFE COMMISSION STATE TRANSPORTATION ENVIRONMENTAL PROTECTION	ST. JOHNS RIVER WMD	ENVIRONMENTAL POLICY UNIT

RECEIVED
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2555 SHUMARD OAK BLVD
TALLAHASSEE, FLORIDA 32399-2100
(850) 414-6580 (SC 994-6580)
(850) 414-0479

EO. 12372/NEPA

- [x] No Comment
- [ ] Comment Attached
- [ ] Not Applicable

Federal Consistency

- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:
Division/Bureau: ENVIRONMENTAL SERVICES
Reviewer: BRIAN BARNETT
Date: 8/2/02

Comment Letter #4 Attachment #3

COUNTY: BREVARD

DATE: 7/24/2002
COMMENTS DUE DATE: 8/23/2002
CLEARANCE DUE DATE: 9/5/2002
SAI#: FL200207242467C

Message:

STATE AGENCIES	WATER MNGMNT. DISTRICTS	OPB POLICY UNITS
AGRICULTURE OTTED X COMMUNITY AFFAIRS FISH and WILDLIFE COMMISSION STATE TRANSPORTATION ENVIRONMENTAL PROTECTION	ST. JOHNS RIVER WMD	ENVIRONMENTAL POLICY UNIT RECEIVED JUL 31 2002 RPM BSP PLAN PROCESSING TEAM

RECEIVED
AUG 02 2002
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To: **Florida State Clearinghouse**
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2555 SHUMARD OAK BLVD
TALLAHASSEE, FLORIDA 32399-2100
(850) 414-6580 (SC 994-6580)
(850) 414-0479

EO. 12372/NEPA

- ☒ No Comment
- ☐ Comment Attached
- ☐ Not Applicable

Federal Consistency

- ☐ No Comment/Consistent
- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

From:
Division/Bureau: DCA/DCP
Reviewer: [signature]
Date: 8/1/02

Comment Letter #4 Attachment #4

COUNTY: BREVARD

Message:

DATE: 7/24
COMMENTS DUE DATE: 8/23
CLEARANCE DUE DATE: 9/5
SAI#: FL2002072424

STATE AGENCIES	WATER MNGMNT. DISTRICTS	OPB POLICY UNITS
AGRICULTURE OTTED COMMUNITY AFFAIRS FISH and WILDLIFE COMMISSION STATE X TRANSPORTATION ENVIRONMENTAL PROTECTION	ST. JOHNS RIVER WMD	ENVIRONMENTAL POLICY UNIT

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To: **Florida State Clearinghouse**
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2555 SHUMARD OAK BLVD
TALLAHASSEE, FLORIDA 32399-2100
(850) 414-6580 (SC 994-6580)
(850) 414-0479

EO. 12372/NEPA
- [x] No Comment
- [ ] Comment Attached
- [ ] Not Applicable

Federal Consistency Mars Exploration
- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:
Division/Bureau: FDOT
Reviewer: Sandra Whitmire
Date: 7/31/02

Comment Letter #4 Attachment #5

COUNTY: BREVARD

Rec'd 8/6/02
2205

Message:

DATE:	7/24/2002
COMMENTS DUE DATE:	8/23/2002
CLEARANCE DUE DATE:	9/5/2002
SAI#:	FL200207242467C

Voice-Line 8/22

STATE AGENCIES	WATER MNGMNT. DISTRICTS	OPB POLICY UNITS
AGRICULTURE OTTED COMMUNITY AFFAIRS FISH and WILDLIFE COMMISSION STATE TRANSPORTATION ENVIRONMENTAL PROTECTION	X ST. JOHNS RIVER WMD	ENVIRONMENTAL POLICY UNIT RECEIVED AUG 27 2002 OIP/OLGA

To: Florida State Clearinghouse
AGENCY CONTACT AND COORDINATOR (SCH)
2555 SHUMARD OAK BLVD
TALLAHASSEE, FLORIDA 32399-2100
(850) 414-6580 (SC 994-6580)
(850) 414-0479

EO. 12372/NEPA

- ☐ No Comment
- ☐ Comment Attached
- ☐ Not Applicable

Federal Consistency

- ☒ No Comment/~~Consistent~~
- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

From:

Division/Bureau: OCGA / SJRWMD

Reviewer: [signature]

Date: 8/22/02

Comment Letter #4 Attachment #6

COUNTY: BREVARD

Message:

