



**Federal Aviation
Administration**

Draft Environmental Assessment for SpaceX Falcon Launches at Kennedy Space Center and Cape Canaveral Air Force Station

February 2020



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Draft Environmental Assessment for SpaceX Falcon Launches at Kennedy Space Center and Cape Canaveral Air Force Station, Brevard County, Florida

AGENCIES: Federal Aviation Administration (FAA), lead federal agency; National Aeronautics and Space Administration (NASA) and U.S. Air Force, cooperating agencies.

This Draft Environmental Assessment (EA) is submitted for review pursuant to section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code 4321, et seq.), Council on Environmental Quality NEPA-implementing regulations (40 Code of Federal Regulations Parts 1500 to 1508), and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*.

DEPARTMENT OF TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION: SpaceX is applying to the FAA for launch licenses to launch the Falcon 9 and Falcon Heavy from Kennedy Space Center's (KSC) Launch Complex 39A and Cape Canaveral Air Force Station's (CCAFS) Launch Complex 40. SpaceX is also applying to the FAA for reentry licenses for Dragon reentry operations. The FAA's proposal to issue licenses to SpaceX is considered a major federal action subject to environmental review under NEPA. Due to SpaceX's ability to launch more frequently at KSC and CCAFS, SpaceX's launch manifest includes more annual Falcon launches and Dragon reentries than were considered in previous NEPA analyses. Also, SpaceX is proposing to add a new Falcon 9 southern launch trajectory from Florida for payloads requiring polar orbits.

The Draft EA evaluates in detail the potential environmental impacts from the Proposed Action and No Action Alternative on the following impact categories: air quality; biological resources; climate; coastal resources; Department of Transportation Act Section 4(f); hazardous materials, solid waste, and pollution prevention; land use; natural resources and energy supply; noise and noise-compatible land use; socioeconomics; visual effects (including light emissions); and water resources (surface waters and groundwater). Potential cumulative impacts are also addressed in the Draft EA.

PUBLIC REVIEW PROCESS: In accordance with the applicable requirements, the FAA is initiating a public review and comment period for the Draft EA. The public comment period for the NEPA process begins with the publication of the Draft EA. Comments are due on March 20, 2020.

CONTACT INFORMATION: To submit comments on the Draft EA or ask questions, please contact Mr. Daniel Czelusniak, Environmental Protection Specialist, Federal Aviation Administration, 800 Independence Avenue, SW, Suite 325, Washington, DC 20591; email FAAFalconProgramEA@icf.com.

This environmental assessment becomes a federal document when evaluated, signed, and dated by the responsible FAA Official.

Responsible FAA Official:



Wayne R. Monteith
Associate Administrator for Commercial Space Transportation

Date: 21 FEB 2020

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Environmental Assessment for SpaceX Falcon Launch Vehicle at KSC and CCAFS

ACRONYMS & ABBREVIATIONS

ACS	attitude control system
CAA	Clean Air Act
CCAFS	Cape Canaveral Air Force Station
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CNS	Canaveral National Seashore
CO	carbon monoxide
CO ₂	carbon dioxide
dB	decibels
dba	A weighted sound pressure level
DNL	day-night average noise level
DoD	Department of Defense
DOT	Department of Transportation
EA	Environmental Assessment
EFH	Essential Fish Habitat
EO	Executive Order
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FPF	Fairing Processing Facility
FPL	Florida Power and Light
ft	feet
GHG	greenhouse gas
GN ₂	gaseous nitrogen
GPS	global positioning system
HAP	Hazardous Air Pollutants
HAPC	Habitat Area of Particular Concern
IRL	Indian River Lagoon
IRP	Installation Restoration Program
ISS	International Space Station
KSC	John F. Kennedy Space Center
LC	Launch Complex
LOX	liquid oxygen
LZ	Landing Zone
M1D	Merlin 1D
MINWR	Merritt Island National Wildlife Refuge
MMH	monomethylhydrazine
MSAT	Mobile Source Air Toxics
MSL	mean sea level
MST	mobile service tower
mt	metric tons
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act

NESHAP	National Emission Standards for Hazardous Air Pollutants
NMS	National Marine Sanctuary
NO ₂	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NO _x	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NTO	nitrogen tetroxide
O ₃	ozone
ODS	Oxygen Depleting Substance
OSHA	Occupational Safety and Health Administration
PA	Programmatic Agreement
PAFB	Patrick Air Force Base
Pb	lead
PCB	polychlorinated biphenyl
PM ₁₀	particulate matter less than or equal to 10 microns in diameter
PM _{2.5}	particulate matter less than or equal to 2.5 microns in diameter
PPF	Payload Processing Facility
psf	pounds per square foot
RCRA	Resource Conservation Recovery Act
RHIB	rigid-hulled inflatable boat
RP-1	kerosene
SEL	sound exposure level
SLF	Shuttle Landing Facility
SLS	Space Launch System
SO ₂	sulfur dioxide
SpaceX	Space Exploration Technologies
SPCC	Spill Prevention, Control, and Countermeasures
SWMU	Solid Waste Management Unit
U.S.	United States
USAF	United States Air Force
U.S.C.	United States Code
USFWS	United States Fish and Wildlife Service
VAFB	Vandenberg Air Force Base
VOC	Volatile Organic Compounds

1. PURPOSE AND NEED FOR THE PROPOSED ACTION

1.1. Introduction

Founded in 2002, SpaceX Exploration Technologies Corporation (SpaceX) is a space transportation and technology company headquartered in Hawthorne, California. SpaceX currently operates its Falcon family of launch vehicles, which includes the Falcon 9 and the Falcon Heavy, from launch complexes at Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), and Vandenberg Air Force Base (VAFB).¹ All Falcon 9 and Falcon Heavy launch vehicles can carry payloads, including satellites, experimental payloads, and SpaceX's Dragon spacecraft (Dragon). SpaceX has two versions of Dragon: Dragon-1 and Dragon-2. Dragon-1 is currently used for cargo missions to the International Space Station (ISS) and Dragon-2 was developed with the intent to carry astronauts (crew) and future cargo missions (cargo). The last mission of Dragon-1 will be in the first quarter of 2020. Following that commercial resupply mission, only Dragon-2 will be used. Most Falcon launches are conducted for commercial clients, but some are government-sponsored launches. SpaceX first launched the Falcon 9 at CCAFS on June 4, 2010, from Launch Complex 40 (LC-40). SpaceX has launched over 80 times from CCAFS, KSC, and VAFB. Over 15 of SpaceX's Falcon 9 launch missions have included boost-back and landing of the first stage booster with the landing occurring either on a SpaceX drone ship (a special-purpose barge) in the Atlantic Ocean or Pacific Ocean, or on land at Landing Zones 1 and 2 (LZ-1 and LZ-2) at CCAFS and Landing Zone 4 (LZ-4) at VAFB.

All of SpaceX's past construction activities at KSC and CCAFS, as well as SpaceX's past Falcon operations at these launch sites, were analyzed by the U.S. Air Force (USAF), National Aeronautics and Space Administration (NASA), and/or the Federal Aviation Administration (FAA) in accordance with the National Environmental Policy Act (NEPA; 42 United States Code [U.S.C.] §4321 et seq.), Council on Environmental Quality (CEQ) NEPA-implementing regulations (40 Code of Federal Regulations [CFR] Parts 1500–1508), and agency-specific NEPA regulations or policies.

Due to SpaceX's ability to launch more frequently at KSC (LC-39A) and CCAFS (LC-40), SpaceX's launch manifest includes more annual Falcon launches and Dragon reentries than were considered in previous NEPA analyses. Also, SpaceX is proposing to add a new Falcon 9 southern launch trajectory from Florida for payloads requiring polar orbits. SpaceX is also proposing to construct a mobile service tower (MST) at LC-39A to support commercial launches and USAF's National Security Space Launch program.² NASA is responsible for managing areas on KSC for space-related development and operations and provides oversight for non-NASA space and technology development use of KSC property. NASA is responsible for approving the construction of the MST at LC-39A. The FAA has no federal action related to the construction of the MST. The FAA is preparing this EA to assess the potential environmental impacts of SpaceX's proposed 1) increase in launch and reentry rates for the years 2020–2025, 2) new southern launch trajectory, and 3) MST construction and use at LC-39A.

SpaceX intends to apply to the FAA's Office of Commercial Space Transportation for new launch and reentry licenses or modifications to existing launch and reentry licenses. A list of existing commercial space launch licenses held by SpaceX is available in Section 2.2. Issuing launch licenses is considered a federal action subject to environmental review under NEPA. As the lead federal agency for this action, the FAA prepared this EA in accordance with NEPA, CEQ NEPA-implementing regulations, and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*. The USAF (45th Space Wing) and NASA are

¹ Vandenberg Air Force Base (VAFB) is mentioned as background and context for describing SpaceX operations, but operations from VAFB are not included in the scope of this EA.

² This program was previously named the Evolved Expendable Launch Vehicle program.

cooperating agencies in the development of this EA (see Section 1.2 for a description of agency roles).

1.2. Location and Background

1.2.1. KSC and CCAFS Overview

KSC is located on Florida's east coast, midway between Miami and Jacksonville on Merritt Island, Florida, and is north-northwest of Cape Canaveral on the Atlantic Ocean. KSC is approximately 34 miles long and roughly 6 miles wide, covering 219 square miles (Figure 1-1). NASA manages many space-related operations at KSC. Currently, SpaceX launches the Falcon 9 and Falcon Heavy from LC-39A, which previously supported Space Shuttle launches.

SpaceX also launches the Falcon 9 from LC-40 at CCAFS. CCAFS occupies approximately 15,800 acres of land on Florida's Cape Canaveral barrier island (Figure 1-1). It is approximately 4.5 miles wide at its widest point. CCAFS is directly south and adjacent to KSC and has 81 miles of paved roads connecting various launch support facilities within the centralized industrial area.

The following sections provide a brief history of SpaceX's past and current operations at CCAFS and KSC. All NEPA documents identified in these sections are briefly summarized in Section 3.0.

Figure 1-1. Kennedy Space Center and Cape Canaveral Air Force Station Map



1.2.2. CCAFS LC-40

In 1998, as a result of USAF's decision to implement the Evolved Expendable Launch Vehicle Program (now called the National Security Space Launch program) at CCAFS (USAF 1998), the 45th Space Wing initially decided to deactivate LC-40 and place it in a "pre-demolition" state. However, in 2007, the 45th Space Wing decided to renew the complex for use by SpaceX. SpaceX's proposal to revitalize LC-40 was analyzed in a 2007 USAF EA (USAF 2007). Since then, SpaceX has conducted refurbishment of and upgrades to the existing support buildings and launch pad to bring LC-40 back into operation as a launch facility for the Falcon launch vehicle program. The 2007 USAF EA analyzed the potential environmental impacts of operating the Falcon 1 and Falcon 9 (Block 1) from LC-40. In addition to Falcon launch operations, the 2007 USAF EA included construction of a new hangar facility with supporting systems, as well as Dragon reentry. At the time, SpaceX's goal was to conduct 8 to 12 launches per year for both the Falcon 1 (no longer in operation) and Falcon 9. All flights were expected to have payloads, including either satellites or Dragon.

In 2011 and 2012, SpaceX constructed a hangar annex and support facilities. Launch pad and facility modifications also were accomplished. The potential environmental impacts of this construction were analyzed by the 45th Space Wing (two Air Force Form 813³ dated June 2011 and February 2012). In 2013, a supplemental EA (USAF 2013; referred to as the 2013 USAF SEA) was prepared to expand on the action analyzed in the 2007 USAF EA to include operation of an upgraded Falcon 9 (referred to as the Falcon 9 version 1.1. [v1.1]). The FAA was a cooperating agency in the preparation of the 2013 USAF SEA. The Falcon 9 v1.1 was similar to the vehicle design of the Falcon 9 (Block 1), except it was taller, heavier, and had more thrust due to a newer model of the rocket's Merlin engine. The Falcon 9 v1.1 was a medium-lift class launch vehicle with a gross lift-off weight of approximately 1,100,000 pounds. The Falcon 9 v1.1 used the same propellants as Block 1: liquid oxygen (LOX) and highly refined kerosene (RP-1). Additional modifications necessary to increase thrust were subsequently analyzed in FAA's Written Re-evaluation⁴ (FAA 2018a), which concluded that the modified Falcon 9 vehicles 1) conformed to the prior environmental documentation; 2) that the data contained in prior environmental documentation remained substantially valid; 3) there were no significant environmental changes; and 4) all pertinent conditions and requirements of the prior approvals were met or would be met in the current action at the time. The 45th Space Wing documented similar conclusions in a Form 813. Therefore, additional NEPA documentation was not necessary to support issuing licenses to SpaceX for subsequent modifications to the Falcon 9.

As of October 2019, SpaceX has launched the Falcon 9 vehicle from LC-40 46 times. One anomaly occurred in June 2015 when, approximately 139 seconds into flight, the second stage exploded over the Atlantic Ocean. After assessment of operations, SpaceX successfully launched the Falcon 9 with 11 ORBCOM satellites in December 2015. Another anomaly occurred when LC-40 was heavily damaged following the September 2016 catastrophic failure during a static fire test. The complex was repaired and returned to operational status in December 2017. Current activities at LC-40 remain consistent with those analyzed in the 2007 USAF EA and 2013 USAF SEA.

³ The USAF uses AF Form 813 to document the need for environmental analysis or for certain categorical exclusion determinations for proposed actions. The form helps narrow and focus the issues to potential environmental impacts. 32 CFR § 989.12.

⁴ A Written Re-evaluation is a document the FAA uses to determine whether the contents of a previously prepared environmental document (i.e., a draft or final EA or EIS) remain valid, or if a new or supplemental environmental document is required (FAA Order 1050.1F, Paragraph 9-2.).

1.2.3. CCAFS LZ-1 and LZ-2

Over the past several years, SpaceX has developed the technology and ability to boost-back and land the Falcon 9 first stage booster. To support the environmental review of boost-back and landing, the USAF prepared an EA in 2014 (2014 USAF EA) for landing at LC-13, later renamed LZ-1. The 2014 USAF EA assessed construction of a main landing pad (LZ-1) and boost-back and landing of the first stage booster on the pad or on a drone ship in the Atlantic Ocean. In 2017, the USAF prepared a supplemental EA (referred to as the 2017 USAF SEA) to analyze Falcon Heavy boost-back and landing at CCAFS (USAF 2017a). The 2017 USAF SEA analyzed conducting boost-backs and landings of up to three Falcon Heavy boosters, which would have required construction of two additional landing pads. The 2017 USAF SEA also included the option of landing one or two Falcon Heavy boosters on a drone ship in the Atlantic Ocean. The 2017 USAF SEA also addressed construction and operation of a Dragon processing and testing facility. Both the FAA and NASA were cooperating agencies on the 2014 USAF EA and 2017 USAF SEA. SpaceX eventually constructed only one of the two additional landing pads evaluated in the 2017 USAF SEA, which is referred to as LZ-2. On February 6, 2018, SpaceX landed two of Falcon Heavy's first stage boosters at LZ-1 and LZ-2.

1.2.4. KSC LC-39A

LC-39A construction was started in 1965 and completed in 1966 to support the Apollo Program. Both LC-39A and LC-39B were later modified for the Shuttle Program. NASA prepared an EA in 2013 to increase KSC spaceport capabilities and allow both commercial and governmental entities to use LC-39A and LC-39B for launch purposes involving a variety of vertical launch vehicles, including Falcon launch vehicles (NASA 2013; referred to as the 2013 NASA EA). The FAA was a cooperating agency for the 2013 NASA EA. In 2014, NASA granted a lease to SpaceX to operate at LC-39A and construct a horizontal integration facility. Additional components of SpaceX activities at LC-39A were reviewed by NASA via KSC's Environmental Checklist and Record of Environmental Consideration process. SpaceX successfully launched the first of several Falcon 9 v1.1 launch vehicles at LC-39A on February 19, 2017 and, as of October 2019, there have been 18 total launches. The Falcon Heavy launched for the first time on February 6, 2018 and again on April 11, 2019 and June 25, 2019, all from LC-39A. In a 2016 Programmatic Environmental Impact Statement (EIS), NASA identified potential environmental impacts associated with proposed operations, activities, and facilities at KSC over a 20-year period, including at LC-39A (NASA 2016a).

1.2.5. Other Launch Support Locations

Since 2010, SpaceX has also used facilities formerly used by the USAF and NASA for a variety of purposes that support launch operations at both LC-40 and LC-39A. The USAF has leased the following facilities to SpaceX: Hangar AO, Hangar M, Payload Processing Facility (PPF), Fairing Processing Facility (FPF), and Area 59.

1.2.5.1. Hangar AO (Facility #60530)

Hangar AO was built in 1964 as a concrete block building that was used for payload processing and flight hardware testing. Modifications to the rear high bay portion of this building were completed in 1995. Hangar AO formerly had several other designations, including Spacecraft Building #2 (1964), Spacecraft Building #2 Mar AO (1971), and Spacecraft Building #2 AO (1975). NASA contractors occupied the facility from the time it was built in 1964 until 1996. The Gemini, Apollo, Space Shuttle, and Delta programs all used this facility to process payloads. The facility consists of two floors containing office space, storage spaces, and a high bay area. During the period of NASA occupation, the high bay was used for buildup and testing of flight control operation systems, while the remainder of the facility provided the engineering control console, office, and logistical support areas. United Launch Alliance occupied the

building from 1996 to 2011 and conducted Delta payload processing operations and testing of the Delta rocket. The surrounding paved area has been used for parking and storage. In 2011, SpaceX assumed use of the hangar through a real property lease with USAF. SpaceX uses the facility as a logistics center for storage of new material and launch vehicle parts inventory, shipping and receiving center, and minor launch vehicle work. SpaceX also uses the facility as a reception and meeting area for clients. Surrounding paved areas are used for parking and limited storage for bulk material and/or re-landed first stage boosters.

1.2.5.2. Hangar M

Hangar M is directly adjacent (to the north) of Hangar AO. SpaceX is in the process of renovating the hangar for similar activities being performed in Hangar AO. It is currently used for storage of flight hardware, particularly returned Falcon first stage boosters.

1.2.5.3. Payload Processing Facility

SpaceX uses the large processing facility (former USAF Facility 70000, also known as Solid Motor Assembly Building or Large Processing Facility) at CCAFS to prepare payloads. The Titan Integrate-Transfer-Launch system was originally located here. The processing facility was initially designed for assembling, checking out, and integrating the Titan IIIC's major components before the Titan IIIC booster was transferred to the pad for payload mating and launch operations. SpaceX leases this facility for payload processing activities and hypergolic fuel loading of certain payloads and has named it the PPF. SpaceX provides this ISO Class 8 (Class 100,000) PPF for processing customer spacecraft, including equipment unloading, unpacking/packing, final assembly, non-hazardous flight preparations, and payload checkout. The PPF is also designed to accommodate hazardous operations, such as hypergolic propellant loading and ordnance installation. Any required fueling operations are performed with assistance from SpaceX personnel. All personnel use certified Self-Contained Atmospheric Protective Ensemble (SCAPE) suits, pass a physical, and attend SCAPE training classes.

1.2.5.4. Fairing Processing Facility

Located very close to and north of the PPF, the FPF also has a high-bay and clean rooms and is used for payload processing and storage. This building was formerly known as the Solid Motor Assembly and Readiness Facility (USAF Facility 69800) used for mating the core vehicles to the solids.

1.2.5.5. Area 59

SpaceX recently obtained access to and use of a set of buildings named Area 59, located adjacent to and south of the CCAFS runway known as the Skid Strip. The area was previously used for satellite processing and associated hypergolic fuel-related operations, which is consistent with SpaceX's use of the facility. The area will be used for Dragon capsule processing.

1.2.6. Proposed KSC Campus Facility

SpaceX is developing a campus facility in an area of KSC currently known as the Roberts Road site. The campus would support ongoing Falcon 9 and Falcon Heavy launches at LC-39A and LC-40. The proposed campus could include a facility for a launch and landing control center, booster and fairing processing and storage facility, security office, and utilities yard. The site would require approximately 67 acres of land for proposed facility development. Roberts Road and A Avenue would be paved to provide access on the south and north sides. The purpose of the site is to enable improved access to KSC's space launch and test operation capabilities by commercial and other non-NASA users, and to advance NASA's mission by fostering a commercial space launch and services industry. NASA completed an EA and issued a finding of no significant impact (FONSI) for construction of this facility in December 2018 (NASA 2018). It is mentioned here for payload processing completeness.

1.3. Federal Agency Roles

1.3.1. FAA Office of Commercial Space Transportation

As the lead federal agency, the FAA is responsible for analyzing the potential environmental impacts of the Proposed Action. As authorized by Chapter 509 of Title 51 of the U.S. Code, the FAA licenses and regulates U.S. commercial space launch and reentry activity, as well as the operation of non-federal launch and reentry sites. The mission of the Office of Commercial Space Transportation is to ensure protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch or reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation.

1.3.2. Cooperating Agencies

As defined in 40 CFR §1508.5, a cooperating agency may be any federal agency other than the lead agency that has jurisdiction by law or special expertise with respect to the environmental impacts expected to result from a proposal. An agency has “jurisdiction by law” if it has the authority to approve, veto, or finance all or part of the proposal (40 CFR §1508.15). An agency has “special expertise” if it has statutory responsibility, agency mission, or related program experience with regards to a proposal (40 CFR §1508.26). A lead agency must request the participation of cooperating agencies as early as possible in the NEPA process, use the environmental analyses and proposals prepared by cooperating agencies as much as possible, and meet with cooperating agencies at their request (40 CFR §1501.6[a]).

The FAA requested the participation of NASA and the USAF (45th Space Wing) as cooperating agencies in the preparation of this EA due to their jurisdiction by law and special expertise. LC-39A is located on KSC property and the KSC Director has ultimate responsibility for all operations and improvements that occur on KSC property. Additionally, NASA provides special expertise with respect to environmental issues concerning space launch vehicles, especially crewed capsules like the Dragon-2. LC-40 is located at CCAFS, which is controlled by the 45th Space Wing. The 45th Space Wing has a special interest and specific expertise with regards to all activities located at CCAFS. The 45th Space Wing also has interest in managing their local environmental related activities performed by the growing number of tenants at CCAFS who may be affected by any proposed actions.

1.4. Purpose and Need

The purpose and need provide the foundation for identifying intended results or benefits and future conditions. In addition, the purpose and need define the range of alternatives to a proposed action. According to FAA Order 1050.1F, Paragraph 6-2.1(c), the purpose and need presents the problem being addressed and describes what the FAA is trying to achieve with the Proposed Action.

1.4.1. FAA’s Purpose and Need

The purpose of FAA’s Proposed Action is to fulfill the FAA’s responsibilities as authorized by the Commercial Space Launch Act (51 U.S.C. Subtitle V, ch. 509, §§ 50901-50923) for oversight of commercial space launch activities, including licensing launch activities. The need for FAA’s Proposed Action results from the statutory direction from Congress under the Commercial Space Launch Act, 51 U.S.C 50901(b) to, in part, “protect the public health and safety, safety of property, and national security and foreign policy interests of the United States” while “strengthening and [expanding] the United States space transportation infrastructure, including the enhancement of United States launch sites and launch-site support facilities, and development of reentry sites, with Government, State, and private sector involvement, to support the full range of United States space-related activities.”

1.4.2. SpaceX's Purpose and Need

The purpose of SpaceX's proposal to modify and expand several elements of its Falcon launch vehicle program at KSC and CCAFS is to continue to support missions for NASA and USAF, as well as to conduct business with commercial customers. SpaceX's proposed changes provide greater capability in its mission to support the ISS, the U.S. Department of Defense (DoD), and other commercial enterprises. SpaceX's activities continue to fulfill the U.S. expectation that space transportation costs are reduced to make continued exploration, development, and use of space more affordable.

SpaceX's proposal is needed to increase the operational capabilities and cost effectiveness of its space flight programs. Satisfaction of these needs benefits government and public interests to continue resource protection and reduce operation costs. Demand for launch services continues to increase beyond that originally proposed over the past 20 years, and the space industry growth projections indicate this will continue into the foreseeable future.

1.5. Public Involvement

In accordance with CEQ's NEPA-implementing regulations and FAA Order 1050.1F, the FAA has made this Draft EA available for public review. The FAA encourages all interested parties to provide comments concerning the content of the Draft EA on or before March 20, 2020. Comments should be as specific as possible and address the analysis of potential environmental impacts and the adequacy of the proposed action or merits of alternatives and any mitigation being considered. Reviewers should organize their participation so that it is meaningful and makes the agency aware of the viewer's interests and concerns using quotations and other specific references to the text of the Draft EA and related documents. Matters that could have been raised with specificity during the comment period on the Draft EA may not be considered if they are raised for the first time later in the decision process. This commenting procedure is intended to ensure that substantive comments and concerns are made available to the FAA in a timely manner so that the FAA has an opportunity to address them. Prior to including your address, phone number, e-mail address, or other personal identifying information in your comment, be advised that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold from public review your personal identifying information, we cannot guarantee that we will be able to do so.

The FAA provided public notice of the availability of the Draft EA for public review and comment through the *Federal Register*, local newspaper advertisement, and an e-mail notice to interested parties. See Chapter 7 for a list of agencies and persons receiving notification of the Draft EA. An electronic version of the Draft EA is available on the FAA's website:

https://www.faa.gov/space/environmental/nepa_docs/.

Following the close of the public comment period, the FAA will revise the EA, as appropriate, in response to comments received on the draft document, and a Final EA will be prepared. The Final EA will reflect the FAA's consideration of comments and will provide responses to substantive comments. Following review of the Final EA, the FAA will either issue a FONSI or decide to prepare an EIS.

2. DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

This chapter describes the Proposed Action (Section 2.1) and the No Action Alternative (Section 2.2).

2.1. Proposed Action

The FAA is proposing to modify existing SpaceX launch licenses or issue new launch licenses to SpaceX to continue conducting Falcon launch operations at KSC and CCAFS and to issue new reentry licenses to SpaceX for Dragon reentry operations. NASA is responsible for managing areas on KSC for space-related development and operations and provides oversight for non-NASA space and technology development use of KSC property. NASA is responsible for approving the construction of the MST at LC-39A. The FAA has no federal action related to the construction of the MST.

Due to SpaceX's ability to conduct launches, including booster landings, more frequently at KSC (LC-39A) and CCAFS (LC-40, LZ-1, and LZ-2), SpaceX's launch manifest includes more annual Falcon launches and Dragon reentries than were considered in previous NEPA analyses. This section provides the following:

- a description of the Falcon launch vehicles and Dragon spacecraft that FAA would license to conduct commercial space launch and reentry operations (Section 2.1.1)
- a description of the MST that SpaceX would construct to support launch operations at LC-39A (Section 2.1.1)
- a description of Falcon launch vehicle operations at LC-39A and LC-40 that FAA would license (Section 2.1.2)
- a description of Dragon reentry and recovery operations that FAA would license (Section 2.1.3)
- a description of payload processing associated with Falcon launch operations that FAA would license

2.1.1. Description of the Falcon Launch Vehicles, Dragon Spacecraft, and the MST

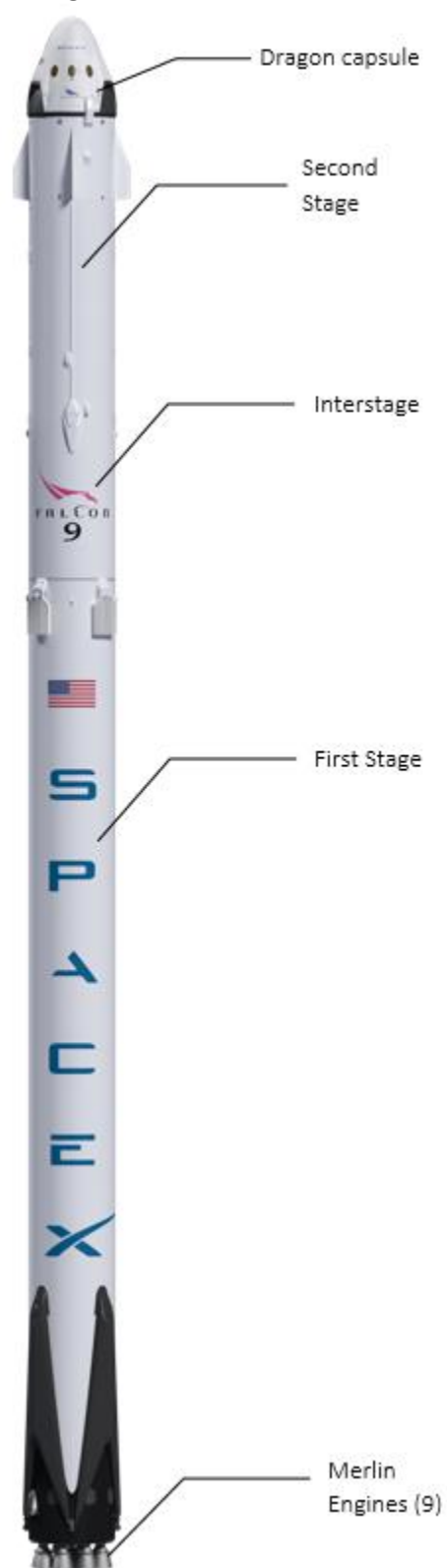
2.1.1.1. Falcon 9 Launch Vehicle

SpaceX recently upgraded the Falcon 9 with a newer version of its Merlin engine to increase the amount of thrust. The upgraded vehicle is referred to as Falcon 9 Block 5, but is referred to generally as the Falcon 9 in this EA. Additional changes include improvements to the landing legs and modifications to increase the efficiency of the recovery and reusability of the first stage boosters. Each of the Falcon 9 upgraded Merlin 1D (M1D) engines is capable of providing 190,000 pounds (pound-force) of thrust at sea level (for a total of approximately 1.7 million pounds of thrust at liftoff). The current Merlin engine used on Falcon 9 produces 170,000 pounds of thrust at sea level. The Falcon 9 is 229 feet tall with a diameter of 12 feet (Figure 2-1). These dimensions are the same as the previous Falcon version. Falcon 9 launches would occur at LC-40 and LC-39A. Consistent with past practices, a static fire test would be performed prior to each launch.

2.1.1.1.1. First Stage Booster

The Falcon 9 first stage includes nine M1D engines, which are propelled by LOX and RP-1. The engines are configured in a circular pattern, with eight engines surrounding a center engine. The first stage has four deployable landing legs which are locked against the first stage during ascent. These legs are used on missions that include first stage boost-back and landing. Four grid fins near the top of the first stage support precision reentry and landing operations. The grid fins help align the first stage booster for reentry after separating from the rest of the launch vehicle in space.

Figure 2-2. Falcon 9 Overview



A performance comparison of the current version of Falcon 9 to previous Falcon 9 launch vehicles is shown in Table 2-1.

Table 2-1. Performance Comparison of Falcon 9 Launch Vehicles

Parameter	Units	Falcon 9 (original)	Falcon 9 v1.1	Falcon 9 Block 5
Propellant	-	RP-1/LOX	RP-1/LOX	RP-1/LOX
Propellant Quantity ^a (total)	lbm	1,033,975	1,120,925	1,135,925
Engine Thrust (per engine)	lbf	147,000	170,000	190,000
Total Thrust (at liftoff)	lbf	1.32 M	1.53 M	1.71 M

Notes:

^a Propellant quantities vary based on mission parameters.

lbf = pound-force; lbm = pound-mass; LOX = liquid oxygen; M = million; RP-1 = highly refined kerosene.

