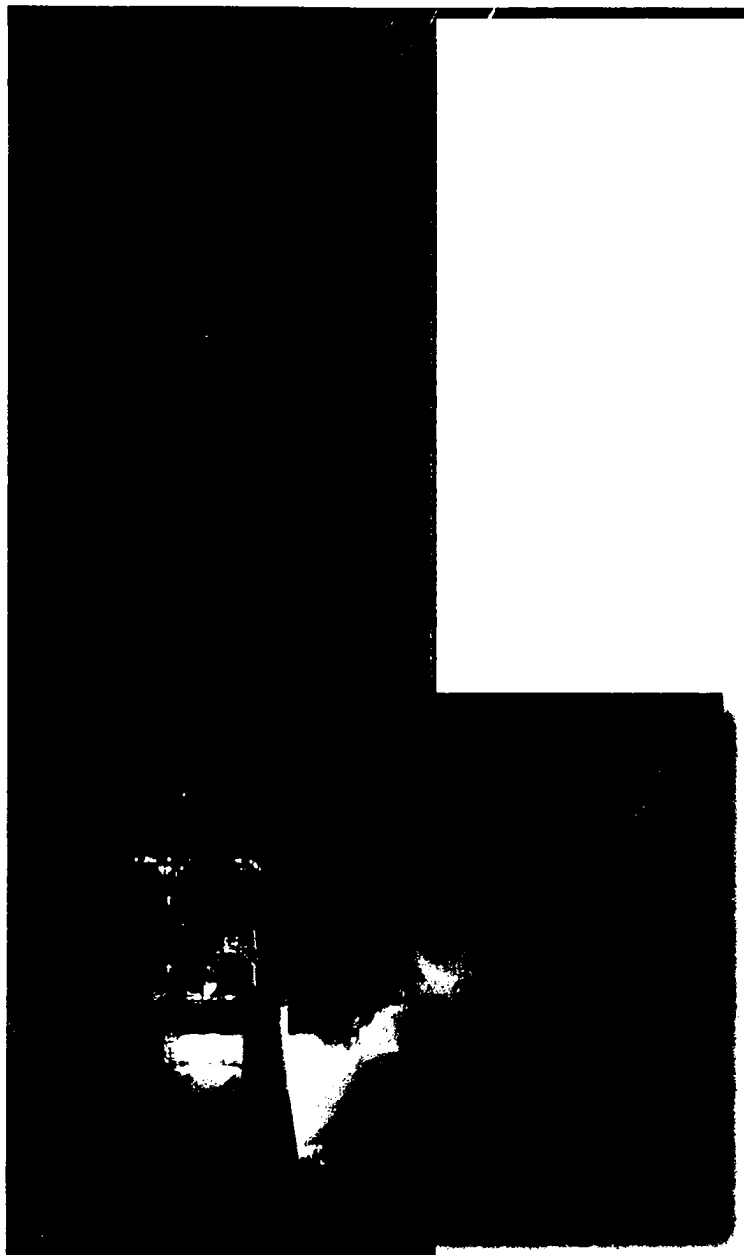

Final Environmental Impact Statement of Engine Technology Support for NASA's Advanced Space Transportation Program

With Emphasis on Liquid Oxygen and Kerosene Engine Technology Development

National Aeronautics and Space Administration

George C. Marshall Space Flight Center and John C. Stennis Space Center

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Executive Summary

The Engine Technology Support for the Advanced Space Transportation Program is proposed by the National Aeronautics and Space Administration to meet the technical and programmatic challenges of the development of future Reusable Launch Vehicles (RLV's). This proposed propulsion initiative is a lead element necessary to reduce development risk and overall program cost from research through development and operation of the selected propulsion system(s). Therefore, this program focuses on research and technology development of a wide variety of early prototype and advanced engines, manufactured in the United States and foreign countries, such as Russia. Subsequent testing of engines for development, certification, and qualification leading to flight acceptance is also considered. This Environmental Impact Statement (EIS) addresses potential alternative engines and components to be tested, alternative facilities and associated facility modifications, and respective operational requirements at the alternative facilities.

Proposed NASA facilities for research and technology testing on alternative engines including component tests and both single and multiple engine testing are located at the Marshall Space Flight Center (MSFC) in Huntsville, Alabama and at the Stennis Space Center (SSC) near Bay St. Louis, Mississippi. A third alternative for the proposed testing is the U.S. Air Force's (USAF) Phillips Laboratory, Edwards Air Force Base, California. This alternative was evaluated by the USAF separately, and the determinations are incorporated for consideration in this document (Air Force Flight Test Center, 1993). The USAF's Environmental Assessment focused on testing single RD–170 engines with thrust levels of 1.637 million pounds (lbs) (7.259 million newtons (MN)) and a Finding of No Significant Impact was subsequently issued. The ultimate decision as to where various elements of the proposed testing will occur is the responsibility of SSC, as it serves as NASA's Lead Center for propulsion testing. Environmental and programmatic concerns will be used by SSC to determine where best to perform testing of a particular engine technology.

The potential environmental impacts of a wide variety of engine alternatives are assessed. Engine alternatives range in thrust from approximately 0.1 to 1.8 million lbs of thrust. All use liquid oxygen (LOX) as an oxidizer. Fuel sources are liquid hydrogen (LH_2), rocket propellant–1 (RP–1, a refined kerosene), and a combination of LH_2 and RP–1.

The No Action Alternative would be the continued reliance on existing, operational systems such as the space shuttle main engine and the redesigned solid rocket motor. Neither system independently or in combination would satisfy the flexibility and cost objectives of the Advanced Space Transportation Program or the larger program encompassing the development of an affordable leapfrog technology vehicle.

A comprehensive evaluation of environmental impacts associated with the NASA alternatives was conducted. No significant environmental impacts are expected to result from any of the proposed alternatives at MSFC or SSC except for: (1) noise and air emissions generated from the testing of engines producing 0.8 million lbs or greater of thrust and using RP–1 as a total or partial fuel source; (2) oil products (RP–1) and usage; and (3) accidental events—large release of RP–1, fire, explosion, etc.

Environmental impact from noise is expected to be moderate on public property in closest proximity to the test facilities for single large engine testing at MSFC and multiple large engine testing at SSC. However, all predictive calculations are conservative because they do not include factors that may reduce impacts such as trees and topography.

Air quality projections were based on state-of-the-art combustion modeling techniques and a dispersion model approved by the U.S. Environmental Protection Agency. Impact is expected to be moderate for full duration test firings of engines producing 0.8 million lbs of thrust or greater. However, carbon monoxide concentration predictions combined with local values are still well within health-based regulatory limits. A monitoring program for both noise and air will be in place by the time of the first engine test firings to validate the predictions and refine operating constraints, if necessary.

The use of RP–1 associated with this program is considered a moderate impact due to the large volume of RP–1 handled, stored, and used although an incident with this oil product is considered unlikely.

If an accident or mishap occurs as a result of this program, there may be a moderate impact. NASA will take all necessary precautions to insure that testing is done under the safest conditions possible to minimize any impact on public health and safety as well as the environment.

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Introduction

Program Background, Need, and Goals

For many years, the United States has recognized that space transportation costs must be significantly reduced so that the nation can afford to continue to expand its exploration, development, and use of space. In NASA's "Access to Space Advanced Technology Team Final Report," advanced space transportation architecture, based on new rocket propulsion technology, was identified, and candidate systems delineated for the next generation of Reusable Launch Vehicles (RLV). The selected system must meet future mission requirements with significant reductions in annual operating costs (NASA, 1993). On August 11, 1994, President Clinton declared that NASA will be the lead agency for advanced technology development and demonstration for the next-generation reusable launch systems. Improved engines are also needed for future generations of non-RLV's referred to as Evolved Expendable Launch Vehicles (EELV's).

To meet the technical and programmatic challenges of the development of future RLV's and EELV's, key advanced technologies in propulsion systems must be explored. These advanced technologies will also be used to enhance existing space vehicle fleet(s), where possible. The goal of Engine Technology Support for the Advanced Space Transportation Program is to demonstrate the technology maturity levels necessary to reduce development risk of the selected propulsion system(s) to an acceptable level and produce highly operable, high thrust-to-weight propulsion systems for future RLV's and EELV's. An additional goal is to examine, evaluate, and/or demonstrate the potential for foreign hardware and technology in order to enhance the capability of the existing expendable launch vehicle fleet, the Space Shuttle Transportation System, and Advanced Space Transportation Systems.

As stated in NASA Research Announcement (NRA) 8-11, NASA is focusing on technology needs for highly reusable and operable systems, requirements/analyses, and performance feasibility technology in the following categories (NASA/MSFC,1994a):

1. Subscale propulsion system demonstrators
2. Modular bipropellant and tripropellant thrusters and thrust cells
3. Oxygen-rich turbine drive
4. Utilization of developed foreign hardware such as Russian, and technology for RLV's, EELV's, and other advanced transportation systems.

Work involved to support this effort will focus on liquid oxygen (LOX)/rocket propellant–1 (RP–1) and LOX/liquid hydrogen LOX/(LH_2)/RP–1 engines. LOX/LH_2 and LOX/RP–1 are bipropellant engines and LOX/LH_2/RP–1 is a tripropellant engine. RP–1 is a highly refined kerosene product that may be used exclusively as the fuel or in combination with LH_2. Many aspects of this program parallel activities of propulsion development undertaken in the 1960's for the Apollo Program and represent restoration, modernization, and enhancement of NASA's original propulsion test infrastructure. As part of the planning for this new program and in consideration of NASA's environmental responsibility under the National Environmental Policy Act of 1969, as amended (NEPA), (42 U.S.C. 4321 et. seq.) this Environmental Impact Statement (EIS) was prepared for the activities required to support the Engine Technology for the Advanced Space Transportation Program. The propulsion initiative is part of the Advanced Space Transportation Program.

Purpose

Presently, NASA is interested in engines that can be used for RLV, EELV and fleet enhancement applications and which will improve the U.S. commercial launch industry's competitiveness. The specific projects addressed in this document will provide unique national test resources and meet advanced propulsion development objectives that would otherwise be cost prohibitive.

The primary test facility to support this program will be an operational LOX/LH_2 test stand modified to include an RP–1 run tank and its ancillary support systems, a common functional and structural interface, and an engine mounting adapter. The primary test facility will be able to be changed quickly from one particular engine type to another, with minimal hardware, operational, and cost impacts, through skid-mounted engine systems and quick-change interface components. This new way of doing business will provide NASA, the Department of Defense (DOD), and private industry with a multipurpose test stand with which to reduce engine research, development, and future operational costs. At the same time, this testbed facility will enable the aerospace industry significant latitude in thrust and propellant options for engine system test and evaluation. Subsequent development, certification, and qualification of engines will necessitate a similar modification of a second test stand and further testing to meet flight acceptance and readiness requirements.

Purpose and Evaluation Methods

Specific Objectives as Stated in NRA–11

The specific objectives of this program are:

1. To design, fabricate, and test subscale demonstrator versions of candidate advanced technology propulsion systems with emphasis on the demonstration of operability;
2. To demonstrate the performance and manufacturing processes of modular combustion chamber concepts which support LOX/LH_2 and LOX/LH_2/RP–1 engine system concepts;
3. To demonstrate an oxygen-rich turbine drive combustor and associated materials evaluation;
4. To evaluate, by technical review and/or test demonstrations, the viability of utilizing foreign engine systems and/or incorporation of foreign technology in current launch vehicles or on RLV's, EELV's, or other advanced transportation systems.

Scope of the Environmental Impact Statement

This EIS was prepared to assess the environmental impacts associated with the Engine Technology Support for the Advanced Space Transportation Program in keeping with the intent of the NEPA. The EIS addresses potential alternative engines and components to be tested, facility modifications, and operational requirements that are under consideration for this program. No new manufacturing facilities are contemplated by NASA at this time; therefore, none will be addressed in this EIS.

Scoping and Public Involvement Process

On November 30, 1994, NASA published the Notice of Intent (NOI) to prepare this EIS in the Federal Register (59FR61346). The NOI along with advertisements of public meetings in Huntsville, AL, on December 6, 1994, and Hancock County, MS, on December 13, 1994, were published in local newspapers in the MSFC and SSC vicinities, respectively. A list of scoping comments is provided in appendix A–1. The majority of comments were program endorsements and expressions of confidence in NASA to conduct testing in an environmentally safe manner. The Tennessee Valley Authority requested to be kept informed. The U.S. Fish and Wildlife Service (USFWS) requested impact analyses on federally listed species and respective habitats in the vicinity of MSFC and SSC.

The Hancock County School Board requested impact data on the local schools (SSC area). One private citizen in the SSC area provided a detailed list of requirements concerning program elements; the use and handling of kerosene, and other issues. The EIS was prepared in accordance with Council of Environmental Quality regulations for implementing the procedural provision of NEPA (40 CFR Parts 1500-1508) and NASA policy and procedures (14 CFR subpart 1216.3) and consideration of the above scoping comments. The environmental effects for testing F–1 and RD–170 engines at EAFB were evaluated by the Air Force separately, and the determinations are incorporated for consideration in this document (Air Force Flight Test Center, 1993).

On November 14, 1996, NASA published the Notice of Availability (NOA) of the draft Environmental Impact Statement in the Federal Register (61FR 58548). The NOA along with advertisements of public meetings in Huntsville, AL on December 2, 1996 and Hancock County, MS, on December 12, 1996 were published in local newspapers in the MSFC and SSC vicinities, respectively. Appendix A–2 provides a summary of both public meetings and the sign-in sheets. No negative opposition to the program was made. Appendix A–3 includes all comments received during the comment period which ended February 15, 1997. Immediately after each letter are the responses to the comments.

Regulatory Agency Coordination

Letters of coordination with a project summary description were sent from NASA to the relevant offices of the USFWS and State Historic Preservation Officer. Response letters are provided in appendix B.

Evaluation Methods

Determinations of environmental consequences associated with facility modifications (construction) and engine testing (operational) issues were made in a two-step process that included developing a cause-and-effect matrix and using either quantitative or qualitative means to evaluate the size of each impact compared to the baseline condition. Impact significance was determined systematically by assessing each impact's magnitude, extent, duration, and likelihood of occurrence in relation to the importance of each resource. Significance criteria and methodology for all alternatives are included in appendix C.

The assessment of impacts was based on descriptions of various project aspects provided by NASA and its contractors. Quantitative methods and state-of-the-art predictive models for combustion chemistry, air emissions modeling, noise projections, and stratospheric ozone impact modeling were used for preparation of data in this EIS. In most cases, quantitative estimates were based on best-available preliminary project design information. NASA has attempted to conservatively scope the magnitude of the test program in order to provide maximum potential impacts to be associated with the conduct of this program. Some evaluations in this EIS have been prepared in more detail than others. For each evaluation, the level of detail is in keeping with the importance of the issue.

Description of Proposed Action and Alternatives

The proposed action is to initiate minor modification to test stand(s) and component test facilities to achieve rapid replacement of a variety of engines and to test these engines for potential use on now and existing launch vehicles with the purpose of improving reliability, performance, and reducing cost.

Engine technology support for the Advanced Space Transportation Program is comprised of testing new and advanced engines and components and providing government-owned facilities with modifications to support the program. Program facility requirements can be met at NASA's Marshall Space Flight Center (MSFC) in Huntsville, Alabama; NASA's Stennis Space Center (SSC) near Bay St. Louis, Mississippi; and/or USAF's Phillips Laboratory, Edwards Air Force Base near Lancaster, California. Each installation could modify at least one test stand, as necessary, to meet respective program requirements. These test facilities will be able to be changed quickly from one particular engine type to another with minimal hardware, operational, and cost impacts through skid-mounted engine systems and quick-change interface components.

The proposed test program would be supported primarily by technical and management personnel who would be reassigned from similar engine programs with no anticipated net increase of civil service workforce at the installations. Private companies under contract to NASA or in cooperation with NASA through Space Act Agreements, etc., are still to be determined. However, the additional contractor workforce associated with this program is expected to be less than 500 at a maximum and will compensate for the anticipated workforce reductions of other programs and institutional support.

The proposed NASA sites have been used for similar activities for the space shuttle main engine (SSME), the Saturn vehicle engines used during the Apollo Program, and other rocket engine programs for many years. An EIS in fulfillment of NEPA requirements for the SSME engine test program at MSFC and SSC to support the Space Shuttle Transportation System has been issued (NASA/MSFC, 1972). The Apollo Program predated the NEPA, and no specific environmental documentation for Saturn engines exists. Environmental baseline reports have been prepared for MSFC and SSC in accordance with NASA Handbook NHB 8800.11 (NASA/MSFC, 1991a; NASA/SSC, 1992).

Testing of components and complete engines and possibly vehicle propulsion stages (simultaneously testing multiple engines in a single configuration) would take place intermittently. Both U.S. and Russian engines are under consideration at this time for the Advanced Space Transportation Program. To facilitate preparation of this EIS, representative engines have been grouped into three categories and one selected from each category for detailed analysis in this document. The engine groups are presented in Table 1.

NASA anticipates that other engine manufacturers and models, not listed on Table 1, may also be tested and evaluated as part of this program. However, none will exceed the maximum thrust of the largest engines evaluated in this EIS or use different fuels and oxidizer than those considered herein. Engine evaluations in this EIS should be regarded in a generic or representative sense. Only engines outside the bounds of this EIS will require additional NEPA documentation.

Three major activities will be addressed in this EIS: (1) test support modifications and use; (2) engine testing; and (3) major component and subscale engine testing. Ancillary activities such as component and engine cleaning and propellant transportation, storage, and handling will be described and addressed in lesser detail. The potential test installations have some complementary as well as unique facilities, equipment, and infrastructure to support this test program. For the purpose of this EIS, each test location can be considered an alternative to the other, except for testing of multiple large engines, which can only be accommodated, if necessary, at SSC. Since the environments surrounding these installations are significantly different, consideration of the three alternatives provides a broad picture of the potential environmental impacts resulting from the proposed test program.

The third alternative location for testing is the USAF's Phillips Laboratory, Edwards Air Force Base (EAFB), California. The environmental effects for testing F–1 and RD–170 engines at EAFB were evaluated by the Air Force separately, and the determinations are incorporated for consideration in this document (Air Force Flight Test Center, 1993). An environmental evaluation of potential environmental effects of the EAFB alternative are available in the EAFB Environmental Assessment and are not specifically covered in this EIS (Air Flight Test Center, 1993). The ultimate decision as to where the proposed testing will occur is the responsibility of SSC, as it serves as NASA's Lead Center for propulsion system testing. Environmental and programmatic concerns will be used by SSC to determine where best to perform testing of a particular engine technology.

NASA shares the view noted in the EAFB Environmental Assessment concerning consideration of the Russian large rocket engine test facility outside Moscow, Russia, as an alternative test facility: "In order to evaluate whether an engine would suit U.S. mission requirements, testing should be done using U.S. instrumentation and equipment. Data collected and evaluated using U.S. methods to demonstrate and validate performance would allow more direct comparison of these engines with U.S. tests of other engines and motors. As a result, the Russian large-rocket-engine test facility located outside of Moscow, Russia, was eliminated from further consideration." (U.S. Air Force Flight Test Center, 1993).

TABLE 1.—*Engine categories*

Type	Thrust Mlb (mean sea level (msl))	Thrust, MN	Fuel	Oxidizer
Large Engines				
F–1	1.522	6.770	RP–1	LOX
F–1A	1.800	8.007	RP–1	LOX
RD–170*	1.632	7.259	RP–1	LOX
Medium Engines				
RD–180*	0.816	3.630	RP–1	LOX
RD–701 (Mode 1)	0.714	3.176	RP–1/LH_2	LOX
Small Engines				
Aerospike	0.400	1.780	LH_2	LOX
RD–701 (Mode 2)	0.357	1.588	LH_2	LOX
RD–701A* (Mode 1)	0.386	1.717	LH_2/RP–1	LOX
RD–701A (Mode 2)	0.176 (vacuum)	0.783	LH_2	LOX
MA5B	0.300	1.334	RP–1	LOX
RD–704 (Mode 1)	0.450	2.002	LH_2/RP–1	LOX
RD–704 (Mode 2)	0.200	0.890	LH_2	LOX
SSME	0.375	1.668	LH_2	LOX
NK–31	0.090	0.4003	RP–1	LOX
RD–0120	0.400 (vacuum)	1.800	LH_2	LOX
RD–120	0.187 (vacuum)	0.833	RP–1	LOX
Multiple Engines				
5 Large (RD–170)*	8.160	36.300	RP–1	LOX
3 Medium (RD–701)*	2.142	9.528	LH_2/RP–1	LOX
7 Small (RD–704, Mode 1)*	3.150	14.012	LH_2/RP–1	LOX
3 Small (RD–704, Mode 1)*	1.350	6.005	LH_2/RP–1	LOX
MA5B Stage (3 engines)	0.900	4.003	RP–1	LOX

* Selected for representative detailed analysis in this EIS.
BI—Bipropellant—LOX/LH_2 or LOX/RP–1
TRI—Tripropellant—LOX/LH_2/RP–1

Note: For tripropellant engines, Mode 1 is used at launch in the booster phase and Mode 2 at an altitude beginning at approximately 30 miles (48 km) and continuing through orbital insertion.

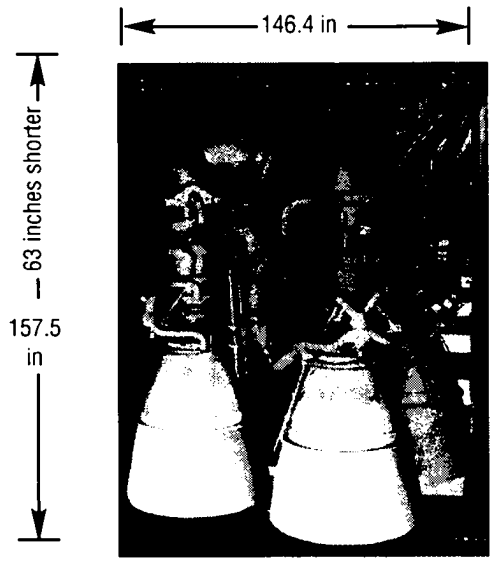
Proposed Advanced Space Transportation Engines and Systems

Large Thrust Engines

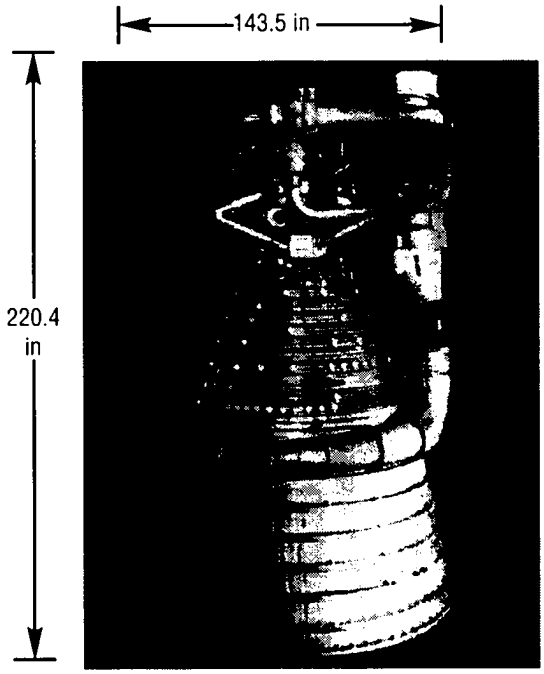
Clusters of large engines with thrusts exceeding 1.5 Mlb (6.7 MN) each are used in first stage, heavy lift boosters to achieve vehicle lift-off and initial acceleration up to velocities of approximately 5,000 mph (8,000 km/hr). Three engine candidates are under consideration for the Advanced Space Transportation Program: F–1, F–1A, and RD–170. The F–1 and RD–170 engines were used on the Saturn V (now retired) and Energia (a Russian operational vehicle), respectively. The F–1A was an advanced engine whose development had progressed through initial prototype fabrication prior to termination of the Apollo Program. It has never been flight certified nor flown on a launch vehicle. F–1 and F–1A engines have been in storage since termination of the Apollo Program. These engines would require a thorough checkout for test suitability. The RD–170 is currently in production in Russia. A physical comparison of the engines is shown in Figure 1. These large engines use LOX/RP–1 as propellant. Single and multiple engine tests are proposed.

Medium Thrust Engines

For the purposes of this EIS, engines designated medium thrust can produce thrust levels of approximately 0.8 to 0.9 Mlb (3.6 to 4.0 MN). Both the RD–180 and RD–701 are Russian development engines that have not been flight-certified or flown on a space vehicle. The RD–180 is a bipropellant (LOX/RP–1) engine whose design was adapted from the RD–170. The RD–701 is a tripropellant engine which burns LOX/RP–1 with 6 percent LH_2 on lift-off in Mode 1 and then converts to burning LOX/LH_2 in Mode 2 to accelerate the vehicle to orbital velocities of approximately 17,500 mph (28,100 km/hr). In essence, the RD–701 can accommodate propulsion characteristics of a two-stage launch vehicle with two different types of engine configurations in one housing. The MA5B stage is a three-engine



RD–170



F–1

	RD–170		F–1		F–1A	
IOC date	1985		1966		19XX	
Thrust (SL)	1,632,000 lb	7,259,136 N	1,522,000 lb	6,769,856 N	1,800,000 lb	8,006,400 N
(vacum)	1,777,000 lb	7,904,096 N	1,748,000 lb	7,775,104 N	2,020,700 lb	8,988,074 N
Isp (SL)	309		264.5		271	
(vacum)	337		304		304.2	
Throttle	50–100 percent		None		Optional	
Weight	21,510 lb	9,756.95 kg	18,616 lb	8,444.22 kg	19,000 lb	8,618.4 kg

FIGURE 1.—Comparison of F–1, F–1A, and RD–170 engines.

system to be tested as one operational unit. The MA5B stage is the basic propulsion system for the Atlas, a DOD launch vehicle. Single and multiple engine tests are proposed.

Small Thrust Engines

The small engine category contains the most diverse group of engines to be considered in the Advanced Space Transportation Program. Four LOX/LH_2 engines or engine modes are found in this group: the RD–701 (Mode 2), RD–701A (Mode 2), RD–704 (Modes 1 and 2), and the SSME. The SSME has been the subject of previous NEPA and environmental baseline documentation which would encompass the expected environmental impacts of these engines and will not be addressed further in this EIS (NASA/MSFC, 1972, 1991a). In Mode 1, the RD–701A and RD–704 use a mixture of LOX/LH_2/RP–1 similar to Mode 1 of the RD–701, only with reduced burn rates. The MA5B and NK–31 engines use LOX/RP–1. The RD–704 (Mode 1) was selected for detailed analysis in this EIS because it has the highest thrust capability in this category and utilizes RP–1 for fuel. Single and multiple engine tests are proposed.

Description of Alternative Test Facilities

MSFC, SSC, and EAFB test facilities are proposed as alternative locations. Since the environments surrounding these installations are substantially different, consideration of them as alternative test locations to each other provides a broad picture of the potential environmental impacts resulting from the proposed test program.

Marshall Space Flight Center

MSFC is located on approximately 1,841 acres (745 hectares) within the grounds of the Department of the Army's Redstone Arsenal (RSA), southwest of the city of Huntsville, Alabama (fig. 2). Wheeler National Wildlife Refuge overlaps part of MSFC's western and southern boundary.

MSFC is a NASA field installation with the primary mission of space transportation systems development. The MSFC facilities are capable of simulating space environment; testing large propulsion systems, and developing new materials, hardware, and procedures. The Center has engineering test facilities for materials, components, and system development, including thermal/vacuum chambers, material environmental evaluation facilities, cryogenic facilities, optics facilities, fluid and gas facilities, and numerous propulsion test facilities. All test facilities are located in the southern portion of MSFC. MSFC is almost centrally located within RSA's 38,000 ac (15,379 ha), which provides a physical separation around the test stands from private property of approximately 2.5 to 7 mi (4 to 11.3 km).

Advanced Engine Test Facility

The Advanced Engine Test Facility (AETF) is located in the West Test Area and shown in Figure 3. The test stand was constructed in 1964 to test the LOX/RP–1 S–1C stage (Saturn V first stage with a combined thrust of 7.5 Mlb (33.4 MN) from five F–1 engines). Its original foundation thrust rating was 12 Mlb (53 MN). It was last modified in 1986 to accommodate static testing of the SSME. As currently configured, the AETF has two positions for hot firing LOX/LH_2 engines or stages up to 0.75 Mlb (3.34 MN) thrust. With modifications to the superstructure, the stand can easily accommodate thrust loadings anticipated with static testing of any of the engines under consideration for this program.

To accommodate testing of engines utilizing RP–1 as a fuel source, a 14,000 gal (53,000 L) run tank would have to be installed on the stand. In addition, a new 20,000 gal (75,700 L) above-ground storage tank will be installed to support testing.

Existing ancillary support to the stand includes a deflector with water cooling capacity of 340,000 gal/min (1,287,040 L/min) at 150 psi (1,034 kPa), all necessary utilities, hydraulics from 2,000 to 5,000 psig (13,790 to 34,475 kPa) at 15 gal/min (56.78 L/min), and a complete test data acquisition system. Cooling water is a purchased utility from RSA. Water is obtained from the Tennessee River and treated to potable water standards prior to charging the industrial water system used on MSFC for all test facility cooling water systems. Only minor modifications to these systems would be needed. Structural modifications would be designed with a skid-mounted engine mounting adapter and quick-change interface components to provide the ability to change from one engine type to another with minimal hardware, operational, and cost impacts. Capability to static test the SSME would be retained.

F–1 Stand

The F–1 stand, also referred to as the Hydrocarbon Engine Test Facility, is located in the West Test Area and shown in Figure 3. It was built in 1963 to test the F–1 engine and last used in 1969. It was built with the capability to support hot firing of LOX/RP–1 engines up to 2 Mlb (39.57 MN) thrust. It contains a 105,000 gal (397,468 L) LOX run tank and a 50,700 gal (191,920 L) RP–1 tank. Storage facilities for RP–1 are used in common with the AETF. A new LOX storage facility would be constructed. It was equipped with utilities similar to those supporting the AETF. Since it has not been in use since 1969, it would require significant refurbishment to restore the facility to operational status. It is only under consideration for bipropellant LOX/RP–1 engine testing since LH_2 capability does not exist at the stand.

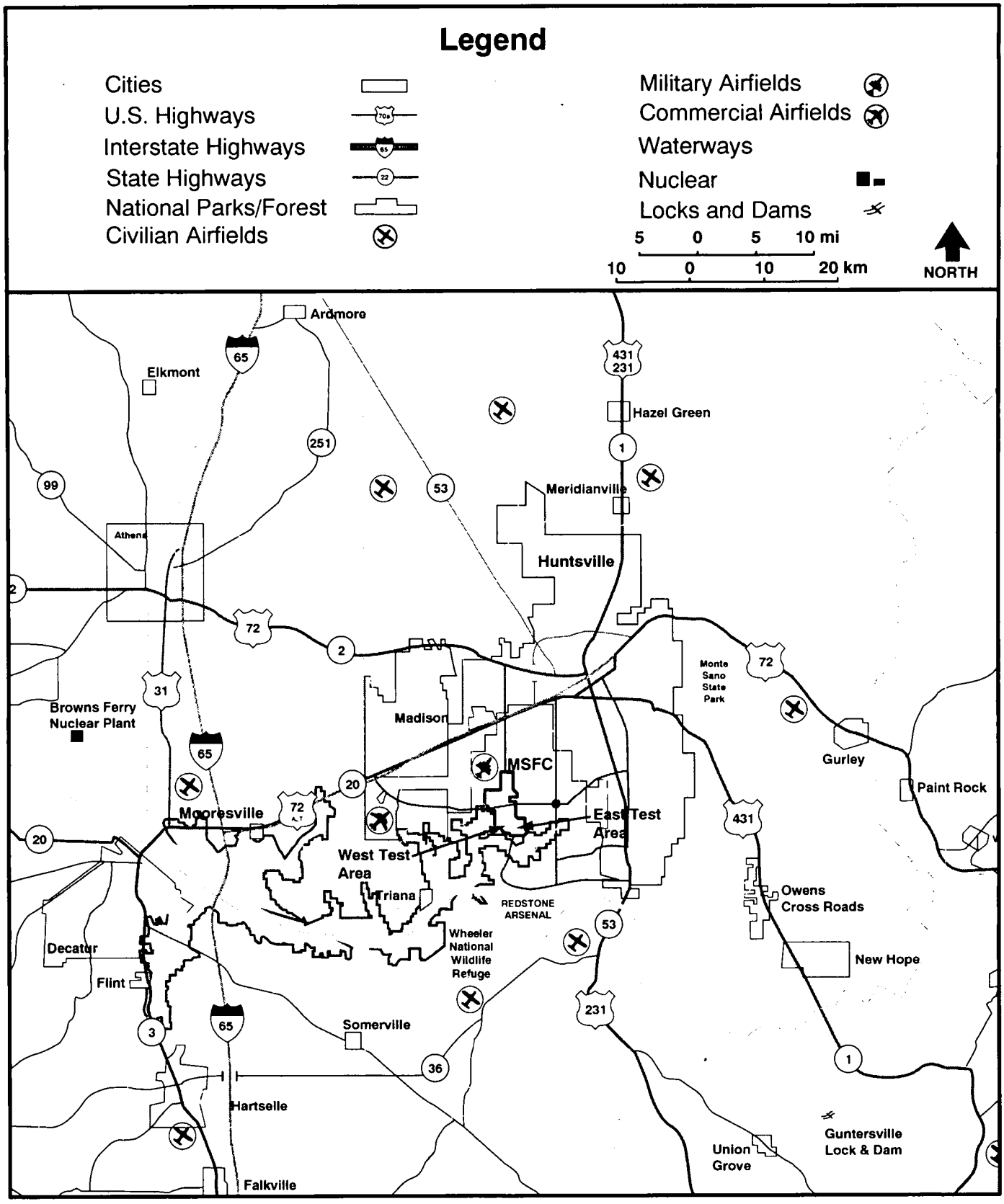


FIGURE 2.—Map of Marshall Space Flight Center.

East Test Area

The East Test Area, shown in Figure 3, has a significant variety of unique component test capabilities proposed to support the Advanced Space Transportation Program. This area contains four test facilities, multiple control centers with data acquisition and recording capability, and full utilities.

Candidates for use in this program are Test Facilities (TF) 115, 116, 300, and 500. TF 115 is a multipurpose dual position LOX/LH_2 facility. The facility is equipped to test model engines, hot gas devices, cryogenic tanks, and liquid hydrogen flowmeters.

TF 116 is a diversified component test stand for test programs requiring high pressure and high flow rates of ambient or cryogenic propellants. For the proposed program, TF 116 is proposed for combustion chamber component work. It has two positions rated for 0.04 and 0.750 Mlb thrust. RP–1 capability has been added to this facility.

TF 300 is a five position stand with capability to simulate launch thermal and pressure profiles. TF 300 is proposed for high-altitude testing for LOX/LH_2 and LOX/RP–1 engines.

TF 500 is a five position stand designed for hazardous testing of propulsion components and subsystems. This facility is currently configured for LOX/LH_2 component testing. No significant modifications of this facility are planned at this time. However, additional RP–1 capability could be added, upgrading the capability of the facility for tripropellant test work.

Stennis Space Center

SSC is situated near Bay St. Louis, Mississippi (fig. 4). The Center occupies 13,800 ac (5,585 ha) in western Hancock County known as the government-owned fee area.

Currently, SSC is the site for development and testing of the SSME's and other rocket propulsion system testing. SSC is host to other federal, state, and related organizations including, the U.S. Department of Commerce, the U.S. National Oceanic and Atmospheric Administration, the U.S. Environmental Protection Agency Toxic Analysis Center, the U.S. Department of Defense, the U.S. Geological Survey, and Mississippi and Louisiana State agencies.

Within the fee area, NASA and the other resident government agencies have constructed the test facilities, laboratories, offices, and support buildings necessary to conduct their operations.

Surrounding the fee area, the government has acquired a perpetual restrictive easement which prohibits the maintenance or construction of dwellings and other buildings suitable for human habitation or occupancy. This region is known as the buffer zone and covers 125,071 ac (50,616 ha). Together the fee area and buffer zone provide a physical separation of 5 to 7 mi (8 to 13 km) between engine testing and private habitable structures, therefore mitigating the possibility of damage to private property from acoustical pressure or vibrations. On the west side of SSC, the buffer zone extends into Louisiana. The SSC buffer zone is surrounded by the Mississippi towns of Pearlington, Waveland, Bay St. Louis, Kiln, and Picayune and the Louisiana town of Slidell.

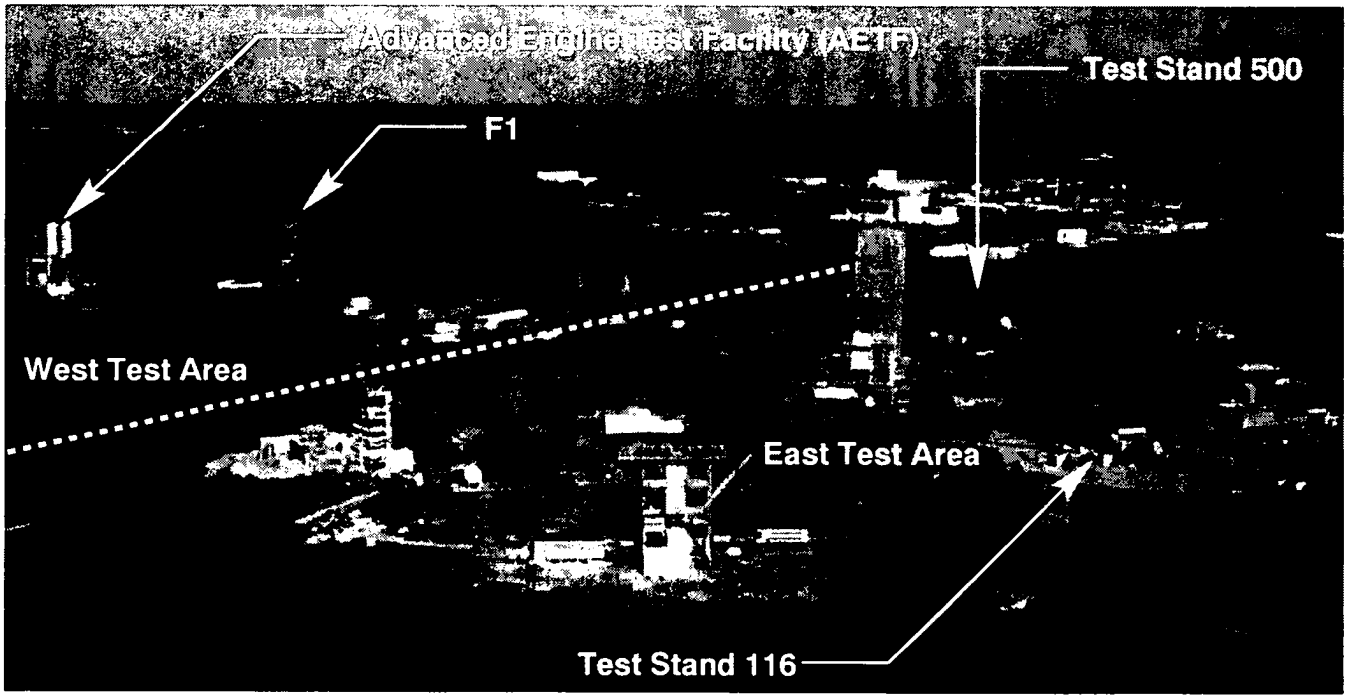


FIGURE 3.—Marshall Space Flight Center propulsion test facilities.

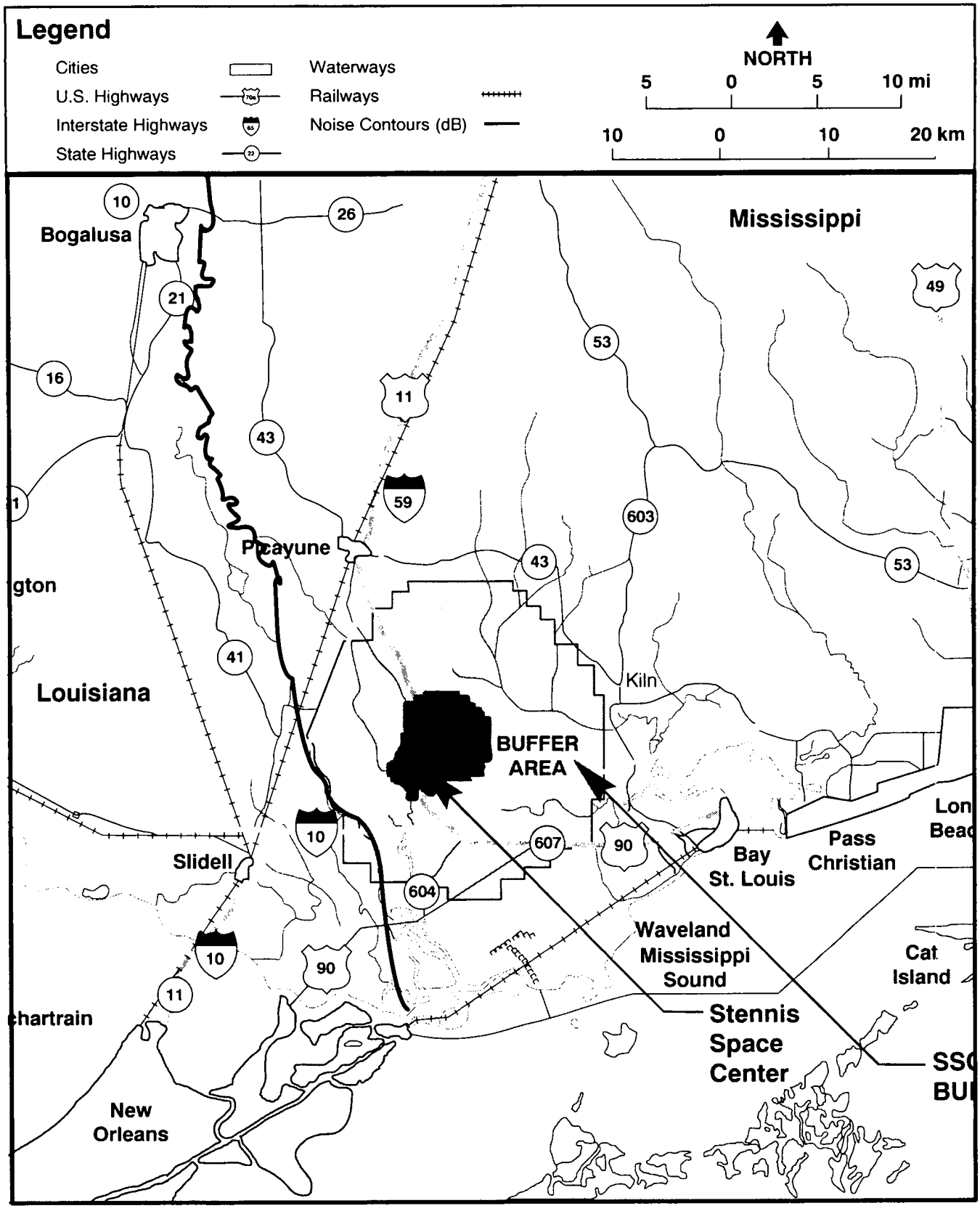


FIGURE 4.—Map of Stennis Space Center.

SSC's principal mission is propulsion testing. The task of ground testing engines is accomplished by securing engines in one of SSC's four test stands and static test firing them for various periods of time under different operating conditions to determine their flight worthiness. In this way, NASA is able to verify design changes, develop components, and resolve any problems in the engines before they are used for actual flights.

B1/B2, A–1, and A–2 Test Stands

SSC was originally established to perform development and acceptance testing for large liquid propellant rocket systems in support of the U.S. Space Program. The Center was responsible for the static testing of the first and second stages of the Saturn V rocket. The B engine test complex (fig. 5) is a two-sided stand that includes test positions B–1 and B–2. The A–1 and A–2 test stands are single position, single engine static test stands (fig. 5). Test stands B–1, B–2, A–1, and A–2 are proposed as prime engine test locations. The RP–1 support system pumping, valves, etc., would require restoration since the stand is reconfigured for use with the LOX/LH_2 SSME engine. The test stands would be modified for this program in such a manner as described in the section "Descriptions of Alternative Test Facilities, AETF" (MSFC).

Existing ancillary support equipment includes water-cooled deflectors, utilities, hydraulics and a test data acquisition system. The test stand deflectors are serviced with a cooling water system capable of a maximum flow rate of 300,000 gal/min (1,135,500 L/min) withdrawn from a 66 Mgal (250 ML) reservoir filled by pumping surface water from the adjacent canal. Three industrial groundwater wells are available for backup supply. Minor modifications to these systems are anticipated. Structural modifications will be designed with a skid-mounted engine-mounting adapter and quick-change interface components to provide the ability to change from one engine type to another with minimal hardware, operational, and cost impacts. Capability to static test the SSME would be retained.

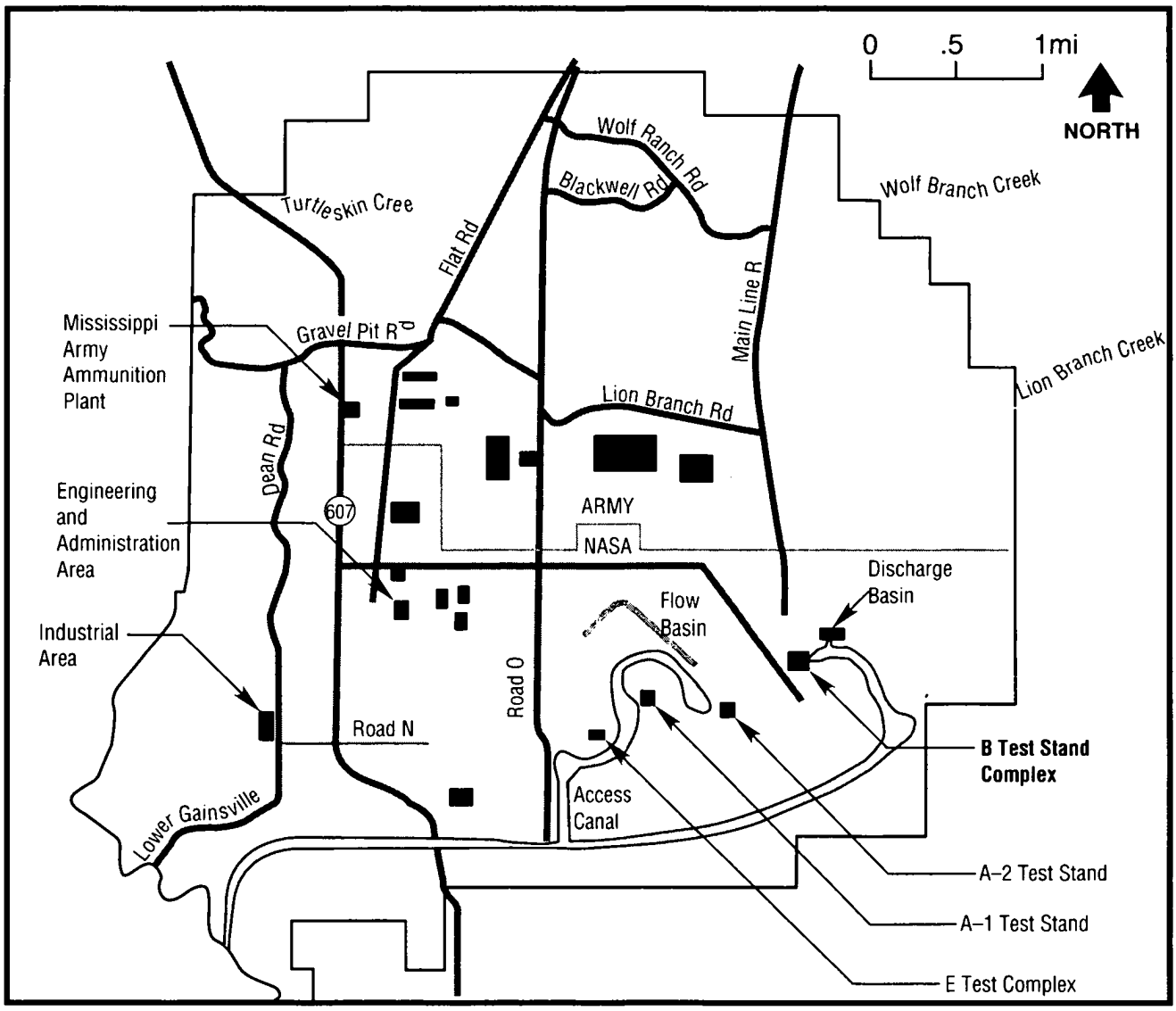


FIGURE 5.—Engine test facilities at Stennis Space Center.

SSC was designed with a radius of 5 to 7 mi (8 to 13 km) including the acoustical buffer zone to reduce the impact of engine testing noise on the public. Noise levels associated with engine testing would be equal-to-or-less- than the noise associated with previous tests conducted with five (5) F–1 engines during the Apollo Program.

The E Test Complex

The E Test Complex, shown in Figure 5 is composed of the E–1 and E–2 Test Stands. The E–1 Test Stand was designated and constructed for the testing of propulsion system components. An environmental assessment (EA) for construction of the E–1 was prepared (NASA/SSC, 1989). Since that time, the facility has also proven useful in the testing of small-thrust rocket engines and motors. The facility is permitted by the Mississippi Department of Environmental Quality for the release of air emissions for testing LOX/methane and LOX/RP–1 engine components. No modification would be needed for LOX/LH_2 component work. Minor modifications are needed to add the capability to test hydrocarbon fueled engines/components to the E Test Complex. Because of the nature of the E Test Complex, i.e., a common test control center, test operations building, and service systems, additional test cell will be located in order to maximize test operational efficiency.

Edwards Air Force Base

Edwards Air Force Base (EAFB) is located on approximately 301, 000 ac (121,815 ha) in the Antelope Valley region of the western Mojave Desert, approximately 100 miles northeast of Los Angeles.

The Environmental Assessment (Air Force Flight Test Center, 1993) that EAFB prepared is for liquid-fueled rocket engine testing and associated Test Stand 1-A modifications and renovation activities. The Environmental Assessment specifically covered environmental consequences for a single large engine test activities of the F–1 and RD–170. The "Finding of No Significant Impact" for this Environmental Assessment is included in appendix D.

Alternative Actions

No Action Alternative

Inclusion of the "No Action Alternative" is prescribed by the Council on Environmental Quality guidelines implementing NEPA. The "No Action Alternative" provides the benchmark against which the proposed actions are evaluated. The "No Action Alternative" would maintain the status quo and entail continued production and use of existing engine and motor designs for current and future space vehicle programs. Motors in propulsion terminology denote a propulsion system using solid, not liquid, propellants. NASA currently depends on solid rocket motors containing aluminum and ammonium perchlorate fixed in a rubber-like binder to provide the majority of thrust on lift-off. The new engines in this program are candidates to replace solid rocket motors as well as the SSME. The "No Action Alternative" would not meet NASA's objective to reduce development risk and annual operations cost of an advanced propulsion system required for an SSTO vehicle.

Comparison of Alternatives

A comparison of alternative test location impact ratings against the baseline "No Action Alternative" is provided in Table 2. Environmental consequences for EAFB are included on the table as stated in the Environmental Assessment for Liquid-Fueled Rocket Engine Testing at Test Stand 1–A (Air Force Flight Test Center, 1993) with the exception of the following three areas: air quality; noise; and threatened and endangered species. For comparative purposes in each of these three areas, NASA upgraded the impact rating to "moderate" based on NASA's significance criteria definitions found in Appendix C. All locations can fulfill program obligations without major modifications or potential environmental harm. There may be moderate impact at MSFC and SSC from use of RP–1 and unplanned events (mishaps). Noise impacts at MSFC and EAFB may be moderate. Impact to threatened and endangered species at EAFB may be moderate. SSC is the only test location considered for multiple engine testing, due to its large acoustical buffer zone.

A comparison of the facility locations shows that they can serve as excellent alternatives to each other from an environmental perspective except for multiple large engine testing. All have certain environmentally-sensitive areas. However, careful consideration and avoidance of these areas provide protection from impacts. SSC would be less impacted from noise due to the large acoustical buffer zone surrounding the Center.

The testing outlined in this EIS is being proposed for existing test facilities in the United States. Short-term effects associated with rocket engine testing, as described in the following pages of this EIS has no long-range negative impact on the productivity of the environment surrounding these test facility locations. By focusing in on the use of existing test facilities, this program also does not add to the irreversible and irretrievable commitment of environmental resources which have previously occurred at the test locations when they were constructed.

TABLE 2.—*Alternative test locations impact ratings for operational impacts*

Environmental Effect Area	No Action	MSFC	SSC	EAFB
Air Quality				
Large Engines				
Single Engine	Insignificant due to RSRM environmental control restrictions	Moderate	Moderate	Moderate
Multiple Engines	N/A	N/A	Moderate	N/A
Medium Engines				
Single Engine	N/A	Moderate	Moderate	N/A
Multiple Engines	N/A	N/A	Moderate	N/A
Small Engines				
Single Engine	Insignificant (SSME)	Insignificant	Insignificant	N/A
Multiple Engines	Insignificant (SSME)	Insignificant	Moderate	N/A
Archeologic Resources	None	None	Insignificant	None
Biotic Resources	Insignificant	Insignificant	Insignificant	Insignificant
Cultural and Historical Resources	None	Insignificant	Insignificant	Insignificant
Facilities and Infrastructure	Insignificant	Insignificant	Insignificant	Insignificant
Groundwater Resources	None	Insignificant	Insignificant	Insignificant
Hazardous Substances	Insignificant	Insignificant	Insignificant	Insignificant
Hazardous Waste	Insignificant	Insignificant	Insignificant	Insignificant
Noise				
Large Engines				
Single Engine	Moderate	Moderate	Insignificant	Moderate
Multiple Engine	N/A	N/A	Moderate	N/A
Medium Engines				
Single Engine	N/A	Moderate	Insignificant	N/A
Multiple Engine	N/A	N/A	Insignificant	N/A
Small Engines				
Single Engine	Insignificant (SSME)	Insignificant (SSME)	Insignificant	N/A
Multiple Engine	N/A	N/A	Insignificant	N/A
Oil Products and Use	Insignificant	Moderate	Moderate	Insignificant
Public and Employee Health and Safety	Insignificant	Insignificant	Insignificant	Insignificant
Socioeconomics	Insignificant	Insignificant	Insignificant	Insignificant
Threatened and Endangered Species	None	None	None	Moderate
Transportation	None	Insignificant	Insignificant	Insignificant
Waste Generation and Treatment	Insignificant	Insignificant	Insignificant	Insignificant
Water Quality	Insignificant	Insignificant	Insignificant	Moderate
Wetlands and Flood Plains	None	None	Insignificant	None

Notes: 1. All construction impacts are insignificant or none (no impact).
2. For Edwards Air Force Base operational impacts, see reference Air Force Flight Test Center (1993).

Potential Environmental Effects—Marshall Space Flight Center

The following sections describe the potential impacts of the Advanced Space Transportation Program testing on the natural and human environment at MSFC. Impacts as a result of construction or operational activities are included within each major section. Mitigation alternatives in each category are detailed.

Facilities and Infrastructure

Affected Environment

MSFC has a fully developed infrastructure, including road access and all utilities to support over 7,000 federal employees and contractor personnel. Existing land use for MSFC consists of: administration and management; offices and laboratories; services and support facilities; industrial/manufacturing and test areas (which are the predominant land use of the MSFC); recreation areas; open areas; and circulation and parking areas.

As discussed in the section "Description of Alternative Test Facilities" two main facilities in the West Test Area are alternatives for testing full-scale engines associated with this program. The AETF (Building 4670) could be used for testing any of the medium- or small-thrust engines. The F–1 Test Stand (Building 4696) could be re-activated for testing large-thrust engines and as an alternative for testing medium- and small-thrust engines. All component tests are proposed to be accommodated at TF 115, TF 116, TF 300, and TF 500 in the East Test Area. The AETF, TF 115, TF 116, TF 300 and TF 500 are currently operational and support various test programs at MSFC, such as SSME. Modifications to the AETF would include the addition of a 14,000 gal (53,000 L) RP–1 run tank (the fuel tank on the stand used only during a test) and its ancillary support systems, a common functional and structural interface, and an engine mounting adapter.

The detention pond, which can receive runoff of cooling water from the AETF and F–1 test stands, is currently National Pollutant Discharge Elimination System (NPDES) permitted and identified as a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) site (commonly known as Superfund). This pond received cooling water which may have been contaminated with RP–1 and organic solvents prior to regulations requiring containment of these chemicals. There are two interim actions to be conducted under CERCLA for this site. The first is the installation of a treatment system to clean groundwater pumped from test stand basements into the pond. It is scheduled for construction completion by September 1997. Second is removal of pond sediments that are contaminated and installation of a synthetic pond liner, scheduled for construction in early 1998. The interim action schedule is compatible with the testing schedule for this project.

Construction Impacts

Modifications to these test facilities would be minor. Impact to the environment and workers is considered insignificant. Disturbance of asbestos and/or lead paint will be minor. Procedures will be followed that prevent exposure to workers and release to the environment. Construction projects will follow regulatory standards for disturbance of lead (29 CFR 1926.62) and asbestos (29 CFR 1926.1101). Normal maintenance and cleanup of the test facilities should not disturb the asbestos or lead. However, all on-site contractors are made aware of these concerns by NASA and are familiar with asbestos and lead guidelines to minimize exposure to personnel.

Operational Impacts

These test facilities were originally designed and built to operate in the same manner as proposed in this program. Previous testing included firing similar or identical engines of equivalent or greater thrust capabilities for a comparable duration. Therefore, there will be no operational impacts to the test facilities or surrounding buildings. The pond is large enough to handle the anticipated volumes of cooling water. Pond restoration will include lining the pond and receiving ditches with a synthetic liner. The existing subsurface drain will not be affected by the new liner. The pond will be fully capable of meeting the requirements of this project. Overall operational impacts will be insignificant.

Mitigation

No mitigation is required.

Oil Products and Hazardous Substances and Wastes

Affected Environment

MSFC utilizes petroleum products as fuel for emergency generators, boiler plants, and vehicles. The Center currently has storage capacity for 195,000 gal (738,075 L) of diesel fuel, 200 gal (757 L) of jet fuel and 3,000 gal (10,600 L) of RP in above-ground storage tanks. In addition, the Center has storage capacity in underground storage tanks for 120,000 gal (454,249 L) of diesel fuel, 17,000 gal (64,352 L) of gasoline, and 64,000 gal (242,266 L) of jet fuel.

The Center will construct a 20,000 gal (75,700 L) above-ground storage tank for the RP–1. RP–1 is less volatile than gasoline or jet fuel and, therefore, less hazardous. MSFC maintains a Spill Prevention Control and Countermeasure/ RCRA Contingency Plan to handle oil and hazardous material emergencies and is modified as new tanks are installed.

MSFC maintains a data base inventory of hazardous and regulated substances used at the facility which it provides annually to the Redstone Arsenal Emergency Planning Committee and the RSA Fire Department. Additionally, Material Safety Data Sheets (MSDS's) are maintained for all chemicals on site. Building 4249 is the central repository where the MSDS's are maintained.

MSFC is a less-than-90-day, large quantity, hazardous waste generator as defined in 40 Code of Federal Regulations (CFR) 262. Approximately 250 sources generate hazardous waste on MSFC. These wastes include: cadmium, chromium, lead, and other metals; characteristic wastes that exhibit the characteristics of ignitability, corrosiveness, or reactivity; lab packs of small amounts of hazardous waste; spent solvents; and wastewater treatment sludge. Collection and management of hazardous waste is the responsibility of the Institutional Mission Services contractor and is an ongoing current contract.

Once generated, hazardous wastes are collected in designated waste containers at satellite accumulation areas. Containers of hazardous waste are labeled and entered into a waste inventory data base while at the satellite accumulation area. When containers are full, they are transported to Building 4640 (Hazardous Waste Storage Area). Containers of waste accumulate at Building 4640 for less than 90 days and are disposed of off site at certified hazardous waste disposal facilities.

Sources of ionizing radiation emissions at MSFC include radioisotopes and x-ray machines. Laser, microwave, and radio frequency emissions are examples of nonionizing radiation at MSFC.

Construction Impacts

Refurbishment of test stands and ancillary facilities for this program may involve use of toxic and hazardous materials, such as paints and adhesives, which would be used or disposed of according to manufacturers' recommendations, standard NASA/MSFC procedures, and appropriate federal and state environmental regulations. No radioactive material would be used in the construction except for radiographic testing of large steel joints after modifications. Such testing would be carried out in accordance with standard NASA/ MSFC procedures as defined in Marshall Management Instruction (MMI) 1860.2D, Radiation Safety Manual. Therefore, impacts due to construction should be insignificant.

The storage of RP–1 at the West Test Area will be in a new 20,000 gal (75,700 L) above-ground storage tank. Secondary containment for this tank will meet the requirements of 40 CFR 112, Environmental Protection Agency (EPA) Regulations on Oil Pollution Prevention, to provide 110 percent capacity. Overfill protection will be installed on the storage tank. A 14,000 gal (53,036 L) run tank for RP–1 will be added to the AETF.

Operational Impacts

Current practices include use of some ozone-depleting chemicals (ODC), such as Freon–113™, and 1,1,1–trichloroethane (TCA) for cleaning parts at the test stand. The MSFC Specification 164 that provides guidance on cleaning sensitive space hardware has been revised to a performance specification with alternative solvent selection such as trichloroethylene (TCE), a non-ODC. MSFC has eliminated the acquisition of Freon–113™ and TCA effective January 1, 1996. At this time, TCE is targeted as a Freon–113™ replacement. TCE was originally used to clean engines in the 1950's and 1960's. However, TCE is a volatile organic compound which must be properly managed to ensure worker exposure remains within acceptable Occupational Safety and Health Administration (OSHA) guidelines as found in 29 CFR 1910.132 and is under the purview of the MSFC Environmental Health and Safety Office. Upon issuance of the Title V Air Emission Permit, the use of TCE will be governed by conditions outlined in 40 CFR 63, Subpart T. Bulk storage and transportation of all hazardous materials on MSFC is conducted in accordance with OSHA, National Fire Protection Association, EPA, and Department of Transportation (DOT) regulations.

Types of solvents to be used with estimated quantities are: acetone (100 lb/yr (45.4 kg/yr)), methyl ethyl ketone (100 lb/yr (45.4 kg/yr)), TCE (2,400 lb/yr (1,090 kg/yr)), lacquer thinner (100 lb/yr (45.4 kg/yr)), and isopropyl alcohol (500 lb/yr (227 kg/yr)). Freon–113™ and TCA may be used after January 1, 1996, until the in-house stock is depleted. Estimated usage will be up to 800 (363 kg/yr) and 1,600 lb/ yr (725 kg/yr) for Freon–113™ and TCA, respectively. However, this usage is not likely to occur.

One to four hypergol canisters containing TEA/TEB (triethylaluminum and triethylboron) weighing 2.5 lb (1.13 kg) each are planned to be used per test for ignition. The hypergol system planned for use in this program ignites spontaneously on contact with the fuel.

Overall operational impact is expected to be moderate for oil products and insignificant for other hazardous substances and waste.

Mitigation

MSFC's Spill Prevention Control and Countermeasure/ RCRA Contingency Plan would be updated to include the requirements of this program. Potential impacts from spills or leaks of RP–1 would be mitigated by the spill plan and secondary containment.

Overall impact for oil products is expected to be moderate. Only small amounts of other hazardous materials would be used. Therefore, impacts of hazardous substances and waste are expected to be insignificant.

Air Quality

Affected Environment

The National Ambient Air Quality Standards (NAAQS's) for criteria pollutants have been adopted by the state of Alabama and the city of Huntsville. Primary NAAQS are levels set by the EPA that identify the ambient concentrations necessary to protect human health and welfare with an adequate margin of safety. Secondary NAAQS are levels set by the EPA that define ambient concentrations necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Four criteria air pollutants relevant to the releases associated with engine testing have NAAQS's . These pollutants include carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and suspended particulate matter less than 10 microns in size (PM_{10}) which are airborne particles that are so small in size that they can remain airborne and disperse as a gas. Available air monitoring data for the MSFC/ Huntsville area indicate that this area is in "attainment" or meets all NAAQS's for the criteria pollutants including the other criteria pollutants—ozone (O_3) and lead (Pb) as shown in Table 3 (ADEM, 1992). In addition to the NAAQS, federal and state regulations have set Significant Air Quality Impact Levels (SAQIL). SAQIL's are listed in Table 6.

Carbon monoxide combines with hemoglobin (red blood cells) and interferes with the oxygen-carrying capacity of blood. Initial symptoms include headache and dizziness. The PM_{10} represents small "dust-like" particles of soot which are sufficiently small to disperse essentially like a permanent gas (e.g., CO). Due to their small particle size, PM_{10} can be inhaled, and its airborne concentrations are regulated to prevent adverse effects associated with the inhalation of high levels of dust. SO_2 can cause nose and throat irritation at high levels and is a precursor to sulfuric acid, a major contributor to acid rain. NO_2's initial symptoms include irritation to eyes, nose and throat. It is also a precursor to nitric acid, a major contributor to acid rain and is also a major contributor to ambient ozone. For further toxicity information, see Sitting, 1991.

For hazardous air pollutants other than criteria pollutants, the state of Alabama has adopted guidelines for new air emissions sources such that the emission of a substance for which no specific regulation exists should not cause ambient air concentrations (on public property) to exceed 1/40th (one hour average) and 1/420th (annual average) of the published threshold limit value as published by the American Conference of Governmental Industrial Hygienists (ACGIH, 1994–1995). Onsite worker exposure is regulated by the U.S. Department of Labor, OSHA, which publishes maximum permissible exposure levels (PEL) for toxic and hazardous substances in the workplace (29 CFR 1910.1000).