DATE: 7/24/2002
COMMENTS DUE DATE: 8/23/2002
CLEARANCE DUE DATE: 9/5/2002
SAI#: FL200207242467C

FILE COPY

STATE AGENCIES	WATER MNGMNT. DISTRICTS	OPB POLICY UNITS
AGRICULTURE X OTTED COMMUNITY AFFAIRS FISH and WILDLIFE COMMISSION STATE TRANSPORTATION ENVIRONMENTAL PROTECTION	ST. JOHNS RIVER WMD	ENVIRONMENTAL POLICY UNIT

RECEIVED
JUL 31 2002
OFFICE OF POLICY AND BUDGET
ENVIRONMENTAL POLICY UNIT

To: **Florida State Clearinghouse**
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2555 SHUMARD OAK BLVD
TALLAHASSEE, FLORIDA 32399-2100
(850) 414-6580 (SC 994-6580)
(850) 414-0479

EO. 12372/NEPA

- ☑ No Comment
- ☐ Comment Attached
- ☐ Not Applicable

Federal Consistency

- ☐ No Comment/Consistent
- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

From:
Division/Bureau: OPB, DRGG
Reviewer: [signature]
Date: 8/23/02

RECEIVED
AUG 30 2002
OIP/OLGA

Comment Letter #4 Attachment #7

MyFlorida.com

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- Home
- My In-Box
- New Project
- Search Project
- DB Maintenance
- Help

Public Area

- Brochure
- Manual

GO help | 411 | feedback | directory

email Governor Jeb Bush

Gov. Bush's E-Newsletter

STATE CLEARINGHOUSE

Home > My In-Box > Search Project > **Add Agency Comments**

User: ROSALYN KILCOLLINS, , Clearinghouse

Project Information

Project:	FL200207242467C
Description:	National Aeronautics and Space Aministration - Draft Environmental Impact Statement for the Mars Exploration Rover-2003 Project (MER-2003) - July 2002 - Cape Canaveral, Brevard County, Florida.
Keywords:	NASA - DEIS - MER-2003 - Cape Canaveral, Brevard
Program:	

Review Comments **Page:** GO! Page **1/11**

Agency:	AGRICULTURE
Date:	08/23/2002 (mm/dd/yyyy)
Description:	No Comment
Comment Type:	Draft ◉ Final

Save

Comment Letter #4 Attachment #8

MyFlorida.com

Clearinghouse

help | 411 | feedback | directory

email Governor Jeb Bush

Gov. Bush's E-Newsletter

STATE CLEARINGHOUSE

Home > My In-Box > Search Project > **Update Agency Comments**

User: ROSALYN KILCOLLINS, , Clearinghouse

Home

My In-Box

New Project

Search Project

DB Maintenance

Help

Public Area

Brochure

Manual

Project Information

Project:	FL200207242467C
Description:	National Aeronautics and Space Aministration - Draft Environmental Impact Statement for the Mars Exploration Rover-2003 Project (MER-2003) - July 2002 - Cape Canaveral, Brevard County, Florida.
Keywords:	NASA - DEIS - MER-2003 - Cape Canaveral, Brevard
Program:	

Review Comments Page: GO Page **10/11**

Agency:	E. CENTRAL FL RPC
Date:	08/13/2002 (mm/dd/yyyy)
Description:	N/C
Comment Type:	Draft ◉ Final

Save

Comment Letter #4 Attachment #9

Norma J. F. Harrison, 7/30/02 6:19 PM -0700, Don't send me your lies, your huge package 1

Date: Tue, 30 Jul 2002 18:19:26 -0700
From: "Norma J. F. Harrison" <normaha@pacbell.net>
Subject: Don't send me your lies, your huge packages,
your expensive trappings designed to smack me in the face and
To: marsnepa@hq.nasa.gov
X-Priority: 3
Status: RO

I told you not to put fission and fusion into outer space. I said you're walking you don't know where. You and your god of armageddon - being that god, yourselves - proceed apace to blow up as much of the universe as you can reach as much as you can. |– 5-1

I did not address a Mars exploration, and certainly have no use for the thick and lengthy volume our tax money paid to have sent to me. I know, it costs you little to send it, not that you charge little...

And you laugh, in your imperialist robes - you laugh at us all who try to keep grace and beauty...

Don't send me your lies, your huge packages, your expensive trappings designed to smack me in the face and to appear to be reasonable because they're bound fancily.