2.1.1.1.2. Second Stage

Recent modifications to the second stage are relatively minor and include improvements to the engine nozzle, mass optimization, and engine control enhancements. For added reliability of restart, the engine contains dual redundant triethylaluminum-triethylborane (TEA-TEB) pyrophoric igniters. In addition, the second stage contains a cold nitrogen gas (GN2) attitude control system (ACS) for pointing and roll control. The GN2 ACS is more reliable and produces less contamination than a propellant-based reaction control system. The second stage is either left in orbit after payload (e.g., satellite) separation or planned for deorbit and reentry. During reentry, the second stage would eventually disintegrate and be consumed as it falls back into the upper atmosphere. SpaceX safes the second stage according to FAA regulations.

2.1.1.2. Falcon Heavy

The Falcon Heavy has a mass of approximately 3.1 million pounds and an overall length of 229 feet. Falcon Heavy has the ability to lift up 64 tons (141,000 pounds) into low Earth orbit. Merlin engines are used on both stages of the Falcon Heavy. The propellants are the same as the Falcon 9 (LOX and RP-1). The Falcon Heavy contains 1,898,000 pounds of LOX and 807,000 pounds of RP-1 in the first stage, and 168,000 pounds of LOX and 64,950 pounds of RP-1 in the second stage. The center and two side boosters are essentially the same design as the Falcon 9 first stage booster. The Falcon Heavy produces a total of 5.13 million pounds of thrust at liftoff. An illustration of the Falcon Heavy launch vehicle is shown in Figure 2-2.

Figure 2-3. Falcon 9 and Falcon Heavy Launch Vehicles

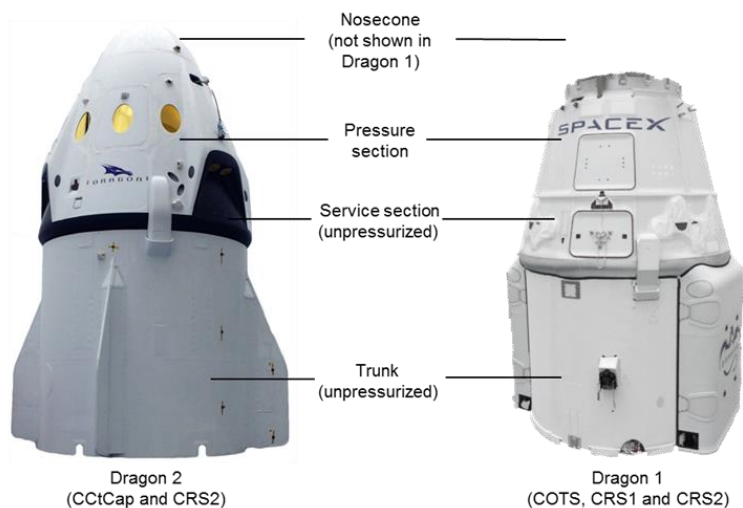


2.1.1.3. Dragon Spacecraft

SpaceX developed the Dragon-2 to deliver cargo and experiments to the ISS and Low Earth Orbit and to transport astronauts to the ISS. Dragon-2 weighs approximately 18,000 pounds without cargo and is

approximately 17 feet tall with a base width of 13 feet. Dragon-2 is similar to the previous Dragon-1 (Figure 2-3). Both are composed of two main elements: the capsule for pressurized crew and cargo, and the unpressurized cargo module or “trunk.” The capsule contains a pressurized section, an unpressurized service section, and a nosecone. Other primary structures include a welded aluminum pressure vessel, primary heat shield support structure, and back shell thermal protection system support structure. The thermal protection structure supports secondary structures, including the SuperDraco engines, propellant tanks, pressurant tanks, parachute system, and necessary avionics.

Figure 2-4. Dragon-1 and Dragon-2



One of the primary differences between Dragon-1 and Dragon-2 is that Dragon-2 has an integrated launch escape system capable of providing powered abort from the launch pad all the way to orbit, with enough thrust to escape from the Falcon 9 under worst-case conditions. The SuperDraco engines of the launch abort system are integrated into the sidewalls of Dragon-2.

After Dragon leaves the ISS, Dragon re-enters Earth’s atmosphere at a pre-planned trajectory and splashes down (lands with parachutes) in the Atlantic Ocean (5 to 200 nautical miles east of Cape Canaveral). The Gulf of Mexico or the Pacific Ocean would be used as an alternate splash down area if conditions in the Atlantic Ocean are unfavorable. The potential environmental impacts of Dragon landings in the Gulf of Mexico were previously analyzed by the FAA in an EA (FAA 2018b), which resulted in a FONSI, and are not assessed in this EA.

Dragon’s propulsion system consists of a reaction control system and the integrated launch abort system. Dragon contains 18 Draco engines and 8 SuperDraco engines. The propulsion system uses nitrogen tetroxide (NTO) and monomethylhydrazine (MMH) propellant combination because of its hypergolic ignition and long-term in-orbit storage benefits. Dragon could contain up to 5,650 pounds of propellant, which includes 3,500 pounds of NTO and 2,150 pounds of MMH. The pressurization subsystem, which uses gaseous helium, is separated between the oxidizer and fuel to prevent propellant migration reactions. Dragon’s propellant storage is designed to retain residual propellant, preventing release into seawater upon splashdown.

2.1.1.4. Vertical Integration

SpaceX plans to develop vertical integration capabilities at LC-39A to support commercial launches, NASA launches, and USAF’s National Security Space Launch program. An MST would be constructed on the existing LC-39A pad to support this capability. The MST would consist of a steel trussed tower, a base, and a rail bridge (Figure 2-4). Four transport wheel assemblies located at the corners of the tower

would be constructed and used to move the tower 130 feet from an integration to a launch position (Figure 2-5). The tower would have 11 floors and would be approximately 284 feet tall. The MST would meet all applicable codes, including IBC 2015, ACI 318-14, ASCE 7-10, AISC, 15th Ed., 91-710 requirements, and AWS D1.1.

Figure 2-5. Mobile Service Tower Design

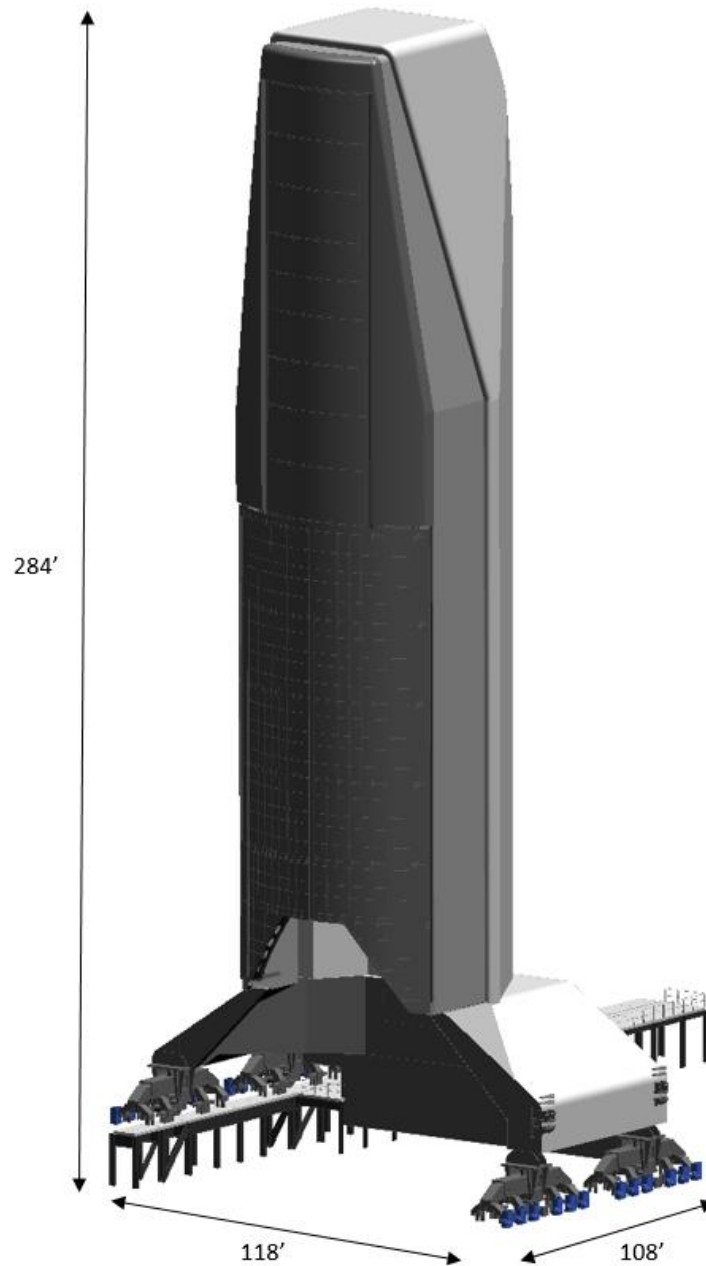
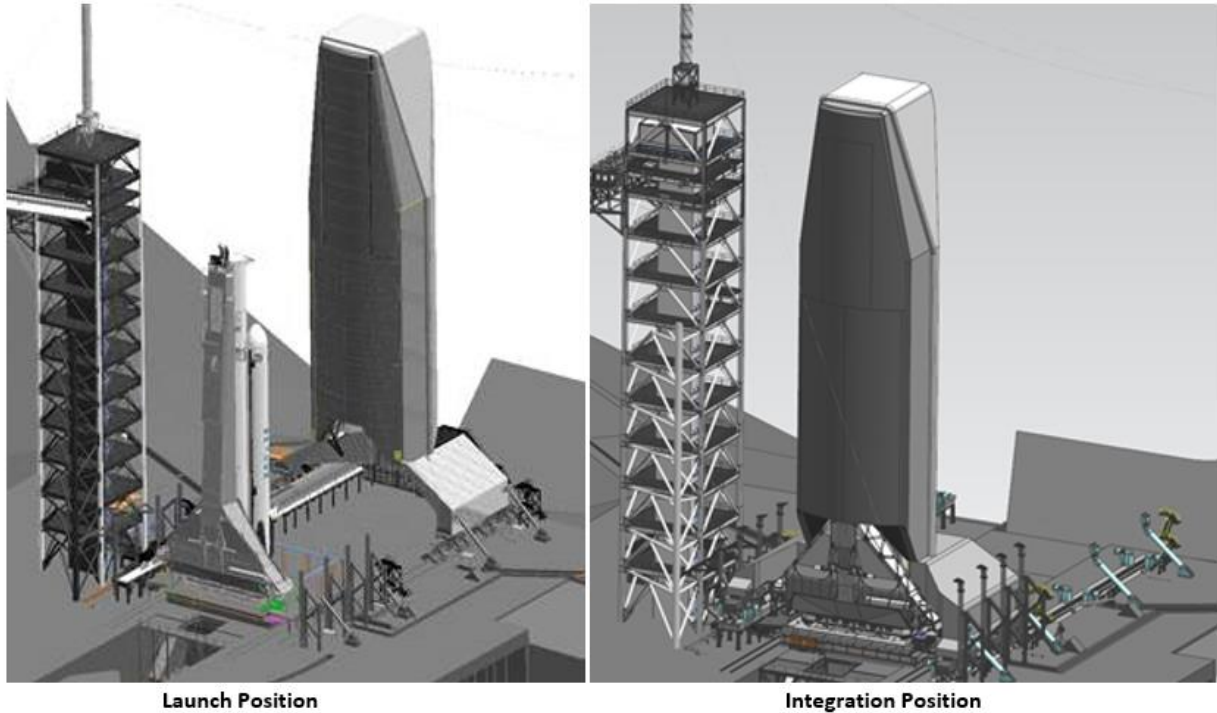
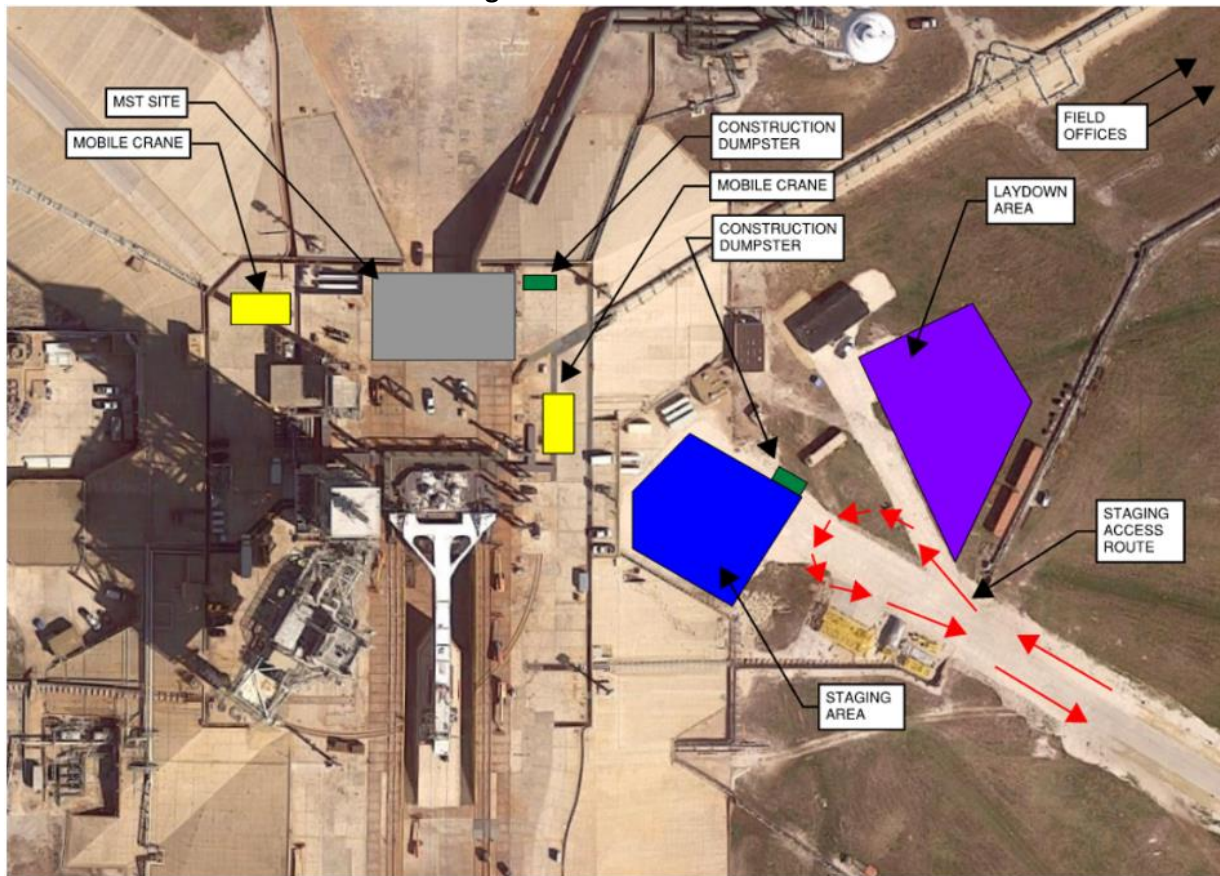


Figure 2-6. Pad Configurations for Mobile Service Tower



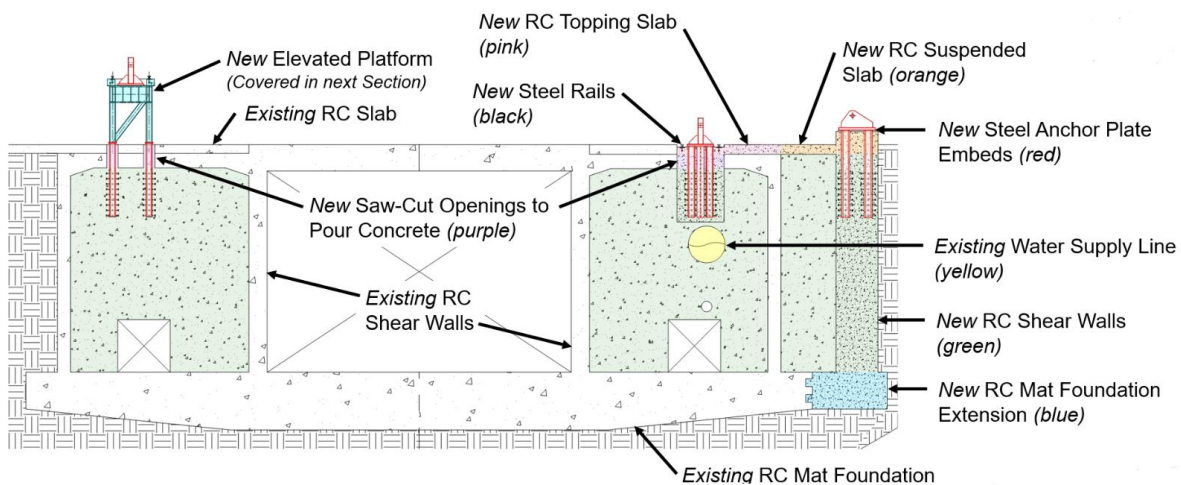
During tower construction, equipment and build materials would be staged east of the pad deck in the laydown area. Mobile cranes on the east and west of the tower site would be used to construct and assemble the tower. Construction dumpsters would be placed around the area and all materials would be disposed of according to federal and state regulations. Minimal demolition would occur on top of the MST area to allow access to the top of the existing concrete and install new shear walls and foundations. Figure 2-6 shows a general site overview for the proposed staging and laydown operations.

Figure 2-7. Site Overview



New reinforced concrete slabs would be placed over the existing flame trench. No new impervious areas would result from tower construction. Design drawings of the foundation modifications are shown in Figure 2-7.

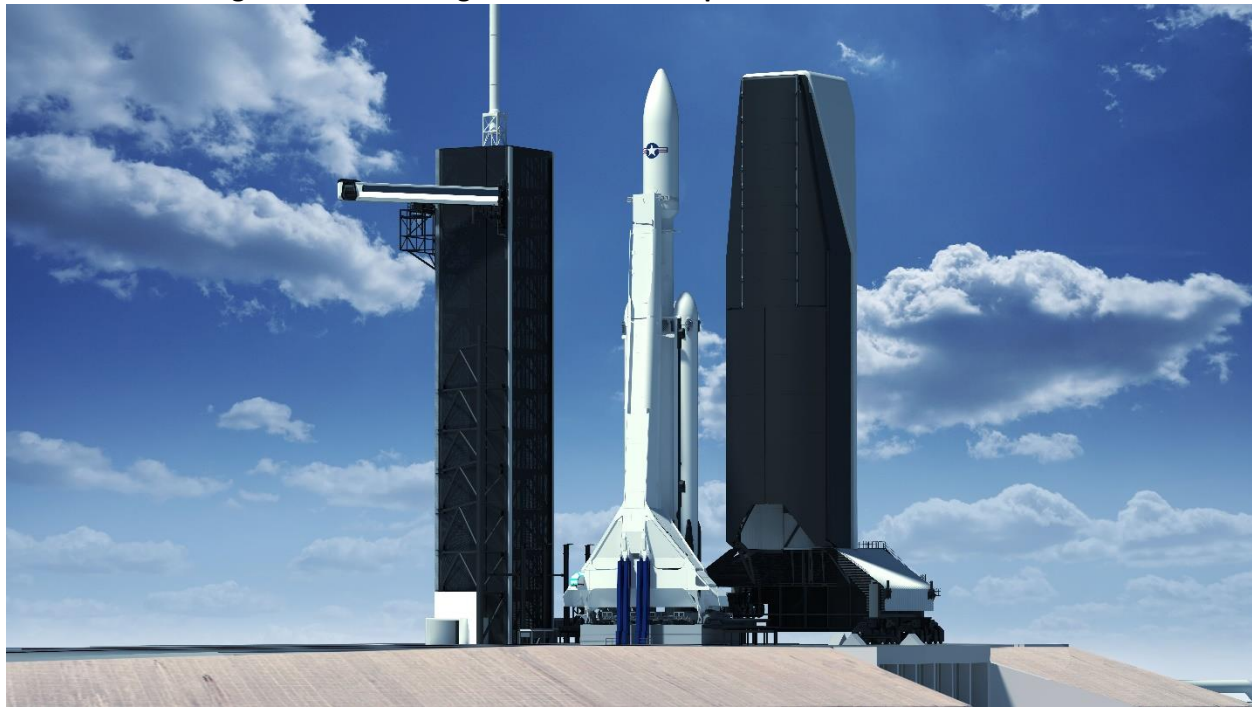
Figure 2-8. Foundation Modifications



New lighting would only be added inside the tower, which would be shielded by the walls of the tower. If any additional exterior lighting were planned later, the designs would be included in the LC-39A Light

Management Plan, which is a plan intended to minimize nighttime lighting impacts on the environment (e.g., sky glow). A rendering of LC-39A with the existing infrastructure and the proposed MST is presented in Figure 2-8.

Figure 2-9. Rendering of LC-39A with Proposed Mobile Service Tower



2.1.2. Falcon Launch Operations at LC-39A, LC-40, LZ-1, and LZ-2

All launch operations would continue to comply with the necessary notification requirements, including issuance of Notices to Airmen (NOTAMs) and Local Notices to Mariners (LNMs), consistent with current procedures. As part of the licensing process for a Falcon 9 polar mission (a southern launch and landing trajectory, which has not been conducted previously from Florida), SpaceX would negotiate and enter into Letters of Agreement (LOA) with relevant Air Traffic Control facilities and maritime security organization to accommodate the flight parameters of the integrated launch system. These LOAs would call for and define procedures for Air Traffic Control to issue a NOTAM defining the affected airspace and for the maritime security organization to issue LNMs prior to launch. A NOTAM provides notice of unanticipated or temporary changes to components of, or hazards in, the National Airspace System (FAA Order JO 7930.2M, *Air Traffic Policy*). A LNM provides notice of temporary changes in conditions or hazards in navigable waterways.

The Proposed Action does not include altering the dimensions (shape and altitude) of the airspace. However, temporary closures of existing airspace and navigable waters would be necessary to ensure public safety during launch operations. Advance notice via NOTAMs and LNMs would assist general aviation pilots and mariners in scheduling around any temporary disruption of flight or shipping activities in the area of operation. Launches would be of short duration and scheduled in advance to minimize interruption to airspace and waterways. For these reasons, significant environmental impacts of the temporary closures of airspace and waterways, and the issuance of NOTAMS and LNMs under the Proposed Action, are not anticipated. Moreover, in accordance with FAA Order 1050.1F, Paragraph 5-6.1 (Categorical Exclusions for Administrative/General Actions), issuance of NOTAMS are categorically excluded from NEPA review, absent extraordinary circumstances. However, until SpaceX completes the

LOA with Air Traffic Control for a southern launch trajectory that identifies any temporary airspace closures prior to launch, the FAA will not have the information necessary to determine the existence of any extraordinary circumstances deriving from such an LOA. The FAA would analyze any extraordinary circumstances and associated impacts before finalizing the operator LOA to the extent necessary under NEPA.

2.1.2.1. Launches

The Proposed Action includes annual SpaceX Falcon launches and related operations at LC-40, LZ-1, LZ-2, and LC-39A for the next six years (Table 2-2). Each takeoff would be preceded by a static fire test of the engines, which lasts a few seconds. This launch schedule is based on SpaceX's anticipated need to support NASA and DoD missions, as well as commercial customers. In addition to its typical launch trajectories, SpaceX is proposing to increase the launch azimuth window to include a new Falcon 9 southern launch trajectory to support missions with payloads requiring polar orbits. SpaceX estimates approximately ten percent of its annual Falcon 9 launches would fly this new southern launch trajectory. Falcon launch vehicle trajectories would be specific to each particular mission. Each trajectory would be provided in SpaceX's Flight Safety Data Package and submitted to the FAA in advance of the launch.

Table 2-2. Past and Estimated Future Falcon 9 and Falcon Heavy Launch Frequency^a

Year	KSC Launch Complex 39A		CCAFS Launch Complex 40	Total Launches
	Falcon Heavy	Falcon 9	Falcon 9	
2015	0	0	8	8
2016	0	0	8	8
2017	0	12	1	13
2018	1	2	12	15
2019	2	1	8	11
2020	3	5	30	38
2021	10	10	44	64
2022	10	10	44	64
2023	10	10	50	70
2024	10	10	50	70
2025	10	10	50	70

^a Data for the years 2015–2019 represent launches that occurred.

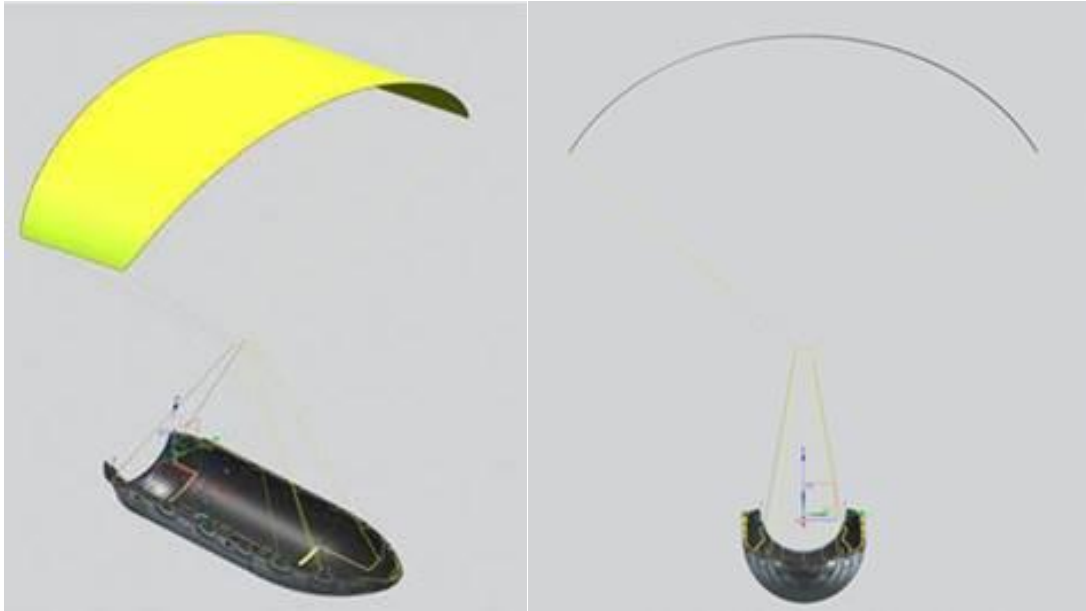
The following subsections describe nominal launch operations, including takeoffs and first stage boost-backs and landings.

2.1.2.2. Payload Fairing Recovery Operations

The Falcon vehicle payload system includes a fairing cover that protects non-Dragon payloads (e.g., satellites). The fairing consists of two halves which separate, allowing the deployment of the payload at the desired orbit. In the past, following the fairing separation, both halves of the fairing were left to splash down in the ocean, break apart, and sink. SpaceX is currently attempting to recover and reuse the payload fairings by adding a parachute system to the fairing halves. The parachute system consists of one drogue parachute and one parafoil (Figure 2-9). Following re-entry of the fairing into Earth's atmosphere, the drogue parachutes deploy at a high altitude (approximately 50,000 feet) to begin the initial slow down and to extract the parafoil. The drogue parachute (and the attached deployment bag) cuts away following the successful deployment of the parafoil. The parachute system slows the descent of the fairing to enable a soft splashdown so that the fairing remains intact. The predicted impact points within desired recovery areas of both the fairing (with parafoil) and drogue parachute assembly are developed using modeling tools. Various parachute systems are being tested, but generally, the drogue parachute canopy area is approximately 110 square feet and the fairing parafoils are approximately

3,000 square feet. In addition to various parachute systems, SpaceX is also testing recovery of the fairings using power boats to “chase and catch” the chutes and fairings as they descend to the ocean surface. SpaceX successfully caught a fairing half using a power boat after a Falcon Heavy launch on June 25, 2019.

Figure 2-10. Payload Fairing Half with Parafoil Deployed



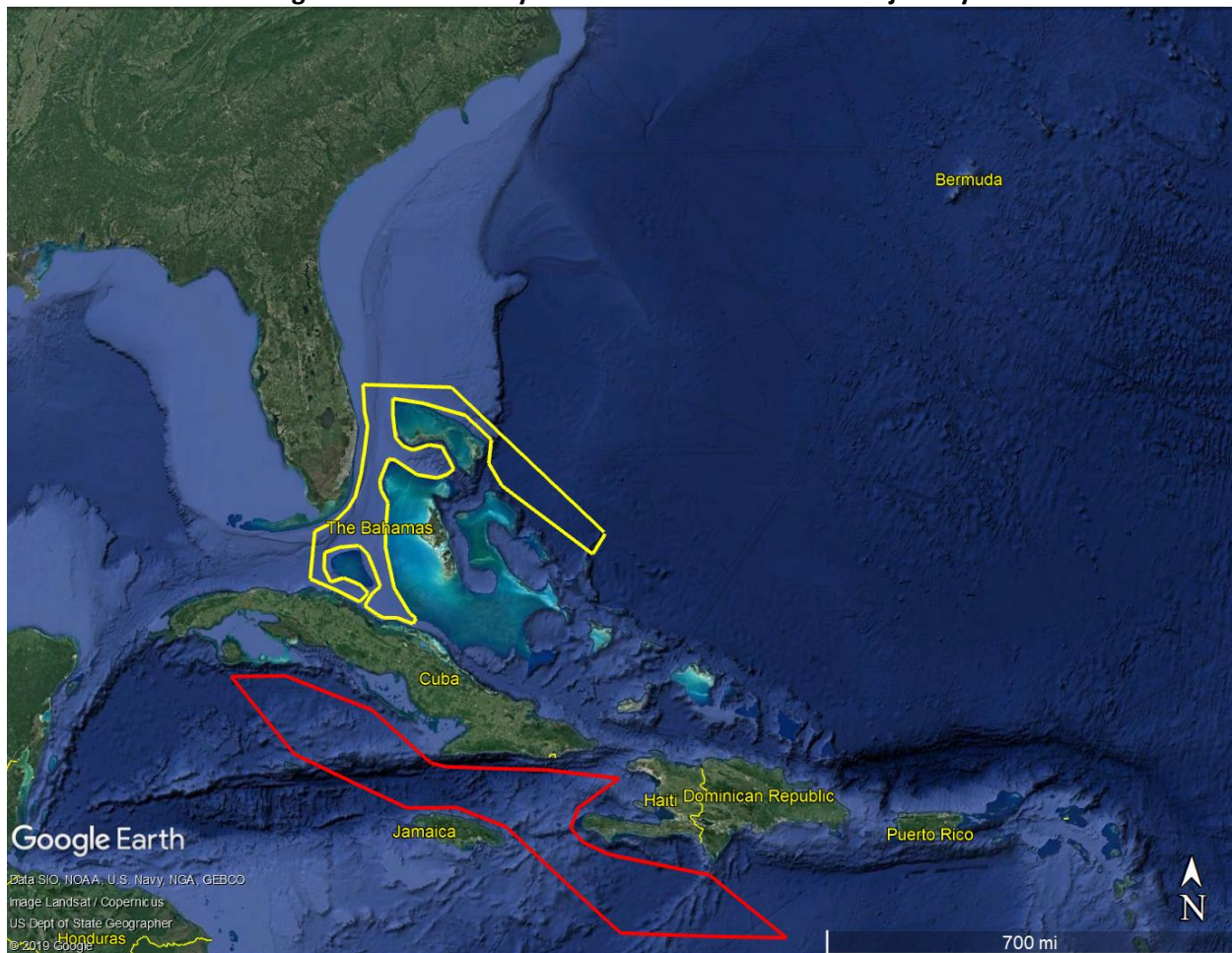
In 2020 through 2025, SpaceX anticipates approximately three recovery attempts per month involving recovery of both halves of the fairing. Thus, during these six years, SpaceX anticipates up to 432 drogue parachutes and up to 432 parafoils would land in the ocean. SpaceX would attempt to recover all parafoils over this time period, but it is possible some of the parafoils would not be recovered due to sea or weather conditions at the time of recovery. Recovery of the drogue parachute assembly would be attempted if the recovery team can get a visual fix on the splashdown location. Because the drogue parachute assembly is deployed at a high altitude, it is difficult to locate. In addition, based on the size of the assembly and the density of the material, the drogue parachute assembly would become saturated and begin to sink. This would make recovering the drogue parachute assembly difficult and unlikely. SpaceX is working on an engineering solution for recovery of the drogue parachute assembly, including landing the assembly on a pre-positioned recovery vessel that would be equipped with a landing pad/mechanism.