The Clean Air Act Amendments of 1990 required all states to submit State Implementation Plans (SIP's) for regulating 189 Hazardous Air Pollutants (HAP's). The state of Alabama has submitted its proposed SIP to the EPA. Under this plan, MSFC will likely be considered a major source and is required to submit an application for a Title V operating permit by December 1997, if it has the potential to emit 10 ton/yr (9.1 mt/yr) of one of the HAP's, 25 ton/yr (22.7 mt/yr) of

TABLE 3.—*National Ambient Air Quality Standards (adopted by the state of Alabama) (40 CFR 50) and Huntsville, Alabama, air quality levels for 1995 (Huntsville, 1995). Highest Huntsville values are reported below. Sulfur dioxide is not routinely measured in Huntsville due to its historically low levels in prior years.*

Pollutant	Averaging Period	Primary NAAQS ($\mu g/m^3$)	Secondary NAAQS ($\mu g/m^3$)	Maximum Concentrations Huntsville Air Quality ($\mu g/m^3$)
CO	8 hr	10,000	—	5,600
	1 hr	40,000	—	6,060
PM_{10}	Annual arithmetic mean	50	50	23
	24 hr	150	150	68
SO_2	Annual arithmetic mean	80	—	—
	24 hr	365	—	<42[1]
	3 hr	—	1,300	—
NO_2	Annual	100	100	26[2]
O_3	1 hr (maximum daily)	235	235	217
Pb	Quarterly arithmetic mean	1.5	1.5	<0.09[3]

[1] November 1993-May 1994 data
[2] 1991-1993 data
[3] 1990-1995 data

any combination of HAP's, or 5 ton/yr (4.5 mt/yr) or more of any of the criteria pollutants. Major sources must address best available control technologies (BACT). Currently, MSFC is required to maintain an air emissions permit issued by the Alabama Department of Environmental Management (ADEM) for two boilers. Air emissions are below permit thresholds for other activities, and observed toxic emissions levels have been within ADEM's guidelines (NASA/MSFC, 1991a). However, existing operations will meet the new guideline criteria requiring a Title V operating permit.

Additional regulations for the "Prevention of Significant Deterioration" (PSD) of air quality exist for a source, defined as the total of all individual release points under contiguous ownership, which has the potential to emit greater than 250 ton/yr (227 mt/yr) of a criteria pollutant (federal regulations adopted by the state of Alabama in ADEM Admin. Code R, Rule 335-3-14-0.04). The purpose of the PSD regulations is to prevent the ambient air quality of any area, whether in attainment or not, from becoming significantly dirtier as the result of significant air pollution releases from new or modified sources. If ADEM determines that this program requires a PSD permit, MSFC will submit an application addressing best available control technology (BACT). For large space engine testing in the United States, BACT is achieved by assuring atmospheric conditions are adequate to achieve disbursement of the emissions and maintain ambient air quality levels within the NAAQS's or other applicable and relevant health-based guidelines. NASA is committed to exercising proper procedures to assure maintaining air quality under either permit scenario deemed appropriate by ADEM. A preliminary release inventory of criteria pollutants during the 1960's, when kerosene engines were developed for use in the Apollo Program, indicates that an average of 2,500 ton/yr (2,268 mt/yr) of CO was released as a result of F–1 engine development. The highest annual release of 7,900 ton (7,100 mt) of CO occurred in 1966. The data will be supplied as background information with MSFC's application to assist ADEM in determining if the program falls within MSFC's normal baseline and is subject to a Title V operating permit, or if it should be considered a new source subject to PSD requirements and review.

Emissions from testing will be transported and dispersed regionally, and, therefore, impact to the general area must be considered. The natural environments potentially affected by the proposed testing include the Wheeler National Wildlife Refuge, rural woodlands, and pasture lands, as well as publicly developed property in the area surrounding the test areas, and Sipsey National Wildlife Refuge. The Sipsey National Wildlife Refuge is a national wilderness area located approximately 42 mi (68 km) southwest of the West Test Area and is the only Class I air quality area within 62 mi (100 km) of the test stands. All other areas within the potentially affected areas are designated as Class II. PSD regulations are more protective of the air quality within Class I areas than Class II areas, as evidenced by the reduced "cap" or maximum allowable "increment" or increase in air pollution concentration from new or modified sources. The Wheeler National Wildlife Refuge, which borders the West Test Area, could be exposed to the highest levels of air pollutants under certain wind conditions.

Impacts to humans result from exposure to pollutants for specific periods of time. Because the test facilities are in the interior of RSA, ADEM has indicated that the criterion for meeting NAAQS's will be exterior RSA boundaries (Hartman, 1994). The nearest permanent public dwellings to the test sites are along the western boundary of RSA at approximately 2.5 mi (4 km) on and near Zierdt Road. A day care center for minor age children exists within MSFC at 1.5 mi (2.5 km) from the test areas. These sensitive areas, as well as others like RSA residential areas, which are approximately 5 mi (8.3 km) from the test stands, will be considered in the air emissions analysis in the following section.

Construction Impacts

The level of construction activity would be slightly higher than the present operations. Most of the test facilities are surrounded by pavement or concrete, resulting in very little dust and airborne particulate matter. Although some of the test facilities still contain lead-based paint, no construction or stand modification activities would result in the release of airborne lead (see the section Facilities and Infrastructure). Therefore, impacts due to construction should be insignificant.

Operational Impacts

For this program, test firing of engines which use RP–1 as a sole or partial fuel source is the only activity resulting in significant releases of regulated pollutants to the ambient air environment. A detailed computer analysis of the combustion products ultimately released to the environment from testing a large engine was conducted (Wang, 1995a). A summary of the rocket exhaust emissions factors and model input values can be found in appendices E and F, respectively. The only pollutant exceeding PSD thresholds is CO. Maximum annual releases of the other three criteria pollutants were less than 5 percent of thresholds. Large engine results were used to estimate releases for other engines at various test durations. Maximum potential test firings are projected to include one full duration test per week of 190 sec and other smaller test firings of engines or components for a few seconds at a time, for a collective total test firing schedule of 250 sec/wk or 13,000 sec/yr. Maximum daily (based on one full duration test in a day and no more than one per week), weekly, and yearly air emissions releases for the large-, medium-, and small-thrust engine classes are shown in Table 4.

TABLE 4.—*Maximum pollutant emission rates for representative small- , medium-, and large-thrust engines. Maximum daily, weekly, and yearly rates are based on a total of 190, 250, and 13,000 sec of testing, respectively.*

Engine	Unit	CO	PM_{10}	NO_2	SO_2
Large	lb/sec (kg/sec)	597 (271)	1.54 (0.70)	1.74 (0.79)	1.03 (0.47)
	ton/day (metric ton/day)	57 (52)	0.15 (0.14)	0.17 (0.15)	0.10 (0.09)
	ton/wk (metric ton/wk)	75 (68)	0.19 (0.17)	0.22 (0.20)	0.13 (0.12)
	ton/yr (metric ton/yr)	3,880 (3,520)	9.88 (8.96)	11.4 (10.3)	6.76 (6.13)
Medium	lb/sec (kg/sec)	298 (135)	0.77 (0.35)	0.87 (0.40)	0.51 (0.23)
	ton/day (metric ton/day)	29 (26)	0.07 (0.06)	0.08 (0.07)	0.05 (0.04)
	ton/wk (metric ton/wk)	37 (34)	0.10 (0.09)	0.11 (0.10)	0.06 (0.05)
	ton/yr (metric ton/yr)	1,940 (1,760)	4.94 (4.53)	5.67 (5.14)	3.33 (3.02)
Small	lb/sec (kg/sec)	53 (24)	0.14 (0.06)	0.15 (0.07)	0.21 (0.10)
	ton/day (metric ton/day)	5 (5)	0.01 (0.009)	0.01 (0.09)	0.02 (0.02)
	ton/wk (metric ton/wk)	7 (6)	0.02 (0.02)	0.02 (0.02)	0.03 (0.03)
	ton/yr (metric ton/yr)	343 (311)	0.94 (0.85)	0.99 (0.90)	1.37 (1.24)

A distinctive difference in exhaust cloud concentrations of solid carbon particles or soot exists between the RD–170 and F–1 (F–1A) engines. F–1 engines use film cooling to cool the engine's combustion chamber. Injection of RP–1 close to the combustion chamber's wall provides a protective cool film of gas which separates the wall from the hot combustion gases. Therefore, gases close to the wall are cooler than the mainstream flow. Cooler combustion of the RP–1 film leads to soot formation, characterized as suspended particulates; a significant percentage will disperse in the air as regulated PM_{10} (Ziebland and Parkinson, 1971; Ruf, 1993). The PM_{10} estimates provided in Table 5 do not represent soot formation from RP–1-fueled engines which solely depend on thin film cooling. If these engines are tested with this design feature, further CFD analyses with field verification would be conducted to refine the PM_{10} projections for air emission permit purposes.

The RD–170, other Russian engines, and newer U.S. models use either regenerative cooling or a combination of regenerative and film cooling to cool the walls of the engine's combustion chamber. In regenerative cooling, one of the propellants is circulated around the outside of the engine before injection into the combustion chamber. Heat transferred to the circulating propellant is recovered as a slight increase in energy. No fraction of the propellant is used solely for cooling purposes as in thin film cooling; therefore, no RP–1 is subjected to cooler combustion temperatures that lead to soot formation (Ziebland and Parkinson, 1971; T.S. Wang, 1995b).

Exposure levels for individual tests were determined using the Rocket Effluent Exhaust Diffusion Model (REEDM), a NASA-developed model which provided projections on initial cloud size and stabilization height (how high the cloud rises), and the Integrated Puff Model (INPUFF), an EPA-approved model for projecting cloud dispersion and exposure levels. Details of the REEDM and INPUFF modeling procedures for projecting maximum exposure levels and distance from the test area are provided in technical memos from Earth Technology Corporation and CH2M Hill, respectively (Earth Technology Corporation, 1994; CH2M Hill, 1994a). Actual meteorological data from RSA's meteorological station was analyzed to determine the meteorological conditions which would result in maximum impact (CH2M Hill, 1994b). Maximum pollutant concentrations and zone of influence from the test areas on MSFC were determined. The results which represent the highest concentrations possible or worst case are presented in Table 6 and compared to applicable NAAQS's. The distance from the test area represents the area which would be maximally impacted from a test. Following a test, the exhaust cloud will rise to an average altitude of approximately 2,000 ft (610 m) at cloud centerline for the large engines. The estimated cloud radius will be 1,400 ft (420 m). The medium engines will produce an exhaust cloud that will rise to approximately 1,600 ft (500 m) with an average radius of 1,050 ft (320 m). The small engines will produce an exhaust cloud that will rise to approximately 1,200 ft (380 m) with an average radius of 850 ft (260 m).

The exhaust cloud, after rising above ground level within a short distance of the test area, will begin to grow in size due to entrainment of air, thus diluting the exhaust products. The cloud will become very dilute as it expands in size sufficiently to mix with ground level air. The cloud will move with prevailing winds. From 1985–1989, predominant wind directions were from the south and southeast and occurred 44 percent of the time. Other wind directions occurred less frequently. Appendix G contains the wind rose for the MSFC and Huntsville area, which is a graphical representation of the prevailing wind speeds, direction, and percent of time that they occurred.

TABLE 5.— *Maximum projected ambient air-emissions exposure levels for single engine tests with a duration of 190 sec at MSFC*

	Carbon Monoxide Air Quality Exposure Levels, μg/m3					
	Large Thrust		Medium Thrust		Small Thrust	
	1 hr	8 hr	1 hr	8 hr	1 hr	8 hr
Engine	8,410	1,070	5,390	680	736	92
Background	9,300	5,900	9,300	5,900	9,300	5,900
Total	17,710	6,970	14,690	6,580	10,036	5,992
NAAQS	40,000	10,000	40,000	10,000	40,000	10,000
Distance from test area:						
km	19	13	13	7	5	3
mi	12	8	8	4	5	3

Table 5 contains the sum of the engine pollutant concentration and existing background levels. A comparison of the NAAQS's for CO shows that air quality standards will not be exceeded by the proposed test program. However, ADEM and EPA define significant ambient air quality increases for CO to be 500 and 2,000 $\mu g/m^3$ for 8-hr and 1-hr exposure levels, respectively (Table 6). Since exhaust concentrations for CO will exceed these levels but remain under the NAAQS guidelines for large and medium size engines for a zone of up to 16 mi (26 km) from the test area, impact to air quality from the test activity is projected to be moderate for these categories; impacts for small engines are expected to be insignificant. Air quality impacts from other criteria pollutants released from testing are very low and well below all NAAQS's levels since their respective release rates were less than 1 percent of the CO levels. Since no NAAQS's will be violated (see Table 5), air quality at these receptors will remain within limits protective of human health and the environment.

The maximum pollutant concentrations were calculated for Sipsey National Wildlife Refuge, the closest Class I air quality area, and are shown in Table 7 with the various regulatory standards. All calculated pollutant concentrations in the Sipsey Wilderness Area are under the NAAQS's, PSD Class I increments, and SAQIL. None of the impacts will be cumulative in nature; i.e., are not additive. Exhaust products from tests will be rapidly dispersed, and incomplete combustion products such as CO will be further oxidized to CO_2, a natural gas in the atmosphere. The CO_2 from testing will be so small that it will not measurably affect the CO_2 concentration in the air. Sensitive receptors such as day care centers, RSA residential housing, and tour bus occupants will not be subjected to any higher levels of pollutants than offsite receptors and consequently will not be adversely affected by this project.

TABLE 6.—*Regulatory standards and modeling results*

Pollutant	Averaging Period	Class II PSD Increment $\mu g/m^3$	Class I PSD Increment $\mu g/m^3$	SAQIL $\mu g/m^3$	Center Maximum Calculated Conc. $\mu g/m^3$		
					Large Thrust	Medium Thrust	Small Thrust
CO	8 hr	—	—	500	1,070	680	92
	1 hr	—	—	2,000	8,410	5,390	736
PM_{10}	Annual	17	5	1	1.04	NM	NM
	24 hr	30	10	5	1.04	NM	NM
SO_2	Annual	20	2	1	0.92	NM	NM
	24 hr	91	5	5	0.92	NM	NM
	3 hr	512	25	25	7.36	NM	NM
NO_2	Annual	25	2.5	1	0.61	NM	NM

NM = not modeled; value too low to require further analysis.

Note: Pb will not be released during testing; therefore, no further analysis was conducted. Contributions to O_3 production form NO_2 and volatile organic compounds released from testing and operations are projected to be extremely low and negligible.

TABLE 7.—*Regulatory standards and Sipsey maximum concentrations from large engines (CH2M Hill, 1994a)*

Pollutant	Averaging Period	Class II PSD Increment ($\mu g/m^3$)	SAQIL ($\mu g/m^3$)	Pollutant* Conc. ($\mu g/m^3$)
CO	8 hr	NA	500	194
	1 hr	NA	2,000	972
PM_{10}	Annual	17	1	0.19
	24 hr	30	5	0.19
SO_2	Annual	20	1	0.17
	24 hr	91	5	0.17
	3 hr	512	25	1.32
NO_X	Annual	25	1	0.11

*Pollutant concentration represents only the air quality burden from testing and does not include background concentrations to directly compare with the NAAQS. If the assumption is made that Sipsey air quality is equal to or better than that of Huntsville, the total 1-hr and 8-hr CO concentrations would not exceed 9,400 and 1,300 $\mu g/m^3$, respectively. These values are below the NAAQS's.

Propulsion systems that use only LOX and LH_2 produce water in the form of steam as the main combustion product. Small quantities of nitrogen oxides may form as a result of the high temperature flames oxidizing nitrogen in the ambient air. Small quantities of materials from inside the engines may be emitted as particulate matter. Prior to each test firing, the LOX and fuel tanks are pressurized with GN_2 and GH_2 and then vented to the atmosphere after each test.

Testing of main injectors, gas generators, FasTrak engines (subscale), and any of the full-scale engines under consideration in this program will result in the use of small quantities of hypergol as igniters. Hypergols are chemicals capable of spontaneous ignition upon mixing or in contact with a catalyst. The hypergol planned for use in this program is TEA/TEB (85 percent triethylaluminum and 15 percent triethylboron). One to four hypergol-containing canisters will be used per test for ignition. Each canister contains 2.5 lb (1.1 kg) of TEA/TEB for a total of 2.5 to 10 lb (1.1 to 4.5 kg) of hypergol burned per test. Based on the maximum potential test projections, approximately 685 lb (311 kg) of TEA/TEB may be used annually during peak testing. Assuming complete combustion of TEA/TEB, combustion of 10 lb (4.5 kg) would produce 3.8 lb (1.7 kg) of aluminum oxide and 0.54 lb (0.25 kg) of boron oxide. By scaling the ground-level concentrations calculated for the F–1 test in previous NASA documents to the maximum potential use of 10 lb (4.5 kg) of TEA/TEB per test, the estimated maximum 8-hr concentrations of the combustion products is expected to be 80 and 10 $\mu g/m^3$ for aluminum oxide and boron oxide, respectively (NASA/MSFC, 1991a). The Alabama guideline limit for both of these compounds is 250 $\mu g/m^3$. The maximum concentrations would occur within MSFC and RSA. Offsite concentrations would be lower due to the additional dispersion which would occur between the point of maximum impact (525 ft (160 m) from the test area) and the site boundary. Therefore, air quality impacts should be insignificant.

Estimated releases to the air from operational activities other than testing, such as fuel loading, solvent cleaning, and general facilities maintenance, are presented in Table 8. These releases would occur at very low rates (estimated to be less than 10 lb/hr (5 kg/hr) during a maximum release rate) and, therefore, will result in insignificant impacts to air quality. These releases will be added to the total releases of the Center and permitted under a Title V air operating permit to be requested from ADEM.

Trichlorethylene, 1,1, 1–trichloroethane, and methyl ethyl ketone are classed as hazardous air pollutants (HAP's) under Title III of the Clean Air Act Amendment of 1990. The projected releases of 4100 lb (1860 kg) is <1% of MSFC's projected estimated maximum potential releases of organic HAP's, and therefore, represents an inconsequential increase in these releases. In addition, all pollutants listed in Table 8 except Freon–113™ are considered to be volatile organic compounds which can contribute to the formation of ozone in the lower atmosphere. The combined projected annual releases of VOC's is 5,400 lb (2,449 kg) or 2.7 t (2.5 mt). The extremely low release rate of 10 lb/hr (5 kg/hr) is too low to quantitate a noticeable impact on ambient ozone production and is therefore considered as an insignificant impact on air quality.

TABLE 8.—*Estimated annual releases to the air from program activities other than engine and component testing*

Pollutant	Annual Release, lb (kg)	
Freon–113™*	800	(363)
1,1,1–Trichloroethane*	1,600	(726)
Trichloroethylene**	2,400	(1,089)
RP–1	600	(272)
Acetone	100	(45)
Methyl ethyl ketone	100	(45)
Paint thinners	100	(45)
Isopropyl alcohol	500	(227)

* To be phased out of production by 1/1/96
** Most probable replacement for ODC's

Four discrete component test activities have been proposed for the East Test Area. Two of these activities involve testing of FasTrak engines or small, scaled-down LOX/RP–1 test engines and preburner components at TF 115 and TF 116. TF 116 equipped with a water dousing system. Therefore, the combustion process will typically undergo quenching shortly after ejection of the hot gases from the nozzle or end component of the engine and inhibit complete combustion of CO to CO_2. The third activity involves simulated altitude testing for the LOX/RP–1 engines at TF 300.

The fourth activity involves testing of gas generators for the LOX/RP–1 engines at TF 500. This facility will not be water cooled, and, therefore combustion of RP–1 should be over 99 percent complete. Water and CO_2 are the main products of combustion with insignificant amounts of CO remaining in the final exhaust cloud. Estimated details of these component tests are provided in Table 9. Smaller, similar test activities will likely be conducted throughout the East Test Area, all of which are expected to have insignificant environmental impact.

TABLE 9.—*Estimated component test parameters for emissions in the East Test Area*

	Single test duration (sec)	Tests per yr	Carbon monoxide released	
			lb/sec	ton/yr
FasTrak	30	30	7	3
Preburner	30	30	7	3
Gas generator	180	30	<1	<1

The above release rates are very small. Therefore, further modeling of impact was not conducted. Insignificant impact to air quality is projected from any small component testing associated with the Advanced Engine Technology Program.

Mitigation

Based on the projected air quality impacts above, air quality will continue to conform to all standards and no mitigation is required. However to obtain a representative data base of seasonal conditions and impacts, MSFC intends to monitor combustion products, exposure levels, and meteorological conditions for the first six tests and thereafter for at least two tests each season for a year. If air quality levels approach the NAAQS's, test firing criteria for full scale testing will be reevaluated to establish controls that will ensure protection of employees and the public. If combustion is determined by measurement to be more efficient than projected by combustion modeling, thus resulting in significantly less CO released per test, air quality monitoring will be suspended after the first three tests.

Noise

Affected Environment

MSFC is surrounded by a large federally-owned area consisting of RSA and the Wheeler National Wildlife Refuge. This area is an effective physical barrier between MSFC engine testing and the general public. Development of space propulsion systems has been the primary mission of MSFC since its establishment in 1960. The U.S. Army had been developing and testing rocket engines at RSA since soon after the end of World War II. The history of MSFC, surrounding land uses, and noise associated with rocket engine testing are described in the "MSFC Environmental Resources Document" (NASA/MSFC, 1991a).

Full scale engine testing for this program may be considered for either the AETF or F–1 test stands. Both are located in the southwest portion of MSFC and oriented to the west-southwest in a manner that directs sound to the south and west. The AETF is currently being used for testing SSME's. The F–1 test stand, which is currently inactive, was used for testing F–1 engines.

Engine component testing is proposed for TF 115, TF 116, TF 300, and TF 500. All of these facilities are located in the southeast portion of MSFC and are currently being utilized for component testing.

Several populated areas surround RSA. Huntsville borders on the east, north, and west; Madison on the west-northwest; Triana on the southwest; Mooresville on the west; Somerville on the southwest; Decatur on the west-southwest; Hartselle on the southwest; and Falkville on the south-southwest.

Construction Impacts

Construction activities needed to facilitate engine testing at proposed facilities are described in the sections "Description of Alternative Test Facilities" and "MSFC Facilities and Infrastructure." They are primarily minor modifications to existing facilities, such as the addition of a RP–1 fuel run tank and associated piping. There would be no noise impact due to such activities.

Operational Impacts

Potential impacts from significantly high noise levels are typically health effects or structural damage. OSHA regulates permissible noise exposures without hearing protection. Maximum exposure to impulsive noise should never exceed 140 dB peak sound pressure level (29 CFR 1910.95). The more conservative NASA Health Standard on Hearing Conservation (NASA, 1996) also sets the permissible exposure limits as detailed in Table 10. Based on experience from testing engines at MSFC, NASA has estimated the chances for claims at structural damage versus overall sound pressure level (OASPL) (fig. 6). These predictions indicate a 1 in a thousand chance of structural damage claims occurring at levels of 111 dB and a 10 in a thousand chance at 119 dB (NASA/MSFC, 1991a).

TABLE 10.— *Permissible exposure limits for Noise (NASA Hearing Conservation Program)*

Duration (Hours)	Sound Level (dBA)
16	80
8	85
4	90
2	95
1	100
0.5	105
0.25	110
0.125 or less	115

Maximum potential test firings are projected to include one full duration test per week of 190 sec and other smaller test firings of engines or components for a few seconds at a time, for a collective total test firing schedule of 250 sec/wk or 13,000 sec/yr. Predictions of the noise levels that would be produced from testing large, medium, and small engines have been made using the approach described in appendix H. This approach was used to develop OASPL, measured in dB, contours for the engine testing. Another scale, the A-weighted scale, is used to account for the hearing range of the human ear. This adjusted sound pressure scale, measured in dBA, accounts for the insensitivity of the human ear to low frequencies. The acoustic energy generated by engine testing is concentrated in the low-frequency range. High-frequency noise is attenuated (reduced) as distance from the noise increases and when obstructions such as trees and buildings occur between the noise generator and listener. Modeling results do not take into account attenuation due to obstructions and are, therefore, conservative. Measurements for background noise were taken using a Rion Real-Time Sound Level Analyzer, Model NA–23. Measurements were taken at five different locations on or around MSFC over a 28-hr time period. The computed average for background noise along with other common noise levels is given in Table 11.

TABLE 11.—*MSFC background and common noise levels*

dBA Level	Source
46	MSFC background
70	Normal street traffic
90	Lawn mower
100	Loud music
140	Thunder

A-weighted sound levels and background noise levels were used in determining the equivalent A-weighted sound level (Leq). The Leq is defined as the constant sound level that conveys the same A-weighted sound energy as the actual time-varying A-weighted sound (NASA, 1978). Leq values are given below in Table 12 (Holland, 1995).

The maximum sound pressures to the closest private property of 115–119 dB correspond approximately to A-weighted sound levels of 97 dBA, 96 dBA and 94 dBA for the large, medium, and small engines, respectively. These correspond to 24-hour average sound levels, Leq, of 70 dBA, 69 dBA and 67 dBA, respectively, assuming a 190-second test and an overall average background noise of 46 dBA.

The OASPL contours in Figures 7, 8, and 9 show the extent of low-frequency noise or rumble that can cause vibration in buildings. Maximum predicted offsite noise levels at the outer boundaries of Redstone Arsenal are shown in Table 12.

TABLE 12.—*Maximum offsite noise levels*

Engine	Maximum Noise Levels Off RSA dB	dBA	Leq
Large	119	97	70
Medium	116	96	69
Small	107	94	67

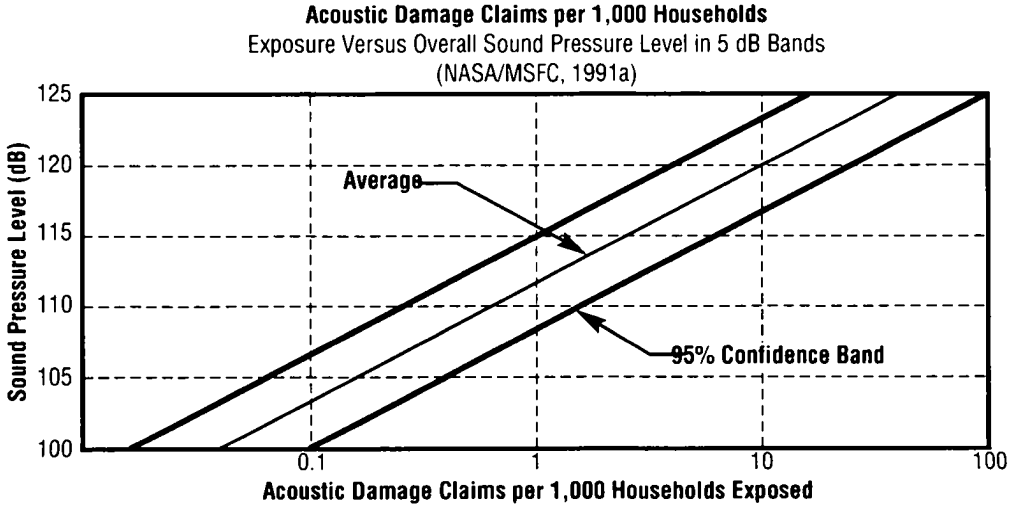


FIGURE 6.—Structural damage claims versus OASPL (dB).

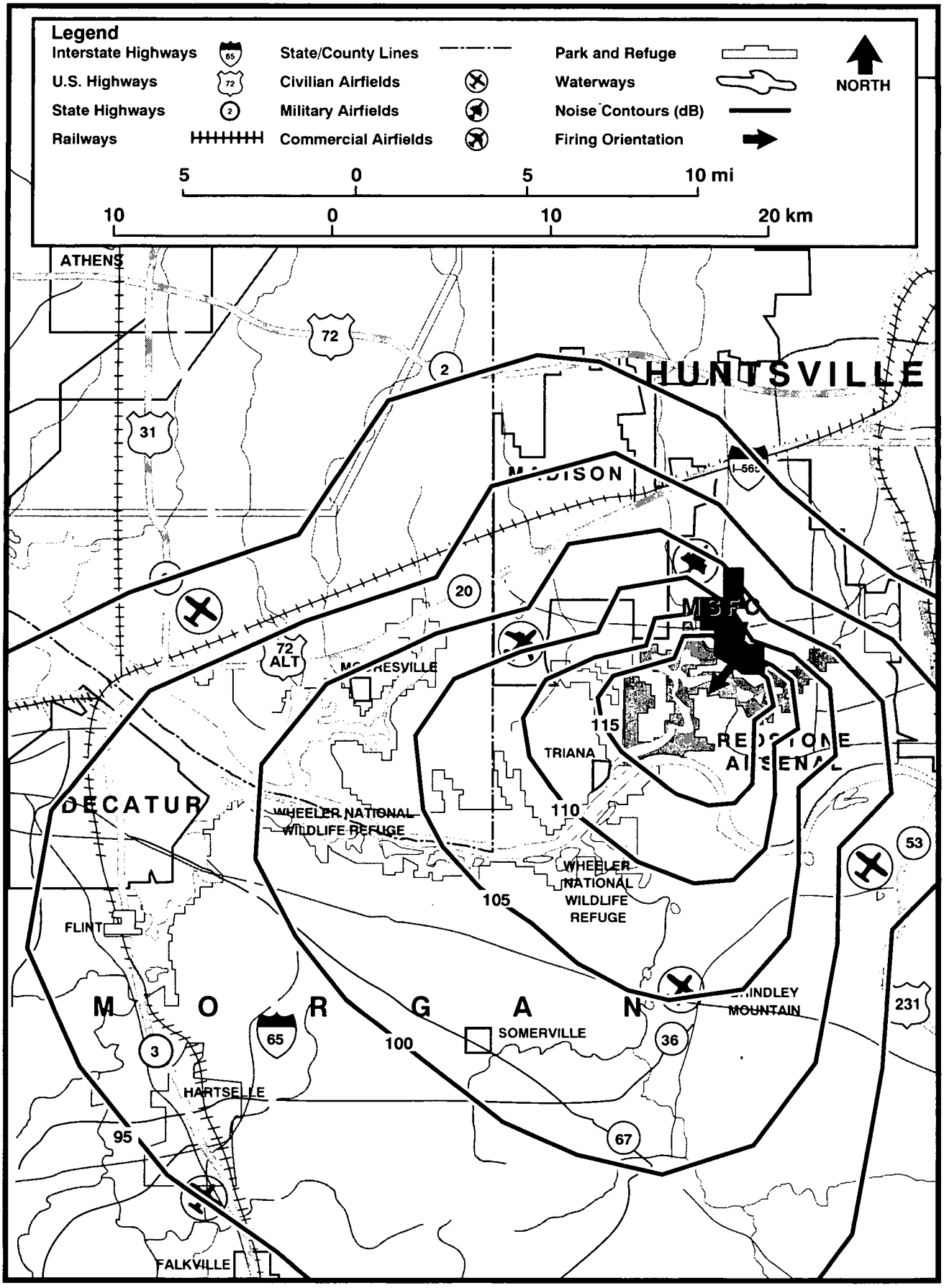


FIGURE 7.—OASPL projections (dB) representing the large-engine classification.

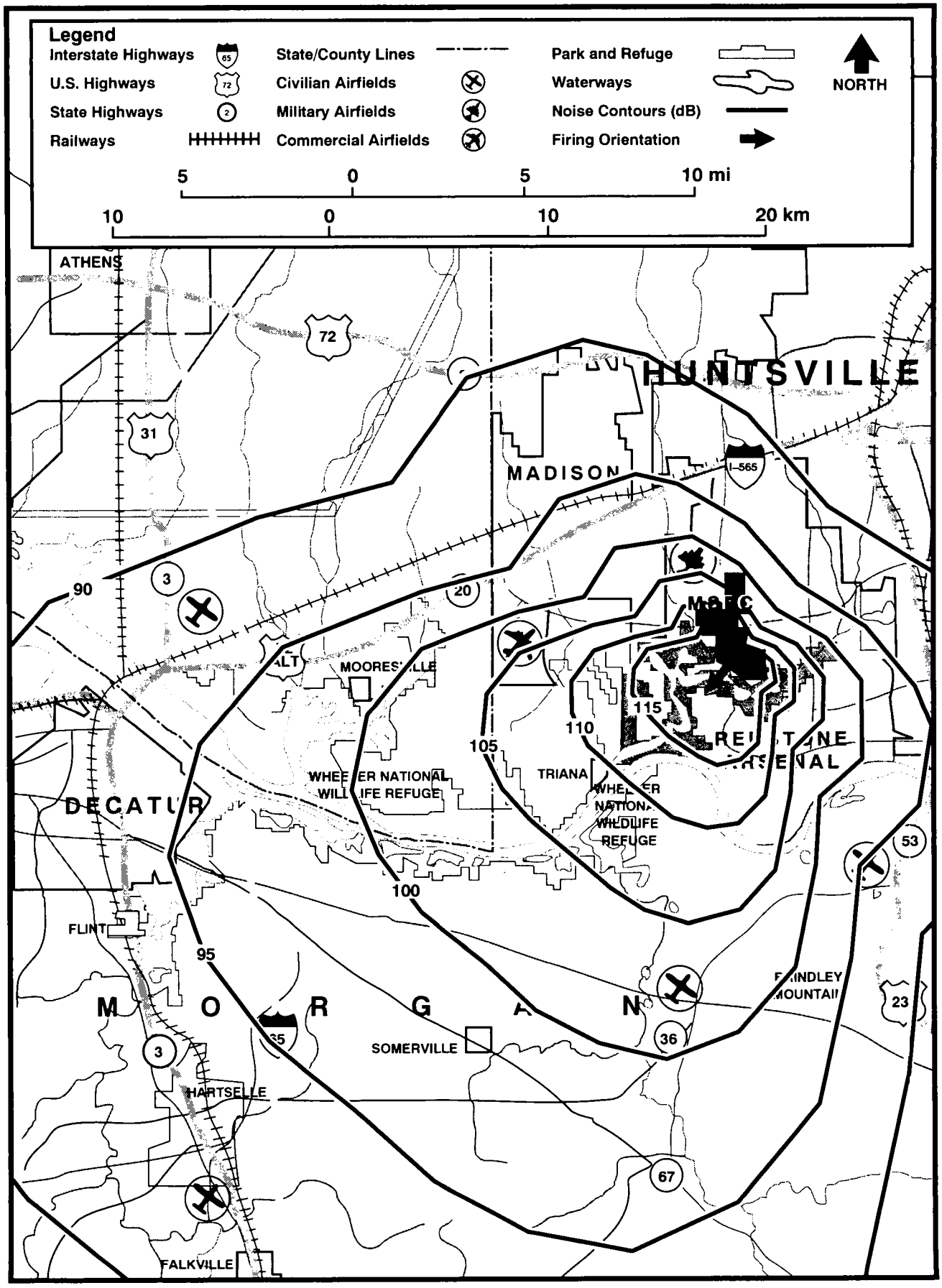


FIGURE 8.—OASPL projections (dB) representing the medium-engine classification.

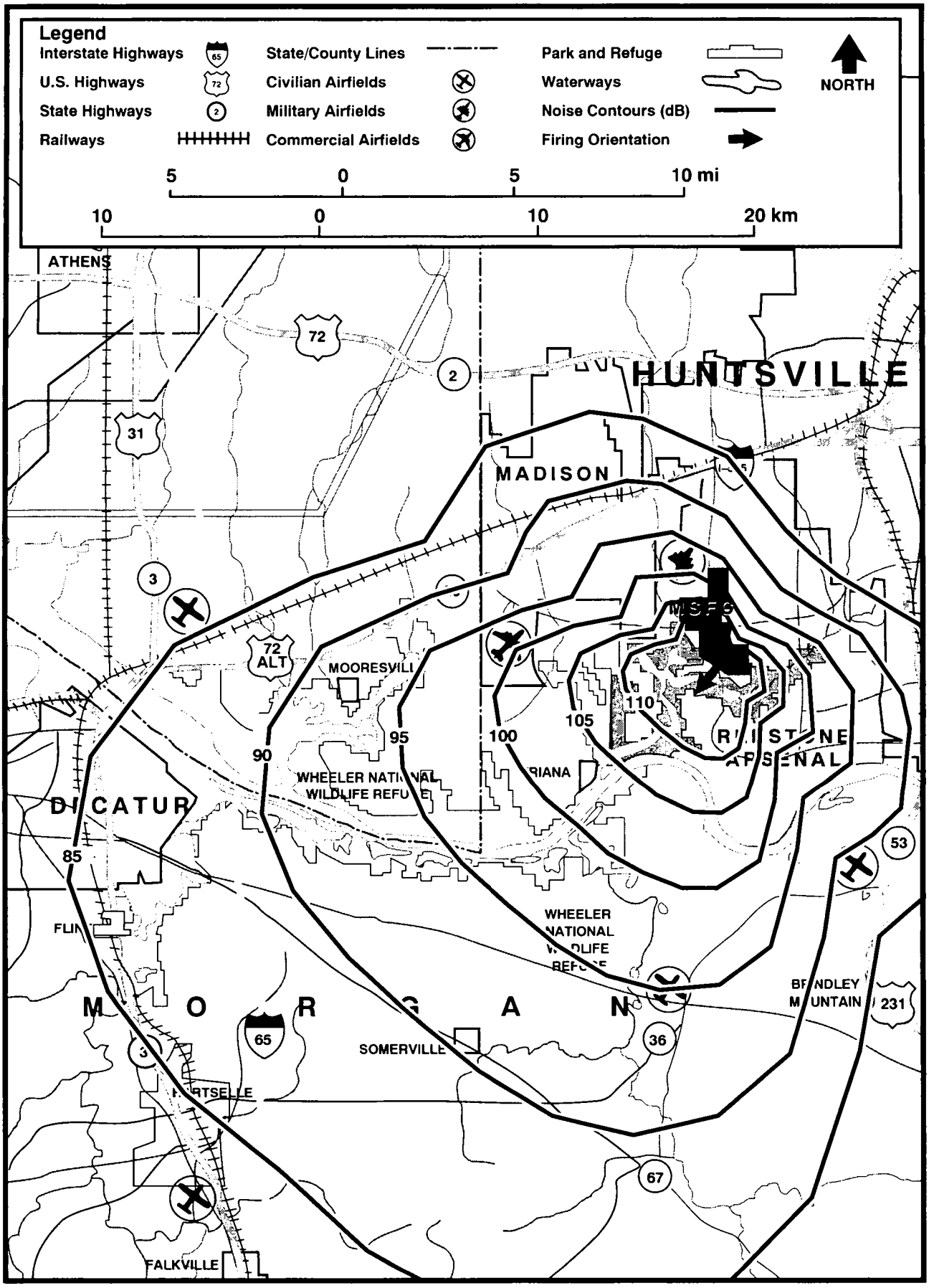


FIGURE 9.—OASPL projections (dB) representing the small-engine classification.

The maximum offsite OASPL for a large engine test is estimated to be 119 dB. At these levels, the chance of structural damage claims would be about 1 percent or 10 claims per 1,000 households. Testing of a large engine represents a moderate impact to the community southwest of RSA. The natural obstructions (trees) and short duration of the tests would lower the risk of structural damage. Maximum chances of structural damage claims for the medium and small engines are approximately 0.6 percent and less than 0.1 percent, respectively, resulting in moderate and insignificant impacts to the community.

The A-weighted noise contours in Figures 10, 11, and 12 show the extent of middle- and high-frequency noise that humans can hear (Appendix H). These contours cover a much smaller area than the OASPL contours because of the low content of middle- and high-frequency sounds produced by rocket engines. The A-weighted process attenuates the overall sound pressure spectrum to match the frequency response of the human auditory system. The predicted maximum offsite A-weighted sound levels would be approximately 97 dBA. These noise levels would be very noticeable but would be an insignificant noise impact because of the short duration (maximum 190 second full duration test). People are exposed to similar noise levels from traffic, aircraft, and other normal daily activities. Table 11 shows common noises and their levels.

Acoustic focusing can increase noise levels due to certain meteorological conditions. When the speed of sound increases with altitude due to temperature and/or wind profile, sound energy is refracted causing higher noise levels at a given distance than normally expected. Acoustic focusing and its effects on noise levels from engine testing at MSFC are discussed further in appendix H.

Mitigation

The physical separation between test facilities and public property by RSA mitigates or reduces the sound levels under normal atmospheric conditions. NASA will monitor meteorological conditions prior to testing to determine if focusing may occur which would result in structural damage probabilities higher than predicted for large engines. If conditions are favorable for acoustic focusing, continuation of testing will be evaluated for program risk, although compliance will be maintained with environmental requirements. A noise monitoring program will be established to determine actual noise levels at various locations produced by engine testing. Employee safety programs have been established by prior testing programs that adhere to OSHA guidelines. These safety procedures will be utilized for this program. MSFC will make available test firing schedules through Public Affairs office releases to the news media for large engine testing.

Water Quality

Affected Environment

The AETF and F–1 stands in the West Test Area are used to test large propulsion systems. Industrial water supplied by RSA is stored in large tanks to provide for cooling water and fire protection of the test stands and flame deflector during testing. No additional cooling water storage is being planned to meet LOX/RP–1 or LOX/LH_2 testing needs. After use, the cooling water is discharged into an 11 ac (4 ha) detention pond. Water from the detention pond flows into Indian Creek through an unnamed tributary. The discharge is intermittent and regulated by a state of Alabama NPDES permit, discharge serial number (DSN) 019. The NPDES DSN 019 permit allows only testing of LOX/LH_2 -fueled rocket engines and would require modification.

A 14,000 gal (53,000 L) run tank for RP–1 fuel will be added to the AETF. A new 20,000 gal (75,700 L) aboveground storage tank to be constructed near the AETF will be used for bulk storage of RP–1 fuel. The F–1 stand has a 50,700 gal (192,000 L) RP–1 run-tank, which will be filled from the 20,000 gal (75,700 L) storage tank the day prior to testing. Accidental releases from the bulk storage tank would be retained in the surrounding 110-percent secondary containment area.

TF 115, TF 116, TF 300, and TF 500 in the East Test Area are also being considered for use in component testing. Discharge water from TF 115 and TF 116 will discharge through NPDES permit point DSN 012, and water from TF 300 and TF 500 will discharge through NPDES permit point DSN 016. Both DSN 012 and DSN 016 would require NPDES permit modifications.

Accidental releases from the run tanks at AETF and F–1 would flow into the 11 acre (4 hectare) detention pond. The pond was constructed in the 1960's at the time the test stands were built. Because of the use of RP–1 in that era, the pond was designed as a large oil and water separator. Effluent from the pond exits through a subsurface drain, thus retaining any spilled RP–1 floating on the surface. The MSFC Spill Response Team would initiate cleanup in accordance with MM 1040.3E, "MSFC Emergency Plan." Water samples will be taken to verify cleanup effectiveness.

Construction Impacts

Upgrades to the test stand would involve minor modifications to existing concrete surfaces and would not require earth moving. Due to the size and type of proposed construction, no water quality impacts are anticipated and no NPDES permit for construction (land disturbance greater than 5 acres (2 hectare)) will be necessary.

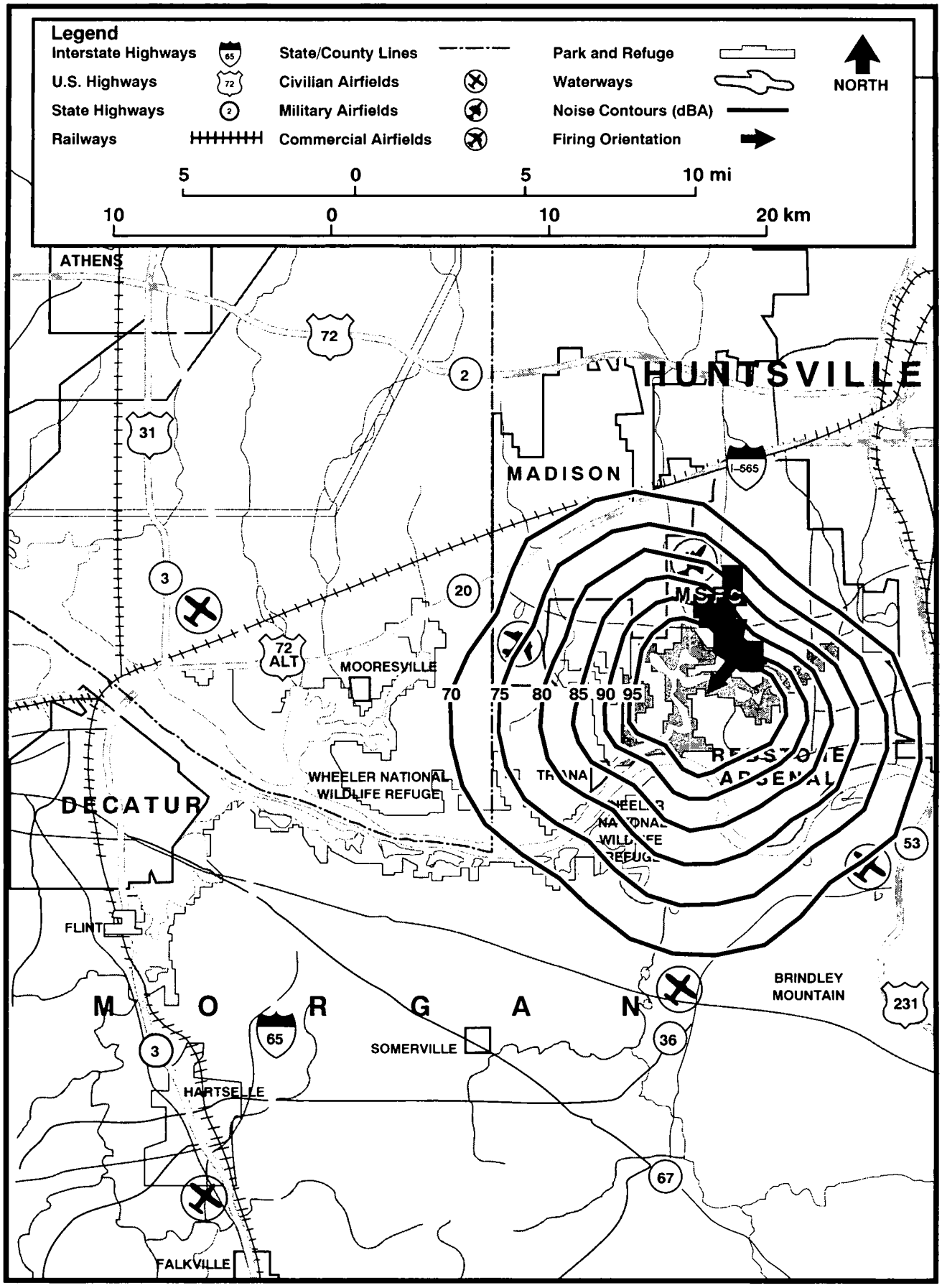


FIGURE 10.—A-weighted sound-level projections (dBA) representing the large-engine classification.

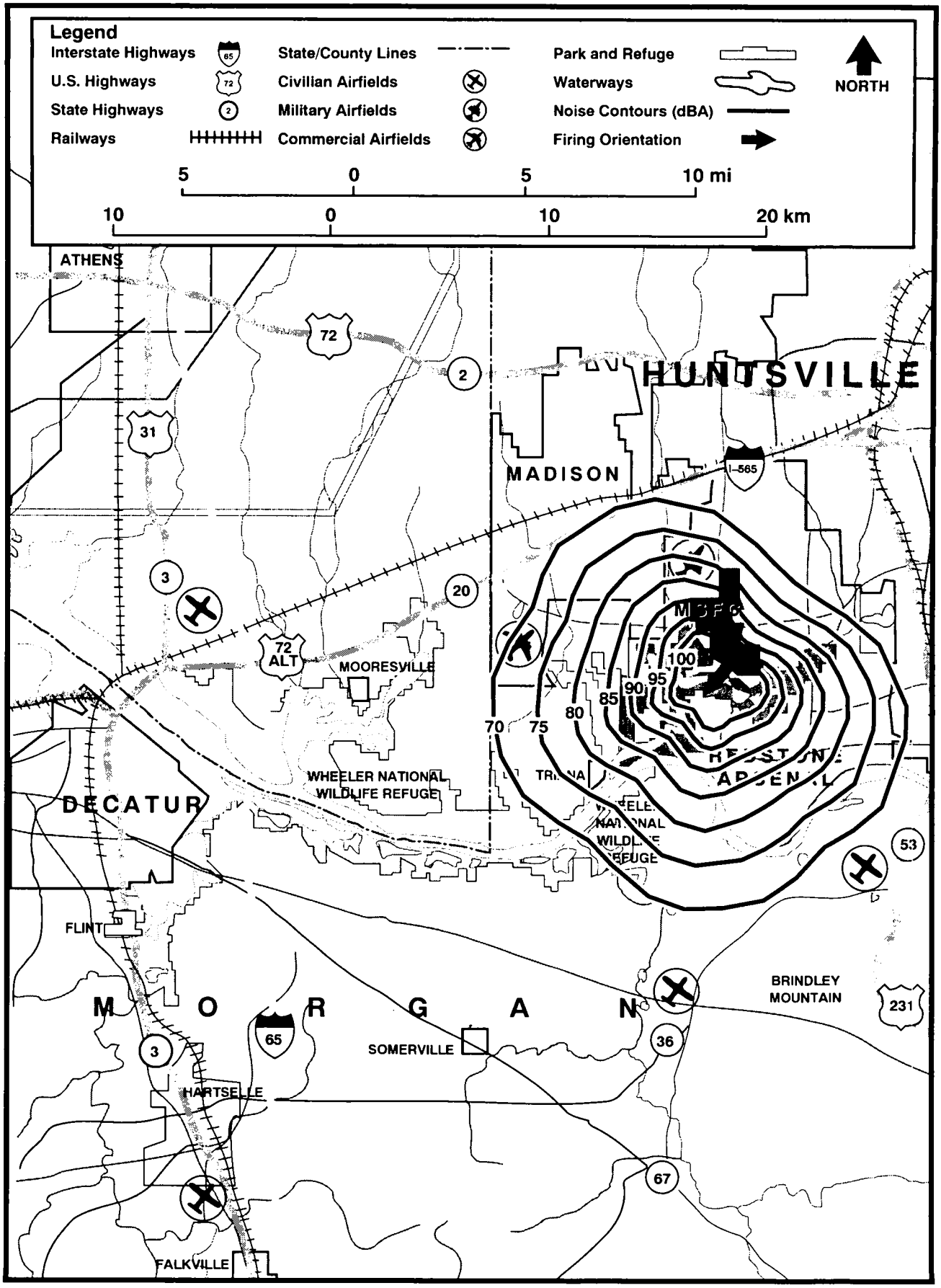


FIGURE 11.—A-weighted sound-level projections (dBA) representing the medium-engine classification.

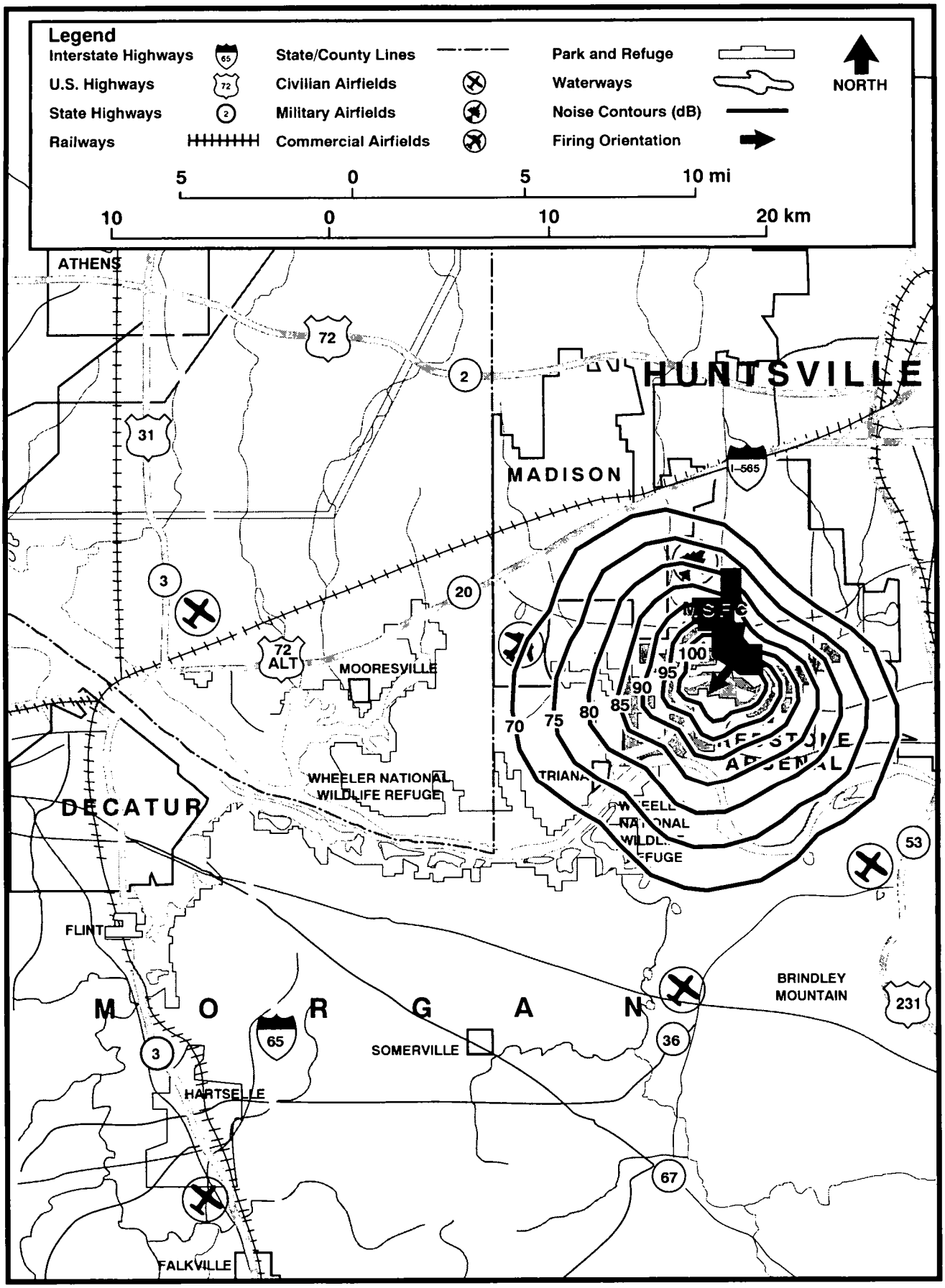


FIGURE 12.—A-weighted sound-level projections (dBA) representing the small-engine classification.

Operational Impacts

Operation at the AETF would involve single engine testing for the LOX/RP–1 program. LOX/RP–1 engine testing will generally be of shorter duration than those for the SSME. Therefore, the quantity of cooling water used for each LOX/RP–1 single-engine test would typically be lower than the 1.5 M gal required for a full duration SSME test. The existing 5 Mgal cooling water system would be adequate for LOX/RP–1 testing activities.

Small quantities of waste solvents, oils and lubricants, as well as dust particles from the test stand, may be washed into the cooling water discharge. Approximately 30 gal (114 L) of RP–1 will be released per engine test of the LOX/RP–1 or LOX/LH_2/RP–1 engine. The discharge water quality would be different, requiring modification of the NPDES permit at all points receiving the deluge water. Currently, the NPDES permits for DSN 012 and 019 requires analyses for oil and grease, total suspended solids, and trichloroethylene. Flow measurement of effluent is also required. No change to the sampling parameters is anticipated for these points after consultation with ADEM. The NPDES permit for DSN 016 requires visual inspection for oil sheen and would require the same parameters as DSN 012 and 019 to be added to permit requirements. Any cleaning solvents, such as TCE, will be used with proper controls and containment to prevent releases to the pond.

Rocketdyne has been testing similar engines in California using a deluge pond for water collection. These ponds are unlined earth ponds that collect water from the Sewage Treatment Facility and other operations, including the cooling water used in the engine testing. Based on their NPDES monitoring data, there is no impact to the environment from test firings. Small amounts of benzene, a constituent of RP–1, have been found at the flame bucket. However, analyses of the water at the NPDES discharge point indicate no detectable level of benzene, and the water is considered uncontaminated by the regulating California State Water Board (Nelson, 1994). Based on the nature of the tests proposed at MSFC and information obtained from Rocketdyne, impacts from operation of the LOX/RP–1 or LOX/LH_2/RP–1 test programs are expected to be insignificant.

Mitigation

No mitigation is required based on the above information and the fact that secondary containment measures will be incorporated into the design and conduct of this program.

Groundwater Resources

Affected Environment

MSFC is underlain by a sensitive hydrogeological environment. Two aquifers or layers of groundwater are present near the surface at MSFC. The first layer, called the residuum aquifer, includes soil and unconsolidated material from the surface to the bedrock. The residuum serves as a large groundwater reservoir. Wells completed on MSFC in the residuum typically produce 1 to 15 gal/min (4 to 57 L/min). These rates indicate that groundwater is transmitted slowly through the residuum to the bedrock below.

The second layer of groundwater, called the Tuscumbia limestone/Fort Payne aquifer, is characterized by an intricate network of cavities along bedding, joint, and fracture planes through which groundwater can readily flow. By contrast with the water-retentive residuum aquifer, wells intercepting these bedrock cavities have yielded upward to 2,000 gal/min (7,570 L/min). Springs where these water-filled solution cavities intersect the surface can produce over 5 Mgal/day (19 ML/day).

Construction Impacts

No groundwater wells or deep subsurface disturbance is planned for this project. Therefore, no impact to groundwater resources is anticipated.

Operational Impacts

Secondary containment of all above-ground bulk storage tanks for RP–1 will be provided. Run tanks filled with RP–1 will be tested and inspected in accordance with the best management practices plan for oil and hazardous substances and updated as necessary in accordance with the MSFC Stormwater Permit. Therefore, insignificant impact to groundwater resources is expected.

Mitigation

Since secondary containment will be incorporated into the design and operation of facilities used or modified for this program, no further mitigation is required.

Wetlands and Flood Plains

Affected Environment

The AETF and F–1 test stands are located in the West Test Area within the boundary of the Wheeler National Wildlife Refuge and approximately 1,000 ft (305 m) from the Wheeler Lake wetlands. They are separated from the Wheeler Lake wetlands by a levee that surrounds the detention pond common to both test stands. Immediately outside the levee and within the MSFC boundary are approximately 95 ac (38 ha) of Palustrine (P) wetlands—both forested (PFO) and scrub/shrub (PSS). The hydrology of this wetland area is controlled by the Wheeler Lake impoundment, surface runoff, and MSFC process water discharge. Within the levee there are approximately 11 ac (4 ha) of Palustrine unconsolidated bottom (PUB) wetland and open water pond. This non-jurisdictional system is a man-made treatment pond that receives NPDES permitted

cooling water blowdown from the test facilities. Figure 13 shows the wetland areas and 100-yr flood plain elevation within the MSFC boundary. During a field inspection in August 1992, there were no signs of stress to the wetland vegetation within or immediately outside the levee. The AETF and F–1 test stands are above the 100-yr flood plain elevation (572 ft (174 m) elevation).

TF 115 and TF 116 are located in the East Test Area and approximately 400 ft (122m) north and northwest of Wheeler National Wildlife Refuge. Both test facilities have a drainage ditch and detention pond that are classified PFO and PUB, respectively. The drainage ditch consists of approximately 1 ac (0.4 ha) of PFO wetland. The hydrology of this wetland system is controlled by storm water and process water from the test facility. The detention pond is approximately 2 ac (0.8 ha) and receives NPDES permitted process water from the East Test Area.

TF 300 and TF 500 also have associated drainage and detention ponds that are classified PFO and PUB, respectively. The drainage system is approximately 1 ac (0.4 ha) in area and flows into the West Test Area wetland. There are three separate ponds in this area that total approximately 2 ac (0.8 ha), all of which are supported by surface and process water runoff.

Construction Impacts

Modifications to be undertaken primarily for the Advanced Space Transportation Program will be made on the existing facilities. There would be no construction-related impacts to wetlands or flood plains.

Operational Impacts

Proposed engine testing activities would not result in wetland or flood plain disturbance. Cooling water used during testing will be retained in the detention pond and analyzed and/or treated before release. The detention pond is currently being investigated for existing contamination and designs will be developed and implemented to assure proper containment. The potential for wetland impacts from accidental material spills would be minimized through compliance with all applicable spill prevention and control requirements. No impacts are anticipated to the wetlands outside the levee. Deposition of particles released to the air during test firings are anticipated to contribute no impact to the overall quality of the wetland and flood plain areas. Therefore, this project is projected to have insignificant impact to wetlands and flood plains.

Mitigation

No mitigation is required.

Biotic Resources—Wildlife and Vegetation

Affected Environment

(A) Terrestrial Biota

Physiographically, MSFC is located in the Tennessee Valley district on the Highland Rim section of the Interior Low Plateaus. Ecologically, this position has resulted in the presence of rich biological diversity associated with an abundance of animal and plant communities. Also contributing to this fact is that the Appalachian Plateaus, Ridge and Valley, Piedmont, and Coastal Plain physiographic provinces intersect within a 100 mi (161 km) radius. This region's dominant vegetation is mixed pine and hardwood forests interspersed with pasture and active fallow and abandoned cropland in various stages of regrowth. Wetland prairies occur in the appropriate hydrologic settings that cannot support trees or shrubs.

Within MSFC, nearly half the land area is developed. The remaining undeveloped areas support mostly forest, old fields, and marsh-cover types in various stages of ecological succession. In upland areas, forest cover includes pure stands of planted pines such as loblolly, short leaf, Virginia, slash pine and stands of pines mixed with hardwoods such as various oaks, black walnut, and hickories. Bottomland hardwoods are found in transition- and low-lying areas. Less than 10 percent of MSFC is considered wetlands.

MSFC supports a variety of wildlife species including white-tailed deer, opossum, beaver, mink, and various waterbirds. The most sensitive natural habitats at MSFC are those adjacent to the test areas in the Wheeler National Wildlife Refuge, which is a major waterfowl wintering area and year-round habitat for many species. Vegetation and wildlife species occurring at MSFC are identified in the "MSFC Environmental Resources Document" (NASA/MSFC, 1991a).
The proposed test area is located within an area of developed land covered by pavements or mowed grass. The site is surrounded by mixed pine and hardwood forest. Wildlife habitat in the immediate area of the test stand is considered marginal because of the present use of this facility. This area may be a suitable foraging area for various species (e.g., deer, mice, song birds, and hunting raptors). However, activity associated with current engine tests and operations limits its suitability as nesting or roosting habitat except for more common rodents, lizards, etc., that have adapted to the present habitat conditions.

(B) Aquatic Biota

Few aquatic habitats exist at MSFC. With the exception of undeveloped wetlands comprising less than 10 percent of MSFC in the southwestern portion of the site, and small segments of Indian Creek on the MSFC western boundary, most aquatic habitats are intermittent or ephemeral ditches and swales, except for a few very small impoundments.

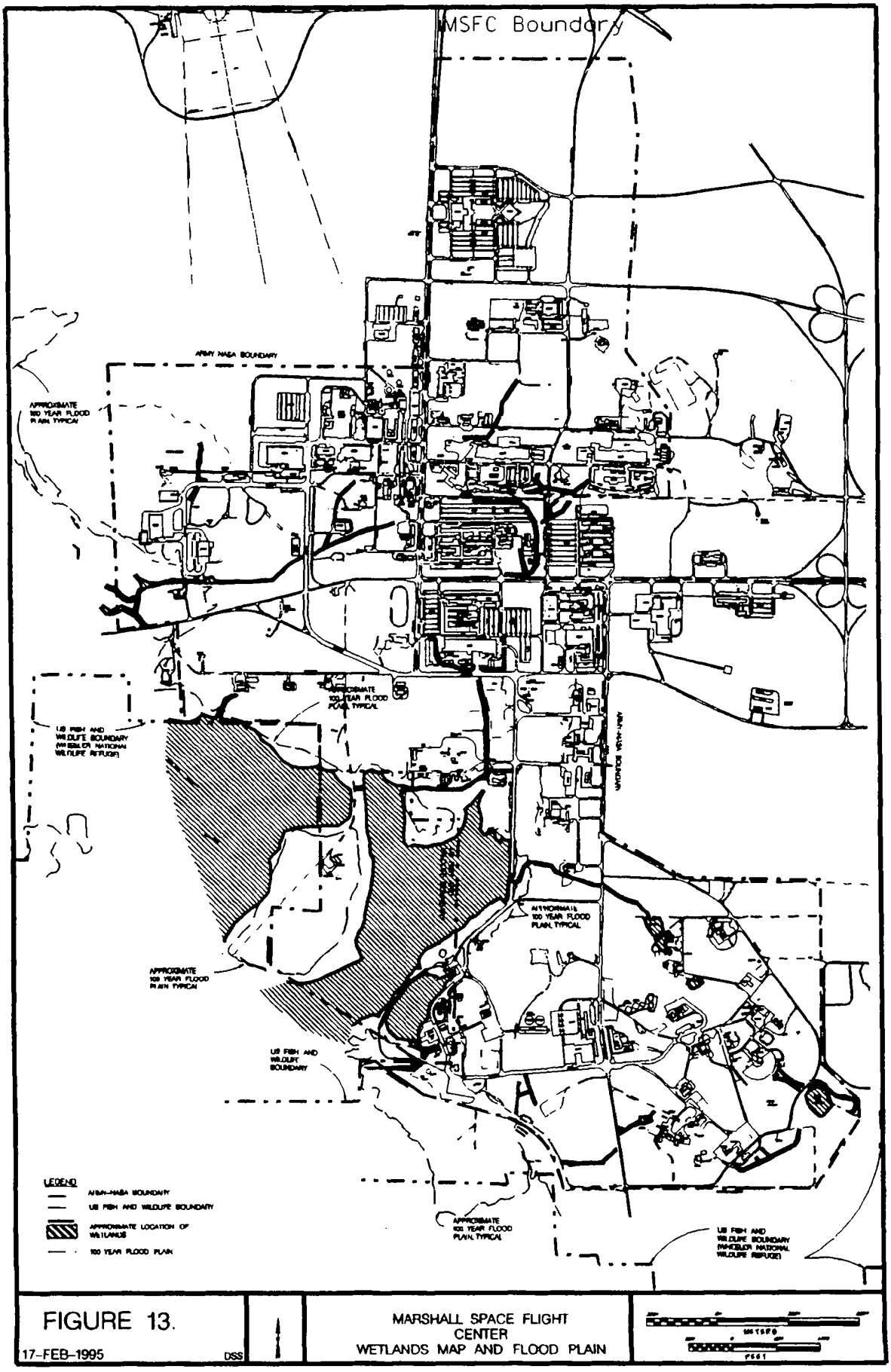


FIGURE 13.—Marshall Space Flight Center wetlands and flood plains.