Norma J F Harrison
1312 Cornell
Berkeley 94702 Ca
normaha@pacbell.net
510-527-9584 non-business
510-526-3968 Summit Bay Realty/& facs

Printed for marsnepa <marsnepa@hq.nasa.gov> 1

Comment Letter #5: Norma J. F. Harrison

From: kevcross@webtv.net (+ Kev +)
Date: Fri, 26 Jul 2002 06:23:45 -0400 (EDT)
To: kevcross@webtv.net
Cc: osspluto@hq.nasa.gov (Mr. Kurt Lindstrom),
roger.launius@hq.nasa.gov (Roger Launius),
steve.garber@hq.nasa.gov (Steve Garber), whill@hq.nasa.gov,
prutledg@hq.nasa.gov, OOSA@unov.un.or.at,
sandra.m.dawson@jpl.nasa.gov (Sandra M. Dawson), Cassini@jpl.nasa.gov,
david.f.doody@jpl.nasa.gov (David F. Doody), history@lists.hq.nasa.gov,
leslie.j.deutsch@jpl.nasa.gov (Leslie J. Deutsch),
info@universetoday.com (Editor, Universe Today),
opa@nrc.gov (Office of Public Affairs/NRC),
osseuropa@hq.nasa.gov (Europa Orbiter comments),
osspluto@hq.nasa.gov (Pluto-Kuiper Express comments),
comments@www.hq.nasa.gov (NASA comments),
marsnepa@hq.nasa.gov (Mr. David Lavery),
fgregory@hq.nasa.gov (Fred Gregory), rxw@nrc.gov (Russell Wise, NRC),
eec@nrc.gov (Elmo Collins), tpg@nrc.gov (Pat Gwynn),
pac@cpuc.ca.gov (Clanon, Paul), JEA@cpuc.ca.gov (Ajello, Julian E.),
czw@cpuc.ca.gov (Wong, Zee Z.), rwc@cpuc.ca.gov (Clark, Richard W.),
the.secretary@hq.doe.gov (NRC), boba@energy.ca.gov (Bob Aldrich),
BByron@energy.state.ca.us (Barbara Byron),
swoods1@dhs.ca.gov (Steve Woods),
energia@energy.ca.gov (Calif Energy Committee),
webmaster.oria@epa.gov (Webmaster, Yucca Mountain Project)
Subject: Space4Peace.org - KEEP SPACE FOR PEACE

== + ==
http://Antiwar.com.
http://www.Space4Peace.org.
Thank you.
+ Kev +
== + ==
"Seek love in the Pity of other's Woe,
in the gentle relief of another's care,
In the darkness of night and winter's snow,
In the naked and outcast. Seek Love there!"

-- William Blake (in "William Bond")
============== + ==============
Support http://Antiwar.com & the Global Network Against Weapons &
Nuclear Power in Space http://www.Space4Peace.org.
== + ==
STOP STAR WARS - KEEP SPACE FOR PEACE
== + ==
A NEW WAVE OF WEAPONRY:
Directed Energy Weapons (DEWs): A Bibliography - websites
http://web.nps.navy.mil/~library/bibs/dewweb.htm
== + ==
'SPACE WAR LINKS' on U.S. military plans for global control through, in
their words, "full spectrum dominance":

(1) U.S. Space Command's LONG RANGE PLAN:
http://www.spacecom.af.mil/usspace/LRP/cover.htm
(2) http://www.af.mil/vision
(3) http://www.dtic.mil/jv2020
(4) http://www.spacecom.af.mil/usspace

Comment Letter #6: Kev

(5) Report of the Commission to Assess United States National Security Space Management and Organization
http://www.defenselink.mil/pubs/space20010111.html
== + ==
Please help the Plowshares, Catholic Worker & anti-Trident movements & similar progressive peace-justice-faith-spirit groups.

The blessings of love, peace & justice from Kevin, 47; U.S. Navy veteran (Vietnam evacuation-pull-out, 1975), former law school student & newspaper reporter. Pacifist, cyber-info-warrior, gardener, stay-home father-of-4, in Fla. (Tampa Bay) USA.

Repent now, rejoice in all things, endure affliction, make each act a prayer offering to God, pray without ceasing:

"Blessed are the nonviolent peacemakers and the truthtellers. Lord, open and soften our hearts, make us instruments of Your peace. Help us speak truth to power yet love our enemies, to pray for the salvation of those who persecute us, to reconcile with and forgive those who've hurt us, to feed, clothe, house the poor and infirm. Oh gentle, Merciful Jesus Christ, you have already sent us your Holy Spirit, now come quickly in Your Grace and Glory. Come with Your Kingdom beloved Son of God, Lamb of God, Prince of Peace. Amen.