If SpaceX did not catch the fairings prior to falling in the ocean, the fairing and parafoil would be recovered by a salvage ship stationed in a Range Safety-designated zone near the anticipated splashdown area no closer than 5 nautical miles offshore. The salvage ship would be able to locate the fairing using GPS data from mission control and strobe lights on the fairing data recorders. Upon locating the fairing, a rigid-hulled inflatable boat (RHIB) would be launched. Crew members would hook rig lines to the fairing and connect a buoy to the parafoil. Then the crew would release the parafoil riser lines and secure the canopy by placing it into a storage drum. If sea or weather conditions are poor, recovery of the fairing and parafoil may be unsuccessful.

The southern launch trajectory would increase the potential fairing splashdown area to include the red-lined and yellow-lined areas in Figure 2-10. The yellow-lined area would also include any potential downrange first stage booster landing during Falcon 9 polar missions using the SpaceX drone ship. These areas consist of deep waters. SpaceX cannot conduct recovery operations in shallow waters near the

Bahamas. The Florida Keys National Marine Sanctuary (NMS) is located along the southern Florida coast near the new proposed yellow-lined area.

Figure 2-11. Recovery Area for Southern Launch Trajectory



Yellow = new proposed area for first stage booster and fairing recovery for polar missions

Red = new proposed area for fairing recovery only for polar missions

2.1.2.3. Boost-back and Landing

The Proposed Action includes conducting boost-back and landing of Falcon 9 and Falcon Heavy first stage boosters. After first stage engine cutoff and separation from the second stage, three of the nine first stage M1D engines are restarted to conduct a reentry burn. This reduces the velocity of the booster and places it in the correct angle for descent. Each booster has internal carbon overwrapped pressure vessels which are filled with either nitrogen or helium and are used to orient the position of the booster. Once the booster is in position and approaching its landing target, the three engines are cut off to end the entry burn. A final burn of one to three engines slows the booster to a velocity of zero for landing on the drone ship or at LZ-1 and/or LZ-2.

For missions involving boost-back and landing, SpaceX measures wind speed in the landing area using weather balloons. Measurements are taken at various intervals before launch and landing events and used to create the required profiles of expected wind conditions during the landing event. A radiosonde, which is approximately the size of a shoe box and is powered by a 9-volt battery, is attached to a weather balloon and transmits data to SpaceX and to vehicle onboard predictive systems. The balloon,

which is made of latex, rises to approximately 12 to 19 miles and bursts. The balloon is shredded into many pieces as it falls back to Earth, along with the radiosonde, and lands in the ocean. The radiosonde does not have a parachute and would not be recovered.

2.1.2.3.1. Landing at LZ-1 and LZ-2

LZ-1 and LZ-2 support preparations for and the landing of Falcon 9 and Falcon Heavy first stage boosters. They also support post-flight landing and safing activities which begin upon completion of all landing activities and engine shutdown. Once a booster(s) is safed, it is eventually transported to a SpaceX facility for refurbishment.

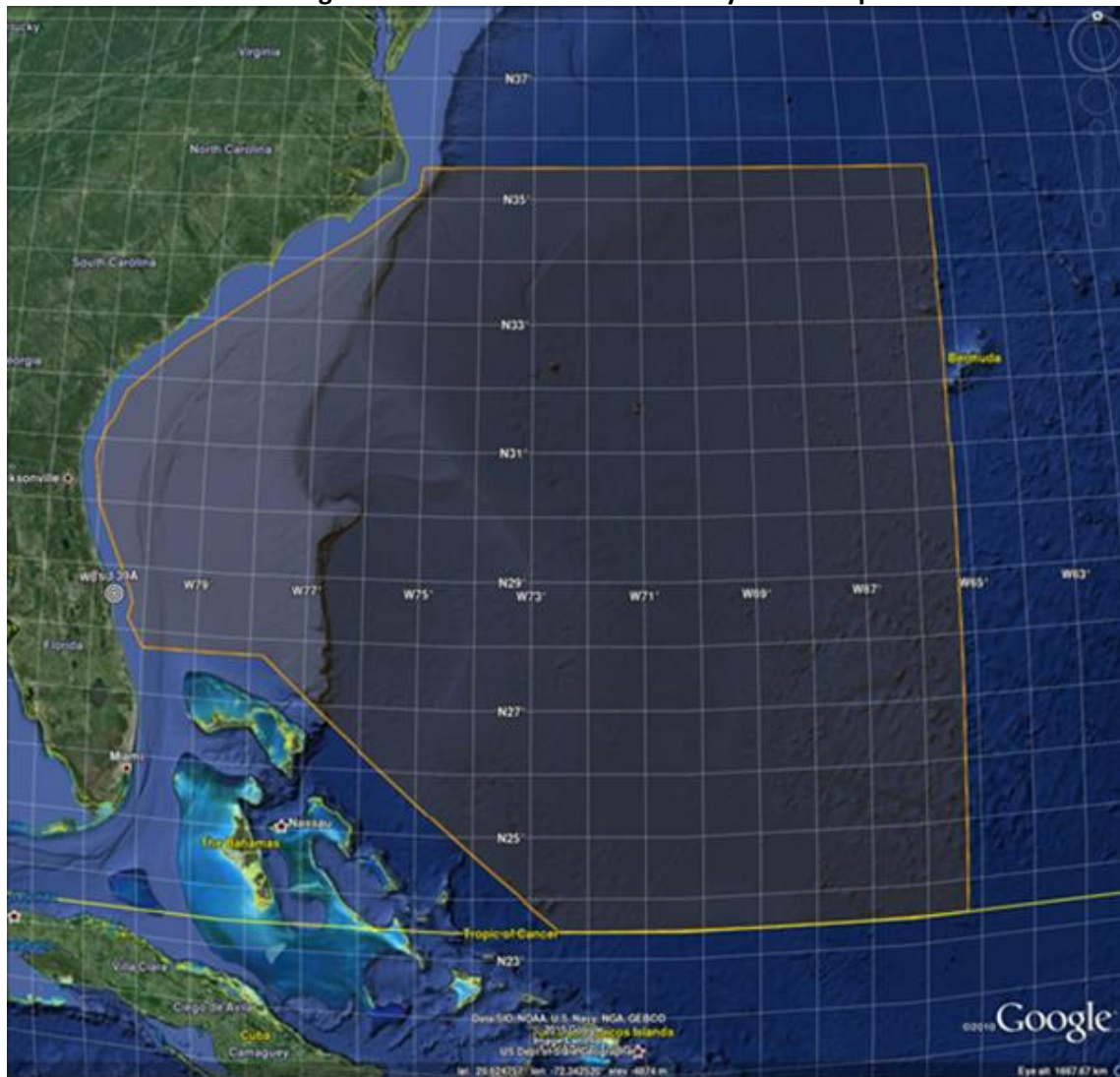
Following a nominal launch from LC-40 or LC-39A (including a polar mission), the first stage booster(s) would return to LZ-1 and/or LZ-2 for potential reuse (or land on a drone ship; see next section), rather than splashing down in the Atlantic Ocean. After first stage engine cutoff, exoatmospheric cold gas thrusters would be triggered to flip the booster(s) into position for retrograde burn, and three of the nine booster engines would be restarted to conduct the retrograde burn. This reduces the velocity of the booster and places it in the correct angle to land. Once the booster is in position and approaching its landing target, the three engines would be shut down to end the reentry burn. During the boost-back stage, sonic booms would be generated by each booster (the number of booms depends on the number of returning boosters). The landing legs on the booster(s) would then deploy in preparation for a final single-engine burn that would slow the booster to a velocity of zero before landing on the pad.

The detailed sequence of events for first stage booster landing(s) along with trajectory data would be provided in SpaceX's Flight Safety Data Package submitted to the FAA prior to the operation. Although propellants would be burned to depletion during flight, there is a potential for residual LOX and RP-1 to remain in the booster(s) upon landing. Final volumes of propellant would be included in the Flight Safety Data Package. A small amount of ordnance, such as small explosive bolts and batteries, would typically also be onboard. Any hazardous materials would be handled in accordance with federal, state, and local laws and regulations. SpaceX has an established emergency response team and any unexpected spills would be contained and cleaned up per the procedures identified in the SpaceX Emergency Action Plan and Spill Control and Countermeasures Plan.

2.1.2.3.2. Landing on a Drone Ship

If SpaceX is unable to return the first stage booster(s) to LZ-1 and/or LZ-2, SpaceX would attempt a drone ship landing. SpaceX's drone ship includes four outboard dynamic positioning devices which allow the barge to maintain a constant position for booster landings. In addition to the drone ship, SpaceX charts a crewed tug that tows the drone ship into position prior to launch. An accompanying crew boat also houses crew and communications equipment. Once on location, the drone ship positioning system is remotely activated, tow is broken, and the crew boat and tug boat fall back and stage themselves cross-range of the rocket's flight path. This puts the nearest vessel approximately 5 nautical miles from the drone ship, and the furthest vessel no more than 12 nautical miles from the drone ship. The drone ship would be no closer than 5 nautical miles from shore, but could be located several hundred miles offshore in the Atlantic Ocean. This area is referred to as the "superbox" and is shown in Figure 2-11. For polar missions, downrange drone ship recovery operations could include areas of the Atlantic Ocean north and south of Cuba and west of the Bahamas (Figure 2-10).

Figure 2-12. Atlantic Ocean Recovery Area – Superbox



Following a drone ship landing, automated and remotely operated systems are initiated to ensure the booster completes its landing and safing operations. Commands are transmitted through a satellite-based communication system that provides feedback and pertinent data about the systems to SpaceX controllers. The safing steps include venting pressure of stored helium and nitrogen, purging residual hazardous ignition fluid (TEA-TEB), and emptying remaining LOX from the booster. In some cases, the booster may fail to make a successful landing due to a number of variables (e.g., lack of fuel or hydraulic fluid, wind shear, etc.). In the case of an unsuccessful landing, any remaining fuel would ignite and burn off, and the wreckage would sink, similar to the fate of traditional non-reusable first stage boosters.

A remote controlled robot device is used to secure the booster. Once the booster is remotely safed, SpaceX personnel board the drone ship to service the fluids system to further remove hazards and protect against corrosion. Operations are optimized to require a small amount of time with a small number of personnel on the drone ship. After safing and securing operations are complete, the drone ship is placed under tow and all vessels return to shore.

As the drone ship approaches shore, automated systems ensure the booster is in a safe-state to proceed into port. SpaceX personnel are mobilized at the port to receive and off-load the booster. The booster is

then placed into processing fixtures on-shore that allow any residual fuel to be offloaded into storage tanks, landing gear removed, ordnance removed, and to ultimately facilitate on-road transport to a SpaceX facility for further processing.

2.1.2.3.3. Frequency of Boost-back and Landing

While it is SpaceX's goal to renter and land all first stage Falcon boosters for reuse, some payloads require additional propellant to reach desired orbits or destinations (due to increased weight or extended trajectory), and, as a result, not all the launches listed in Table 2-2 would include boost-back and landing. Approximately 75 percent of missions are expected to include a boost-back and landing. In the event SpaceX is unable to locate an expended first stage in the Atlantic Ocean (refer to Figures 2-10 and 2-11 for locations), SpaceX expects the stage would sink and therefore not be recovered. If the stage lands intact, SpaceX would attempt to recover it (as described in the 2007 USAF EA).

For Falcon Heavy boost-back and landing (which involves three first stage boosters), each of the three boosters would be controlled separately so their approach and landing would be managed independently. Not all of the boosters would land at CCAFS. Some would land on one of SpaceX's drone ships in the Atlantic Ocean. For a conservative analysis, the FAA is assuming a maximum of 54 annual first stage boosters landing at CCAFS (LZ-1 and/or LZ-2) and 27 annual first stage boosters landing on a drone ship (Table 2-3). If SpaceX operations exceed these numbers in the future, the FAA would conduct further environmental review to the extent necessary under NEPA.

Table 2-3. Returning First Stage Boosters^a

Year	From Falcon Heavy Launches	From Falcon 9 Launches	Total Boosters Returning
2020	9	19	28
2021	14	44	58
2022	14	44	58
2023	27	54	81
2024	27	54	81
2025	27	54	81

^a Not all boosters would land at CCAFS (LZ-1 and/or LZ-2). Some boosters would land on SpaceX's drone ship in the Atlantic Ocean. For a conservative analysis, the FAA is assuming 54 boosters per year would land at CCAFS and 27 boosters per year would land on the drone ship.

2.1.3. Dragon Reentry and Recovery Operations

The Proposed Action includes Dragon reentry and recovery operations. SpaceX plans to continue supporting its Commercial Cargo and Commercial Crew contracts with NASA by transporting cargo and NASA astronauts to the ISS onboard Dragon. These Dragon missions are included in the number of Falcon launches discussed above.

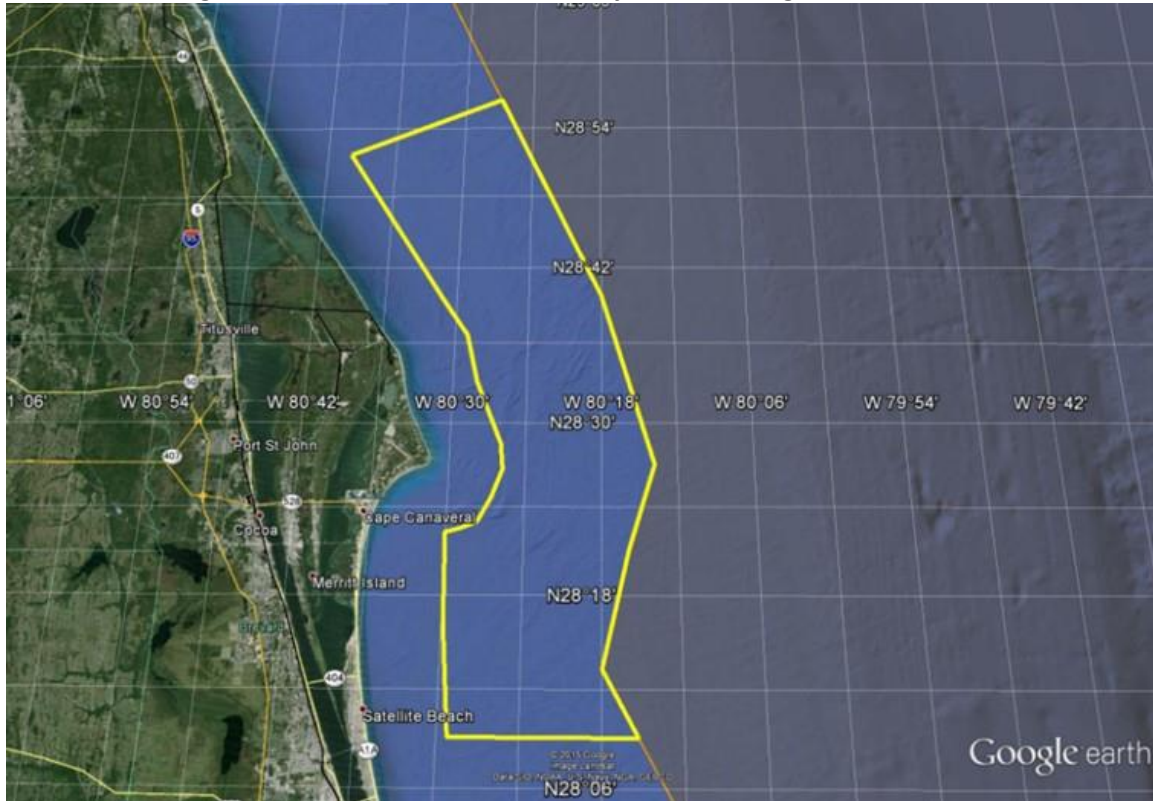
2.1.3.1. Atlantic Ocean

For Dragon recovery in the Atlantic Ocean, Dragon would be shipped to SpaceX facilities located at Port Canaveral or a CCAFS-located wharf. For Dragon recovery in the Pacific Ocean, Dragon would be shipped to the Port of Los Angeles. SpaceX would be responsible for coordinating local approvals with the relevant state and local agencies, including port authorities. Upon arriving at a port, Dragon would be offloaded and transported by truck to a SpaceX facility for further post-flight processing. In accordance with U.S. Department of Transportation (DOT) requirements, as outlined in SpaceX's DOT permit regarding the transport of hazardous waste, SpaceX would ensure all pressurized tanks are vented to a DOT-mandated maximum pressure prior to transport.

As Dragon-2 could contain astronauts, SpaceX and NASA plan to splash down Dragon-2 as close to the

shore as possible (an area referred to as the “bulb;” Figure 2-12). The bulb would be the nominal landing area for Dragon-2, with the Superbox acting as the contingency splashdown location. SpaceX designed the shape of the bulb such that all locations within the bulb are greater than 5 nautical miles from the coast to avoid North Atlantic right whale critical habitat.

Figure 2-13. Atlantic Ocean Recovery Area for Dragon-2 – The Bulb

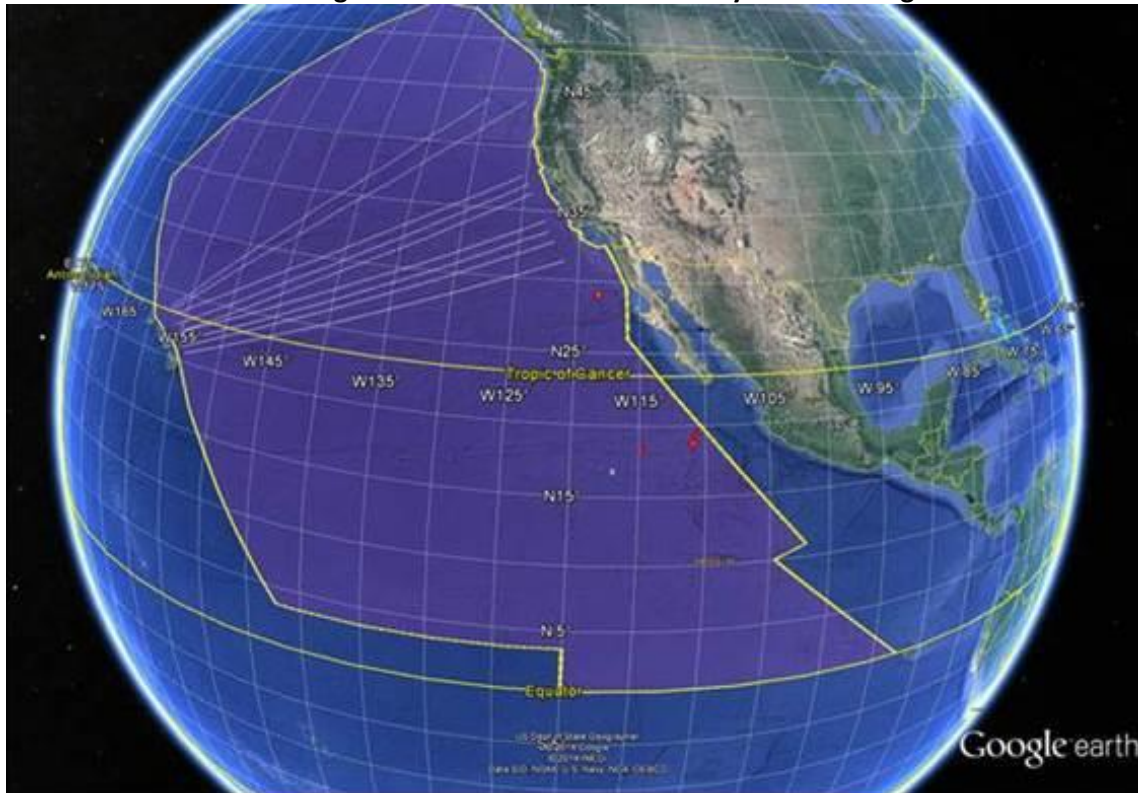


2.1.3.2. Pacific Ocean

The eastern boundary of the Pacific Ocean recovery area starts a minimum of 5 nautical miles offshore (Figure 2-13). There are several nearshore marine sanctuaries along the Pacific coast. In previous consultation with the FAA and National Marine Fisheries Service (NMFS), SpaceX agreed to never locate the nominal splashdown in a marine sanctuary (NMFS 2017⁵). The Pacific Ocean recovery area would be a contingency splashdown location for Dragon-2 missions.

⁵ The FAA conducted consultation with NMFS in 2017 to address SpaceX landing and recovery operations in the Atlantic Ocean, Gulf of Mexico, and Pacific Ocean.

Figure 2-14. Pacific Ocean Recovery Area for Dragon



2.1.3.3. Dragon Re-entry Operations

After completing its mission in space, Dragon executes a deorbit burn and reenters the atmosphere at a pre-planned trajectory. It is tracked to a splashdown area within a larger recovery circle with a radius of approximately 5.4 nautical miles. Dragon lands using drogue and main parachutes (Figure 2-14) with both versions using two drogue parachutes. Dragon-1 uses three main parachutes and Dragon-2 uses four main parachutes.

Figure 2-15. Dragon-1 Main and Drogue Parachutes



Following splashdown, an electronic locator beacon on Dragon would assist SpaceX in locating and recovering Dragon by a pre-positioned recovery vessel. The recovery vessel is a 160-foot ship equipped with a helideck and “A-Frame” (Figures 2-15 and 2-16).

Figure 2-16. Dragon Recovery Vessel



Figure 2-17. Recovery A-frame Crane Operation



Pre-positioned RHIBs arrive at Dragon's location first to assess Dragon's condition. This assessment includes checking for hypergol vapors, which can be fatal if inhaled, and ensuring the capsule is floating in an upright and stable position. Dragon propellant storage is designed to retain residual propellant, so any propellant remaining in Dragon is not expected to be released, and it is unlikely a propellant leak would occur. In the unlikely event the tank ruptures on impact, the fuel would almost immediately form nitric and nitrous acid on contact with water, and would be quickly diluted and buffered by seawater.

Following the assessment, the lift brings Dragon gently out of the water and onto the deck of the recovery vessel. While Dragon is loaded onto the recovery vessel, a RHIB attempts to recover all of the drogue and main parachutes deployed. However, it is possible some or all of the parachutes would not be recovered due to sea or weather conditions.

For crewed missions, Dragon would be secured in the on-deck hangar, egress equipment would be positioned in front of Dragon, Dragon's pressure would be equalized, and the side hatch would be opened. Crew egress would then begin. Crew would be helped from the capsule into shipboard medical evaluation quarters. Medical assessments would begin in private medical quarters. The crew and time-critical cargo would be transported via helicopter to the nearest airport.

The following is an estimate of the total number of Dragon parachutes expected to be recovered from 2020–2025.

- 2020: 6 Dragon reentries
 - 1 Dragon-1 reentry in the Pacific Ocean – total of 2 drogue parachutes and 3 main parachutes
 - 5 Dragon-2 reentries in the Atlantic Ocean – total of 10 drogue parachutes and 20 main parachutes
- 2021: 7 Dragon reentries per year. All Dragon-2 reentries in the Atlantic Ocean – total of 14 drogue parachutes and 28 main parachutes

- 2022–2025: 10 Dragon reentries per year. All Dragon-2 crew and cargo reentries are targeted for the Atlantic Ocean – total of 20 drogue parachutes and 40 main parachutes each year.

2.1.4. Payload Processing

In addition to Dragon, SpaceX continues to fly commercial satellites as well as NASA, DoD, and Intelligence Community missions. SpaceX has various facilities across CCAFS and KSC that are used for payload processing and vehicle refurbishment operations. These facilities include LC-40, LC-39A, Hangars AO and M, the PPF, and FPF. SpaceX continues to process vehicles and payloads in its LC-40 hangar. Operations also include recovered booster and fairing refurbishment for reuse. SpaceX plans to conduct static fires of Dragon-2 engines at the new Dragon site at LZ-1 prior to and following launch and recovery of Dragon-2. SpaceX is planning to process Dragon-2 at Area 59 near the CCAFS skid strip, and estimates there may be up to two Dragon test fires per month at LZ-1.

2.2. No Action Alternative

CEQ regulations (44 CFR §1502.14) require agencies to consider a “no action” alternative in their NEPA analyses to compare the effects of not taking action with the effects of the action alternative(s). Thus, the No Action Alternative serves as a baseline to compare the impacts of the Proposed Action. Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for Falcon launch and Dragon reentry operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS, as well as Dragon reentry operations, as analyzed in previous NEPA and environmental reviews and in accordance with existing FAA licenses until the licenses expire. Under the No Action Alternative, SpaceX would not conduct polar missions from LC-39A and LC-40 using a southern launch trajectory. Under the No Action Alternative, SpaceX would not construct the MST at LC-39A. SpaceX currently holds two FAA licenses for launches at KSC or CCAFS and one Dragon reentry license:

- License LLO 18-105 authorizes Falcon 9 launches at LC-40 to deliver payloads to geostationary transfer orbit; expires January 18, 2023.
- License LLO 19-110 authorizes Falcon 9 and Falcon Heavy launches from LC-39A to deliver payloads to low Earth or geosynchronous transfer orbit; expires February 14, 2024.
- License RLS 15-006 authorizes three reentries of Dragon from Earth orbit to a reentry location in the ocean in support of the NASA Commercial Resupply Services Missions; expires October 1, 2020.

Previous environmental reviews included up to 12 Falcon 9 annual launches at CCAFS (including boost-back and landing at LZ-1 or LZ-2), up to 10 Falcon 9 and 10 Falcon Heavy annual launches at KSC (including boost-back and landing of the first stages at LZ-1 or LZ-2), up to three Dragon-1 landings in the Pacific Ocean and three Dragon-2 landings in the Atlantic Ocean annually through 2020, and 12 Dragon landings in the Atlantic Ocean annually from 2021 through 2024.

3. AFFECTED ENVIRONMENT

This chapter provides a description of the environmental impact categories that have the potential to be affected by the Proposed Action, as required by FAA Order 1050.1F. The environmental impact categories assessed in detail in this EA include air quality; biological resources; climate; coastal resources; Department of Transportation Act Section 4(f); hazardous materials, solid waste, and pollution prevention; land use; natural resources and energy supply; noise and noise-compatible land use; socioeconomics; visual effects (including light emissions); and water resources (surface waters and groundwater). In accordance with 40 CFR §1502.15 and Paragraph 6-2.1.e of FAA Order 1050.1F, the level of detail provided in this section is commensurate with the importance of the potential impact on the environmental impact categories. The following environmental impact categories are not analyzed in detail for the reasons stated:

- **Farmlands:** There are no designated agricultural lands at CCAFS or KSC. Therefore, the Proposed Action would not impact farmlands.
- **Floodplains and Wetlands:** Although the proposed MST construction at LC-39A would occur within a flood hazard area (the 500-year floodplain), the construction would occur at an existing launch complex and would not result in new impervious surfaces. Thus, the construction would not impact any natural or beneficial floodplain values. The construction would not occur within a wetland. Launch operations would not affect floodplains or wetlands at KSC or CCAFS. Therefore, the Proposed Action would not impact floodplains or wetlands.
- **Environmental Justice and Children's Environmental Health and Safety:** The Proposed Action includes activities that regularly occur at KSC and CCAFS. There would be no impacts that disproportionately adversely affect environmental justice populations. Additionally, no component of the Proposed Action would result in a disproportionate health and safety risk to children.
- **Wild and Scenic Rivers:** The Proposed Action would not impact wild and scenic rivers because there are no wild and scenic rivers located near KSC and CCAFS.

The geographic area potentially affected by the Proposed Action is referred to as the study area. Each resource area discussed in this section has a distinct study area, which is described in each section below. Previous NEPA documents have addressed and described the affected environment for SpaceX's Falcon launch vehicle program at LC-39A, LC-40, LZ-1, and LZ-2, as well as Dragon recovery in the Atlantic and Pacific Oceans, as follows:

- **LC-39A:** The 2013 NASA EA for the multi-use of LC-39A and LC-39B (NASA 2013). The FAA was a cooperating agency in the preparation of this EA and issued a FONSI (FAA 2016) to support issuing launch licenses to SpaceX for Falcon 9 and Falcon Heavy launch operations at LC-39A.
- **LC-40 and Dragon Recovery in Atlantic and Pacific Oceans:** The 2007 USAF EA and 2013 USAF SEA for Falcon 9 and Falcon Heavy launch operations at LC-40, including Dragon recovery in the Atlantic Ocean or Pacific Ocean (USAF 2007, 2013). The FAA was a cooperating agency in the preparation of the 2007 USAF EA and 2013 USAF SEA and issued FONSIs (FAA 2009, 2013) to support issuing licenses to SpaceX for Falcon 9 and Falcon Heavy launch operations at LC-40 and Dragon reentry.
- **LZ-1:** The 2014 USAF EA for Falcon 9 first stage boost-back and landing at LZ-1 (formerly called LC-13) (USAF 2014). The FAA was a cooperating agency in the preparation of the 2014 USAF EA and issued a FONSI (FAA 2015) to support issuing launch licenses to SpaceX for Falcon 9 first stage boost-back and landing at LZ-1.

- **LZ-2:** The 2017 USAF SEA for Falcon Heavy first stage boost-back and landing at LZ-1 and LZ-2 (only referred to as LZ-1 in the SEA) (USAF 2017a). The FAA was a cooperating agency in the preparation of the 2017 USAF SEA and issued a FONSI (FAA 2017) to support issuing launch licenses to SpaceX for Falcon Heavy first stage boost-back and landing at LZ-1 and LZ-2.

In accordance with 40 CFR §1502.21, this section incorporates material from the EAs mentioned above by reference to avoid redundancy without impeding agency and public review of the Proposed Action. The incorporated material is cited and briefly described.

3.1. Land Use

The study area for land use includes KSC and CCAFS. Land and open water resources of KSC and CCAFS are located in Brevard County and Volusia County and are located along the east coast of central Florida. The majority of the KSC land is located on the northern part of Merritt Island, which forms a barrier island complex adjacent to Cape Canaveral. Undeveloped areas (uplands, wetlands, mosquito control impoundments, and open water) comprise approximately 95 percent of KSC. Nearly 40 percent are open water areas of the Indian River Lagoon (IRL) system, including portions of the Indian River, Banana River, Mosquito Lagoon, and all of Banana Creek (NASA 2015a).

Neither Brevard County nor the City of Cape Canaveral has land use or zoning authority over CCAFS land. The general plans of Brevard County and City of Cape Canaveral designate compatible land uses and zoning around CCAFS. CCAFS designates its own land use and zoning regulations. Land uses at CCAFS include launch operations, launch and range support, airfield, port operations, station support area, and open space, and does not include farmland. The launch operations land use category is present along the Atlantic Ocean shoreline and includes both inactive and active launch sites and support facilities. Open space is dispersed throughout the station. There are no public beaches located on CCAFS.

KSC was established under NASA jurisdiction for the purpose of implementing the Nation's space program (National Space Act 1959). NASA maintains operational control over approximately 4,400 acres of KSC (NASA 2015a). These are the operational areas, which are dedicated to NASA ground processing, launch, and landing activities and include facilities and associated infrastructure such as roads, parking areas, and maintained right-of-ways. Undeveloped lands within the operational areas are dedicated safety zones or are reserved for planned and future expansion.