Most of the site wetlands are heavily vegetated, reducing their use by important aquatic species. Important sport species of fish found on the site include largemouth bass, bluegill, and channel catfish (NASA/MSFC, 1991a). The detention pond, which receives cooling water discharge from the West Test Area stands, supports bass, sunfish, frogs, and turtles, as well as rooted and floating aquatic plants. No significant or permanent impacts to the fauna and flora have been recorded in association with past test activities.

Construction Impacts

Only small scale land disturbances will result from construction. Any sedimentation that results will settle out in the detention pond as designed and not impact local waters offsite. Therefore, impacts from construction on biota are considered insignificant.

Operational Impacts

Proposed testing activities at the AETF and F–1 test stands would be similar to current and past uses of these facilities. No additional impacts to vegetation or wildlife habitat on MSFC or in adjacent areas are anticipated. Noise from engine testing could affect waterfowl and other wildlife at Wheeler National Wildlife Refuge adjacent to the test area. Testing would generate high noise levels for brief periods and low frequency vibrations intermittently for large distances .

The effects of noise on animals is variable, not only between different species but also between individuals (Evans and Cooper, 1978). In general, field studies on a variety of animals have demonstrated few, if any, measurable lasting physiological or reproductive effects from impulse or steady state noise, particularly at levels below 120 dB (Evans and Cooper, 1978). However, many animals including cattle and raptors (birds of prey), often exhibit a "startle reflex" in response to sudden impulse noise. Impulse noise greater than 85 dB have been shown to cause the startle reflex in birds (Evans and Cooper, 1978). Ducks either lifted for a short flight or interrupted their behavior. Other birds showed increased alertness and many temporarily abandoned their nests, thus leaving eggs open to predation (Evans and Cooper, 1978). Nesting raptors have been observed to interrupt their behavior and leave the nest. However, studies conducted on the response or raptors to noise from low level flights by military jets found no evidence of nest site abandonment or reproductive failure (Institute for Raptor Studies, 1981). The noise from engine testing would startle wildlife and possibly drive them from the area temporarily. However, animals in the vicinity of engine testing and similar abrupt, loud noises adapt and do not appear to be unduly disturbed by the activity. Overall operational impacts are projected to be insignificant.

Mitigation

Using contemporary standards for controlling sedimentation and guarding against accidental spills during loading and off-loading fuels or other hazardous materials negate the need for mitigation. Wheeler National Wildlife Refuge personnel expressed interest in receiving projected test schedules for tests of engines larger than those tested currently, and NASA will honor this request (Dukes, 1994). Schedules will be provided as requested for possible use by wildlife specialists to study noise response and adaptation of animals residing on the refuge.

Threatened and Endangered Species

Affected Environment

The United States Fish and Wildlife Service (USFWS) Daphne Field Office, in a letter dated December 15, 1994, provided a list of federally-listed endangered and threatened species and candidates for listing which may be present in the project area (appendix B). Additional listed and state-ranked species with potential habitat in the project area are identified in the "Field Manual of Threatened and Endangered Species Potentially Occurring at the Marshall Space Flight Center" (NASA, 1994b). To date, the Alabama cave shrimp and Tuscumbia darter are the only known endangered and threatened species, respectively, with high probability of habitat in the vicinity of the project area. The cave shrimp is a blind organism dwelling in cave water pools and possibly subterranean caverns in the bedrock. No known caves with surface entrances exist in the test areas. The only known and potential habitat of the Tuscumbia darter is more than a mile northwest of the West Test Area and upstream of any flowing-water bodies draining from either test area.

Construction Impacts

New construction will be minimal. No drilling into the bedrock is planned. No impacts from construction are expected.

Operational Impacts

The USFWS (appendix B) stated that the primary concern for impact would be potential water pollution from chemical by-products during engine test firings. No impacts are expected to the species within the affected area; however, monitoring will be conducted as described in the section "MSFC Water Quality-Operational Impacts" section.

Mitigation

No mitigation will be required. MSFC will follow consultation procedures with the USFWS as described in Section 7 of the "Endangered Species Act," if required.

Archeological Resources

Affected Environment

An estimated quarter of RSA property has been examined, to some degree, for archeological resources of a prehistoric (12000 B.C. to pre-A.D. 1500) and historic (since A.D. 1500) nature. Through these studies and based on similar topography and migration patterns in known archeologically significant areas, the RSA may contain as many as 1,000 individual sites (Hubbert, 1989; U.S. Army/ RSA, 1992).

Two archeological sites, designated as 1Ma104 and 1Ma110, have been identified on RSA and are the closest to the proposed test facilities. The site 1Ma104 lies within the flood zone area, is classified as prehistoric, and is thought to cover an area approximately 0.5 mi by 0.2 mi. (0.8 km by 0.3km). The 1Ma104 site is within the Wheeler National Wildlife Refuge boundary, partially within the MSFC boundary, and located northwest of MSFC's West Test Area test facilities. It is estimated that the closest part of the 1Ma104 area is at least 0.4 mi away from either the AETF or F–1 test facilities. The U.S. Army Corps of Engineers (USACE) cultural resources personnel have recommended that additional testing be performed in this area to further evaluate its archeological potential. This site has officially been registered with the state of Alabama as an archeological site and could possibly be eligible for the National Register of Historic Places (NRHP).

Site 1Ma110 is located just east of the RSA-MSFC eastern boundary and is approximately 1 mi (1.6 km) away from the West Test Area test facilities. The closest East Test Area test facility is TF 116 which is approximately 0.2 mi (0.32 km) away but is separated from 1Ma110 by trees. This site has been classified as prehistoric, but has not been recommended for further testing and evaluation.

The Alabama Historical Commision has reviewed the proposed project and has provided concurrence, as shown in Appendix B.

Construction Impacts

Soil disturbance in the West Test Area during construction would be minor, and no disturbances are planned for the East Test Area. Therefore, insignificant impact to archeological sites is expected. If any previously undiscovered archeological site is uncovered during construction, construction will stop until the State Historical Preservation Officer and the NASA Federal Preservation Officer have been notified and the requirements of Advisory Council on Historic Preservation (36 CFR 800) have been satisfied.

Operational Impacts

Operational plans as projected would not impact archaeological sites.

Mitigation

No mitigation is required.

Cultural and Historical Resources

Affected Environment

The AETF was constructed in 1964 for the static testing of the Saturn V engines. The stand was modified in 1974 to perform shuttle external tank structural tests and again in 1986 to accommodate the SSME testing. This facility has also been known as the Propulsion and Structural Test Facility, S–1C Stand, Saturn Test Stand, and Technology Test-Bed. The F–1 Test Facility was constructed in 1963 to test the LOX/RP–1 Saturn V F–1 engines. The facility was used in this capacity until February 1969. The F–1 stand was never on the consideration list for landmark status.

The primary facilities in the East Test Area that would be utilized for projects covered by this EIS include TF 116, TF 300, and TF 500.

Four facilities on MSFC have been listed as National Historic Landmarks (Advisory Council on Historic Preservation, 1991). Such a listing automatically places these facilities on the NRHP. The facilities and their locality relationship to the AETF, F–1 Stand, TF 115, TF 116, and TF 500 are provided in Table 13.

Five known cemeteries are located within 1 mi (1.6 km) of the proposed test facilities. All of these cemeteries pre-existed the establishment of MSFC. Three of the cemeteries are located on RSA property and lie south of the West Test Area. Of the two located on MSFC property, the closest is the Jordan Cemetery located within the East Test Area.

TABLE 13.—*Landmark distances and orientation from test facilities*

National Landmark	AETF	F–1	TF 116	TF 300	TF 500
		TF 115—Same data as for TF 116 distance in miles/direction (distance in km/direction)			
Redstone Rocket Test Facility					
	0.4/NE. (0.6/NE.)	0.3/ENE. (0.5/ENE.)	0.6/NW. (1.0/NW.)	0.3/W. (0.5/W.)	0.3/W. (0.5/W.)
Dynamic Structural Test Facility					
	0.7/E. (1.1/E.)	0.6/SSE. (1.0/SSE.)	0.2/NW. (0.3/NW.)	0.2/SW. (0.3/SW.)	0.1/S. (0.2/S.)
Propulsion and Structural TF					
	0.9/SE. (1.4/SE.)	0.8/SE. (1.3/SE.)	0.2/S.SW. (0.3/SSW.)	0.6/SSW. (1.0/SSW.)	0.5/S.SE. (0.8/SSE.)
Neutral Buoyancy Simulator					
	1.6/N. (2.6/N.)	1.4/NW. (2.3/NW.)	1.9/NW. (3.1/NW.)	1.6/NW. (2.6/NW.)	1.6/NW. (2.6/NW.)

The Alabama Historical Commision has reviewed the proposed project and has provided concurrence, as shown in Appendix B.

Construction Impacts

Any structural reinforcements or modifications made to any of the test stands and accompanying facilities for the purposes of engine testing would enhance the cultural resources of MSFC in general, and the structures specifically, as advanced engine test facilities.

Operational Impacts

The testing of LOX/RP–1 engines and/or other advanced engine systems could enhance the historical significance of the test facilities by being the area for U.S./Russian propulsion systems development for the next generation of space transportation. The facilities at MSFC would be exposed to hot gaseous emissions resulting from the tests. Maintenance and cleanup of the structures would be conducted as part of the proposed test operation to prevent deterioration of the test facilities, if needed.

Since the Redstone Rocket Test Stand sits at a higher elevation and is the closest landmark to the AETF and F–1 test stands, it would be potentially impacted most by static test air emissions. The landmark would probably lie in the downwind path of the emissions when the wind is southwesterly. The gaseous emissions would not be corrosive in nature to painted surfaces. Insignificant impact is expected.

Mitigation

The Redstone Rocket Test Stand will be visually inspected periodically and appropriate maintenance or cleanup of the structure will be conducted as needed.

Transportation

Affected Environment

MSFC is located approximately 10 mi (16 km) east of the Huntsville International Airport and Huntsville-Madison County Jetplex. The Jetplex is the hub of a regional transportation center being developed to accommodate the multi- and intermodal capabilities of major air, land, rail, and water transportation at one central location. The airport layout is one of the relatively few in the world with parallel runways 5,000 ft (1,524 m) apart, providing the capability of simultaneous aircraft operations. Both runways are 8,000 ft (2,438 m) in length and are strengthened to accommodate all types of aircraft.

MSFC and Huntsville are served directly by U.S. Highways 72, 72A, 231, and 431, all of which are four lane facilities. Access to Interstate Highway 65 (I-65), approximately 16 mi (24 km) west of MSFC, is by way of U.S. 72, U.S. 72A, and Interstate Highway 565 (I-565).

The MSFC has direct access to low-cost, deep-water transportation via the Tennessee-Tombigbee Waterway and the Tennessee/Ohio/Mississippi River system including barge-loading docks on the adjacent RSA and supporting road system to handle very large cargo.

Construction Impacts

No new construction to the existing transportation system is anticipated; therefore, no impacts are expected.

Operational Impacts

Most of the major hardware would be transported by road or barge. Special flatbed, tractor-trailer units may be required for the transportation of the rocket component parts, which the existing infrastructure such as roads and bridges should be adequate to handle. Foreign components could be air freighted into the nearby international airport.

Large volumes of propellants would be required to support the proposed propulsion tests. Based upon a maximum propellant flow rate of 5,288 lb/sec with an oxidizer-to-fuel ratio of 2.43 and a propellant test rate of 13,000 sec/yr, the volume of RP–1 required is expected to increase by 60,000 gal/wk (253,000 L/wk) and the volume of LOX is expected to increase by 132,000 gal/wk (558,000 L/wk). This usage will result in an increase of approximately six 10,000 gal (47,000 L) truckloads of RP–1 per week and twenty-two 6,000 gal (25,000 L) truckloads of LOX per week. An increase in LH_2 usage is also anticipated. It is estimated that approximately one additional 12,000 gal (51,000 L) truckload of LH_2 per week will be required.

Trucking of rocket propellants via public access ways is the most common method of transportation that has been used for the life of rocket testing at MSFC with no known accidents on public property to date. The same safe handling, transfer, and storage procedures will be used with this program. Therefore, insignificant impacts are expected from transportation activities and practices.

Mitigation

No mitigation is required.

Waste Generation and Treatment

Affected Environment

Most of the solid waste generated at MSFC is burned at the City of Huntsville Refuse-to-Steam Plant, which opened in 1990. Approximately 150 t (136 mt) of solid waste generated each month at MSFC is sent to the facility. Ash from the plant is disposed of in the city's municipal landfill.

Unacceptable wastes, such as hazardous or radioactive waste, paint products, fuels, explosives, and construction debris, are excluded from disposal at the plant. Construction waste, rubble, vegetation, and asbestos are disposed of in the RSA inert landfill located south of Building 5678. To the maximum extent possible, wastes are turned over to the Defense Reutilization and Marketing Office (DRMO) on RSA for reuse, recycling, or appropriate disposal. Hazardous and radioactive wastes are packaged and transported to qualified hazardous waste disposal facilities.

Construction Impacts

Construction wastes would be disposed of at the RSA inert landfill. Metallic construction wastes would be turned in for recycling. Construction impacts on solid waste generation and disposal would be insignificant because little construction would be required.

Operational Impacts

Nonhazardous solid waste would be disposed of at the Refuse-to-Steam Plant. Solid waste generation would insignificantly increase the volume of waste generated by MSFC. Impacts from the operation of the facility on solid waste generation and treatment would be insignificant. Cleaning solvents, such as TCE, would be redistilled and recycled to the maximum extent possible.

Mitigation

No mitigation is required.

Socioeconomics

Affected Environment

Located in the city of Huntsville in Madison County, Alabama, MSFC employs over 3,000 federal workers. An additional 3,000 contractor employees use the facilities. Huntsville and Madison County's populations are approximately 170,000 and 250,000, respectively. Huntsville's population has grown from a small town of 16,400 to its present population of 170,000 in the past 40 years. This growth is largely attributable to establishment and rapid growth of the high technology space and defense industries.

Construction Impacts

No impacts on population and employment are expected.

Operational Impacts

Implementation of the Advanced Space Transportation Program at MSFC would result in employment of high-tech personnel and contractors. Due to projected downsizing in other MSFC programs and institutional support, the net effect would result in no noticeable difference in total employment numbers on MSFC. Therefore, impact is insignificant.

Mitigation

No mitigation is required.

Public and Employee Health and Safety

Affected Environment

MSFC East and West Test Areas are centrally located within RSA. These hazardous operations are over 2.5 mi (4 km) from any public property. MSFC facilities were located and designed to minimize risks to public and employee health and safety.

Construction Impacts

Proposed construction involves modifications and enhancements to existing facilities. Only small quantities of hazardous substances will be required for use or storage during construction. Therefore, impact is projected to be insignificant.

Operational Impacts

MSFC operations are regulated by stringent federal and state laws governing the conduct of all operations, with respect to environmental, worker, and public protection. Existing environmental permits issued to MSFC and the new permits that will be required for the conduct of the activities proposed in this program ensure that discharges and emissions to surface water, groundwater, and air are protective of the public health and safety. MSFC adheres to OSHA and applicable NASA standards for protection of employees on site. Procedures are in place to monitor and protect employees, as necessary, e.g., proper ventilation, safety exclusion zones for employees, or worker-required protection equipment.

A gaseous release or tank rupture with subsequent fire or explosion would send metal fragments and hot gases into the surrounding area. All cryogenic (LOX and LH_2) facilities are provided with adequate safety measures to minimize accidental releases of this type. MSFC currently uses LOX and LH_2 in day-to-day operations with no problem. The probability for a cryogenic, unplanned release is minimal.

Additionally, physical placement of hazardous operations, especially those involving propellants and hypergols, is determined by their hazard potential. Facilities accommodating hazardous operations are separated from other facilities by quantity-distance (QD) requirements designed to isolate a hazardous facility and minimize damage to other facilities should an explosion or release of a hazardous substance occur. QD's associated with the proposed operations are less than those calculated for the existing SSME test program conducted on the AETF (Aguinaga, 1994). Based on current calculations, the existing 23,000 gal (87,000 L) LOX and 75,000 gal (284,000 L) LH_2 run tank combination presents a greater danger than the 23,000 gal (87,000 L) LOX and 14,000 gal (53,000 L) RP–1 run tanks proposed for testing of the new engines.

The MSFC Emergency Plan (MM 1040.3E and subsequent revisions) details specific emergency procedures to respond to natural and man-made disasters and emergencies. There is an ongoing training program to ensure emergency preparedness. Strict security is maintained in the test areas.

Due to the physical and operational considerations, impact to the public and employee health and safety is expected to be insignificant.

Mitigation

No mitigation is required.

Potential Environmental Effects—Stennis Space Center

The following sections describe the potential impacts of the technology support for the Advanced Space Transportation Program testing on the natural and human environment at SSC. Impacts as a result of construction or operational activities are included within each major section. Any mitigation alternatives in each category are detailed.

Facilities and Infrastructure

Affected Environment

SSC has a fully developed infrastructure which includes road access and all utilities to support the nearly 3,500 federal employees and contractor personnel presently employed and in the past has supported up to 5,500 employees. Existing land use for SSC consists of general institutional facilities, industrial and test areas, laboratories, industrial and recreational areas, open areas, and circulation and parking areas. The Mississippi Army Ammunition Plant is maintained in a "mothball" condition by a small contingency of personnel on most of the northern half of the fee area.

As discussed in the section "Description of Alternative Test Facilities", four main facilities are under consideration as sites for testing engines under this program. The E Test Complex, comprised of The E–1 Test Stand, (formerly called the Component Test Facility), and the E–2 Test Stand (formally known as the High Heat Flux Facility), is proposed for testing components and subscale engines. The B–1/B–2 test stand is proposed for multiple engine testing. The A–1, A–2 and the B–1/B–2 Test Stands are proposed for testing small-, medium- and large-thrust engines. These test facilities are currently operational and support various test programs at SSC such as SSME. Modifications to these test facilities to meet operational requirements include the addition of RP–1 run tanks and ancillary support systems, common functional and structural interfaces, and an engine mounting adapter.

A detention pond exists at the B1/B2 Test Complex to receive runoff of cooling water from engine testing. It can function in the same capacity as the one described for MSFC in the vicinity of the AETF test stand. Runoff cooling water at A1 and A2 test stands drains directly to the Access Canal, that is a 7.5 mi (11.3 km) man-made canal and lock system built to permit barge access from the Pearl River.

Construction Impacts

Modifications to the test facilities will be minor. Disturbance of asbestos and/or lead paint will be minor. Safety procedures will be followed that prevent exposure to workers or release to the environment. Construction projects will follow regulatory standards for disturbance of lead (29 CFR 1926.62) and asbestos (29 CFR 1926.1101). Normal maintenance and cleanup of the test facilities should not disturb the asbestos or lead. However, all on-site contractors are made aware of these concerns by NASA and are familiar with asbestos and lead guidelines to minimize exposure to personnel.

In addition, a lined detention pond for cooling water drainage from the A-1 and/or A-2 test stands may have to be built with subsurface discharge to prevent accidental releases of RP–1 or other hazardous substances from easily entering the access canal. Pond construction may require a wetlands permit under Section 404 of the Clean Water Act regulations, administered by the USACE. Discharge would be regulated through a NPDES permit to be requested from MDEQ. However, the project would be covered by an established SSC wetlands management plan implemented under approval of the Vicksburg District of the USACE in 1992. Because of SSC's proactive wetlands management policy, insignificant impact to the environment is expected.

RP–1 will be provided in several possible ways to the test stands depending on programmatic needs. Initially there will be a reliance on small (up to 25,000 gal (74,600 L)) above-ground storage tanks with secondary containment. Other potential delivery systems include the use of tanker trucks, fuel barges and possibly larger storage tanks. In all the above cases, the SSC Spill Prevention Control and Counter measures Plan and the "SSC Contingency Plan for Response to Oil and Hazardous Substances" will be modified, as needed, prior to operation. Immediately prior to testing, the propellant will be transferred to the stand-mounted run tanks. If test duration requires, continuous transfer from tanks or barges will be provided during testing.

Construction of the E–1 test stand will be completed in late 1997 to accomplish component testing for the program, as previously evaluated under a separate Environmental Assessment (NASA/SSC, 1989). The test stand design will be modified to meet increased run durations requirements by incorporating liquid fuel and gas storage tanks transferred from MSFC. Elsewhere in the E Test Complex, additional test cells will be constructed near the present testing area to accommodate test scheduling conflicts. No impact to wetlands is anticipated.

Operational Impacts

These test facilities were originally designed and built to operate in the same manner proposed in this program. Previous testing included firing similar or identical engines of equivalent or greater thrust capabilities for comparable durations. Therefore, there will be no operational impacts to the test facilities or surrounding buildings. The canal system is large enough to handle the anticipated volumes of cooling water. Overall operational impacts should be insignificant.

Mitigation

See "Potential Environmental Effects—SSC Wetlands and Floodplains."

Oil Products and Hazardous Substances and Wastes

Affected Environment

SSC utilizes petroleum products as fuel for emergency generators, boiler plants, pumps, and vehicles. The Center currently has storage capacity for 273,000 gal (1.03 ML) of diesel fuel in above-ground storage tanks. In addition, the Center has underground storage tank capacity of 16,000 gal (61,000 L) of diesel fuel and 38,000 gal (144,000 L) of gasoline. These tanks were installed during 1990 and 1991 to meet secondary containment and spill prevention requirements with appropriate interstitial monitoring. SSC maintains a "Spill Prevention Control and Countermeasure Plan" and "Contingency Plan" to handle potential oil and hazardous material emergencies.

SSC maintains an inventory of hazardous and toxic substances used at the facility. Additionally, Material Safety Data Sheets (MSDS's) are maintained for all chemicals purchased by SSC. Building 1100 is the central repository where the MSDS's are maintained. The "SSC Environmental Resources Document" contains a list of all toxic substances used on site (NASA/SSC, 1992).

SSC is a "less-than-90-day," large-quantity generator, as defined in 40 CFR 262. Collection and management of hazardous waste on SSC is the responsibility of the Facilities Operations and Support Services (FOSS) contractor and is an ongoing current contract.

Once generated, hazardous wastes are collected in selective accumulation containers at satellite accumulation areas. When containers are full, they are transported to Building 2210 (Hazardous Waste Handling Facility). Containers of waste accumulate at Building 2210 for less than 90 days and are disposed of by the FOSS contractor. All hazardous waste generated at SSC is disposed of off site at certified hazardous waste disposal facilities.

Sources of ionizing radiation emissions at SSC include radioisotopes and x-ray machines. Laser, microwave, and radio frequency emissions are examples of nonionizing radiation at SSC.

Construction Impacts

Refurbishment of the test stands and ancillary facilities for this program may involve use of toxic and hazardous materials such as paints and adhesives, which would be used or disposed of according to the manufacturers' recommendations and standard NASA/SSC procedures. No radioactive material would be used in the construction except for possible radiographic testing of large steel joints after modifications. Such testing would be carried out in accordance with standard NASA/SSC procedures, as defined in SSC HB 1700.3B. Insignificant impacts are expected from construction activities.

Operational Impacts

Testing of the proposed engines would not require use of radioactive materials. Current practices are the same as those at MSFC and include use of some ODC's, such as Freon–113™ and TCA, for cleaning parts. SSC standard 7900.1 is the governing standard for guidelines on cleanliness requirements for space hardware. SSC anticipates using the same types and quantities of solvents as those described in the section "Potential Environmental Effects—MSFC, Oil Products and Hazardous Substances and Wastes, Operational Impacts." Hypergol use will also be the same as previously described in the same section. The sensitive nature of hypergols will require designated storage areas consistent with their hazards.

Initially, SSC will utilize small above-ground storage tanks to provide RP–1 fuel for testing. As program requirements increase, SSC will use tanker trucks, barges, and larger storage tanks as described in "Operational Impacts" in SSC's "Facilities and Infrastructure" section.

Storage and transportation of all hazardous materials on SSC is conducted in accordance with OSHA, National Fire Protection Association, EPA, and DOT regulations. Moderate impact is expected from the overall Advanced Space Transportation Program operations at the various test facilities for oil-product (RP–1) use. Insignificant impact is expected from other hazardous substances and wastes.

Mitigation

No mitigation is required.

Air Quality

Affected Environment

The NAAQS for criteria pollutants have been adopted by the state of Mississippi and are the same as those shown in Table 3. The closest ambient air monitoring station for the criteria pollutants and 1996 air quality data are shown in Table 14. All sources of air pollution at SSC are regulated by the Mississippi Department of Environmental Quality (MDEQ), Office of Pollution Control. Mississippi regulates sources through permitting that includes two federal programs, New Source Review (NSR) and PSD, which are adopted by reference in Mississippi's Air Pollution Control Regulations. SSC is considered an attainment area for NAAQS. In addition to regulating pollutants with established air quality standards, the state of Mississippi has adopted, by reference, all National Emissions Standards for Hazardous Air Pollutants (NESHAP). Mississippi regulations regarding toxic and hazardous air pollutants are the same as those for Alabama in the MSFC "Air Quality Section." For further discussion of criteria pollutants, toxic chemical standards and toxicity issues associated with the pollutants addressed in this project, see section "Potential Environmental Effects—MSFC, Air Quality, Affected Environment."

SSC currently has an air emissions permit to test small engines and components up to a maximum thrust of 350,000 lb (1.6MN) utilizing LOX/RP–1 on its E–1 and H–1 Test Stand. The E–2 Test Stand is limited by the amount of fluorine needed for ignition during a test and may be permitted in the future, for RP–1 testing. In addition, the MDEQ has agreed that SSC capability to test large-propulsion engines or engine systems (multiple) of LOX/RP–1 engines as conducted in the early 1960s is permitable under the existing facility permit. Maximum annual release of CO during the Apollo era is estimated to have been approximately 1,250 tons (1,130 mt). If program requirements demand greater testing capacity or frequency than currently permitted, modification of these permits will be requested. A Title V permit to include these emissions is pending.

Since emissions from testing will be transported and dispersed beyond the SSC boundaries, impact to the general area must be considered. The natural environments potentially affected by the proposed testing include wetlands, rural woodlands, and pasture lands in the surrounding areas. Because the test facilities are in the interior of SSC, MDEQ has used the Fee Area boundaries as the criteria for NAAQS compliance evaluation.

The only Class I air quality area within 62 mi (100 km) of SSC is the Breton National Wildlife Refuge (BNWR) in Louisiana. The refuge is approximately 50 mi (80 km) from the SSC test area.

The permanent public dwellings nearest to the test sites are on the boundaries of the buffer zone approximately 6 mi (10 km) from the test areas. A children's day care center is located on the SSC property approximately 1 mi (1.6 km) from the test stands. These sensitive areas are considered in the air emissions analysis.

Construction Impacts

The level of construction activity would be slightly higher than the present operations. The test facilities are surrounded by pavement or concrete, resulting in very little fugitive dust and particulate matter. Although some of the test facilities still contain lead-based paint, no construction or stand modifications will result in the release of airborne lead. Impacts due to construction are insignificant.

Operational Impacts

Test firing of engines which use RP–1 as a sole or partial fuel source will emit pollutants at the same rate as described in the section "Potential Environmental Effects—MSFC, Air Quality, Operational Impacts."

TABLE 14.—Ambient Air Quality for SSC. CO, PM_{10}, NO_2, and Pb data are from Orleans Parrish, LA; SO_2 data is from Harrison County, MS; O_3 data is from Hancock County, MS. The source of data is from 1996 Aerometric Information Retrieval System (AIRS) provided by EPA.

Pollutant	Averaging Period	SSC Ambient Concentration, $\mu g/m^3$
CO	8 hr	5,700
	1 hr	6,380
PM_{10}	Annual Arithmetic Mean	22
	24 hr	43
SO_2	Annual Arithmetic Mean	9
	24 hr	149
	3 hr	418
NO_2	Annual Arithmetic Mean	34
O_3	1 hr (maximum daily)	22.1
Pb	Quarterly Arithmetic Mean	0.01

Table 15 contains estimated pollutant release rates for multiple-engine tests which are proposed for testing at SSC. Small cluster engine tests have pollutant release rates comparable to those of a single medium-engine test. A cluster of 3 medium engines would result in approximately 50 percent more pollutant emissions than a single large engine.

Exposure levels from individual tests were determined using the same modeling procedures as described in the section "Potential Environmental Effects—MSFC, Air Quality, Operational Impacts." SSC used actual meteorological data that is site-specific for SSC. Results shown in Table 16 represent the highest concentrations possible or worst-case conditions (Sverdrup, 1994). The distance from the test area represents the area which would receive maximum impact from a test.

After rising above ground level within a short distance of the test area, the exhaust cloud will begin to grow in size due to entrainment of air, thus diluting the exhaust products. The cloud will move with prevailing winds. Prevailing surface winds are observed from the south and southeast approximately two-thirds of the time and from a northerly direction the remainder of the time (see appendix F).

The NAAQS for CO will not be exceeded by the proposed testing program. Sensitive receptors such as the day care center should not be adversely affected by the test program. The EPA defines SAQIL for CO to be 2,000 $\mu g/m^3$ for 1 hr and 500 $\mu g/m^3$ for 8 hr. The exhaust concentrations for CO will exceed the SAQIL for engine testing except those involving only 1 small engine, but remain under the NAAQS.

The maximum CO concentrations were calculated for the BNWR and are shown in Table 17. Since the BNWR is approximately 20 percent further from SSC than the Sipsey National Wildlife Refuge is to MSFC and the PM_{10}, SO_2, and NO_2 were generally projected to be less than 1 percent of PSD increments, no further modeling on these pollutants was conducted. CO concentrations and other pollutants are expected to be under NAAQS, PSD Class I increments, and SAQIL's.

Air quality impacts from the test activity are projected to be moderate for the large- and medium- thrust engines and insignificant for the small-thrust engines. Air quality impacts from the other criteria pollutants released are very low and well below NAAQS levels. Their expected release rates are estimated to be less than 1 percent of the CO levels.

Current propulsion system testing using LOX and LH_2 produces water in the form of steam as the main combustion product. Small quantities of NO_2 may form as a result of the high-temperature flames oxidizing nitrogen in the ambient air. Following each test firing, pressurized fuel and oxidizer tanks are purged with gaseous nitrogen and helium that are released to the atmosphere. This testing is expected to continue. Small quantities of materials from inside the engines may be emitted as particulate matter.

Testing of the main injectors, gas generators, and full-scale engines under consideration in this program will result in the use of small quantities of hypergol as igniters with the total use and projected emissions similar to those described previously in the section "Potential Environmental Effects—MSFC, Air Quality, Operational Impacts." Based

TABLE 15.— *Maximum pollutant emissions rates for proposed multiple engine tests. Maximum daily, weekly, and yearly rates are based on a total of 190, 250, and 13,000 sec of testing, respectively.*

Engines	Unit	CO	PM_{10}	NOX	SO_2
3 Medium	lb/sec (kg/sec)	894 (405)	2.3 (1.1)	2.6 (1.2)	1.5 (0.69)
	ton/day (mt/day)	87 (78)	0.21 (0.18)	0.24 (0.21)	0.15 (0.12)
	ton/wk (mt/wk)	111 (102)	0.30 (0.27)	0.33 (0.30)	0.18 (0.15)
	ton/yr (mt/yr)	5,820 (5,280)	14.8 (13.6)	17.0 (15.4)	10.0 (9.1)
7 Small	lb/sec (kg/sec)	371 (72)	0.98 (0.42)	1.1 (0.5)	1.5 (0.70)
	ton/day (mt/day)	35 (32)	0.07 (0.06)	0.07 (0.06)	0.14 (0.13)
	ton/wk (mt/wk)	49 (44)	0.14 (0.13)	0.14 (0.13)	0.21 (0.19)
	ton/yr (mt/yr)	2,400 (2,160)	6.6 (5.9)	6.9 (6.2)	9.6 (8.6)
3 Small	lb/sec (kg/sec)	159 (72)	0.42 (0.18)	0.45 (0.21)	0.63 (0.30)
	ton/day (mt/day)	25 (23)	0.03 (0.06)	0.03 (0.06)	0.06 (0.05)
	ton/wk (mt/wk)	21 (19)	0.06 (0.05)	0.06 (0.05)	0.09 (0.08)
	ton/yr (mt/yr)	1,030 (930)	2.8 (2.5)	3.0 (2.7)	4.1 (3.7)
5 Large	lb/sec (kg/sec)	2,985 (1,354)	7.7 (3.5)	8.7 (3.9)	5.2 (2.3)
	ton/day (mt/day)	285 (258)	0.73 (0.66)	0.83 (0.75)	0.49 (0.45)
	ton/wk (mt/wk)	373 (338)	0.96 (0.87)	1.09 (0.99)	0.65 (0.59)
	ton/yr (mt/wk)	19,400 (17,600)	50.0 (45.4)	56.6 (51.3)	33.8 (30.7)

TABLE 16.— *Maximum projected ambient air emissions exposure levels for single- and multiple-engine tests with a duration of 190 sec at SSC.*

Carbon Monoxide Air Quality Exposure Levels, μm/m³

	3 Medium		Large		Medium		Small		5 Large	
	1 hr	8 hr	1 hr	8 hr	1 hr	8 hr	1 hr	8 hr	1 hr	8 hr
Engine	5,936	742	5,050	631	3,411	426	1,350	169	6,241	780
Background	6,380	5,700	6,380	5,700	6,380	5,700	6,380	5,700	6,380	5,700
Total	12,316	6,442	11,430	6,331	9,791	6,126	7,730	5,869	12,621	6,480
NAAQS	40,000	10,000	40,000	10,000	40,000	10,000	40,000	10,000	40,000	10,000
Distance From Test Area:										
Km	1.8		2.0		2.2		1.6		1.0	1.0
mi	1.1		1.2		1.4		1.0		0.6	0.6

TABLE 17.—*Regulatory Standards and Breton National Wildlife Refuge maximum concentrations for selected engine tests.*

Concentration, μg/m³

Pollutant	Averaging Period	SAQIL	3 Medium	1 Large	1 Medium	1 Small	5 Large
CO	8 hr	500	70	52	34	6	127
	1 hr	2,000	559	408	230	41	1,010

on MSFC projections, the maximum 8-hr concentrations are estimated to be 80 $\mu g/m^3$ for aluminum oxide and 10 $\mu g/m^3$ for boron oxide. Air quality impacts are considered insignificant.

Estimated releases from all other operational activities are described in "Potential Environmental Effects - MSFC Air Quality, Operational Impacts."

Component test activities proposed for this program can be conducted in the E Test Complex test cells. One of the activities involves testing preburner components. The second activity involves testing of gas generators for the LOX/RP–1 engines. SSC is permitted for LOX/methane and LOX/RP–1 testing under Mississippi Air Emission Permit 1000-00013, and the interim Title V permit for the E–1 Test Stand and associated test cells.

Releases from component and subscale engine tests are very small, and modeling was not conducted for this EIS. Insignificant impact to air quality is projected from any of the component testing.

HAP and VOC potential releases would be similar to those described in "Potential Environmental Effects—MSFC Air Quality, Operational Impacts" and insignificant impact on the SSC air quality is also expected.

Mitigation

No mitigation is required.

Noise

Affected Environment

SSC is surrounded by a large, uninhabited buffer zone consisting of mostly forests, pasture lands, and wetlands. Development and testing of space propulsion systems has been the primary mission of SSC since its establishment in the mid-1960's. The history of SSC, surrounding land uses, and noise associated with rocket engine testing are described in the "SSC Environmental Resources Document" (NASA, 1992).

Full scale engine testing for this program is proposed for either the B–1/B–2, A–1, or A–2 test stands. All are located in the central portion of SSC and oriented to the north-northeast in a manner that directs sound to the north and east. The E–1 test stand will support engine testing up to 0.35 Mlb (1.5 MN) thrust. Noise propagation is expected to be minimal and directed to the south. The B–1/B–2, A–1 and A–2 test stands are currently being used for testing SSME's. The test stands well within the acoustic buffer zone were used for testing Saturn F–1 engines, including a cluster of five F–1's on the B–1/B–2 test stand.

Several communities are situated just outside the buffer zone including Pearlington, Waveland, Bay St. Louis, Kiln, and Picayune, Mississippi, as well as Slidell and Pearl River, Louisiana. Noise created by static testing of the large F–1 engines affected the local environment. F–1 tests were conducted using five engines simultaneously. Historically, the only measure of SSC's effect on local ambient noise levels has been complaints by citizens in the communities surrounding the facility. During the Saturn V rocket testing program, NASA logged 160 complaints, of which 57 resulted in formal administrative claims to NASA. Eighteen of the complaints resulted in financial settlements. No noise level data from current SSC engine tests is available at the buffer zone, except for 1988 data collected along Interstate 10 and Route 607. Background noise levels range from 41-45 dBA for SSCC (NASA, 1989)

Construction Impacts

Construction activities needed to facilitate engine testing would be minor modifications. There would be insignificant noise impact due to such activities.

Operational Impacts

Predictions of the noise levels that would be produced from testing large, medium, small, and clusters of engines have been made using the approach described in appendix G. This approach was used to develop OASPL, (measured in dB) contours for the engine testing. The A-weighted scale was used to account for the hearing range of the human ear. Modeling results do not take ground effects into account, which would reduce noise level and produce conservative results. Damage probabilities, OSHA, and public permissible noise levels, and other general descriptive information is provided in "Potential Environmental Effects - MSFC, Noise, Operational Impacts".

Maximum potential test firings are projected to include one full duration test per week of 190 sec and other smaller test firings of engines or components for a few seconds at a time, for a collective total test firing schedule of 250 sec/wk or 13,000 sec/yr. The OASPL contours in Figures 14 through 20 show the extent of low frequency noise or rumble that can cause vibration in buildings from testing of large, medium, small, and cluster firings of five large, three medium, three small, and seven small engines, respectively. The maximum offsite OASPL's occur for cluster firing of 5 large engines is estimated to be 112 dB, occurring at the northwestern edge of the buffer zone at SSC. At these levels the chances of structural damage claims would be less than 0.2 percent or less than two claims per thousand households. The DOD uses an OASPL criterion of 120 dB as a guideline of acceptability (Air Force Flight Test Center, 1993).

A-weighted dBA contours for the single and cluster engines are shown in Figures 21 through 27. Predicted maximum offsite sound levels for any single engine or cluster firing will be below 70 dBA for the 24 hour time weighted average (Leq) at the edges of the buffer zone. The highest noise levels would be generally in a northerly direction. These noise levels would have an insignificant noise impact due to the short duration. Based on the above noise levels, all noise impacts are predicted to be insignificant with the exception of the large multiple engine testing which would be considered a moderate impact. A-weighted sound levels were used in determining the Leq. Leq values are given in Table 18 (Holland, 1995).

TABLE 18.—*Maximum offsite noise levels*

Engine	dBA	dB	Leq
Large	69	106	50
Medium	65	103	50
Small	60	96	49
5 Large	77	112	52
3 Medium	70	108	51
3 Small	68	102	50
7 Small	77	104	52

Mitigation

Due to the large acoustic buffer zone surrounding SSC and the fact that the maximum predicted sound levels outside the buffer zone are 105 dB , no mitigation is required. Acoustical focusing will be considered on 5 large-engine and 3 medium-engine tests. If deemed necessary, a program as described in "Potential Environmental Effects—MSFC, Noise, Mitigation" will be developed and implemented.

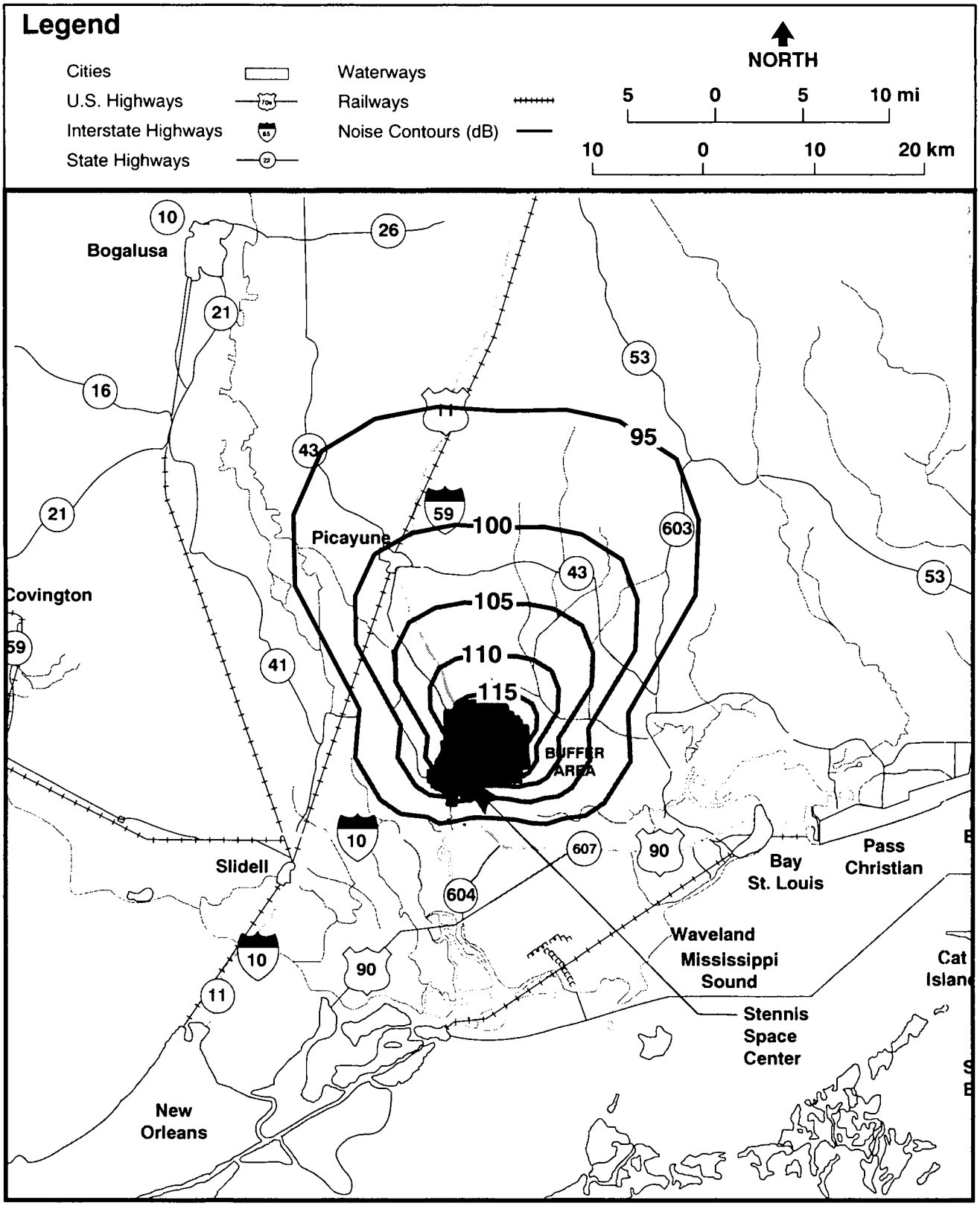


FIGURE 14.—OASPL projection (dB) representing the large engine classification.

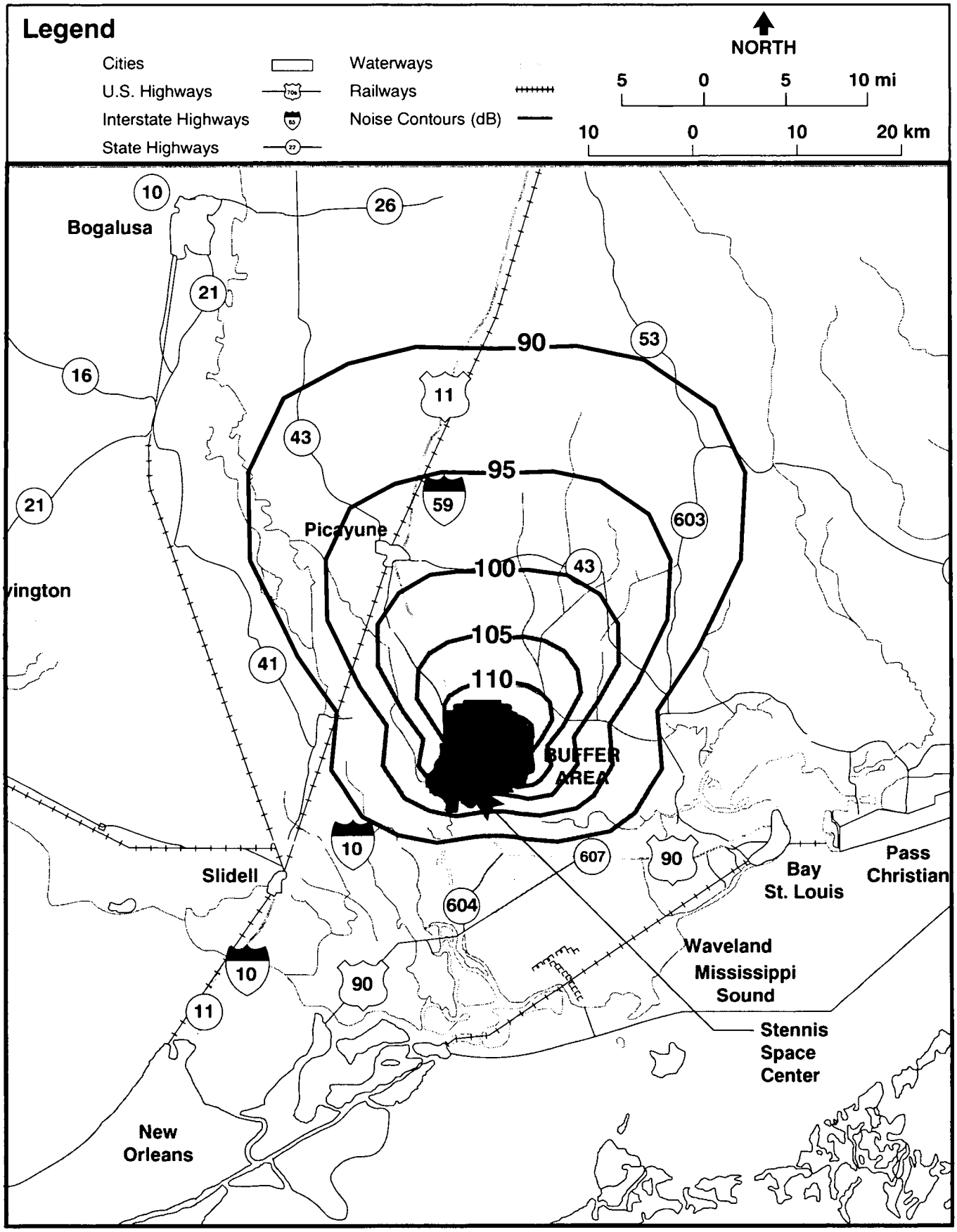


FIGURE 15.—OASPL projection (dB) representing the medium engine classification.

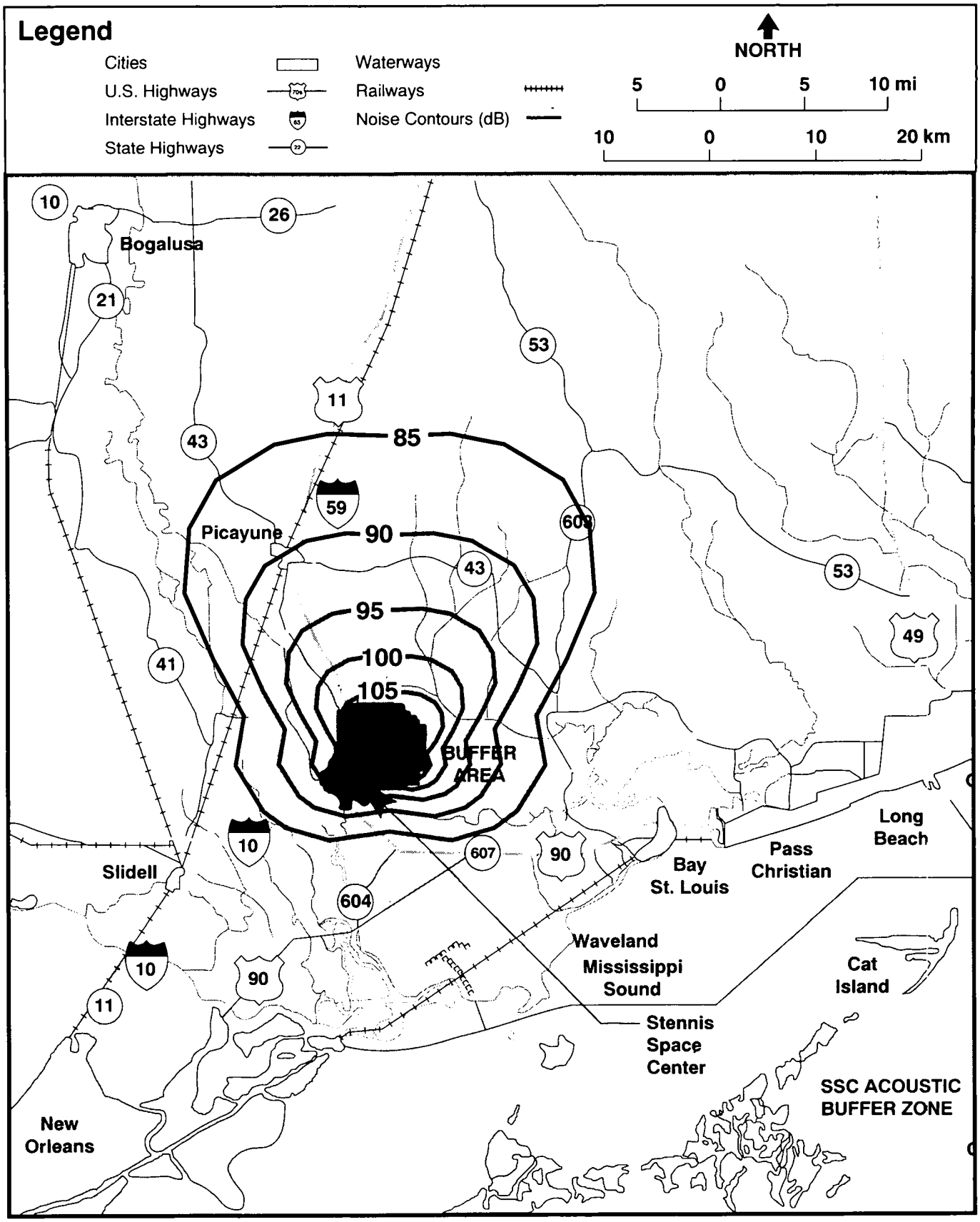


FIGURE 16.—OASPL projection (dB) representing the small engine classification.

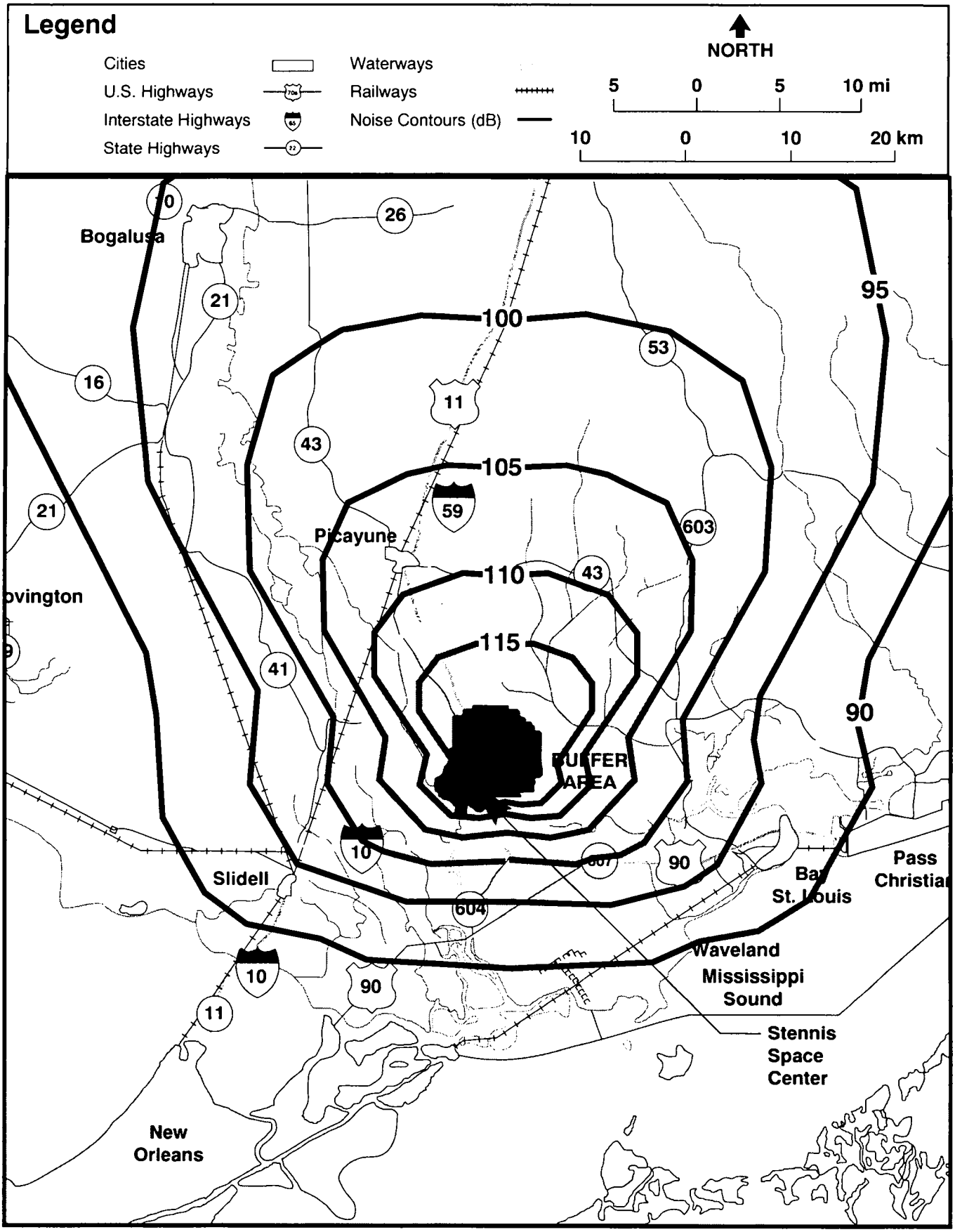


FIGURE 17.—OASPL projection (dB) representing a cluster firing of five large engines.

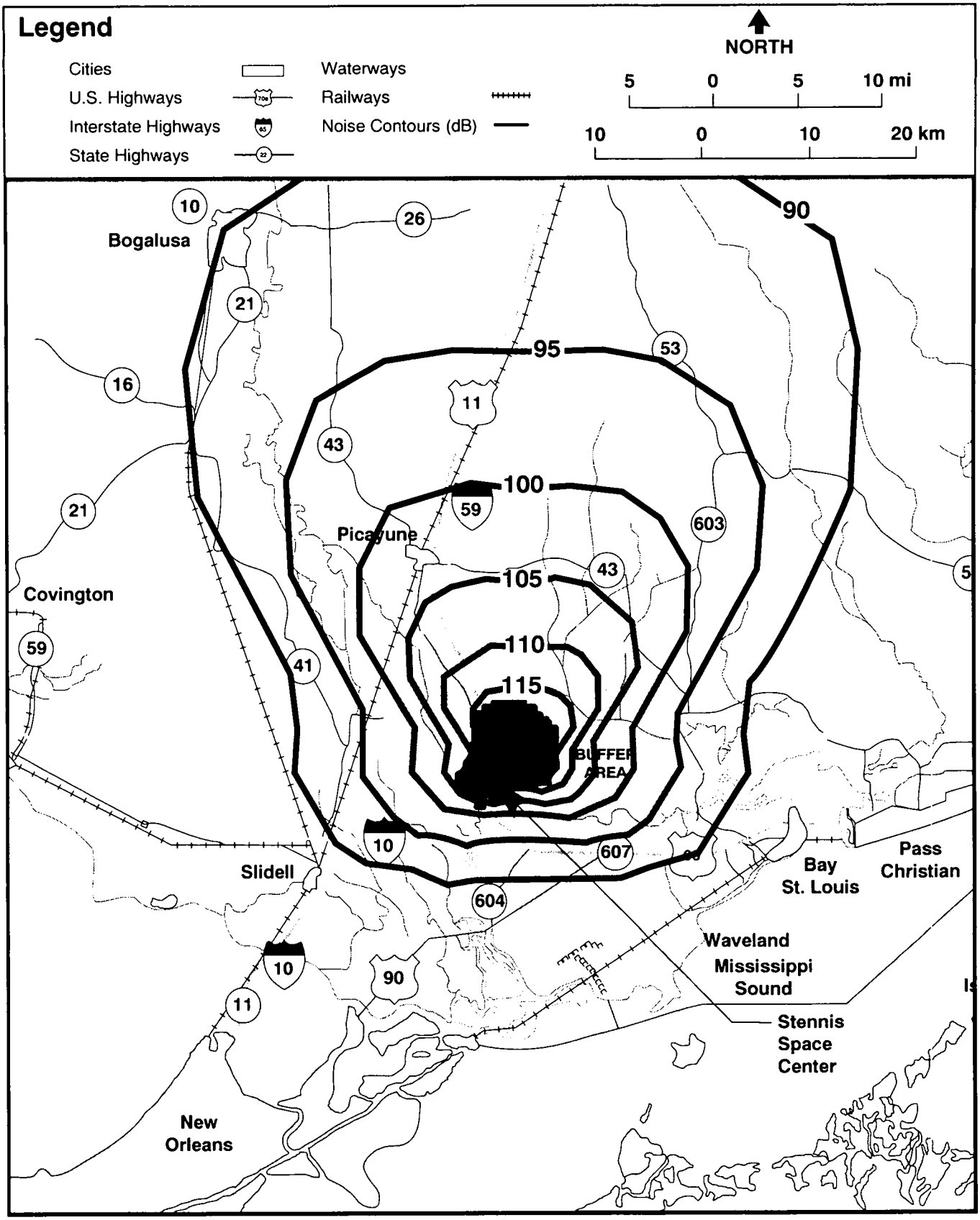


FIGURE 18.—OASPL projection (dB) representing a cluster firing of three medium engines.

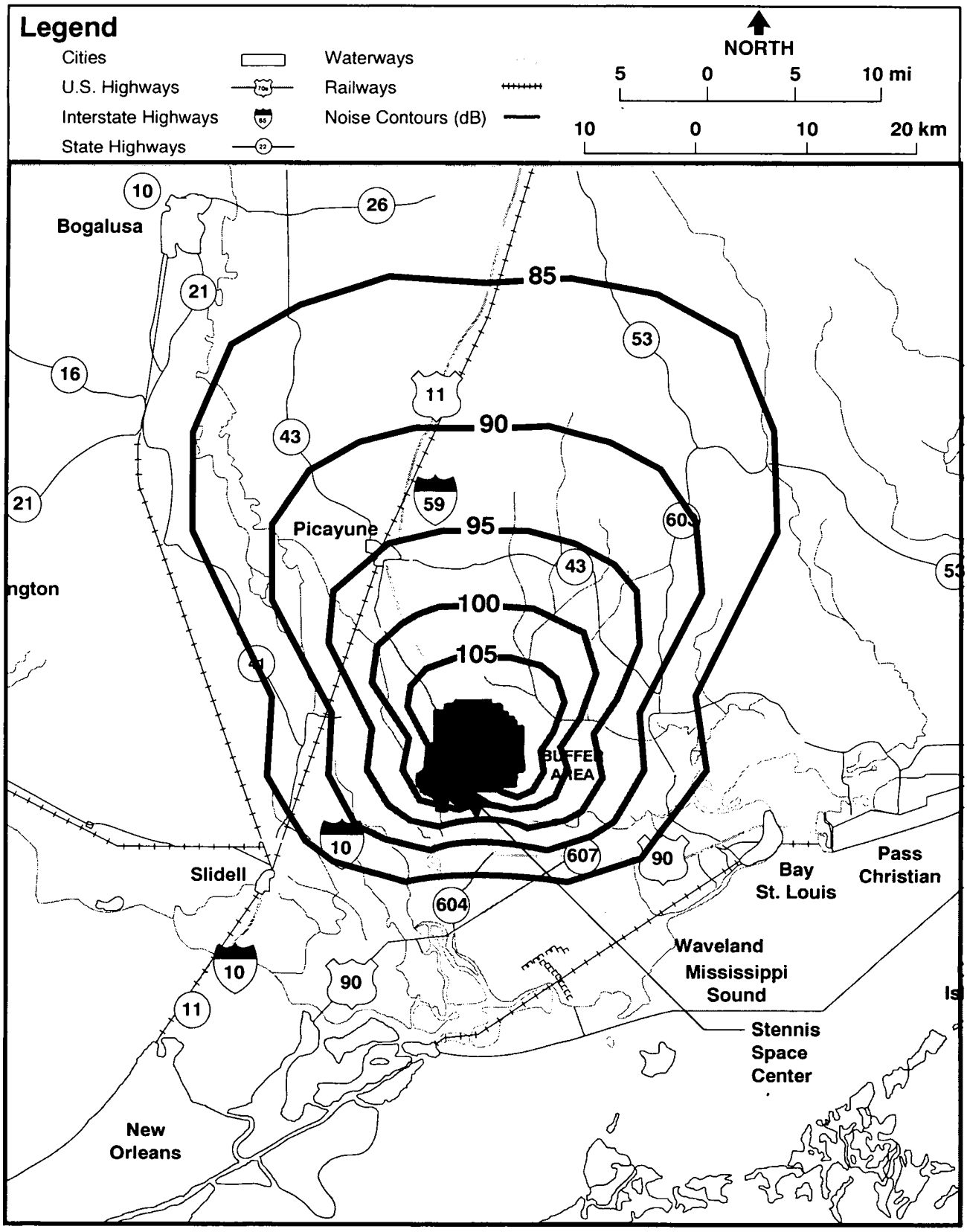


FIGURE 19.—OASPL projection (dB) representing a cluster firing of three small engines.

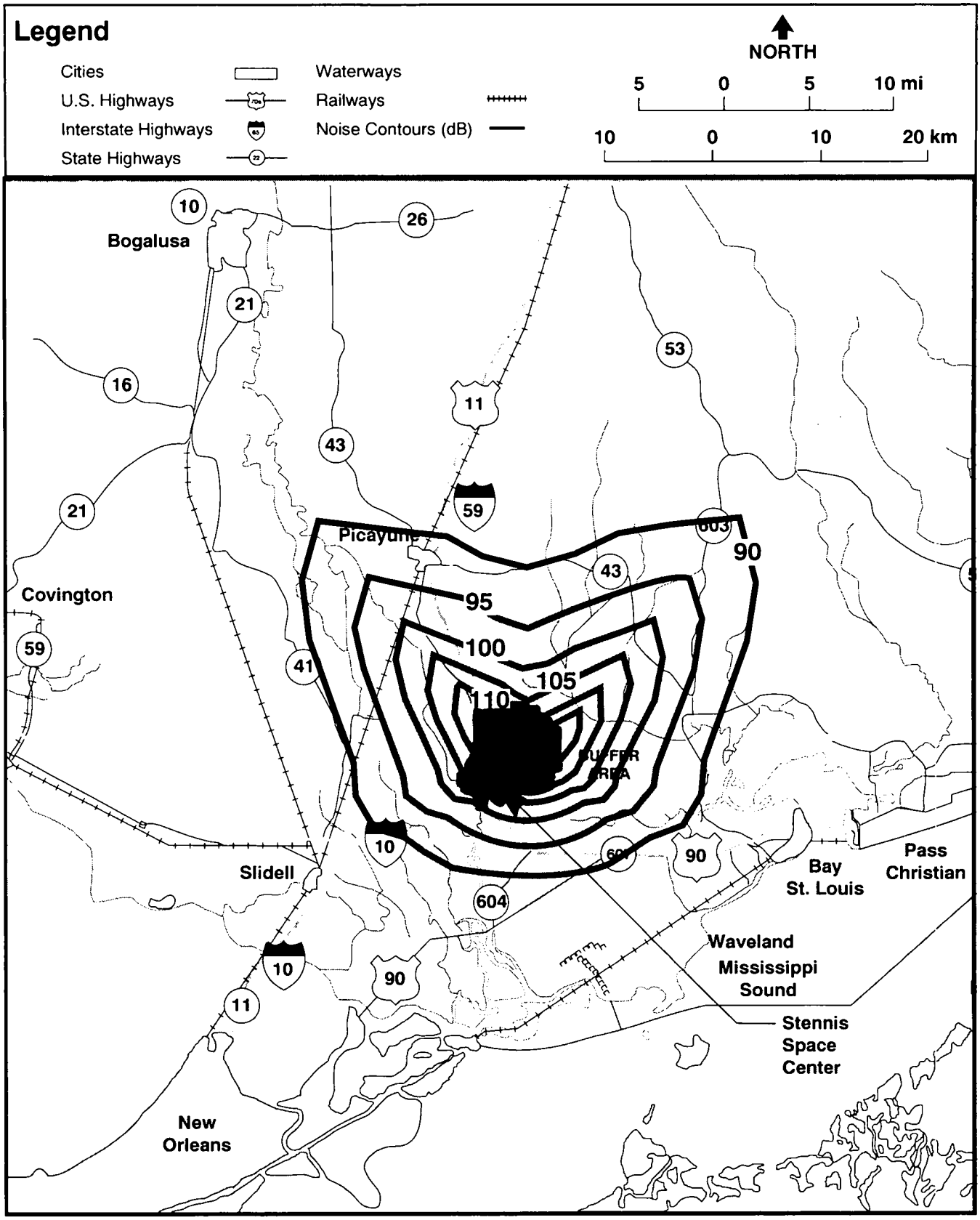


FIGURE 20.—OASPL projection (dB) representing a cluster firing of seven small engines.