Gratitude to Daniel and Philip Berrigan (& Liz), and to Thich Nhat Hanh, plus the countless, nameless, faceless others. Hats off to Bob Dylan, Bruce Springsteen & the E Street Band, Bob Marley, Joe Strummer and The Clash, Van Morrison and Stevie Wonder. Fervent ongoing prayers for Beverley Britton, Marshall "Eminem" Mathers, Leonard Peltier, Bill Smirnow, Eric Garris, Justin Raimondo, Bruce Gagnon, Bill Sulzman, Karl Grossman, Carol Wolman, Lew Rockwell, the Los Angeles Catholic Worker, Max Obuszewski, Jonah House, Bishop Robert N. Lynch, Rev. William Swengros and Pope John Paul II.

+ Honoring the memory of St. Francis of Assisi ("Brother Sun") & St. Clare of Assisi ("Sister Moon"), St. Anthony of Padua, St. Teresa of Avila, St. John of the Cross, St. Therese of Lisieux ("the Little Flower"), Charles de Foucauld, St. Maximilian Kolbe, Mahatma Gandhi, Peter Maurin, Pope Blessed John XXIII, Thomas Merton, Martin Luther King Jr., St. Padre Pio, Oscar Romero, Father John Hugo, Cesar Chavez, Dorothy Day, Mother Teresa and Our Lady of Lourdes. +

Amen, beloved, in blessedness I say unto you precious friends, empty yourself, renounce and strip yourself of worldy goods ... store up your treasures in heaven (not here below) ... and work out your salvation with diligence. Live in humility like a lamb among the wolves and pray for God's mercy on them. Try to give-give-give, for who can outgive God? Gently redeem your suffering by doing all for God and neighbor with unconditional Love. Serve God by loving His creation. Use whatever freedom and resources you have to pursue righteousness and the truth that works for justice ... and you will find peace. Be grateful for your pain, count it all joy to the end, which is the beginning. In your charity you will know God's Grace. Love without limitation, without judgement. And please: Love and Forgive, love and forgive, love, forgive. Trust the salvific life and death of Christ ... and in His Second Coming. May His Divine Mercy be upon you. Amen.

"Heart-felt work grows purely." "Speak the Gospel at all times; use words if necessary."

Peace be with you (my saintly Magpie).

Comment Letter #6 Page #2

"Blessed is He who comes in the name of the Lord."

"Did you know that I have come?"

+ Kev-Cross of the gardens, grotto and Sacred Heart +

"Resurrection." Deo gratias.
=============== + ================

Comment Letter #6 Page #3

Table C-2. Responses to Comments

Comment Number	Response
1-1	Thank you for your comments.
2-1	The text in Section 2.1.3 Paragraph 2 has been modified. Thank you for your comments.
2-2	Restrictions for public distribution of launch dates and times do not apply to launches of NASA missions on expendable vehicles. The quoted dates are the openings of the launch periods for the MER–A and MER–B missions, respectively, as stated in Sections 2.1.5.7 and 2.1.6.
2-3	NASA cannot, at this time, commit to any decisions regarding continuing with the project or making other arrangements should one of the launch opportunities be missed for any reason. A decision after a loss of a spacecraft would depend on the facts and circumstances regarding such a loss.
2-4	Table 2-7, Calculated Individual Risk of Fatality by Various Causes in the United States, in Section 2.4.4.4 provides the requested information. In Section 4.1.5.2 the reader is referred to this table.
3-1	The text in the noted paragraph on page iv has been modified. Thank you for your comments.
3-2	The text in Section 2.1.4 has been modified.
3-3	A single Delta II would not have the necessary capability to simultaneously launch the combined mass of both MER spacecraft.
3-4	The text in Section 3.1.6.3 Paragraph 2 has been modified.
3-5	The text in the noted paragraph on page 3-19 has been modified.
3-6	The text in Section 3.1.7.4 Paragraph 2 has been modified.
3-7	The text in the noted paragraph on page 4-28 has been modified.
3-8	The text in the noted paragraph on page 4-29 has been modified.
3-9	If needed, charcoal filters can be installed in the air conditioning handler intakes during the entire duration of spacecraft processing activities at both the Payload Hazardous Servicing Facility (PHSF) and the launch pad. Furthermore, if the spacecraft instruments are known to be particularly sensitive to smoke particles, the mission managers can request to become part of the approval process for scheduling controlled burns in the areas surrounding the PHSF and launch pad.
4-1	Thank you for your comments.
5-1	The heat generated by a radioisotope heater unit (RHU) comes from the natural decay of the encapsulated plutonium dioxide. Such decay is neither fission nor fusion.
6	The MER–2003 project is for peaceful scientific purposes.

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