The overall land use and management objectives at KSC are to maintain the Nation's space mission operations while supporting alternative land uses that are in the Nation's best interest. KSC land use is carefully planned and managed to provide required support for missions while maximizing protection of the environment. Land use planning and management responsibilities for areas not directly used for NASA operations are delegated to the U.S. Fish and Wildlife Service (USFWS) at Merritt Island National Wildlife Refuge (MINWR) and the National Park Service (NPS) at Canaveral National Seashore (CNS). The approximately 135,225 acres outside NASA operational control are managed by the NPS and the USFWS. The NPS administers an approximate 6,655-acre area of the CNS, while the USFWS administers the remaining approximately 128,570 acres of the CNS and the MINWR (NASA 2015b). This unique relationship between space flight and protection of natural resources is carefully orchestrated to ensure that both objectives are achieved with minimal conflict.

MINWR was created in 1963 by agreement between the Bureau of Sport Fisheries and Wildlife (later USFWS) and NASA to manage the undeveloped lands needed as a safety buffer around KSC. Congress established CNS in 1975. It is located in both Brevard and Volusia Counties and includes 58,000 acres of barrier islands, open lagoons, coastal hammocks, and pine flat woods and 24 miles of undeveloped beaches. KSC has an agreement with the U.S. Department of the Interior for management of a portion of the CNS by the NPS and a portion by the USFWS.

Under the Interagency Agreement between NASA and USFWS for Use and Management of Property at KSC known as MINWR (KCA-1649 Rev. B), the USFWS conducts habitat management activities, including prescribed burning. The USFWS coordinates prescribed burns on MINWR in accordance with the “Joint Operating Procedure between the 45th Space Wing, USFWS, and KSC for Prescribed Burning on the MINWR, KSC, and Cape Canaveral Air Force Station, Florida,” (KSC 2019).

For more than 35 years, MINWR has conducted prescribed fire and wildfire control operations in smoke-sensitive areas of KSC and CCAFS. KSC facilities are intermixed with fire-dependent wildland habitats including oak-palmetto scrub, pine flat woods, and marshlands. Due to the high occurrence of lightning strikes, wildfires occur on MINWR. These wildfires can be managed but not eliminated, and unplanned wildfires pose a risk to public health and safety and interfere with spaceflight operations.

Prescribed burning is the intentional ignition of grass, shrub, or forest fuels for specific purposes. Burn programs on CCAFS and KSC are used as an important natural resource and land management tool and provide biological, ecological, environmental, and safety benefits. Prescribed burns are conducted to enhance and restore wildlife habitats to pre-fire exclusion conditions, to promote and benefit wildlife species that are dependent on fire adapted ecosystems, to aid the control of exotic plants and vegetation or “hazardous fuel loads” to reduce wildfire threat, and to protect critical spaceflight infrastructure on CCAFS and KSC.

LC-39A is adjacent to Fire Management Unit (FMU) 5.3 to the north and west, and approximately 0.2 mile from FMU 7.4 to the southeast. Approximately 116 acres of the 1,000 acres contained in FMU 5.3 burned in May 2011. FMU 7.4 encompasses 1,863 acres, of which 793 acres burned in August 2011. Smoke-sensitive areas are located northwest and southwest of this burn unit. This unit does not receive fire according to the prescribed fire schedule.

LC-40 is approximately 0.6 mile to the south of FMU 7.4 (Figure 3-1). As described above, the USFWS attempts to manage wildfire threats through planned prescribed burn ignitions. Although some FMUs do not receive fire according to the fire schedule due to restrictions, all FMUs are scheduled to receive fire on a 3 to 4 year rotation and will receive fire when restrictions allow.

Figure 3-18. Fire Management Units near LC-39A and LC-40



3.2. Visual Effects (including Light Emissions)

Visual resources are defined as the natural and man-made features that give an area its aesthetic qualities. These features define the landscape character of an area and form the overall impression received by an observer of the property. The study area for visual resources includes the viewshed around the Proposed Action site, such as adjacent lands at KSC and CCAFS within view of facilities. Visual resources are any naturally occurring or man-made feature that contributes to the aesthetic value of an area. Areas such as coastlines, national parks, and recreation or wilderness areas are usually considered to have high visual sensitivity.

Visual and aesthetic resources refer to natural or developed landscapes that provide information for individuals to develop their perceptions of the area. The existing conditions at KSC are characterized as having low visual sensitivity because the site is currently an industrialized area that supports rocket launches. Notable visual structures include the lightning protection towers at LC-39A, LC-39B, LC-41, and those launch pads further south of the proposed site. Due to the flat topography and the height of the lightning protection towers (approximately 600 feet tall), the towers can be seen several miles away. Other highly visible structures include the Vehicle Assembly Building and the KSC Visitor Complex Space Shuttle Atlantis External Tank and Solid Rocket Booster Display.

The visual resources at KSC are typical of an administrative and industrial campus. The LC-39 area is characterized by facilities for launch vehicle assembly, testing, and processing, while the industrial area includes various facilities dedicated to administration, payload and launch vehicle processing, and research. Specialized development at KSC includes the Shuttle Landing Facility (SLF) (with associated hangars and

fueling facility), LC-39A, and LC-39B.

CCAFS, located just to the south of LC-39A, is primarily flat with scrub oak and palmetto as dominant land cover types. Visual resources at CCAFS are typical of a military installation with hangars and administrative facilities, but also encompass launch complexes, lightning protection towers, and a lighthouse.

CNS, located north of KSC, consists of naturally dark conditions. Lighting impacts can disrupt this and degrade the views of the night sky in the park. The existing conditions on KSC, including LC-39A, require lighting that may cause skyglow, which is light that escapes into the sky and illuminates particulates and degrade the views of the night sky in the park.

Existing light sources at KSC and CCAFS include nighttime security lighting at the launch complexes and buildings. NASA has guidelines to address the light impacts to wildlife species under the KSC exterior lighting requirements in Chapter 24 of Kennedy NASA Procedural Requirements 8500.1 Rev. E (NASA 2018). The installation and use of any lighting that is visible from the exterior of a facility must be in compliance with these guidelines. Development of a Light Management Plan that meets the exterior lighting requirements is mandatory for all new structures.

3.3. Air Quality

This section describes air quality resources for KSC and CCAFS at altitudes below 3,000 feet, which contain the atmospheric boundary layer. The Earth's atmosphere consists of five main layers: the troposphere, stratosphere, mesosphere, ionosphere, and exosphere. For the purposes of this EA, the lower troposphere is defined as at or below 3,000 feet above ground level (AGL), which the U.S. Environmental Protection Agency (EPA) accepts as the nominal height of the atmosphere mixing layer in assessing contributions of emissions to ground-level ambient air quality under the Clean Air Act (CAA) (EPA 1992). Although Falcon 9 launch vehicles and Dragon emissions from operations at or above 3,000 feet AGL would occur, these emissions would not result in appreciable ground-level concentrations. Since the Falcon launch vehicle program occurs at both KSC and CCAFS, and the proposed Dragon reentry, splashdown, and recovery operations would primarily occur in Atlantic Ocean, Pacific Ocean, Port Canaveral, Florida, and Port of Los Angeles, California, the study area for air quality is Brevard County, Florida and Los Angeles County, California.

Atmospheric monitoring for chemicals at KSC and CCAFS occurs within the atmospheric boundary layer where people live and work. Air quality at KSC and CCAFS is regulated under the CAA regulations (40 CFR Parts 50 through 99) and Florida Administrative Code (FAC) Chapters 62-200 through 62-299. Both KSC and CCAFS are located in Brevard County which is classified as in attainment with the National Ambient Air Quality Standards (NAAQS) (Table 3-1). The Florida Department of Environmental Protection (FDEP) has exclusively adopted the NAAQS. KSC operates under a Title V Operating Permit that governs the air emissions from activities considered a major source of air pollution. This permit is designed to improve compliance by clarifying actions that must be taken to control air pollution. CCAFS had operated under a Title V Air Operation Permit by designation until recently. Following a USAF review which indicated that over the past several years criteria air pollutants and Hazardous Air Pollutants (HAP) emitted annually did not warrant having a Title V permit, CCAFS surrendered the Title V Permit back to FDEP and requested a General Permit. The General Permit (62-210.310, F.A.C.) was issued on May 5, 2017. The General Permit only covers internal combustion engines and generators. All other air emissions units at CCAFS are currently exempt under the General Permit. All emissions types that would occur under the Proposed Action are exempt from air permitting requirements pursuant to FAC Rule 62-210.300(3)(a), Categorical and Conditional Exemptions. These types of categorically excluded emissions units or activities are considered to produce "insignificant" emissions pursuant to FAC Rule 62-213.430(6).

3.3.1. National Ambient Air Quality Standards

Under the CAA, criteria pollutants include carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), ozone, particulate matter less than or equal to 10 microns in diameter (PM₁₀), particulate matter less than or equal to 2.5 microns in diameter (PM_{2.5}), and lead (Pb). CO, SO₂, Pb, nitrogen oxides, and some particulates are emitted directly into the atmosphere from emissions sources. Ozone, NO₂, and some particulates are formed through atmospheric chemical reactions that are influenced by weather, the ultraviolet component of sunlight, and other atmospheric processes.

The NAAQS represent the maximum levels of pollution that are considered acceptable, with an adequate margin of safety, to protect public health and welfare (Table 3-1). Short-term standards (1-, 3-, 8-, and 24-hour periods) are established for pollutants contributing to acute health effects, while long-term standards (quarterly and annual averages) are established for pollutants contributing to chronic health effects.

Table 3-1 National Ambient Air Quality Standards

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon monoxide		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead		primary and secondary	Rolling 3 month average	0.15 µg/m ³ ⁽¹⁾	Not to be exceeded
Nitrogen dioxide		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb ⁽²⁾	Annual Mean
Ozone		primary and secondary	8 hours	0.070 ppm ⁽³⁾	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particulate Matter	PM _{2.5}	primary	1 year	12.0 µg/m ³	annual mean, averaged over 3 years
		secondary	1 year	15.0 µg/m ³	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 µg/m ³	98th percentile, averaged over 3 years
	PM ₁₀	primary and secondary	24 hours	150 µg/m ³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide		primary	1 hour	75 ppb ⁽⁴⁾	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years

Pollutant	Primary/ Secondary	Averaging Time	Level	Form
	secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

Source: 40 CFR 50, EPA 2016. Criteria Air Pollutants NAAQS

Notes: mg/m³ = milligrams per cubic meter; µg/m³ = micrograms per cubic meter; ppb = parts per billion; ppm = parts per million; PM₁₀ = particulate matter less than or equal to 10 microns in diameter; PM_{2.5} = fine particulate matter 2.5 microns or less in diameter

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 µg/m³ as a calendar quarter average) also remain in effect.

(2) The level of the annual NO₂ standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) ozone standards additionally remain in effect in some areas. Revocation of the previous (2008) ozone standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

(4) The previous SO₂ standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which implementation plans providing for attainment of the current (2010) standard have not been submitted and approved and which is designated nonattainment under the previous SO₂ standards or is not meeting the requirements of a SIP call under the previous SO₂ standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the required NAAQS.

Based on measured ambient criteria pollutant data, the EPA designates all areas of the U.S. as having air quality better than the NAAQS (attainment), worse than the NAAQS (nonattainment), or unclassifiable (40 CFR Part 81, Subpart C, Section 107). The designation of attainment for any NAAQS is based on the evaluation of ambient air quality monitoring data collected through federal, state, and/or local monitoring networks. According to the EPA, Brevard County is in attainment for all criteria pollutants (EPA 2019). Los Angeles County is in nonattainment for PM_{2.5} and O₃ (EPA 2019).

Florida and California's air monitoring effort is concentrated on the six criteria pollutants. In 2016, Florida continued to be in attainment for all criteria pollutants, with the exception of Tampa's nonattainment designation for lead and sulfur dioxide nonattainment areas in Hillsborough County and Nassau County (EPA 2018a). As of March 31, 2019, 40 counties in California were in nonattainment, mainly for ozone. The state coastal boundaries are part of the same air quality jurisdiction area as the contiguous land area. Coastal waters for most states lie within 3 nautical miles of a shoreline. Dragon splashdowns and recovery operations would occur at a minimum of 5 nautical miles from shore and would be outside state coastal water jurisdictions.

The CAA defines conformity as the upholding of a set of air quality goals by eliminating or reducing violations of the NAAQS and achieving attainment of these standards. Conformity determinations are not required for launch operations in Florida since both launch facilities (LC-39a and LC-40) are located within NAAQS attainment area for all regulated criteria pollutants. The ambient air quality at both facilities is predominantly influenced by daily operations such as vehicle traffic, utilities, fuel combustion, and standard refurbishment and maintenance operations. Other operations occurring infrequently throughout the year, including launches and prescribed fires, also play a role in the quality of air as episodic events.

The Port of Los Angeles and adjacent coastal waters are in the South Coast Air Basin (SCAB) under the jurisdiction of the South Coast Air Quality Management District. The SCAB is classified as an attainment/unclassified area for the NAAQS for CO, NO₂, SO₂, and PM₁₀, and a nonattainment area for O₃, PM_{2.5}, and Pb. The CAA's General Conformity rule applies to federal actions occurring in non-attainment or maintenance areas. The General Conformity rule requires federal agencies to demonstrate that their

actions conform with the applicable State Implementation Plan.

3.3.2. Hazardous Air Pollutants

In addition to the NAAQS, national standards also exist for HAPs. The National Emission Standards regulate 187 HAPs based on available control technologies (40 CFR Parts 61 and 63). The majority of HAPs are volatile organic compounds. Mobile sources of air emissions include launch vehicles, commercial ships, recreational boats, cruise ships, and aircraft. HAPs emitted from mobile sources are called Mobile Source Air Toxics (MSATs). MSATs are compounds emitted from highway vehicles and non-road equipment that are known or suspected to cause cancer or other serious health and environmental effects. In 2001, EPA issued its first Mobile Source Air Toxics Rule, which identified 21 compounds as being HAPs that required regulation (EPA 2001). A subset of six of these MSATs compounds were identified as having the greatest influence on health and included benzene, 1,3-butadiene, formaldehyde, acrolein, acetaldehyde, and diesel particulate matter. EPA issued a second Mobile Source Air Toxics Rule in February 2007, which generally supported the findings in the first rule and provided additional recommendations of compounds having the greatest impact on health. The rule also identified several engine emission certification standards that must be implemented (EPA 2007).

MSATs would be the primary HAPs emitted by mobile sources during pad launch activity and recovery operations. The recovery vessel and RHIB used during recovery operations would likely vary in age and have a range of emission controls. It is anticipated that recovery equipment and vehicles would be operated for approximately five days for each launch-recovery operation and would produce negligible ambient pollutant emissions in a widely dispersed area. HAPs from the combustion of fossil fuel, which is the cause of emissions from mobile sources, are anywhere from one to three orders of magnitude less than criteria pollutant emissions from these sources. Because of small scale of the emissions and in the context of the minimal mobile source operations required by the proposed action, HAP emissions are not considered further in this analysis.

Table 3-2 is a summary of ambient air quality measurement data for 2013–2017 for the local region. The table shows that ground-level concentrations of criteria pollutants in the study area are within the NAAQS.

Table 3-2 Measured Ambient Air Concentrations of Criteria Pollutants in the Region^a

Pollutant	Averaging Time	Nearest Monitoring Station	Maximum Measured Concentration (ppm, except PM in $\mu\text{g}/\text{m}^3$)				
			2013	2014	2015	2016	2017
O ₃	8 Hours	Palm Bay-Melbourne- Titusville	0.063 (4 th max)	0.063 (4 th max)	0.059 (4 th max)	0.061 (4 th max)	0.061 (4 th max)
CO	1 Hour	Orlando-Kissimmee-Sanford	1.1	1.8	1.5	1.9	2.8
	8 Hour		1.0	1.5	1.2	1.2	1.4
NO ₂	1 Hour	Orlando-Kissimmee-Sanford	0.034	0.036	0.025	0.029	0.030
	Annual (mean)		0.005	0.005	0.004	0.004	0.004
SO ₂	1 Hour	Orlando-Kissimmee-Sanford	0.003	0.007	0.003	0.002	0.005
	24 Hour		0.0004	0.0023	0.0005	0.0013	0.0008
PM ₁₀	24 Hour	Palm Bay-Melbourne- Titusville	54 (2 nd max)	44 (2 nd max)	47 (2 nd max)	38 (2 nd max)	49 (2 nd max)
PM _{2.5}	24 Hour	Palm Bay-Melbourne- Titusville	21	14	12	10	20
	Annual		5.7	5.8	5.2	5.2	6.6

Lead	Quarterly	No lead monitors are located within 100 miles of LZ-1	-	-	-	-	-
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Source: EPA 2018a.

^a Each maximum is measured as defined by the respective standard.

Tables 3-3 and 3-4 are summaries for years 2009 through 2016 of KSC and CCAFS Air Emissions Inventory Reports of actual tons per year of the criteria pollutants and total HAPs that are included in the current permits. The KSC Title V permit covers four categories of air emission units: hot water generators/boilers, internal combustion engines, chromate conversion operations, and portable aggregate material crushing operations. The CCAFS General Permit is for emissions from internal combustion engines.

Table 3-3. KSC History of Actual Annual Emissions (tons per year)

Pollutants	2016	2015	2014	2013	2012	2011	2010	2009
CO	3.21	4.62	6.12	7.22	9.57	10.77	10.39	11.17
HAPS	0.48	0.62	0.49	0.55	0.55	0.66	0.60	1.16
NO _x	10.48	15.35	23.11	24.98	34.00	38.69	36.86	40.12
PM	0.68	1.13	1.45	1.69	2.36	2.68	2.55	2.81
PM ₁₀	0.68	1.08	1.44	1.69	2.35	2.67	2.56	2.80
PM _{2.5}	0.53	0.86	1.25	1.44	2.05	2.35	2.23	2.49
SO ₂	0.02	0.02	0.02	0.03	0.44	0.52	0.49	0.50
VOC	4.58	4.72	3.56	4.37	4.68	6.28	10.69	11.16

Source: FDEP 2018.

Table 3-4. CCAFS History of Actual Annual Emissions (tons per year)

Pollutants	2016	2015	2014	2013	2012	2011	2010	2009
CO	11.66	10.75	9.83	10.95	19.47	17.87	22.72	17.50
HAPS	0.02	0.03	0.03	0.03	0.15	0.15	0.22	0.22
NO _x	42.21	36.28	33.56	35.79	73.58	63.76	73.80	60.89
PM	3.00	2.59	2.66	2.63	5.20	4.84	5.41	4.56
PM ₁₀	2.76	2.31	2.215	2.29	5.03	4.36	4.91	4.18
SO ₂	2.52	2.08	1.95	2.15	4.92	3.96	4.47	3.74
VOC	3.35	2.86	2.69	2.84	6.22	5.17	6.02	5.21

Source: FDEP 2018.

3.4. Climate

While the topic of climate can be global in nature, the “local weather” for this environmental impact category lies along the Atlantic coast in Brevard County, Florida, the western Atlantic Ocean, and the California Coast in Los Angeles, County, California. However, climate change resulting from GHG emissions is a cumulative global phenomenon, so the affected environment (study area) is the global climate (EPA 2009a). Given the minor nature of activities that would occur in Los Angeles County (i.e., one Dragon reentry and recovery operation at the Port of Los Angeles), climate change is not expected to affect Dragon recovery operations in California in the foreseeable future. Therefore, this EA does not discuss in detail the local climate in Los Angeles County.

Brevard County experiences a subtropical climate of hot, humid summers with distinct wet and dry seasons. From 1981 to 2010, precipitation averaged 54 inches per year, with high precipitation months during August and September, and December, the driest month averaging 2.3 inches (US Climate Data 2018). During the same time period, temperatures vary between an average high of 71.4°F in January to an average of 90.6°F in July and August.

At the coast, mean sea level (MSL) is defined as the height of the sea with respect to a local land benchmark, averaged over a period of time long enough to eliminate the effects of wave, tidal, and seasonal fluctuations. Changes in MSL as measured by coastal tide gauges are called “relative sea level changes,” because they can come about either by movement of the land on which the tide gauge is situated or by changes in the height of the adjacent sea surface. MSL from NOAA is established at CCAFS as 19.9 feet. The average high tide for CCAFS is 21.5 feet, while the average low tide is 18.2 feet. The highest observed water level at CCAFS was 25.9 feet on September 26, 2004 (NASA 2013). According to the International Panel on Climate Change (IPCC), global mean sea level continues to rise due to thermal expansion of the oceans in addition to the loss of mass from glaciers, ice caps, and the Greenland and Antarctic Ice Sheets (NASA 2013).

Inclement weather for Brevard County is characterized by large storm cells moving west to east across North America in the cool, winter months and local or tropical systems during the hot, summer months. Occasional hurricanes do affect the area, with storm surge and wind playing a dominant factor in the damage incurred. Hurricane season extends from June through November. The most active hurricane season in the area’s history was 2004, when damages to KSC facilities alone exceeded \$100 million. Additionally, many habitats, such as marshes, shoreline, and dunes were affected, at least temporarily, due to the storm surge and beach erosion (NASA 2013). The central Florida region has the highest number of thunderstorms in the United States during the summer months (May – September), and over 70 percent of the annual 48 inches of rain occurs in the summer. During thunderstorms, wind gusts of more than 60 miles per hour and rainfall of over 1.0 inch often occur in a one-hour period, and there are numerous cloud-to-ground lightning strikes.

Solar irradiance, the greenhouse effect, and earth’s reflectivity are the key factors interacting to maintain temperatures on Earth within critical limits. Relatively recent changes in greenhouse gas concentrations [primarily carbon dioxide (CO₂)] have been identified as the primary factor influencing Earth’s current climate trends (EPA 2009b). Human land use changes and burning of fossil fuels for energy are the major contributors to increases in greenhouse gases that are accelerating the rate of climate change. Impacts include warmer temperatures, rising sea levels, changes in rainfall patterns, and a host of other associated and often interrelated effects. For the KSC and CCAFS region, the average air temperature for the 30-year climate baseline period is 72° F (NASA 2015a). Climate forecasts indicate that average temperatures will increase by as much as 6°F during the latter part of the century. Emissions of CO₂ at KSC and CCAFS are primarily associated with vehicle traffic, ground support operations, and launch events. On KSC, CO₂ emissions in 2016 were estimated at 99,025.2 metric tons, equaling a 54 percent reduction in sources controlled by the government and a 32 percent reduction from non-government sources from 2008 baseline emission statistics (unpublished data summarized in NASA 2016a).

During the last two decades, erosion along the KSC and CCAFS coastline has increased as a result of frequent storm surges from nor’easters, tropical storms, and hurricanes. Erosion may have been exacerbated by effects from rising sea levels which have exceeded 5 inches in the last 20 years as measured at the Trident Pier in the adjacent Port Canaveral. As a result, the area has been categorized as “critically eroded” by the Florida Department of Environmental Protection (FDEP 2016). Nearly 3.0 miles of artificial dune have been created along the KSC coastline to protect space program assets and important wildlife habitat; additional dune creation is planned. The coastal dune along CCAFS has not experienced the same erosion as the KSC beaches and is accreting in most areas.

Greenhouse gases (GHG) are gas emissions that trap heat in the atmosphere. These emissions occur from natural processes and human activities. Some scientific evidence indicates a trend of increasing global temperature over the past century which may be due to an increase in GHG emissions from human activities. The climate change that may be associated with this global warming may produce negative

economic and social consequences across the globe.

The FAA has developed guidance for considering GHGs and climate under NEPA, as published in the Desk Reference to Order 1050.1F.⁶ Considering GHG emissions for an FAA NEPA review should follow the basic procedure of considering the potential incremental change in CO₂ emissions that would result from the proposed action and alternative(s) compared to the no action alternative for the same timeframe, and discussing the context for interpreting and understanding the potential changes. For FAA NEPA reviews, this consideration could be qualitative (e.g., explanatory text), but may also include quantitative data (e.g., calculations of estimated project emissions).

Discussion of the estimated GHG emissions associated with the Proposed Action and the impact analysis can be found in the environmental consequences analysis in Section 4.4. Table 3-5 below summarizes GHG emissions for all activities at CCAFS (USAF 2017a). While more recent data are not available, the CCAFS landfill was the primary methane emission source for all GHG. The landfill was closed in 2013 and a decision was made by the USAF that residual methane emissions would be negligible. Therefore, methane emission can be taken as zero for 2014 and beyond (USAF 2017a).

Table 3-5. Summary of Greenhouse Gases Emissions for CCAFS (Years 2011 through 2013)

GHG	GHG Emissions for 2011		
	Ton (Short)	Ton (Metric)	MtCO ₂ e
CO ₂	3,160.034	2,866.735	2,866.735
N ₂ O	0.052	0.047	14.624
CH ₄	122.215	110.872	2,328.303
TOTAL REPORTABLE GHG for 2011			5,209.662
GHG	GHG Emissions for 2012		
	Ton (Short)	Ton (Metric)	MtCO ₂ e
CO ₂	2,827.90	2,565.43	2,565.42
N ₂ O	0.05	0.04	13.21
CH ₄	211.41	191.79	4,027.65
TOTAL REPORTABLE GHG for 2012			6,606.28
GHG	GHG Emissions for 2013		
	Ton (Short)	Ton (Metric)	MtCO ₂ e
CO ₂	6,148.266	5,577.651	5,577.651
N ₂ O	227.900	206.500	61,153.000
CH ₄	241.542	219.085	5,433.214
R-22	0.085	0.077	0.004
R-123	0.076	0.069	0.002
TOTAL REPORTABLE GHG for 2013			72,547.870

Source: USAF 2017a. NOTE: MtCO₂e = Metric Ton Carbon Dioxide Equivalent – describes greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO₂e denotes the amount of CO₂ which would have the equivalent global warming impact. R-22 = Chlorodifluoromethane or difluoromonochloromethane is a hydrochlorofluorocarbon (HCFC-22) refrigerant being phased out, R-123= 2,2-Dichloro-1,1,1-trifluoroethane or HCFC-123 is a replacement refrigerant being phased in.

Table 3-6 shows trends in GHG emissions at KSC from 2008 through 2017. Emissions in Scope 1 and 2 pertain to sources owned or controlled by the government (e.g. government fleet, stationary sources), and purchased electricity, heat, or steam. Scope 3 emissions are from activities not directly controlled by the government such as emissions from non-government vehicles (e.g. employee travel). NASA's goal is to reduce Scope 1 and 2 GHG emissions by 22.4 percent and Scope 3 emissions by 15.2 percent by FY2020, as

⁶

https://www.faa.gov/about/office_org/headquarters_offices/apl/enviro_policy_guidance/policy/faq_nepa_order/de_sk_ref/

compared to emissions in 2008 (NASA 2016b).

Table 3-6. NASA KSC Greenhouse Gas Emissions Trends (FY2008 through FY2017)

GHG Emission Scope and Category	GHG Emissions MTCO ₂ e			
	FY2008	FY2015	FY2016	FY2017
Scope 1 Stationary Combustion; Mobile Emissions	27,051.1	9,309.5	10,343.4	14,032.4
Scope 2 Purchased Electricity Consumption	149,861.7	76,337.9	77,068.3	67,731.6
Scope 3 Transmission and Distribution; Travel; Wastewater Treatment, Solid Waste Disposal	24,289.3	15,939.1	16,880.4	14,880.9

Source: Dan Clark/NASA/ 8-16-2018 email; Erik Tucker/ 8-20-2018 email.

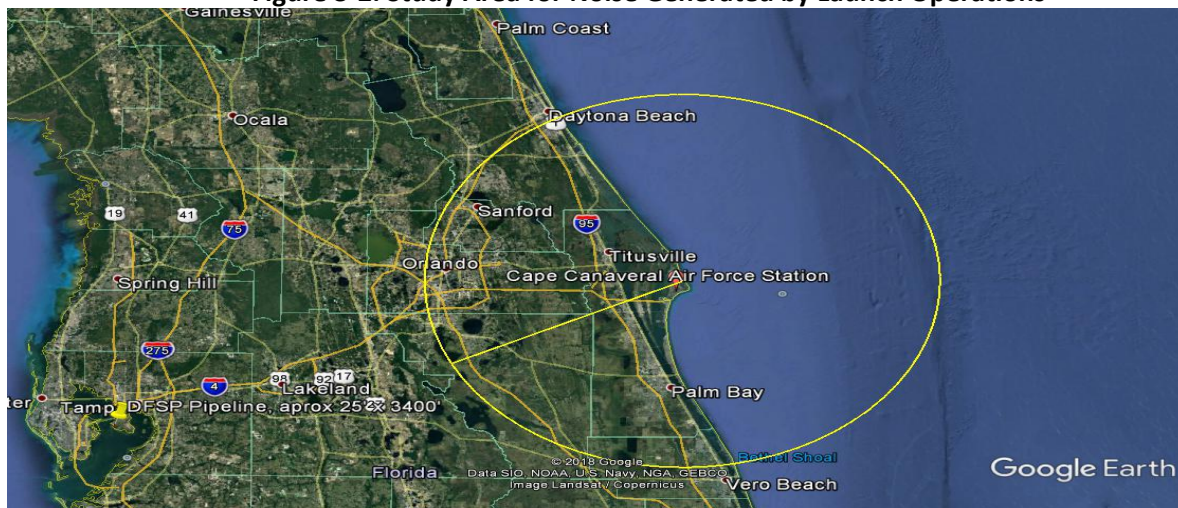
3.5. Noise and Noise-Compatible Land Use

Compatible land use means the use of the land is normally consistent with the outdoor noise environment at the location (14 CFR § 150.7). Compatible land use analysis considers the effects of noise on special management areas, such as national parks, national wildlife refuges, and other sensitive noise receptors. The concept of land use compatibility corresponds to the objective of achieving a balance or harmony between the Proposed Action and the surrounding environment. Noise is defined as unwanted or annoying sound that interferes with or disrupts normal human activities. Although exposure to very high noise levels can cause hearing loss, the principal human response to noise is annoyance. The response of different individuals to similar noise events is diverse and influenced by the type of noise, perceived importance of the noise, its appropriateness in the setting, time of day, type of activity during which the noise occurs, and sensitivity of the individual.

The study area for noise and noise-compatible land use includes KSC, CCAFS, and extends into central Florida with a center point between LC-39A and LC-40 (Falcon 9 and Falcon Heavy launch operations). Given that 1) noise associated with Dragon splashdown in the Pacific Ocean would be minor and not affect noise sensitive areas and 2) noise associated with transporting Dragon to the Port of Los Angeles would not appreciably affect noise levels at the port, the study area does not include Dragon recovery operations on the west coast.

The study area has an approximate radius of 55 miles (Figure 3-2). This area has experienced sonic booms during previous SpaceX first stage booster landings (USAF 2017a). It also includes the recovery area positioned 5 to 140 nautical miles off the Atlantic coastline where the majority of sonic boom noise would occur. This study area includes those areas where the effects of launch noise and sonic boom noise from reentry may occur, and where recovery offloading activities would occur at CCAFS and Port Canaveral.

Figure 3-2. Study Area for Noise Generated by Launch Operations



CCAFS and KSC are relatively isolated facilities which reduces the potential for noise impacts on adjacent communities. The nearest residential area is the City of Titusville to the west, across the Indian River. Open space lies to the north. Land just to the south-southwest of KSC is largely undeveloped with low density housing located approximately 9 miles from LC-39. The beach cities of Cape Canaveral and Cocoa Beach are also to the south, immediately south of Port Canaveral, approximately 15 miles from the LC-39 area, and 10 miles from LC-40. The sound produced by current rocket launches is noticed in all of these areas and the perimeter locations are commonly visited by the public for launch viewing. In the cities of Merritt Island and Cape Canaveral, ambient noise levels are normally low, with higher noise levels occurring in the communities' industrial areas, and lower noise levels (normally about 45 to 55 A-weighted decibels [dBA]) in the residential areas and along the beaches. Aircraft fly-overs and rocket launches from CCAFS and KSC increase noise levels for short periods of time; sonic booms from returning first stage boosters also cause very short noise events.