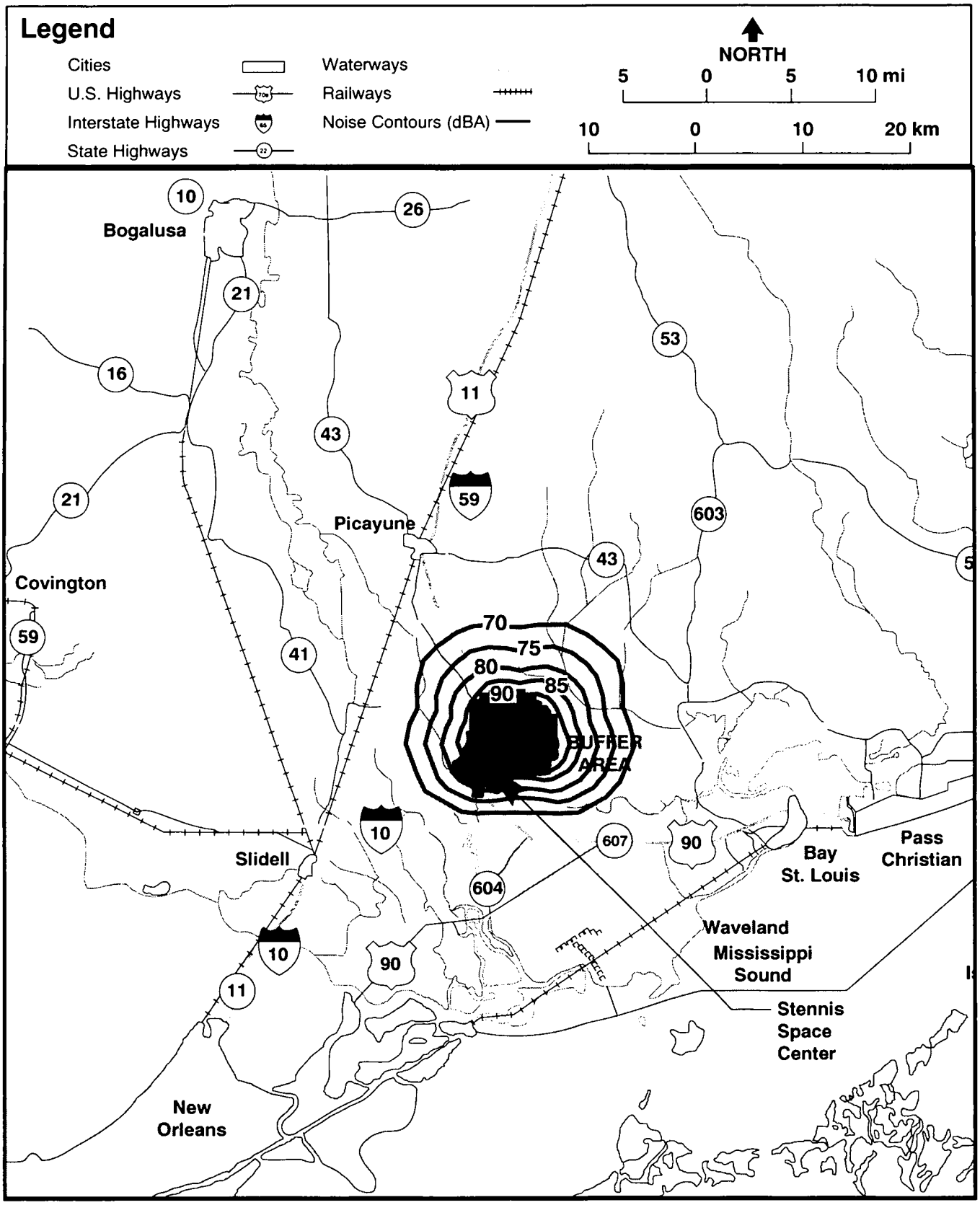


FIGURE 21.—A-weighted sound level projection (dBA) representing the large engine classification.

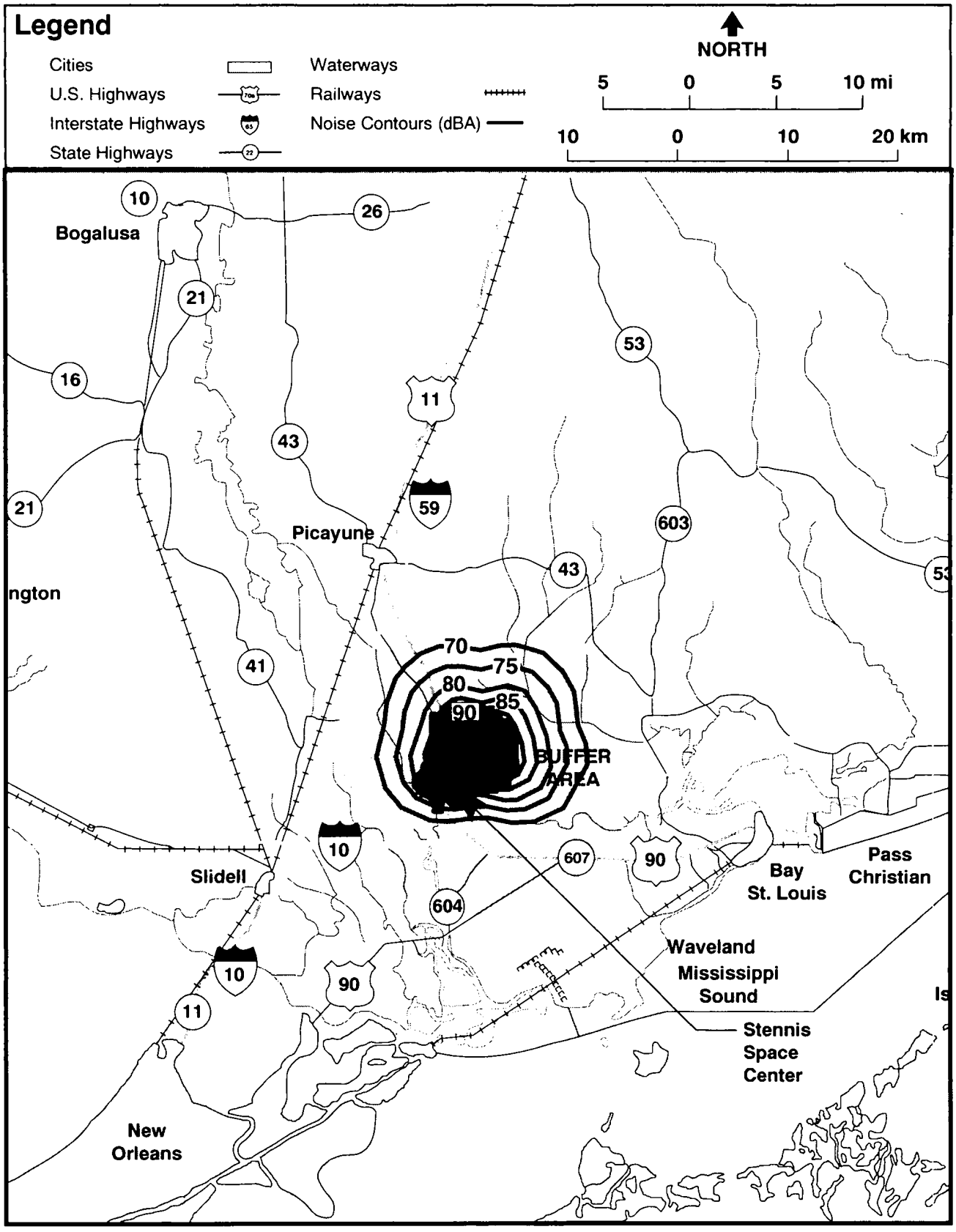


FIGURE 22.—A-weighted sound level projection (dBA) representing the medium engine classification.

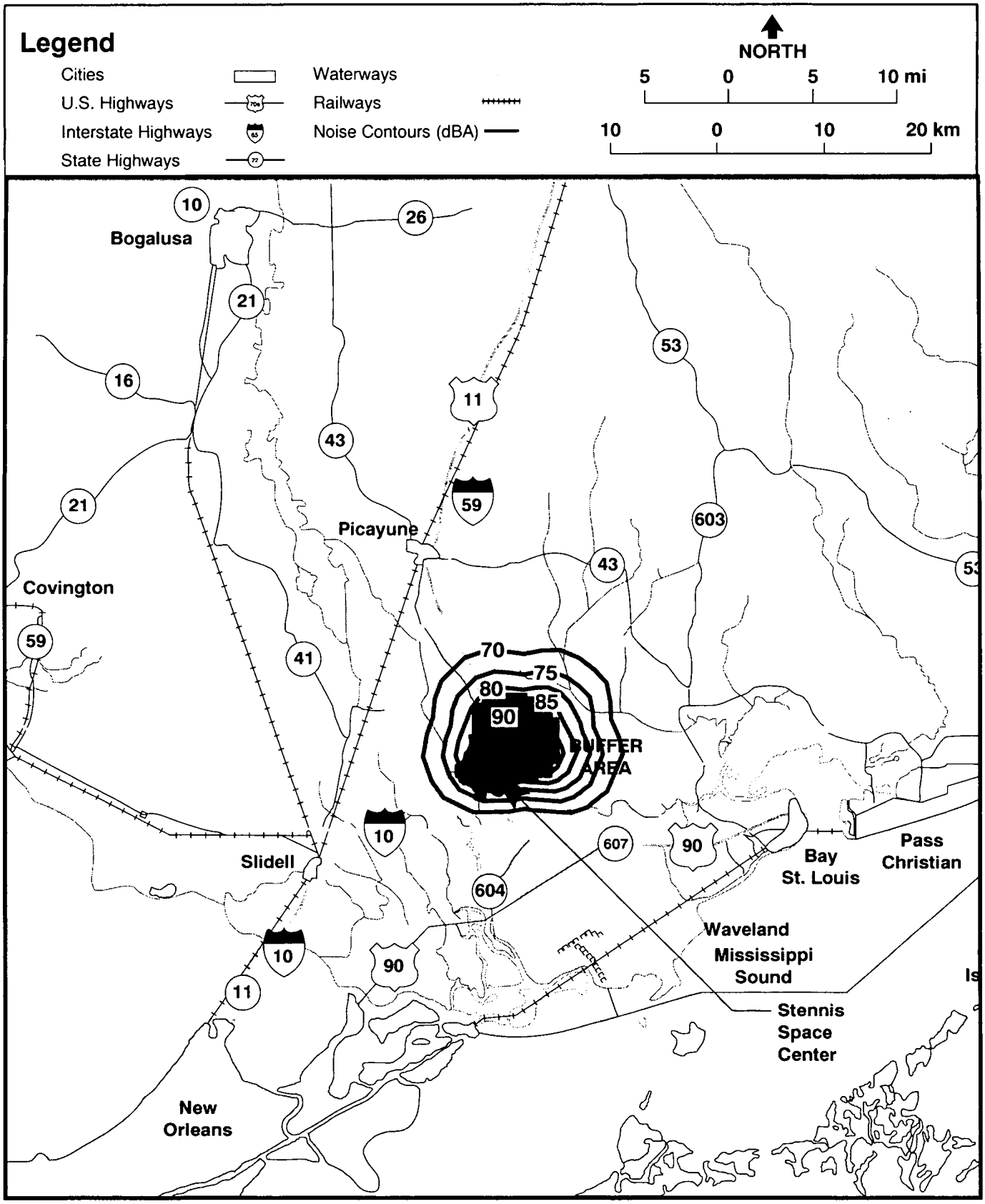


FIGURE 23.—A-weighted sound level projection (dBA) representing the small engine classification.

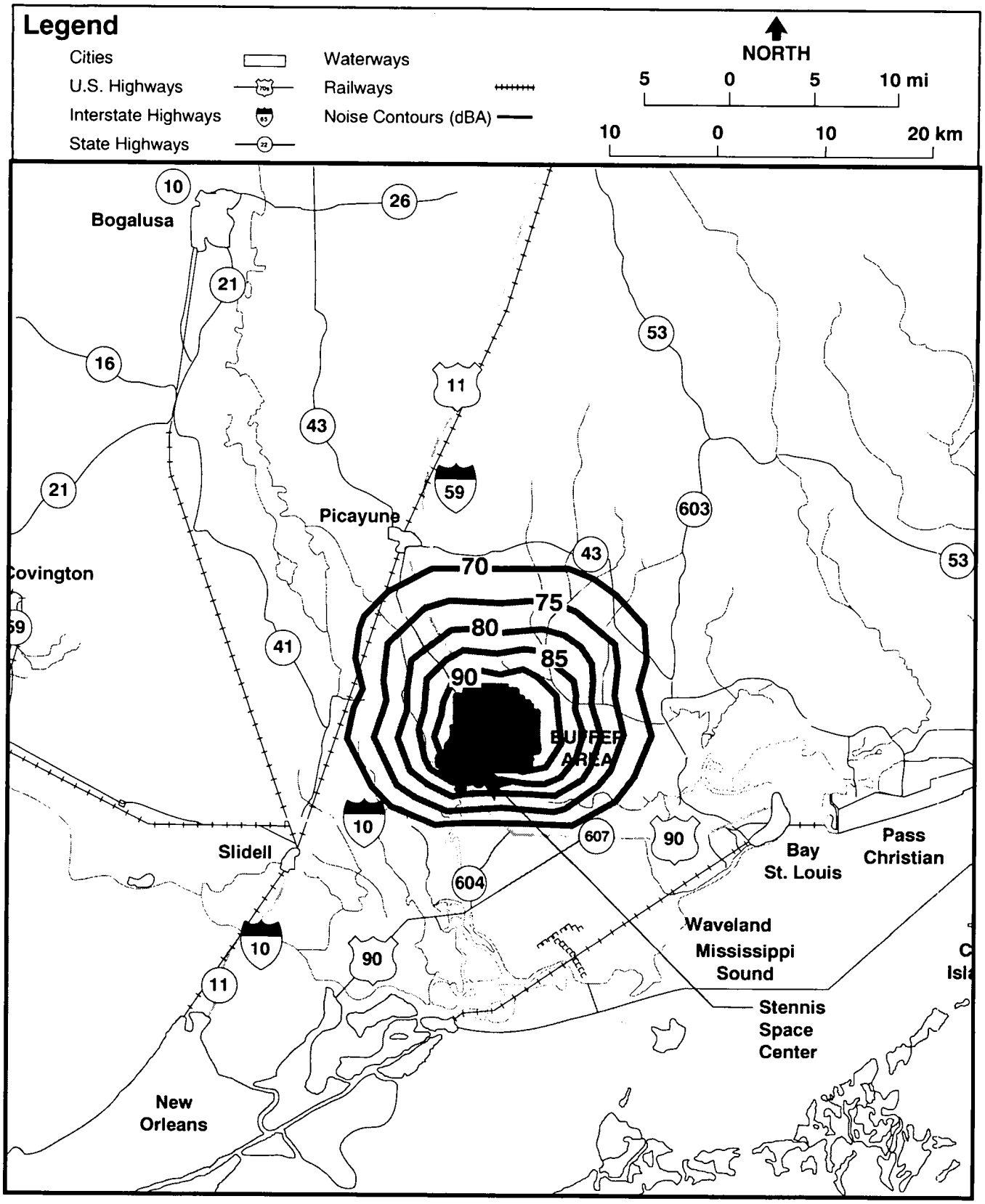


FIGURE 24.—A-weighted sound level projection (dBA) representing a cluster firing of five large engines.

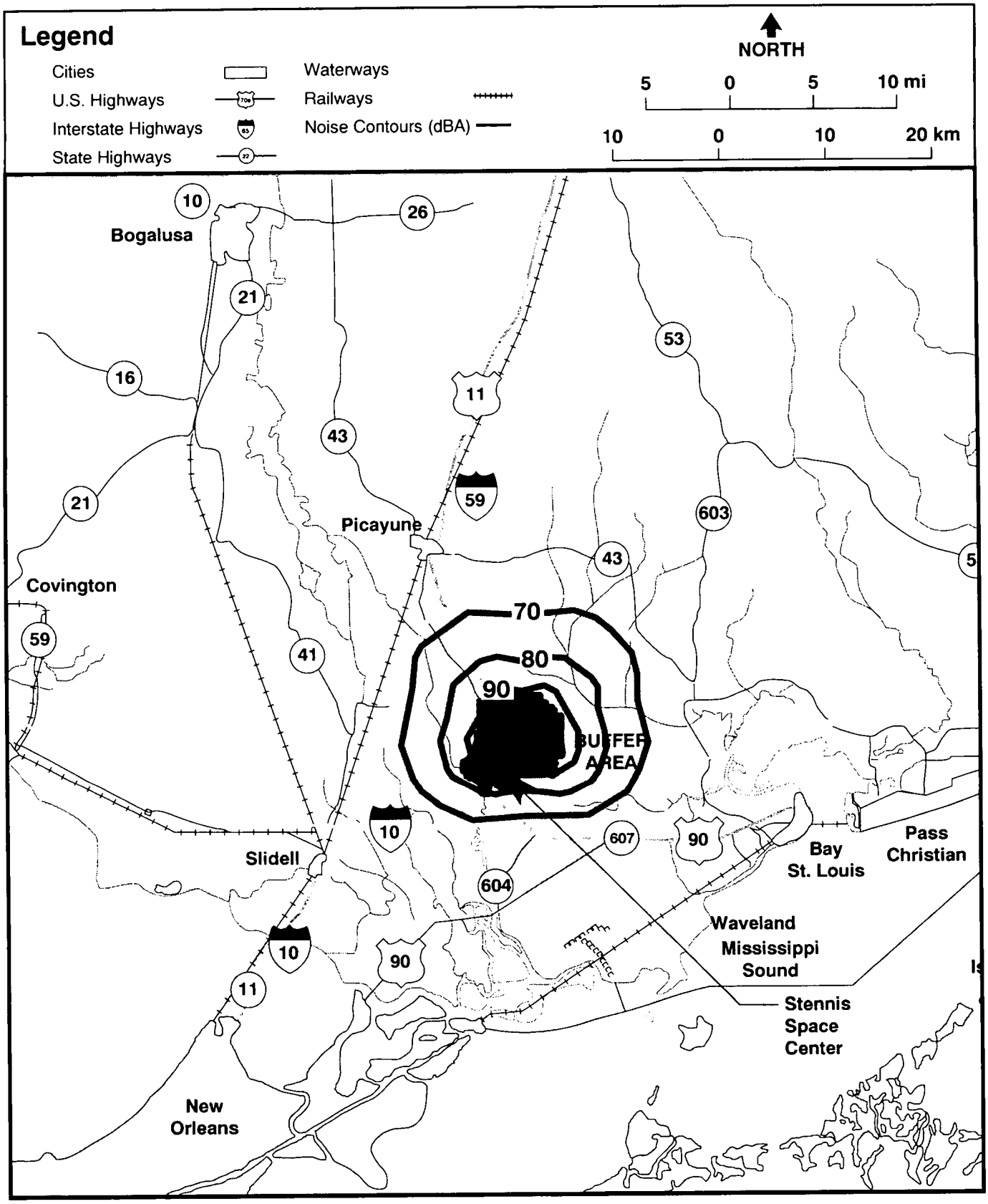


FIGURE 25.—A-weighted sound level projection (dBA) representing a cluster firing of three medium engines.

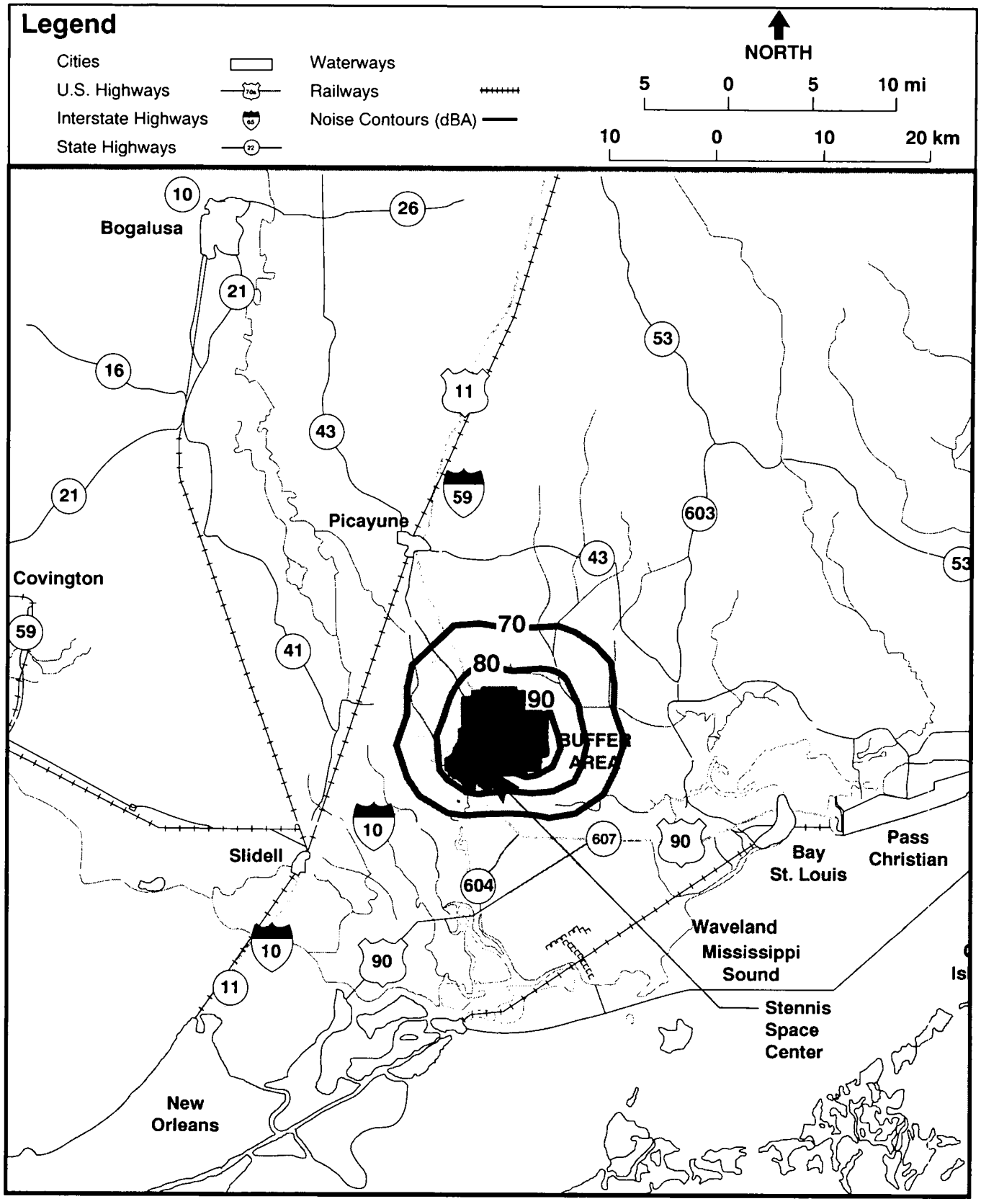


FIGURE 26.—A-weighted sound level projection (dBA) representing a cluster firing of three small engines.

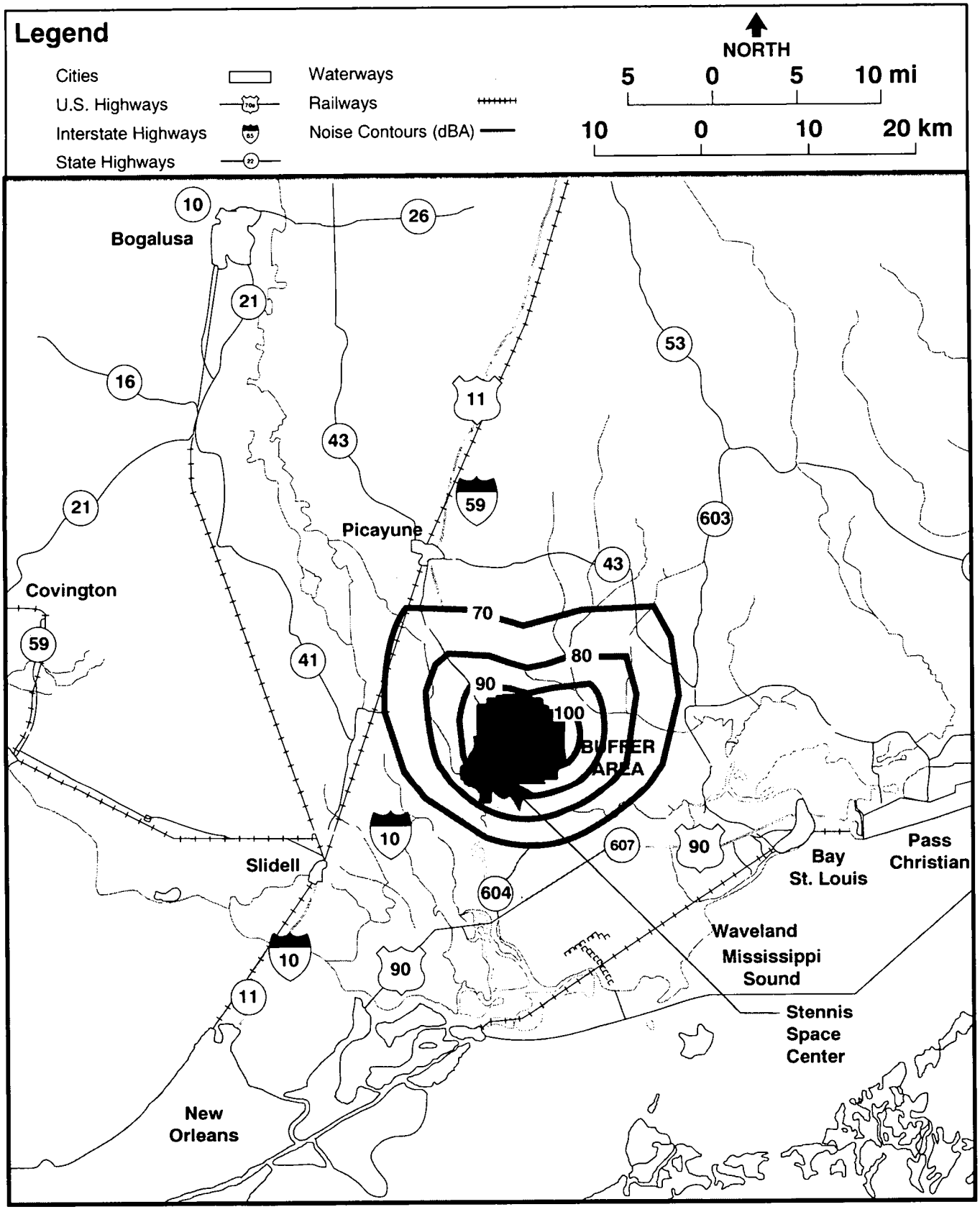


FIGURE 27.—A-weighted sound level projection (dBA) representing a cluster firing of seven small engines.

Water Quality

Affected Environment

Test stands B–1, B–2, A–1, A–2, E–1 and E–2 are heavy concrete and steel structures used to test large propulsion systems. SSC is permitted by the state of Mississippi to divert or withdraw water for beneficial use from the access canal (Permit No. MS-SW–0232). The canal will be the primary source of water for the 66 Mgal (250 ML) industrial water reservoir which is used to provide deluge fire water protection and deflector cooling water for the test stands. No additional cooling water storage is being planned to meet LOX/RP–1 testing needs. After use, the cooling water is discharged into the SSC canal system. Water from the canal is directed to the East Pearl River through a lock system. A spillway and overflow of the canal drains into Devils Swamp, which discharges into Bayou LaCroix and the Bay of St. Louis to the Mississippi Sound.

Construction Impacts

See "Construction Impacts" in SSC's "Facilities and Infrastructure" section. Due to the size and type of proposed construction, insignificant impacts are anticipated.

Operational Impacts

Operation at the test stands would involve single- and multiple-engine testing for the LOX/RP–1 program. Cooling water quantities used for each LOX/RP–1 single engine test could be significantly lower than the amount required for SSME tests due to shorter duration tests. The existing fire protection system would be adequate for LOX/RP–1 testing activities. Small quantities of waste solvents, oils and lubricants, as well as dust particles from the test stand, may be washed into the cooling water discharge. Based on prior knowledge of RP–1 engine testing, potential exists for the introduction of unburned fuel into the cooling water discharge. There is no indication that the volume would be significant or that treatment of the discharge water to meet water quality standards will be required (see the section "Potential Environmental Effects -MSFC, Water Quality, Operational Impacts"). The NPDES permit has been modified to include the potential discharge of RP–1 in the deluge water associated with rocket testing. No containment was required in the permit due to the fact that the volume of RP–1 would not be expected to be significant. Sampling is required with a reporting requirement within 6 months of RP–1 testing commencement.

Mitigation

Mitigation is not required. Detention of the discharge for analysis and possible treatment may be required at A-1 and/or A-2 test stand if RP–1 is used.

Groundwater Resources

Affected Environment

Several aquifers can be traced through Hancock County where SSC is located. The area is underlain by freshwater bearing, southward tipping sands of the Miocene and Pliocene ages. Within these freshwater bearing sands, one unconfined aquifer is found near the surface, with ten or more confined aquifers at depth. The fresh water bearing zone is 2,000 to 3,000 ft (600 to 900 m) thick in the area. The sequence of alternating sands and discontinuous clay layers, creating the confining nature of the deeper aquifers, is part of the Coastal Lowlands Aquifer System or the Southeastern Coastal Plain System.

Water for potable and industrial use at SSC is supplied through six large-capacity wells on site. Well permit numbers, well use and well depth can be found in the "SSC Environmental Resources Document" (NASA/SSC, 1992).

Construction Impacts

No additional groundwater wells or deep subsurface disturbance is planned for this project. No impact from construction is anticipated.

Operational Impacts

Secondary containment of all above-ground bulk storage tanks for RP–1 will be provided. Run tanks filled with RP–1 will be tested annually and inspected daily. Insignificant impact to groundwater resources is expected.

Mitigation

No mitigation is required.

Wetlands and Flood Plains

Affected Environment

The SSC facility straddles the watersheds of two rivers: the East Pearl River on the western fee area boundary and the Jourdan River on the eastern fee area boundary. Some tributaries at the facility flow west to Harper Bayou and eventually drain into the East Pearl River. Other tributaries flow east into Catahoula Creek, with some intermittent streams flowing south into Devil's Swamp. Catahoula Creek and Devil's Swamp both eventually drain into the Jourdan River. The Pearl River empties into Lake Borgne, while the Jourdan River drains into the Bay of St. Louis. Both Lake Borgne and the Bay of St. Louis discharge into the Mississippi Sound.

As a result of the wetlands hydrology found at and around SSC and the presence of hydric soils and hydrophytic vegetation, a large portion of both the fee area and buffer zone are considered jurisdictional wetlands by the USACE. The proposed testing activities are not in a functional wetlands area and will not encroach on jurisdictional wetlands. A map of the wetland areas is shown in the "SSC Environmental Resources Document" (NASA/SSC, 1992) available at the SSC Environmental Office.

The documented floodplains at SSC include a 100-year floodplain along the Wolf Branch and along the Lion Branch of Catahoula Creek in the northeast portion of the Fee Area. The majority of SSC is in an area of minimal flooding. The proposed testing locations are not in the 100-year floodplain.

Construction Impacts

Modifications to be undertaken for this engine test project will not affect the SSC wetlands unless a detention pond is needed in the A–1 and A–2 test areas. However, due to the proactive wetland management program at SSC as described in "Construction Impacts" of SSC's "Facilities and Infrastructure" section, insignificant impact to wetlands is expected even if these small facilities are required. There will be no construction-related impacts to wetlands or floodplains other than the potential detention pond in the A–1 and A–2 test areas..

Operational Impacts

Proposed engine testing activities at this facility would not result in wetland or floodplain disturbance. Cooling water used during testing will be discharged into the SSC canal system. Thermal studies of the current testing program do not indicate any impact on the canal system. Insignificant impact is anticipated from the proposed testing. The potential for wetland impacts from accidental material spills would be minimized through compliance with all applicable spill prevention and control requirements. No wetlands impacts are anticipated. Deposition of particles released to the air during test firings is anticipated to be an insignificant impact to the overall quality of wetland and floodplain areas.

Mitigation

Wetlands mitigation will be required if a new RP–1 above-ground storage tank and a detention pond are constructed in the A-1 or A-2 test stand areas. However, SSC established a wetlands mitigation plan in 1992 to make provision in advance for small wetlands impacts from future programs. This construction effort on wetlands, if needed, would follow the plan in negotiating a wetlands permit with the USACE.

Biotic Resources—Wildlife and Vegetation

Affected Environment

(A) Terrestrial Biota

Pine forest communities account for the majority of the vegetation in the uncleared portions of SSC and the surrounding buffer zone. Bottomland hardwood communities occur in low, poorly drained soils, which may have standing or slowly-moving water. Pitcher plant bogs are unique to the coastal plain of the southeastern United States and occur in low-lying, drained areas with acidic soil. These communities occur where the area is burned regularly, which prevents transition to forest of bottomland hardwood-type communities. Some pitcher plant bogs occur at SSC. Grasslands often occur in disturbed areas of SSC where the land has been either cleared for construction or burned.

Due to the number of diverse terrestrial habitats at SSC, including grasslands, forests and wetland areas, a number of terrestrial animal species are found. Vegetation and wildlife species occurring at SSC are identified in the "SSC Environmental Resources Document" (NASA/SSC, 1992).

The proposed test area is located within an area of developed land covered by pavement or mowed grass. The site is surrounded by canals and wetlands. Wildlife habitat in the immediate area of the test stand is considered marginal because of the present use of this facility. This area may be a suitable foraging area for various species (e.g., deer, mice, song birds, and hunting raptors). However, activity associated with current engine tests and operations limits its suitability as a nesting or roosting habitat, except for more common rodents, lizards, etc., that have adapted to the present habitat conditions.

(B) Aquatic Biota

The topography at SSC is generally low and flat with low gradient streams. Aquatic habitats present at the facility include the Pearl River, the Access Canal, lakes, ponds, borrow pits, drainage ditches, shallow swamps, marshes, and small creeks. Aquatic fauna include fish, amphibians, and reptiles.

Several species of sport fish were identified at SSC. These include bluegill, largemouth bass, white crappie, and various species of sunfish. Any species of amphibian capable of inhabiting poorly drained lowlands with a vegetation cover of pine and mixed hardwood is likely to be found at SSC. No significant or permanent impacts to the fauna and flora have been recorded in association with past test activities.

Construction Impacts

Only small land disturbances will result from construction. Construction impacts on biota are considered insignificant.

Operational Impacts

Proposed testing activities would be similar to current and past uses of these facilities. Insignificant impacts to vegetation or wildlife habitat at SSC or in adjacent areas are anticipated. Noise from engine testing could affect waterfowl and other wildlife adjacent to the test area. Testing would generate high noise levels for brief periods and low frequency vibrations for large distances intermittently. The noise from engine testing would startle wildlife and possibly drive them from the area temporarily. However, animals in the vicinity of engine testing and similar abrupt, loud noises adapt and do not appear to be unduly disturbed by the activity (see "MSFC Biotic Resources—(B) Aquatic Resources—Operational Impacts.")

Mitigation

No mitigation is required.

Threatened and Endangered Species

Affected Environment

There is a significant number of threatened, endangered, and ranked species with ranges overlapping the SSC fee area and buffer zone. Listed and state-ranked species that potentially occur in the project area are identified in the "SSC Environmental Resources Document" (NASA/SSC, 1992) and the USFWS, Daphne office, letter dated December 15, 1994. Proposed construction and testing activities should not affect any threatened and endangered species or critical habitat that may exist in the SSC fee area. A survey of the SSC Fee Area was conducted for the eastern indigo snake and gopher tortoise as part of the threatened and endangered species study of SSC (Kaiser & Lago, 1991; Kaiser, 1994). No sitings or critical habitat were found in the test area for either species. If a listed or ranked species is identified, the appropriate agency will be consulted. Management procedures will be in place to protect any species located during testing activities.

Construction Impacts

No impact to critical habitat or a listed species is expected.

Operational Impacts

No impacts should occur to species that may inhabit the project area due to the noise levels projected in the SSC "Noise" section.

Mitigation

No mitigation is required. SSC will follow consultation procedures with the USFWS as described in Section 7 of the "Endangered Species Act," if required.

Archeological Resources

Affected Environment

In 1988, the USACE conducted an archaeological survey (COE, 1988) of the proposed location of the Advanced Solid Rocket Motor (ASRM) project site and three proposed sites for relocation of the Hazards Test Range. An archaeological reconnaissance was also conducted on all other land within the SSC fee area. The survey found that, historically, the land at SSC has been severely disturbed by timber harvesting and the associated naval stores industry during the late nineteenth and early twentieth centuries. More recently, the land was disturbed by the construction of the facility during the 1960's, making it unlikely that undisturbed archaeological sites would be found.

The USACE completed a reconnaissance of the remainder of the fee area to determine if archaeological resources were present or could reasonably be predicted in the areas of SSC not yet surveyed. Staff determined from the reconnaissance that only those areas bordering the Pearl River floodplain had potential for the presence of archaeological resources, and a pedestrian survey of this area was conducted. No evidence of prehistoric or aboriginal sites was found in any of the areas examined. Based on these findings, the USACE concluded that, within the fee area, only the previous town site of Gainesville would require future archaeological considerations if land-disturbing activities were proposed for that area.

Construction Impacts

Soil disturbance during construction will be minor. Insignificant impact is expected.

Operational Impacts

No archaeological sites would be impacted by the projected operational plans.

Mitigation

No mitigation is required.

Cultural and Historical Resources

Affected Environment

The three test stands at SSC, the A–1 Rocket Propulsion Test Complex (Building 4120), the A–2 Rocket Propulsion Test Complex (Building 4122), and the B–1/B–2 Rocket Propulsion Test Complex (Building 4220) have been designated as National Historic Landmarks and appear on the NRHP. These test stands and associated control centers have been designated because of their importance in the testing of Saturn rockets, and the importance of the Saturn rocket in landing men on the moon.

When SSC and the buffer zone were established in 1961, four towns existed in what is now the buffer zone, and one town was located in what is now the fee area. The towns of Napoleon, Santa Rosa, Logtown, and Westonia were logging towns located in the buffer zone, and Gainesville was a logging town located in the fee area. When NASA acquired the fee area and restrictive easement in the buffer zone, most of the buildings in these towns were removed.

A recently approved Historic Preservation Plan for SSC documents all of the previous investigations conducted at SSC and has narrowed cultural and historic preservation concerns down to A–1, A–2, and B–1/B–2 test stands as National Historic Landmarks and to the two extinct town sites of Gainesville and Logtown, which are potentially eligible for the NRHP. In the year 2013, SSC will also evaluate 1963–1967 era buildings for potential NRHP eligibility. The only potential for impact from this testing effort will be the three National Historic Landmark test stands. Since these test stands were still active when nominated, NASA entered into a programmatic agreement with the National Conference of State Historic Preservation Officers and the Advisory Council on Historic Preservation on September 20, 1989, that allows for needed modifications to the test stands after a consultation phase with the Mississippi State Historic Preservation Officer. The Mississippi State Historical Officer has reviewed the proposed project and has provided concurrence, as shown in appendix B.

Construction Impacts

This project will not alter the primary function, architecture, or structure of the test positions. The project will preserve and possibly enhance the character and physical attributes of the facility. Insignificant impact is expected.

Operational Impacts

The testing of RP–1 engines, especially Russian engines and/or other advanced engine systems, could enhance the historical significance of the test stands. All three test stands at SSC are proposed for test activities and will be exposed to hot gaseous emissions resulting from the tests. Maintenance and cleanup of the structures will be conducted as a part of the proposed test operations to prevent any deterioration of the test stands. There are no other historically-significant structures at SSC that could be affected by these test activities. Insignificant impact is expected.

Mitigation

No mitigation is required.

Transportation

Affected Environment

Interstates 10 and 59 (I-10 and I-59), U.S. Highway 90, and Mississippi 607 serve the SSC area. Direct access to and through SSC from I–10 and I–59 is provided by Mississippi Highway 607. Highway 607 also connects with U.S. 90 approximately 9 mi (14.5 km) southeast of SSC.

Approximately 8.5 mi (13.7 km) of canals inside the fee area are available to transport material within SSC. The SSC canal system links to the East Pearl River through a lock system. The East Pearl River links SSC to the national waterway transportation system. It is 21 mi (33.8 km) from the main canal entrance to the Gulf Intracoastal Waterway.

Construction Impacts

No new transportation construction is anticipated; therefore, no impact is expected.

Operational Impacts

Most of the major hardware would be transported by road or barge. Special flatbed, tractor-trailer units may be required for the transportation of the rocket component parts; however, the existing infrastructure such as roads and bridges should be adequate to handle the transportation of rocket components. The estimates for projected propellant transport can be found in the "Operational Impacts" of MSFC's "Transportation" section. No known transportation accidents have occurred. Therefore, insignificant impact is expected.

Mitigation

No mitigation is required.

Waste Generation and Treatment

Affected Environment

The solid waste generated at SSC is recycled or placed in the onsite Class A landfill. Unacceptable wastes, such as hazardous or radioactive waste, paint products, fuels, and explosives, are excluded from disposal in the landfill. Some construction waste, rubble, and vegetation will be disposed of in the SSC Class II rubbish landfill. Asbestos wastes are placed in the SSC landfill cell designated to receive such wastes. Hazardous or other unacceptable wastes are shipped off site for treatment or disposal.

Construction Impacts

Construction wastes and debris generated during modifications of the test stands would be disposed of in the SSC rubbish landfill and sanitary landfill. Construction impacts on solid waste generation and disposal will be insignificant.

Operational Impacts

Solid waste generated during test operations would be placed in the SSC landfill. Solid waste generation will not significantly increase the volume of waste generated by SSC. Solid waste impacts will be insignificant.

Mitigation

No mitigation is required.

Socioeconomics

Affected Environment

SSC is located along the central Gulf Coast between the cities of New Orleans, Louisiana, and Mobile, Alabama, where the population is concentrated. Population in the five county/parish area where SSC is located was approximately 423,000 in 1990. Mississippi cities within the area are Picayune, Poplarville, Long Beach, Waveland, Pass Christian, Bay St. Louis, Gulfport, and Biloxi. Louisiana cities located within the area include Covington, Slidell, Pearl River, Mandeville, and Bogalusa. The area varies from rural to urban.

Construction Impacts

No impacts on population and employment are expected for performing the modifications at the test stands.

Operational Impacts

Implementation of the Advanced Space Transportation Program at SSC would result in employment of high-tech personnel and contractors. Due to current and projected downsizing in other SSC programs, the net effect would most likely produce no noticeable difference in total employment numbers at SSC and would be within the SSC infrastructure support capability. Therefore, impact is insignificant.

Mitigation

No mitigation is required.

Public and Employee Health and Safety

Affected Environment

SSC test areas are designed with consideration of the hazardous nature of the operations and provisions for the protection of employees. The hazardous operations take place in areas safely isolated from the general public. SSC was located and designed to minimize risks to public health and safety.

Construction Impacts

Proposed construction involves modifications and enhancements to existing facilities. Only small quantities of hazardous substances will be required for use or storage during construction. Insignificant impacts are expected from construction.

Operational Impacts

SSC operations are regulated by stringent federal and state laws governing the conduct of all operations with respect to environmental, worker, and public protection. Environmental permits issued to SSC and new ones that will be required for the conduct of the proposed activities ensure that discharges and emissions to the surface water, groundwater, and air are within acceptable limits and protect the public health and safety. SSC adheres to OSHA standards for protection of employees on site. Procedures are in place to monitor and protect, as necessary (e.g., proper ventilation, safety exclusion zones for employees, or worker-required protection equipment).

Additionally, physical placement of hazardous operations, especially those involving igniters, oxidizers, and propellants, is determined by their hazard potential. Facilities accommodating hazardous operations are separated from other facilities by QD requirements designed to isolate a hazardous facility and minimize damage to other facilities should an explosion or release of a hazardous substance occur. A minimum number of personnel are allowed in test areas during propellant and igniter loading. All personnel are removed from the QD zones or to approved facilities constructed to safely withstand effects of tests or unplanned event during actual tests.

The "SSC Contingency Plan" (SHB 4130.3) details specific emergency procedures to respond to natural and man-made emergencies. There is an ongoing training program to ensure emergency preparedness. The Local Emergency Planning Committee would be notified of any significant quantities of propellants as they are introduced to the facility, and the SSC Contingency Plan would be modified as appropriate. Transportation of propellants onto the facility meets all Department of Transportation regulations and has been routine at SSC for over 30 years. On site, strict security is maintained in the test areas. Due to the physical and operational considerations of public and employee health and safety, no impact to the public and employee health and safety is expected.

Mitigation

No mitigation is required

Pollution Prevention And Environmental Justice

In accordance with Executive Order (EO) 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements," and NASA's implementation plan of this EO (NASA, 1995b), MSFC (NASA/MSFC, 1996b) and SSC (NASA/SSC, 1995&1996) have written pollution prevention strategies into their Pollution Prevention Plans.

The plan will establish goals for the following areas:

1) Toxic chemicals

Each federal agency must strive to eliminate or reduce the production or acquisition of products which contain extremely hazardous substances or toxic chemicals. In addition, the Community Right-to-Know Act requires all federal facilities that manufacture more than 25,000 lb (11,300 kg) or otherwise use more than 10,000 lb (4,500 kg) of listed toxic chemicals to publicly report their wastes and releases to EPA's Toxic Release Inventory (TRI). Facilities which exceed these threshold requirements for TRI toxic chemicals must develop goals to reduce their releases and offsite transfers by 50 percent by the end of 1999.

2) Energy efficiency

Each facility should strive to:

a) Reduce overall energy use by 30 percent by the year 2005 from their 1985 energy use levels.
b) Increase energy efficiency by 20 percent, using 1990 as the baseline year.
c) Minimize use of petroleum products.
d) Increase the use of solar and other renewable energy sources.

3) Solid waste reduction and recycling

Each agency must establish goals for solid-waste reduction and for recycling, to be achieved by the end of 1995. In addition, each facility is required to implement a waste reduction and recycling program.

4) Water conservation

Each federal agency is required to evaluate opportunities for water conservation and implement cost-effective recommendations for water conservation technology.

5) Hazardous waste and oil spill prevention

Each federal agency is required to comply with the emergency planning and response provision of Emergency Planning and Community Right-to-Know Act. Compliance requires that each agency submit an emergency planning notification to the Local Emergency Planning Committee.

In an effort to meet the goals set forth by EO 12856, MSFC and SSC have initiated projects affecting both NASA's institutions (physical infrastructure) and program/project operations. Many elements of this program will benefit from incorporation of newer, more environmentally-friendly processes, such as those described in the proceedings of the "Aerospace Environmental Technology Conference" (NASA, 1995). Some examples of new technology include:

a) Convergent spray processes for environmentally friendly coatings

b) Waterjet processes for coating removal

c) Evaluation of pressurized water cleaning systems for hardware refurbishment

d) Environmentally-compatible, hand-wipe cleaning solvents

e) A water-blown, urethane insulation for use in cryogenic environments

f) Replacement of corrosion-protection chromate primers used in cryogenic applications on the space shuttle with wire-arc-sprayed aluminum coatings

In accordance with EO 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," MSFC and SSC have issued their respective Environmental Justice Implementation Plans as part of, or in coordination with, their respective Pollution Prevention Plans (MSFC 1996b and SSC 1996). The Centers' Environmental Justice Plans reflect agency policy established in Environmental Justice Strategy (NASA, 1995c.)

MSFC's Environmental Justice Plan (MSFC 1996b) evaluated 43 census tracts to determine if low- income or minority populations were within 4 to 5 miles of Redstone Arsenal. Of these census tracts, 13 block groups were

determined to contain low-income or minority populations. A census tract is a permanent, statistical subdivision of a county that typically contains between 2,500 and 8,000 people. A block group is a portion of a census tract that contains 250 to 550 housing units. Thus, several block groups make up a census tract. Census tracts and block groups are areas as defined by the U.S. Census.

MSFC operations were evaluated for potential to disproportionately and adversely affect minority and low-income populations. The evaluation factors are human health effects and environmental effects. The activities evaluated were noise and air emissions from rocket engine testing, releases of wastewater to Indian Creek, onsite contamination from past operations, and accidental spills of hazardous materials. Based on this evaluation, it was determined that no offsite effects on human health and the environment are expected. Thus, low-income and minority populations will not be affected because of current or projected operations. However, MSFC plans to initiate environmental justice program activities to include newsletters, fact sheets, educational outreach programs, employee training, etc.

SSC's Environmental Justice Plan (SSC, 1996) evaluated 10 census tracts in Louisiana and 36 block groups in Mississippi to determine percentage of persons of color, percentage of blacks, per capita income, median household income, percentage female, and percentage of children under 18. The census tracts and block groups were within 5 to 10 miles of SSC. The SSC Environmental Justice Implementation Study identified six block groups where environmental justice exposure is potentially high. These block groups are concentrated in Picayune, MS, and surrounding environs. An additional block group was found in Pearlington, MS. SSC plans to initiate environmental justice program activities to include updating community relations plans, Environmental Resources Documents, and preliminary environmental study forms, along with integrating environmental justice goals and objectives into SSC's educational outreach programs, procurement practices, employment practices, etc.

Stratospheric Global Impact

The work by Molina and Rowland, 1974, that first linked stratospheric ozone destruction with chorine atoms has had a profound and pervasive effect on chemical (primarily solvents, refrigerants, and fire suppressants) selection and process/system acceptability. Our understanding of ozone and the processes that influence it are discussed extensively in "World Meteorolgical Organization (WMO)" 1985, 1989, and 1994. The initial hypothesis by these scientists initiated unprecedented studies of atmospheric processes and identification of the chemicals, commonly referred to as ODC's. The scientific data and modeling projections created world-wide concern and led to the first meeting of nations in Montreal, Canada, in 1987 to review the data, projections, and potential consequences and develop prudent measures to resolve or prevent significant adverse global impacts. The result was the 1987 Montreal Protocol to control the production and consumption of ODC's. Currently 92 foreign countries and the United States, representing over 90% of the world's consumption of chlorofluorocarbons and halons (the most prevalent ODC's), have committed by signature to the original Montreal Protocol.

Stratospheric ozone shields the Earth's surface and all life forms from harmful ultraviolet (UV) radiation. Many studies have been conducted on the UV radiation effects on humans, plants, and animals. Increased exposure to UV radiation, especially UV-B, has been linked by the medical community to higher incidence of skin cancers and cataracts. Genetic alterations can also be induced, causing damage to plants, crops, and marine life. Some studies have also indicated that increased UV exposure may affect the human immunological system. Some discussions on this subject include: (1) U.S. National Academy of Sciences/ National Research Council, 1984; (2) EPA, 1987; (3) Monastersky, 1990; (4) Moteff, 1991; and (5) Potter, 1977.

When NASA committed to the shuttle design using a combination of solid rocket boosters with primary emissions of hydrogen chloride and aluminum oxide and LOX/LH_2 engines releasing water vapor, the Agency addressed stratospheric ozone depletion and concluded that the projected launch rate of 60 shuttles per year and annual release quantities of exhaust gases containing chlorine would result in an estimated annual ozone reduction of approximately 0.25 percent. Ozone levels would not be affected by shuttle exhaust products for more than 2 to 6 years after termination of launches (NASA, 1978). A more recent ozone impact analysis of nine Shuttle and six Titan IV launches per year projected corresponding maximum ozone depletions of less than 0.2 percent at an altitude of 25 mi (40 km) (WMO, 1991).

Since stratospheric ozone impact from the exhaust products of space propulsion systems is an issue that cannot be readily mitigated once the vehicle concept is approved, ozone impact for a RLV or EELV concept that utilizes a propulsion system consisting of seven small engines at a launch rate of eight per year was modeled and compared to the ozone impact of eight shuttle launches per year using the same launch trajectory and atmospheric conditions (see appendix I). The model predictions of ozone change are presented in Table 19. Based on these data, ozone reduction in the northern polar latitudes due to this vehicle concept would be approximately 6,000 times less than that produced by an equivalent number of shuttle or Titan launches required to lift the same maximum payload weight under similar conditions. On a yearly average global basis, this vehicle concept would produce approximately 4,000 times less ozone reduction than an equivalent number of shuttle or Titan launches required to lift the same maximum payload weight under similar conditions. Since the water contribution to ozone depletion from the vehicle concept was more important than the carbon species such as CO_2 and CO, it can be assumed that all SSTO concepts utilizing either LOX/LH_2 or LOX/LH_2/RP-1 would produce ozone reductions of approximately three orders of magnitude (1,000 times) less than the current space launch vehicles whose exhaust products contain substantial quantities of chlorine.

TABLE 19.— *Comparative stratospheric ozone change for the current space transportation system (space shuttle) and an SSTO vehicle concept using seven RD–704 engines for its propulsion system, assuming eight launches each per year (Jackman, et al., 1995)*

Stratospheric Zone	Change in Ozone	
	Shuttle	SSTO
Upper	8×10^{-2}%	-4×10^{-5}%
Northern polar latitudes	3×10^{-2}%	-5×10^{-6}%
Yearly average global total change	8×10^{-3}%	-2×10^{-6}%

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Federation of American Scientists
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Ducks Unlimited—Picayune
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Harrison County Development Commission
Pearl River County Development Association
Hancock County Port and Harbor Commission
Chamber of Commerces
- Mississippi Gulf Coast
- Biloxi Bay
- Hancock County
- Picayune

Index of Abbreviations and Acronyms

ac	acre
ACGIH	American Conference of Governmental Industrial Hygienists
ADEM	Alabama Department of Environmental Management
AETF	Advanced Engine Test Facility, MSFC, Building 4670, also known as Technology Test Bed, Saturn Test Stand, and Saturn 1C (S–1C) Test Stand
ASME	American Society of Mechanical Engineers
ASRM	advanced solid rocket motor
BACT	Best Available Control Technology
BNWR	Bretan National Wildlife Refuge
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFD	computational fluid dynamics
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
dB	decibel
dBA	decibel, A-weighted
DOD	Department of Defense
DOT	Department of Transportation
DRMO	Defense Reutilization and Marketing Office
DSN	Discharge Serial Number
EA	Environmental Assessment
EAFB	Edwards Air Force Base
EELV	Evolved Expendable Launch Vehicle
ELV	expendable launch vehicle
EPA	Environmental Protection Agency
FOSS	Facilities Operations and Support Services
ft	feet
g	gram
gal	gallon
gal/day	gallons per day
gal/min	gallons per minute
HAP	hazardous air pollutant
ha	hectare
hr	hour
INPUFF	Integrated Puff Model
IOC	initial operational capability
JANNAF	Joint Army Navy NASA Air Force (Committee)
kg	kilogram
Klb	kilopounds
km	kilometer
L	liter
lb	pound
LH_2	liquid hydrogen
LOX	liquid oxygen
M	million or mega
MDEQ	Mississippi Department of Environmental Quality
mg	milligram
mi	mile
Mlb	million pound thrust
MMI	Marshall Management Instruction
MN	million newton thrust
mph	miles per hour
mt	metric ton
MSDS	Material Safety Data Sheet
MSFC	Marshall Space Flight Center
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NRA	NASA Research Announcement
NRHP	National Register of Historic Places
NSR	New Source Review
OASPL	overall sound pressure level
ODC	ozone depleting chemicals
OSHA	Occupational Safety and Health Administration
O_3	ozone
P	Palustrine
Pb	lead
P-G	Pasquill-Gifford
PEL	permissible exposure levels
PEM	Palustrine emergent wetlands
PFO	Palustrine forested
PM_{10}	particulate matter < 10 micron in size
PSD	prevention of significant deterioration
psi	pounds per square inch
psig	pounds per square inch gauge
PSS	Palustrine scrub/shrub
PUB	Palustrine Unconsolidated Bottom
QD	quantity-distance
RACT	Reasonably Achievable Control Technologies
RCRA	Resource Conservation and Recovery Act
REEDM	Rocket Effluent Exhaust Diffusion Model
RLV	Reusable Launch Vehicle

Index of Abbreviations and Acronyms (continued)

RP–1	rocket propellant
RSA	Redstone Arsenal
RSRM	redesigned solid rocket motor
sec	second
SIP	State Implementation Plans
SL	sea level
SSC	Stennis Space Center
SSME	space shuttle main engine
SSTO	single-stage-to-orbit
SWMU	Solid Waste Management Unit
S–1C	Saturn 1C Test Facility, MSFC, Building 4670
TCA	trichloroethane
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leach Procedure
TEA	triethylaluminum
TEB	triethylboron
TF	test facility
TLV–TWA	Threshold limit value—time weighted average
ton/yr	tons per year
TWA	time weighted average
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
wk	week
yr	year
μ	micron
$\mu g/m^3$	micrograms per cubic meter
1-hr	1 hour average
8-hr	8 hour average

Index of Definitions

Bipropellant
Propellant system of a liquid engine that utilizes two chemical components from lift-off to orbit, e.g., LOX and RP–1 or LOX and LH_2.

Characteristic waste
Any one of four categories used in defining hazardous waste: ignitability, corrosivity, reactivity, and toxicity. (Sullivan, 1993).

Criteria air pollutants
Chemical elements or compounds known to be hazardous to human health that are ozone, carbon monoxide, total suspended particulates, sulfur dioxide, lead, and nitrogen dioxide. The Clean Air Act of 1970 directed the EPA to identify the pollutants and to set National Ambient Air Quality Standards for these chemicals. The term "criteria pollutants" derives from the requirement that the EPA must describe the characteristics and potential health and welfare effects of these pollutants. It is on the basis of these criteria that standards are set or revised (Sullivan, 1993).

Hypergol
A liquid rocket fuel or propellant which consists of combinations of fuels and oxidizers that ignite spontaneously on contact with each other (Lewis, 1993).

Material safety data sheet
A compilation of information required under the OSHA Communication Standard on the identity of hazardous chemicals, health, and physical hazards; exposure limits; and precautions (Sullivan, 1993).

Run tank
Fuel tank on the stand used only during a test.

Solid waste management unit
Area where hazardous chemicals may have been released in the past.

Tripropellant
Propellant system of a liquid engine that utilizes three chemical components burning in different combinations at different altitudes that enables the vehicle to lift off and to reach orbit. For example, at lift-off the vehicle could initially burn liquid oxygen and rocket propellant (RP) and as the vehicle gains altitude, the RP would be consumed. At this point, the engine could begin to burn liquid oxygen and liquid hydrogen.

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Appendix A–1—Public Comments

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TABLE A–1.—*Public Scoping Comments*

Comment Number	Name	Organization	Comment
1.	Ron Creel	Private citizen, Huntsville, AL	Expressed confidence in NASA's ability to study and report on potential environmental efforts of engine testing.
2.	Dale V. Wilhelm	Tennessee Valley Authority (TVA)	Requests to be kept informed of project since it might affect TVA lands and waters.
3.	Mack Herring	Private ctizen and retired NASA employee in SSC vicinity	Confident that proposed engine testing will be environmentally safe and contribute positively to economic growth.
4.	Ted LaMunyon	Private citizen and retired NASA employee in SSC vicinity	Expressed confidence and pride in NASA.
5.	Chuck Breath	Representing Hancock Bank in south Mississippi	Expressed appreciation for SSC and positive economic impact by NASA.
6.	Joey Manieri	Private citizen, Hancock Co., MS	Requested documentation on program and information on program purpose, length, cost, jobs, noise, and other environmental concerns. Provided a chronology of NASA projects with projected and actual costs which reflect a pattern of significant overruns. Questioned the need for an acoustical buffer zone at SSC and alleged that NASA and political leaders breached early commitment to return the buffer zone after the Apollo Program. Requested specific data concerning the handling and use of kerosene be included in the EIS.
7.	Tony Caston	Hancock County School Board Hancock Co., MS	Requested impact data on school system such as number of additional students and noise impact on Hancock County High School. Supports the proposed program.
8.	Gill Ganucheau, Jr.	Private citizen, Slidell, LA	Supports the proposed program.
9.	Larry E. Goldman	U.S. Dept. of the Interior, Fish and Wildlife Service, Daphne, AL	Does not expect proposed action to result in significant adverse impacts to nonendangered fish and wildlife provided best management practices are implemented. Provided list of federally-listed species in vicinity of MSFC and SSC and requested full consideration of program impact on listed species and respective habitats.

Appendix A–2—Summary of MSFC and SSC Public Meeting

MSFC Public Meeting (Synopsis)
Sign In Sheets

SSC Public Meeting (Synopsis)
Sign In Sheets

■ MSFC Public Meeting Synopsis

A public meeting was held on December 2, 1996, at the Huntsville/Madison County Public Library, Huntsville, Alabama. The moderator for the meeting was Dr. Dom Amatore (Public Affairs Office.) Speakers for the event were Susan M. Smith (Associate Director, MSFC), Gary Lyles (Manager, Advanced Transportation Program), and Dr. Rebecca McCaleb (Director, Environmental Engineering and Management Office.) Mrs. Smith's presentation was a broad overview of missions and roles assigned to MSFC. Mr. Lyles' presentation was specific to the types of vehicles and associated propulsion systems considered for test and evaluation by the ASTP. Dr. McCaleb's presentation covered potential environmental affects associated with the proposed testing at MSFC. The potential environmental effects emphasized at the meeting included air, noise and oil products impacts. After the presentations, the meeting was turned over to Dr. Amatore. One individual had a comment/question. The question was how the environmental impact review would impact commercial testing that is starting to be attracted to Marshall. Dr. McCaleb replied that engine testing at MSFC would be evaluated to determine if any additional environmental review was required based on the type of proposed testing. The meeting ended.

Commentor	Affiliation	Comment
1. James Hopkins	Space Trans. Inc.	If the environmental impact will impact commercial testing that is starting to be attracted to Marshall.

PUBLIC MEETING
FOR
DRAFT ENVIRONMENTAL IMPACT STATEMENT
12/2/96

NAME	CITY AND STATE	REPRESENTING
FARLEY DAVIS	HARVEST, AL	NASA/MSFC
Dorothy Hollis	Huntsville, AL	NASA/MSFC
Arthur Petrini	Huntsville AL	NASA/MSFC
NANCE J. OGUZALEK	HUNTSVILLE, AL	NASA/MSFC
Rebecca McCaleb	Huntsville, AL	NASA/MSFC
John Hilliard	New Hope, AL	NASA/MSFC
William Douglas	Huntsville, AL	NASA/MSFC
WALT WHITACRE	Huntsville, AL	NASA/MSFC
Amy Keith	Huntsville, AL	NASA/MSFC
Donna Holland	Hsv, AL	NASA/MSFC
GARRY LYLES	HUNTSVILLE, AL	NASA/MSFC
GREG BURNS	Huntsville, AL	NASA/MSFC
SUSAN M.G. SMITH	HSVILLE, AL	NASA/MSFC
GAIL MURPHREE	HUNTSVILLE	USBI, Co. (MSFC)
Robert Bruce	Huntsville, AL Gulfport, MS	NASA/SSC @ MSFC
June Malone	Huntsville, AL	NASA-MSFC
Louis Turaya	" "	" "
DOMINIC AMATORE	MADISON, AL	NASA-MSFC
Dr. Ruben Rojas-Oviedo	MADISON, AL	A&MU.
SHERMAN JOBE	HUNTSVILLE, AL	MSFC
CRAIG SUMNER	Huntsville, AL	MSFC
Karen Dugard	Huntsville AL	MSFC
Doug Shores	Huntsville, AL	WAFF TV
GREG MCCOMPSEY	HSV	WAFF TV

PUBLIC MEETING
FOR
DRAFT ENVIRONMENTAL IMPACT STATEMENT
12/2/96

NAME	CITY AND STATE	REPRESENTING
Tim Pickens	MADISON	SELF
JAMES Hopkins	HUNTSVILLE	SPACETRANS, INC.
Trent Faulk	Huntsville	Birmingham News
James B. Keller	Huntsville	Self

■ SSC Public Meeting Synopsis

A public meeting was held on December 11, 1996, 7:00 PM, at the Hancock County High School Cafeteria, Hancock County, Mississippi. The welcoming comments, introduction of speakers, summary of environmental data and moderator for public comments was Ronald Magee, SSC Environmental Officer. Other speakers were Mark Craig, SSC Deputy Center Director and Robert Bruce, SSC Chief Advanced Projects. Mr. Craig provided an overview of the history, missions and goals of SSC. Mr. Bruce's presentation included specific types of vehicles and propulsion systems tested at SSC in the past and proposed for the future as part of the Advanced Space Transportation Program. Mr. Magee discussed the Environmental Impact Statement process and provided a summary of the environmental data with special emphasis on noise, air quality and oil product impacts. Following Mr. Magee's presentation, the public was invited to provide comments. Six individuals requested to speak.