Noise levels around facilities at CCAFS and KSC approximate those of any urban industrial area, reaching levels of 60 to 80 dBA. Additional on-site sources of noise are the aircraft landing facilities at the CCAFS Skid Strip and the KSC SLF. Other less frequent but more intense sources of noise in the region are launches from CCAFS and KSC, which includes both engine noise and sonic booms produced as launch vehicles reach supersonic speeds. Sonic booms produced during vehicle ascent over the Atlantic Ocean are directed in front of the vehicle and do not impact land areas; however, returning Falcon first stage vehicles (that land at LZ-1) do produce a double sonic boom that has been heard as far away as the metro-Orlando area.

For the increased launch azimuth window, the study area for downrange landing operations includes the Bahamas and near-shore waters in Bahamas and Cuba, as defined by the sonic boom footprints (see Figures 4-5 and 4-6). The FAA is aware that noise generated from launches may be audible beyond the U.S. border. NEPA requires that federal agencies include analysis of potential transboundary effects extending across the border and affecting another country's environment.

3.5.1. Noise Metrics

The decibel (dB) is a ratio that compares the sound pressure level of the sound source of interest (e.g., a launch) to a reference sound pressure level (e.g., the quietest sound that can be heard). It is a logarithmic unit that accounts for the large variations in amplitude. A number of factors affect sound as the human hearing mechanism perceives it. These include the actual level of noise, the frequency content, the time period of exposure to the noise, and changes or fluctuations in noise levels during exposure. Various noise metrics are used to assess and correlate the assorted effects of noise on humans, including land use

compatibility, sleep and speech interference, annoyance, hearing loss, and startle effects. To correlate the frequency characteristics from typical noise sources to human response, several frequency weighting scales have been developed. Sound levels that have been adjusted to correspond to the frequency response of the human hearing mechanism are referred to as A-weighted (dBA) sound pressure levels. The long-term equivalent A-weighted sound level (Leq) is an A-weighted sound level that is "equivalent" to an actual time-varying sound level. If structural damage is a concern, then the overall sound pressure level (OASPL) is used. This quantity has no frequency weighting and includes low frequencies which may induce vibration in structures. The largest portion of the total acoustic energy produced by a launch vehicle is usually contained in the low-frequency end of the spectrum (1 to 100 Hz). Launch vehicles (and returning first stage boosters) also can generate sonic booms. A sonic boom, the shock wave resulting from the displacement of air in supersonic flight, differs from other sounds in that it is impulsive and very brief (often less than one second). A sonic boom is not generated until the vehicle reaches supersonic speeds or reduces velocity to below supersonic for landing vehicles and/or returning capsules. The launch site itself does not experience a sonic boom during launch; the entire boom footprint is usually some distance downrange of the launch site. However, during the landing sequence, the landing site and areas surrounding may experience a sonic boom. Although derived for humans, A-weighted sound level descriptors can also be used to qualitatively assess the effects of noise on wildlife.

3.5.2. Day-Night Average Noise Level

FAA Order 1050.1F requires the FAA to assess noise impacts on noise sensitive areas using the Day-Night Average Sound Level (DNL) metric to determine if significant impacts would occur. Normally, noise sensitive areas include residential, educational, health, and religious structures and sites, and parks, recreational areas (including areas with wilderness characteristics), wildlife refuges, and cultural and historical sites. There are other federal agency noise standards that pertain to hearing conservation (e.g., those established by the National Institute for Occupational Safety and Health [NIOSH] and the Occupational Safety and Health Administration [OSHA]).

The DNL is a cumulative noise metric that is an average of noise levels over a 24-hour period with a 10 dB upward adjustment of noise levels during the nighttime (10:00 p.m. to 7:00 a.m.). This adjustment accounts for increased human sensitivity to noise at night. The DNL can be calculated on the basis of the Sound Exposure Level (SEL) and the number of daytime and nighttime noise events. The SEL represents all of the acoustic energy associated with a noise event such as a vehicle pass-by. The SEL normalizes the sound level as if the entire event occurred in one second. The SEL is also useful for directly comparing two different noise events with differing maximum noise levels and durations.

3.5.2.1. Engine Noise

Noise contour maps of noise metrics are used to assess the noise level and impact of noise on a community. Noise contours depict the area within which a certain noise level occurs, as predicted by a computer model and/or measured with sound level meters. A significant noise impact would occur if the action would increase noise by DNL 1.5 dB or more for a noise sensitive area exposed to noise at or above the DNL 65 dB noise exposure level, or that will be exposed at or above the DNL 65 dB due to a DNL 1.5 dB or greater increase, when compared to the no action alternative for the same timeframe.

Launches and landings are a major source of operational noise; all other noise sources in the launch area are considered minor compared to rocket noise. Generally, three types of noise occur during a standard vehicle launch or landing: 1) combustion noise from the launch vehicle chambers; 2) jet noise generated by the interaction of the exhaust jet and the atmosphere; and 3) combustion noise from post-burning of combustion products. The initial loud, low frequency noise heard in the immediate vicinity of the launch pad is a result of the three types of noise combined. SpaceX measured noise levels for its May 22, 2012,

Falcon 9 (Block 1) launch at LC-40. The launch time was 3:44 p.m. with all nine Merlin engines firing. SpaceX also measured near-field noise levels during the Falcon Heavy launches. SpaceX's noise data are presented in Table 3-7.

Table 3-7. SpaceX Acoustic Data

Falcon 9 (Block 1)		
Location	Distance from Vehicle (feet)	Acoustics (OASPL)
1	800	145 dB
2	975	136 dB
3	1,450	132 dB
4	1,600	130 dB
5	1,900	129 dB
6	2,500	126 dB
Falcon Heavy		
Location	Distance from Vehicle (feet)	Acoustics (OASPL)
1	400	152 dB
2	800	151 dB
3	1,300	152 dB

db = decibels; OASPL = overall sound pressure level

3.5.2.1.1. Sonic Booms

Another characteristic of typical launch or landing vehicles is that they reach supersonic speeds (faster than the speed of sound) and generate sonic booms. Sonic booms are measured in pounds per square foot (psf) of overpressure. This is the amount of the increase over the normal surrounding atmospheric pressure (2,116 psf/14.7 psi). At one-pound overpressure, no damage to structures would be expected.

Overpressures of 1 to 2 psf are produced by supersonic aircraft flying at normal operating altitudes. Some public reaction could be expected between 1.5 and 2 psf. Rare, minor damage may occur with 2 to 5 psf of overpressure (NASA 2013). During the shuttle landing events, a double sonic boom was heard at times across central Florida and the east coast, depending upon the specific flight trajectory.

SpaceX performed a sonic boom study in 2014 to support its first landing operation; however, since that time, several other studies, including one by the USAF have been conducted. Additionally, SpaceX has been measuring sonic boom events for the drone ship landings and for landings at LZ-1. These studies are included in Appendix A. These data and further discussions of sonic boom impacts are detailed in Section 4.5.

3.5.2.1.2. Existing Noise Environment

This section presents an estimate of the existing noise environment (DNL) for 2017 launch operations and other typical noise events occurring at CCAFS and KSC. These estimates can be used to determine how future launch operations of the Falcon 9 and Falcon Heavy would be expected to influence the DNL. To accurately describe the DNL at CCAFS and KSC, a detailed study would be required involving either the modeling of all major noise sources or conducting noise monitoring throughout these areas for a period of time that adequately represents the different types of launch vehicles and frequency of launches conducted. The estimates of DNL presented here are basic and serve to identify whether launch operations at CCAFS and KSC are expected to have a significant noise impact per the guidelines in FAA Order 1050.1F.

Before estimating DNL for the CCAFS and KSC properties and surrounding cities, it is important to note that these areas have a variety of land uses. CCAFS and KSC have areas that should be considered rural or remote, except where NASA or other launch facilities are located. KSC encompasses a wildlife refuge. Populated areas of Merritt Island could be considered rural or quiet suburban residential areas, whereas Titusville and the city of Cape Canaveral are more urban areas with mixed residential and industrial uses. It

is therefore important to consider the land use category and associated background noise levels when determining if launch operations will have a significant noise impact.

To determine DNL for 2017, background noise levels were estimated, as was the DNL from all 2017 launch operations at CCAFS and KSC. Background DNL was rated using ANSI/ASA S12.9-2013/Part 3⁹ which provides estimated background noise levels for different land use categories and population density. Table 3-8 shows the DNL estimated for rural or remote areas and several different categories of suburban and urban residential land use which can be used to represent DNL for the various land uses within CCAFS, KSC, and surrounding areas. According to these values, many of the remote areas within the CCAFS and KSC properties would be expected to have a DNL less than 49 dBA, while parts of Titusville and the city of Cape Canaveral would be expected to have a DNL as high as 59 dBA. The DNL values in Table 3-8 provide an estimate of the background levels expected in typical noise environments and do not include noise from launch operations.

Table 3-8. Estimated Background Noise Levels

Example Land Use Category	Average Residential Intensity (people per acre)	DNL (dBA)	Leq (dBA)	
			Daytime	Nighttime
Rural or remote areas	<2	<49	<48	<42
Quiet suburban residential	2	49	48	42
	4	52	53	47
	4.5	52	53	47
Quiet urban residential	9	55	56	50
Quiet commercial, industrial, and normal urban residential	16	58	58	52
	20	59	60	54

Source: ANSI/ASA S12.0-2013/Part 3.

dBA = A-weighted decibels; DNL = day-night average sound level; Leq = equivalent continuous sound level

To estimate the 2017 DNL for CCAFS, KSC, and the surrounding areas, the noise from all 2017 launches at CCAFS and KSC should be added to the background noise estimated for these areas. Table 3-9 shows all of the 2017 launches at CCAFS and KSC. There were 19 total launches, including 13 Falcon 9 Full Thrust launches (12 of these occurred at LC-39A and one occurred at LC-40). The remaining six launches by the Atlas V, Delta IV, and Minotaur occurred at three other CCAFS launch sites. Of the 19 launches in 2017, three (about 16 percent) were nighttime launches.

Table 3-9. Launches at CCAFS and KSC in 2017

Launch Vehicle	Launch Site	Thrust (1 st stage) lbf (SL)	Launches		
			Day	Night	Total
Falcon 9 Full Thrust	KSC LC-39A	1,710,000	11	1	12
Falcon 9 Full Thrust	CCAFS LC-40	1,710,000	1	0	1
Atlas V 401 (3) or 421 (1)	CCAFS LC-41	860,000	3	1	4
Delta IV M+(5,4)	CCAFS LC-37B	705,000	1	0	1
Minotaur/Orion	CCAFS LC-46	210,000	0	1	1

lbf = pound-force

KBRwyle (2018) estimated the DNL for the 2017 launches (see Appendix A for the noise report). As stated in the noise report, the SEL 100 dBA contour shown in the report's Figures 10 and 11 can be used to represent the DNL for all 2017 launch operations and is equivalent to a DNL of 40 dBA. The estimated DNL exposure from all 2017 launches at CCAFS and KSC is in most areas less than any of the estimated background DNL values in Table 3-8 (KBRwyle 2018). The SEL and maximum A-weighted sound pressure level (L_{Amax}) contours in the KBRwyle report model discrete noise events associated with launches (e.g., Appendix A, Figures 4 to 9).

3.6. Historical, Architectural, Archeological, and Cultural Resources

Cultural resources encompass a range of sites, properties, and physical resources relating to human activities, society, and cultural institutions. Such resources include past and present expressions of human culture and history in the physical environment, such as prehistoric and historic archaeological sites, structures, objects, and districts that are considered important to a culture or community. Cultural resources also include aspects of the physical environment, namely natural features and biota that are a part of traditional ways of life and practices and are associated with community values and institutions.

The major law that protects cultural resources is the National Historic Preservation Act (NHPA). Section 106 of the NHPA requires a federal agency to consider the effects of its action (referred to as the *undertaking*) on historic properties. Compliance with Section 106 requires consultation with the State Historic Preservation Officer (SHPO) and other parties, including Indian tribes. The Section 106 process is outlined in 36 CFR Part 800. Major steps in the process include identifying the Area of Potential Effects (APE) in consultation with the SHPO, identifying and evaluating any historic properties within the APE, and assessing the effect of the undertaking on any historic properties. If a historic property would be adversely affected, the consultation process includes resolution of adverse effects.

As part of previous NEPA reviews for SpaceX launches operations at LC-39A, LC-40, LZ-1, and LZ-2, NASA and USAF analyzed potential impacts to historic properties and conducted Section 106 consultation with the Florida State Historic Preservation Officer (SHPO) as needed. During preparation of the 2013 NASA EA, which included Falcon 9 and Falcon Heavy launches from LC-39A, NASA determined the action analyzed in the EA would constitute an adverse effect on LC-39A (a historic property) in accordance with the 2009 *Programmatic Agreement Among the National Aeronautics and Space Administration, John F. Kennedy Space Center, Advisory Council on Historic Preservation, and the Florida State Historic Preservation Officer Regarding Management of Historic Properties at the Kennedy Space Center*, Florida (2009 PA) and consulted the SHPO. The SHPO concurred with NASA's finding and noted that KSC has previously completed and will be following the appropriate mitigation stipulations identified in the 2009 Programmatic Agreement (PA) (DHR Project File Number: 2013-1817).

The 2013 USAF SEA analyzed potential effects to historic properties from Falcon 9 operations at LC-40. USAF's analysis concluded that Falcon launch operations at LC-40 would not affect historic properties because there are no historic properties located at or near LC-40.

The 2017 USAF SEA analyzed the potential effects to historic properties for Falcon Heavy first stage boost-back and landing at LZ-1 and LZ-2. Three previously unrecorded archaeological sites were identified during an archaeological survey conducted by the USAF between June and August 2014. The USAF determined the sites were ineligible for listing on the National Register of Historic Places (NRHP) and the SHPO concurred with that determination. USAF's analysis concluded that Falcon booster landings at LZ-1 and LZ-2 would not affect historic properties (DHR Project File Number: 2014-4037).

The only aspect of the FAA's undertaking that has not been previously evaluated as part of Section 106 consultation with the SHPO is SpaceX's proposed Falcon 9 southern launch and landing trajectory (polar missions). Therefore, the FAA is focusing the cultural resource analysis on that aspect of the project.

The study area for this impact category is referred to as the Area of Potential Effects (APE), which is a term defined in the Section 106 regulations (36 CFR §800.16). The APE is the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist. In addition to engine noise generated during rocket takeoff from LC-39A or LC-40 (which was considered in the previous Section 106 consultations identified above), a sonic boom is expected to impact parts of Florida during a Falcon 9 polar launch, including landing at LZ-1 or LZ-2 (see Figures 4-3 and 4-4). Therefore, the FAA has defined the APE based on the sonic boom footprint

generated during a Falcon 9 polar launch. The FAA is currently conducting Section 106 consultation with the SHPO to confirm the APE and identification of historic properties within the APE (see Appendix B for correspondence).

The FAA conducted a search of properties listed on the National Register of Historic Places (NRHP) using the National Park Service's geospatial database. The identified properties within the sonic boom APE are listed in Table 3-10. The majority of the historic properties in the sonic boom APE are buildings.

Table 3-10. NRHP-Listed Properties in the Sonic Boom APE for a Falcon 9 Polar Launch

Property Name	Reference Number	Resource Type	City
Driftwood Inn and Restaurant	94000751	Building	Vero Beach
Vero Railroad Station	86003560	Building	Vero Beach
Gregory, Judge Henry F., House	94000540	Building	Vero Beach
Vero Beach Community Building, Old	92001746	Building	Vero Beach
Vero Beach Woman's Club	95000051	Building	Vero Beach
Indian River County Courthouse	99000768	Building	Vero Beach
Pueblo Arcade	97000211	Building	Vero Beach
Royal Park Arcade	98000925	Building	Vero Beach
Vero Theatre	92000421	Building	Vero Beach
Maher Building	94001274	Building	Vero Beach
Vero Beach Diesel Power Plant	99000252	Building	Vero Beach
Old Palmetto Hotel	91001650	Building	Vero Beach
Osceola Park Historic Residential District	12001196	District	Vero Beach
Hausmann, Theodore, Estate	97000230	Building	Vero Beach
McKee Jungle Gardens	97001636	Site	Vero Beach
Hallstrom House	02000605	Building	Vero Beach
Immokolee	93001450	Building	Fort Pierce
Casa Caprona	84000955	Building	Fort Pierce
St. Lucie Village Historic District	89002062	District	St. Lucie Village
Hurston, Zora Neale, House	91002047	Building	Fort Pierce
Moore's Creek Bridge	01000890	Structure	Fort Pierce
St. Anastasia Catholic School, Old	00000941	Building	Fort Pierce
Fort Pierce City Hall, Old	01001338	Building	Fort Pierce
Fort Pierce Old Post Office	01000567	Building	Fort Pierce
Arcade Building	01001085	Building	Fort Pierce
Sunrise Theatre	01001339	Building	Fort Pierce
Cresthaven	85000770	Building	Fort Pierce
St. Lucie High School	84000956	Building	Fort Pierce
Fort Pierce Site	74002181	Site	Fort Pierce
Frere, Jules, House	95000467	Building	Fort Pierce
Hammond, Captain, House	90000310	Building	White City
First Methodist Episcopal Church, South	15000509	Building	Okeechobee
Freedman-Raulerson House	85000764	Building	Okeechobee
Okeechobee Battlefield	66000269	Site	Okeechobee
Red Barn	08001243	Building	Okeechobee
Moore Haven Downtown Historic District	95001166	District	Moore Haven
Moore Haven Residential Historic District	98000714	District	Moore Haven
Florida Power and Light Company Ice Plant	82001033	Building	Melbourne
Gleason, William H., House	96001608	Building	Melbourne
Rossetter, James Wadsworth, House	05000734	Building	Melbourne
Green Gables	16000269	Building	Melbourne

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Community Chapel of Melbourne Beach	92000505	Building	Melbourne Beach
Melbourne Beach Pier	84000829	Structure	Melbourne Beach
St. Joseph's Catholic Church	87000816	Building	Palm Bay
Fell, Marian, Library	96001059	Building	Fellsmere
Fellsmere Public School	96001368	Building	Fellsmere
First Methodist Episcopal Church	96001521	Building	Fellsmere
Heiser, Frank and Stella, House	100001862	Building	Fellsmere
Jungle Trail	03000700	Site	Orchid
Lawson, Bamma Vickers, House	90001116	Building	Sebastian
Old Town Sebastian Historic District East	03000728	District	Sebastian
Old Town Sebastian Historic District, West	03001364	District	Sebastian
Pelican Island National Wildlife Refuge	66000265	Site	Sebastian
Sebastian Grammar and Junior High School	01000889	Building	Sebastian
Smith, Archie, Wholesale Fish Company	94001275	Building	Sebastian
Spanish Fleet Survivors and Salvors Camp Site	70000186	Site	Sebastian
Desert Inn	93001158	Building	Yeehaw Junction
Auburndale Citrus Growers Association Packing House	90001277	Building	Auburndale
Auburndale City Hall	72000350	Building	Auburndale
Baynard, Ephriam M., House	90001272	Building	Auburndale
Jenks, Holland, House	75000567	Building	Auburndale
Babson Park Woman's Club	90001085	Building	Babson Park
Dundee ACL Railroad Depot, Old	90001271	Building	Dundee
Atlantic Coast Line Railroad Depot	90001273	Building	Lake Wales
Bok Mountain Lake Sanctuary and Singing Tower	85003331	Building	Lake Wales
Bullard, B. K., House	90001275	Building	Lake Wales
Casa De Josefina	89001481	Building	Lake Wales
Chalet Suzanne	00000265	Building	Lake Wales
Church of the Holy Spirit	90001274	Building	Lake Wales
Dixie Walesbilt Hotel	90000732	Building	Lake Wales
El Retiro	97000858	Building	Lake Wales
First Baptist Church	91000113	Building	Lake Wales
Johnson, C. L., House	93000871	Building	Lake Wales
Lake of the Hills Community Club	01001086	Building	Lake Wales
Lake Wales City Hall	01000306	Building	Lake Wales
Lake Wales Commercial Historic District	90001276	District	Lake Wales
Lake Wales Historic Residential District	14000152	District	Lake Wales
Mountain Lake Colony House	01001414	Building	Lake Wales
Mountain Lake Estates Historic District	02000266	District	Lake Wales
North Avenue Historic District	01001337	District	Lake Wales
Roosevelt School	00000660	Building	Lake Wales
Tillman, G. V., House	98000927	Building	Lake Wales
Cypress Gardens	90001277	Site	Winter Haven
Downtown Winter Haven Historic District	72000350	District	Winter Haven
Interlaken Historic Residential District	90001272	District	Winter Haven
Pope Avenue Historic District	75000567	District	Winter Haven
Winter Haven Heights Historic Residential District	90001085	District	Winter Haven
Woman's Club of Winter Haven	90001271	Building	Winter Haven

3.7. Department of Transportation Act, Section 4(f)

Section 4(f) properties are publicly owned lands including public parks, recreation areas, wildlife and waterfowl refuges, and public and private historic sites of national, state, and/or local significance. The term historic sites includes prehistoric and historic districts, sites, buildings, structures, or objects listed in, or eligible for listing in, the NRHP. Section 4(f) properties are protected under Section 4(f) of the U.S. Department of Transportation (DOT) Act, codified and renumbered as 49 U.S.C. § 303(c). In accordance with Section 4(f), the FAA will not approve any program or project that requires the use of a Section 4(f) property unless no feasible and prudent alternative exists to the use of such land and the program or project includes all possible planning to minimize harm resulting from the use.

The term use, as it relates to Section 4(f), denotes an adverse impact to, or occupancy of, a Section 4(f) property. There are three conditions under which use occurs:

- Permanent Incorporation – when a Section 4(f) property is acquired outright for a transportation project
- Temporary Occupancy – when there is temporary use of property that is adverse in terms of Section 4(f)'s preservationist purpose
- Constructive Use – when the proximity impacts of a transportation project on a Section 4(f) property, even without acquisition of the property, are so great that the activities, features, and attributes of the property are substantially impaired. Substantial impairment would occur when impacts to Section 4(f) lands are sufficiently serious that the value of the site in terms of its prior significance and enjoyment are substantially reduced or lost.

The study area for this resource area includes CCAFS, KSC, Port Canaveral, Port of Los Angeles, and the surrounding area that would be affected by operations (i.e., potential operational-related closure and noise).

LC-39A, LC-39B, the Crawlerway, and a portion of the KSC railroad track are listed on or eligible for listing on the NRHP, making them Section 4(f) properties. Additional Section 4(f) properties located at KSC further from LC-39A include the Vehicle Assembly Building, Launch Control Center, Headquarters Building, and Operations and Checkout Building (renamed the Neil Armstrong Building), all of which are listed on the NRHP. Section 4(f) properties directly adjacent to KSC include CCAFS (listed on NRHP), MINWR, and CNS.

MINWR and CNS property within KSC boundaries are also considered Section 4(f) properties. KSC land use is carefully planned and managed to provide required support for missions while maximizing protection of the environment. Other public parks and recreation areas in addition to the MINWR and CNS located near CCAFS and KSC include Jetty Park and Port Canaveral, located just south of the CCAFS boundary, and Kelly Park; Kennedy Athletic, Recreation, and Social (KARS) Park; Kings Park; and Manatee Cove Park located on Merritt Island.

As noted in Section 3.1, land use planning and management responsibilities for areas not directly used for NASA operations are delegated to the USFWS at MINWR and the NPS at CNS. This unique relationship between space flight and protection of natural resources is carefully orchestrated to ensure that both objectives are achieved with minimal conflict. The designation of MINWR and CNS, in 1963 and 1975, respectively, on the 135,225 acres outside NASA's operational control reflects this mutually beneficial objective. Both MINWR and CNS effectively provide a buffer zone between NASA operations and the surrounding communities (NASA 2013). The NPS administers a 6,655-acre area of the CNS, while the USFWS administers the remaining 128,570 acres of the CNS and MINWR. The USFWS and NPS exercise control over habitat management, recreation, and environmental programs within their respective jurisdictions at KSC, subject to operational requirements defined by NASA, such as temporary closures for

launch and landing-related activities (NASA 2013). NASA remains the landowner and retains the authority to remove lands or construct facilities within MINWR or CNS as needed to support the space program.

Section 4(f) properties within the sonic boom footprint for a Falcon 9 polar launch (see Figures 4-3 and 4-4) include those NRHP-listed properties shown in Table 3-10 above. Other potential Section 4(f) properties within this sonic boom footprint include numerous public parks, recreation areas, and wildlife management and conservation areas, such as the Fisheating Creek Wildlife Management Area, Savannas Preserve State Park, Florida National Scenic Trail, Fort Pierce Inlet State Park, Oars and Paddles Park, Samsons Island National Park, Erna Nixon Park, Gleason Park, Wickham Park Community Center, Pelican Island National Wildlife Refuge, Sebastian Inlet State Park, Indian River Lagoon Preserve State Park, St. Sebastian River State Park, and Lake Kissimmee State Park. The potential Section 4(f) properties range in location from developed areas to natural, undisturbed environments, and contain a variety of uses, including hunting, recreation, and wildlife viewing. The below description exemplifies the variety of settings and uses found among the potential Section 4(f) properties.

Fisheating Creek Wildlife Management Area provides recreational opportunities such as hunting, bird watching, and fishing. Visitors to Savannas Preserve State Park can enjoy canoeing, kayaking, fishing, hiking, bicycling, horseback riding, and wildlife photography. The Florida National Scenic Trail, better known as the Florida Trail, is a federally designated, non-motorized recreation trail that meanders approximately 1,300 miles in Florida, including around Lake Okeechobee. Fort Pierce Inlet State Park welcomes visitors for swimming, snorkeling, surfing, fishing, beachcombing, picnicking, and scuba diving. Oars and Paddles provides the public a place to launch canoes, kayaks, or paddleboards in the Whiting Waterway. Samsons Island is a federally designated, recreation island, only accessible by non-motorized boats and watercrafts. Erna Nixon is a 54-acre nature preserve with elevated boardwalks that gently wind up and through a natural Florida hammock. Gleason Park is a 27-acre area for the public to enjoy the outdoors and water. Wickham Park Community Center is community park of nearly 400 usable acres that includes recreational activities such as walking, jogging, biking, swimming lakes, and other outdoor amenities. Pelican Island is only accessible by boat or chartered tours and holds hundreds of species of animals including birds, fish, plants, and mammals. Sebastian Inlet State Park boasts salt-water fishing, including mackerel, snook, and bluefish, plus surfing and scuba diving. Indian River Lagoon Preserve State Park is home to abundant wildlife and is one of the most biologically diverse estuaries in North America. St. Sebastian River State Park is a vast open grassy forests of long leaf pines with miles of trails. Visitors of Lake Kissimmee State Park can enjoy boating, canoeing, fishing, trail hiking, and camping.

3.8. Biological Resources

Biological resources include vegetation, wildlife, and the habitats in which they are found. This section describes the terrestrial habitats on KSC and CCAFS, and habitats and wildlife in the Atlantic and Pacific Oceans that are within the study area. It is organized into three primary parts: terrestrial habitat and wildlife, marine habitats and wildlife, and protected species and critical habitat. Detailed descriptions of biological resources at KSC and CCAFS, and the Atlantic and Pacific Ocean study areas, are found in the EAs previously prepared for the Falcon 9 and Falcon Heavy launch vehicle programs (USAF 2007, 2013, 2014, 2016, 2017; NASA 2013, 2015). The resources are summarized in the following subsections.

3.8.1. Terrestrial Habitat and Wildlife

The study area for terrestrial habitat and wildlife includes LC-39A, LC-40, LZ-1, LZ-2, the areas immediately surrounding these launch and landing complexes, and the terrestrial areas that would be exposed to a sonic boom (see Figures 4-3, 4-4, and 4-5). The KSC and CCAFS areas provide for some of the greatest wildlife diversity among federal facilities in the continental United States (Breininger et al. 1994, NASA 2013, 2015a). The properties are bordered on three sides by parts of the Indian River Lagoon (IRL) system,

considered to be one of the most diverse estuarine ecosystems in the United States (Swain et al. 1995). Further to the west lies the St. Johns River Basin ecosystem, one of the largest freshwater marsh systems in the state. In addition, the proximity to the coast fosters an abundance of migratory birds. According to the USFWS Information for Planning and Consultation (IPaC) system (USFWS 2019b), there are 63 species of birds of conservation concern that use habitat in Brevard County, Florida (USFWS 2019a). All of these factors contribute to the exceptional species diversity found in the area. Much of the land is undeveloped and in a semi-natural state. Topography is generally flat, with elevations ranging from sea level to approximately 20 feet above sea level. More than 50 percent of KSC is classified as wetlands.

The habitats in the vicinity of LC-39A and LC-40 include uplands (oak scrub, palmetto scrub, hardwood hammocks, coastal strand, dune), wetlands (freshwater marsh, brackish marsh, cabbage palm hammock, wetland scrub-shrub), and disturbed habitats consisting of maintained and unmaintained ruderal vegetation. These habitat types are described in detail in NASA (2013) and KSC's environmental resources document (NASA 2015b).

Over 430 species of wildlife have been documented on KSC and CCAFS. Surveys for amphibians and reptiles have occurred sporadically on KSC and CCAFS since the 1970s; documented taxa include four salamanders, 16 species of frogs and toads, the alligator, 11 turtles (not including marine turtles), 13 lizards, and 27 snakes. Four of the lizards and two of the frogs are introduced exotic species (IMSS 2018).

The area of east-central Florida that includes KSC and CCAFS is considered by the Audubon Society to be the fourth most diverse Important Bird Area in Florida, with over 330 documented species. Many are year-round residents (e.g., great blue heron, osprey, Florida scrub-jay, eastern towhee), some species come just for their breeding season (e.g., eagles, black-necked stilts), to winter (e.g., ducks), or visit during spring and/or fall migration (e.g., many warblers). MINWR is one of the top birding destinations in the United States and the Space Coast Birding and Wildlife Festival is the largest event of its kind.

Thirty species of mammals inhabit KSC lands and waters. Typical terrestrial species include the opossum, hispid cotton rat, raccoon, river otter, and bobcat. These species now hold the position of top mammalian predators on KSC due to the regional loss of large carnivores such as the Florida panther, bobcat, and otter. The gray fox also occurs on KSC and CCAFS, and there has been an increase in sightings of coyotes since the mid-2000s.

3.8.2. Marine Habitats and Wildlife

The Atlantic Ocean and Pacific Ocean study areas (Figures 2-10, 2-11, 2-12, and 2-13) are vast. However, SpaceX recovery operations in these study areas would occur in considerably smaller areas as SpaceX intends to recover Dragon and first stage boosters in an economical and rapid fashion, typically within 400 nautical miles of shore. Marine wildlife resources in the study areas include mammals, fish, reptiles, birds, and invertebrates (e.g. shrimp, mollusks, jellyfish, etc.). Marine wildlife and habitats that have federal protected status are discussed in Section 3.8.3.

3.8.2.1. Atlantic Ocean

Several aforementioned EAs for launch systems, facilities, and projects provide recent descriptions of the local marine wildlife and oceanographic resources for the KSC and CCAFS areas and the Atlantic Ocean study area (USAF 2007, 2013; NASA 2015a, 2018). In addition, a large marine resources study of the region, including southeast coastal Florida and the Bahamas just east of Andros Island, provides extensive biological and oceanographic details (Navy 2007). The Atlantic Ocean study area (Figures 2-10, 2-11, and 2-12) begin at least 5 nautical miles east of the Atlantic coastline and are composed of pelagic, open ocean that provides habitat for various life stages of a wide range of species. While the largest zone extends from the eastern tip of North Carolina toward Bermuda and then south and east of the southeastern Bahamas,

the primary study area is restricted to within 400 nautical miles of Cape Canaveral, Florida. As shown in Figure 2-10, the study area for the downrange polar mission landings extends just south of Cuba and Hispaniola but north of Jamaica (Figure 2-10). The study area does not include territorial waters of Cuba, Dominican Republic, and Jamaica. These areas support important commercial and recreational fish species such as wahoo, cobia, marlin, sailfish, swordfish, tuna, etc., in addition to sea turtles and whales. Numerous invertebrates and fishes rely on the upper, middle, and bottom of the water column, in addition to the benthic substrates.

The nearshore benthic habitat off of Cape Canaveral is described by NASA (2015, 2018) as consisting primarily of topographically elevated sand ridges and includes important food or energy resources for fish and larger organisms. These habitats include soft bottom substrates, consolidated substrates, and the surf zone.

The northern boundary of a unique strip of deep water corals known as the Oculina Bank is located 20 nautical miles east of Cape Canaveral. This reef is in water depths of 262 to 450 feet and runs approximately 90 nautical miles from Cape Canaveral south to Ft Pierce, Florida. The area is named after the slow-growing ivory tree coral, *Oculina varicosa*, which forms massive thickets that support diverse communities of finfish and invertebrates. The coral provides essential habitat for many species, including those managed by the South Atlantic Fishery Management Council's Snapper Grouper Fishery Management Plan. The site was first protected in 1994, as the *Oculina* Habitat Area of Particular Concern (HAPC) and was closed to all manner of bottom fishing and designated as the Experimental *Oculina* Research Reserve. Since 2000, the area was expanded to 300 square miles and prohibited all fishing gear that caused mechanical disruption to the habitat (NASA 2015a).

The requirements of the Magnuson-Stevens Fishery Conservation and Management Act provide for the protection of Essential Fish Habitat (EFH) and was described in detail for these local waters by NASA (2015). The waters off Cape Canaveral have several areas designated as EFH and are of particular importance to sharks, other game fish, and numerous species of shrimp, lobster, and crabs.

Sand shoal sites off Brevard County and several counties to the south are reported to include 63 fish taxa and 32 taxa of stomatopods, decapod crustaceans, echinoderms, and squid. The densities of several economically valuable fish species are relatively high, including red drum (*Sciaenops ocellatus*), black drum (*Pogonius cromis*), pompano (*Trachinotus carolinus*), sheepshead (*Archosargus probatocephalus*), and whiting (*Menticirrhus* sp.). Additionally, the open surf zone and longshore troughs serve as a high value nursery for juvenile lemon sharks (*Negaprion brevirostris*).

NASA (2015) reported that the regionally dominant commercial finfish species are sharks, kingfish (*Menticirrhus americanus*), Spanish mackerel (*Scomberomorus maculatus*), striped mullet (*Mugil cephalus*), and king mackerel (*Scomberomorus cavalla*). Recreational catch numbers are dominated by spotted seatrout (*Cynoscion nebulosus*), crevalle jack (*Caranx hippos*), kingfish, gray snapper (*Lutjanus griseus*), and red drum. Pinfish (*Lagodon rhomboides*) are also recorded as a large component of the recreational fishery. Decapod crustaceans sustain the largest commercial and recreational fisheries by weight in east Florida, with landings dominated by white shrimp (*Litopenaeus* sp.) and blue crabs (*Callinectes sapidus*).

All marine mammals in the study area (dolphins, whales, seals, etc.) are protected under the Marine Mammal Protection Act (MMPA) and some are also protected under the Endangered Species Act (ESA). The five marine reptile species (sea turtles) present in the study area are protected under the ESA. These protected species and designated critical habitats are addressed in Section 3.8.3.

The Florida Keys NMS is located along the southern Florida coast. The Florida Keys NMS protects approximately 3,800 square miles of coastal and ocean waters from the estuarine waters of south Florida along the Florida Keys archipelago, encompassing more than 1,700 islands, out to the Dry Tortugas

National Park, reaching into the Atlantic Ocean, Florida Bay, and the Gulf of Mexico.

3.8.2.2. Pacific Ocean

The Pacific Ocean study area depicted in Figure 2-13 is extensive, but the recovery area is operationally focused and is within 400 nautical miles of the west coast, but no closer than 5 nautical miles offshore. Multiple EAs (USAF 2007, 2009, 2016a, 2016b) for Falcon 9 operations and Dragon recovery near VAFB, located just north of Santa Barbara, California, provide extensive reviews of biological resources in the region based on information from the California Natural Diversity Database, the Cetacean Density and Distribution Mapping Working Group records, North American range maps for seabird species, and marine mammal density estimates. The EAs assessed the potential occurrence, distribution, and habitat use of wildlife resources, including special status species, within the region.

The Pacific Ocean study area is comprised of open ocean, submarine canyons, and seamounts. The bathymetry is varied, with the continental shelf being fairly close to shore; the 656-foot isobath is rarely more than 40 nautical miles off the coast and in some areas of southern California is less than 5.3 nautical miles offshore.

Submarine canyons are known for enhanced primary productivity due to upwelling which results in concentrations of macrobenthos, micronekton, demersal fishes, and cetaceans relative to surrounding areas on the Pacific slope and shelf. They provide EFH for groundfish and provide large quantities of food on the deep sea floor. The canyons provide habitat for larger size classes of some species that prefer structures of high relief such as boulders, vertical walls, and ridges. The upper, shallower portions of submarine canyons are where coastal upwelling fronts have been shown to contain high abundance of certain larval fish (PFMC 2018, MBNMS 2018).

Seamounts within the Pacific Ocean study area are areas of volcanic origin rising over 3,280 feet above the surrounding seafloor. Studies by the Monterey Bay Aquarium Research Institute (MBNMS 2018) have documented unique and diverse biological communities, including long-lived coral and sponge habitats along the crests and slopes of several seamounts with at least 24 coral taxa on Davidson Seamount. Seamounts show enriched biological activity with enhanced biomass of pelagic and benthic organisms relative to the surrounding waters and essentially function as deep sea islands of localized species distributions, dominated by suspension feeders like corals and sponges. On the U.S. west coast, the major seamounts include Thompson Seamount, San Juan Seamount, Davidson Seamount, Gumdrop Seamount, Pioneer Seamount, Guide Seamount, President Jackson Seamount, and Taney Seamount.

The Pacific Ocean study area has partial overlap with the jurisdiction of the Pacific Fisheries Management Council (PFMC 2018), which designated EFH and HAPCs for Pacific Groundfish, Pacific Coast Salmon, Coastal Pelagic Species, and Highly Migratory Species, and was previously described by USAF (2016a, 2016b). The HAPC designated for groundfish includes all waters, substrates, and associated biological communities falling within estuaries, canopy kelp or kelp forests, seagrasses, rocky reefs. The rocky reefs are submerged rock outcrops occurring from the intertidal zone to deep water and include seamounts, described above. While the part of the EFH for the Pacific Coast Groundfish is located within the Pacific Ocean study area, a 5-mile buffer was established previously with SpaceX and is maintained around the EFHs and HAPC.

The Pacific Ocean study area includes EFH for the federally managed fish species within the Coastal Pelagic Species and Highly Migratory Species Fishery Management Plans (FMPs), as described in earlier EAs (USAF 2017a, 2016b). Coastal pelagic species within the study area include finfish such as Pacific sardine (*Sardinops sagax*), Pacific chub mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), jack mackerel (*Trachurus symmetricus*), and market squid. The EFH for Coastal Pelagic Species includes all marine and estuarine water from the coast to the limits of the Exclusive Economic Zone (200 nautical miles from shore) and above the thermocline, where sea surface temperatures seasonally range between 50°

and 70° F. The southern limit of this EFH is the U.S. and Mexico maritime boundary and the northern boundary is located north of VAFB (PFMC 2018). There are no HAPC designated for coastal pelagic species.

Highly Migratory Species in the Pacific Ocean study area include five species of tuna and five species of shark, as well as the striped marlin, swordfish, and Dorado. The EFH extends between 3 and 200 nautical miles from shore and is delimited by the maritime boundaries of the U.S. and Canada to the north and U.S. and Mexico to the south. There are no HAPCs designated at this time for Highly Migratory Species.

Various species of fish, sea turtles, and marine mammals protected under the ESA and/or MMPA that occur in the Pacific Ocean study area are described in Section 3.8.3.

There are currently four listed NMS along the California Pacific coast, all of which are north of Los Angeles, including the Channel Islands NMS, Monterey Bay NMS, the Greater Farallones NMS, and Cordell Bank NMS (NOAA 2018). The Channel Islands NMS is closest to the Los Angeles Harbor (59 nautical miles). The Channel Islands NMS extends about 6 nautical miles offshore from mean high water line of each island.

3.8.3. Protected Species and Habitat

This subsection describes the wildlife species and habitats in the study areas with legal protection status, including species and habitat protected by ESA, MMPA, and the Bald and Golden Eagle Protection Act (BGEPA). Section 7 of the ESA requires all federal agencies to consult with USFWS and/or NMFS before initiating any action that may affect a listed species or designated critical habitat.

3.8.3.1. Terrestrial

The FAA used the USFWS IPaC system (USFWS 2019b) to identify ESA-listed, proposed to be listed, or candidates for listing in the study area (refer to the FAA's USFWS ESA consultation letter in Appendix B for the list of species). In addition to these ESA-listed species, the bald eagle, which is protected by BGEPA, is located in the study area.

3.8.3.2. Marine

The ESA and the MMPA are the primary federal statutes protecting marine species in U.S. waters. All marine mammals, sea turtles, and sharks are also protected in Bahamian waters (potential downrange location of Falcon first stage booster drone ship landings for polar missions) by the Minister of Agriculture and Fisheries of The Bahamas. The fairing recovery locations include economic exclusion zones of Bahamas, Cuba, Jamaica, and Haiti. All marine mammals, sea turtles, and sharks are protected in Cuban waters by the Minister of Science, Technology and Environment of the Republic of Cuba, also known as CITMA. Wildlife in Jamaica is protected by the National Environment and Planning Agency under the Wildlife Protection Act. The FAA is aware that recovery efforts may be extended beyond the U.S. border. NEPA requires that federal agencies include analysis of potential transboundary effects extending across the border and affecting another country's environment.

Under the MMPA, NMFS has jurisdiction over whales, dolphins, seals, and sea lions. NMFS also has jurisdiction under the ESA for marine and anadromous species and designates critical habitat for ESA-listed species. NMFS and USFWS share jurisdiction over sea turtles with life stages that overlap on the land and the sea. NMFS is responsible for sea turtles in the marine environment.

In 2017 and 2018, the FAA conducted ESA consultations with NMFS (see Appendix B). A total of 10 marine mammals, 6 species of sea turtles, and 13 species of fish were considered in the consultations. Refer to Appendix B for a complete list and descriptions of the species. Note that the 2017 ESA consultation with NMFS also included species in the Gulf of Mexico, which are not part of this EA.

3.8.3.3. Critical Habitat

There is terrestrial critical habitat in the study area for the Everglade snail kite. Within the Pacific Ocean study area for Dragon recovery, designated critical habitat exists for the endangered North Pacific right whale, leatherback sea turtle, southern resident killer whale, and the green sturgeon. In the Atlantic Ocean study area, designated critical habitat exists for the North Atlantic right whale and loggerhead sea turtle (NOAA 2014, 2018a). Refer to Appendix B for a discussion of these critical habitats.

3.9. Coastal Resources

Coastal resources include all natural resources occurring within coastal waters and their adjacent shorelands. Coastal resources include islands, transitional and intertidal areas, salt marshes, wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as fish and wildlife and their respective habitats within these areas. Inland water resources are described in Section 3.10.

The Coastal Zone Management Act provides for management of our Nation's coastal uses and resources. Coastal states are encouraged to develop and implement comprehensive management programs that balance the need for coastal resource protection with the need for economic growth and development in the coastal zone. Once a management program is developed and approved by NOAA, the state is authorized to review certain federal activities affecting the land, water uses, or natural resources of its coastal zone for consistency with the program. This authority is referred to as "federal consistency".

Any activities which directly affect a state's coastal zone are subject to a determination of consistency with the State's Coastal Management Program (15 CFR 930.30-46, 930.50-66). The FAA may not issue a license, permit, or authorization to an applicant unless an applicant's proposed action meets the consistency requirements of the state's coastal management program. A license or permit means any authorization that an applicant is required by law to obtain in order to conduct activities affecting any land or water use or natural resource of the coastal zone and that any federal agency is empowered to issue to an applicant. Florida's statewide coastal management program, executed by the FDEP, oversees activities occurring in or affecting the coastal zone and is based on a network of agencies implementing 24 statutes protecting coastal resources. The State of Florida's coastal zone is the area encompassed by the entire state and its territorial seas. It is SpaceX's responsibility to consult with FDEP to ensure its action is consistent with the coastal management program.

In addition to KSC, CCAFS, and the nearshore habitat, the study area for coastal resources includes the nearshore habitat along the California coastline where Dragon recovery operations would occur. The California Coastal Zone extends 3,000 feet inland and up to 3 nautical miles seaward. However, the California Coastal Zone may extend up to 5 miles inland for significant coastal estuarine, habitat, and recreational areas and less than 333 feet inland in urban areas. Federal lands are typically excluded from the California Coastal Zone. Dragon recovery operations would occur in the California Coastal Zone when traveling out to and returning from the sea.

3.10. Water Resources

Water resources include groundwater and surface water, and their physical, chemical, and biological characteristics. The study area for groundwater includes the local aquifers that are directly or indirectly used by KSC and CCAFS. The surface water study area is the watershed in which KSC and CCAFS are located and the ocean waters where Dragon would splash down and the fairing and booster recovery areas. The affected environment for water resources at the launch and landing sites has been described in previous EAs (NASA 2013; USAF 2007, 2013, 2014, and 2017) and is briefly summarized here.

3.10.1. Groundwater

The State of Florida has created four categories used to rate the quality of groundwater in a particular area. The criteria for these categories are based on the degree of protection that should be afforded to that groundwater source, with Class G-I being the most stringent and Class G-IV being the least. The groundwater at KSC is classified as Class G-II, which means that it is a potential potable water source and generally has a total dissolved solids content of less than 10,000 mg/l (parts per million [ppm]). The groundwater at LC-39 and LC-40 has been classified as Class G-III because of their proximity to the ocean. The subsurface of KSC is comprised of the Surficial Aquifer, the Intermediate Aquifer, and the Floridian Aquifer. Recharge to the Surficial Aquifer system is primarily due to precipitation. Of the approximately 55 inches of precipitation occurring annually, approximately 75 percent returns to the atmosphere through evapotranspiration. The remainder is accounted for by runoff, base flow, and recharge of the Surficial Aquifer. However, the quality of water in the KSC and CCAFS aquifer is influenced by the intrusion of saline and brackish surface waters from the Atlantic Ocean and the IRL. This is evident from the high mineral content, principally chlorides, that has been measured in groundwater samples from various KSC surveys.

3.10.2. Surface Waters (Inland)

The inland surface waters in and surrounding KSC are shallow estuarine lagoons and include portions of the Indian River, Banana River, Mosquito Lagoon, and Banana Creek. The area of Mosquito Lagoon within the KSC boundary and the northernmost portion of the IRL, north of the Jay Jay Railway spur crossing (north of State Road 406), are designated by the State as Class II, Shellfish Propagation and Harvesting areas. All other surface waters at KSC have been designated as Class III, Recreation and Fish and Wildlife Propagation areas. All surface waters within MINWR are designated as Outstanding Florida Waters (OFW) as required by Florida Statutes for waters within national wildlife refuges. Surface water quality at KSC is generally good, with the best water quality being found adjacent to undeveloped areas of the IRL, such as Mosquito Lagoon and the northernmost portions of the Indian and Banana Rivers (NASA 2015a). However recent brown tide events in the IRL have extended into the Mosquito Lagoon and Banana River, reducing light availability and causing great reduction in seagrasses. CCAFS is also located within the IRL watershed and is bordered by the Banana River to the west and the Atlantic Ocean to the east.

The U.S. EPA designated the IRL as an “estuary of national significance” in 1990 and the IRL supports over 400 species of fishes, 260 species of mollusks, and 479 species of shrimps and crabs (NASA 2015a). Lagoon habitats serve as important nursery areas for fish resident within the lagoon, as well as many offshore species. It also supports protected species including mammals and sea turtles, which are discussed in Section 3.8.3. Fresh surface waters within KSC and CCAFS are primarily derived from the surficial groundwater, which is recharged by rainfall. Shallow groundwater supports numerous freshwater wetlands.

In October 2000, the EPA authorized the FDEP to implement the National Pollutant Discharge Elimination System (NPDES) stormwater permitting program in Florida. This program regulates point source discharges of stormwater into surface waters from municipal facilities, and from industrial and construction activities. The NPDES permit requires that the City of Cape Canaveral (City) develop/implement strategies for reducing pollutants in stormwater runoff, thereby improving overall water quality. The primary method of attaining these goals is through the implementation of Best Management Practices (BMPs) which include:

- **Public Education:** Requires the City educate the public concerning stormwater issues;
- **Public Involvement/ Participation:** Requires the City involve the public in the stormwater management process;
- **Illicit Discharges:** Requires the City implement a monitoring and enforcement program to identify

and eliminate illicit discharges to the storm sewer system;

- **Runoff Control – Construction Sites:** Requires the City monitor and enforce regulations limiting the amount of stormwater runoff from active construction sites;
- **Runoff Control – Post-Construction:** Requires the City continue to monitor and enforce regulations limiting the amount of stormwater runoff from completed construction projects; and
- **Pollution Prevention:** Requires the City monitor and enforce regulations concerning the illegal discharge of pollutants to the storm sewer system.

The City maintains a NPDES permit and continually implements the six required BMPs. To assist in implementation, as well as funding of stormwater improvement projects, a Stormwater Utility was established by the City Council in 2003.

The Stormwater Utility ensures that dedicated funding is available for:

- The management of stormwater runoff;
- The performance of facility maintenance of the storm sewer system (City of Cape Canaveral 2018).

3.10.3. Surface Waters (Ocean)

The study area for ocean waters is the Dragon, fairing, and booster recovery areas (Figures 2-10 to 2-13). Ocean waters within the study area include offshore, deep high salinity waters that are defined by prevailing currents. Water quality in ocean waters may be characterized by temperature, salinity, dissolved oxygen, and nutrient levels.

3.11. Hazardous Materials, Solid Waste, and Pollution Prevention

Hazardous materials, solid waste, and pollution prevention as an impact category includes an evaluation of the following:

- waste streams that would be generated by a project, potential for the wastes to impact environmental resources, and the impacts on waste handling and disposal facilities that would likely receive the wastes;
- potential hazardous materials that could be used during construction and operation of a project, and applicable pollution prevention procedures;
- potential to encounter existing hazardous materials at contaminated sites during construction, operation, and decommissioning of a project; and
- potential to interfere with any ongoing remediation of existing contaminated sites at the proposed project site or in the immediate vicinity of a project site.

Solid Waste is defined by the implementing regulations of the Resource Conservation and Recovery Act (RCRA) generally as any discarded material that meets specific regulatory requirements, and can include such items as refuse and scrap metal, spent materials, chemical by-products, and sludge from industrial and municipal waste water and water treatment plants (see 40 CFR § 261.2 for the full regulatory definition).

Hazardous waste is a type of solid waste defined under the implementing regulations of RCRA. A hazardous waste (see 40 CFR § 261.3) is a solid waste that possesses at least one of the following four characteristics: ignitability, corrosivity, reactivity, or toxicity as defined in 40 CFR part 261 subpart C, or is listed in one of four lists in 40 CFR part 261 subpart D, which contains a list of specific types of solid waste that the U.S. EPA

has deemed hazardous. RCRA imposes stringent requirements on the handling, management, and disposal of hazardous waste, especially in comparison to requirements for non-hazardous wastes.

Hazardous substance is a term broadly defined under Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (see 42 U.S.C. § 9601(14)). Hazardous substances include:

- any element, compound, mixture, solution, or substance designated as hazardous under Section 102 of CERCLA;
- any hazardous substance designated under Section 311(b)(2)(A) or any toxic pollutant listed under Section 307(a) of the Clean Water Act (CWA);
- any hazardous waste under Section 3001 of RCRA;
- any hazardous air pollutant listed under Section 112 of the CAA; and
- any imminently hazardous chemical substance or mixture for which the EPA Administrator has “taken action under” Section 7 of the Toxic Substances Control Act (TSCA).

The definition of hazardous substances under CERCLA excludes petroleum products, unless specifically listed or designated there under.

Hazardous material is any substance or material that has been determined to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce. The term hazardous materials includes both hazardous wastes and hazardous substances, as well as petroleum and natural gas substances and materials (see 49 CFR § 172.101).

Pollution prevention describes methods used to avoid, prevent, or reduce pollutant discharges or emissions through strategies such as using fewer toxic inputs, redesigning products, altering manufacturing and maintenance processes, and conserving energy.

The study area for hazardous materials, pollution prevention, and solid waste is CCAFS, KSC, the Port Canaveral, CCAFS wharf facilities, the Port of Los Angeles, and Atlantic Ocean and Pacific Ocean recovery areas which could be affected by the materials transported, stored, and used; waste generated; or spills/releases that may occur during launch operations, landings, and recovery. KSC and CCAFS each have their own pollution prevention programs. SpaceX is compliant with those programs and also strives to prevent and reduce various forms of pollution.

3.11.1. Launch Complexes and Payload Processing Facilities

3.11.1.1. Hazardous Materials and Waste Management

Numerous types of hazardous materials are used to support the various missions and general maintenance operations at KSC and CCAFS. These materials range from common building paints to industrial solvents and hazardous fuels. Hazardous materials used at KSC and CCAFS include petroleum products, oils, lubricants, volatile organic compounds (VOC), corrosives, refrigerants, adhesives, sealants, epoxies, and propellants. Waste may be classified as hazardous because of its toxicity, reactivity, ignitability, or corrosivity. All hazardous wastes at KSC and CCAFS must be managed, controlled, stored, and disposed of according to regulations found in 40 CFR Parts 260 through 282 and FAC Chapter 62-730. SpaceX manages hazardous materials through the Hazardous Materials Contingency Plan developed for the Falcon 9 and Falcon Heavy launch vehicles program.

The KSC Spill Prevention, Control, and Countermeasures (SPCC) Plan outlines the criteria established by KSC to prevent, respond to, control, and report spills of oil. Various types and quantities of oil are stored, transported, and handled to support the operations of KSC. The KSC SPCC Plan describes both the facility-wide and site-specific (KSC-PLN-1920) approaches for preventing and addressing spills. At CCAFS, in the

event of a spill of hazardous materials at any of the launch facilities, the USAF would provide initial emergency spill response; however, the remaining emergency/corrective actions would be the responsibility of SpaceX. SpaceX is responsible for preparing its own Emergency Response Plan as part of the FAA licensing process as well as for the Falcon Launch Vehicle Program in accordance with the CCAFS Hazardous Materials Emergency Response Plan. SpaceX has developed specific SPCC plans for each of its facilities at CCAFS and KSC that address petroleum-related storage tanks and systems. SpaceX also developed and successfully uses hypergolic fuel handling procedures at its LC-40 facility, and other processing locations which are used to manage any related operations for the Dragon capsule processing at Area 59.

Solid waste at both KSC and CCAFS are managed similarly. Commercial firm Waste Pro, Inc. provides solid waste collection under franchise agreement with both organizations. Solid waste generated in Brevard County is disposed of at the Central Disposal Facility located on Adamson Road in Cocoa.

3.11.1.2. KSC Remediation Program

KSC has a remediation program to evaluate sites where contamination is present under RCRA and its Hazardous and Solid Waste amendments. KSC's Remediation Program was initiated in response to an agreement with FDEP in the late 1980s regarding KSC's oldest contamination remediation sites or Solid Waste Management Units (SWMU), Wilson Corners and Ransom Road Landfill. Since then, KSC has been working with the EPA and FDEP to identify potential release sites and implement corrective action at those sites as warranted. EPA's SWMU Assessment initially identified 16 sites for investigation under the corrective action program. More sites were also identified by KSC as the program was implemented. In addition to corrective action sites, the NASA Remediation Group also manages petroleum contamination sites. To date, KSC has identified and investigated approximately 200 sites.

SWMUs and Potential Release Locations (PRLs) are generally concentrated in operational areas such as the Vehicle Assembly Building, LC-39, Industrial Area, and facilities on CCAFS currently or formerly operated by NASA. The most prevalent soil contaminants are petroleum hydrocarbons, RCRA metals, and polychlorinated biphenyls (PCB). The most prevalent groundwater contaminants are chlorinated solvents and associated degradation products. LC-39A has been designated as SWMU 8. RCRA Facility Investigation (RFI) activities were performed at LC-39A from early 1998 through mid-2000. In the DBA portion of the site, groundwater impacts due to VOCs were observed. In the HOF area, PAHs, pentachlorophenol, and 2, 4, and 6-trichlorophenol were detected above maximum contaminant levels and groundwater cleanup target levels (MCLs/GCTLs) in two monitoring wells. Surface water inside and outside of the perimeter fence contained PAHs and metals above Surface Water Cleanup Target Levels (SWCTLs) and some pesticides were also detected outside the fence line. An interim measure (IM) was conducted in 2000 which removed soils contaminated with PCBs and PAHs (NASA 2013)

3.11.1.3. USAF Installation Restoration Program

The DoD established the Installation Restoration Program to identify, characterize, and evaluate past disposal sites and remediate associated contamination as needed to protect human health and the environment for CCAFS and Patrick Air Force Base (PAFB). The IRP was initiated at CCAFS in 1984. The IRP efforts at CCAFS have been conducted in parallel with the program at PAFB and in close coordination with the EPA, the FDEP and NASA. CCAFS is not a National Priorities List (NPL) site, and the IRP sites are being evaluated and remediated under RCRA authority while meeting the CERCLA regulations.

As a former active launch complex, a number of hazardous chemicals were stored and used at LC-40 and at LZ-1 (SWMU C038), including trichloroethylene (TCE), trichloroethane, fuels, methyl ethyl ketone, alcohols, oils, hydrazine, red fuming nitric acid, paints, lubricants, Freon and PCBs. It has also been established that historical paint formulations used on launch structures included PCBs and lead. Routine sand blasting

activities following launches dispersed the PCBs throughout site surface soils (3E Consultants 2013). Additionally, paint delamination from the launch structure also contributed to PCB and lead contamination throughout the site. The groundwater is monitored regularly at the various SWMUs; details can be found at the 45th Space Wing Installation Restoration Program Office and in the 45th Space Wing Land Use Controls Management Plan, and the CCAFS HSWA Permit.

3.11.2. Port Canaveral and CCAFS Wharf Assets

3.11.2.1. Hazardous Materials and Waste Management

Routine operations at Port Canaveral and CCAFS-based wharf facilities require use of a variety of hazardous materials, including petroleum, oil, and lubricant products, solvents, cleaning agents, paints, adhesives, and other products necessary to perform ship, ground vehicle, and equipment maintenance and repair.

Bulk quantities of fuel are managed by the Port in two petroleum tank farms totaling 5 million barrels in capacity. These storage locations and facilities represent potential sources of spills. Petroleum tanks and associated systems and operations at Port Canaveral are managed and permitted in accordance with federal and state regulations.

3.11.2.2. Pollution Prevention

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes and was adopted at the International Maritime Organization in 1973. The Convention includes regulations aimed at preventing and minimizing pollution from ships, both accidental pollution and that from routine operations, and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes. Annex I covers prevention of pollution by oil from operational measures as well as from accidental discharges. Annex II details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk. Annex III contains general requirements for the issuing of detailed standards on packing, marking, labeling, documentation, stowage, quantity limitations, exceptions and notifications. Annex IV contains requirements to control pollution of the sea by sewage. Annex V deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed. Annex VI sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances.

Large commercial vessels routinely discharge ballast water, gray and black water, bilge water, and deck runoff consistent with applicable international and national standards. Discharges of sewage (also known as black water) and gray water, which is the effluent generated from wash basins and showers on board ships, are regulated under MARPOL Annex IV. Discharges of black water are prohibited except for specific conditions stipulated under the Annex. In addition to the international standards established under MARPOL Annex IV, the U.S. regulates vessel discharges of sewage, gray water, bilge water, and a variety of other vessel discharges through the EPA's Clean Water Act (CWA) NPDES Program.

Port Canaveral Port Authority has conducted a voluntary water quality monitoring program since 1992, regularly analyzing water samples from six stations in the Harbor and five stations in the Barge Canal. This enables the identification of short-term fluctuations and long-term trends in water quality. Water is regularly sampled from Port stormwater outfalls. Efforts to decrease contaminants include sweeping piers after cargo operations, cleaning pipes, installing stormwater treatment boxes and educating tenants on managing potential pollutants.

The Port also monitors water quality along the beaches south of the Port. In 2005, a study funded by the Port Authority and Brevard County and carried out by NOAA concluded there was no evidence of a water quality problem in the form of elevated bacteria or nutrient levels along these beaches. However, to

increase available data and maintain water quality, additional monitoring stations have been added (Port Canaveral 2018).

3.12. Natural Resources and Energy Supply

As an impact category, natural resources and energy supply provides an evaluation of a project's consumption of natural resources and use of energy supplies. The FAA has not established a significance threshold for natural resources and energy supply. While permanent or existing natural resources or energy supplies will be impacted, it is FAA policy to encourage the development of facilities that exemplify the highest standards of design, including principles of sustainability. The following regulations provide guidance to Federal agencies regarding sustainable use of natural resources and energy:

- EO 13123, Greening the Government through Efficient Energy Management;
- EO 13423, Strengthening Federal Environmental, Energy, and Transportation Management; and

The study areas for natural resources and energy supply include LC-39A on KSC, and LC-40, LZ-1, and LZ-2 on CCAFS, along with recovery areas in the Atlantic and Pacific Oceans, as well as drone ship landing areas in the Atlantic.

Water for CCAFS and KSC is acquired from the City of Cocoa municipal potable water distribution system. Launch pad use of non-potable water include noise abatement, cooling, and shock wave attenuation associated with the deluge system. The City of Cocoa operates the Claude H. Dyal Water Treatment Plant that treats the raw water primarily from a Floridan Aquifer wellfield located in east Orange County, and has the ability to also draw surface water from the Taylor Creek Reservoir, located in Brevard County. The City has a Consumptive Use Permit (CUP) with the St. Johns River Water Management District allowing withdrawal of up to 12 million gallons per day from the aquifer. Because KSC and CCAFS are consecutive systems, CUPs are not required. Water from the Dyal Plant is transmitted to KSC and CCAFS via interconnects at the southern end of each system. The distribution systems of KSC and CCAFS are also connected at the NASA Causeway and at the northern extreme of the system near LC-41. Throughout KSC and CCAFS there are various storage systems and secondary pump systems to supply water needs for fire suppression, launch activities, and potable water (NASA 2015b).

Florida Power and Light (FPL) provides power for CCAFS and KSC. FPL owns the transmission, but CCAFS and KSC own the distribution. FPL delivers electricity to CCAFS at 115 kilovolts (kV), which is distributed throughout the installation at various reduced voltages. The CCAFS electrical distribution system includes three major subsystems: high-voltage, medium-voltage, and low-voltage. CCAFS has five substations with individual locations at the south end, the north end, and at the Titan area.

The electric power distribution system at KSC is a combination of a FPL transmission system and two NASA-owned distribution systems. FPL transmits 115 kilovolts (kV) to KSC, which are distributed to two major substations. The C-5 substation serves the LC-39 Area, providing 13.8 kV, and the Orsino substation serves the Industrial Area, providing 13.2 kV, for a total of 25% of the electricity currently allocated to KSC.