Commenter	Affiliation	Comment
1. Joey Manieri	Private citizen, Bay St Louis, MS	Requests investigation into reducing the size of the buffer zone and noise suppression studies conducted at MSFC. Expressed concern over the size of this EIS compared to the ASRM EIS, the costs and time lines of NASA projects, success of NASA projects, and the lack of technological assistance to the local community.
2. Frank N. Egger	The Informer Newspaper, Picayune, MS	Stated support for SSC. Expressed concern over the proximity of the new airport in Picayune and whether it will be impacted by rocket testing especially with regard to restricted flying zones and aircraft radio transmissions.
3. Jon Ritten	Partners For Stennis, Diamondhead, MS	Supports the advancement of SSC, especially propulsion testing and commercial remote sending.
4. Mack Herring	Private citizen, Waveland, MS	Supports SSC and the opportunities it has provided for the local citizens. Supports the necessity of the buffer zone.
5. Ted LaMunyon	Private citizen, Picayune, MS	Expressed confidence in NASA's engine testing programs, employees and contractors.
6. Woody Spiers	Mayor, City of Picayune, Picayune, MS	Expressed appreciation for the opportunities afforded to the local communities by SSC. Stated that there is no indication that the location of the airport will be a problem.

A few responses to public comments were provided during the meeting. In response to Mr. Manieri's comments, Mr. Magee stated that the reason this EIS is not as lengthy as the ASRM EIS is the amount of material covering public health issues. Mr. Craig stated that SSC works very hard with the local government and with local economic entities to try to make sure we are being a good citizen of the community. Mr. Magee agreed, stating that NASA has and will continue to provide valuable computer products utilizing remote sensing data and digitized formats. This data has been used by the tax assessors office.

In response to Mr. Egger's comments, Mr. Magee stated that the restricted flying zone over the test stands at SSC should not pose a problem to local airports. He also stated that SSC would provide a more complete answer on the question of radio transmissions after consulting with other staff members.

All other speakers did not require a response. The meeting ended at approximately 8:00 PM.

PUBLIC MEETING
FOR
DRAFT ENVIRONMENTAL IMPACT STATEMENT
12/11/96

NAME	CITY AND STATE	REPRESENTING
Myron Webb	Long Beach, MS	NASA
Kelly Smith	Picayune, MS	Johnson Controls
Delous Smith	Slidell, LA	Johnson Controls
Lance Cobb	Carriere, MS	NASA
Robert Bruce	Gulfport, MS	NASA
FRANK N. EGGER	PICAYUNE, MS.	INFORMER NEWS PAPER
Claudia Egger	Picayune MS	informer News Paper
Cheryl Bennett	Pearlington, MS	Johnson Controls
Will Sullivan	Picayune, MS	Picayune Item
Wendy Robinson	OH, MS	J Controls
Al Watkins	Picayune MS	LMSO
Ted LaMessena	Picayune	citizen
Jon Mueller	Bogalusa Tr	JCWS
Billie H. Edwards	Picayune, MS	NASA
Evelyn Edwards	Picayune MS	NASA
Jerry L. Ladin		

PUBLIC MEETING
FOR
DRAFT ENVIRONMENTAL IMPACT STATEMENT
12/11/96

NAME	CITY AND STATE	REPRESENTING
Ronald G. Magee	BSL, MS	NASA
Jenette B Gordon	Slidell, LA	NASA
Carolyn D. Kennedy	Waveland, MS	Johnson Controls
MARK CRAIG	SLIDELL, LA	NASA
Rocky Pullman	Hancock County	Supervisor
Mack Herring	Hancock County	Citizen
MARK LOUGHMAN	LONG BEACH, MS	JOHNSON CONTROLS
C. Randy Holland	PICAYUNE, MS	CITIZEN
Jon E Ritter	Diamondhead	CITIZEN
Linda Slade	Diamondhead	NASA
Fy Kailuwai-Barnett	Picayune, MS	NASA
Larry Mainin	BSL MS	Citizen
Mark Hughes	DECATUR, AL	NASA
Perry Chey	Long Beach	JCWS
[illegible]	Diamondhead	GB Tech
CHRIS LAGARRE	5th DISTRICT	Gee Taylor
WOODY SPIERS	PICAYUNE, MS	City
Steve Dice	Pass Christian MS	NASA
Patrick [illegible]	PICAYUNE MS	NASA
W.S. Bamble	PICAYUNE MS	LOCKHEED MARTIN
Don Cox	Long Beach, MS	NASA

APPENDIX A–3—Public Comments on the Draft EIS

EO 12372 STATE OF MISSISSIPPI LETTER NO. 1
WEEKLY LOG STATE CLEARINGHOUSE FOR FEDERAL PROGRAMS DATE 11/07/96
PGM=N150 11/18/96

MS APPLICANT NO.: MS961114-001
IMPACT AREA(S):

CONTACT: DR. REBECCA C. MCCALEB
PHONE: (000) 000-0000

APPLICANT:
NAT'L AERONAUTICS & SPACE ADMIN.
GEORGE C. MARSHALL SPACE
FLIGHT CENTER
AL 35812

FEDERAL AGENCY: NASA

FUNDING: FEDERAL APPLICANT STATE
LOCAL OTHER PROGRAM
TOTAL

DESCRIPTION: DRAFT ENVIRONMENTAL IMPACT STATEMENT OF ENGINE TECHNOLOGY SUPPORT FOR NASA'S ADVANCED SPACE TRANSPORTATION PROGRAM. NOTICE OF AVAILABILITY (NOA) PUBLISHED IN FEDERAL REGISTER NOVEMBER 15. NOA GIVES DETAILS OF PUBLIC MEETINGS AND HOW TO FORWARD COMMENTS THROUGH JANUARY 10, 1997.
CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER

---

455 NORTH LAMAR STREET - JACKSON, MS 39202 (601) 359-6762

- THIS IS AN ACKNOWLEDGEMENT ONLY -

STATE AGENCIES MUST REVIEW CERTAIN PROPOSALS PRIOR TO RECEIVING MISSISSIPPI INTERGOVERNMENTAL REVIEW PROCESS CLEARANCE. THE MISSISSIPPI DEPARTMENT OF ARCHIVES AND HISTORY REVIEWS ANY PROPOSALS INVOLVING CONSTRUCTION, SUCH AS A HIGHWAY OR AN APARTMENT COMPLEX FOR COMPLIANCE WITH CULTURAL RESOURCES AND HISTORIC PRESERVATION. MISSISSIPPI DEPARTMENT OF ENVIRONMENTAL QUALITY, OFFICE OF POLLUTION CONTROL, REVIEWS APPLICATIONS IN ACCORDANCE WITH THE FEDERAL WATER POLLUTION CONTROL ACT. THE MISSISSIPPI DEPARTMENT OF MARINE RESOURCES REVIEWS APPLICATIONS FOR CONSISTENCY WITH THE COASTAL PROGRAM.

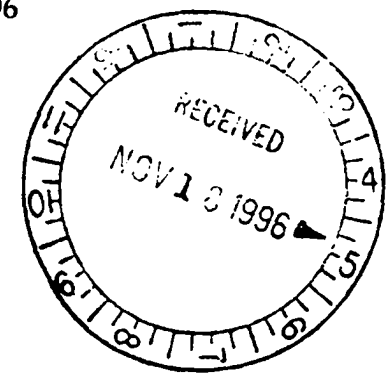
IF APPLICATIONS ARE FOR PROJECTS OF LOCAL IMPACT, THEY SHOULD BE SENT TO THE APPROPRIATE PLANNING AND DEVELOPMENT DISTRICT AT THE SAME TIME. PLEASE NOTE THAT ONE OF OUR REQUIREMENTS IS THE USE OF STANDARD FORM 424. THE DEPARTMENT OF FINANCE AND ADMINISTRATION PREPARES AND DISTRIBUTES A WEEKLY LOG LISTING PERTINENT INFORMATION CONTAINED ON THIS FORM. OUR ADDRESS IS 455 NORTH LAMAR STREET 39202 AND OUR PHONE NUMBER IS (601) 359-6762.

LETTER NO. 2

HUNTSVILLE
The Sky is not the limit.

One of the World's Top 10 Economic Development Organizations
Site Selection Magazine 1995

November 15, 1996



Dr. Rebecca C. McCaleb
Director, Environmental Engineering
and Management Office
Code AE01
MSFC, Alabama 35812

Dear Dr. McCaleb:

Thank you for providing the Chamber with a copy of the Draft Environmental Impact Statement of Engine Technology support for NASA's Advanced Space Transportation Program and for giving us an opportunity to provide comments.

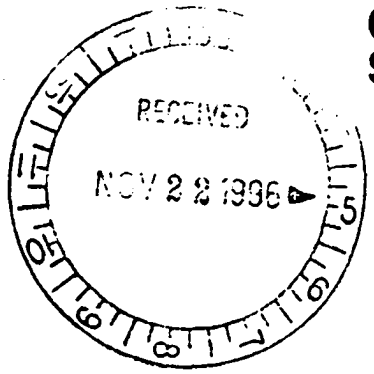
We concur with the EIP assessment that Launch Technology work done at MSFC, as directed by the prime contractor, Lockheed Martin, is compatible with environmental standards set by MSFC and the Agency and would not have an adverse impact on our environment. (1)

Sincerely,

Larry Waller
President

LETTER NO. 3

UNION OF
CONCERNED
SCIENTISTS



19 November 1996

Dear Friend,

Thank you for writing to the Union of Concerned Scientists and sending us information about your work*. We appreciate receiving these materials. I will share them with appropriate members of our staff. (1)

Thank you again for sending this information. For additional information about the Union of Concerned Scientists, you may visit the UCS World Wide Web Home Page at http://www.ucsusa.org.

Sincerely,

Denise Barrant

Denise Barrant
Communications Officer
ucs@ucsusa.org

* "Draft Environmental Impact Statement of Engine Technology Support for NASA's Advanced Space Transportation Program"

Two Brattle Square • Cambridge, MA 02238 • 617-547-5552 • FAX: 617-864-9405
PRINTED ON RECYCLED PAPER

LETTER NO. 4

ADEM

ALABAMA
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Fob James, Jr
Governor

James W. Warr
Director

(334) 271-7700

1751 Cong. W. L.
Dickinson Drive
Montgomery, AL
36109-2608

Mailing Address:
PO Box 301463
Montgomery, AL
36130-1463

FAX: (334)
Admin: 271-7950
Air: 279-3044
Land: 279-3050
Water: 279-3051
Sp Proj: 213-4399
Field Ops: 272-8131
Backup: 270-5612

Field Offices:

110 Vulcan Road
Birmingham, AL
35209-4702
(205) 942-6168
FAX: 941-1603

90 Well St, N.E.
P.O. Box 953
Decatur, AL
35602-0953
(205) 353-1713
FAX: 340-9359

2204 Perimeter Rd
Mobile, AL
36615-1131
(334) 450-3400
FAX: 479-2593

December 4, 1996

Dr. Rebecca C. McCaleb
Director, Environmental Engineering and Management Office
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Dear Dr. McCaleb:

We have received and reviewed the Draft EIS of the Engine Technology Support for the Advanced Space Transportation Program which you sent to us on November 4, 1996. Thank you for the opportunity to review and comment on this important program. We have only one comment:

We recommend that the following statement be added on page 15 of the draft EIS concerning guidelines for new air-emissions. (1)

> "For air pollutants other than criteria pollutants, the state of Alabama has adopted guidelines for new air emission sources such that the emission of a substance for which no specific regulation exists, should not cause ambient air concentrations to exceed 1/40th (one hour average) and 1/420th (annual average) of the published threshold limit values."

If you have any questions regarding, please contact Mr. Nate Hartman of the Department's Air Division at (334) 271-7861.

Sincerely,

Richard E. Grusnick
Deputy Director

REG/NH:mog

S:\WATE\MARSHALL\LETTERS\EISCOMM.DOC

LETTER NO. 5

Teddy M. LaMunyon
P.O. Box 1062
Picayune, MS 39466
December 14, 1996 Saturday

National Aeronautics and
Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

ATTN: AE01/276-96

Dr. Rebecca C. McCaleb

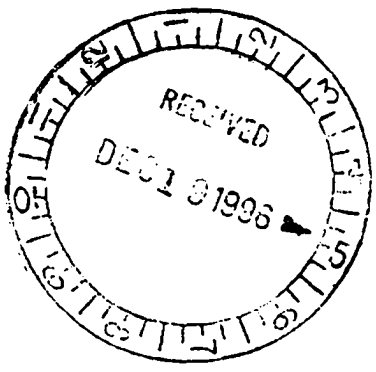
After reviewing the Environmental Impact Statement of Engine Technology Support for NASA's Advanced Space Transportation Program, and attending the public hearing, on the subject, in Hancock County, December 11, 1996, this letter is to express my full support for this future program at SSC. It will have a positive economic impact on the area. It should also make great scientific advancement for space transportation. (1)

I was personally involved at MSFC and SSC in testing of the siiple F-1 engine. It certainly never reached its full potential. As an American tax payer and alumni member of the Apollo test team, I am pleased that NASA is using more of the proven space engines from the past. (2)

Yours truly,

Teddy M. LaMunyon

Teddy M. LaMunyon -(citizen)



LETTER NO. 6

United States Department of the Interior

FISH AND WILDLIFE SERVICE
2001-A Highway 98
P. O. Drawer 1190
Daphne, Alabama 36526

IN REPLY REFER TO:

December 18, 1996

Dr. Rebecca McCaleb, Director
Environmental Engineering and Management Office
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812

Dear Dr. McCaleb:

The following comments are relative to the *Draft Environmental Impact Statement of Engine Technology Support for NASA's Advanced Space Transportation Program* dated November 4, 1996.

Marshall Space Flight Center

Appendix B of the Environmental Impact Statement (EIS) contains two letters from this office dated April 21, 1994 and December 15, 1994. There is no September 21, 1992 letter, as cited on page 32 of the EIS. (1)

We concur with your determination that no adverse impacts to federally listed species will occur from the proposed project, as currently described. (2)

Stennis Space Center

Page 60 of the EIS references the Stennis Space Center (SSC) Environmental Resources Document (NASA/SSC, 1992) for description of federally threatened and endangered species located in the area. The EIS should also reference the more recent list of federally threatened and endangered species, described in our December 15, 1994 letter included in Appendix B of the document. (3)

The federally threatened gopher tortoise, *Gopherus polyphemus*, inhabits portions of SSC and may be located within or adjacent to the Fee Area. Also, the federally threatened eastern indigo snake, *Drymarchon corais couperi*, is commonly co-located with the gopher tortoise by utilizing the tortoise burrows. We recommend conducting a survey within and surrounding the Fee Area for the presence of these two species or suitable habitat. If individual indigo snakes or gopher tortoises or tortoise burrows are encountered, please contact this office at your earliest convenience so we may work with your office in developing preventive measures for these species during the proposed testing activities. (4)

Should you have further questions regarding our concerns, please contact Sharon Delchamps of my staff at 334/441-5181 ext. 31.

Sincerely,

Larry E. Goldman
Field Supervisor

RESPONSES TO LETTER NO. 6—U. S. DEPARTMENT OF INTERIOR (DAPHNE)

1. The reference date on page 32 has been modified to address the comment.

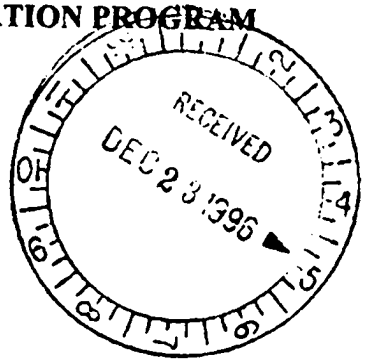
2. Concurrence that no adverse impacts to federally listed species will occur from the proposed project is noted.

3. Text on page 60 has been modified to address the comment.

4. Survey of the SSC Fee Area has been conducted for the eastern indigo snake and gopher tortoise as part of a threatened and endangered species study at SSC (Kaiser and Lago, 1991; Kaiser, 1994). No sitings were made or critical habitat found in the test areas for either species. If either, the indigo snake or gopher tortoise or burrows were to be encountered, the USFWS will be contacted.

LETTER NO. 7

PUBLIC COMMENTS ON
DRAFT ENVIRONMENTAL IMPACT STATEMENT
OF ENGINE TECHNOLOGY SUPPORT FOR
NASA'S ADVANCED SPACE TRANSPORTATION PROGRAM



DATE: 16 DECEMBER 1996

TO: **Dr. Rebecca C. McCaleb**
NASA
Code AE01
MSFC, AL 35812

FROM: C. RANDY HOLLAND
419 E. Z. GOSS ROAD
PICAYUNE, MS 39466
601-798-0805

PUBLIC COMMENT ON DRAFT ENVIRONMENTAL IMPACT STATEMENT:

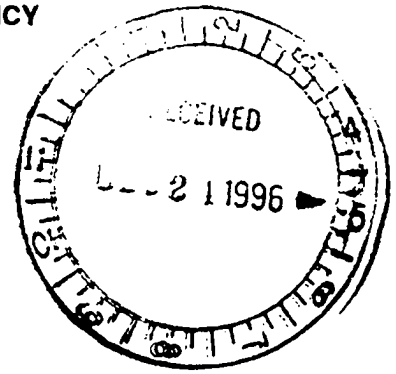
AS A RETIRED FEDERAL EMPLOYEE (NAVY) AND RESIDENT OF PEARL RIVER COUNTY, MS, I AM ALWAYS INTERESTED IN WHAT HAPPENS AT THE STENNIS SPACE CENTER. HAVING ATTENDED THE PUBLIC MEETING ON 11 DECEMBER 1996, STUDIED THE DRAFT ENVIRONMENTAL IMPACT STATEMENT OF ENGINE TECHNOLOGY SUPPORT FOR NASA'S ADVANCED SPACE TRANSPORTATION PROGRAM, AND LISTENED TO THE DISCUSSION AMONG INTERESTED PARTICIPANTS, I AM CONVINCED THAT NASA STENNIS IS EXERCISING DUE CAUTION AND CONCERN REGARDING ITS ROCKET ENGINING TESTING OPERATIONS HERE IN SW MISSISSIPPI. I BELIEVE THE PROJECTS ARE BEING CONDUCTED SAFELY AND WITH NO ADVERSE EFFECTS ON THE ENVIRONMENT OR THE CITIZENS WHO LIVE AND WORK IN THE GEOGRAPHICAL AREA. (1)
NASA STENNIS IS TO BE COMMENDED FOR THEIR EFFORTS TO DATE TO BE A "GOOD NEIGHBOR" AND A VALUE ADDED EMPLOYER. I LOOK FORWARD TO A LONG AND BENEFICIAL ASSOCIATION. (2)

C. Randy Holland (MEMBER)
PARTNERS FOR STENNIS

LETTER NO. 8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
100 ALABAMA STREET, S.W.
ATLANTA, GEORGIA 30303-3104

DEC [illegible]



Dr. Rebecca McCaleb, Director
Environmental Engineering and Management Office, Code AE01
Marshall Space Center, Alabama 35812

Subject: Draft Environmental Impact Statement (DEIS) for the Engine Technology Support for NASA's Advanced Space Transportation Program

Dear Dr. McCaleb:

Under the authority of Section 309 of the Clean Air Act and Section 102(2)(C) of the National Environmental Policy Act (NEPA), EPA, Region 4 has reviewed the subject document; an evaluation of the consequences that testing various prototype and advanced engines would have on the natural/human environment of Stennis Space Center (SSC), Mississippi and Marshall Space Flight Center (MSFC), Alabama. The EIS specifically addresses the different engines and their components as well as comparing operational requirements at the noted test facilities.

The details of our review are provided in the attached comments for use in finalizing the NEPA process for this action. As a result of this assessment, EPA has assigned a rating of EC-2 to the proposal. That is, we have environmental concerns regarding the long-term and/or unanticipated consequences of the noise impacts attendant to this testing, especially at MSFC site. However, our uncertainties in this regard can be satisfactorily addressed in the final EIS by providing the requested information.

If we can be of further assistance in this matter, Dr. Gerald J. Miller (404-562-9626) will serve as initial point of contact.

Sincerely yours,

Heinz Mueller

Heinz J. Mueller, Chief
Office of Environmental Assessment

SPECIFIC COMMENTS

The detention pond at MSFC was contaminated with organic solvents entrained in the cooling water runoff from previous engine testing episodes. While it was mentioned that clean-up actions are planned to address this problem, the actual schedule for same was not specified. We did note that the engine testing schedule is anticipated to be compatible with the interim actions, but believe that a more precise work schedule would benefit all parties. (1)

As soon as the design (and accompanying wetland impact(s)) for the lined detention pond at SSC (servicing A-1 and A-2 test areas) is available, Mr. Mike Wylie of our wetland regulatory staff should be contacted at (404) 562-9407 for comment. (2) If a wetland site is chosen for the pond, Table C-4, with its characterization, Wetlands/Floodplains - "no impact", will have to be reevaluated. (3)

Table C-4 (p.24) notes that the overall impact rating for the designation, transportation accidental potential, was characterized as "no impact" rather than one of the more significant categories. While we understand that the actual quantified risk for an accident with accompanying fuel release may be small from an absolute perspective, there are real risks in transporting hazardous/toxic materials via rail/road. In fact, it is our recollection that one of the reasons SSC was chosen as the preferred site for testing the advanced solid rocket motor (ASRM) engine was its existing barge access capability. That is, it was noted in the ASRM EIS that barge mode of travel had less inherent risk than land based modes. We suggest that NASA provide a summary of its transport profile associated with fuel movement to other test facilities together with accidents (if any) by degree of severity. (4) An evaluation of these data would tend to determine if the "no impact" characterization is substantiated.

We suggest that Tables C-3 and C-4 be reexamined for other apparent incongruities. (5) For example, Table C-3 notes that property, environmental, or human health damage resulting from a transportation accident is, in effect, nonexistent. We agree that the likelihood may be small, but the duration of an accident's effects could be long; hence, the potential consequences would seem to be more than the noted, "not affected by the project".

Notwithstanding the experience of Rocketdyne in California, we agree with the decision to upgrade the MSFC detention pond and associated ditches via installation of a clay or synthetic liner. The merits of each should be discussed between your technical staff and representatives of state/local regulatory agencies; a decision on same should (6)

be presented in the final document. In a related matter there should be an explanation about how the new liner will affect (if at all) the operation of the existing subsurface drain. (7)

Modifications of the test stands at MSFC/SSC will result in disturbance of both asbestos and lead paint. The "procedures" (p.13) which will be followed to lessen worker/environmental exposure to these materials should follow recognized regulatory practices and be specified in the bids for subsequent contracts. Similarly, the procedures used in the maintenance/cleanup of the test stands should be outlined in the final document. (8)

Upgrade design(s) to meet secondary containment standards for the RP-1 tank at the MSFC West Test Area and at SSC are currently under evaluation by NASA technical staff. When a decision is made regarding the specifications of this facility, they should be noted in the final document together with the relationship of same to the revised spill prevention plan. (9)

TCE will be used as cleaning solvent at the test stands. As noted, this material must be properly managed to protect both workers and the environment. The procedures which will be used by MSFC/SSC environmental/safety staff to accomplish same should be outlined in the final document. (10)

The MSFC NPDES permits - DSN 019, 005, and 006 will have to be changed to accommodate discharges from the new engine testing. The significant points of these changes should be noted in the final document. The details of any new NPDES permit conditions for the discharge from the detention pond (B1/B2) at SSC should also be made available in the final document. If detention/treatment becomes necessary for A1/A/2, how will this be accomplished? It would be acceptable to extrapolate a design and treatment method(s) from similar testing at other NASA sites. (11) (12)

After an unspecified period of time RP-1 will be transferred from fuel barges to the test stands (Test Complexes A,B, and E?) at SSC. It would be helpful if some discussion were provided regarding the frequency/degree of spills which have previously occurred during this facility's operation . Moreover, the changes to the spill prevention which were made in response to these release episodes should be outlined. (13)

The underground storage tanks for diesel and gasoline at SSC were mentioned (p.38) as providing peripheral support to the subject rocket motor testing program. While this fuel is not used to power the various thruster engines, continued use of these tanks in an ancillary role could have an adverse (if future) impact on groundwater. Given the

elevated water table in this area, even a small leak would have immediate consequences. Therefore, we suggest that NASA determine the remainder of their usable life and make plans for their retirement prior to development of a problem. At the least, test wells in the vicinity should be monitored for elevated hydrocarbon contamination. (14)

Air emissions from the test firings were characterized as having no impact on the adjacent wetlands. It would be more precise to indicate that no significant impacts to these important communities are anticipated. However, we suggest that a remote sensing protocol similar to that planned for the solid rocket motoring testing SSC be implemented to verify this supposition. If an examination of this nature has already been conducted for this engine at another location, the results could be extrapolated here. (15)

It was noted that the adverse impacts of any soil disturbance associated with construction attendant to this action at MSFC would be minimized via an erosion/sedimentation plan. It has been our experience that these plans are usually very well crafted, but less well executed. We suggest that third party monitoring be made an element of the contractor's delivery order with significant penalties for non-performance. (16)

Hazardous or other unacceptable waste will be shipped off-site for disposition. The contract (new or on-going) for this activity should be let prior to publication of the final document and the pertinent points of same cited. (17)

GENERAL NOISE OBSERVATIONS

From an overall noise perspective, it appears that the SSC site is better buffered (locationally) than the MSFC test stands; hence, lower offsite noise levels are predicted. Therefore, from a noise perspective the SSC site would be the preferred site alternative for test firings. If MSFC is selected or also used for engine testing, noise mitigation is recommended. (18)

ALABAMA - MSFC/RSA Site

The maximum sound pressure levels for the MSFC test site range from 119 to 116 to 107 dB for the large-to-medium-to-small rocket engines, respectively. We appreciate that these sound pressure levels are converted to the dBA metric (97 to 96 to 94 dBA) and the Leq metric (70 to 69 to 67 Leq) on Table 12 (pg. 21). Of these, the most useful descriptor to the public is the dBA metric since it is audible to the human ear and is an instantaneous value rather than an averaged value (Leq). Instantaneous noise levels are appropriate in this case for the short-termed and intrusive (19)

("impulsive") noise associated with test firings.

The DEIS characterized these noise levels as "maximum offsite noise levels." It is unclear, however, as to what is meant by "maximum" since no distance between the source and receptor is provided, i.e., are the noise levels predicted or measured at the source, a set distance from the source (e.g., 50-100 ft), at the nearest human activity (e.g., technician work area), or the nearest sensitive receptor (e.g., residence), etc? It is also somewhat unclear as to what the actual maximum noise level would be since Table 12 lists the above 94-97 dBA range while page 25 states that "[t]he predicted maximum offsite A-weighted sound levels would be approximately 96 dBA." Presumably, the 96 dBA is the maximum level that is not only offsite but also outside the buffer zone. The FEIS should clarify this point. (20) (21)

From a noise impact perspective, levels of 94-97 dBA are quite high (particularly compared to a 46 dBA ambient noise level and that each 10 dBA incremental increase is perceived as a doubling of noise), even though test firings are short-termed. There may also be a startle-effect for affected people. Will the test firings be announced in an effort to reduce such startle-effects? Also, what is the expected duration range of the firings (190 seconds was referenced on page 21 - is this a normal, average, maximum or minimum duration)? Will firings be conducted daily, weekends, or holidays? Are any night time test firings planned? We recommend that firings are not a daily or weekend event, do not occur at night, and that they are announced in the media prior to implementation. (22) (23) (24)

MSFC is generally buffered from human residences on the southwestern side by the Wheeler National Wildlife Refuge. However, refuge wildlife may also be affected by noisy single events and experience a startle-effect. Conversely, some species may acclimate. Were any on-site studies conducted that suggest certain sensitive animals may emigrate or perhaps remain, but no longer breed in the refuge? In any case, literature studies exist for some species and should be referenced in the FEIS. (25) (26)

We note the reference to the NASA Hearing Conservation Program. This program has determined that a sound pressure level "should never exceed 140 dB" (pg. 20). Table 12 data indicate compliance with this guideline. However, some background in the FEIS on this program would be helpful to the public. Is this program independently audited, reviewed, or endorsed by agencies such as OSHA? (27)

In reference to the test firing Leq values of 70 to 69 to 67 dBA and a background of 46 dBA, page 21 states that "[t]his level is equal to or less than the 70 dB(A) Leq guideline

from the EPA (NASA, 1978)." It should be noted that this level was "identified by EPA as requisite to protect public health and safety with an adequate margin of safety" and was "based on annual averages of the daily level over a period of 40 years." As such, it is a somewhat relevant noise level in this case, but represents protection against the rather extreme measure of hearing loss over a long time period. We suggest that the FEIS provide the direct EPA citation rather than the indirect citation of a citation within the NASA reference. We suspect the EPA citation is the so-called "Levels" document (EPA, 1974). In general, however, there are no real EPA guidelines for noise, although we have documented equipment noise emissions at 50 feet, test for selected product noise compliance, and have documented outdoor noise target levels for "activity interference and annoyance" such as 55 dBA DNL (day-night level) and 55 dBA Leq for outdoor residential or public areas, respectively (EPA, 1974). It may be noted that the predicted noise levels for the MSFC in Leq (70 to 69 to 67 Leq) are above this target level. (28)

In regard to noise mitigation for MSFC (pg. 25), we note that a noise monitoring program is planned. We agree with such model verifications and suggest monitoring under various weather conditions and seasons (particularly during less attenuating conditions, viz., after leaf fall for deciduous trees). (29) Also, what buffers (topography, buildings, etc.) exist on the sides of the MSFC other than the Wheeler Refuge buffer for residences located there (e.g., Madison, AL)? (30) In addition, what pollution prevention methods could be added by the RSA to reduce noise to shield, absorb, or otherwise attenuate noise at the source? (31) How many occupied residences (i.e., number of people impacted) exist within the noise contour(s) subjected to (at least) the maximum predicted noise level for large-to-medium-to-small engines (94-97 dBA)? (32)

Editorially, we suggest that Figures 7-9 include a legend indicating that the contour noise levels are in the pressure sound level (dB) metric as opposed to the dBA metric with which the public is more familiar and is audible to the human ear. (33) While the fact that contours represent sound pressure levels is referenced in the text, we suggest the figures should also make this distinction. Moreover, we strongly recommend that comparable figures be generated for dBA contours (as was provided for the SSC site: Figs. 21-27) since the public can better relate to dBA values than to the sound pressure or Leq metric. (34)

MISSISSIPPI - SSC SITE

The above MSFC comments also generally apply to the SSC site, although offsite noise levels appear to be substantively lower. The maximum offsite noise levels for (35)

SSC (Table 18) are sound pressure levels of 106 to 103 to 96 dB for small-to-medium-to-large engines, which equates to 69 to 65 to 60 dBA and 50 to 50 to 49 Leq, respectively. It is unclear, however, as to what the ambient noise level is (i.e., "background" noise level was mentioned on page 42 but was apparently not quantified in the DEIS). It is again confusing as to what the actual predicted maximum noise level is since the DEIS text states that "[t]he maximum offsite OASPL's [offsite sound pressure levels] occur for cluster firings of 5 large engines is estimated to be 112 dB, occurring at the northwestern edge of the buffer zone at SSC." The 112 dB is much greater than the 106 dB listed in Table 18. Either the table should include cluster firing levels in the FEIS or it should be appropriately footnoted. Also, how frequent are 5-engine and other cluster firings? (36) (37) (38)

The maximum offsite noise levels for the SSC appear reasonable (69 dBA) and the Leq levels are below the EPA 55 dBA Leq target level, although a startle-effect for humans and wildlife may still be a consideration given the impulsive nature of the firings and a presumed much-lower background noise (again, this ambient level should be quantified in the FEIS). Notification in the media should still be provided for test firings and weekends, nights, etc. should be avoided. Also, the buffer area of the SSC should be characterized, i.e., is it also a wildlife area as was the case for MSFC and, if so, were any wildlife noise studies conducted? (39) (40)

As in the case of MSFC, the legend for the sound pressure level (OASPL) noise contour figures for the SSC (Figs. 14-20) should indicate that contours are in the sound pressure level metric (dB). Conversely, the subsequent figures (Figs. 21-27) depicting the A-weighted metric (dBA) are clear based on their captions. (41)

■ RESPONSES TO LETTER NO. 8 —U.S. EPA, REGION IV

1. Text on page 13 has been modified to address the comment. Construction is anticipated to be completed by September 1997 and early 1998, for treatment system and pond liner, respectively

2. Mike Wylie has been involved in the establishment of a General Permit covering SSC wetland impacts from construction activities. The General Permit Number is CELMK-OD-FE 14-GDP (Vicksburg District)-53.

3. Currently it is not anticipated that a wetland site will be chosen for the pond. However, if a wetland site is chosen, the no impact for "Wetlands/Floodplains" will be reevaluated.

4. This comment is correlating information gathered during preparation of the Environmental Impact Statement (EIS) for the Advanced Solid Rocket Motor (ASRM) with this EIS. However, the ASRM EIS considered transportation impacts associated with solid rocket motor segments, loaded with solid propellant. All test articles associated with this Program would be "unloaded" and would be fueled by tanks at the test stands. However the impact rating of "no impact" has been changed on Table C-3 (page C-21 and 22) and C-4 (page C-23 and 24), page 34 and 61 to insignificant.

5. Tables C-3 and C-4 have been revisited and text has been modified on Tables C-3 and C-4. Table C-3 changes include the significance rating for Archaeological Resources, Cultural and Historic Resources, and Transportation. Table C-4 changes include the significance rating for Air - Small Thrust (single engine), Archaeological Resources, Transportation, and Water Resources-Supply.

6. Discussion of pond liner upgrade with appropriate environmental agencies is noted and is all ready ongoing with a synthetic liner chosen and text modified on page 13 to address the comment.

7. Text modified on page 13 to address the comment. No effect on the existing subsurface drain is expected with installation of the new synthetic liner.

8. Text modified on pages 13 and 37 to address the comment. Construction projects will follow recognized regulatory practices (OSHA 29 CFR 1926.1101 and 29 CFR 1926.62 and EPA) for disturbance of lead and asbestos. Normal maintenance and cleanup of the test stands should not disturb the asbestos or lead. All onsite contractors are aware of these concerns and are familiar with asbestos and lead guidelines to minimize exposure to personnel.

9. Text modified on pages 14, 37 and 38. Page 14 changed to a 20,000 gallon (75,500 L) above ground storage tank (AST) for RP storage that meets 110 percent secondary containment per 40 CFR 112. Page 37 changed to reflect the use of up to 25,000 gallons (94,600 L) AST's that meets 110 percent secondary containment per 40 CFR 112 and the potential future use of barges, tanker trucks, and larger tanks for storage of RP.

10. Text modified on page 14 to add in the OSHA citation 29 CFR 1910.132 and referencing the Title V Air Emissions permits for MSFC and SSC and the citation for 40 CFR 63, Subpart T for handling TCE.

11. Text modified on pages 25 and 57 to address the comment. MSFC is in process of modifying the NPDES permit. The SSC permit has been modified for RP-1 testing at the test facilities.

12. Presently MDEQ does not see a need for retention. If a need does arise for a retention pond, a similar retention pond to the one constructed at B1/B2 will be constructed in adjacent land areas.

13. The text on page 37 has been modified to address the other means of storing RP–1 at the test stands. The last time that SSC tested engines using RP–1 was in the early 1970's and we have no records of spill frequency and/or degree from that time to be able to address your question specifically. However, to ready ourselves for renewed RP–1 testing at SSC, we are modifying our spill prevention procedures slightly to address the reintroduction of RP–1 onto the SSC facility. In addition to adding RP–1 to the list of potential chemical and POL releases, we are including information on tankage to address prevention requirements under 40 CFR part 112.7. Spill containment boom and other absorbent will be also located in the vicinity of any potential releases.

14. Text modified on page 38 to address the comment. SSC has upgraded or installed new UST's to meet secondary containment and spill prevention requirements with appropriate interstitial monitoring.

15. Text modified on pages 58 and C-24 to address the comment by changing the impact rating from no impact to insignificant. However, a remote sensing sampling protocol is not warranted at this time since test emissions addressed in the EIS have little potential for significant deposition outside the immediate test area.

16. Third party monitoring for erosion/sedimentation implementation has been noted and is part of MSFC's standard operating procedure. In addition, the construction contractor will also be required to obtain a greater than 5-acre (2.0 ha) storm water permit for construction.

17. Text modified on pages 14 and 38 to indicate that hazardous waste disposal at MSFC and SSC are handled by current ongoing contracts.

18. From a noise perspective, SSC being preferred is noted, and noise mitigation will be implemented as shown on page 25 for MSFC.

19. Comment that dBA is the most useful descriptor to the public is noted.

20. Text modified on page 21 to address the comment that maximum noise levels are to the closest private property.

21. Text modified on page 32 to address the comment with the 96 dBA being changed to 97 dBA.

22. Text modified on page 25 to address the comment by adding text with regards to the startle effect to people and animals and adding references to support the conclusions.

23. Unfortunately due to technical difficulties of engine testing, test firing are subject to being conducted any day or time of the week including nights and weekends. Typically test firings are planned for normal duty hours (8:00 a.m. to 4:30 p.m.), but may be conducted at any time. Releases of targeted schedules for large engine testing will be made available to the news media.

24. Unfortunately due to technical difficulties of engine testing, test firing are subject to being conducted any day or time of the week including nights and weekends. Typically test firings are planned for normal duty hours (8:00 a.m. to 4:30 p.m.), but may be conducted at any time. Releases of targeted schedules for large engine testing will be made available to the news media.

25. See response to comment 22 above.

26. See response to comment 22 above.

27. The "140 dB" is referenced to 29 CFR 1910.95 and is not referenced by the NASA Health Standard on Hearing Conservation. Text on page 20 has been modified to address the comment regarding the NASA Health Standard on Hearing Conservation.

28. Reference to EPA levels document has been deleted on page 21.

29. Concurrence with model verifications is noted.

30. Redstone Arsenal buffers MSFC on all sides. Barriers include buildings, trees, and topography (hills and elevated land).

31. Any potential pollution prevention measures to reduce noise have not been identified. Redstone Arsenal buffers MSFC on all sides. Barrier including buildings, trees, and topography already in place that will help attenuate noise.

32. None. The maximum projected dBA levels are within the boundaries of Redstone Arsenal.

33. Captions on Figures 7 through 12 and 14 through 20 have been modified to address the comment by adding either dB or dBA to the title of the figures.

34. Figures 10 through 12 provides the requested dBA noise contours.

35. Applicability of comments to SSC is noted.

36. Text modified on page 42 to address the comment regarding background noise levels at SSC (41- 45 dBA).

37. Cluster engine testing is included on Table 18 (page 42).

38. Cluster engine testing frequency will be one full duration (190 seconds) test per week maximum or several tests of short duration.

39. See comment 23 and 24 above.

40. The buffer zone at SSC provides a habitat for wildlife but the area is not managed as an official wildlife or refuge area. Startle effects for wildlife are discussed on page 32.

41. Figures 14 through 20 have been modified to address the comment by adding dBA to the title of the figures.

FACSIMILE TRANSMITTAL COVER SHEET

ENVIRONMENTAL MANAGEMENT
DIRECTORATE
5 E. Popson Bldg 2650A
Edwards AFB CA 93524-1130
TEL: (805) 277-1401 DSN: 527-1401
FAX: (805) 277-6145 DSN: 527-6145

TO: DR. R. McCALEB

COMPANY: NASA MSFC Code AE01

FAX: 205/544-8259 TEL: 205/544-4367

FROM: TIMOTHY GUEST EXT: 805/277-9023

SUBJECT: DEIS of ENGINE TECH SUPPORT for NASA's Advanced Space TRANSPORTATION System Review COMMENTS

SENDER'S COMMENTS: Following ARE AFFTC/EM Review COMMENTS ON THE SUBJECT DOCUMENT. Questions? CALL TIMOTHY GUEST @ 805/277-9023

PAGE ONE OF 4 PAGES

AFFTC/EM
ENVIRONMENTAL IMPACT ANALYSIS PROCESS (EIAP)
EDWARDS AFB, CA

EIAP DOCUMENT REVIEW COMMENTS

COMMENTS DUE BACK TO AFFTC/EM NLT: 10 Jan 97 **DATE SENT OUT:**

DOCUMENT TITLE: Draft EIS of Engine Technology Support for NASA's Advanced Space Transportation Program

PREPARED BY: NASA MSFC & SSC

DOCUMENT DATE: Nov 96

REVIEWER: AFFTC/EM Consolidated Comments

REVIEWER ORGANIZATION: TYBRIN Corp , Computer Sciences Corp.

DOCUMENT STAGE: DRAFT: X; DRAFT FINAL:

DOCUMENT TYPE: SECONDARY:; PRIMARY: X; OTHER:

DUE FOR REGULATORY REVIEW? Yes

REVIEW DATE: 2-9 Jan 96

PHONE: 805/277-1425

REF #	PG	PARA	# OF LINES FROM TOP	SPECIFIC COMMENTS / REVISIONS / REMARKS	DOC PREPARER USE ONLY APPROVED/ DISAPPROVED/ HOLD / REMARKS
(1)	1	all	n/a	RE: "Program Background, Need, and Goals." Clearly state the need and goals of the proposed action as a paragraph topic sentence (e.g., "The proposed action is needed because..."). Your proposed action is not specifically stated or readily communicated in the text.	
(2)	1	all	n/a	RE: "Purpose." Clearly state the purpose of the proposed action (e.g., "The purpose of the proposed action is..."). This is also not readily communicated in the text.	
(3)	2	1st	all	Move the "Specific Objectives as Stated in NRA 11" under "Purpose" on pg 1. Otherwise you have two paras addressing your purpose. For clarity, keep the purpose organized together in the first legally required "Purpose" section.	
(4)	2	Column 1, para 3	30	Edwards Air Force Base, selected as an alternative location for the research of potential alternative engines and components, has been excluded from public scoping meetings. A suggestion would be to state in this section the reason(s) why Edwards Air Force Base was excluded from this scoping process.	
(5)	3	6th	6th from botto m	Buried in the 2nd to last sentence of the 6th para is the decision that must be made ("where the proposed testing will occur") and the identity of the decisionmaker ("the responsibility of SCC"). Legally, the decision to be made **must be** whether or not to implement the Engine Technology Support for the Advanced Space Transportation Program, and if so, then where the testing will occur. Otherwise, you have already made your decision and violated 40 CFR 1502.2(g). Add structure to this chapter by breaking-out those legally required elements of a NEPA EIS Chapter 2.	
(6)	3	6th	10th from bottom	RE: "The environmental effects for testing I-1 and RD-170 engines." After this sentence, insert the following sentence: "A comprehensive treatment of the existing environment and environmental effects of the EAFB alternative are available in the EAFB environmental document and are not covered in this EIS."	

(7)	3	1st	1st	This page lacks a concise statement of your proposed action. Begin this chapter with a section titled "Proposed Action" and put a topic sentence in the first para stating something like "NASA proposes to implement the following actions:" Then give a bullet list of all the actions you propose to do in this project. Then add a section titled "Alternatives" and include subsections that clearly define each of your action alternatives. This section does not clearly identify any of these legally-required elements. Help the reader follow your logic by adding more structure to your discussions.	
(8)	5	all	all	RE: the sections under "Proposed Advanced Space Transportation Engines and Systems." These sections only describe engine characteristics and do not define any alternatives to the proposed action. If these are not realistic alternatives, then simply describe the engines under the Proposed Action. If these are real alternatives, then discuss how they fit into your various action alternatives.	
(9)	3-11	n/a	n/a	This chapter does not identify your agency's preferred alternative as required by 40 CFR 1502.14 (e).	
(10)	11	Column 2, para 3	10-13	"The Environmental Assessment (Air Force Flight Test Center, 1993) that EAFB prepared is for liquid-fueled rocket engine testing at Test Stand 1A." In addition, the Environmental Assessment also includes Test Stand 1A modifications, renovations, and associated testing activities for liquid-fueled rocket engine testing. The statement could read as follows: "The Environmental Assessment (Air Force Flight Test Center, 1993) that EAFB prepared is for liquid-fueled rocket engine testing and associated Test Stand 1A modification and renovation activities	
(11)	11	Column 2, para 3	12-14	"The Environmental Assessment specifically covered environmental consequences for a single large engine test." This statement is misleading in that it describes the Environmental Assessment as only addressing the environmental consequences of "a single large engine test." This Environmental Assessment covers single large engine tests and specifically discusses the F-1 and RD-170 engines. A more accurate statement could read as follows: "The Environmental Assessment specifically covered environmental consequences for single large engine test activities of the F-1 and RD-170."	
(12)	12	Table 2, Column 5	27	The comment that "Insignificant" impacts with regard to archaeological resources would occur should read as "None" per the Significance Definitions reported in Appendix C. No impacts to any archaeological resources from implementation of the Proposed Action in the Environmental Assessment would result	
(13)	12	Table 2, Column 5	31	The comment that "Insignificant" impacts with regard to groundwater resources would occur should read as "None" per the Significance Definitions reported in Appendix C. In addition, the Environmental Assessment reports the following: "Due to the high level of evaporation, depth to ground water, and subsurface clay lenses existing between the surface and the aquifer, little of the release water is expected to infiltrate to the aquifer."	
(14)	12	Table 2, Column 5	45	The comment that "Insignificant" impact with regard to population and employment should have read "Insignificant (Positive)" to reflect that the impact of the Proposed Action on area population and employment within the Antelope Valley of California would be positive. This incremental positive impact regarding EAFB socioeconomics is discussed in the Environmental Assessment.	
(15)	12	Table 2, Column 5	50	The comment that "Moderate" impacts with regard to water quality would occur should read as "Insignificant" per the Significance Definitions reported in Appendix C. Only a waiver for wastewater discharge from the Lahontan Water Quality Control Board would be required	

(16)	12	Table 2, Column 5	51	The comment "Not Addressed" regarding wetlands and flood plains impacts should read as "None." No impacts to wetlands and flood plains from implementation of the Proposed Action discussed in the Environmental Assessment would result.
(17)		Appendix B		Regulatory Agency Consultations (Appendix B should also be include) Edwards Air Force Base Edwards Air Force Base consulted with the U.S. Fish and Wildlife Service and the State Historic Preservation Office.
(18)		General Comment		It is not clearly understandable as to why sites were selected for specifically-sized engine testing. For instance, Edwards Air Force Base was not evaluated for multiple large engine or single and multiple medium and small engine testing. A statement of the reason(s) why Edwards Air Force Base was not evaluated as a separate alternative test site for testing other than single large engine testing (or why Marshall may not be able to handle multiple large engines) would make it more clearly understandable how the alternatives were developed
(19)		General Comment		It is unclear as to how many single large engine firings are to be conducted over time in the Environmental Impact Statement. The Environmental Assessment evaluated air quality impacts for 10 large engine firings over a two-year period. Kern County Air Pollution Control District (KCAPCD) has a maximum per test poundage for class pollutants which, due to an air quality exemption, would require only the proper notification of KCAPCD prior to firing activities. Proper weather/wind conditions are to be achieved prior to firing to prevent the plume from reaching off-base. If firings greater than 10 large engine firings over a two-year period are to be conducted, further air quality calculations and additional analysis may be required.

■ RESPONSES TO LETTER NO. 9—EDWARDS AIR FORCE BASE

1. The document is written for use by multiple programs. Therefore we anticipate using this EIS in the same capacity as military installations use range wide or planning EIS's.

2. See comment 1.

3. The EIS is formatted in accordance with NASA policy and procedure for NEPA compliance.

4. Text modified on page 2 to address the comment.

5. Requirements of NEPA EIS Chapter 2 have been met as the text is written. A decision has not been made but the identity of the decision maker clarified.

6. Text modified on page 3 to address the comment.

7. See comment 3.

8. Text modified on page 3 to address the comment.

9. The preferred alternative will be clarified in the Record of Decision.

10. Text modified on page 11 to address the comment.

11. Text modified on page 11 to address the comment.

12. Text modified on page 12 to address the comment.

13. Impacts to MSFC and SSC modified on page 12 to insignificant.

14. Comment noted.

15. Based on the EIS criteria of 1 full duration test and several shorter duration tests per week, the water quality area was assigned a moderate impact for EAFB.

16. Text modified on page 12 to address the comment.

17. Consultations with U.S. Fish and Wildlife Service and State Historic Preservation Office is noted but was not included here since the Edwards Air Force Base EA was referenced in Appendix D.

18. The EAFB environmental assessment was the basis for information that was included with this EIS.

19. The maximum annual quantity of testing is found on page 16.

GREATER PICAYUNE AREA CHAMBER OF COMMERCE

201 HIGHWAY 11, NORTH
PICAYUNE, MISSISSIPPI 39466
(601) 798-3122

January 8, 1997

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Attn: AEO/276--96

Dear Dr. Rebecca C. McCaleb:

The Greater Picayune Area Chamber of Commerce is in full support of the planned testing program at Stennis Space Center. The Environmental Impact Statement of Engine Technology Support for NASA's Advanced Space Transportation Program has been reviewed, and several members of the Chamber attended a public hearing on the subject in Hancock County on December 11, 1996.

In addition to the scientific advancement for space transportation, the program should have a positive economic impact on the south Mississippi area including Picayune. The Stennis Space Center has contributed to the growth of the area, and the Chamber is confident that a cooperative effort will continue to exist. The members of the Chamber look forward to working with you now and in the future. (1)

Sincerely,

Bill Edwards
President

RESPONSES TO LETTER NO. 10 —GREATER PICAYUNE AREA CHAMBER OF COMMERCE

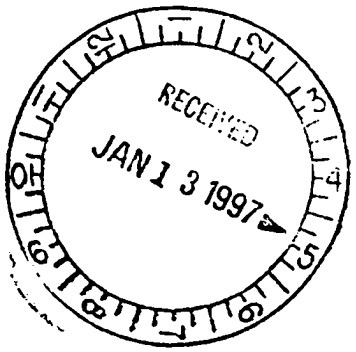
1. Comment concerning positive economic impact on south Mississippi area including Picayune is noted.

LETTER NO. 11

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Wheeler National Wildlife Refuge
Route 4, Box 250
Decatur, Alabama 35603

January 9, 1997



Dr. Rebecca C. McCaleb
Director, Environmental Engineering
and Management Office (AEDI/276-96)
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Dear Dr. McCaleb:

Thank you for the opportunity to review and comment on the Draft Environmental Impact Statement of Engine Technology Support for NASA's Advanced Space Transportation Program. The U.S. Fish and Wildlife Service (Service) has two primary concerns that are addressed below.

The first concern is the possibility of air pollutants or other contaminants affecting the adjacent Wheeler National Wildlife Refuge. A December 15, 1996 diesel fuel spill that may have entered the Refuge is cause for concern. Contaminants released onto the Refuge have negative effects on water quality and wildlife. The Refuge needs to be notified immediately of any spills that affect Refuge lands. (1)

The Service is also concerned about the noise associated with engine testing. Many species of wildlife are negatively affected by high noise levels. This is of particular concern for wintering waterfowl. The Service recommends that noise levels be kept to a minimum during winter when greatest waterfowl use occurs. (2)

The Service would like to be informed of future developments at the Marshall Space Flight Center that may affect the Refuge. Thank you for the opportunity to review and comment on the Draft Environmental Impact Statement of Engine technology Support for NASA's Advanced Space Transportation Program. (3)

Sincerely,

H. T. Stone
Refuge Manager

RESPONSES TO LETTER NO. 11—U. S. DEPARTMENT OF INTERIOR (DECATUR)

1. Comment noted. USFWS will be promptly notified in the event of a spill.

2. Comment that noise levels be kept to a minimum during the winter is noted. However, due to technical difficulties associated with rocket engine testing, test firings are subject to being conducted throughout the year.

3. The Service would like to be informed of future developments at MSFC that may affect the Refuge is noted.

LETTER NO. 12

City of Picayune
203 Goodyear Boulevard
Picayune, Mississippi 39466
(601) 798-9770 FAX 798-0564

MAYOR
Woody Spiers

CITY MANAGER
Kay Johnson

COUNCIL
Kelly L. McQueen
Leavern Guy
Harvey Smith
Serena Martin
Jonas Bates

January 9, 1997

Dr. Rebecca C. McCaleb
Director, Environmental Engineering
and Management
National Aeronautics and
Space Administration
Marshall Space Flight Center, AL 35812

Dear Dr. McCaleb:

I have received and reviewed the Draft Environmental Impact Statement of Engine Technology Support for NASA's Advanced Transportation Program. I find no reason to believe that the program would impact negatively on the City of Picayune from an environmental perspective, or otherwise. (1)

As a matter of record, I wish to offer my support for the project at the John C. Stennis Space Center. Our relationship with NASA at Stennis Space Center has always been harmonious and NASA's record of environmental responsibility at Stennis is excellent. (2)

The City of Picayune is committed to continued support of Stennis Space Center and the outstanding work being accomplished there.

Very truly yours,

Woody Spiers
Mayor

RECEIVED
JAN 14 1997

RESPONSES TO LETTER NO. 12 - CITY OF PICAYUNE

1. Comment that no negative environmental impacts is expected is noted.

2. Support for the project is noted.

Mayor:
Billy Spiers

City Clerk:
Aaron Russell

City of Poplarville
200 Highway 26 East
Poplarville, Ms 39470

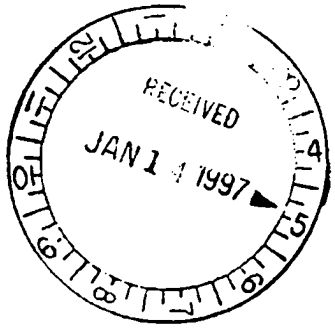
(601) 795-8161 *fax (601) 795-0141*

LETTER NO. 13

UPON REVIEW OF THE RECENT ENVIRONMENTAL IMPACT STATEMENT OF ENGINE TECHNOLOGY SUPPORT FOR NASA'S ADVANCED SPACE TRANSPORTATION PROGRAM WITH EMPHASIS ON LIQUID OXYGEN AND KEROSENE ENGINE TECHNOLOGY DEVELOPMENT - - THE CITY OF POPLARVILLE LOCATED IN PEARL RIVER COUNTY MISSISSIPPI, FULLY SUPPORTS STENNIS SPACE CENTER (SSC) IN ITS FUTURE TESTING ENDEAVORS. (1)

OUR CITY HAS ENJOYED SSC'S PUBLIC EDUCATION SUPPORT ALONG WITH OTHER WORTHWHILE BENEFITS IN ADDITION TO THE ECONOMIC BOOST IT GIVES TO THE AREA. THE MAYOR AND BOARD OF ALDERMEN ARE THANKFUL FOR THIS OPPORTUNITY TO EXPRESS THEIR SUPPORT. (2)

RESPECTFULLY,
Billy Spiers
BILLY SPIERS, MAYOR



RESPONSES TO LETTER NO. 13—CITY OF POPLARVILLE

1. Support for the project is noted.

2. Public education support along with other worthwhile benefits in addition to the economic boost is noted.

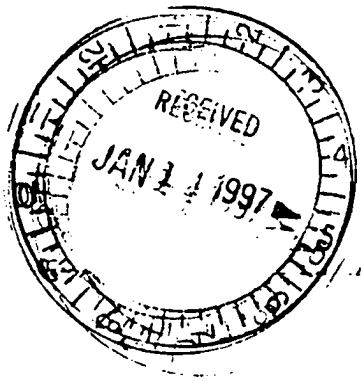
LETTER NO. 14

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

In Reply Refer To:
ER 97/14

JAN 9 1997



Dr. Rebecca C. McCaleb
Director, Environmental Engineering
and Management Office
National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 38120

Dear Dr. McCaleb:

This is in regard to the request for the Department of the Interior's comments on the draft environmental impact statement for Engine Technology Support for NASA's Advance Space Transportation Program.

This is to inform you that the Department may have comments, but will be unable to reply within the allotted time. Please consider this letter as a request for an extension of time in which to comment on the document. (1)

Our comments should be available by mid February 1997.

Sincerely,

Terence N. Martin
Team Leader, Natural Resources
Management
Office of Environmental Policy
and Compliance

■ RESPONSES TO LETTER NO. 14—U. S. DEPARTMENT OF INTERIOR (WASHINGTON D. C.)

1. Request for extension was granted. No additional comments were received.

LETTER NO. 15

DEPARTMENT OF THE ARMY
UNITED STATES ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA
35898-5000

REPLY TO
ATTENTION OF

January 9, 1997

Redstone Arsenal
Support Activity

Dr. Rebecca C. McCaleb
Director
Environmental Engineering and Management Office
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812

Dear Dr. McCaleb:

This is in response to your November 4, 1996 letter requesting our review of the Draft Environmental Impact Statement of Engine Technology Support for NASA's Advanced Space Transportation Program.

We have reviewed the subject document and found it to adequately address the environmental impacts of proposed actions at Marshall Space Flight Center. Overall, the document appears to be well written and addresses those areas where impacts are likely to occur. (1)

If we can be of any further assistance in this matter, please contact Mr. Danny Dunn, Directorate of Environmental Management and Planning, 205-955-6970.

Sincerely,

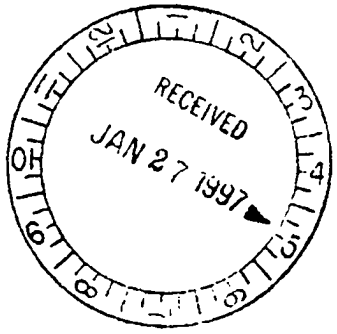
James M. Link
Major General, U.S. Army
Commanding

AN EQUAL OPPORTUNITY EMPLOYER

■ RESPONSES TO LETTER NO. 15—REDSTONE ARSENAL

1. Comment that document is well written and addresses those areas where impacts are likely to occur is noted.

Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902-1499



January 14, 1997

Dr. Rebecca McCaleb
Director, Environmental Engineering and Management Office
National Aeronautics and Space Administration
Code AE01
Marshall Space Flight Center, Alabama 35812

Dear Dr. McCaleb:

TVA staff have reviewed the Draft Environmental Impact Statement: *Engine Technology Support for NASA's Advanced Space Transportation Program With Emphasis on Liquid Oxygen and Kerosene Engine Technology Development.* We have the following comments:

1. These comments on the community/environmental noise sections of the DEIS are limited to potential response of people using TVA land or on the Tennessee River. These comments do not address impacts to the surrounding environments that are not under TVA control, such as the city of Madison. (1)

According to NASA modeling, the large engine firing at MSFC will project noise levels of 90 to 95 dBA at the Tennessee River and adjacent shoreline. Research suggests that the human startle response can be stimulated in this noise range. Short noise bursts (millisecond range) cause involuntary muscle reaction in humans. This usually stops within a couple of seconds upon recognition of the noise. If the startling noise lasts several seconds and is not recognized, then a period of disorientation or bewilderment occurs causing apprehension. If the noise continues and is still not recognized, then a reactionary or defensive period begins and people do something, such as investigate or retreat. (2)

The rocket engine testing will last long enough to potentially cause some recreational users of TVA land or the river to enter the reactionary or defensive mode of response. It would be highly speculative to try to predict (with certainty) the response of these potentially startled people. The range of responses probably would be from do nothing to rapidly leave the impacted area. Some assessment of human impacts and impacts to recreation activities such as hunting, fishing, boating, and wildlife observation would be appropriate in this EIS. (3)

NASA's assumption of insignificant impact would be reasonable if the people in the impacted area are aware of the possible noise bursts and their origin. The people (4)

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would still be startled, but they would recognize the noise and probably not respond adversely. NASA might want to consider some public notification and awareness plan as mitigation for this project if it is conducted at MSFC.

2. Literature should be cited to support the conclusion (see Operational Impacts on page 32) that noise impacts to nearby wildlife are projected to be insignificant. There may also be seasonally dependent wildlife impacts during nesting or mating periods. Also, resuming rocket engine test programs that may have had unknown impacts in the past should not be used as a basis for concluding there are no additional impacts from the proposed program. The proposed program may cause resumption of adverse environmental effects or an increase of cumulative impacts. (5)

3. The mitigation commitment (see page 25) to establish a noise-monitoring program to determine "actual noise levels at various locations" should be more specific. Sensitive receptors or resources (human, wildlife, and property) should have already been identified as part of analyzing the affected environment. The noise-monitoring program could be linked to protection of these specific receptors and resources. (6)

4. The following comments concern air quality:

Page 15 - Air Quality - Affected Environment

There are some inconsistencies, potential errors and omissions in the text:

One of the criteria pollutants that is omitted from consideration is ozone. Nitrogen oxides (NO_X) is a precursor pollutant as are volatile organic compounds (VOC). This process emits NO_X and theoretically could have an impact on ozone production. (From the Consequences section, the NO_X emissions are minor). There should be a discussion or at least documentation of the existing ambient ozone levels in this section. In addition, any VOC emissions should also be addressed because of their potential contribution to ozone production. (7)

A statement that Huntsville area is in attainment for all criteria pollutants would be of benefit to this section, for documentation purposes. (8)

Table 3 should contain ozone and lead as documentation of levels for all criteria pollutants. In addition, the secondary standard for SO_2 (3-hr average of 1300 $\mu g/m^3$) should also be included. (9)

In paragraph 2, there is a discussion of NO_X as a contributor to acid rain. There should also be a reference to NO_X as a contributor to ambient ozone. (10)

The third paragraph is rather confusing. The guidelines discussed are the state guidelines for hazardous air pollutants (HAP), not all other pollutants besides criteria pollutants. This needs to be clarified early in the paragraph. (11)

The fourth paragraph begins with "In addition to these Title V regulations...". This is inaccurate as Title V deals with operating permits that comply with Clean Air Act requirements. The rest of the sentence is also confusing. The promulgation of standards for HAP is taking place by source category. EPA has set Maximum Achievable Control Technology (MACT) standards for HAP for some categories of industry, and will continue to set MACT standards for others through the year 2000. (12)

The statement, "major sources must address reasonably achievable control technologies (RACT)" pertains to industry located in nonattainment areas. Since Huntsville meets National Ambient Air Quality Standards (NAAQS) for all criteria pollutants, there should be no requirement for RACT. For a PSD permit application, there is a requirement to consider Best Available Control Technology (BACT) for pollutants exceeding an emission threshold. (13)

Operational Impacts

The only pollutants addressed are the criteria pollutants and ozone depleting substances. Emissions of HAP are not addressed in this section, although some of the ozone depleting substances are on the HAP list. There should be a discussion of the HAP emissions from the testing. (14)

Stennis Space Center (SSC)

We did not review in detail the SSC alternative. However, we would like to point out one thing. Mississippi has not adopted a different set of standards for SO_2. No state may adopt a more stringent standard than the NAAQS, and both the annual and 24-hr standard cited in the DEIS are below NAAQS levels. (15)

Please call me at 423-632-3012 or e-mail me at jmloney@tva.gov should you have any questions concerning TVA's comments.

Sincerely,

Jon M. Loney

Jon M. Loney, Manager
Environmental Management

■ RESPONSES TO LETTER NO. 16—TENNESSEE VALLEY AUTHORITY

1. TVA comments only address people using TVA land or on the Tennessee River is noted.

2. Text modified on page 32 to address the comment by adding text with regards to startle effect to people and animals and adding references to support the conclusions.

3. See comment 2.

4. See comment 2.

5. See comment 2.

6. The noise projection program will be established for determining if meterological conditions would be favorable to produce elevated sound levels at unanticipated areas due to focusing. Noise attentuation under normal conditions modeled under this EIS are not projected to be of concern.

7. Text modified on pages 19 and 41 to address comment.

8. Text modified on page 15 to address the comment.

9. Text modified on pages 19 and 41 to address the comment.

10. Text modified on page 15 to address comment.

11. Text modified on page 15 to address comment.

12. Text modified on page 15 and 16 to address comment.

13. Text modified on page 15 to address comment.

14. None of the emissions from engine testing are on the HAP list. However, HAP emissions that may occur from routine maintenance is addressed on page 19.

15. Mississippi Regulation APC-S-4 does have a more stringent air quality standard for SO2. States must meet as a minimum the NAAQS, but are allowed to have more stringent standards.

LETTER NO. 17

RECEIVED
DEC 17 1996
SSC ENVIRONMENTAL

December 11. 1996

Draft Environmental Impact Statement of Engine Technology

Support for NASA's Advanced Space Transportation Program

(Public Hearing)

Is this the continuance of the EIS process from the December 13, 1994 Public Scoping Meeting for NASA's Advanced Propulsion Technology Program? I understand the answer to this question to be yes. (1)

The ASRM EIS was over 3 times the amount of information and the same person who was responsible for the development of the ASRM EIS appears to be responsible for this draft EIS. In the Executive Summary of the Draft EIS of Engine Technology, it was stated, "A comprehensive evaluation of environmental impacts associated with the alternatives was conducted. **No significant environmental impacts are expected to result from any of the proposed alternatives at Marshall or Stennis except for ..."** A similar statement was made in the ASRM EIS. We all know what a mess that was. At least we have a multi billion dollar monument test stand to the deceased ASRM program.

Why is there less material covered in this EIS than in the ASRM EIS when you are dealing with a number of different engines as compared to only one ASRM engine? (2)

In the Draft Environmental Impact Statement of Engine Technology under the heading of **Stennis Space Center** and subheading of **B1/B2, A-1, and A-2 Test Stands**, it was stated that SSC was designed with a radius of 5 to 7 miles including the acoustical buffer zone to reduce the impact of engine testing noise on the public. In the **Potential Environmental Effects—Stennis Space Center** section of the Draft EIS under the heading **Operational Impacts**, it was stated that these test facilities were originally designed and built to operate in the same manner proposed in this program. Previous testing included firing similar or identical engines of equivalent or greater thrust capabilities for comparable durations. Therefore, there will be no operational impacts to the test facilities or surrounding buildings.

How is one going to make a decision on the validity of this EIS without knowing what the original design criteria was for the test stands or the buffer zone in question? I would like to see this in the final EIS. What is the original decibel rating for the fee area as well as the buffer zone? How can it be concluded that there be no operational impacts to surrounding structures (3) (4)

when there is no past experiences on the newer structures that were built after the Apollo program?