3.13. Socioeconomics

Socioeconomics is an umbrella term used to describe aspects of a project that are either social or economic in nature. A socioeconomic analysis evaluates how elements of the human environment such as population, employment, housing, and public services might be affected by the proposed action and alternative(s).

Section 1508.14 of the Council on Environmental Quality (CEQ) Regulations states that "economic or social effects are not intended by themselves to require preparation of an EIS. When an EIS is prepared and economic or social and natural or physical environmental effects are interrelated, then the EIS will discuss

all of these effects on the human environment.” Therefore, the requirement to prepare socioeconomic analysis in an EA or EIS is project specific and is dependent upon the existence of a relationship between natural or physical environmental effects and socioeconomic effects. The study area for socioeconomics includes KSC, CCAFS, and Brevard County, Florida. Dragon recovery in the Pacific study area does not involve onshore activities that could affect economic activity, population and housing, or social conditions.

Vital statistics from the from the US Census Bureau were accessed January 16, 2019⁷ and report an estimated population of 590,000 for Brevard County. The median household income in Brevard County was \$51,184. The most current data on Brevard employment is for the years 2015–2016 and the percentage change was a positive increase of 3.7 percent.

The Falcon program fits within the range of several planned and notional programs that were evaluated in the NASA (2016), KSC Programmatic Environmental Impact Statement (PEIS). The PEIS was prepared as KSC proposed the transition to a multi-user spaceport over a 20 year period (2012 to 2032). The PEIS provides extensive review of data for Brevard and Volusia counties and compares them to demographic and economic data for the State of Florida. The PEIS describes age groups, housing, employment, earnings, property values, taxation, tourism, community cohesion, etc., within the study area for the 2000 to 2013 time frame. They concluded that the short term overarching direct economic impacts from the transition to a multiuser spaceport would be beneficial, but insignificant. A moderate creation of jobs and labor income would be created but most jobs were expected to be filled by area residents. Over the long term, however, the indirect impacts would be adding employees for non-NASA projects (i.e. SpaceX, Blue Origin, etc.,) that could support increases in jobs that expand to payroll at local service establishments and retailers.

⁷ <https://www.census.gov/quickfacts/fact/table/brevardcountyflorida>

4. ENVIRONMENTAL CONSEQUENCES

This chapter presents the environmental consequences associated with the Proposed Action and No Action Alternative. As noted at the beginning of Chapter 3, the environmental consequences of Falcon 9 and Falcon Heavy launches at KSC and CCAFS (including first stage booster landings at CCAFS), as well as Dragon reentry and recovery operations in the Pacific and Atlantic Oceans, have been previously analyzed (NASA 2013; USAF 2007, 2013, 2014, 2017). The FAA was a cooperating agency in the preparation of each of those environmental documents, formally adopted them, and issued independent FONSIs (FAA 2009, 2013, 2015, 2016, 2017). In accordance with 40 CFR §1502.21, this chapter summarizes the environmental consequences of launch operations previously analyzed and focuses on the intensity of potential impacts from increased annual launch and reentry operations (including landings and payload processing), as well as a new southern launch trajectory. Also, the potential impacts of MST construction and use are discussed.

In determining whether a potential impact would be significant under NEPA, the analysis in this chapter takes into account the FAA's significance thresholds and factors to consider presented in FAA Order 1050.1F, Exhibit 4-1. Please note that the "factors to consider" are not intended to be thresholds. If these factors exist, there is not necessarily a significant impact; rather, the FAA must evaluate these factors in light of context and intensity to determine if there are significant impacts.

As explained at the beginning of Chapter 3, several environmental impact categories are excluded from detailed analysis. Only those impact categories for which existing conditions were discussed in Chapter 3 are presented here.

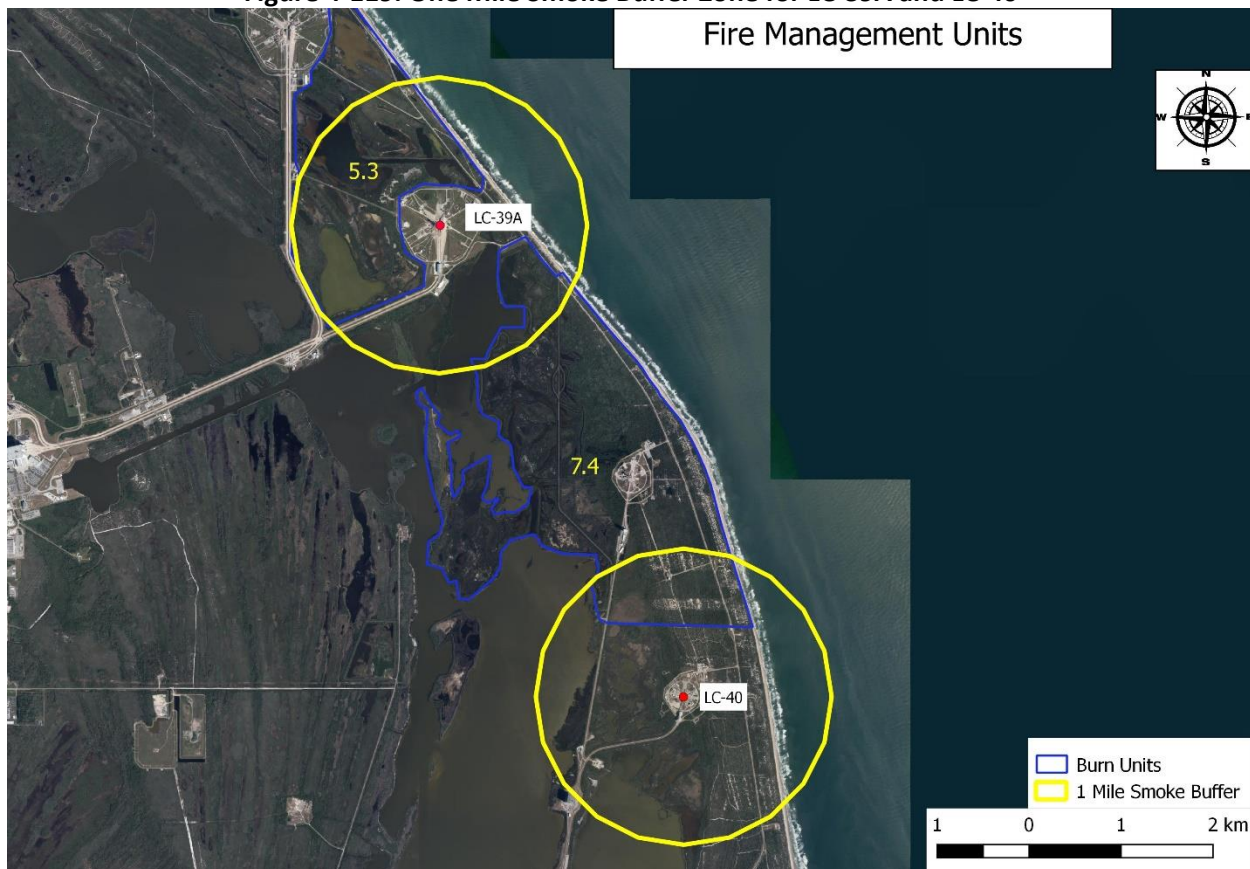
4.1. Land Use

The FAA has not established a significance threshold or identified factors to consider when evaluating the context and intensity of potential environmental impacts for land use. The determination that significant land use impacts exist is normally dependent on the significance of other impacts.

4.1.1. Proposed Action

The unique location and purpose of the CNS and MINWR, overlaid on KSC lands, creates a threshold that is also unique as compared to other more remote park lands. The land is surrounded by Operational Buffer/Conservation areas managed by MINWR. These conservation lands are currently designated as non-operational areas by NASA and are managed by MINWR. These areas, and areas on CCAFS, are subject to controlled burning operations, one of the Refuge's primary management tools. NASA, working with MINWR, would continue to include SpaceX in their prescribed fire planning and coordination activities to ensure that controlled burning of adjacent land and related issues are well-communicated with the ultimate goal of limited, if any, impact to operations at the launch complexes. The burn planning and operations of these operational areas adhere to a Prescribed Burn MOU, KCA-4205 Rev B (NASA 2019). This document lays out conditions and constraints for conducting prescribed burns, both on KSC and CCAFS. The document states no prescribed burning would occur on CCAFS or KSC/MINWR within a 1-mile radius of a smoke-sensitive spaceflight hardware or payload transport route beginning one day prior to arrival and/or transport. LC-39A and LC-40 are considered smoke-sensitive areas. The 1-mile radius around LC-39A and LC-40 would include FMU 5.3 and 7.4 (Figure 4-1).

Figure 4-119. One Mile Smoke Buffer Zone for LC-39A and LC-40



The fire management program administered by MINWR controls vegetative fuel loads at KSC to reduce the potential of wildfires. When NASA KSC or CCAFS receives USFWS notification of a planned prescribed burn adjacent to LC-39A or LC-40, NASA KSC or CCAFS shall notify SpaceX within three days to allow coordination of prescribed burns. NASA KSC management and CCAFS would assist the USFWS in resolving any operational or other barriers in order to accomplish prescribed burns. The Proposed Action would not change the fire management program activities in the area surrounding LC-39A and LC-40 and would not change the existing use of the land.

In summary, the Proposed Action would not result in significant impacts related to land use.

4.1.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. Also, SpaceX would not construct and use the MST at LC-39A. As documented in the previous EAs and FAA FONSI, the No Action Alternative would not result in significant impacts on land use.

4.2. Visual Effects (including Light Emissions)

The FAA has not established a significance threshold for visual effects. However, the FAA has identified factors to consider when evaluating the context and intensity of potential visual effects. Factors to consider that might be applicable to visual effects include:

- The degree to which the action would have the potential to:

- Create annoyance or interfere with normal activities from light emissions; and
- Affect the visual character of the area due to the light emissions, including the importance, uniqueness, and aesthetic value of the affected visual resources.
- The extent the action would have the potential to:
 - Affect the nature of the visual character of the area, including the importance, uniqueness, and aesthetic value of the affected visual resources;
 - Contrast with the visual resources and/or visual character in the study area; and
 - Block or obstruct the views of visual resources, including whether these resources would still be viewable from other locations.

4.2.1. Proposed Action

Potential visual impacts to the landscape in the study area include the proposed 284-foot tall MST at LC-39A. A site plan with details on structure dimensions and site layout would be submitted to NASA for review. The KSC site plan review process identifies potential constraints including land use, operational conflicts, natural resources, line-of-sight, safety, and security. The addition of the MST at LC-39A would be consistent with existing infrastructure at KSC. All lighting associated with the MST would have to comply with SpaceX's Light Management Plan for LC-39A, which is intended to reduce nighttime lighting impacts in the surrounding areas. Compliance with the Light Management Plan would prevent significant lighting impacts in the study area.

All launch operations would occur at established launch complexes and industrial areas. Launches (including landings at LZ-1 and LZ-2) would occur more frequently than what was analyzed in previous environmental reviews, and therefore rockets would be visible in the sky more often and there could be greater instances of nighttime lighting. As noted above, the visual sensitivity of KSC and CCAFS is low because they are federal launch ranges. All SpaceX operations at KSC and CCAFS must comply with Light Management Plans to minimize the amount of sky glow. Given the industrialized environment of KSC and CCAFS and lighting mitigation in place, significant land use and visual effects are not expected. First stage drone ship landings, Dragon splashdowns, and fairing recoveries would not be visible from the coast, because they would occur a minimum of 5 nautical miles offshore.

In summary, the Proposed Action would not result in significant visual effects.

4.2.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. Also, SpaceX would not construct and use the MST at LC-39A. As documented in the previous EAs and FAA FONSI, the No Action Alternative would not result in significant visual effects.

4.3. Air Quality

Significant air quality impacts would occur if the action would cause pollutant concentrations to exceed one or more of the National Ambient Air Quality Standards (NAAQS), as established by the Environmental Protection Agency under the Clean Air Act, for any of the time periods analyzed, or to increase the frequency or severity of any such existing violations. For most of the United States, the territorial seas extend 12 nautical miles from the coast. Beyond this area, the CAA does not apply. Air pollutant emissions outside U.S. territorial seas are calculated in the same manner as emissions over

territorial waters. These emissions are evaluated under Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, as the CAA does not apply to actions outside the United States.

4.3.1. Proposed Action

The primary emission products from the Falcon liquid engines, which use RP-1 and LOX, are CO₂, CO, water vapor, oxides of nitrogen, and carbon particulates. Calculations were performed to estimate the far-field exhaust constituents of SpaceX's M1D rocket engine firing under sea-level conditions (Sierra 2018). Although the exhaust is fuel-rich and contains high concentrations of CO, subsequent entrainment of ambient air results in complete conversion of the CO into CO₂ and oxidation of the soot from the gas generator exhaust. A small amount of thermal nitrous oxides (NO_x) is formed as NO. The NO emission rate is predicted to be 2.3 pounds/second under nominal power. Effects of the vehicle dynamics and multiple engines are difficult to estimate. Necessary assumptions were made to best capture the characteristics of the LOX/RP-1 plume. The analysis was done using a single engine firing into a stable environment within 516 feet of the engine exhaust. This assumes the gas generator exhaust is efficiently entrained into the rocket exhaust. The analysis from the single engine was then extrapolated to estimate the emissions for all 9 engines for the Falcon 9 and 27 engines for the Falcon Heavy. Additionally, the presence of any sound suppression water could change the environment, likely cooling the near-plume air. This could slow the rate of combustion; therefore, as the rocket gains altitude, the more efficiently the combustion process becomes.

The Performance Correlation Program (PERCORP) is a model that uses known engine performance to estimate mixing and vaporization efficiencies in liquid rocket engines and provide a simple method of predicting nozzle exit-plane flow constituents and properties. The PERCORP analysis model was used to estimate the oxidizer/fuel mixture ratio variations that exist within the M1D thrust chamber. The fuel-rich combustion model in PERCORP was also used to estimate the gas generator exhaust constituents. Table 4-1 shows the estimated emissions from the M1D engine.

Table 4-1. M1D Engine Exhaust Species

TCA Mass Fractions				Gas Generator		Engine Exit		Entrained Air	Mixed Exhaust at 501 ft	
Species	Mixed Chamber (%)	Exit (%)	Exit Mass (lb/s)	Mass Fraction	Exit Mass (lb/s)	Mass Fraction (%)	Exit Mass (lb/s)	Mass (lb/s)	Mass Fraction (%)	Exit Mass (lb/s)
CO	41.14	25.36	161.78	0.3035	8.65	24.76	165.02	0.00	0	0.00
CO ₂	25.51	42.30	269.84	0.0625	1.78	40.62	270.68	0.00	3.35	639.12
H ₂ O	21.72	25.38	161.89	0.0918	2.62	24.34	162.19	0.00	1.30	247.22
O ₂	6.28	3.67	23.40	0	0.00	3.51	23.42	18390.00	21.36	4069.50
OH	3.18	0.64	4.09	0	0.00	0.66	4.40	0.00	0	0.00
H ₂	1.32	0.86	5.50	0.003	0.09	0.81	5.41	0.00	0.00	0.02
O	0.74	0.13	0.84	0	0.00	0.14	0.92	0.00	0.00	0.06
H	0.07	0.01	0.08	0	0.00	0.01	0.08	0.00	0	0.00
HO ₂	0.04	0	0.00	0	0.00	0	0.00	0.00	0	0.00
HCO	0.00	0.00	0.01	0	0.00	0	0.00	0.00	0	0.00
H ₂ O ₂	0.00	0	0.00	0	0.00	0	0.00	0.00	0	0.00
CH ₂ O	0.00	0	0.00	0	0.00	0	0.00	0.00	0	0.00
CH ₄	0.00	0.27	1.75	4.76E-02	1.36	0.54	3.58	0.00	0	0.00

TCA Mass Fractions				Gas Generator		Engine Exit		Entrained Air	Mixed Exhaust at 501 ft	
Species	Mixed Chamber (%)	Exit (%)	Exit Mass (lb/s)	Mass Fraction	Exit Mass (lb/s)	Mass Fraction (%)	Exit Mass (lb/s)	Mass (lb/s)	Mass Fraction (%)	Exit Mass (lb/s)
O ₃	0.00	0	0.00	0	0.00	0	0.00	0.00	0	0.00
CH ₃	0.00	0	0.00	0	0.00	0	0.00	0.00	0	0.00
C(GR)	0	0.66	4.23	3.00E-03	0.09	0.50	3.34	0.00	0	0.00
C ₂ H ₂	0	0.62	3.98	1.14E-02	0.32	2.27	15.11	0.00	0	0.00
C ₂ H ₄	0	0.08	0.50	0.2098	5.98	1.84	12.25	0.00	0	0.00
C ₂ H ₆	0	0	0.00	0.0471	1.34	0	0.00	0.00	0	0.00
C ₃ H ₆	0	0	0.00	6.62E-02	1.89	0	0.00	0.00	0	0.00
C ₇ H ₁₄	0	0	0.00	3.97E-02	1.13	0	0.00	0.00	0	0.00
C ₁₂ H ₂₃	0	0	0.00	1.14E-01	3.26	0	0.00	0.00	0	0.00
N ₂	0	0	0.00	0	0.00	0	0.00	0.00	73.98	14098.16
NO	0	0	0	0	0	0	0	0	0.0121	2.313
NO ₂	0	0	0	0	0	0	0	0	0	0.00
Total	100.0	100.0	637.90	100.0	28.50	100.0	666.40	18390.00	100.0	19056.40

Engine flow rate (air + exhaust) = 19056.40 lb/s

Notes:

CO = carbon monoxide; CO₂ = carbon dioxide; H₂O = water; O₂ = oxygen; OH = hydroxide; H₂ = dihydrogen; O = oxygen; H = hydrogen; HO₂ = hydroperoxyl; HCO = bicarbonate; H₂O₂ = hydrogen peroxide; CH₂O = formaldehyde; CH₄ = methane; O₃ = ozone; CH₃ = methyl; C(GR) = carbon; C₂H₂ = acetylene; C₂H₄ = ethylene; C₂H₆ = ethane; C₃H₆ = propene; C₇H₁₄ = heptane; C₁₂H₂₃ = jet fuel; N₂ = nitrogen; NO = nitric oxide; NO₂ = nitrogen dioxide

% = mass percent in flow

ft = feet; lb/s = pounds per second

4.3.1.1. Launch Vehicle Emissions

Potential air emissions from the proposed launches would include activities related to liquid fuel loading (LOX and RP-1) and projected numbers of maximum launches. Air permits are not required for emissions from the launches, as these are mobile sources, are temporary in nature, and not considered to be major emissions of criteria pollutants or HAPs (FAC Rule 62-210.300(3)(a)). All emissions types described for the Proposed Action are exempt from air permitting requirements at KSC and CCAFS pursuant to FAC Rule 62-210.300(3)(a), Categorical Exemptions. These types of categorically excluded emissions units or activities are considered to produce “insignificant” emissions pursuant to FAC Rule 62-213.430(6). The liquid fuel loading operations are categorically excluded from air permitting and are considered insignificant sources of air pollution by the FDEP. Although permitting is not required, the air emissions of the Proposed Action are still required to be analyzed for potential impacts.

Emissions from Falcon 9 and Falcon Heavy launches at LC-39 and LC-40 were previously characterized as CO₂, CO, water vapor, NO_x, and carbon particulates (USAF 2007, 2013; NASA 2013). Most CO emitted by the engines is oxidized to CO₂ during afterburning in the exhaust plume. The only pollutant not converted is NO_x. The launch of the Falcon 9 would be expected to reach the upper limit of the mixing area (3,000 feet) within 23 seconds and the Falcon Heavy within 21 seconds. For the maximum launch

frequency of 60 Falcon 9 launches per year, the Falcon 9 would emit approximately 6.5 tons of NO_x per year. The Falcon Heavy would emit approximately 3.0 tons of NO_x per year at a launch frequency of 10 annual launches. These levels are well below the 100 tons-per-year threshold (General Conformity Rule basic *de minimis* threshold). While the General Conformity Rule does not apply for regulatory reasons because Brevard County is in attainment, these values are useful for assessing the scale of the operational emissions. All of the emissions are well below the threshold and would be expected to have little or no impact on regional air quality.

Air emissions from Falcon first stage booster landings at LZ-1 and LZ-2 include CO₂, CO, hydrogen, water, NO_x, VOC, and PM. As discussed in the USAF EAs (USAF 2007, 2013), these emissions are expected to be minimal. The amount of CO emissions that would result from landing a Falcon booster would be between 60 and 88 percent less than a Falcon 9 or Falcon heavy launch, since only three engines would be re-lit during landing (for each returning first stage). This amount is not enough to result in an exceedance of the NAAQS for CO. Brevard County, including CCAFS, is in attainment; therefore, the General Conformity Rule does not apply. Additionally, the subsequent entrainment of ambient air results in complete conversion of the CO into CO₂ and oxidation of the soot from the gas generator exhaust.

4.3.1.2. Falcon Booster Recovery and Fairing Recovery

Three vessels would be required for a Falcon booster drone ship landing in the Atlantic Ocean: drone ship, support vessel, and ocean tug. The support vessels would originate from Port Canaveral and travel to a position in the ocean to support drone ship landings. The tug and support vessel would be staged just outside the landing location. The support vessel is a research vessel that is capable of housing the crew, instrumentation, and communication equipment, and supporting debris recovery efforts, if necessary. The tug is an open-water commercial ocean vessel. The tug tows the drone ship into position at the landing area and tows the drone ship and rocket back to Port Canaveral. The vessels would be within the boundary of Florida's Coastal Zone for approximately eight hours of the total transit time (four hours outbound and four hours inbound). Emissions from operating the three vessels would be below the major source threshold of 100 tons per year for all criteria pollutants (Table 4-2).

During a fairing recovery mission, one recovery vessel is required for each fairing half. Each of the two recovery vessels are equipped with a sizeable net that is positioned underneath the falling fairing and catches it before it hits the ocean surface. The vessels would be within the boundary of Florida's Coastal Zone for approximately two hours of the total transit time (one hour outbound and one hour inbound). Emissions from the operation of the two vessels would be below the major source threshold of 100 tons per year for all criteria pollutants (Table 4-2).

4.3.1.3. Dragon Engine Testing and Payload Processing

Loading of hypergolic propellants would be performed at Area 59 in a manner similar to previous operations with the Dragon capsule at LC-40. Each loading or unloading operation would be independent, sequential, and conducted using a closed-loop system. During the operation, all propellant liquid and vapors are contained (USAF 2014). Although both NTO and hydrazine are classified as hazardous air pollutants (HAPs), the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations under Title III of the CAA have not yet established control standards. The packed bed scrubber systems usually used are considered Best Available Control Technology (BACT) and would be considered acceptable when NESHAPs regulations are promulgated. SpaceX would comply with applicable state and federal regulations.

Inadvertent releases of toxic air contaminants are unlikely, but possible as a result of accidents during Dragon capsule system testing. The highest possible contaminant release scenario would result from the

unlikely event of a spillage of the entire quantity of liquid propellants. Lesser releases would result from the unlikely event of fires or explosions and would consume substantial amounts of the propellants. SpaceX implements safety procedures to ensure there is minimal risk for these events to occur. In addition, spill response planning procedures are in place to minimize spill size and duration, as well as possible exposures to harmful air contaminants (USAF 2014).

The Proposed Action would involve increased activity from Dragon capsule payload processing at Area 59 than previously performed at LC-40. In 2017, there were fourteen launches from LC-39A or LC-40, four of which involved the Dragon, the remaining 10 launches carried a payload which would have required some amount of processing. For years 2019 through 2020, the number of missions with Dragon is expected to be up to seven per year, and payload processing would rise with the increase in expected launches per year. However, each processing event would still involve limited mobile source activities on an annual basis and therefore limit any effects.

4.3.1.4. Dragon Recovery

Recovery efforts under the Proposed Action would consist of the use of one 160-foot recovery vessel equipped with a helideck and six RHIBs to track down, collect, and transport Dragon and potentially six parachute recovery teams back to shore. By 2025, SpaceX anticipates up to ten Atlantic Ocean recovery operations per year that would originate from Port Canaveral or a CCAFS-based wharf facility in Florida and traveling no more than 1,000 nautical miles roundtrip. From 2019–2020, SpaceX anticipates up to four Dragon recoveries per year in the Pacific Ocean, and by 2025, all recovery operations would occur in the Atlantic Ocean.

Emissions associated with the combustion of diesel fuel being consumed by the recovery vessels would have the potential to affect air quality. The primary combustion products of the diesel fuel would be nitrogen, oxygen, CO₂, water vapor, and pollutant emissions. Common pollutants contained in these emissions would include unburned hydrocarbons, CO, NO_x and PM. For this analysis, it was assumed that up to 6 RHIBs would be deployed from the salvage vessel for capsule and parachute recovery. For the purposes of this analysis, the salvage vessel is assumed to be a modern, fuel efficient, dynamic positioning, multi-role construction/intervention vessel similar to the offshore supply ship, Havila Harmony.

Emissions associated with Dragon reentry would be generated by the combustion of the NTO/MMH propellant during the reentry burn, but these emissions would occur at elevations well above the 3,000-foot boundary layer and would have no impact on ground-level ambient air quality. The combustion of fuel by the helicopter that would potentially transport crew and time critical cargo to Port Canaveral or the closest airport is a source of emissions that would operate below the boundary layer for most or all of its operation time. Any fuel payloads remaining in the capsule would wait in the fuel storage containers until they could be safely transferred and stored.

The use of a helicopter up to ten times a year would generate minimal pollutant emissions. Information on the emission factors for the H-47 Chinook, which uses two turboshaft engines of similar horsepower as the ones used on the Erickson S-64E, were used to estimate the helicopter emissions. Helicopter operations include taking off from the recovery vessel, airborne visual monitoring during parachute recovery, and transfer of any crew and critical cargo to the closest airport, which would not exceed 150 miles. The emissions analysis assumes the helicopter would operate below 3,000 feet, which is the vertical threshold for assessing ground-level pollutant impacts.

The total annual operational emissions, which include the helicopter and recovery vessel operations for Dragon recovery, are presented in Table 4-2. All of the emissions are well below the 100-ton threshold. Additionally, most of the emissions would occur offshore, beyond state boundaries, where attainment

status is unclassified and the NAAQS do not apply.

Table 4-2. Estimated Annual Operation Emissions (tons per year) Compared to KSC and CCAFS Emissions

Emissions	Volatile Organic Compounds	Nitrogen Oxides	Carbon Monoxide	Sulfur Dioxide	PM ₁₀	PM _{2.5}
Helicopter Operations (Dragon Recovery)	0.26	0.92	0.75	0.32	0.32	0.32
Boat Operations (Dragon Recovery)	1.27	45.4	7.75	0.03	1.23	1.18
Fairing Recovery Operations	0.22	8.71	0.52	<0.10	0.10	0.10
Booster Recovery	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Approximate Total Annual Operational Emissions	1.75	55.04	9.02	0.35	1.65	1.61
GCR <i>de minimis</i> thresholds	100	100	100	100	100	100
KSC (2016)	4.58	10.48	3.21	0.02	0.68	0.53
CCAFS (2016)	3.35	42.21	11.66	2.52	2.76	----
Exceedance of Major Source Threshold	No	No	No	No	No	No

Sources: FAA 2018b; Rindlisbacher 2015; 40 CFR 93, Subpart B

Notes: GCR = General Conformity Rule; PM₁₀ = particulate matter less than or equal to 10 microns in diameter; PM_{2.5} = fine particulate matter 2.5 microns or less in diameter.

Port Canaveral and Port of Los Angeles, where vessels involved in the recovery mission would depart from and return to offload Dragon, are located in Brevard County and Los Angeles County, respectively. Because this is the only known location with activities that would be covered under the Clean Air Act, all of the emissions from the operations have been conservatively compared to KSC and CCAFS emission inventories and General Conformity Rule thresholds to assess worst-case impacts.

Based on the infrequency and limited scale of the operations, emissions impacts from vessels engaged in SpaceX recovery operations ten times per year would represent small percentages of the Brevard County and Los Angeles County emissions and would not cause an exceedance of any NAAQS. Dragon recovery efforts would not have a significant impact on local or regional air quality.

4.3.1.5. Summary

Table 4-3 shows the maximum emissions from all aspects of the Proposed Action.

Table 4-3. Total Estimated Annual Operation Emissions (tons per year) for the Proposed Action

Emissions	Volatile Organic Compounds	Nitrogen Oxides	Carbon Monoxide	Sulfur Dioxide	PM ₁₀	PM _{2.5}
Falcon 9 and Falcon Heavy Launches	-	9.47	Converted to CO ₂	-	-	-
Falcon Landings	-	3.79 ^a	Converted to CO ₂	-	-	-
Annual Recovery Operation Emissions	1.75	55.04	9.02	0.35	1.65	1.61
Total	1.75	68.3	9.02	0.35	1.65	1.61
GCR <i>de minimis</i> thresholds	100	100	100	100	100	100
Exceedance of Major Source Threshold	No	No	No	No	No	No

^a Emissions that would result from landing a Falcon booster would be 60 percent less than a Falcon 9 launch, since only three engines would be re-lit during landing.

Notes: GCR = General Conformity Rule; PM₁₀ = particulate matter less than or equal to 10 microns in diameter; PM_{2.5} = fine particulate matter 2.5 microns or less in diameter.

Based on these estimates, the total potential emissions of any criteria pollutants from Falcon 9 and Falcon Heavy launches, first stage boost-backs and landings, and Dragon recovery would not be expected to cause exceedances of the NAAQS. Emissions below 3,000 feet would be of short duration (a matter of seconds) as the vehicle rises above the launch pad and accelerates. The high temperatures of the exhaust products cause them to rise rapidly and disperse with prevailing winds. Therefore, impacts to air quality from these launch activities are expected to be insignificant.

4.3.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. SpaceX's Falcon launch vehicle program results in temporary air emissions. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in exceeding the NAAQS and therefore would not result in significant air quality impacts.

4.4. Climate

The FAA has not established a significance threshold or factors to consider for climate. The CEQ-issued NEPA guidance for considering the effects of climate change and GHG emissions was withdrawn on March 28, 2017. CEQ subsequently issued draft guidance on this topic in 2019. There are currently no accepted methods of determining significance applicable to aviation or commercial space launch projects given the small percentage of emissions they contribute. There is a considerable amount of ongoing scientific research to improve understanding of global climate change and FAA guidance will evolve as the science matures or if new federal requirements are established.

4.4.1. Proposed Action

4.4.1.1. Falcon 9 and Falcon Heavy Launches

The estimated amount of GHG (CO₂) emissions generated during Falcon 9 and Falcon Heavy launches is

compared to total global, U.S., CCAFS, and KSC GHG emissions in Table 4-4 below. The KSC GHG emissions in the table do not include launch activity. Twelve launches from KSC occurred in 2017 which would have resulted in a higher value reported in the table. The estimated CO₂ emissions from annual Falcon operations at KSC and CCAFS are significantly less than the total GHG emissions generated by the United States in 2018 and the total CO₂ emissions generated worldwide (EIA 2018; WRI 2018). CO₂ emissions from first stage boost-backs and landings would be appreciably less than launch (takeoff) emissions because fewer engines would be operating. At present, no methodology exists that would enable estimating the specific impacts (if any) that this incremental change in GHGs would produce locally or globally.

Table 4-4. Estimated Carbon Dioxide (CO₂) Emissions Comparison

Annual Emissions Source	Metric Tons CO ₂ e per Year
Total 2018 Global CO ₂ Emissions	3,710 x 10 ¹¹
Total U.S. 2018 GHG Emissions	5,140 x 10 ⁶
Total 2013 CCAFS GHG Emissions	72,547
Total 2017 KSC GHG Emissions ^a	96,645
60 Falcon 9 launches	23,226
10 Falcon Heavy launches	11,613
81 Falcon RLV landings	12,542

Source: EPA 2018b; Tables C-1 and C-2 to Subpart C of 40 CFR 98

^a Emissions from launch operations are not included.