In the Executive Summary of the Draft EIS of Engine Technology, it was stated, "The Engine Technology Support for the Advanced Space Transportation Program is proposed by the National Aeronautics and Space Administration to meet the technical and programmatic challenges of the development of future Reusable Launch Vehicles (RLVs). This proposed propulsion initiative is a lead element necessary **to reduce development risk** and **overall program cost** from research through development and operation of the selected propulsion systems. How is this going to reduce development risk and cost? Why is there no consideration for sound suppression equipment or anti noise devices? In the early stages of the Apollo program, MSFC investigated sound suppression possibilities and noted it was economically feesable to reduce the noise levels at the source by 20 decibels. To put it simply, there is just not enough information in this draft EIS to make a proper evaluation. (5) (6)

Why is this EIS so hard to believe?

In order for us to be in a position of understanding of what that really means, one must do a tremendous amount of research. I mean for instance, after the Apollo program, NASA proposed an ambitious program: a space station in orbit, launched using the Saturn V and eventually housing 100 people; a space shuttle to go back and forth to it from earth; and a space tug to go from the station to a base on the moon. That was back in the early 1970s. The only thing to survive that proposal was a stripped down version of the shuttle you fly today.

According to the February 1992 issue of the Florida Trend it was stated that the shuttle was to fly 60 flights a year. It would offer cargo space at $300-a-pound to orbit and a weekly Monday morning launch, just like hopping on a DC-3 jet airliner. The shuttle managed only 44 flights in its first 10 years at a cost of $10,000-a-pound to orbit at a cost of $500 million per launch. In terms of mission it was conceived to do, well lets say it was just a proposal, it really don't mean anything or did it? The article went on to say, "**By NASA's own estimates, there is a 1-in-78 chance of losing a space shuttle**. If they launch 8 shuttles a year – the base schedule through the year 2000 –- there will be another major shuttle accident before the end of the decade." **So if those projections are correct, then we will have another major catastrophe in the next 4 years** and I wonder if NASA will survive at all.

Anticipation of this happening is evident through the hype about life on MARs. I mean that it is hard to swallow that a **rock from MARs containing fossilized life forms was blown out to space by a meteorite and wound up on earth over millions of years ago and then recently NASA scientist happen to find this very same rock sitting on top of the snow**. I mean when

the government can't find out what happen to a jumbo jet airliner that blew up just off the coast line that happened recently...? Really gentlemen, don't you think this is a little desperate.

Consider the Hubble Telescope. Its original price to congress in 1973 was $300 million. Its actual cost at delivery was $2.1 billion. Hubble was originally schedule for a shuttle flight, December 20, 1983. It was launched April 24, 1990 and immediate need of repairs.

Also we need to consider the space station as announced by then President Ronald Regan in 1984. It would be a research lab, manufacturing facility, permanent observatory, space transportation hub, pressurizes spacecraft and satellite repair depot, spacecraft assembly facility, fuel storage area and staging point for a moon base and a Mars mission. NASA insisted the price for this would be $8 billion. NASA has already spent $8 billion on this space station and where is it?

In NASA Legislative Affairs "Month in Review", (House of Representatives - June 26, 1996), an amendment offered by Congressman Roemer of Indiana was introduced. Mr. Roemer stated, " the space station was first designed in 1984 to cost $8 billion. My colleagues might ask me, how much is that space station today? GAO estimates about $90 billion -- $8 billion to $90 billion, and we are trying to balance the budget in the next 6 years.

Maybe one might say we are getting great science out of the space station. No, the scientific objectives on the space station have gone from platforms to study the environmental problems on earth, platforms to study space, and a docking station to repair broken satellites. It can not do any of that anymore. Now all it can do is help us study the gravitational effects of men and women in space. For $90 billion? ...".
So, I ask you, why should we trust you on this EIS or any other?

One thing is for sure, if you test Kerosene engines here, we will see a further degradation to our environment. We already suffer a degradation to our environment from chemical and power plants as well as car emissions coming from Louisiana.

In the Socioeconomic section of this EIS under Construction & Operational Impacts it was stated, "No impacts on population and employment are expected for performing the modifications to the test stands. ... the net effect would most likely produce no noticeable difference in total employment numbers at SSC and would be within the SSC infrastructure support capability. Therefore, the impact is insignificant.

So, what is the benefit to Hancock County? (7)

In the **Strategic Outlook for NASA** as posted on the Internet by Mr. Daniel Goldin, NASA Administrator, Washington DC and the **NASA Strategic Plan - Vision, Mission and Goals**, these reports talked about how NASA will contribute to a better life here on earth.

I ask how is NASA going to help Hancock County? By controlling over one third of its land base? By forcing families out of there homes and taking their land? (8)

I think it is time for NASA to live up to its share of the bargain.

In a November 23, 1994 congressional report, it was stated that NASA is rewarding contractors with undeserved bonuses, excessive profits and millions of dollars worth of computers and other equipment. For once in your existence here in Hancock County, Reward us.

I am not asking you to give us your supercomputers, but to work with us. Help us come into the 21st century. Work with the Board of Supervisors, the Chancery Clerk and the Tax Assessor. Provide them with the technology and technical assistance to automate local government operations and train our people. Do for us as you have done for Huntsville.

In the report titled, "Progress Continues on Supercomputing Consolidation Effort" it was stated that it is projected that the Agency could meet its future production supercomputing needs with only a modest investment in both supercomputers and mass storage technology. In the report titled, "Archival Storage Systems Experience for High Speed Computing" it was stated that each panel member will provide their software and hardware solutions and cost for three proposed archive requirements (5 TB, 125 TB, and 1000 TB).

Since NASA has been working some with the tax assessor's office, you should have some idea how Hancock County lacks in automated archival storage and retrieval systems. If that is not enough, check out the chancery clerk's office on how court and land records are handled. NASA is well known for its development of software capabilities. I do not understand how it is that a county with a facility that has such technical capability, that we are so far behind the times. Do to this lack of technical capabilities, the county government does not function as well as it could, business moves slowly. It is cost prohibitive for the County to go to private enterprise to remedy this situation when private enterprise is looking to make a profit, thereby providing software that will always need to be upgraded more than it should. If NASA wants to be a good neighbor, than why not share with us your technology and help train our people more than you have in the past. After all, NASA has been here a long time and I would like to see you here for a long time more.

Joey Manners
207 Keller Ave
Bay St Louis MS 39520 [illegible]

RESPONSES TO LETTER NO. 17—JOEY MANIERI

1. The answer is "yes".

2. The ASRM EIS covered both construction and operation of a manufacturing plant at three locations as well as testing at two locations. In addition, a supplemental EIS was issued to address a large wetland impact potential as well as establish the basis for appropriate proposed exposure levels for hydrogen chloride which did not have a short-term public exposure limit established by regulation.

3. In the context of this EIS, the buffer zone was found to be adequate to mitigate noise levels from the proposed testing. The EIS for siting the SSME testing at SSC (NASA/MSFC, 1972) notes that the test facility (which includes the buffer zone) was designed as a proving ground for the Saturn V Launch Vehicle stages and engines.

4. Structures at SSC are designed to meet the potential vibrations that could result from testing.

5. New propulsion technology, materials, and systems have the potential to be far more efficient and robust and require significantly less maintenance and refurbishment. All new systems require testing to verify targeted specifications.

6. The best engineering and conventional practices that are used today in the United States to mitigate for large noise sources associated with rocket engine testing all involve the use of appropriate acoustical buffer zones.

7. This testing activity will meet the needs of NASA in the implementation of its future programs and in so doing continues to provide a foundation for aerospace work force at SSC.

8. Comments noted.

LETTER NO. 18

The following are question and concerns that Mr. Frank Egger of the Informer News at 309A. Airport Road, Picayune, MS 39466 has:

(1) The overflying of the test facility how high?

(2) Certain time no overflight allowed?

(3) Static electricity from test firings have impact on radios at airport?

(4) Written copy of agreement between NASA to City of Picayune giving them permission to build test flight center.

RESPONSES TO LETTER NO. 18—FRANK EGER OF THE INFORMER NEWS

1. The National Aeronautics and Space Administration (NASA) located at the John C. Stennis Space Center (SSC) has a Joint Letter of Procedure with the Federal Aviation Administration (FAA) for Restricted Air Space R-4403. This is an area approximately 2 miles by 3 miles up to 5,000 feet. This area includes the SSME containing its 3 test stands.

2. Approximately one hour before an engine test contact is made with the Gulfport Air Traffic control Tower to restrict the area. Approximately one hour after the test the Tower is contacted and the area is released.

3. SSC is not aware of any interference with any radio traffic due to an engine test or received complaints about static electricity.

4. SSC does not have any records regarding an agreement between the City of Picayune and NASA concerning the building of the Test Flight Center.

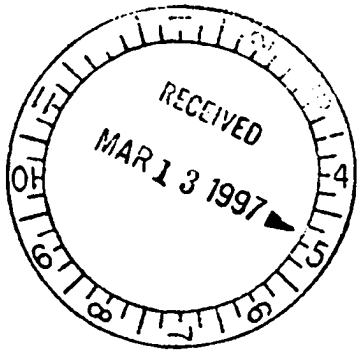
LETTER NO. 19

ALABAMA DEPARTMENT OF TRANSPORTATION
1409 Coliseum Boulevard, Montgomery, Alabama 36130-3050
Telephone: 334/242-6311 - Fax No.: 334/262-8041

Fob James, Jr.
Governor

Jimmy Butts
Transportation Director

March 3, 1997



Dr. Rebecca C. McCaleb
Director, Environmental Engineering
and Management Office
Code AEO1
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Dear Dr. McCaleb:

RE: DEIS of Engine Technology Support for NASA's
Advance Space Transportation Program

Governor James asked that I personally respond to your letter to him dated November 4, 1996. We have reviewed the Draft Environmental Impact Statement for this project. It appears it would not have any adverse affect on any of our existing or proposed transportation facilities. (1)

We appreciate the chance to comment on this important project. Please feel free to contact me or my staff if you need any additional information.

Yours very truly,

Jimmy Butts
Transportation Director

JB:DTA:cmf

c: Governor Fob James (#35688)
File

Appendix B—Regulatory Agency Consultations

Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902-1499

January 26, 1995

Dr. Rebecca C. McCaleb, Director
Environmental Engineering and Management Office
Code AE01
Marshall Space Flight Center, Alabama 35812

Dear Dr. McCaleb:

NOTICE OF INTENT (NOI) TO PREPARE AN ENVIRONMENTAL IMPACT STATEMENT FOR THE ADVANCED PROPULSION TECHNOLOGY PROGRAM

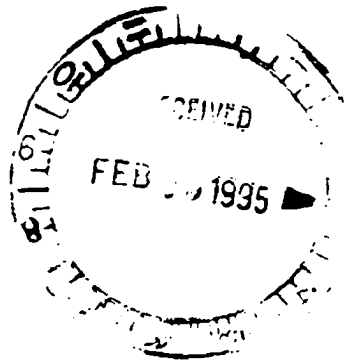
Thank you for sending the NOI and informational package on NASA's Advanced Propulsion Technology Program. TVA has an interest in this project, since it may affect TVA lands and waters, and wishes to be kept informed of future environmental documents. Please send these materials to:

Dale V. Wilhelm
Tennessee Valley Authority
WT 8C-K
400 West Summit Hill Drive
Knoxville, Tennessee 37902

Should you have any questions, please call me at (615) 632-NEPA (6372).

Sincerely,

Dale V. Wilhelm, Liaison
National Environmental Policy Act
Environmental Management



United States Department of the Interior

FISH AND WILDLIFE SERVICE
P.O. Drawer 1190
Daphne, AL 36526

December 15, 1994

Mr. J. A. Bethay
Associate Director
National Aeronautics and Space Administration
George C. Marshall Flight Center
Marshall Space Flight Center, AL 35812

In reply refer to:
Log No. 4-3-95-060C

Dear Mr. Bethay:

Thank you for your letter of November 29, 1994 requesting comments on the Notice of Intent to prepare an environmental impact statement for NASA's Advanced Propulsion Technology Program being considered for the George C. Marshall Space Flight Center, Huntsville, Madison County, Alabama, and the John C. Stennis Space Center, Bay St. Louis, Hancock County, Mississippi. We have reviewed the information you enclosed and provide the following comments in accordance with the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. et seq.) and the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.).

A. Fish and Wildlife Coordination Act

We do not expect the proposed action to result in significant adverse impacts to nonendangered fish and wildlife resources provided the best management practices are implemented, as appropriate, during program development and operation to control sedimentation and protect the water quality of adjacent wetland and aquatic habitats, including ground waters.

B. Endangered Species Act

We have determined that the following Federally listed species may occur within the Marshall Space Flight Center, Madison County, Alabama:

1. Alabama cave shrimp (Palaemonias alabamae), E

We have determined that the following Federally listed species may occur within the John C. Stennis Space Center, Hancock County, Mississippi:

1. Louisiana black bear (Ursus americana luteolus), T
2. Bald eagle (Haliaeetus leucocephalus), E

3. Red-cockaded woodpecker (Picoides borealis), E

4. Gopher tortoise (Gopherus polyphemus), T

5. Ringed sawback turtle (Graptemys oculifera), T

6. Eastern indigo snake (Drymarchon corais couperi),T

7. Gulf sturgeon (Aciperser oxyrhynchus desotoi), T

The above habitats and Federally listed species should be fully considered in the development of your environmental impact statement for the proposed program. If you have any questions or need additional information, please contact Mr. Carl Couret at (205) 441-5181.

Sincerely,

Larry E. Goldman
Field Supervisor

STATE OF ALABAMA
ALABAMA HISTORICAL COMMISSION
468 South Perry Street
MONTGOMERY, ALABAMA 36130-0900

F. LAWERENCE OAKS
EXECUTIVE DIRECTOR

TELEPHONE NUMBER
242-3184

April 20, 1995

Mr. B.R. McCullar
Facilities Office
G.C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Re: AHC# 95-0898, EA NASA Propulsion Technology Prog.
Marshall Space Flight Center
Madison County, AL

Dear Mr. McCullar:

Upon review of the proposed project, the Alabama Historical Commission has determined the following. It is our understanding from the submitted information that little, if any, ground disturbance will be involved in this project. It is also our understanding that no major modifications or renovations to structures potentially eligible for the National Register of Historic Places will occur in conjunction this program. Under these circumstances it is our opinion that the program will have no effect on any NR eligible properties. However, should there ever be a need to affect either a building, structure or archaeological site not currently evaluated for NR potential the cultural resource staff at Redstaone Arsenal should initiate further discussions with our staff.

Therefore, we concur with the proposed project activities. Should you have any questions or comments, please contact Ms. Lee Luis of our office.

Sincerely,

F. Lawerence Oaks
State Historic Preservation Officer

FLO/LAL/gtj

Rec'd: MAY 0 3 1995
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NC

National Aeronautics and
Space Administration
John C. Stennis Space Center
Stennis Space Center, MS 39529-6000

MAY 26 1995
5-187-95

Reply to Attn of GA00

May 24, 1995

Mr. Elbert Hilliard
Mississippi State Historic
Preservation Officer
Attention: Mr. Roger Walker
Interagency Coordinator
Department of Archives and History
P. O. Box 571
Jackson, Mississippi 39205-0571

Dear Mr. Hilliard:

The John C. Stennis Space Center is preparing an Environmental Impact Statement (EIS) jointly with the George C. Marshall Space Flight Center for a proposed rocket testing program that utilizes liquid oxygen and a kerosene based rocket propellant called RP-1 as part of the next generation of Advanced Propulsion Programs. The EIS is being prepared to meet the requirements of the National Environmental Policy Act. A description of the program is provided as an enclosure.

The project will be conducted on our three historic landmark test stands, A1, A2, and B1/B2. The project will not alter the primary function, architecture, or structure of the test positions. In fact, the project will preserve and possibly enhance the character and physical attributes of the facility. Soil disturbance during construction will be minor and will be in the rocket testing area of our facility. If soil disturbance occurs, it would be in areas previously determined by a US Army Corps of Engineers reconnaissance to have no evidence of prehistoric or aboriginal sites as documented in our recently submitted and approved Historic Preservation Plan.

We are therefore requesting your comments on this project and/or your concurrence for incorporation in the EIS process. If you have any questions, please contact me at 601-688-7384.

Sincerely,

Ronald G. Magee

Ronald G. Magee
Environmental Officer

Enclosure

Concurrence: _____ 5.30.95
Mr. Elbert Hilliard
Mississippi State Historic Preservation Officer
Date

United States Department of the Interior

FISH AND WILDLIFE SERVICE

P.O. Drawer 1190
Daphne, AL 36526

April 21, 1994

Mr. Gregory Burns, Environmental Engineer
Environmental Engineering and Management Office
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812

In Reply Refer To:
Log No. 4-3-94-149S

Dear Mr. Burns:

This responds to your letter of April 6, 1994 concerning a proposal to test liquid oxygen and kerosene fueled rocket propulsion systems using the existing facilities at the Marshall Space Flight Center, Marshall County, Alabama. We have reviewed the information you enclosed and have the following comments in accordance with the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.).

According to our records, the following federally endangered (E) aquatic species may be located in that portion of the Tennessee River just south of Marshall Space Flight Center:

pink mucket pearly mussel, Lampsilis abrupta
orange-footed pimpleback mussel, Plethobasus cooperianus
rough pigtoe mussel, Pleurobema plenum

These species are extremely sensitive to siltation, contaminants and destruction of habitat. To prevent adverse impacts to these species during testing, we recommend avoiding drainage of testing-related chemicals such as unburned kerosene into the Tennessee River or its tributaries.

The Alabama caveshrimp, Palaemonias alabamae, is known to be located in four caves adjacent to the MSFC, as described below:

1) **Arrowwood Cave:** located west of the northwest border of Redstone Arsenal and west of Zierdt Road approximately 1 mile south of Interstate 565.

2) **Bobcat Cave:** located in the west-central part of Redstone Arsenal, approximately 0.2 miles east of Zierdt Road on the western boundary of the Arsenal.

3) **Matthews Cave:** located in extreme north-central part of Redstone Arsenal and extends under the north boundary of the Arsenal, underneath I-565 and Alabama Highway 20.

4) **Shelta Cave:** located in northwest Huntsville at the intersection of Cave Avenue and Pulaski Pike approximately 2.2 miles northwest of the County Courthouse and Big Spring in downtown Huntsville.

While none of these caves are located within the boundaries of MFSC, it should be noted that any groundwater contamination from the proposed testing may enter these caves and adversely affect the caveshrimp. Furthermore, there may be additional caves containing this species located within the boundaries of MFSC. Therefore, we recommend preventing all chemical by-products from the proposed testing from entering any caves or groundwater, as well as any physical disturbance to these caves or immediate surroundings. Since this project is in the early planning stages, methods for preventing physical disturbance or chemical effluent from this project should be developed.

Please contact this office if the above recommendations cannot be met so we may work with your office in developing preventive measures in avoiding adverse impacts to the above listed species.

For more information regarding this matter, please contact Sharon Delchamps of our office at 205-441-5181.

Sincerely,

Larry E. Goldman
Field Supervisor

Appendix C—Significance Definitions and Summaries

List of Tables

TABLE C–1.—*Criteria for rating impacts* C–1

TABLE C–2.—*Significance definitions for MSFC and SSC index* C–2

TABLE C–3.—*MSFC significance definitions summary* C–21

TABLE C–4.—*SSC significance definitions summary* C–23

TABLE C–1.—*Criteria for rating impacts*

Impact Rating	Magnitude	Level of Impact		
		Duration	Extent	Likelihood
Significant	Major	Any term	Large or medium	Probable
	Major	Long term	Large or medium	Possible
Moderately Significant	Major	Medium, intermittent, or short term	Any level	Possible
	Major	Any term	Large	Unlikely
	Major	Long term	Medium or small	Unlikely
	Major	Medium, intermittent, or short term	Medium or small	Unlikely
	Major	Any term	Small	Probable
	Major	Long term	Small	Probable
	Moderate	Any term	Large	Possible
	Moderate	Any term	Large or medium	Probable
	Moderate	Any term	Medium or small	Possible
	Moderate	Any term	Small	Probable
	Minor	Any term	Large	Probable
	Minor	Long term	Medium or small	Probable
	Enhance	Long term	Any level	Probable
Insignificant	Moderate to minor	Any term	Any level	Unlikely
	Minor	Any term	Large	Possible
	Minor	Long term	Medium or small	Possible
	Minor	Medium, intermittent, or short term	Medium or small	Possible
	Minor	Medium, intermittent, or short term	Medium	Probable
	Minor	Short term	Medium	Probable
	Minor	Medium, intermittent, or short term	Small	Probable

Note: If an area of consideration is found not to be affected by this project, a rating of "no impact" will be noted.

TABLE C–2.—*Significance definitions for MSFC and SSC Index*

Discipline

Air C–3

Archaeological Resources C–4

Biota: Wildlife and Vegetation C–5

Cultural and Historical Resources C–6

Facilities and Infrastructure C–7

Hazardous Substances C–8

Land Use C–9
- Agriculture and Recreation Restrictions

Noise C–10

Oil Products Storage and Use C–11

Public and Employee Health and Safety C–12

Socioeconomics C–13

Threatened and Endangered Species C–14

Transportation—Accident Potential C–15
- Environmental Damage
- Human Health
- Property Damage

Transportation C–16
- Rail/Waterway Network Effects

Waste Generation and Treatment C–17

Water Quality—Receiving Water Quality C–18
- Groundwater
- Surface Water

Water Resources—Supply C–19

Wetlands and Floodplains C–20

Significance Definitions

■ Discipline—Air

Term	Definition
Magnitude	
Major	Impacts that could cause harm or damage to humans, wildlife, wilderness, or animals
Moderate	Annoying, but not damaging or harmful to humans, plants, or animals
Minor	Not damaging or harmful to humans, plants, or animals
Duration	
Long term	A continuous event of 1 day or greater every month for the project duration
Intermittent	An event lasting on the order of a work shift (8 hours or less) every month for the project duration
Short term	Impact lasting less than 15 continuous minutes a day during the life of the project
Extent	
Large	Regional area extending away from the site and its surrounding buffer
Medium	Beyond the public boundary of the facility site with limited exposure to the public
Small	Impact less than regulatory significance increases and air quality maintained on- and offsite
Likelihood	
Probable	Occurs under typical operating conditions
Possible	Occurs under worst-case operating conditions
Unlikely	Occurs under upset/malfunction conditions

Significance Definitions

■ Discipline—Archaeological Resources

Term	Definition
Magnitude	
Major	Project will unearth and/or destroy one or more previously unidentified archeological sites, and mitigation of the adverse effects is unsuccessful
Moderate	Project will unearth and/or alter one or more previously unidentified archeological sites, and mitigation of the adverse effects is partially successful
Minor	Project will unearth and/or alter one or more known archeological sites, and mitigation of the adverse effects is successful
None	Project will not disturb, alter, or affect any archeological sites
Duration	
Long-term	More than 2 years
Medium-term	Between 6 months and 2 years
Short-term	6 months or less
Extent	
Extra-large	2 or more archeological sites require complete relocation
Large	1 archeological site requires complete relocation
Medium	1 or more archeological sites require over 50-percent relocation each
Small	1 or more archeological sites require between 10- and 50-percent relocation each
Extra-small	1 or more archeological sites require less than 10-percent relocation each
None	No archeological sites require relocation or any special long-term care and/or maintenance
Likelihood	
Probably	Occurs during site or structures modifications or remediation
Possible	Previously unknown archeological site is discovered during site or structures modifications or remediation
Unlikely	Occurs under anomaly conditions

Significance Definitions

■ Discipline—Biota: Wildlife and Vegetation

Term	Aquatic Resources Definition	Terrestrial Ecology Definition
Magnitude		
Major	Greater than 25-percent change in important commercial,recreational, game, or similar aquatic resources	Loss of any commercial, recreational, game, or similar terrestrial species
Moderate	Between 10- and 25-percent change in important commercial, recreational, game or similar aquatic resources	Loss of any sensitive species or habitats; loss or degradation of any unusual plant communities
Minor	Less than 10-percent change with little to no observable effect on current profile of aquatic organisms	Less than 10-percent loss or degradation of undisturbed vegetation or habitat in affected areas
Duration		
Long-term	Greater than 1 year or during critical periods	
Medium-term	Intermittent or limited from 1 month to a year	
Short-term	Less than 1 month	
Extent		
Large	National, state, regional	Greater than 25 percent of regional resources
Medium	Site and immediate environs	Between 2 and 5 percent of regional resources
Small	10 percent of site or available resources	Less than 2 percent of regional resources
Likelihood		
Probable	Occurs under typical operating conditions	
Possible	Occurs under worst-case operating conditions	
Unlikely	Occurs under upset/malfunction conditions	

Significance Definitions

■ Discipline—Cultural and Historical Resources

Term	Definition
Magnitude	
Major	Project will destroy or alter all or part of a structure or site such that it is no longer recognizable for its historically significant purpose that made it eligible for listing on the National Register of Historic Places or World Heritage List.
Moderate	Project will adversely affect a site or structure that is eligible for listing on the National Register of Historic Places or World Heritage List, and mitigation of adverse effects is partially successful.
Minor	Project will adversely affect a site or structure that is eligible for listing on the National Register of Historic Places or World Heritage List, and mitigation of adverse effects is successful.
None	Project will not involve any structure or site currently listed on or likely to be eligible for listing on the National Register of Historic Places or World Heritage List.
Enhance	Project will increase the historical significance of the structure or site such that its potential for future eligibility for inclusion to the National Register of Historic Places or the World Heritage List may be increased.
Duration	
Long-term	More than 5 years with permanent changes
Medium-term	Between 1 and 5 years with limited or intermittent changes
Short-term	Less than 1 year
Extent	
Large	More than 50 percent of the historical or cultural site or structures will be affected.
Medium	Between 25 and 50 percent of the total historical or cultural site or structures will be affected with the largest single affected area to be not greater than 25 percent.
Small	A total of not more than 25 percent of the historical or cultural site or structures will be affected with the largest single affected area to be not greater than 10 percent.
None	Less than 5 percent total of the historical or cultural site or structures will be affected.
Likelihood	
Probable	Occurs during site or structures modifications or remediation
Possible	Occurs during unusual operating conditions
Unlikely	Occurs under anomaly conditions

Significance Definitions

■ Discipline—Facilities and Infrastructure

	Aquatic Resources	Terrestrial Ecology
Term	**Definition**	**Definition**
Magnitude		
Major	Construction or addition of major new facilities or services	
Moderate	Expansion of existing facilities	Expansion of existing facilities or services
Minor	Increase level of usage of existing facilities	
Duration		
Long-term	Project life more than 20 years	More than 3 years exceeding capacities (operational period)
Medium-term	Project life between 5 and 20 years	From 1 to 3 years exceeding capacities (equivalent to construction period)
Short-term	Project life less than 5 years	Less than 1 year exceeding capacities (temporary facilities/services may be necessary)
Extent		
Large	National, state, or regional	
Medium	Entire study area	
Small	Part of study area	
Likelihood		
Probable	Greater than 50-percent chance of occurrence	
Possible	From 5- to 50-percent chance of occurrence	
Unlikely	Less than 5-percent chance of occurrence	

Significance Definitions

■ Discipline—Hazardous Substances

Term	Definition
Magnitude	
Major	Total quantity of one or more hazardous substance(s) meets the threshold quantity/quantities under CERCLA Toxic Release Inventory reporting, or total cryogenic propellant or hypergol quantities exceed existing capacity and handling.
Moderate	Total quantity of one or more hazardous substance(s) meets the reportable quantity/quantities under CERCLA Hazardous Chemical Inventory requirements, or total cryogenic propellant or hypergol quantities saturate but do not exceed existing capacity.
Minor	Total quantity/quantities of one or more hazardous substance(s) does not meet any reporting quantity; use of cryogenic propellants or hypergol does not impact existing infrastructure or exceed current test requirements.
Duration	
Long-Term	Requirements exist throughout life of project (greater than 2 years)
Intermittent	Requirements exist for approximately 2 to 3 years
Short-Term	Requirements exist for 1 year or less
Extent	
Large	Hazardous substances are used weekly and require personal protective equipment, or cryogenic or hypergol storage exceeds QD's.
Medium	Hazardous substances are used monthly and personal protective equipment, or cryogenic or hypergol storage require 100 percent of the QD.
Small	Hazardous substances require minimal personal protective considerations, or cryogenic or hypergol storage require less than existing QD.
Likelihood	
Probable	Occurs under typical operating conditions
Possible	Occurs under worst-case operating conditions
Unlikely	Occurs under upset/malfunction conditions

Significance Definitions

■ Discipline—Land Use

Term	Agriculture Definition	Recreation Restrictions Definition
Magnitude		
Major	A 25-percent or greater reduction in crop yields per acre	Complete closure; all uses restricted
Moderate	Between 5- and 25-percent reduction in crop yields per acre	Certain uses restricted
Minor	Less than a 5-percent reduction in crop yields per acre	1 use restricted
Duration		
Long-term	More than 1 growing season	Over 50 days of closure per year
Medium-term	1 growing season or less	5 to 50 days of closure per year
Short-term	Damage noticed within part of a growing season	Less than 5 days of closure per year
Extent		
Large	Over 5 percent of county agricultural acres affected	Over 5 percent of county or federal available recreation lands affected
Medium	Between 2 and 5 percent of county agricultural acres affected	Between 2 and 5 percent of county or federal available recreation lands affected
Small	1 percent or less of county agricultural acres affected	Less than 2 percent of available recreation lands affected
Likelihood		
Probable	Occurs under typical operating conditions	
Possible	Occurs under worst-case operating conditions	
Unlikely	Occurs under upset/malfunction conditions	

Significance Definitions

■ Discipline—Noise

Term	Definition	
Magnitude	**Short Duration**	
	A-Weighted (Humans)	**OASPL (Structures)**
Major	Greater than 115 dBA sound levels	Greater than 120 dB
Moderate	Between 100 and 115 dBA	Between 111 and 120 dB
Minor	Less than 100 dBA	Less than 110 dB
Duration		
Long-term	A continuous event of one day or greater	
Medium-term	An event lasting for one shift; 8 hours or less	
Short-term	Impact lasting less than 15 minutes for the day, such as static testing	
Extent		
Large	Regional area extending on public property not under lease by government as acoustical buffer zone	
Medium	Beyond the facility site but not beyond the acoustical buffer zone (if present)	
Small	Within the site but not entering the buffer zone	
Likelihood		
Probable	Occurs under typical operating conditions	
Possible	Occurs under worst-case operating conditions	
Unlikely	Occurs under upset/malfunction conditions	

Significance Definitions

■ Discipline—Oil Products Storage and Use

Term	Definition
Magnitude	
Major	Increases daily maximum oil-product storage in one or more single container(s) or daily maximum use by 10,000 gal (38,000 L) or greater
Moderate	Increases daily maximum oil product storage in one or more single container(s) or daily maximum use by 1,000 to 10,000 gal (3,800 to 38,000 L) or greater
Minor	Maximum increase in daily maximum oil product storage in one or more single container(s) or daily maximum use will not exceed 1,000 gal (3,800 L)
Duration	
Long-term	Requirement exists weekly throughout life of project (greater than 1 year)
Medium-term	Requirement exists weekly for a 1-year period
Short-term	Requirement infrequent and met through temporary storage and handling means at time of test only
Extent	
Large	Increases daily maximum oil-product storage in one or more single container(s) or daily maximum use by 10,000 gal (3,800 L) or greater in secured test area(s) and at one or more site outside of test area(s)
Medium	Increases daily maximum oil-product storage in one or more single container(s) or daily maximum use by 10,000 gal (3,800 L) or greater in secured test area(s) or 1,000 to 10,000 gal (3,800 to 38,000 L) in an area outside of test area(s)
Small	Increase daily maximum oil-product storage or daily maximum by no more than 1,000 gal
Likelihood	
Probable	Oil-product release occurs under typical operating conditions
Possible	Oil-product release occurs under worst-case operating conditions
Unlikely	Oil-product release occurs under upset/malfunction conditions

Significance Definitions

■ Discipline—Public and Employee Health and Safety

Term	Definition
Magnitude	
Significant	Catastrophic event resulting in loss of life, severe injuries requiring hospitalization, major property damage, or loss
Moderate	Event resulting in moderate injuries requiring hospitalization, minor property damage, or loss
Minor	Event resulting in minor injuries which do not require hospitalization, minor property damage, or loss
Duration	
Long-term	Greater than 10 years to return to normal
Intermittent	Between 1 and 10 years to return to normal
Short-term	Less than 1 year to return to normal
Extent	
Large	Extending outside buffer zone into region, state, or nation
Medium	Confined to within buffer zone but extending outside site
Small	Confined to site or individual facility on site
Likelihood	
Probable	Occurs under typical operating conditions
Possible	Occurs under worst-case operating conditions
Unlikely	Occurs under upset/malfunction conditions

Significance Definitions

■ Discipline—Socioeconomics

Term	Definition
Duration	
Long-term	Project life more than 10 years
Intermittent	Project life between 3 and 10 years
Short-term	Project life less than 3 years (assuming a 3-year construction phase)
Extent	
Large	National, state, or regional
Medium	Entire study area
Small	Part of study area
Likelihood	
Probable	Greater than 50-percent chance of occurrence
Possible	Between 5- and 50-percent chance of occurrence
Unlikely	Less than 5-percent chance of occurrence
Magnitude	
Significant	Greater than 3-percent change (if measurable)
Moderate	Between 2- and 3-percent change
Minor	Less than 1-percent change

Significance Definitions

■ Discipline—Threatened and Endangered Species

Term	Definition
Magnitude	
Major	Greater than 10-percent change in critical habitat or adverse reproductive or survivability predictions on a candidate, threatened, or endangered species, even with mitigation
Moderate	Slight to 10-percent change in critical habitat, but all potential adverse effects on these species can be safely mitigated.
Minor	Little to no effect on critical habitat on these species predicted; no mitigation required
Duration	
Long-term	Greater than 1 year or during critical periods
Medium-term	Intermittent or limited from 1 month to a year
Short-term	Less than 1 month
Extent	
Large	Affects greater than 50 percent of the critical habitat or species population
Medium	Affects 10 to 50 percent of the critical habitat or species population
Small	Affects less than 10 percent of the critical habitat or species population
Likelihood	
Probable	Occurs under typical operating conditions
Possible	Occurs under worst-case operating conditions
Unlikely	Occurs under upset/malfunction conditions

Significance Definitions

■ Discipline—Transportation—Accidental Potential

Term	Environmental Damage Definition	Human Health Definition	Property Damage Definition
Magnitude			
Major	Greater than 5-percent wildlife population or habitat loss; major water resource contamination	Direct loss of human life	More than $1,000,000 damage
Moderate	1- to 5-percent loss	Multiple serious injuries requiring hospitalization or elevated long-term hazard	$50,000 to $1,000,000 damage
Minor	Less than 1-percent loss	Effect limited to minor, easily-treatable injuries	$50,000 damage or less
Duration			
Long-term	More than 3 years		
Medium-term	Between 1 and 3 years		
Short-term	Less than 1 year		
Extent			
Large	Statewide or greater		
Medium	Multicounty area		
Small	Site and immediate environs		
Likelihood			
Probable	Occurs under typical operating conditions		
Possible	Occurs under worst-case operating conditions		
Unlikely	Occurs under upset/malfunction conditions		

Significance Definitions

■ Discipline—Transportation—Rail/Waterway Network Effects

Term	Discipline
Magnitude	
Major	Shipments would cause diversion of more than 5 percent of traffic on main rail or waterway link.
Moderate	Shipments would cause measurable congestion on key rail or water link, but no projected diversion.
Minor	Shipments cause congestion, but level too small to be quantified.
Duration	
Long-term	More than 3 years
Medium-term	Between 1 and 3 years
Short-term	Less than 1 year
Extent	
Large	Effects noticeable at statewide or broader level
Medium (localized)	Effect limited to study region
Small (limited)	Effect limited to site and immediate link to rail or waterway system
Likelihood	
Probable	Occurs under typical operating conditions
Possible	Occurs under worst-case operating conditions
Unlikely	Occurs under upset/malfunction conditions

Significance Definitions

■ Discipline—Waste Generation and Treatment

Term	Definition
Magnitude	
Major	a. New solid waste landfill on site b. Generates greater than 50 to 55 gal (189 to 208 L) drums of hazardous waste per year
Moderate	a. Utilize offsite and onsite solid waste landfills b. Generates between 30 and 50 to 55gal (189 to 208 L) of hazardous waste per year
Minor	a. Utilize on site solid waste landfill b. Generates less than 30 to 55gal (to 208 L) drums of hazardous waste per year
Duration	
Long-term	a. Permitting and siting of new disposal facility would take more than 2 years. b. Generates hazardous waste throughout life of the project
Intermittent	a. Special waste permitting for onsite and offsite disposal would take more than 6 months. b. Intermittent generator of hazardous waste
Short-term	a. Special waste permitting for onsite and offsite disposal would take less than 6 months. b. Generates hazardous waste only during infrequent operations
Extent	
Large	a. Multiple landfills needed or a large landfill needed to expand capacity (greater than 100 acres) or large groundwater contaminant plume b. Generates hazardous waste at the test stands and at ancillary facilities
Medium	a. Moderate-size landfill needed—40 to 100 acres (16 to 40 hectares) b. Generates hazardous waste at the test stand(s) and at 50 percent of the ancillary facilities
Small	a. Small landfill needed of less than 40 acres (16 hectares) b. Generates hazardous waste at the test stand(s) and at 25 percent of the ancillary facilities
Likelihood	
Probable	Occurs under typical facility operating conditions
Possible	Occurs under worst-case operating conditions
Unlikely	Occurs under upset/malfunction conditions

Significance Definitions

■ Discipline—Water Quality—Receiving Water Quality

Term	Groundwater Definition	Surface Water Definition
Magnitude		
Major	a. Regulated water-quality criteria are exceeded or other specific parameters, e.g., conductivity, are increased by a factor of 10 or greater or b. Immediately observable impact, e.g., fish killed; or c. Possible impact to an endangered, threatened, or listed species.	
Moderate	a. Regulated water-quality met but pollutant concentration approaches limit or b. Specific parameters, e.g., conductivity, increased by a factor of 2 to 10 or c. Some observable biological response, e.g., avoidance.	
Minor	a. Small increases in pollutant or other specific parameters projected, but all water quality criteria maintained well below limits or b. No adverse biological response projected.	
Duration*		
Long-term	Continuous series of events that exhibit chronic effects between 1 and 2 years	
Medium-term	Intermittent events that exhibit acute and subacute effects over a period of 1 to 2 years maximum	
Short-term	A single event that exhibits acute effects	
Extent		
Large	Groundwater affected at bedrock and residuum elevation	a. Effect over entire watershed (basin) or multiple watersheds
Medium	Residuum groundwater affected and corrective action required	a. Effect over 25 percent of watershed (basin), or b. Effect over 50 percent of small body water, or c. Greater than 10 percent but less than 40 percent of major water body
Small	Residuum groundwater affected but does not require corrective measures	a. Affect less than 25 percent of single water shed, less than 10 percent of major water body; may include entire area of 1 to 2 small ponds (less than 5 acres) or small seasonal wetland
Likelihood		
Probable	Occurs under typical operating conditions	
Possible	Occurs under worst-case operating conditions	
Unlikely	Occurs under upset/malfunction conditions	

* Duration is somewhat parameter- and criteria-specific and must be considered in that context.

Significance Definitions

■ Discipline—Water Resources—Supply

Term	Definition
Magnitude	
Major	Requirements exceed current capacity.
Moderate	Requirements demand 25 percent or more of capacity but less than 100 percent.
Minor	Requirements demand less than 25 percent of capacity.
Duration	
Long-term	Extra capacity required for more than 5 years
Medium-term	Extra capacity required for more than 1 year but less than 5 years
Short-term	Extra capacity required for less than 1 year
Extent	
Large	Extra personnel and/or facilities required for greater than 50 percent of the life of the project
Medium	Increase in personnel and/or resources required intermittently
Small	Personnel and/or resources within current capabilities
Likelihood	
Probable	Occurs under typical facility-operating conditions
Possible	Occurs under worst-case operating conditions
Unlikely	Occurs under upset/malfunction conditions

Significance Definitions

■ Discipline—Wetlands and Floodplains

Term	Wetlands Definition	Floodplains Definition
Magnitude		
Major	In conflict with federal or state wetland protection programs	In conflict with federal or state floodplain management
Moderate	Impacts wetland with critical habitat potential	In conflict with regional or county floodplain management
Minor	Wetland losses would be mitigated through consultation with federal and state agencies.	In conflict with nearby municipal or site-specific floodplain management plans
Duration		
Long-term	Project life more than 20 years	
Medium-term	Project life between 5 and 20 years	
Short-term	Project life less than 5 years	
Extent		
Large	Greater than 5 percent of the regional resource	Floodplain cannot be avoided and the floodway would be impaired, even with mitigation.
Medium	Between 2 and 5 percent of regional resource	Floodplain and floodway impacted, but correctable with substantial mitigation
Small	Less than 2 percent of regional resource	Little or no impact in floodplain or floodway and fully correctable with minor mitigation
Likelihood		
Probable	Occurs under typical operating conditions	
Possible	Occurs under worst-case operating conditions	
Unlikely	Occurs under upset/malfunction conditions	

TABLE C–3.—*MSFC significance definitions summary*

Issue	Types of Potential Impacts	Magnitude	Duration	Extent	Likelihood	Impact Rating
Air						
Large thrust	CO emission levels can exceed PSD thresholds and significant ambient air quality increases; maximum radius of influence of 26 km	Major	Short	Large	Probable	Moderate
Medium thrust	CO emission levels can exceed PSD thresholds and significant ambient air quality increases	Moderate	Short	Large	Probable	Moderate
Small thrust	CO emission levels can exceed PSD threshold quantities	Minor	Short	Large	Probable	Insignificant
Archaeological Resources						
Construction	Previously unidentified resources could be disturbed or destroyed either	Minor	Short	None	Possible	Insignificant
Operations	No subsurface operations	N/A	N/A	N/A	N/A	No Impact
Biota—Wildlife, Vegetation, and Threatened and Endangered Species						
Wildlife and vegetation	Loss or adverse effect on vegetation, wildlife, etc.	Minor	Short	Small	Probable	Insignificant
Threatened and endangered species	No critical habitat and/or threatened and endangered species in the Test Areas	N/A	N/A	N/A	N/A	No Impact
Cultural and Historical Resources						
Construction	Potential Enhancement	Minor	Short	Small	Likely	Insignificant
Operations	Some air emissions may contact the Redstone Test Stand, thereby increasing maintenance.	Minor	Short	Small	Unlikely	Insignificant
	One or more of the facilities' importance could be increased.	Enhance	Long	Large	Probable	Insignificant
Facilities and Infrastructure						
Construction	Influx of new workers with exposure to asbestos and lead	Minor	Short	Small	Unlikely	Insignificant
Operation	Damage to surrounding buildings	Minor	Medium	Small	Unlikely	Insignificant
Land Use						
Recreation restrictions	Opportunities limited, constrained, or restricted on the use of Wheeler Wildlife Refuge near MSFC	Minor	Short	Small	Unlikely	Insignificant
Agriculture	Loss of prime or unique farmlands	Minor	Long	Small	Unlikely	Insignificant
Noise						
Large thrust	Noise levels that are not compatible with the existing surroundings and could cause harm to humans, biota, and structure	Moderate	Short	Large	Probable	Moderate
Medium thrust		Moderate	Short	Large	Probable	Moderate
Small thrust		Minor	Short	Large	Probable	Insignificant

TABLE C–3.—*MSFC significance definitions summary (cont'd)*

Oil Products and Hazardous Substances and Wastes						
RP–1 storage and use	Uncontrolled releases of RP–1 to the environment	Major	Long	Medium	Unlikely	Moderate
Hazardous substances	Increased risk to environment or personnel	Moderate	Long	Small	Unlikely	Insignificant
Hazardous wastes	Increased risk to environment or personnel	Moderate	Long	Small	Unlikely	Insignificant
Public Safety and Employee Health and Safety						
Construction	Potential for proposed modification to existing facilities to expose personnel to lead or asbestos.	Minor	Short	Medium	Unlikely	Insignificant
Operations	Potential mishaps with the use of fuel, oxidizer, or hypergol	Moderate	Intermittent	Medium	Unlikely	Insignificant
Socioeconomics						
Workforce	Sufficient qualified workforce unavailable	Minor	Short	Small	Unlikely	Insignificant
Transportation						
Accidental potential	Property, environmental, or human health damage resulting from transportation accident	Minor	Long	Small	Unlikely	Insignificant
Rail/Waterway network	Incompatibility of shipments with capacity (load and size capacity) of local rail and waterway system, or rail and barge congestion	Minor	Long	Small	Unlikely	Insignificant
Waste Generation and Treatment						
Operations	Volume of solid waste can impact current waste handling and procedures.	Minor	Short	Small	Unlikely	Insignificant
Water Resources—Receiving Water Quality						
Groundwater	Leaching of fuel constituents or solvents into groundwater from detention pond	Minor	Intermittent	Small	Unlikely	Insignificant
Surface water	Accidental release of fuel or solvents from run tanks or cleaning procedures to detention pond	Minor	Intermittent	Small	Unlikely	Insignificant
Water Resources—Supply						
Supply	Industrial water supply storage tank ruptures.	Minor	Short	Small	Unlikely	Insignificant
	Industrial water supply from RSA is unavailable.	Minor	Short	Small	Unlikely	Insignificant
Wetlands and Floodplains						
Construction	Wetlands may be filled or altered for project facilities.	N/A	N/A	N/A	N/A	No impact
Surface water discharge	Surface water discharges may alter wetland characteristics or directly impact wildlife.	Minor	Short	Medium	Possible	Insignificant

TABLE C–4.—*SSC significance definitions summary*

Issue	Types of Potential Impacts	Magnitude	Duration	Extent	Likelihood	Impact Rating
Air						
Large-thrust						
Single engine	CO emission levels can exceed PSD thresholds and significant ambient air quality increases. Maximum radius of influence of 26 km.	Major	Short	Large	Probable	Moderate
Multiple engine	Same as above	Major	Short	Large	Probable	Moderate
Medium-thrust						
Single engine	CO emission levels can exceed PSD thresholds and significant ambient air quality increases.	Moderate	Short	Large	Probable	Moderate
Multiple engine	Same as above	Moderate	Short	Large	Probable	Moderate
Small-thrust						
Single engine	CO emission levels can exceed PSD threshold, but not result in significant ambient air quality increase.	Minor	Short	Large	Probable	Insignificant
Multiple engine	Same as above	Minor	Short	Large	Probable	Moderate
Archaeological Resources						
Construction	Impact to archaeological resources. None identified in previous field survey	None	Medium	None	Unlikely	Insignificant
Operations	No subsurface operations	N/A	N/A	N/A	N/A	No Impact
Biota—Wildlife, Vegetation, and Threatened and Endangered Species						
Wildlife and vegetation	Loss or adverse effect on vegetation, wildlife, etc.	Minor	Short	Small	Probable	Insignificant
Threatened and endangered species	Impact to critical habitat and/or threatened and endangered species	Minor	Short	Small	Unlikely	No impact
Cultural and Historical Resources						
Construction	Facilty modifications covered under programmatic agreement.	Enhance	Long	Large	Probable	Insignificant
Operations	Some air emissions may contact the National Historic Landmarks and increase maintenance.	Minor	Short	None	Possible	Insignificant
Unplanned events	National Historic Landmark could be damaged.	Moderate	Long	Large	Unlikely	Insignificant
Facilities and Infrastructure						
Construction	Influx of new workers with exposure to asbestos and lead	Minor	Short	Small	Unlikely	Insignificant
Operation	Damage to surrounding buildings	Minor	Medium	Small	Unlikely	Insignificant
Land Use						
Recreation restrictions	No constraints outside fee area	Minor	Short	Small	Unlikely	Insignificant
Agriculture	Loss of prime or unique farmlands	Minor	Short	Small	Unlikely	Insignificant
Noise						
Large-thrust						
Single engine	Noise levels compatible with buildings in fee area and terms of leases in the buffer zone; impact rating based on exposures outside of fee area and buffer zone	Minor	Short	Large	Probable	Insignificant

TABLE C–4.—*SSC significance definitions summary (cont'd)*

Multiple engine	Same as above	Minor	Short	Large	Probable	Moderate
Medium-thrust						
Single engine	Same as above	Minor	Short	Large	Probable	Insignificant
Multiple engine	Same as above	Minor	Short	Large	Probable	Insignificant
Small-thrust						
Single engine	Same as above	Minor	Short	Large	Probable	Insignificant
Multiple engine	Same as above	Minor	Short	Large	Probable	Insignificant
Oil Products and Hazardous Substances and Wastes						
Oil products: RP–1	Uncontrolled releases of RP–1 to the environment	Major	Long	Medium	Unlikely	Moderate
Hazardous Substances	Increased risk to environment or personnel	Moderate	Long	Small	Unlikely	Insignificant
Public Safety and Employee Health and Safety						
Construction	Potential for proposed modification to existing facilities to expose personnel to lead or asbestos.	Minor	Short	Medium	Unlikely	Insignificant
Operations	Potential mishaps with the use of fuel, oxidizer, or hypergol	Moderate	Intermittent	Medium	Unlikely	Insignificant
Socioeconomics						
Workforce	Sufficient qualified workforce available	Minor	Short	Small	Unlikely	Insignificant
Transportation						
Accidental potential	Property, environmental, or human health damage resulting from transportation accident	Minor	Long	Small	Unlikely	Insignificant
Rail/waterway network	Incompatibility of shipments with capacity (load and size capacity) of local rail and waterway system, or rail and barge congestion	Minor	Long	Small	Unlikely	Insignificant
Waste Generation and Treatment						
Operations	Volume of solid waste can impact current waste handling and procedures.	Minor	Short	Small	Unlikely	Insignificant
Water Resources—Receiving Water Quality						
Groundwater	Leaching of fuel constituents or solvents into groundwater from detention pond or access canal	Minor	Intermittent	Small	Unlikely	Insignificant
Surface water	Accidental release of fuel or solvents from run tanks or cleaning procedures to detention pond or access canal	Minor	Intermittent	Small	Unlikely	Insignificant
Water Resources—Supply						
Supply	Industrial water supply unavailable	Minor	Short	Small	Unlikely	Insignificant
Wetlands and Floodplains						
Construction	Wetlands may be filled or altered for project facilities.	Minor	Short	Medium	Possible	Insignificant
Surface water discharge	Surface water discharges may alter wetland characteristics or directly impact wildlife.	Minor	Short	Medium	Possible	Insignificant

Appendix D—Finding of No Significant Impact for the Liquid Fueled Rocket Engine Testing at Test Stand 1–A, Phillips Laboratory, Edwards AFB, CA

FINDING OF NO SIGNIFICANT IMPACT FOR THE LIQUID-FUELED ROCKET ENGINE TESTING AT TEST STAND 1-A, PHILLIPS LABORATORY, EDWARDS AFB, CA

1.0 INTRODUCTION

Edwards Air Force Base (AFB) proposes to resume the testing of large liquid-fueled engines at Test Stand (TS) 1-A, located at the Phillips Laboratory. The purpose of this project is to use TS 1-A to further develop, test, and evaluate (DT&E) large liquid-fueled engines and components. The project would provide support for the proposed F-1A/RD-170 Technology Demonstration Program, a joint United States and Russian venture. Testing these units would expand the technology base critically needed for heavy lift space applications.

The attached environmental assessment (EA) documents the analysis of the actions required to provide the research for the large liquid fueled engines and the potential to impact the environment as a result of the project.

The EA fulfills the requirements for compliance with the National Environmental Policy Act (NEPA), Title 40 of the Code of Federal Regulations (CFR) Parts 1500-1508, and Air Force Regulation 19-2, which are the applicable implementing regulations for NEPA.

1.1 Proposed Action, Action Alternative, and the No Action Alternative

Edwards AFB has considered the following three alternatives:

1. Proposed Action Alternative: Provide site preparation as required to conduct the DT&E. This would include TS 1-A refurbishment, installation of propellant unloading stations, modifying the instrumentation, data acquisition and control systems specific to the test engines, reactivating and upgrades to observation bunkers, airlifting the engines to Edwards AFB and conducting the research.

2. Other Action Alternatives: Two alternate sites have been considered but were dismissed from further discussion. They are Moscow, Russia and Huntsville, Alabama. Moscow, Russia has been dismissed as research conditions could not be met. The National Aeronautics Space Administration in Huntsville, Alabama is conducting an environmental assessment of their facility for consideration of this DT&E program. Therefore, this is not within the scope of the attached EA. The two EAs will be compared in the program site selection process.

3. No Action Alternative: This action would result in no testing of large liquid-fueled engines at TS 1-A at Edwards AFB. Tests of other liquid-fueled engines would require evaluation on a project-by-project basis.

The selection criteria used to determine the better alternative are as follows:

1. The option that would allow optimum research conditions for data collection and evaluation utilizing U.S. methods and reflecting U.S. mission requirements

2. Provide mission support that would best suit Edwards AFB as a test program support base.

2.0 SUMMARY OF ENVIRONMENTAL EFFECTS

The Proposed Action Alternative will not significantly impact the manmade or natural environment. Measures incorporated into the design of the proposed action and standard operating

procedures at Edwards AFB minimize negative impacts to the environment. For more information on the affected environment, see Section 3.0 of the attached EA. For more information on the consequences of the proposed action, see Section 4.0 of the attached EA.

The No-Action Alternative would have a long-term negative impact as scientific research data would not be provided.

2.1 BIOLOGICAL RESOURCES

Sensitive plant species are not expected to occur within the program area. Desert tortoises (*Gopherus agassizii*) were observed within the survey area. The desert tortoise density in the area of the proposed action is 2 to 20 desert tortoises per square mile. Therefore, it can be concluded that direct or indirect mortality may occur from drainage of deluge water used to cool the engines during firing. The Air Force will comply with the terms and conditions listed in the United States Fish and Wildlife Service Biological Opinion to minimize impacts to the desert tortoise.

2.2 PHYSICAL ENVIRONMENT

2.2.1 Air Quality

Each full duration firing (150 seconds) would release carbon dioxide, water vapor and carbon monoxide. Of these three elements, carbon monoxide is the only regulated emission. Minimization measures incorporated into the project avoid impacts to the surrounding environment.

2.3 Manmade Environment

The component of the manmade environment identified as having the potential for significant impacts as a result of the Proposed Action Alternative is noise.

2.3.1 Noise

The large engine testing would create noise events of very short duration (10 to 150 seconds). The largest rocket engine to be tested, the RD-170, is conservatively estimated to generate 41.1 million watts of acoustic energy. Noise impacts will be minimized by standard safety procedures initiated during rocket engine testing firings. Minimization measures are incorporated into the project which minimize these impacts.

3.0 FINDINGS

A Finding of No Significant Impact is made based upon the absence of significant negative impacts to the environment of Edwards AFB. This decision is supported by the attached EA. Important background papers which supported the research and development of the Finding of No Significant Impact and the EA are on file at Edwards AFB, and can be obtained by contacting the following:

AFFTC/EM
Environmental Management Office
Attn: Mr. Christopher Rush
Edwards AFB, CA 93523-5000

VERNON P. SAXON, JR., Colonel, USAF
Chairman, Environmental Protection Committee
Edwards AFB, California

Appendix E—Estimates of Rocket Exhaust Factor for RD–170 Engine Test Program

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National Aeronautics and
Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

APR 0 4 1994

eply to Attn of:

AE01/78-94

TO: Memorandum for Record

From: AE01/Rebecca McCaleb
AE01/Clay Horan

SUBJECT: Estimates of Rocket Exhaust Emission Factors for the RD-170 Engine Test Program

Final emission rates have been determined for the RD170 engine test program. The emission rates are based on three dimensional computational fluid dynamics (3-D CFD) computer modeling, engineering calculations and empirical historical data. The key emission parameters examined are carbon monoxide, oxides of nitrogen, sulfur dioxide and particulate matter. Values for carbon monoxide (CO) and the oxides of nitrogen (NOx) are based on the 3-D CFD analysis performed by ED32. AE01 calculated the emission rates of CO and NOx based on the ED32 values. Sulfur dioxide emissions are based on the maximum available elemental sulfur in the kerosene (RP-1) fuel. Particulate matter was extrapolated from data acquired by Rocketdyne, Canoga Park, California [1] on other LOX/RP-1 engine tests. A propellant flow rate of 5288 lb/s with an oxidizer to fuel ratio of 2.43 was used as the basis for calculation of sulfur dioxide. A summary of emission values to be used in the dispersion analysis is shown in Table 1. The basis of these input values is provided in the following sections. The attached Table A3 is the relevant data as provided by ED32/T. Wang.

Table 1. Regulated Pollutant Emission Data

Pollutant	Rate (lb/s)	Rate (Tons/190s test)	Annual Release (@ 1 test/wk - TPY)
CO	596.57	56.67	2950.0
NOx	1.026	0.097	5.0
SO_2	1.54	0.146	7.6
PM_{10}**	1.74	0.165	8.3
ROC	25.0*	0.025	1.3
Total	600.87	57.08	2972.2

* Total release time estimated at 2 seconds during engine shut-down.
** As measured for total particulates by Rocketdyne

Based on the CFD results, the emission rate for CO ranges from 1097.6 kg/s (498.91 lb/s) to 1312.54 kg/s (596.57 lb/s). These values are indicated in Table 2, where the mean, standard deviation and associated values are based on data provided by ED32. Data from ED32 and the molar rates for CO and CO2 are shown in Table A1 (enclosed). The availability of elemental carbon almost exclusively for the production and/or reduction of CO2 and CO allows for the use of molar ratios to determine the mass flow rate of CO in the exhaust plume. The molar ratio of CO/CO2 at the nozzle exit plane is 0.939 [2]. Percent reduction is the reduction in molar ratios of CO/CO2 from nozzle exit plane to stabilized plume domain. This reduction level can be used to define the reduction in the mass flow rate of CO at the nozzle exit plane of 6.2818e5 g/s (1382 lb/s)[2]. Values from the table are based on calculations for the last 8 computational output time intervals of the 3D CFD model output.

Table 2. CO Emission Data

Value	Percent Reduction	CO (lb/s)	CO (Tons/190s test)
Mean (σ)	63.90 (2.36)	498.91	47.40
+ 1 σ	61.54	531.46	50.49
+ 2 σ	59.19	564.02	53.58
+ 3 σ	56.83	596.57	56.67

(mean + 3σ = value at 95% confidence level)

The emission rate of oxides of nitrogen are based on the CFD analysis from ED32. Standard air entrainment through the aspirator on the stand and in the plume region after the deluge bucket exit plane provide the available nitrogen for conversion to NOx. The data from Table A2 results in a 3-sigma NOx emission rate of 1.026 lb/s. Values for NOx emissions are shown in Table 3 below.

Table 3. Estimated NOx Emissions based on CFD Results

Value	lb/s	Tons/190s test
Mean (σ)	0.520 (0.168)	0.05
+ 1 σ	0.688	0.07
+ 2 σ	0.857	0.08
+ 3 σ	1.026	0.10

RP-1 contains elemental sulfur with a maximum wt/wt content of 0.05% [3]. Conversion of all available elemental sulfur to sulfur dioxide was assumed. With an oxidizer to fuel

ratio of 2.43, the flow rate of RP-1 is 700.77 kg/s (1541.69 lb/s). The resulting maximum sulfur dioxide release rate to the atmosphere is 3.34 kg/s (1.57 lb/s). PM_{10} using total particulate emission rates are based on measured emission factors from Rocketdyne [1] and extrapolated to an RD-170 by thrust ratio's. With MA-5 booster and RD-170 sea level thrusts of 377.5 K-lbf and 1.643 M-lbf respectively, the resulting emission factor is 0.79 kg/s (1.74 lb/s)

Reactive organic chemicals (ROC) in the form of RP-1 would be released during engine shut-down. This release is a typical procedure that would last for a few seconds, releasing approximately 50 pounds of RP-1 into the engine. The resulting emission factor for ROC is 11.36 kg (25 lb/s) with a release period of 2 seconds. This release can be averaged over the full test duration.

Rebecca C. McCaleb, Director
Environmental Engineering and
Management Office

Clay Horan
Environmental Engineering and Management Office

concurrence:

ED32/Dr. T. Wang

Enclosure

cc:

AE01/reading
AE01/CAA
AE01/R. McCaleb
AE01/C. Horan
ED32/T. Wang
ED31/D. Andrews
ED32/P. McConnaughey

TABLE E–1.—*CO and CO_2 data from ED32 CFD analysis for calculation of CO release rate*

Time (s)	lbmole—CO	lbmole—CO_2	nCO/nCO_2
0.042955	3.46214	9.41250	0.36782
0.047235	3.43568	9.51808	0.36096
0.051516	3.41405	9.67411	0.35291
0.055796	3.39539	9.81455	0.34595
0.062217	3.38071	10.07940	0.33541
0.066498	3.37036	10.23639	0.32925
0.077199	3.34755	10.62794	0.31498
0.08576	3.33103	10.93637	0.30458

TABLE E–2.—*NOX emission data—from CFD for calculation of NOX release rate*

Time (s)	ED32 Data for NO (lb)	NO Mass* Rate (lb/sec)	Twice NO Mass Rate (lb/sec)**
0.001605	1.8430E–04		
0.002376	2.2286E–04	0.0512	0.1024
0.003895	5.5415E–03	3.5014	7.0028
0.008593	7.0330E–03	0.3175	0.6350
0.010326	7.6150E–03	0.3358	0.6717
0.012992	8.8086E–03	0.4477	0.8954
0.019413	1.1331E–02	0.3929	0.7858
0.023693	1.2867E–02	0.3588	0.7176
0.036534	1.7006E–02	0.3223	0.6447
0.042955	1.8771E–02	0.2749	0.5498
0.047235	1.9423E–02	0.1523	0.3047
0.051516	2.0447E–02	0.2392	0.4784
0.055796	2.1093E–02	0.1509	0.3019
0.062217	2.2952E–02	0.2895	0.5790
0.066498	2.3889E–02	0.2189	0.4377
0.077199	2.6021E–02	0.1992	0.3985
0.08576	2.7699E–02	0.1960	0.3920

* NO mass rate based on change of mass in plume with computational time step

** Rate is doubled to account per T. Wang recommendation due to model symmetry

TABLE E–3.—*Plume values from ED32 CFD output*

Time (s)	CO (lb)	NO (lb)	Energy (Btu)	Temp. (R)	Density (g/m^3)	Volume (ft^3)	Velocity u (f/s)	Velocity v (f/s)	Velocity w (f/s)
0.001605	117.17	1.8430E–04	1.165E+06	1057.92	663.57	1.47E+05	638.48	143.88	28.70
0.002376	115.38	2.2286E–04	1.169E+06	1063.81	661.95	1.47E+05	639.98	145.04	10.75
0.003895	113.03	5.5415E–03	1.180E+06	1070.08	660.14	1.48E+05	643.59	146.86	12.44
0.008593	107.85	7.0330E–03	1.208E+06	1077.86	655.45	1.50E+05	661.16	153.04	14.17
0.010326	106.22	7.6150E–03	1.216E+06	1078.98	653.78	1.51E+05	667.38	154.72	14.13
0.012992	104.92	8.8086E–03	1.232E+06	1069.63	656.06	1.53E+05	673.68	156.51	14.05
0.019413	102.90	1.1331E–02	1.261E+06	1046.68	662.59	1.56E+05	684.38	158.73	14.51
0.023693	101.51	1.2867E–02	1.282E+06	1033.03	667.14	1.59E+05	686.00	158.11	14.17
0.036534	98.25	1.7006E–02	1.335E+06	1005.35	678.23	1.66E+05	686.74	156.41	15.08
0.042955	96.94	1.8771E–02	1.368E+06	992.97	685.08	1.70E+05	679.65	152.80	16.75
0.047235	96.20	1.9423E–02	1.389E+06	985.51	689.36	1.73E+05	672.88	149.28	16.54
0.051516	95.59	2.0447E–02	1.410E+06	980.03	693.55	1.76E+05	666.21	146.26	16.62
0.055796	95.07	2.1093E–02	1.436E+06	974.75	699.05	1.79E+05	659.65	143.37	17.32
0.062217	94.66	2.2952E–02	1.4497E+06	957.597	705.80	1.83E+05	647.28	136.68	21.88
0.066498	94.37	2.3889E–02	1.47E+06	947.793	711.70	1.86E+05	635.82	132.14	24.72
0.077199	93.7314	2.6021E–02	1.50E+06	925.169	717.39	1.91E+05	619.56	126.90	23.46
0.08576	93.2688	2.7699E–02	1.53E+06	910.17	739.72	1.95E+05	611.56	124.17	26.28

References

[1] Melvold, R.W., June 1992, Correspondence, Final Report: Air Sampling for Chemical Analysis From Rocket Engine Test Firing Plumes at the Rocketdyne Santa Susana Field Laboratory, Rockwell International, Canoga Park, CA

[2] Dr. Wang, T.S., February 7 and February 10, 1994, Telephone conversation regarding CFD data

[3] Ise, Mike, March 3, 1994, MSFC, Fax transmittal to Allen Elliott, MSFC/AE01, Response to memo AB10/213-93, identifying RP–1 specification Mil Specification MIL-P–25576

Appendix F—Determination of Input Values for Rocket Exhaust Effluent Diffusion Model (REEDM) for Testing of RD–170 Engine

List of Tables

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National Aeronautics and
Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

v to Attn of: AE01/ 74-94

MAR 1 4 1994

TO: Memorandum for Record

FROM: AE01/Clay Horan

SUBJECT: Determination of Input Values for the Rocket Exhaust Effluent Diffusion Model (REEDM) Modeling for Testing of an RD170 Engine

MSFC has proposed the single engine testing of a Russian liquid oxygen/hydrocarbon engine, designated RD170 on the S-IC test stand for a maximum duration of 190 seconds. The RD170 has a sea level thrust of 7268 KN (1.643 M-lbf). High grade kerosene (RP-1) and liquid oxygen flow at 2.404e3 kg/s (5288 lb/s) with the high temperature exhaust quenched by the stand flame bucket water deluge system. Primary pollutants from the combustion process are carbon monoxide, nitrogen oxides and sulfur dioxide. To assess the ambient air impacts of testing, the Rocket Exhaust Effluent Diffusion Model (REEDM) computer code developed by H.E. Cramer Inc. will be used. REEDM will determine the final stabilized condition of a spherical ground cloud that ascends through meteorological layers. Once the stabilized conditions have been determined, dispersion analysis with an EPA approved code, INtegrated PUFF (INPUFF) will be used. To properly use REEDM, it is necessary to define several key input values. These input values have been determined and are presented in this memorandum.

Final values for the fuel and ground cloud radius as input to REEDM were calculated and are shown in Table 1. Mr. T. Wang/ED32 developed a detailed three dimensional computational fluid dynamics (3-D CFD) model which includes all aspects of the physical, chemical and thermodynamic phenomena occurring from engine nozzle exit plane through the flame bucket and into the ambient environment. A schematic of the CFD model is shown in Figure 1. The results from the 3-D CFD model provide necessary data to properly calculate input values for REEDM. The results of the CFD analysis were provided to AE01 in tabular form from Mr. Wang.

Table 1. Input Parameters for REEDM

Parameter	Value	Units
Total Fuel	4.57e8	g
Burn Rate	2.404e6	g/s
Fuel Heat Capacity	96	cal/g
Initial Radius	117	meters

A description of the input parameters, relevant equations within the code and rationale for final input values is provided in the enclosed Sections 1 and 2. Table A1 contains the relevant output values received from ED32 CFD analysis. Table A4 summarizes the values to be used in REEDM based on the respective CFD results and AE01 calculations.

Clay Horan
Environmental Engineering and Management Office

Concurrence: Rebecca C. McCaleb 3/11/94
Rebecca C. McCaleb, Director
Environmental Engineering and
Management Office

Enclosure

cc:
AE01/R. McCaleb
AE01/C. Horan
AE01/Reading
AE01/CAA

Description of Key Input Parameters for REEDM

The key input data needed by REEDM to determine a stabilized cloud height using rawinsonde data for a single engine test burn are shown in table E–1. A description of these parameters as they apply to REEDM follows.

Total Fuel

Total fuel is used primarily for the dispersion sections of the code, which were not used in this effort. Based on total fuel mass and pollutant fraction of total mass as input parameters, pollutant concentrations are calculated.

Fuel Burn Rate

Fuel burn rate is generally taken as the amount of fuel expended during firing. For test-firing of the RD170, a fuel burn rate of 2.404e6 g/s (5,288 lb/s) was used. This parameter plays an important role in the buoyancy flux parameter, as discussed in Section 2. Although water, air, and other constituents are entrained as the fuel flows through the flame bucket and into the ambient air, this additional mass is not accounted for in REEDM calculations with regard to total fuel and fuel burn rate and should not be used.

Fuel Heat Content

Fuel heat content used in REEDM is the *effective* heat content of the "fuel" within the initial ground cloud. A value of 96 cal/g will be used in the REEDM analysis based on the calculations. For the Briggs equation codified in REEDM, the effective heat content is representative of the sensible heat content of the fuel within the ground cloud, and is used as the basis for defining the sensible energy difference between the plume and the ambient air [1]. The value of the fuel-effective heat content should account for afterburning (increases the heat content) and radiation losses (reduces heat content), if they can be determined accurately or if they are significant. Although the exhaust plume from the test stand will contain significant quantities of steam due to vaporization of deluge water, the energy of the water vapor in the cloud and subsequent release during condensation are not considered in the initial cloud conditions in REEDM. Based on a conversation with Mr. J. Bjorkland [2], the values for heat content in the REEDM user's manual are based on empirical measurements and semiempirical derivations, as well as values from the vendor. These values account for some level of air entrainment and afterburning in most cases. The value of 96 cal/g for fuel heat content for the RD–170 analysis is significantly lower than typical values used in the REEDM vehicle data base, 690–3,000 cal/g. The values reported in the manual are based on afterburning effects without water deluge. The deluge water significantly reduces the total cloud energy.

Initial Cloud Radius

The initial cloud radius is an effective radius that represents a spherical volume containing the engine exhaust. The initial radius determines both ground cloud and stabilized cloud concentrations of pollutants. The cloud radius grows as a function of height as it progresses through the meteorological layers. The smaller the initial cloud radius, the smaller the final stabilized cloud radius.

Application of the Key Input Parameters within REEDM

The method of determining the input parameter values and application of the key input parameters are described below. An evaluation of the key equation which uses these input parameters, as well as rationale for the values selected, will be given also.

Total Fuel

Total fuel is used within the dispersion modeling portion of the code and will not be addressed here.

Fuel Burn Rate

The fuel burn rate (W) is the quotient of the total fuel and the test or engine firing duration. The fuel burn rate is used in part for defining the buoyancy flux parameter (Fb) for a continuous source [3]. The buoyancy flux parameter as defined for REEDM is shown in Attachment 1 and can be stated as:

$$Fb = g\ H'W / (\pi\ cp\ T_a\ \rho)$$

During the original development of input values, it was assumed that the fuel burn rate would be taken as the total mass of the cloud, including entrained air mass and water deluge. This assumption was wrong for the following reason. The buoyancy flux parameter as originally developed by Briggs [1] is based on the heat release rate of the source (cal/s) to the ambient. This release rate is the product of the source emission rate (g/s) and the enthalpy difference (cp*(Ts-Ta)) of the source and air. The product H'W (cal/s) within REEDM is in effect, the heat release rate of the propellant to the ambient and should be represented as such. Comparison of Briggs equation for final plume rise of a jet [1] to the REEDM final plume rise of a cloud [3], which both use the buoyancy parameter in a similar fashion, further demonstrates the intent of the H'W product. For this reason, the burn rate (w) was taken to be the actual fuel/oxidizer flow rate of 2.404e6 g/s (5,288 lb/s).

The value Fb used by REEDM is basically a ratio of the enthalpy of the fuel in the ground cloud to the ambient air-sensible enthalpy. The use of heat content (h) and mass rates (W), in the code instead of actual temperatures is for convenience, since this data is more readily available and does not necessarily require knowledge of ground cloud conditions such as temperature.

Fuel Heat Content

The fuel heat content is used in the buoyancy equation as indicated above. For the RD–170, the CFD results were used to calculate a final value. For each computation time step, the quotient of the plume thermal energy (table E–2-converted to calories) and plume mass (table E–2) defined the heat content in the plume as a function of time. The mean value for the last nine computational steps is 96 cal/g, with a standard deviation of 3.23 cal/g. The energy values provided by ED32 included both thermal and kinetic effects. The thermal energy is the difference between the total energy (table E–1) and the kinetic energy (table E–2). Because the determination of the duel heat content is important, several other methods were used for calculating an effective heat content as a basis for comparison. table E–3 summarizes the results. Column 1 of table E–3 is simply the product of the average specific heat of CO and CO_2 (cal/g-K) and the average plume temperature (K - table E–1). Using the average specific heat of CO and CO_2 only is based on the fact that these two gases represent the majority of the plume constituent other than air and steam and varies little over the temperature range of concern. Because air has a very similar value for specific heat, the specific heat value of air can also be introduced with little change in the average specific heat value. A value of 0.242 cal/g-C was used for the calculations in column 1 and 5 of Table E–3. Column 5 is the heat content of a ground cloud at 171.4 °C with a value of 112.2 cal/g. The temperature was the mean value of eight measurements of the Atlas MA–5 booster test program by Rocketdyne [4]. The measurements were made at approximately 120 meters from the deluge bucket exit. The heat values shown in column 2 were described above and are the basis for the input value to REEDM. Table E–3 column 3 values are based on quotient of the calculated energy and mass rates from the ED32 CFD results shown in Table E–2. The mean value is considerably lower than the others in the table, with considerable variance during the later computational intervals. The values shown in column 4 are slightly higher than column 2 due only to the added kinetic energy of the plume. These values are obtained as the quotient of the energy (table E–1) and mass (table E–2).

In summary, the value of 96 cal/g is a nominal value when compared to other heat content values computed by alternate methods. While the mean value of the plume thermal energy and mass is lower than four of the other values, it may be considered a somewhat conservative estimate of the heat content.

Initial Cloud Radius

The initial cloud radius is based on the mass of entrained moist air and plume mass (fuel + oxidizer + deluge water) for the 190-second test duration. Two methods were used to determine the final cloud volume and radius: (1) A classical energy balance method considering the entrained air mass to bring the plume exhaust to its final temperature and (2) directly applying the results from the CFD analysis. The mass of entrained moist air is the amount of moist air necessary to reduce the plume mass from the deluge bucket exit temperature, Te, to a final cloud temperature, Tc. The energy to reduce the plume mass to Tc must be the equivalent energy to raise the moist air from 70. °F to Tc. The plume mean temperature was based on the Rocketdyne measurements, to be 171.4 °C (340.0 °F) was used as the value for Tc. The density of moist air at 20.1 °C (70 F) is 1,115.2 g/m^3 (0.0742 lb/ft^3). The mean density of the plume based on CFD analysis is 698.7 g/m^3. The volume of the plume at Tc = 171. C is 5.938e6 m^3. The resulting radius is 112 meters. Using the CFD analysis results, the volume as a function of computation time was provided (table E–1) and volumetric rate (m^3/s) was calculated based on the rate of change of volume with computation time step (table E–2). The initial cloud volume is calculated by multiplying the volumetric rate by 190 seconds. The radius is calculated from the cloud volume assuming a spherical cloud (table E–2). The mean radius using this method is 117 meters, comparable to the value using the energy balance method and is the value used as input to the REEDM analysis.

References

1. Zanetti, Paolo, Air Pollution Modeling, pg. 95 (eg.'s 5-2 to 5-4 and 5-11).

2. Bjorkland, J. February 22, 1994 telephone conversation,

3. [REEDM (Version 7) Users Manual, pg. 20.

4. Melvold, R.W. June 1992 Correspondence, Final Report: Air Sampling for Chemical Analysis from Rocket Engine Test Firing Plums at the Rocketdyne Santa Susana Field Laboratory, Rockwell International, Canoga Park, CA.

TABLE F–1.—*Data from ED32 CFD analysis of RD–170*

Time (s)	Energy (Btu)	Plume Volume[1] (ft^3)	Temp.[2] (R)	Density (g/m^3)	Velocity u (f/s)	Velocity v (f/s)	Velocity w (f/s)
0.001605	1.1650E+06	1.47E+05	1057.92	663.57	638.48	143.88	28.70
0.002376	1.1690E+06	1.47E+05	1063.81	661.95	639.98	145.04	10.75
0.003895	1.1800E+06	1.48E+05	1070.08	660.14	643.59	146.86	12.44
0.008593	1.2080E+06	1.50E+05	1077.86	655.45	661.16	153.04	14.17
0.010326	1.2160E+06	1.51E+05	1078.98	653.78	667.38	154.72	14.13
0.012992	1.2320E+06	1.53E+05	1069.63	656.06	673.68	156.51	14.05
0.019413	1.2610E+06	1.56E+05	1046.68	662.59	684.38	158.73	14.51
0.023693	1.2820E+06	1.59E+05	1033.03	667.14	686.00	158.11	14.17
0.036534	1.3350E+06	1.66E+05	1005.35	678.23	686.74	156.41	15.08
0.042955	1.3680E+06	1.70E+05	992.97	685.08	679.65	152.80	16.75
0.047235	1.3890E+06	1.73E+05	985.51	689.36	672.88	149.28	16.54
0.051516	1.4100E+06	1.76E+05	980.03	693.55	666.21	146.26	16.62
0.055796	1.4363E+06	1.79E+05	974.75	699.05	659.65	143.37	17.32
0.062217	1.4497E+06	1.83E+05	957.597	705.80	647.28	136.68	21.83
0.066498	1.4660E+06	1.86E+05	947.793	711.70	635.82	132.14	24.72
0.077199	1.5018E+06	1.91E+05	925.169	717.39	619.56	126.90	23.46
0.08576	1.5340E+06	1.95E+05	910.17	739.72	611.56	124.17	26.28

NOTES: 1. Energy and volume are one-half of total due to model symmetry

2. Time is computational time, not actual transient from engine start

TABLE F–2.—*Calculated values from ED32 input*

Time (s)	Plume Energy Rate (cal/sec)	Plume Mass (g)	Flow Rate (g/sec)	Plume Total m^3	Vol. Rate $d/dt(m^3)$ (m^3/sec)	Plume Kinetic E (cal)	Plume Thermal E (cal)	Volume @190 sec (m^3)	Cloud Radius (m)	Plume Heat Content (cal/g)
0.001605		5.51E+06		8.305E+03		2.62E+07	5.61E+08			101.8
0.002376	2.615E+09	5.50E+06	–9.16E+06	8.315E+03	12497	2.63E+07	5.63E+08	2.37E+06	82.76	102.3
0.003895	3.650E+09	5.53E+06	1.50E+07	8.372E+03	37685	2.67E+07	5.68E+08	7.16E+06	119.57	102.8
0.008593	3.004E+09	5.58E+06	1.12E+07	8.512E+03	29919	2.85E+07	5.80E+08	5.68E+06	110.71	104.0
0.010326	2.327E+09	5.59E+06	8.04E+06	8.555E+03	24856	2.91E+07	5.84E+08	4.72E+06	104.08	104.4
0.012992	3.025E+09	5.68E+06	3.10E+07	8.652E+03	36141	3.01E+07	5.91E+08	6.87E+06	117.91	104.1
0.019413	2.276E+09	5.86E+06	2.86E+07	8.843E+03	29835	3.21E+07	6.03E+08	5.67E+06	110.61	103.0
0.023693	2.473E+09	6.00E+06	3.20E+07	8.988E+03	33900	3.30E+07	6.13E+08	6.44E+06	115.42	102.2
0.036534	2.080E+09	6.36E+06	2.85E+07	9.381E+03	30543	3.50E+07	6.38E+08	5.80E+06	111.48	100.2
0.042955	2.590E+09	6.60E+06	3.75E+07	9.639E+03	40162	3.56E+07	6.54E+08	7.63E+06	122.13	99.0
0.047235	2.473E+09	6.76E+06	3.69E+07	9.808E+03	39595	3.57E+07	6.64E+08	7.52E+06	121.55	98.3
0.051516	2.472E+09	6.92E+06	3.63E+07	9.973E+03	38526	3.57E+07	6.75E+08	7.32E+06	120.45	97.6
0.055796	3.097E+09	7.11E+06	4.48E+07	1.017E+04	45818	3.60E+07	6.88E+08	8.71E+06	127.61	96.8
0.062217	1.052E+09	7.32E+06	3.30E+07	1.037E+04	31600	3.56E+07	6.95E+08	6.00E+06	112.75	94.9
0.066498	1.919E+09	7.49E+06	3.95E+07	1.052E+04	35481	3.51E+07	7.04E+08	6.74E+06	117.19	94.0
0.077199	1.686E+09	7.76E+06	2.50E+07	1.081E+04	27065	3.45E+07	7.22E+08	5.14E+06	107.07	93.1
0.08576	1.896E+09	8.19E+06	5.02E+07	1.107E+04	29726	3.54E+07	7.38E+08	5.65E+06	110.47	90.1
	$\Delta(E)/\Delta(T)$	$\nu(\tau)^*\rho(\tau)$	$\Delta(M)/\Delta(T)$		$\Delta(\nu)/\Delta(T)$	$\rho\nu^*\nu/2$		Based on plume total mass and density		$E(\tau)/M(\tau)$
Mean (9)	2.141E+09	7.167E+06	3.687E+07	1.019E+04	3.539E+04	3.540E+07	6.864E+08	6.724E+06	117.00	96.0
1 s.d.	5.960E+08	5.824E+05	7.706E+06	5.541E+02	6.106E+03	4.534E+05	7.288E+08	1.160E+06	6.71	3.23

TABLE F–3.—*Comparisons of various methods for determining the energy content of the plume/cloud*

Time (s)	Heat Content (cal/g)	Heat Content (cal/g)	Heat Content (cal/g)	Heat Content (cal/g)	
0.001605	151.64	101.8		106.5	
0.002376	152.48	102.3		107.0	
0.003895	153.38	102.8	243.89	107.6	
0.008593	154.49	104.0	267.02	109.1	
0.010326	154.65	104.4	289.47	109.6	
0.012992	153.31	104.1	97.47	109.4	
0.019413	145.37	103.0	79.67	108.5	
0.023693	143.48	102.2	77.26	107.8	
0.036534	139.63	100.2	73.04	105.8	
0.042955	137.91	99.0	69.04	104.4	
0.047235	136.88	98.3	66.95	103.5	
0.051516	136.11	97.6	68.08	102.7	
0.055796	134.30	96.8	69.05	101.8	
0.062217	130.34	94.9	31.88	99.8	
0.066498	131.11	94.0	48.53	98.6	
0.077199	127.98	93.1	67.42	97.6	
0.08576	125.91	90.1	37.77	94.4	
Mean (last 9)	133.35	96.00	59.08	100.97	112.20
	Sensible Energy	$(E_{total} = E_{kinetic})/M(t)$	E_{rate}/M_{rate}	$E_{plume}(t)/M_{plume}(t)$	Heat content for estimated cloud temperature of 171.4 °C (473 K— the mean value of Rocketdyne MA–5 plume temperature measurements)

TABLE F–4.—*Summary of ED32 input parameters, calculated values and REEDM input*

Plume Values From ED32				
Mean temperature	964.4	R	535.78	K
Mean density	0.0436	lb/ft^3	698.7	g/m^3
Mean energy	1432200.0	Btu	360914400	cal
Mean volume	359722.22	ft^3	10194.02599	m^3
Mean velocity	668.6	ft/s	203.84	m/s
Plume Mean Calculations				
Total energy rate	8.50E+06	Btu/s	2.14E+09	cal/s
Total energy	2.86E+06	Btu	7.22E+08	cal
Kinetic energy	1.40E+05	Btu	3.54E+07	cal
Thermal energy	2.724E+06	Btu	6.86E+08	cal
Volumetric rate	1.249E+06	ft^3/s	35390	m^3/s
Mass rate	81114	lb/s	3.69E+07	g/s
REEDM Ground Cloud Parameters				
Total fuel	1004720	lb	4.568E+08	g
Fuel burn rate	5288	lb/s	2.40E+06	g/s
Fuel heat content	53.18	Btu/lb	96	cal/g
Radius	383.76	ft	117	m

NOTES: Fuel burn rate based on MSFC/EP13 value for Lox/RP flow

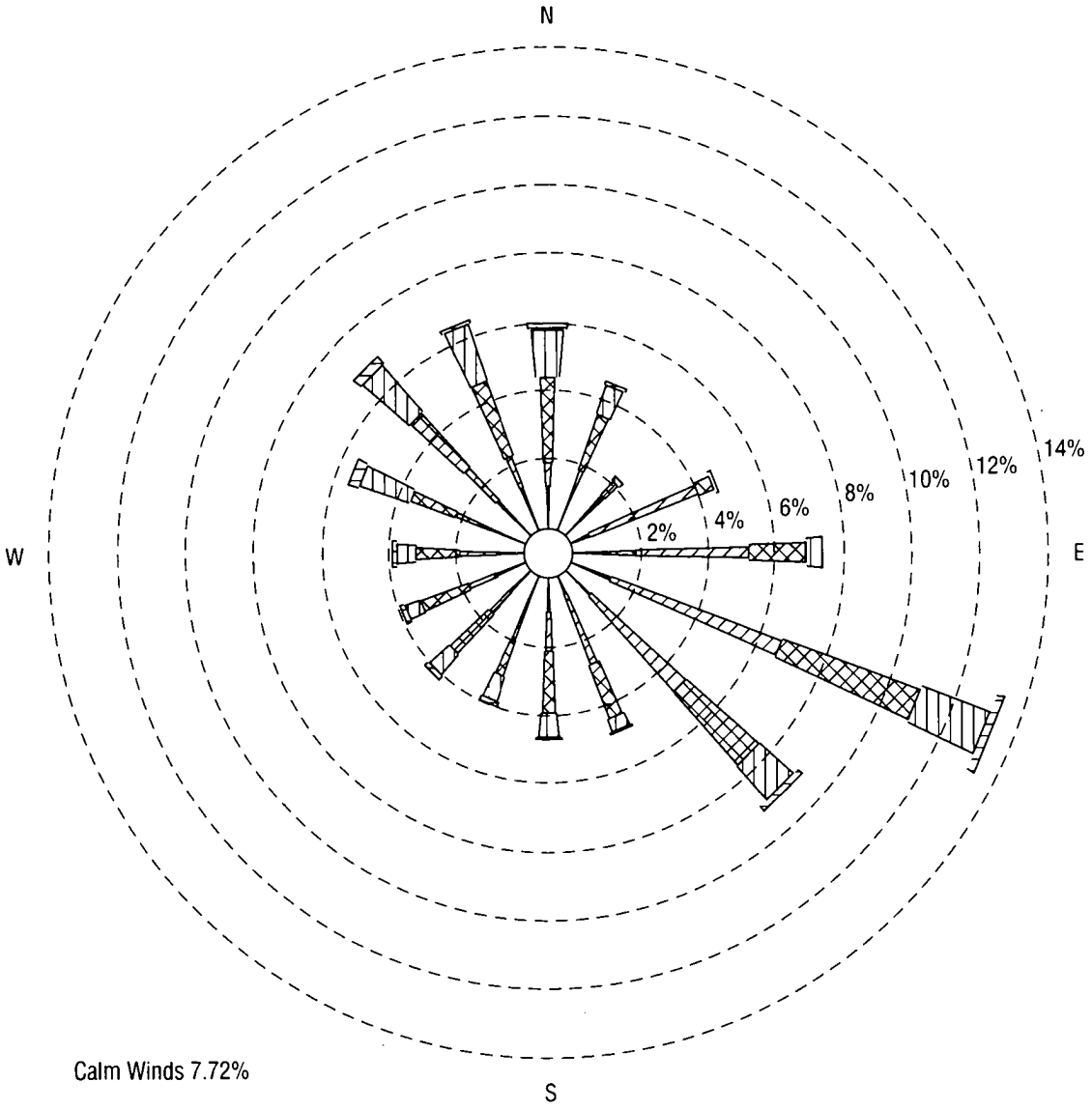
Fuel heat content based on MSFC/ED32 CFD results

Initial cloud radius based on MSFC/ED32 CFD volume rates over 190-sec test duration

Appendix G—Wind Rose Data

Huntsville 1992

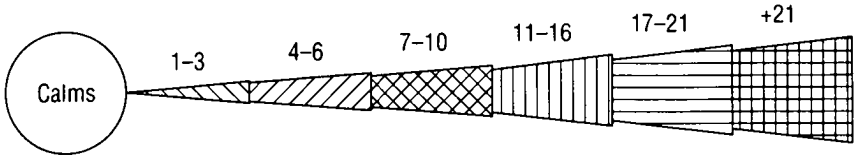
January 1 – December 31; Midnight – 11 p.m.



Calm Winds 7.72%

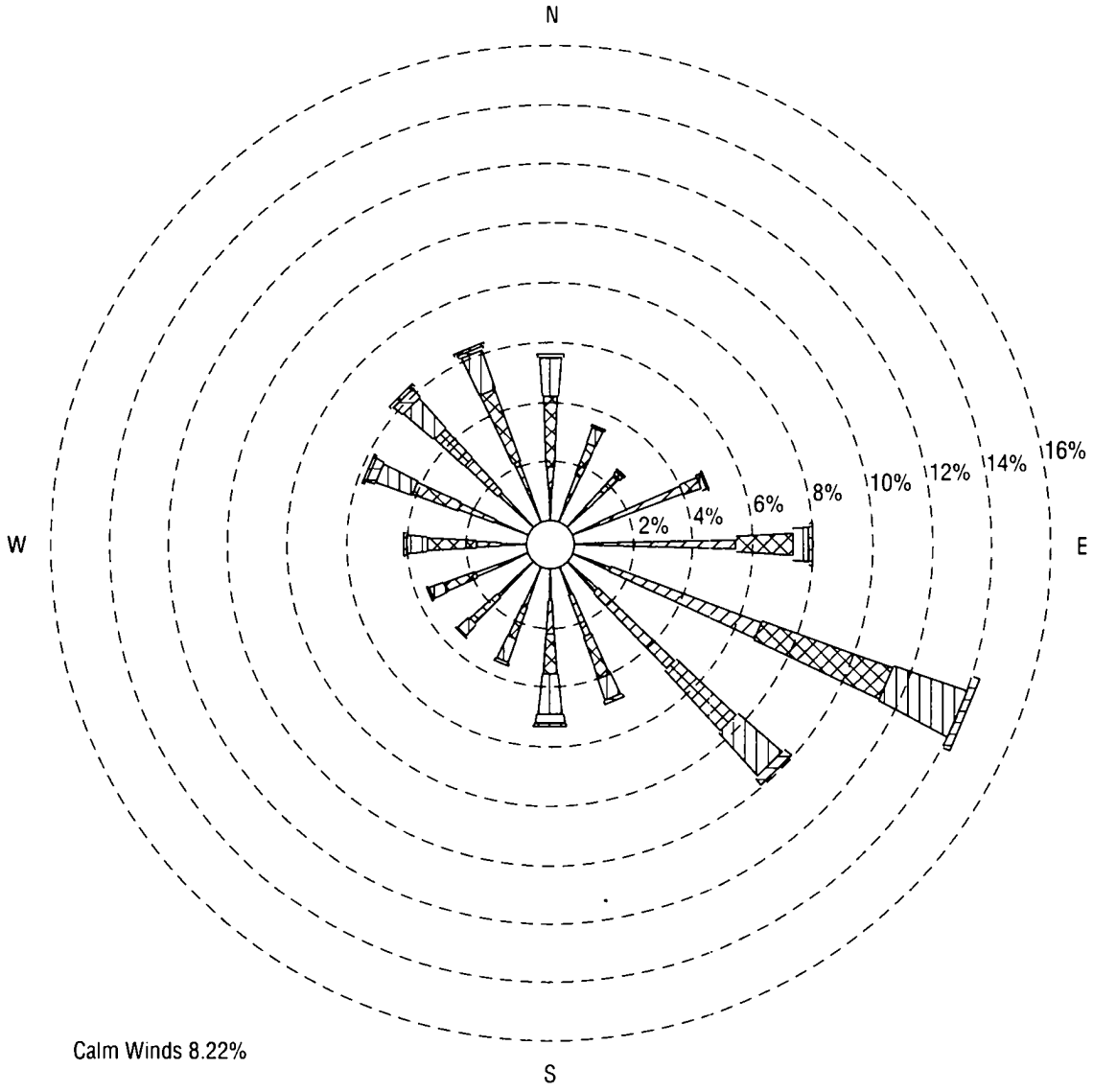
Note: Frequencies indicate direction from which the wind is blowing.

Wind Speed (knots)



Huntsville 1991

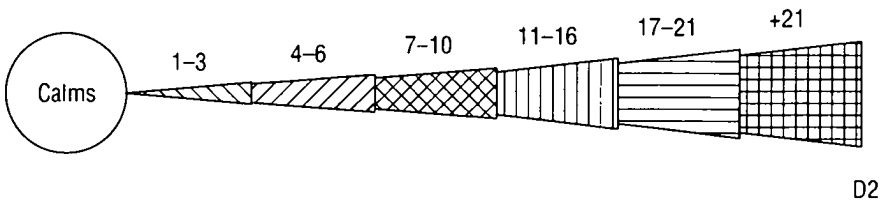
January 1 – December 31; Midnight – 11 p.m.



Calm Winds 8.22%

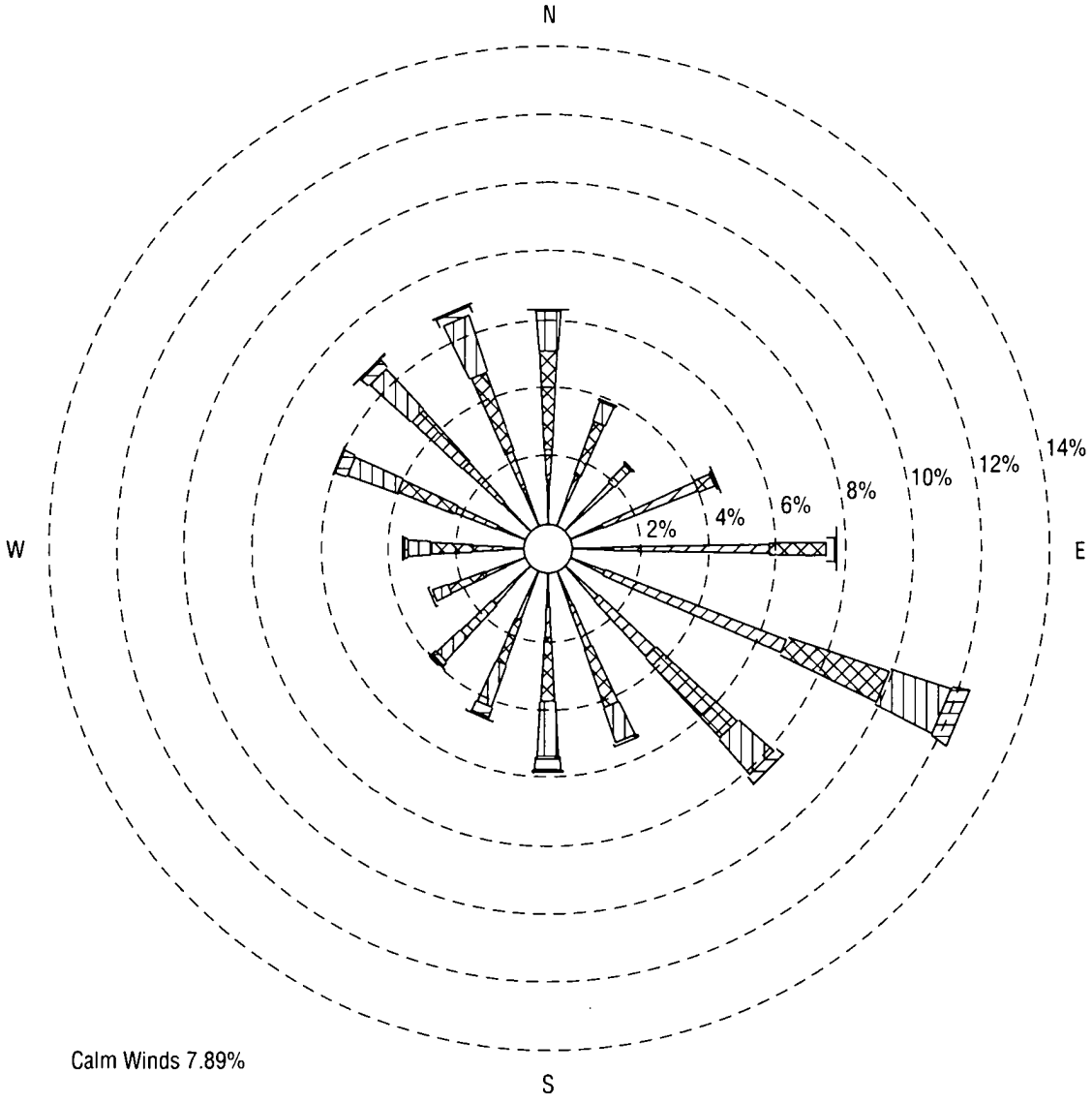
Note: Frequencies indicate direction from which the wind is blowing.

Wind Speed (knots)



Huntsville 1990

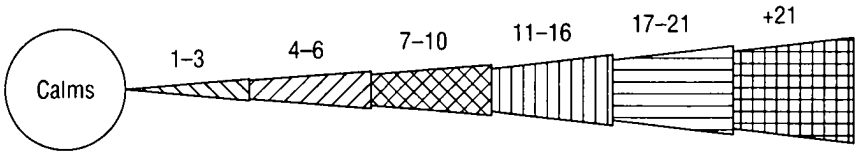
January 1 – December 31; Midnight – 11 p.m.



Calm Winds 7.89%

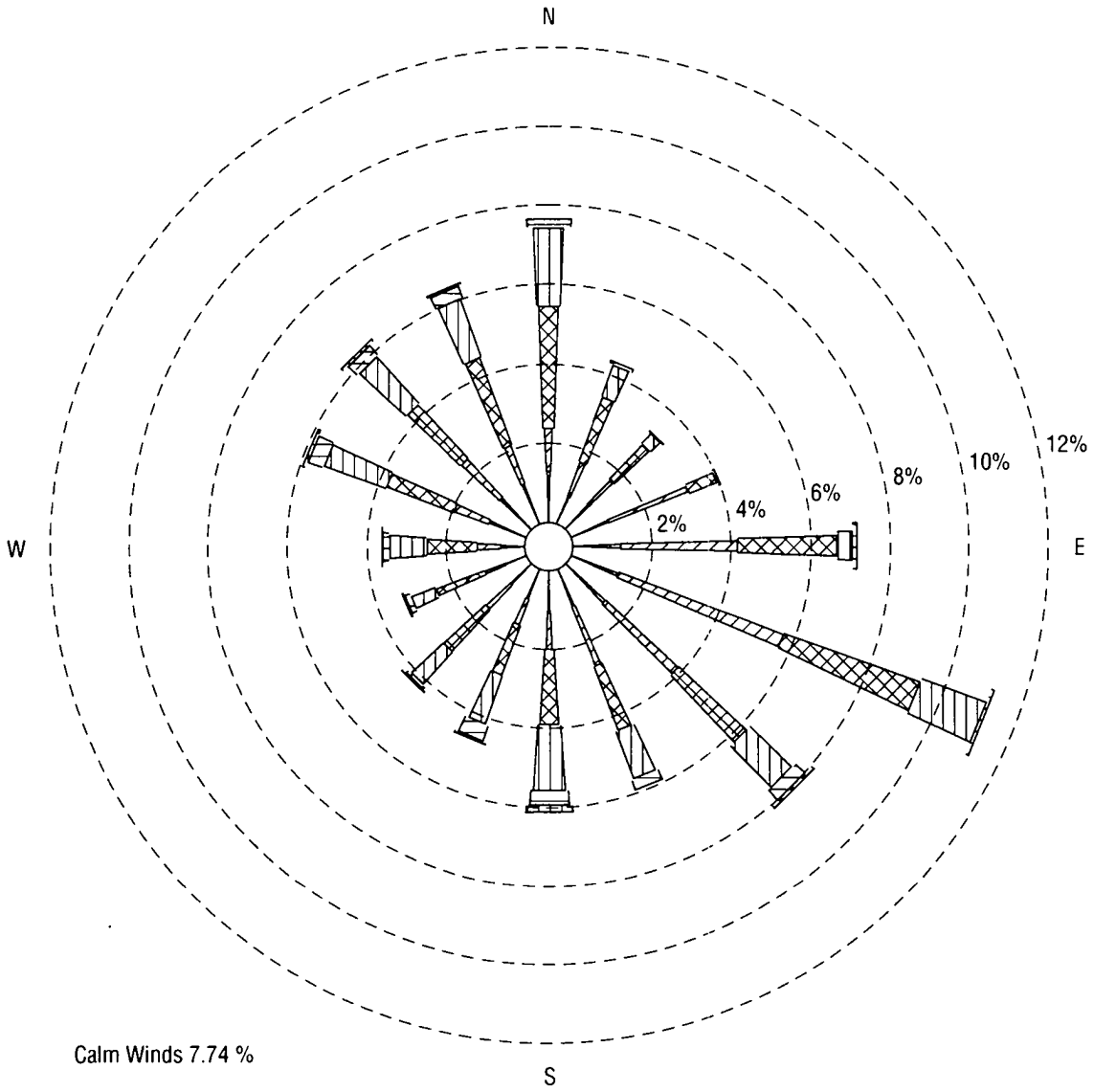
Note: Frequencies indicate direction from which the wind is blowing.

Wind Speed (knots)



Huntsville 1988

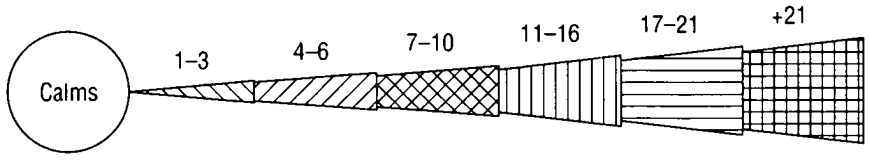
January 1 – December 31; Midnight – 11 p.m.



Calm Winds 7.74 %

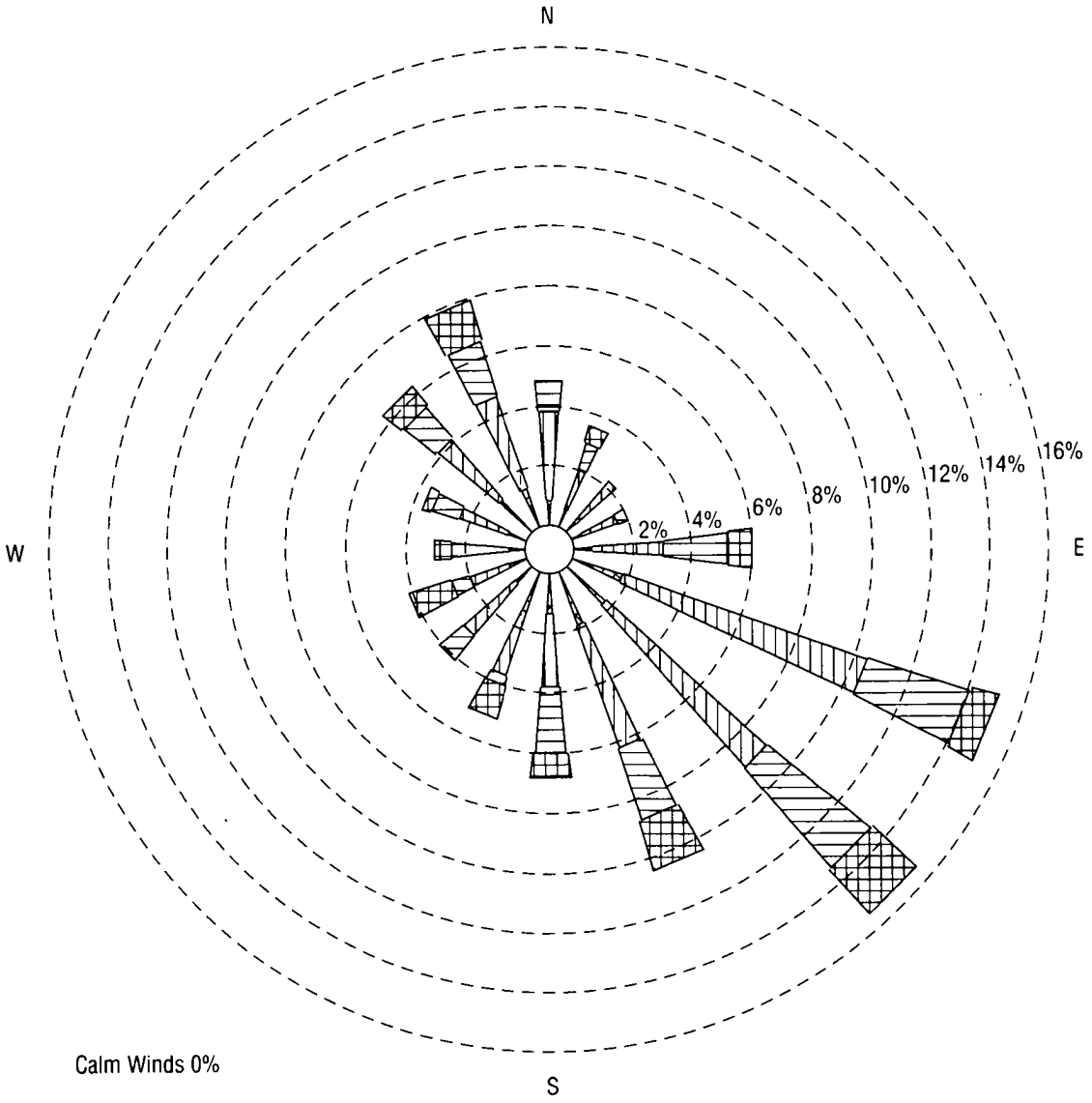
Note: Frequencies indicate direction from which the wind is blowing.

Wind Speed (knots)



SSC Annual

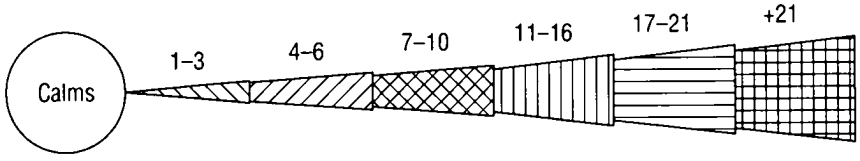
January 1 – December 31; 8 a.m. – 8 a.m.



Calm Winds 0%

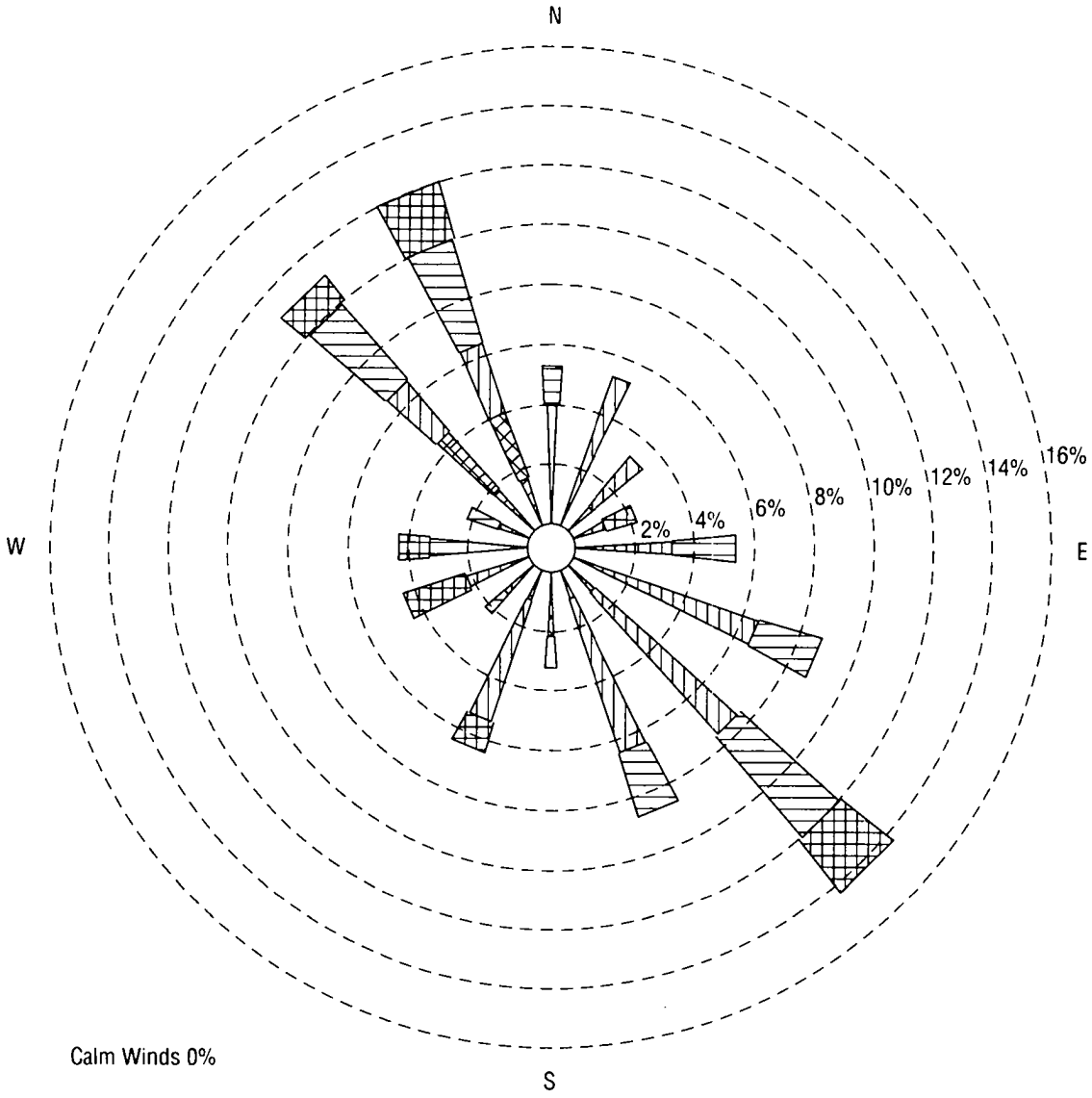
Note: Frequencies indicate direction from which the wind is blowing.

Wind Speed (knots)



SSC Winter

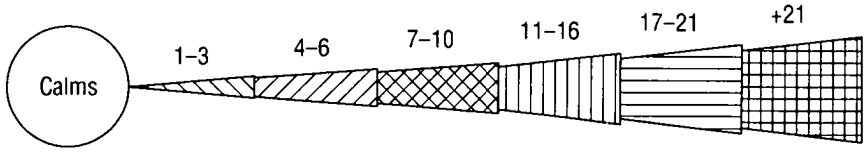
January 1 – March 31; 8 a.m. – 8 a.m.



Calm Winds 0%

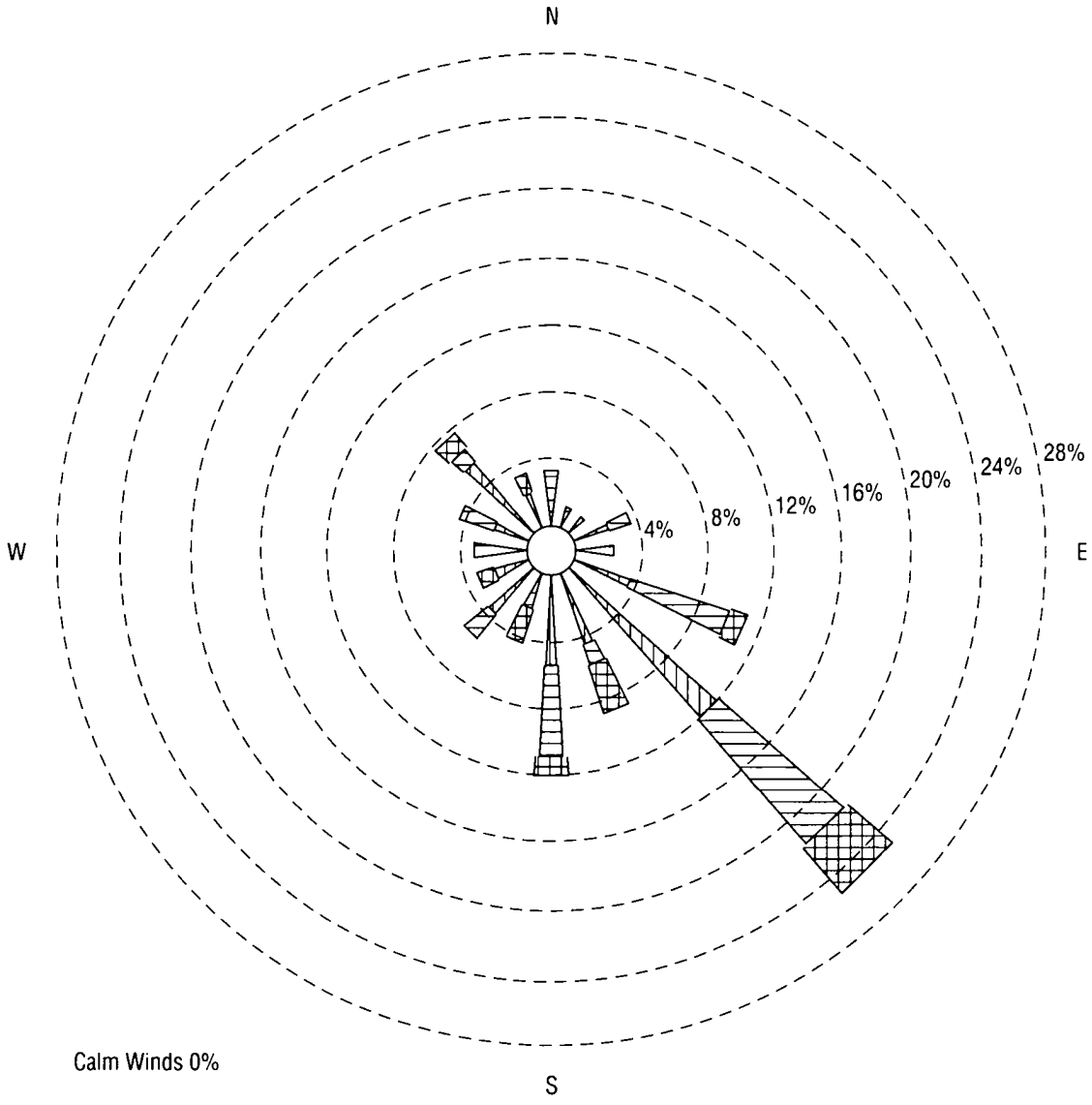
Note: Frequencies indicate direction from which the wind is blowing.

Wind Speed (knots)



SSC Spring

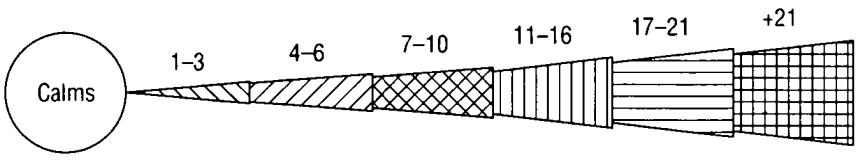
April 1 – June 30; 8 a.m. – 8 a.m.



Calm Winds 0%

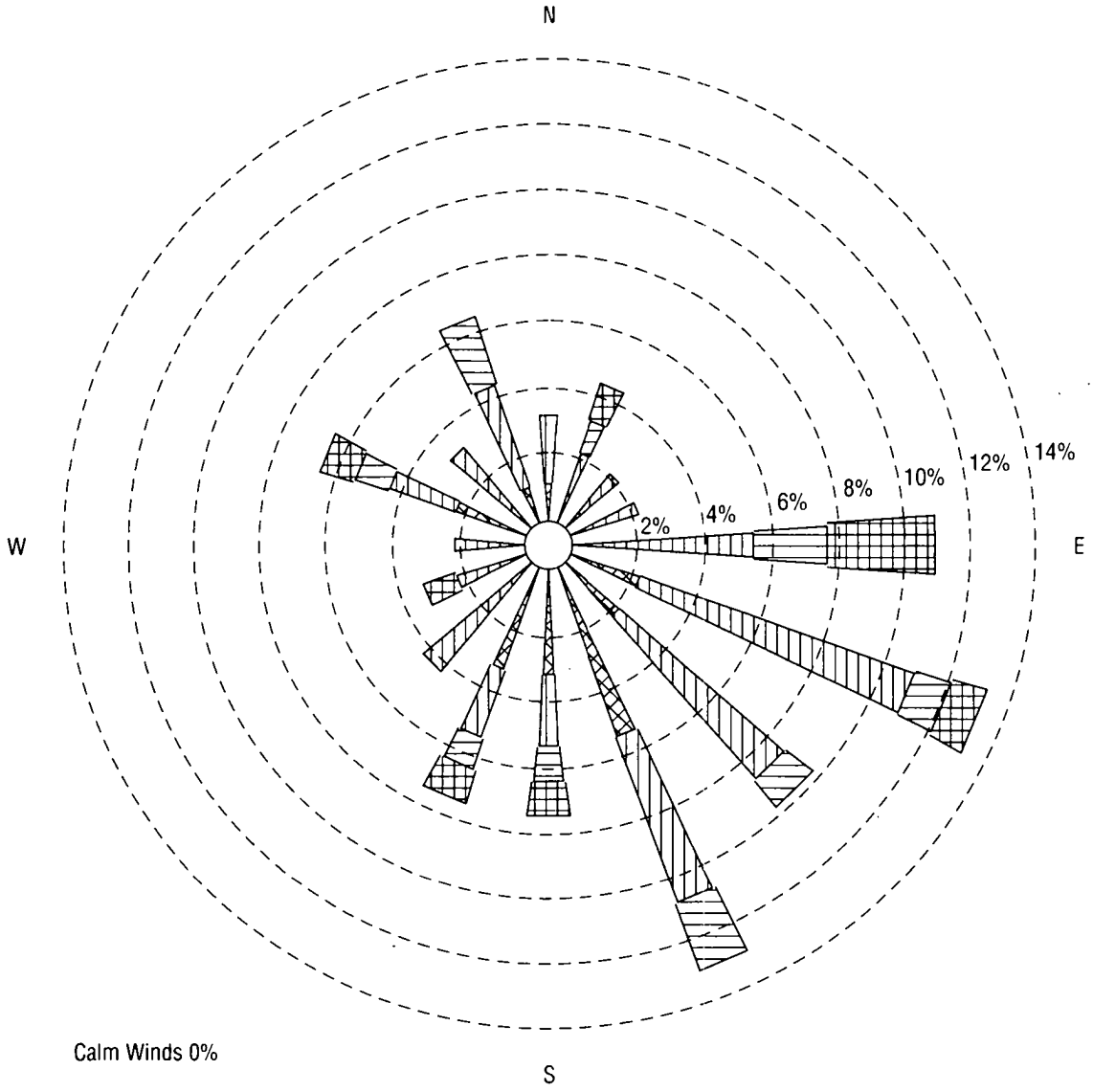
Note: Frequencies indicate direction from which the wind is blowing.

Wind Speed (knots)



SSC Summer

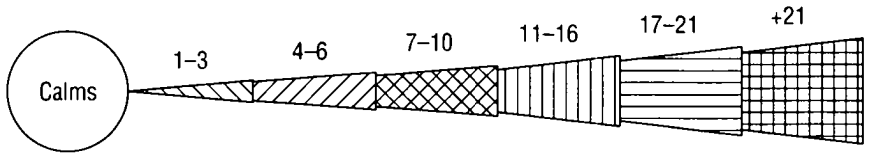
July 1 – September 30; 8 a.m. – 8 a.m.



Calm Winds 0%

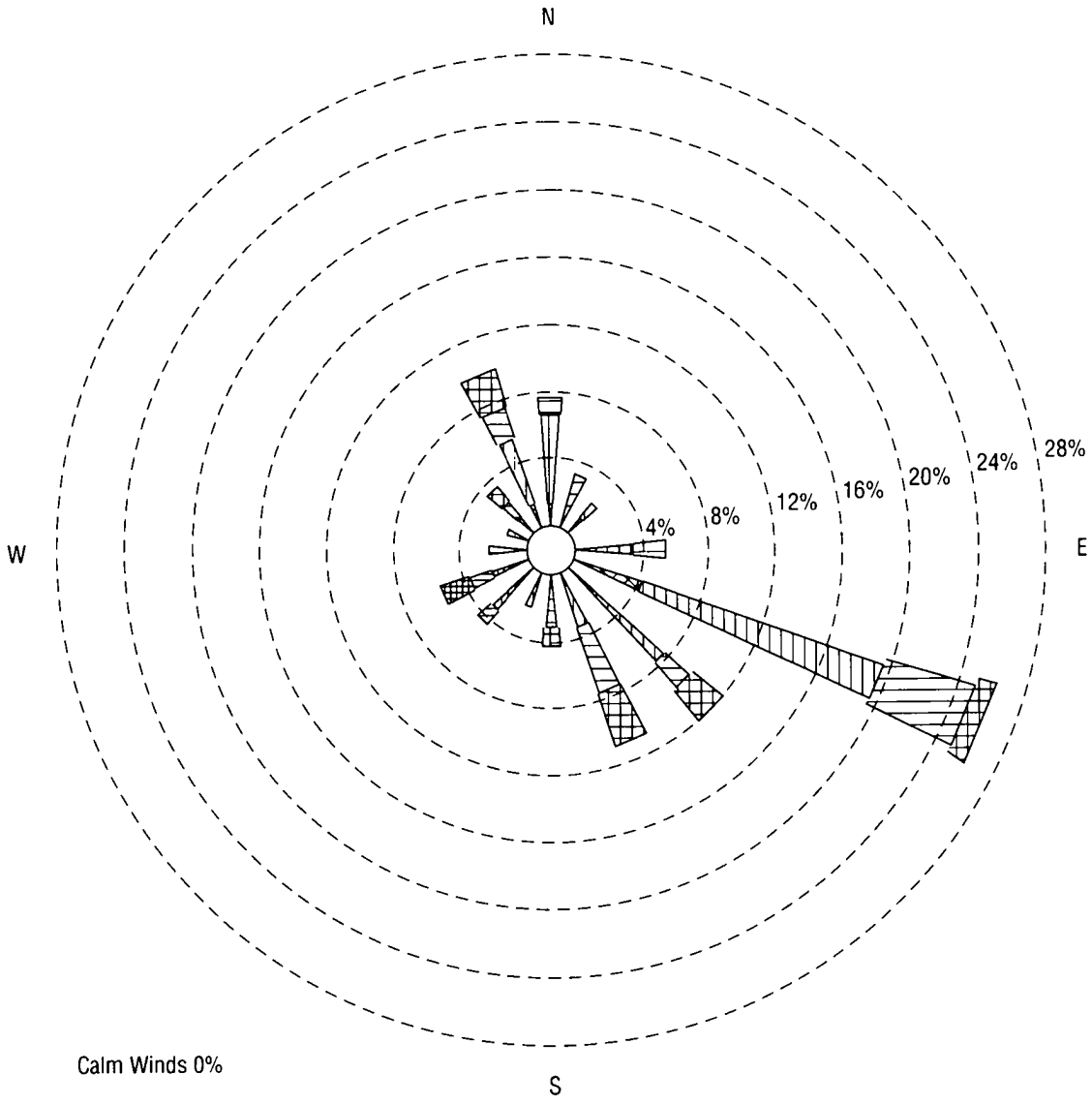
Note: Frequencies indicate direction from which the wind is blowing.

Wind Speed (knots)



SSC Fall

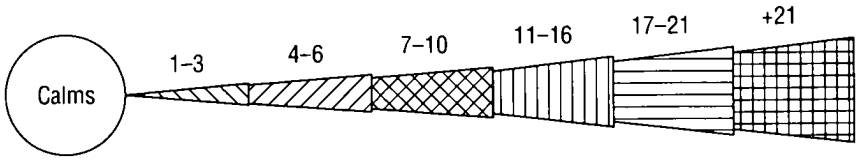
October 1 – December 31; 8 a.m. – 8 a.m.



Calm Winds 0%

Note: Frequencies indicate direction from which the wind is blowing.

Wind Speed (knots)



Appendix H—Noise Projections

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Introduction

Noise modeling was performed for a single engine test of the RD–170, RD–180, and RD–701A engines. Also noise modeling was performed for multiengine tests of five F–1, three RD–701, three RD–180, and seven RD–704 engines. The overall sound pressure level and octave band sound power levels for each engine were determined using the methodology presented in "Chemical Rocket/Propellant Hazards" (JANNAF Propulsion Committee, 1971).

Factors Used to Assess Noise Impacts

Workplace noise exposures are regulated at the federal level by OSHA. The regulations are described in 29 CFR 1910.95, "Occupational Noise Exposure." Workers at all of the manufacturing and testing facilities described in this document are equally protected by the requirements of these regulations. Since workplace noise is not generally considered an environmental problem and the level of protection to workers is equal at all the facilities, such noise is not addressed in this EIS.

There are no state or federal noise standards regulating environmental noise for testing engines at MSFC. Noise ordinance codes have been adopted by the city of Huntsville (Ordinance 93–312) and by the city of Madison (Ordinance 93–82) that regulate noise production by various sources. These local noise ordinances do not specifically address noise from rocket engine testing. Thus, determining compliance of testing activities with such ordinances is difficult. Rather than technical compliance with a nonapplicable ordinance limit, it is more appropriate to discuss the effects of noise on human factors of interest.

Rocket engines produce predominantly low-frequency noise, particularly as the distance from the engine increases. The human auditory system does not respond to this low frequency noise as much as it does to noise containing higher frequencies. The low-frequency sound is, however, detectable in the form of vibration in building walls and windows. Thus, two aspects of the sound require evaluation: sound that rattles buildings and sound that is audible to people (NASA/MSFC 1991a).

Low-frequency sound or vibrations are fairly well described and measured by use of the unweighted sound pressure in decibels (dB), whereas audible (middle-frequency) sound is best described using the A-weighted sound (dBA). Sound pressure levels are also called overall sound pressure levels (OASPL). MSFC has determined, based on experience from previous testing programs, that the respective levels of significance within the community are about 100 dB and 70 dBA for the OASPL and A-weighted scales, respectively (NASA/MSFC, 1991a).

Health Effects

The greatest potential for any health effect would be hearing loss. To protect against hearing loss, OSHA has established noise exposure levels of 90 dBA over an 8-hr work shift over a 40-yr career. Short-term noise exposures at levels up to 115 dBA can be experienced with no permanent hearing loss effects.

Structural Damage Claims

The probability of structural damage claims has been found to be proportional to the intensity of the low-frequency sound measured on the linear scale. One claim in 10,000 households is expected at a level of 103 dB, one in 1,000 households at 111 dB, and one in 100 households at 119 dB (NASA/MSFC, 1991a).

Speech Interference

Speech interference can occur at ambient noise levels above about 70 dBA. This means that people engaged in conversation outdoors would have to speak louder or move closer together to continue the conversation. In some locations, the level will be above 70 dBA during the brief tests and conversation will be momentarily interrupted. However, tests will be of short duration (up to about 2 minutes) and will be infrequent (up to one test per week), and the impact of the disruption would be minimal.

Sleep Interference

Interference with sleep can occur at levels as low as 45 dBA. Since most people sleep at night, daytime testing activities would not interfere. People who sleep during the day must normally learn to sleep with a greater level of exterior noise. However, at levels approaching or exceeding 95 dBA during engine tests, some interference to daytime sleepers would be expected. Again, because of the infrequency of tests, the very short duration, and the small number of daytime sleepers, the impact would be small at any site.

Comparison to Other Noise-Producing Activities

On a daily basis, people are exposed to high noise levels. Common noise levels in everyday life are found in Table 11 in the body of the report.

■ Predicted Far-Field Sound Level Pressures

Three different engine types and sizes were modeled during this analysis. The large engine was modeled after the 1.6-Mlb RD–170, a medium-size engine was modeled after the 816-Klb RD–180, and a small type was modeled after the 386-Klb RD–701A Russian engine. MSFC (ED33) has written a computer program (FARFIELD) based on early findings and procedures that were developed by this branch for publication in the "Chemical Rocket/Propellant Hazards"(JANNAF Propulsion Committee, 1971).

The procedure calculates each engine's total acoustic power (AOA) based on the engine's thrust (T) in pounds, exit velocity (V_e) in ft/sec, and acoustic efficiency (η).

$$\text{Mechanical Power (Mp)} = (0.678)\, T\, V_e \text{ (watts)}$$
$$\text{Total Acoustic Power (AOA)} = \eta\, Mp \text{ (watts)}$$
$$\text{AOA in decibels} = 10 \log (AOA / 10^{-12} \text{ watts})$$

Based on each engine's total acoustic power and by determining the octave band power level (OBPWL), the overall sound pressure level in dB (Re:0.00002 N/m^2) can be calculated for any given location by summing overall octave band frequencies and by taking into consideration the distance away from the source (R) in meters, directivity index data (D.I.) in dB, and normal atmospheric excess attenuation (EA) in dB/meter:

$$OBSPL\,(R, \theta, f) = OBPWL\,(f) + D.I.\,(\theta, f) - 20 \log (R) - EA\,(R, f) + MF - 8 \text{ dB}$$

Homogenous isentropic conditions are assumed for these calculations; consequently, the meteorological factor (MF) is set to zero. The meteorological effects due to refraction of the sound energy are addressed in the acoustical focusing section of this appendix.

TABLE H–1.—*Engine characteristics*

Engine Parameters	Large Type RD–170	Medium Type RD–180	Small Type RD–701A
Thrust, sea level (Klb)	1,632	816	386
Specific impulse, Isp (sec)	309	297	N/A
Exhaust velocity, V_e (ft/sec)	9,949	9,563	8,100
Exit diameter, D_e (ft)	12.14	12.14	5.84
Acoustic efficiency, h	0.5%	0.5%	0.5%
Mechanical power, Mp (watts)	1.101e+10	5.291e+9	2.120e+9
Acoustic power, AOA (dB, re. 10^{-12}watts)	197.41	194.23	190.26

TABLE H–2.—*Overall sound pressure level (dB) modeling data for RD–170 at F–1 stand*

Title: RD–170 Engine
Number of engines: 1
Engine diameter (ft): 12.14
Thrust per engine (lb): 1,632,000
Engine exhaust velocity (ft/sec): 9,949
Acoustic efficiency: 0.50
Engine type: F–1 (LOX/RP–1 1-eng)
Directivity type: deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 5.504263+07 (dB, re 10^{-12} watts) 197.407 (dB)

Constant Overall Sound Pressure Level Radii (meters)

Angle (°)	90 dB	95 dB	100 dB	105 dB	110 dB	115 dB	120 dB	125 dB
0	49,238	33,603	22,740	15,193	9,937	6,331	3,922	2,367
10	50,449	34,413	23,265	15,528	10,152	6,473	4,018	2,431
20	50,881	34,743	23,513	15,720	10,305	6,596	4,115	2,505
30	49,751	34,164	23,274	15,648	10,318	6,653	4,164	2,543
40	43,315	30,535	21,312	14,614	9,786	6,365	4,016	2,461
50	35,232	25,172	17,822	12,389	8,388	5,501	3,489	2,143
60	25,724	18,107	12,611	8,623	5,752	3,725	2,339	1,426
70	19,874	13,719	9,354	6,275	4,124	2,647	1,655	1,007
80	18,752	13,219	9,178	6,243	4,149	2,685	1,690	1034
90	18,951	13,281	9,211	6,281	4,193	2,728	1,724	1,059
100	17,536	12,200	8,378	5,656	3,743	2,421	1,524	933
110	16,626	11,516	7,875	5,303	3,506	2,270	1,432	878
120	14,929	10,289	7,003	4,698	3,097	1,997	1,254	765
130	12,566	8,636	5,854	3,905	2,553	1,629	1,011	610
140	11,631	7,894	5,279	3,476	2,243	1,413	867	518
150	10,219	6,773	4,429	2,853	1,805	1,115	672	396
160	9,165	5,968	3,838	2,430	1,509	916	433	317
170	8,727	5,624	3,577	2,237	1,372	823	484	280
180	8,580	5,508	3,487	2,172	1,326	793	465	269

TABLE H–3.—*Sound level (dBA) modeling data for RD–170 at F1 stand*

Title: RD–170 Engine (A-weighting)
Number of engines: 1
Engine diameter (ft): 12.14
Thrust per engine (lb): 1,632,000
Engine exhaust velocity (ft/sec): 9,949
Acoustic Efficiency: 0.50
Engine type: F–1 (LOX/RP–1 1-eng)
Directivity type: deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 5.504263+07 (dB, re 10^{-12} watts) 197.407 (dB)

Constant Sound Pressure Level Radii (meters)

Angle (°)	65 dBA	70 dBA	75 dBA	80 dBA	85 dBA	90 dBA	95 dBA	100 dBA
0	14,031	11,389	9,171	7,320	5,775	4,482	3,403	2,510
10	14,449	11,822	9,593	7,710	6,124	4,785	3,659	2,722
20	15,030	12,383	10,126	8,212	6,584	5,201	4,024	3,034
30	15,290	12,573	10,273	8,335	6,699	5,310	4,128	3,129
40	15,258	12,480	10,120	8137	6,474	5,080	3,909	2,932
50	15,084	12,282	9,885	7,862	6,171	4,764	3,602	2,649
60	13,941	11,457	9,315	7,487	5,938	4,628	3,526	2,611
70	12,699	10,597	8,764	7,168	5,780	4,576	3,539	2,658
80	12,840	10,730	8,899	7,307	5,922	4,716	3,673	2,781
90	13,110	10,962	9,091	7,462	6,044	4,810	3,744	2,834
100	12,467	10,471	8,727	7,201	5,861	4,687	3,664	2,785
110	12,183	10,278	8,611	7,143	5,846	4,698	3,693	2,821
120	11,660	9,841	8,242	6,827	5,572	4,462	3,489	2,648
130	10,808	9,099	7,596	6,265	5,084	4,041	3,128	2,345
140	10,138	8,527	7,106	5,844	4,720	3,727	2,861	2,121
150	9,164	7,687	6,373	5,201	4,157	3,238	2,443	1,775
160	8,404	6,994	5,742	4,630	3,648	2,791	2,060	1,460
170	7,947	6,570	5,351	4,272	3,324	2,507	1,820	1,266
180	7,783	6,419	5,213	4,146	3,212	2,410	1,739	1,202

TABLE H–4.—*Overall sound pressure level (dB) modeling data for RD–180 at AETF*

Title: RD–180 Engine
Number of engines: 1
Engine diameter (ft): 12.14
Thrust per engine (lb): 816,000
Engine exhaust velocity (ft/sec): 9,563
Acoustic efficiency: 0.50
Engine type: F–1 (LOX/RP–1 1-eng)
Directivity type: deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 2.64536+07 (dB, re 10^{-12} watts) 194.225 (dB)

Constant Overall Sound Pressure Level Radii (meters)

Angle (°)	85 dB	90 dB	95 dB	100 dB	105 dB	110 dB	115 dB	120 dB
0	57,934	39,546	26,812	17,977	11,836	7,604	4,756	2,894
10	59,299	40,511	27,449	18,385	12,096	7,773	4,868	2,969
20	59,773	40,880	27,729	18,596	12,261	7,905	4,973	3,049
30	58,314	40,081	27,350	18,454	12,238	7,938	5,016	3,087
40	50,152	35,353	24,742	17,058	11,513	7,559	4,815	2,978
50	40,493	28,905	20,508	14,336	9,789	6,487	4,158	2,580
60	29,687	20,882	14,570	10,008	6,723	4,392	2,784	1,713
70	23,065	15,932	10,882	7,324	4,838	3,127	1,970	1,208
80	21,520	15,188	10,579	7,233	4,838	3,155	2,002	1,236
90	21,857	15,296	10,619	7,266	4,878	3,197	2,039	1,263
100	20,245	14,094	9,698	6,571	4,371	2,846	1,806	1,115
110	19,227	13,324	9,128	6,164	4,092	2,666	1,694	1,048
120	17,301	11,919	8,124	5,463	3,616	2,347	1,485	914
130	14,536	9,995	6,788	4,543	2,986	1,919	1,202	731
140	13,521	9,187	6,157	4,067	2,638	1,674	1,035	623
150	12,003	7,966	5,217	3,370	2,142	1,333	809	480
160	10,853	7,073	4,556	2,893	1,805	1,103	659	386
170	10,382	6,699	4,269	2,679	1,652	997	590	343
180	10,226	6,574	4,171	2,607	1,600	962	567	329

TABLE H–5.—*Sound level (dBA) modeling data for RD–180 at AETF*

Title: RD–180 Engine (A-weighting)
Number of engines: 1
Engine diameter (ft): 12.14
Thrust per engine (lb): 816,000
Engine exhaust velocity (ft/sec): 9,563
Acoustic efficiency: 0.50
Engine type: F–1 (LOX/RP–1 1-eng)
Directivity type: Deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 2.64536+07 (dB, re 10^{12} watts) 194.225 (dB)

	Constant Sound Level Radii (meters)							
Angle(°)	**70 dBA**	**75 dBA**	**80 dBA**	**85 dBA**	**90 dBA**	**95 dBA**	**100 dBA**	**105 dBA**
0	9,884	7,913	6,270	4,895	3,745	2,789	2,010	1,392
10	10,313	8,317	6,635	5,214	4,018	3,017	2,194	1,536
20	10,854	8,831	7,110	5,646	4,401	3,348	2,470	1,757
30	11,011	8,958	7,225	5,756	4,506	3,446	2,558	1,830
40	10,877	8,771	7,007	5,526	4,281	3,241	2,380	1,685
50	10,655	8,509	6,711	5,211	3,970	2,947	2,120	1,468
60	10,004	8,075	6,436	5,047	3,876	2,899	2,098	1,461
70	9,361	7,687	6,230	4,964	3,870	2,936	2,155	1,520
80	9,493	7,824	6,370	5,105	4,006	3,063	2,266	1,614
90	9,699	7,993	6,504	5,209	4,086	3,123	2,311	1,647
100	9,295	7,698	6,295	5,065	3,991	3,062	2,274	1,626
110	9,154	7,620	6,265	5,068	4,014	3,0956	2,312	1,662
120	8,764	7,288	5,979	4,820	3,799	2,913	2,159	1,539
130	8,085	6,697	5,465	4,375	3,418	2,590	1,893	1,327
140	7,567	6,252	5,081	4,044	3,134	2,351	1,697	1,173
150	6,799	5,579	4,491	3,530	2,692	1,981	1,399	944
160	6,147	4,987	3,961	3,061	2,288	1,644	1,130	742
170	5,744	4,617	3,625	2,764	2,033	1,434	967	623
180	5,602	4,488	3,508	2,661	1,946	1,364	914	585

TABLE H–6.—*Sound sound pressure level (dB) modeling data for RD–701A at AETF*

Title: RD–701A Engine

Number of engines: 1

Engine diameter (ft): 5.84

Thrust per engine (lb): 386,000

Engine exhaust velocity (ft/sec): 8,100

Acoustic efficiency: 0.50

Engine type: F–1 (LOX/RP–1 1-eng)

Directivity type: deflected LOX/RP–1 (F–1, S–1c, S–1b)

Acoustic power: 1.05992+07 (dB, re 10^{-12} watts) 190.253 (dB)

Constant Overall Sound Pressure Level Radii (meters)

Angle(°)	80 dB	85 dB	90 dB	95 dB	100 dB	105 dB	110 dB	115 dB
0	44,967	31,556	22,086	15,302	10,414	6,905	4,442	2,770
10	46,003	32,228	22,510	15,576	10,601	7,042	4,545	2,847
20	46,426	32,552	22,766	15,795	10,803	7,224	4,701	2,971
30	45,661	32,233	22,700	15,867	10,926	7,357	4,816	3,061
40	41,015	29,775	21,477	15,288	10,660	7,238	4,760	3,029
50	34,453	25,512	18,768	13,602	9,621	6,596	4,363	2,783
60	25,855	19,054	13,960	10,064	7,071	4,815	3,163	2,005
70	20,364	14,782	10,638	7,531	5,209	3,504	2,286	1,444
80	19,802	14,661	10,705	7,655	5,331	3,607	2,365	1,501
90	19,870	14,705	10,771	7,747	5,431	3,699	2,439	1,555
100	18,471	13,529	9,787	6,950	4,821	3,258	2,137	1,358
110	17,586	12,835	9,248	6,543	4,530	3,061	2,011	1,281
120	16,004	11,637	8,348	5,881	4,055	2,727	1,784	1,130
130	13,877	10,070	7,185	5,021	3,429	2,280	1,471	920
140	12,840	9,201	6,477	4,464	3,010	1,976	1,259	778
150	11,193	7,838	5,395	3,644	2,408	1,552	970	589
160	9,999	6,902	4,681	3,112	2,019	1,275	782	467
170	9,462	6,463	4,334	2,847	1,823	1,136	688	407
180	9,272	6,304	4,208	2,751	1,754	1,088	656	387

TABLE H–7.—*Sound level (dBA) modeling data for RD–701A at AETF*

Title: RD–701A Engine (A-weighted)
Number of engines: 1
Engine diameter (ft): 5.84
Thrust per engine (lb): 386,000
Engine exhaust velocity (ft/sec): 8,100
Acoustic efficiency: 0.50
Engine type: F–1 (LOX/RP–1 1-eng)
Directivity type: deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 1.05992+07 (dB, re 10^{-12} watts) 190.253 (dB)

	Constant Sound Level Radii (meters)							
Angle(°)	**75 dBA**	**80 dBA**	**85 dBA**	**90 dBA**	**95 dBA**	**100 dBA**	**105 dBA**	**110 dBA**
0	7,211	5,682	4,406	3,346	2,471	1,763	1,208	794
10	7,597	6,025	4,704	3,597	2,678	1,930	1,338	889
20	8,102	6,486	5,116	3,956	2,984	2,181	1,535	1,037
30	8,239	6,608	5,230	4,062	3,080	2,264	1,604	1,089
40	8,042	6,387	5,004	3,849	2,889	2,102	1,474	991
50	7,771	6,085	4,689	3,541	2,605	1,855	1,271	835
60	7,404	5,857	4,557	3,471	2,572	1,843	1,271	840
70	7,063	5,689	4,502	3,484	2,621	1,906	1,332	891
80	7,203	5,831	4,644	3,619	2,744	2,013	1,420	959
90	7,362	5,954	4,737	3,689	2,797	2,052	1,448	979
100	7,095	5,772	4,616	3,612	2,750	2,025	1,434	972
110	7,038	5,756	4,628	3,641	2,788	2,065	1,471	1,003
120	6,730	5,492	4,401	3,446	2,622	1,926	1,360	918
130	6,177	5,014	3,989	3,093	2,326	1,685	1,170	776
140	5,759	4,654	3,678	2,828	2,102	1,502	1,027	671
150	5,128	4,102	3,199	2,419	1,763	1,231	821	524
160	4,545	3,598	2,756	2,039	1,448	983	638	397
170	4,208	3,277	2,474	1,799	1,254	835	531	326
180	4,084	3,166	2,378	1,719	1,190	787	498	304

TABLE H–8.—*Sound pressure level (dB) modeling data for five F–1A engines*

Title: F–1A (5 Engines)
Number of engines: 5
Engine diameter (ft): 11.9600
Thrust per engine (lb): 1,800,000
Engine exhaust velocity (ft/sec): 10,137
Acoustic efficiency: 0.500000
Engine type: S–1C (LOX/RP–1 5-eng)
Directivity type: Ddeflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 3.09280e+08 (dB, re 10^{-12} watts) 204.904 (dB)

Constant Overall Sound Pressure Level Radii (meters)

Angle(°)	90 dB	95 dB	100 dB	105 dB	110 dB	115 dB	120 dB
0	91,544	62,505	42,400	28,627	19,167	12,644	8,160
10	93,515	63,997	43,449	29,320	19,609	12,925	8,341
20	94,540	64,672	43,919	29,652	19,851	13,111	8,490
30	91,814	62,967	42,961	28,183	19,664	13,072	8,523
40	76,022	53,274	37,370	26,105	18,032	12,226	8,083
50	60,258	42,769	30,424	21,583	15,154	10,422	6,967
60	44,585	31,343	22,049	15,455	10,709	7,263	4,785
70	35,120	24,408	16,894	11,606	7,854	5,200	3,353
80	32,336	22,827	16,135	11,301	7,769	5,209	3,387
90	33,259	23,231	16,291	11,377	7,831	5,270	3,443
100	30,798	21,498	14,989	10,366	7,044	4,673	3,017
110	29,470	20,462	14,199	9,768	6,601	4,358	2,800
120	26,683	18,445	12,737	8,708	5,846	3,833	2,446
130	22,387	15,518	10,712	7,293	4,858	3,153	1,990
140	21,083	14,464	9,862	6,618	4,343	2,778	1,729
150	19,227	12,896	8,578	5,608	3,587	2,241	1,367
160	17,812	11,723	7,653	4,917	3,093	1,902	1,143
170	17,213	11,232	7,257	4,615	2,873	1,749	1,042
180	17,017	11,068	7,123	4,511	2,979	1,696	1,008

TABLE H–9.—*Sound level (dBA) modeling data for five F–1A engines*

Title: F–1A (5 Engines)
Number of engines: 5
Engine diameter (ft): 11.9600
Thrust per engine (lb): 1,800,000
Engine exhaust velocity (ft/sec): 10,137
Acoustic efficiency: 0.500000
Engine type: S–1C (LOX/RP–1 5 F–1's)
Directivity type: deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 3.09280e+08 (dB, re 10^{-12} watts) 204.904 (dB)

Constant Overall Sound Pressure Level Radii (meters)

Angle(°)	65 dBA	70 dBA	75 dBA	80 dBA	85 dBA	90 dBA	95 dBA	100 dBA
0	19,250	15,743	12,699	10,092	7,897	6,078	4,593	3,395
10	19,566	16,100	13,085	10,489	8,282	6,433	4,905	3,658
20	20,189	16,709	13,665	11,035	8,788	6,893	5,316	4,016
30	20,668	17,107	13,973	11,263	8,955	7,024	5,425	4,112
40	20,725	17,126	13,955	11,198	8,848	6,880	5,257	3,940
50	20,553	16,974	13,805	11,039	8,665	6,668	5,024	3,699
60	18,721	15,518	12,669	10,176	8,038	6,235	4,741	3,523
70	16,405	13,675	11,263	9,159	7,346	5,801	4,496	3,405
80	16,624	13,844	11,403	9,285	7,468	5,922	4,617	3,522
90	16,992	14,174	11,689	9,526	7,665	6,078	4,737	3,612
100	15,904	13,280	10,979	8,981	7,262	5,790	4,540	3,481
110	15,401	12,867	10,661	8,754	7,116	5,710	4,505	3,477
120	14,638	12,219	10,121	8,310	6,751	5,409	4,255	3,270
130	13,541	11,247	9,275	7,584	6,134	4,886	3,816	2,905
140	12,618	10,453	8,602	7,020	5,662	4,492	3,485	2,630
150	11,218	9,280	7,623	6,201	4,970	3,907	2,992	2,220
160	10,338	8,485	6,909	5,560	4,400	3,404	2,558	1,855
170	9,809	8,009	6,478	5,169	4,049	3,093	2,289	1,630
180	9,602	7,830	6,320	5,030	3,925	2,985	2,197	1,556

TABLE H–10.—*Sound pressure level (dB) modeling data for three RD–180 engines*

Title: RD–180 Engine
Number of engines: 3
Engine diameter (ft): 12.14
Thrust per engine (lb): 816,000
Engine exhaust velocity (ft/sec): 9,563
Acoustic efficiency: 0.50
Engine type: F–1 (LOX/RP–1 1-eng)
Directivity type: deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 7.93607e+07 (dB, re 10^{-12} watts) 198.996 (dB)

Constant Overall Sound Pressure Level Radii (meters)

Angle(°)	85 dB	90 dB	95 dB	100 dB	105 dB	110 dB	115 dB	120 dB
0	82,894	56,943	38,855	26,332	17,636	11,607	7,450	4,651
10	84,690	58,302	39,803	29,957	18,036	11,862	7,616	4,762
20	85,300	58,774	40,168	27,232	18,254	12,026	7,747	4,866
30	82,980	57,350	39,394	26,867	18,119	12,008	7,778	4,908
40	69,978	49,366	34,789	24,334	16,767	11,299	7,407	4,714
50	55,842	39,877	28,461	20,183	14,095	9,609	6,361	4,071
60	41,409	29,215	20,546	14,327	9,834	6,597	4,303	2,723
70	32,588	22,682	15,661	10,689	7,190	4,746	3,063	1,927
80	29,891	21,190	14,944	10,402	7,106	4,746	3,091	1,959
90	30,660	21,504	15,046	10,436	7,139	4,787	3,133	1,995
100	28,459	19,921	13,859	9,528	6,453	4,288	2,788	1,767
110	27,159	18,916	13,099	8,967	6,052	4,016	2,612	1,658
120	24,560	17,013	11,715	7,979	5,364	3,548	2,300	1,453
130	20,638	14,292	9,822	6,667	4,458	2,928	1,880	1,175
140	19,383	13,287	9,023	6,044	3,988	2,585	1,639	1,012
150	17,567	11,783	7,814	5,116	3,303	2,097	1,303	790
160	16,187	10,643	6,936	4,462	2,833	1,766	1,078	643
170	15,620	10,178	6,566	4,179	2,621	1,615	974	575
180	15,434	10,024	6,441	4,083	2,550	1,563	939	553

TABLE H–11.—*Sound level (dBA) modeling data for three RD–180 engines*

Title: RD–180 Engine (A-weighting)
Number of engines: 3
Engine diameter (ft): 12.14
Thrust per engine (lb): 816,000
Engine exhaust velocity (ft/sec): 9,563
Acoustic efficiency: 0.50
Engine type: F–1 (LOX/RP–1 1-eng)
Directivity type: deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic tower: 7.93607e+07 (dB, re 10^{-12} watts) 198.996 (dB)

Constant Sound Level Radii (meters)

Angle(°)	70 dBA	80 dBA	90 dBA	100 dBA	110 dBA
0	12,122	7,832	4,838	2,751	1,368
10	12,556	8,235	5,155	2,976	1,510
20	13,121	8,746	5,585	3,304	1,728
30	13,326	8,871	5,694	3,402	1,801
40	13,251	8,685	4,464	3,197	1,657
50	13,059	8,420	5,150	2,905	1,442
60	12,146	7,995	4,989	2,858	1,435
70	11,189	7,615	4,910	2,897	1,495
80	11,322	7,752	5,050	3,023	1,588
90	11,565	7,918	5,153	3,082	1,620
100	11,033	7,629	5,013	3,023	1,600
110	10,813	7,555	5,017	3,057	1,635
120	10,354	7,225	4,770	2,875	1,513
130	9,579	6,637	4,328	2,556	1,305
140	8,978	6,195	4,000	2,319	1,152
150	8,101	5,526	3,488	1,952	926
160	7,388	4,938	3,022	1,618	727
170	6,954	4,569	2,727	1,410	610
180	6,800	4,440	2,626	1,341	573

TABLE H–12.—*Sound pressure level (dB) modeling data for three RD–701 engines*

Title: RD–701 Engine
Number of engines: 3
Engine diameter (ft): 8.54
Thrust per engine (lb): 386,000
Engine exhaust velocity (ft/sec): 8,100
Acoustic efficiency: 0.50
Engine type: F–1 (LOX/RP–1 1-eng)
Directivity type: deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 3.17975e+07 (dB, re 10^{-12} watts) 195.024 (dB)

Constant Overall Sound Pressure Level Radii (meters)

Angle(°)	80 dB	85 dB	90 dB	95 dB	100 dB	105 dB	110 dB	115 dB
0	63,119	44,250	31,048	21,725	15,046	10,225	6,772	4,350
10	64,573	45,265	31,707	22,140	15,314	10,409	6,907	4,452
20	65,118	45,687	32,026	22,394	15,5324	10,608	7,088	4,607
30	63,692	44,949	31,723	22,336	15,603	10,736	7,221	4,722
40	55,652	40,419	29,339	21,154	15,045	10,481	7,105	4,666
50	45,988	33,987	25,161	18,504	13,397	9,462	6,475	4,278
60	34,673	25,497	18,794	13,760	9,909	6,954	4,726	3,100
70	27,607	20,066	14,564	10,476	7,406	5,119	3,439	2,240
80	26,231	19,536	14,461	10,549	7,435	5,241	3,540	2,317
90	26,481	19,600	14,502	10,616	7,627	5,341	3,631	2,390
100	24,757	18,211	13,333	9,640	6,838	4,739	3,198	2,094
110	23,638	17,337	12,648	9,107	6,437	4,452	3,004	1,971
120	21,554	15,773	11,465	8,219	5,782	3,985	2,677	1,748
130	18,653	13,676	9,920	7,072	4,936	3,367	2,236	1,441
140	17,438	12,648	9,059	6,370	4,388	2,953	1,937	1,233
150	15,531	11,018	7,709	5,300	3,578	2,363	1,519	949
160	14,073	9,835	6,783	4,596	3,051	1,979	1,248	764
170	13,444	9,302	6,349	4,255	2,790	1,784	1,111	672
180	13,229	9,113	6,191	4,130	2,696	1,716	1,063	641

TABLE H–13.—*Sound level (dBA) modeling data for three RD–701 engines*

Title: RD–701 Engine (A-weighted)
Number of engines:3
Engine diameter (ft): 5.84
Thrust per engine (lb): 386,000
Engine exhaust velocity (ft/sec): 8,100
Acoustic efficiency: 0.50
Engine type: F–1 (LOX/RP–1 1-eng)
Directivity type: Deflected LOX/RP–1 (F–1, S–1c, S–1b)
Acoustic power: 3.17975e+07 (dB, re 10^{-12} watts) 195.024 (dB)

	Constant Sound Level Radii (meters)				
Angle(°)	**70 dBA**	**80 dBA**	**90 dBA**	**100 dBA**	**110 dBA**
0	11,122	7,135	4,353	2,435	1,187
10	11,556	7,520	4,649	2,640	1,314
20	12,136	8,022	5,059	2,943	1,510
30	12,354	8,158	5,172	3,039	1,577
40	12,251	7,960	4,946	2,849	1,448
50	12,058	7,685	4,631	2,567	1,248
60	11,290	7,328	4,503	2,535	1,248
70	10,395	6,996	4,452	2,585	1,309
80	10,529	7,137	4,593	2,708	1,396
90	10,771	7,293	4,685	2,760	1,424
100	10,266	7,031	4,566	2,714	1,410
110	10,073	6,976	4,580	2,752	1,447
120	9,646	6,669	4,354	2,587	1,337
130	8,915	6,121	3,945	2,294	1,149
140	8,348	5,706	3,637	2,072	1,008
150	7,520	5,078	3,161	1,736	805
160	6,837	4,517	2,721	1,424	625
170	6,415	4,163	2,441	1,232	520
180	6,267	4,040	2,345	1,169	488

TABLE H–14.—*Sound pressure level (dB) modeling data for seven RD–704 engines*

Title: RD–704 Engine (7 Engines)
Number of engines: 7
Engine diameter (ft): 5.84200
Thrust per engine (lbs): 386,140
Engine exhaust velocity (ft/sec): 13,218
Acoustic efficiency: 0.500000
Engine type: J–2 (LOX/LH2 1-eng)
Directivity type: deflected LOX/LH2 (J–2, S–II, SSME)
Acoustic power: 1.21118e+08 (dB, re 10^{-12} watts) 200.832 (dB)

Constant Overall Sound Pressure Level Radii (meters)

Angle(°)	90 dB	95 dB	100 dB	105 dB	110 dB	115 dB	120 dB
0	19,008	13,377	9,410	6,556	4,486	3,000	1,952
10	20,090	14,256	10,113	7,110	4,911	3,310	2,168
20	23,129	16,738	12,107	8,701	6,154	4,247	2,841
30	26,108	19,545	14,554	10,707	7,728	5,433	3,702
40	30,287	23,551	18,161	13,788	10,236	7,390	5,163
50	27,146	21,128	16,244	12,265	9,048	6,500	4,532
60	23,197	17,778	13,463	10,031	7,325	5,222	3,622
70	19,722	14,901	11,170	8,267	6,013	4,270	2,947
80	17,376	12,922	9,551	6,977	5,011	3,519	2,402
90	16,141	11,763	8,532	6,134	4,348	3,020	2,044
100	16,262	11,591	8,204	5,768	4,022	2,759	1,848
110	15,130	10,647	7,413	5,125	3,515	2,375	1,568
120	12,777	8,922	6,149	4,203	2,843	1,889	1,225
130	11,988	8,309	5,666	3,822	2,550	1,671	1,069
140	11,348	7,823	5,295	3,538	2,335	1,514	958
150	10,693	7,379	5,002	3,344	2,202	1,421	894
160	10,203	7,047	4,780	3,191	2,094	1,344	839
170	9,911	6,840	4,632	3,083	2,013	1,284	796
180	9,800	6,761	4,575	3,042	1,983	1,261	780

TABLE H–15.—*Sound level (dBA) modeling data for seven RD–704 engines*

Title: RD–704 Engine (A-weighted)
Number of engines: 7
Engine diameter (ft): 5.84200
Thrust per engine (lb): 386,140
Engine exhaust velocity (ft/sec): 13,218
Acoustic efficiency: 0.500000
Engine type: J–2 (LOX/LH2 1-engine)
Directivity type: deflected LOX/LH2 (J–2, S–II, SSME)
Acoustic power: 1.21118e+08 (dB, re 10^{-12} watts) 200.832 (dB)

	Constant Sound Level Radii (meters)				
Angle(°)	**70 dBA**	**80 dBA**	**90 dBA**	**100 dBA**	**110 dBA**
0	11,950	8,242	5,495	3,448	1,950
10	12,553	8,640	5,734	3,594	2,039
20	14,263	9,853	6,490	4,041	2,303
30	15,705	10,934	7,271	4,583	2,658
40	17,878	12,470	8,363	5,347	3,166
50	16,997	12,081	8,322	5,440	3,264
60	15,726	11,279	7,801	5,101	3,053
70	14,663	10,521	7,267	4,734	2,828
80	13,418	9,640	6,683	4,364	2,589
90	12,466	8,999	6,259	4,082	2,406
100	11,814	8,565	5,961	3,876	2,271
120	9,874	7,110	4,783	3,077	1,718
130	9,266	6,628	4,501	2,805	1,538
140	8,804	6,256	4,212	2,594	1,400
150	8,618	6,071	4,043	2,456	1,302
160	8,445	5,904	3,890	2,329	1,210
170	8,291	5,763	3,762	2,218	1,128
180	8,232	5,710	3,713	2,176	1,098

Acoustic Focusing

Another important factor that determines the acoustic environment is acoustic focusing due to certain atmospheric conditions (JANNAF Propulsion Committee, 1971). This effect is related to the refraction of the acoustic energy as it propagates through the atmosphere. Refraction occurs when meteorological conditions are such that the speed-of-sound profile due to temperature and wind increases with increasing altitude. This condition refracts the sound energy, resulting in higher levels, at a given point, than those which would be expected for a homogeneous isentropic medium. Generally, for static test conditions, the speed-of-sound profile characteristics of only the lower atmosphere (altitudes between 5,000 to 10,000 m) are effective in returning the sound energy to the ground. If the local speed of sound decreases as altitude increases, a shadow zone or area of decreased sound energy (from the no-refraction condition) will be observed in the far field from the noise source. However, from past experience, it has been observed that, because of wave length effects and dispersion due to turbulence, some acoustic energy will be propagated to these shadow zones.

Experience shows that sound pressure levels in the far field can increase on the order of 20 dB due to atmospheric refraction effects. Engine testing constraints for this program have been developed by NASA that take into account the atmospheric conditions related to the change of temperature with altitude and wind profile. If predictions indicate unfavorable noise levels in the local communities surrounding the test site, then the test would be rescheduled.

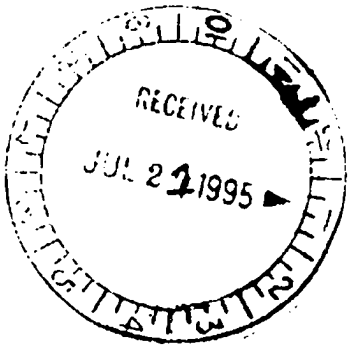
Pretest Procedures for Determining if Constraining Meteorological Conditions Exist

In order to determine if the current atmospheric conditions are favorable for engine testing, a set of procedures has been developed. The Army releases a weather balloon early every morning. This data will be made available to the Induced Environments Branch (ED33) approximately one hour after the balloon has been released. The atmospheric data will be downloaded via modem to a computer operating a ray-tracing program that will analyze the atmospheric wind and temperature profiles and identify any ground problem areas. Problem areas will be defined as those ground sectors that indicate the possibility of an increase of more than 6 dB ideal homogeneous isentropic estimates presented here or OASPL over 110 dB.

Topographic and Vegetation Effects

The calculations included in this section do not take into account the attenuation effects that result from ground coverings such as trees, shrubs, and grasses. MSFC is surrounded by large regions of densely wooded areas that will provide some attenuation of the middle- and high-frequency range. Attentuation due to natural and geographical features will result in lower-than-predicted sound pressure levels for the surrounding areas.

DATE: July 19, 1995



TO: Rebecca C. McCaleb, Ph.D.
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FROM: Charles H. Jackman, Ph.D.
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SUBJECT: Stratospheric Global Impact of Space Shuttle and SSTO

I have looked over the write-up on the "Stratospheric Global Impact" of the Space Shuttle and SSTO. I have a few comments and suggested changes that are given below. Also, I found a small error in my computation of the Yearly Average Global Total Change for the Shuttle. It should be -0.008% rather than -0.009%. I have made the necessary changes in my write-up on the simulations that relate to this error. I enclose a new version of our "Simulations of the Effects of the Space Shuttle Launch Vehicle on the Stratosphere Using a Two-dimensional Model."

Comments and suggested changes for "Stratospheric Global Impact":

First paragraph that starts "The work by Molina and Rowland..." - I would reference all the WMO documents right at the end of this paragraph as they primarily discuss our understanding of ozone and the processes that affect it. They only mention the possible deleterious effects on living organisms from an ozone decrease. I would add: "Our understanding of ozone and the processes that influence it are discussed extensively in a) World Meteorological Organization (WMO), 1985; b) WMO, 1989; c) WMO, 1991; and d) WMO, 1994."

First paragraph, last sentence - Both winter and summer show maximum ozone depletions of less than 0.2% at 40 km. Also, Harwood et al., 1991 is really WMO, 1991. I would change the last part of that sentence from "in the winter hemisphere (Harwood et al., 1991)." to "(WMO, 1991)."

Second paragraph that starts "Stratospheric ozone shields the Earth's surface..." - The last sentence of this paragraph needs to be changed. I am not sure that all of those references have a "comprehensive" discussion on the deleterious effects on living organisms from an ozone decrease. I would leave out the WMO references and rewrite the last sentence as: "Some discussions on this subject include: a) U. S. National Academy of Sciences / National Research Council, 1984; b) EPA, 1987; c) Monastersky, 1990; d) Moteff, 1991; and e) Potter, 1977."

Fourth paragraph that starts "Since stratospheric ozone impact...": Change "would produce 4,500 times less" to "would produce 4,000 times less"

Table 18: Change "-0.009%" to "-0.008%"

References: Add reference for "WMO, 1994, Scientific Assessment of Ozone Depletion: 1994"

Simulations of the Effects of the Space Shuttle Launch Vehicle on the Stratosphere Using a Two-dimensional Model

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Abstract

A two-dimensional (2D) photochemical model {latitude range from 85°S to 85°N and altitude range from the ground to 0.0024 mbar (about 90 km)} has been used to investigate the influence of the present-day Space Shuttle solid rocket launches (SRLs) as compared to the proposed Space Shuttle RD-704 rocket launches (RD704RLs) on the stratosphere. Effluents of HCl from the SRL and effluents of H_2O, CO, OH, and NO from the RD704RL were used in our model simulations. A steady-state launch rate of 8 Space Shuttles per year from Cape Canaveral, FL was assumed for both types of rocket launches. The HCl from the SRLs was computed to increase the total inorganic chlorine (Cl_y = HCl + $ClONO_2$ + HOCl + ClO + 2*Cl_2O_2 + Cl) by a maximum of about 0.4% in the lower stratosphere near 30°N. The H_2O emission of the RD704RLs was computed to cause the largest stratospheric change for those rocket engines through increasing H_2O by a maximum of about 2 X 10^{-4}% in the upper stratosphere near 30°N. The SRLs and the RD704RLs are computed to change ozone by a maximum of -0.08% and -4 X 10^{-5}%, respectively, in the upper stratosphere for the scenario of 8 launches per year. Total ozone is calculated to be changed by a maximum of about -0.03% (SRLs) and -5 X 10^{-6}% (RD704RLs) at northern polar latitudes. Yearly average global total ozone changes are computed to be -0.008% (SRLs) and -2 X 10^{-6}% (RD704RLs). The e-folding recovery time of stratospheric ozone after termination of either type of launches is calculated to be about 2.1 years.

Modeling Approach

The photochemistry and transport 2D model which was used in this study is described in Douglass et al. (1989), applied to an assessment of the atmosphere for a chlorine perturbation in Jackman et al. (1989a), and applied to an assessment of the effects of supersonic stratospheric-flying civil transport aircraft in Jackman et al. (1991) and Considine et al. (1994). The model's domain was extended in Jackman et al. (1990). Further improvements in the model formulation were made in Considine et al. (1994) and Fleming et al. (1995). The model has compared favorably with other 2D models in recent intercomparisons (Jackman et al., 1989b; Prather and Remsberg, 1993).

The vertical extent of the model is from the ground to 0.0024 mbar (approximately 90 km) divided into 46 levels which are equally spaced in log pressure. There are 18 latitude bands from 85°S to 85°N with a 10° grid spacing. The source gases' lower boundary conditions of a steady-state condition for year 1990 are given in Table 1. The source gases' upper boundary conditions were assumed to be zero flux. Reaction rates and photodissociation cross sections are taken from DeMore et al. (1992). All model simulations included heterogeneous chemistry on the background sulfate aerosol layer, following the formulation of Hanson and Ravishankara (1994).

The effects of the present-day Space Shuttle solid rocket launches (SRL) are compared to the proposed Space Shuttle RD-704 rocket launches (RD704RL) in this study. The emissions for the two types of rocket launch vehicles are quite different and are described in the next two paragraphs.

Although there are several emitted products from the Space Shuttle SRL (AIAA, 1991), the emitted chlorine is believed to cause the largest change in stratospheric ozone. The stratospheric chlorine emission information is summarized in Table 2 for a single Space Shuttle SRL (from Prather et al., 1990).

The Space Shuttle RD704RL emissions are given in Table 3 (from Rebecca McCaleb, private communication, 1995). Seven of the RD-704 engines are needed for a single Space Shuttle launch. The H_2O emissions are by far the largest and have the most potential for causing stratospheric ozone change.

All model simulations started on January 1 and were for 40 years. The model boundary fluxes of the source gases were maintained at 1990 values throughout the model simulations. The first 20 years used a constant launch rate of eight Space Shuttles

per year, similar to the present-day launch rate. The launch rate was set to zero Space Shuttles per year for the last 20 years of each simulation to investigate the atmospheric recovery from the rocket influence. Scenario A included only the Space Shuttle SRL and scenario B included only the Space Shuttle RD704RL. A baseline model computation was also included in which no Space Shuttle launches were assumed for all 40 years. The launch site is assumed to be Cape Canaveral, FL at 29°N. The emissions for all the constituents given in Tables 2 and 3 were converted to molecules cm^{-3} sec^{-1} when input into the 2D model. All model 2D profile results are compared for the month of March, when generally the stratospheric effects are larger than other months.

Influence of the Present-day Space Shuttle Solid Rocket Launches on the Stratosphere

We compare the model output in this section for the two model simulations: 1) the baseline run; and 2) scenario A. We found that the chlorine emissions from the SRLs increased total inorganic chlorine, Cl_y ($HCl + ClONO_2 + HOCl + ClO + 2*Cl_2O_2 + Cl$), in the twentieth year of our model simulation by a maximum of about 0.4% in the lower stratosphere near 30°N (see Figure 1). Increases above 0.2% were computed for practically the entire Northern Hemisphere stratosphere.

These increases in Cl_y are computed to cause changes in ozone by a maximum of about -0.08% in the upper stratosphere (see Figure 2). Total ozone is calculated to be changed by a maximum of about -0.03% at northern polar latitudes (see Figure 3). Yearly average global total ozone change in the twentieth year of the simulation is computed to be -0.008%.

The recovery of stratospheric ozone was simulated in years 21-40 of our model run when the launch rate was set to zero. Our model output indicates that the decrease in yearly average global total ozone is reduced by a factor

$$\exp(-1) = 0.37$$

in about 2.1 years after termination of the SRLs. We define this as the e-folding recovery time of stratospheric ozone.

Influence of the Proposed Space Shuttle RD-704 Rocket Launches on the Stratosphere

We compare the model output in this section for the two model simulations: 1) the baseline run; and 2) scenario B. We included the emissions of H_2O, OH, CO, and NO in our computations. Our model presently has CO_2 fixed, so the CO_2 emissions were not included. We found that the H_2O emissions from the RD704RLs caused the largest stratospheric change through increasing H_2O. In the twentieth year of our model simulation, H_2O is increased by a maximum of about 2 X 10^{-4}% in the upper stratosphere near 30°N (see Figure 4). Increases above 5 X 10^{-5}% were computed for practically the entire Northern Hemisphere stratosphere.

These increases in H_2O, through increases in HO_x (H, OH, HO_2), are computed to cause changes in ozone by an extremum of about -4 X 10^{-5}% in the upper stratosphere (see Figure 5). The extremum of total ozone change in the northern polar latitudes is calculated to be about -5 X 10^{-6}% (see Figure 6). Yearly average global total ozone change in the twentieth year of the simulation is computed to be -2 X 10^{-6}%.

As in the previous simulation, the e-folding recovery time of stratospheric ozone in scenario B was computed to be about 2.1 years.

Discussion and Conclusions

The most reliable predictions of these simulations are the direct impact of either of the Space Shuttle rocket launch emissions (SRLs or RD704RLs) on the background constituents Cl_y and H_2O. The computed indirect effects on ozone are less reliable due to uncertainties in the photochemistry used in the computations (see DeMore et al., 1992).

The computed increases in H_2O for the RD704RLs in percent are much less than the computed increases in Cl_y for the SRLs, even though the chlorine emissions from the SRLs (about 6.8 X 10^4 kgm) and H_2O emissions from the RD704RLs (about 2.8 X 10^4 kgm) are similar per Space Shuttle launch. The chlorine from the SRLs is injected into a background Cl_y atmosphere of 1-3 ppbv and the H_2O from the RD704RLs is injected into a background H_2O atmosphere of 3-6 ppmv. Thus the chlorine from the SRLs is injected into a background inorganic chlorine amount that is about a factor of 2000 smaller that the background H_2O in which the H_2O from the RD704RLs is injected.

Both the Cl_y constituents and the HO_x constituents (from H_2O) catalytically destroy ozone. The differences in perturbing the background Cl_y (SRLs) and background H_2O (RD704RLs) given above help explain the large difference (factor of 4000) in the computed yearly average global total ozone changes between the SRL simulation (-0.008%) and the RD704RL simulation (-2 X 10^{-6}%).

The e-folding recovery times for both types of launch vehicles are computed to be about 2.1 years.

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Prather, M. J., and E. E. Remsberg, The Atmospheric Effects of Stratospheric Aircraft: Report of the 1992 Models and Measurements Intercomparison, NASA Reference Publication 1292, 3 Volumes, 1993.

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Table 1. Assumed lower boundary conditions for the source gases in the model simulations for a steady-state condition of year 1990 (adapted from WMO, 1995).

Species	Ground Boundary Value (units)	Value
N_2O	mixing ratio (ppbv)	308
CH_4	mixing ratio (ppmv)	1.683
CH_3Cl	mixing ratio (pptv)	600
CH_3CCl_3	mixing ratio (pptv)	136
CCl_4	mixing ratio (pptv)	105
$CFCl_3$	mixing ratio (pptv)	246
CF_2Cl_2	mixing ratio (pptv)	422
$C_2Cl_3F_3$	mixing ratio (pptv)	55
$C_2Cl_2F_4$	mixing ratio (pptv)	7
C_2ClF_5	mixing ratio (pptv)	5
$CHClF_2$	mixing ratio (pptv)	88
CH_3Br	mixing ratio (pptv)	14
$CBrF_3$	mixing ratio (pptv)	3
$CBrClF_2$	mixing ratio (pptv)	2

Table 2. Assumed present-day Space Shuttle solid rocket launch emissions of stratospheric chlorine per Shuttle launch (from Prather et al., 1990).

Altitude (km)	Kilograms of Chlorine (as Cl)
15-20	19,644
20-25	15,122
25-30	12,178
30-35	9,711
35-40	7,700
40-45	2,878
45-50	500

Table 3. Assumed Space Shuttle RD-704 rocket launch emissions (from Rebecca McCaleb, private communication, 1995). These are stratospheric emissions released per single RD-704 launch. Seven RD-704 engines are required per Space Shuttle launch.

Constituent	Emissions are given in pounds for three altitude intervals (15-27 km)	(27-38 km)	(38-50 km)
H_2O	3,224.	2,874.	2,626.
OH	4.8	14.0	1.1
CO_2	752.	610.	495.
CO	21.5	88.3	159.8
NO	1.57E-4	8.83E-9	3.40E-4

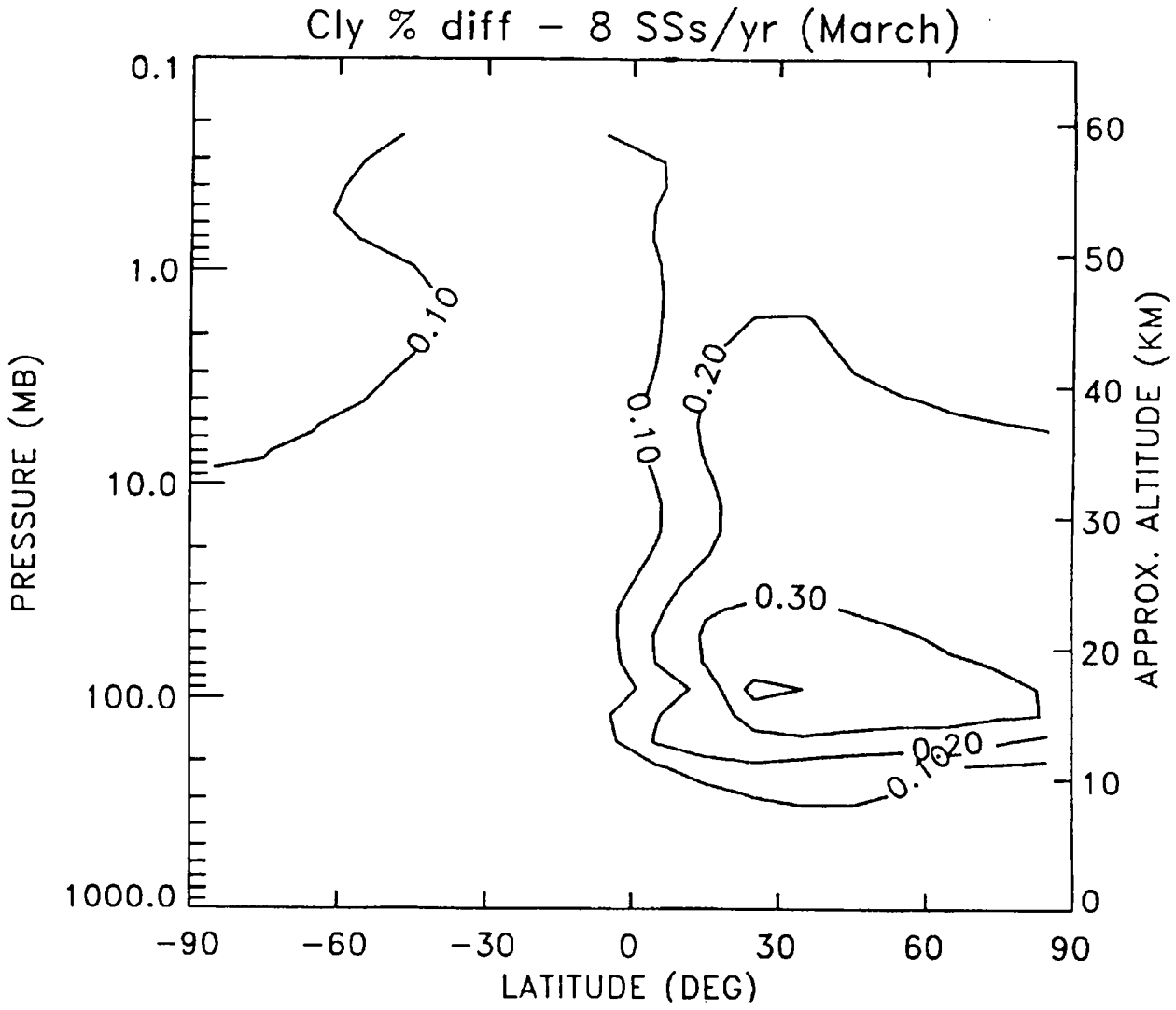

Figure 1. Cl_y percentage increases for steady state scenario A (8 Space Shuttle SRLs per year) in the twentieth year of our model simulation for March.

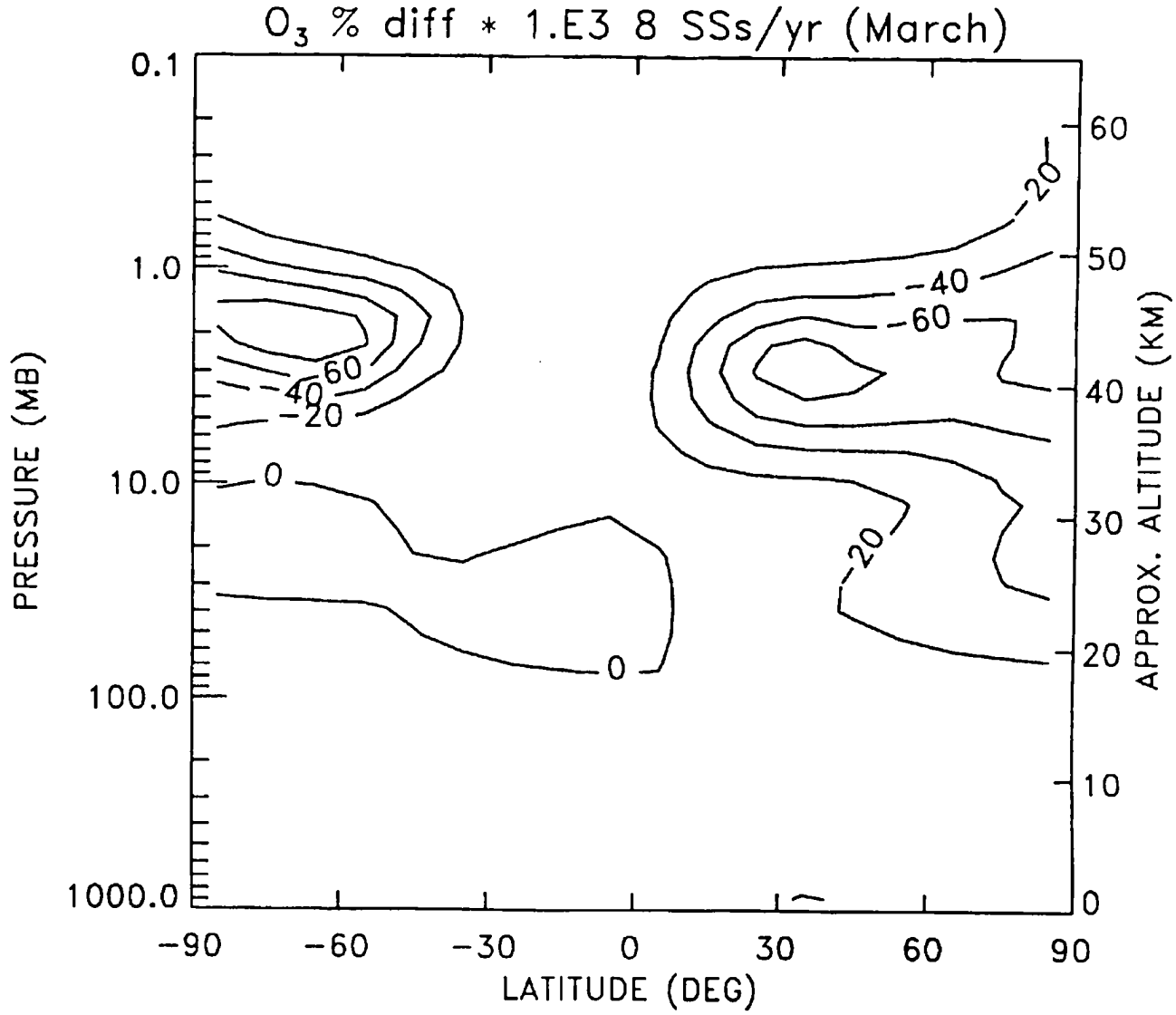

Figure 2. Ozone percentage decreases (X 10^3) for steady state scenario A (8 Space Shuttle SRLs per year) in the twentieth year of our model simulation for March.

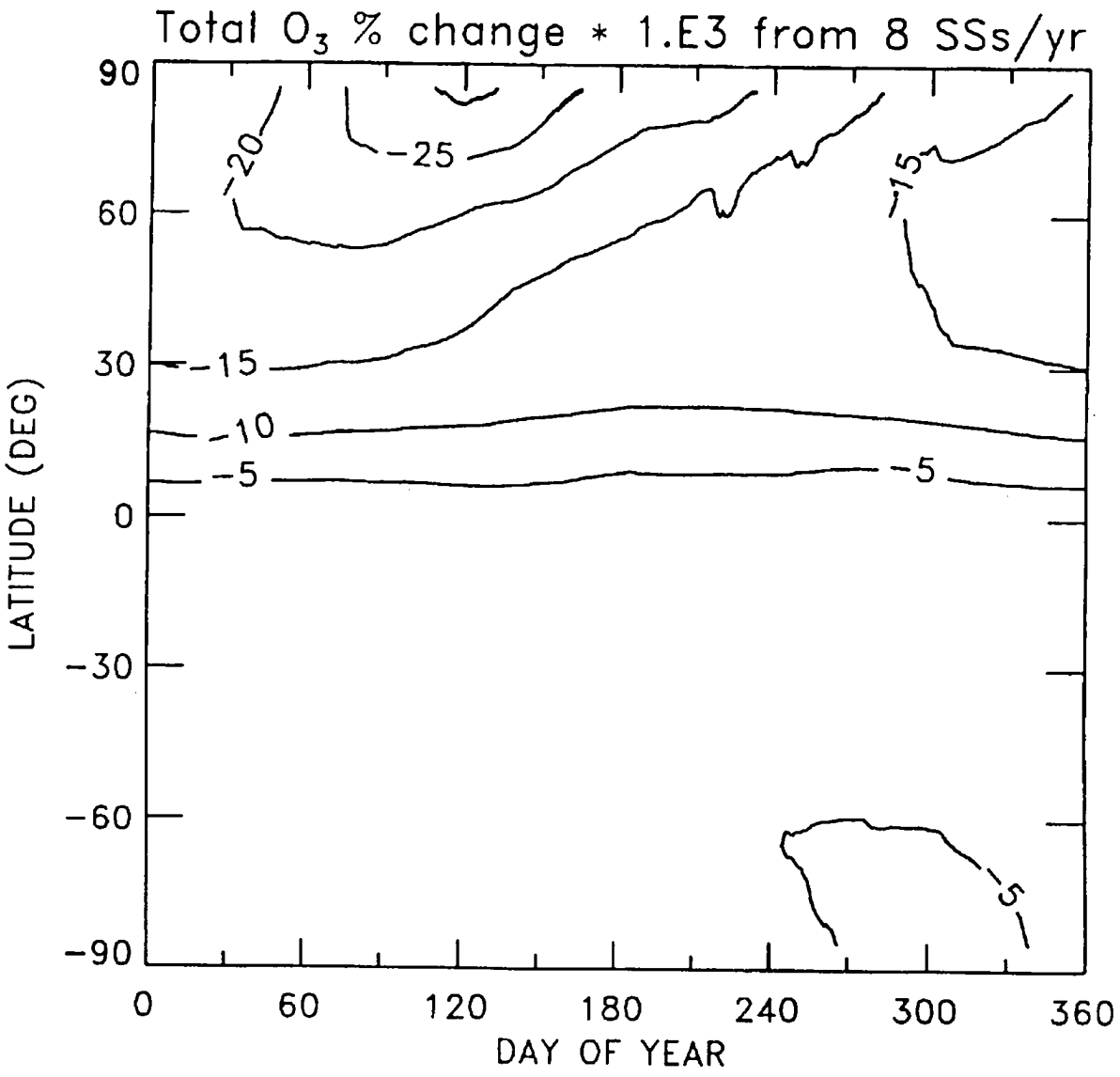

Figure 3. Total ozone percentage decreases (X 10^3) for steady state scenario A (8 Space Shuttle SRLs per year) in the twentieth year of our model simulation.

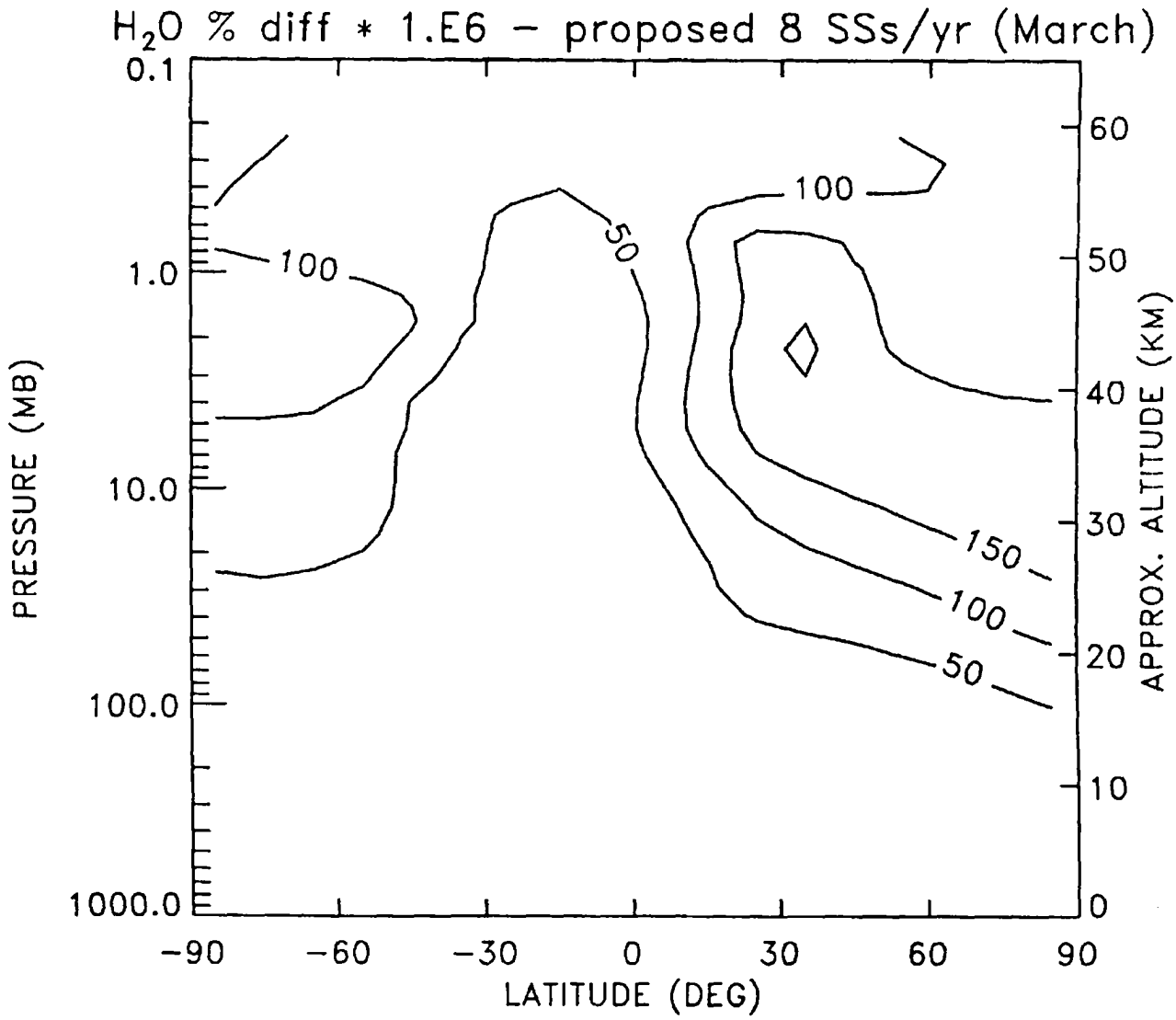

Figure 4. H_2O percentage increases (X 10^6) for steady state scenario A (8 Space Shuttle RD704RLs per year) in the twentieth year of our model simulation for March.

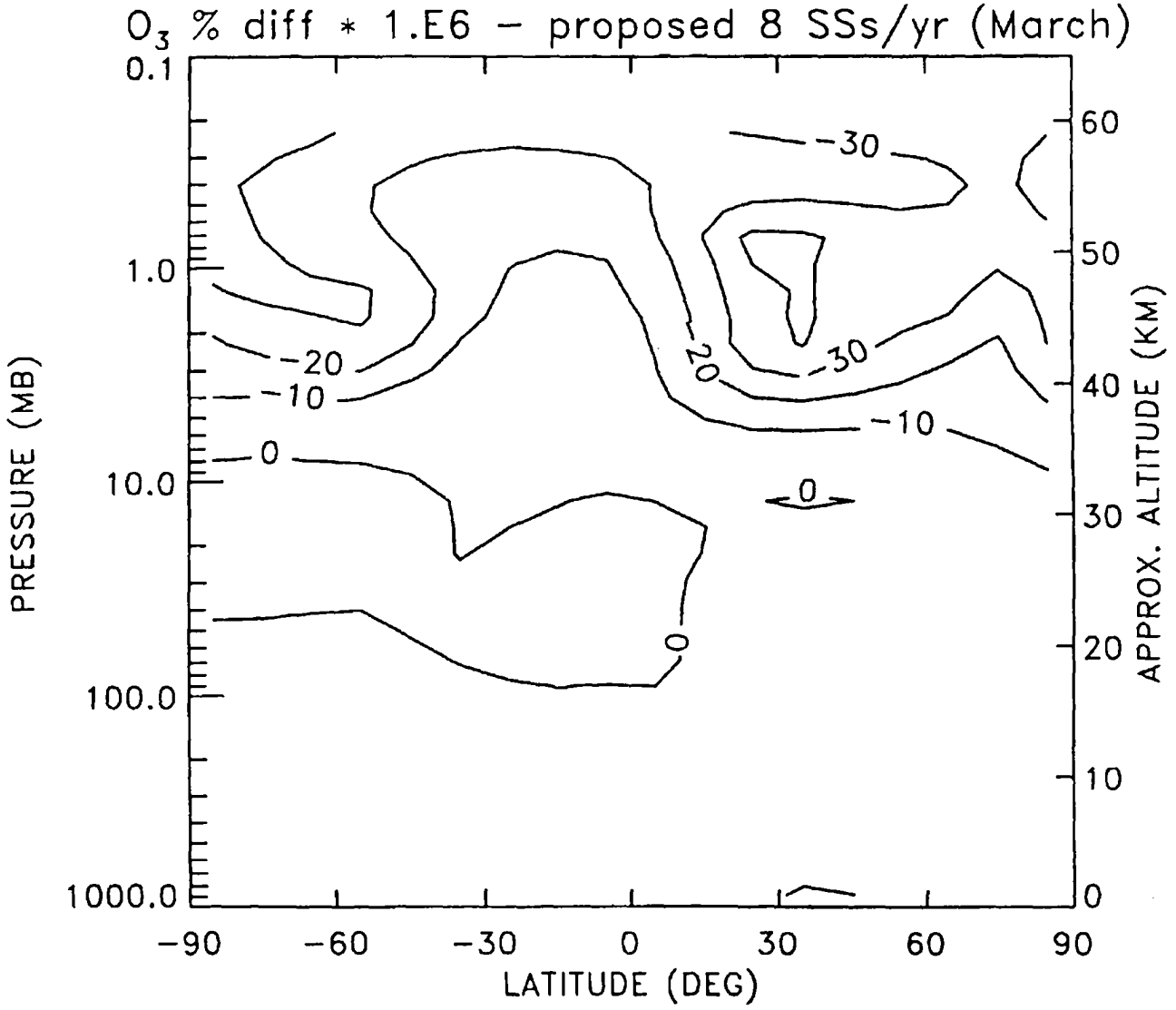

Figure 5. Ozone percentage decreases (X 10^6) for steady state scenario A (8 Space Shuttle RD704RLs per year) in the twentieth year of our model simulation for March.

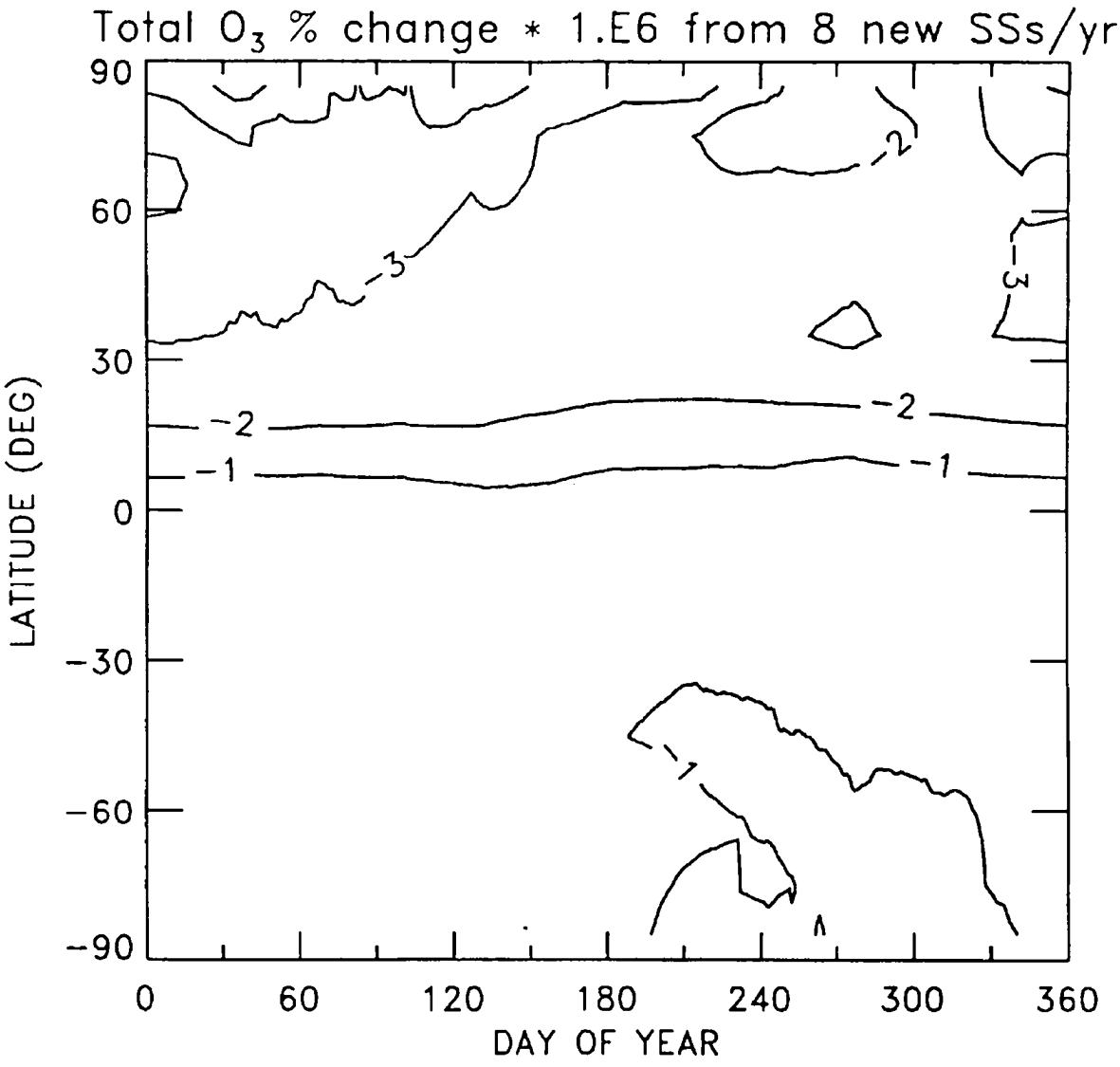

Figure 6. Total ozone percentage decreases (X 10^6) for steady state scenario A (8 Space Shuttle RD704RLs per year) in the twentieth year of our model simulation.