Planned reuse of between 28 and 81 first stage boosters per year between 2020 and 2025 would reduce potential emissions compared to manufacturing and shipping a new booster to the launch site.

The CAA does not list rocket engine combustion emissions as ozone depleting substances (ODSs); therefore, rocket engine combustion emissions are not subject to limitations on production or use. The proposed launch activities do not generate ODSs. While not regulated, rocket engine combustion is known to produce gases and particles that reduce stratospheric ozone concentrations locally and globally (WMO 1991).

The propulsion systems used by the Falcon 9 and Falcon Heavy emit a variety of gases and particles directly into the stratosphere, including CO₂, water vapor, NO_x, and soot (carbon). A large fraction of these emissions are chemically inert and do not affect ozone levels directly. Other low reactive emissions, such as H₂O, have an impact on ozone globally since they react with ozone destroying gases known as radicals. A small fraction of rocket engine emissions are highly reactive radical compounds that attack and deplete ozone in the plume wake immediately following launch. Particulate emissions, such as carbon (soot), may also be reactive in enabling important reactions that would not proceed otherwise. These emissions are a small fraction of the total emissions and are below the CO₂e emissions described above. They are not expected to result in significant climate-related impacts.

4.4.1.2. Dragon Engine Testing and Payload Processing

Since there are only very minor GHG gases associated with Dragon and/or payload processing and other than increased payload frequency, there would be no change from current activities, and there would be no climate-related impact.

4.4.1.3. Dragon Recovery

The Proposed Action would directly and indirectly generate small increases in GHG emissions to the atmosphere as a result of vessel and helicopter activities. Emissions were estimated for total carbon dioxide equivalents (CO₂e) for annual operations, at 3,815 metric tons CO₂e from six Dragon landings (FAA 2018b). The Proposed Action would include up to four additional Dragon landings. Recovery

operations involving limited mobile source activities on an annual basis, would incrementally contribute to global emissions, but are not themselves of such magnitude as to make a direct correlation with climate change. The primary combustion products of the propellants MMH and NTO used in the Dragon propellant system are nitrogen gas and water (Stuetzer 2013, Haas 1984); therefore, there are no significant criteria pollutants or GHG emissions associated with the operation of this system.

4.4.1.4. Summary

Table 4-5 shows all GHG emissions associated with the Proposed Action. No significant climate-related impacts are anticipated.

Table 4-5. Estimated GHG Emissions for the Proposed Action

Annual Emissions Source	Metric Tons CO ₂ e per Year
60 Falcon 9 launches	31,061
10 Falcon Heavy launches	26,747
54 Falcon 1 st stage landings at CCAFS	3,141
27 Falcon 1 st stage landings on Drone Ship	1,570
10 Dragon landings	6,358
Total	68,877

4.4.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. SpaceX's Falcon launch vehicle program results in temporary GHG emissions. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in significant climate-related impacts.

4.5. Noise and Noise-Compatible Land Use

4.5.1. Proposed Action

Under the Proposed Action, potential noise impacts could occur from the proposed construction, increase in launch and landing operations of the Falcon 9 and Falcon Heavy vehicles, and the proposed Dragon reentry and recovery operations. Significant noise impacts would occur if the Proposed Action would increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB, or that will be exposed at or above the DNL 65 dB level due to a DNL 1.5 dB or greater increase, when compared to the no action alternative for the same timeframe. There are other federal agency noise standards that pertain to hearing conservation (e.g., those established by the NIOSH and OSHA). Activities conducted under the Proposed Action would be in compliance with these standards.

Noise levels at KSC would increase during construction of the MST. The construction noise would be contained within KSC and would not affect noise sensitive areas. The workforce would adhere to OSHA safety practices in place at KSC.

4.5.1.1. Falcon 9 and Falcon Heavy Launch Noise

Appendix A contains a noise study entitled *Rocket Noise Study For SpaceX Flight And Static Test Operations At Cape Canaveral Air Force Station And Kennedy Space Center* (October 2018). The study was conducted by KBRwyle. That study addressed engine noise for the Falcon 9 and Falcon Heavy using the noise model RNOISE to compute the L_Amax and SEL contours. The L_Amax contours indicate the maximum sound level at each location over the duration of the launch. As shown in the study, the

L_{Amax} 70 dB through 110 dB contours represent the maximum levels estimated for a Falcon Heavy launch. The higher L_{Amax} contours (90, 100, and 110 dB) are located entirely within either the CCAFS or KSC properties. If a launch occurs during nighttime, when background levels are lower than during the day (e.g., in the 40 dB to 50 dB range), then residents of Titusville, Merritt Island, and Cape Canaveral may notice launch noise levels that exceed 60 dB. If a Falcon 9 launch occurs during the day, when background levels are higher (e.g., 50 dB to 60 dB range), then residents of these communities may notice launch noise levels above 70 dB. A prevailing on-shore or off-shore breeze may also strongly influence noise levels in these communities.

As mentioned previously, SEL is an integrated metric and is expected to be greater than the L_{Amax} because the launch event is up to several minutes in duration whereas the maximum sound level (L_{Amax}) occurs instantaneously. For Falcon 9, the SEL 100 and 110 dB contours are expected to remain almost entirely on CCAFS or KSC property. For Falcon Heavy, the SEL 110 dB contour is expected to remain within the CCAFS and KSC properties, whereas Merritt Island and parts of Titusville are expected to be exposed to SELs higher than 100 dB. In general, the estimated noise exposure from Falcon Heavy launches at LC-39 A is 4 to 5 dB higher than estimated noise exposure from Falcon 9 launches at LC-39A.

Estimated DNL for all rocket operations in 2025 is shown in Figure 4-2. This includes Falcon Heavy and Falcon 9 launches, static fire tests, and booster landings. Estimated SEL contours for these operations are depicted in figures contained in the report provided in Appendix A. The 65 DNL contour for all rocket operations in 2025 is located within the CCAFS and KSC properties. These areas are not considered noise-sensitive for purposes of assessing significance of noise impacts.

Figure 4-2. DNL for Falcon Heavy and Falcon 9 Launches, Static Fire Tests, and Booster Landings in 2025

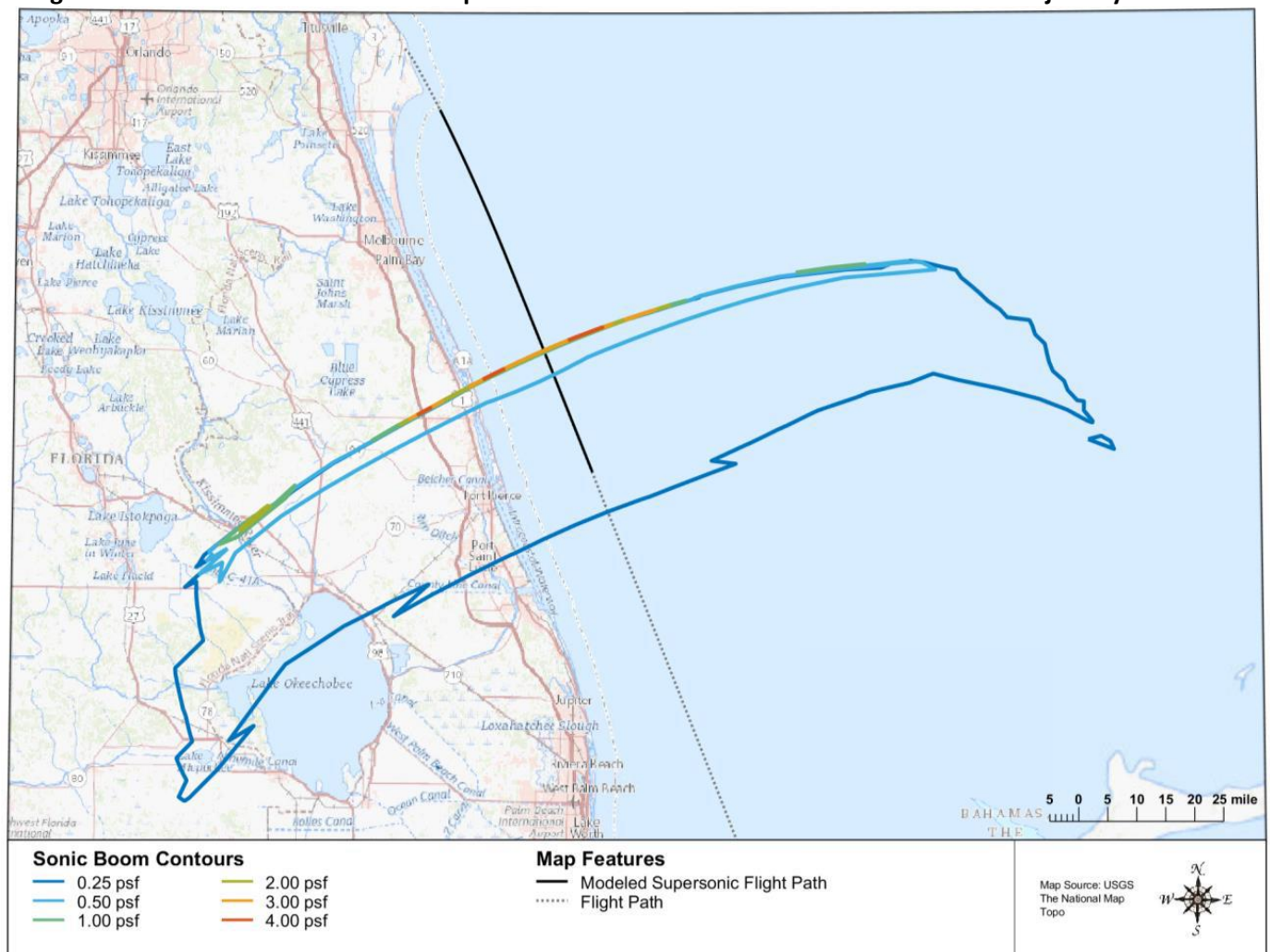


4.5.1.2. Sonic Booms

Results from past studies of launch-related (ascent) sonic booms show that the surface intercept of the sonic boom would be observed more than 40 miles off the coast. Since most launches have sonic boom footprints that occur down track and over the ocean, sonic booms would occur away from the eastern coastline of Florida and would not occur on or near land or other noise sensitive areas. However, for the few launches with southern trajectories (up to six per year), sonic boom peak overpressures were modeled to occur over populated land near Vero Beach, Florida, with the vast majority experiencing peak overpressures of less than 1 psf (BRRRC 2019; see Appendix A). Figure 4-3 shows a narrow region north of Vero Beach with land area less than 3 square miles is predicted to receive overpressures of greater than 2 psf with less than 0.01 square miles experiencing 4.6 psf. The majority of the land area within the sonic boom footprint is expected to experience overpressures of around 0.25 psf, which is similar to distant thunder. The location of focus boom regions is highly dependent on the actual trajectory and atmospheric conditions, and it is unlikely any given location would experience the focus more than once over multiple events. A modeled peak overpressure of 4.6 psf translates to an equivalent C-weighted DNL (CDNL) of 51 dBC. Therefore, the proposed Falcon 9 polar launch operation does not pose a significant impact with regards to human annoyance as the noise exposure is less than the significance threshold of CDNL 60 dBC for impulsive noise sources (equivalent to DNL 65 dBA). The potential for hearing damage (with regards to humans) is negligible, as the modeled sonic boom overpressure levels over land are lower than the approximate 4 psf impulsive hearing conservation noise criteria, except for an area less than 0.01 square miles (BRRRC 2019).

BRRRC's sonic boom assessment for a Falcon 9 polar launch (see Appendix A) discusses the potential for structural damage from sonic booms. In general, for well-maintained structures, the threshold for potential damage from sonic booms is 2 psf; below 2 psf, damage is unlikely. If the sonic boom reaches levels of around 4 psf, it is possible there could be some minor damage (refer to Table 2 in BRRRC's 2019 sonic boom report, attached to this EA in Appendix A). Major damage is unlikely. The FAA does not expect significant impacts related to structural damage from the sonic boom generated during a Falcon 9 polar launch. SpaceX would be responsible for resolving any structural damage caused by the sonic boom.

Figure 4-3. Predicted Sonic Boom Overpressure Contours for Falcon 9 Southern Launch Trajectory



With regard to sonic booms generated during landing (descent), several studies (see Appendix A) have been conducted along with actual sonic boom overpressure measurements. PCBOOM, as well as NASA's 1122 sonic boom prediction method, was used and compared with actual overpressure measurements (Table 4-6). SpaceX measured overpressures for Falcon 9 Flight 19 on the west coast and measured 2.3 psf at the drone ship. SpaceX also measured the sonic boom produced on Flight 21/Orbcomm, which launched from LC-40 and landed at LZ-1. The value measured at LC-40 was 2.5 psf. Sonic booms would be heard over land and are expected to be less than 4 psf. SpaceX and USAF noted that after the landings in July 2016 and December 2017, no broken windows were reported (SpaceX 2018). Additional analysis of sonic booms associated with landings at LZ-1 is provided in Appendix A (BRRRC 2017).

Table 4-6. Sonic Boom Overpressure Measured and Predicted Values

Distance from Pad (miles)	Measured Overpressure (psf)	1122 Predicted Overpressure (psf)	PCBOOM Predicted Overpressure (psf)	CDNL (C-weighted) ¹
0–5	2.9–5.8	2–15	3.4–6.2	48–50
6–10	1.2–3.1	1.1–2.5	1.4–2.2	41–48
11–15	1.2	1.0	1.2	39
16–20	0.1–0.3	1.0	0.9–1.1	20
21–25	0.02–0.26	0.25–0.50	0.2	<20

Source: SpaceX 2018.

Notes:

¹ 95th Air Base Wing and AFFTC 2003

psf = pounds per square foot

KBR conducted sonic boom modeling for a Falcon 9 booster landing at LZ-1/LZ-2 during a polar mission, which could occur up to six times per year (see Appendix A for KBR's report). The outer contours of the sonic boom footprint were modeled to span over populated areas further south than typical landing trajectories at LZ-1 and LZ-2 (see Figure 4-4). These areas include land near Indialantic, West Melbourne, Palm Bay, Sebastian Inlet, and western areas of Florida, south of Orlando. The overpressure levels in the vicinity of the landing pad range from about 2.0 to 2.7 psf, which is consistent with the typical landing trajectories that currently occur. Overpressure levels in the areas adjacent to CCAFS and KSC are predicted between 0.5 to 1.0 psf. The highest overpressure levels, which would occur offshore, are up to 4.6 psf. The broad crescent shown in Figure 4-4, with overpressure levels of 0.1 psf, is located over a large land area south of Orlando and stretching south of Port St. Lucie. The majority of the land area within the sonic boom footprint is expected to experience overpressures of 0.25 to 0.5 psf, which is similar to distant thunder.

The USAF conducted an independent sonic boom analysis for Falcon 9 polar missions and determined that predicted damage to public areas is very low and does not pose a safety concern (see Appendix A).

Because the FAA is required to analyze transboundary impacts, areas in the Bahamas and Cuba are also considered in the analysis. As shown in Figure 2-10, Falcon first stage booster landings during a polar mission could occur in areas near Cuba and the Bahamas. A sonic boom generated during a landing in the eastern portion of the recovery area is predicted to intercept the ground near the southern part of Andros Island, Bahamas (BRRRC 2019; Appendix A), as shown in Figure 4-5. This area of Andros Island is sparsely populated and includes part of West Side National Park and small settlements along the eastern coast near Kemp's Bay. The overpressures are predicted to be less than 0.5 psf. Much of the boom footprint is predicted to be less than 0.25 psf, which is similar in character to distant thunder. A sonic boom generated during a landing in the western portion of the recovery area is predicted to intercept the ground near the northern islands of Cuba (BRRRC 2019; Appendix A), as shown in Figure 4-6. Given that noise levels associated with proposed landing activities would last less than 1 minute and occur infrequently, no significant noise impacts are expected.

Figure 4-4. Predicted Sonic Boom Overpressure Contours for a Polar Landing at LZ-1/LZ-2

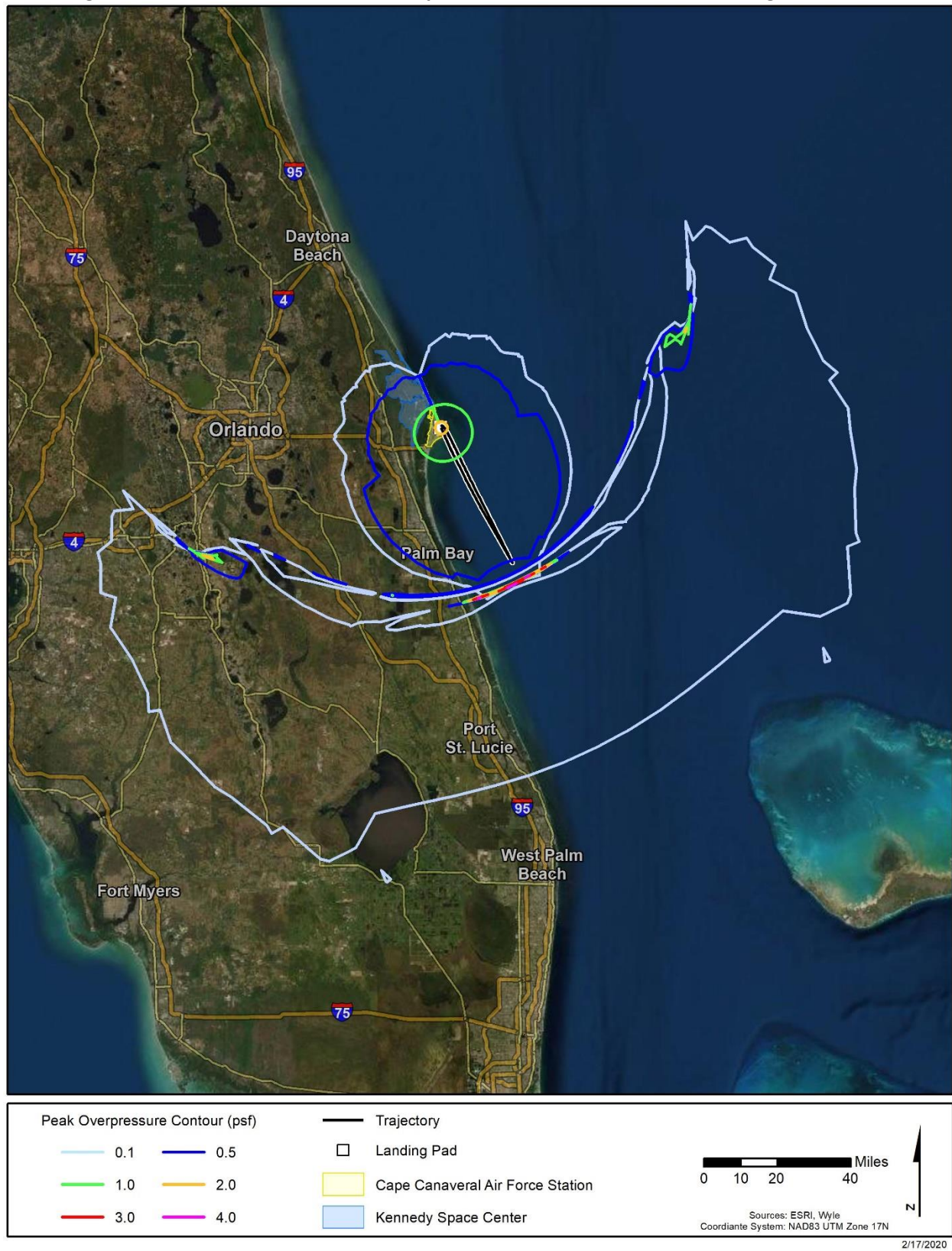


Figure 4-5. Predicted Sonic Boom Overpressure Contours for an Eastern Falcon 9 Drone Ship Landing

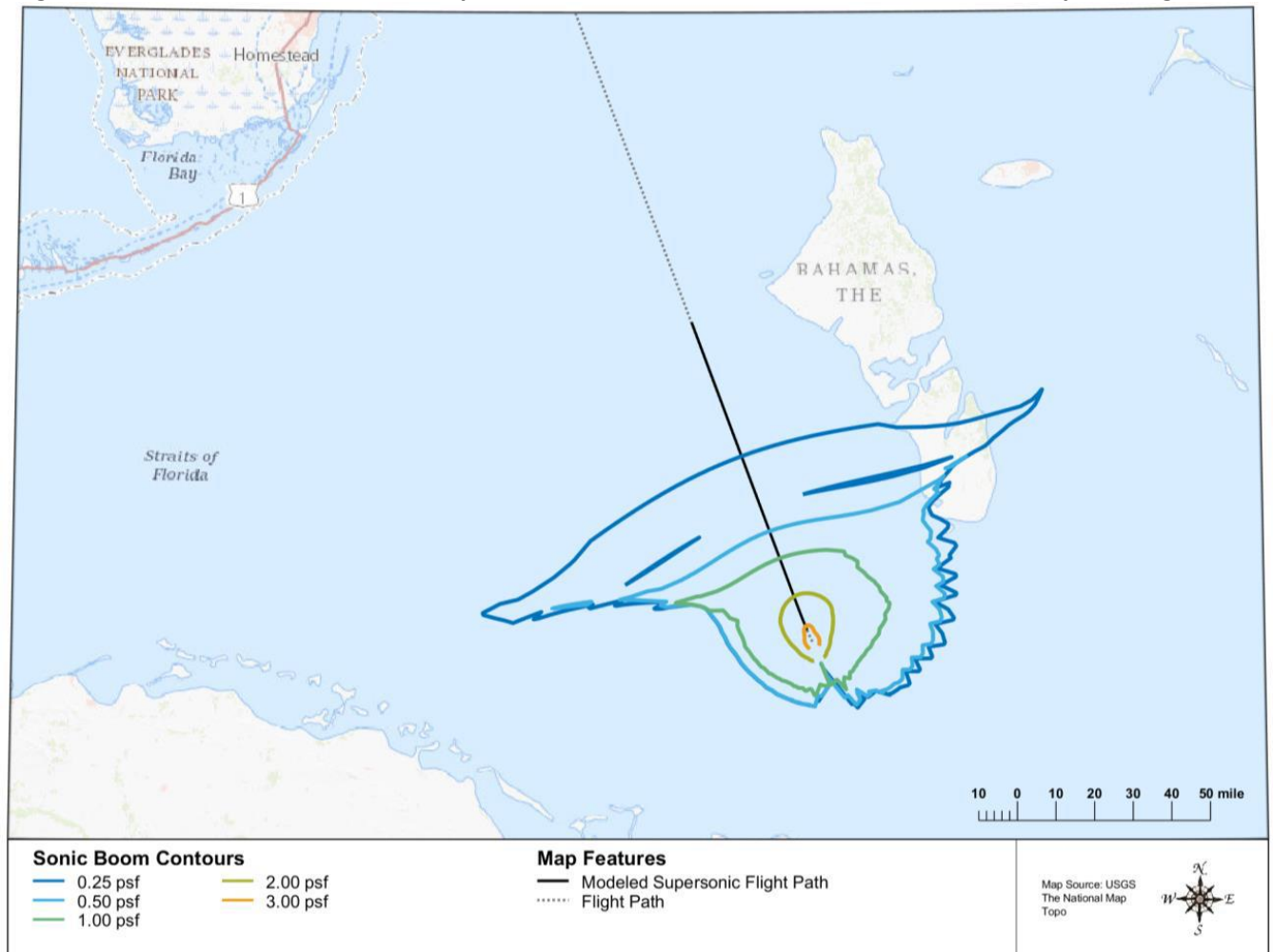
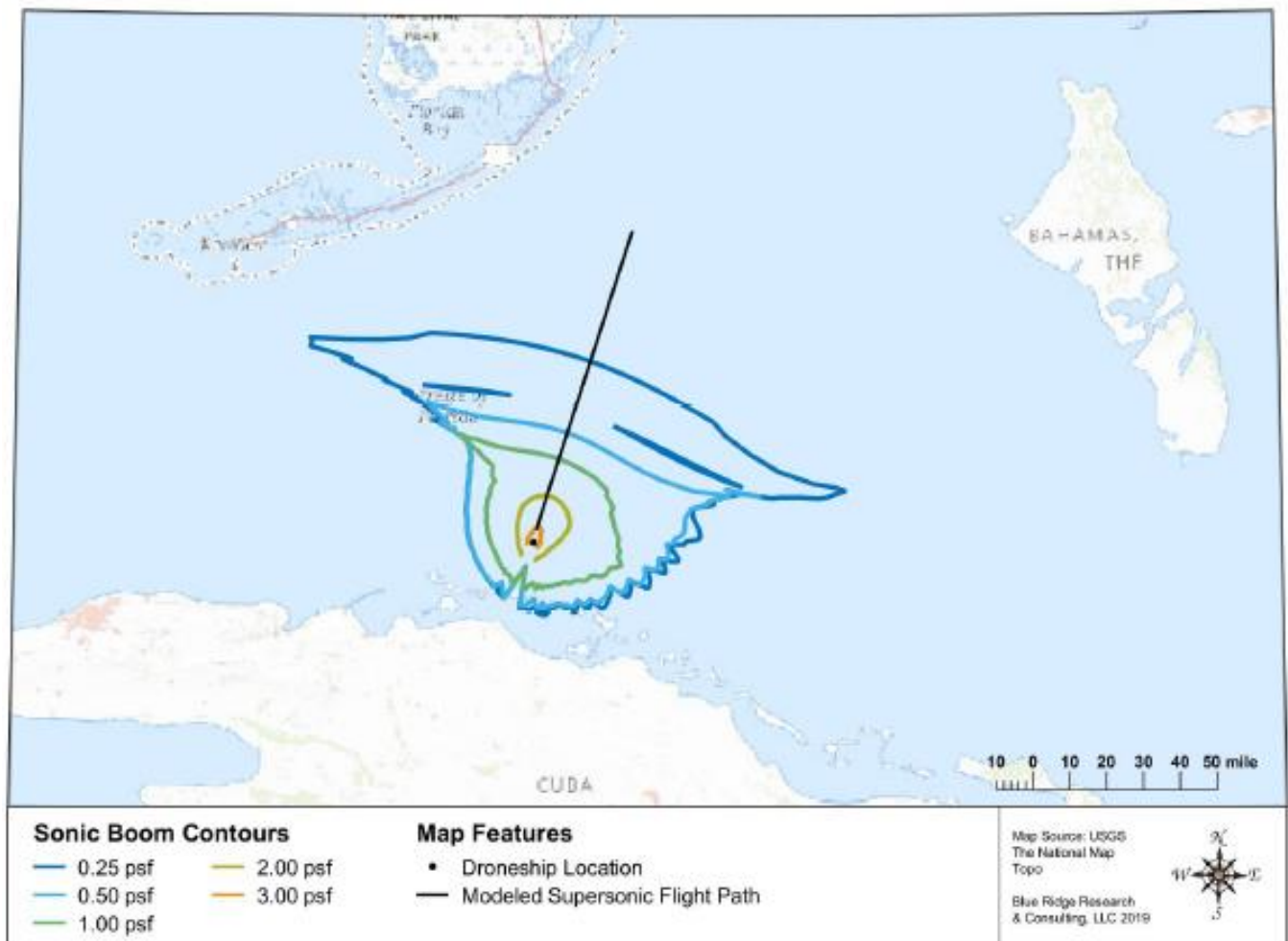


Figure 4-6. Predicted Sonic Boom Overpressure Contours for a Western Falcon 9 Drone Ship Landing



Mitigation and Best Management Practices

SpaceX has developed a notification plan to educate the public and announce when a southern trajectory launch and/or landing event at LZ-1 and/or LZ-2 would take place so that the public is aware they might hear a sonic boom. The plan would involve issuing statements to news outlets and law enforcement regarding the anticipated sonic boom, so that if heard, the public would understand what has occurred. SpaceX would implement a similar plan in coordination with the Bahamian and Cuban government for polar missions.

4.5.1.3. Dragon Engine Testing and Payload Processing

For periodic static test firings of the Dragon, the combined total thrust for would be approximately 131,000 pounds of force, which is less than 10 percent of the amount of thrust generated during a Falcon 9 launch. Thus, the noise associated with a Dragon test fire would be much less than a Falcon 9 launch. Dragon test firings would be less than 2 seconds in duration. Higher SELs above 80 dB would be mostly contained within the CCAFS and KSC properties (KBRwyle 2018; see Appendix A). Based on the above analysis for Falcon launches, normal Dragon processing and test firings would not result in significant noise impacts.

4.5.1.4. Dragon Recovery

The noise analysis assumes a proposed maximum of ten Dragon reentries. SpaceX plans to conduct one Dragon reentry in the Pacific Ocean in 2020 and then all remaining Dragon reentries are planned for the Atlantic Ocean. Under the Proposed Action, there would be no Dragon engine noise during reentry/splashdown, as Dragon would land via parachutes.

Potential noise impacts could occur from both ship and helicopter engines during Dragon recovery. The anticipated noise from both sources are considered relatively low, short-term, and infrequent. Both noise sources are consistent with current Atlantic Ocean use, which includes vessel engine noise associated with common maritime operations. No adverse impacts from vessel and helicopter activity is anticipated.

A sonic boom may be generated during Dragon reentry. Sonic booms generated during reentry and landing in the Pacific Ocean impact the ocean's surface far offshore and do not intersect any noise sensitive areas. Sonic booms generated during reentry and landing in the Atlantic Ocean would most likely only impact the ocean's surface. For Dragon-2 reentry missions, a portion of Florida could experience the boom, depending on the location of the exact landing location in the Atlantic Ocean. Blue Ridge Research and Consulting (BRRRC) conducted a sonic boom analysis for Dragon landings at CCAFS using the single-event prediction model, PCBOOM, which is an FAA-approved model (BRRRC 2015; see Appendix A). Based on BRRRC's analysis and the fact that the reentry trajectories (Mach, altitude, and angle-of-attack profiles) for a landing at CCAFS and a landing offshore in the Atlantic Ocean are the same, an overpressure of 0.4 pound per square foot (psf) would be expected approximately 19 miles from the landing site and 0.35 psf approximately 50 miles from the landing site. Therefore, because it is possible for Dragon to land approximately 50 miles from the coast, overpressures could impact land and oil platforms. Assuming a reentry at the closest point in the recovery area to the shoreline (5 nautical miles offshore), the sonic boom could extend approximately 150 miles inland. However, it would be at an overpressure of less than 0.25 psf. For reference, an overpressure of 0.25 psf is similar to distant thunder. Therefore, sonic booms generated during Dragon reentry would not result in significant noise impacts.

4.5.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. SpaceX's Falcon launch vehicle program results in temporary noise. As documented in the previous EAs and FAA FONSI, the No Action Alternative would not increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB noise exposure level and therefore would not result in significant noise impacts.

4.6. Historical, Architectural, Archeological, and Cultural Resources

The FAA has not established a significance threshold for cultural resources. Factors to consider when assessing the significance of potential impacts on cultural resources include whether the action would result in a finding of *Adverse Effect* through the Section 106 process. However, an adverse effect finding does not automatically trigger preparation of an EIS.

4.6.1. Proposed Action

As noted in Section 3.6, NASA and USAF previously conducted Section 106 consultation for Falcon launches, including landings, at KSC and CCAFS during preparation of the EAs mentioned at the beginning of Chapter 3. NASA KSC has a stewardship responsibility for managing the cultural resources

on NASA-owned lands. To this end, KSC has developed an Integrated Cultural Resources Management Plan (ICRMP) that reflects NASA's commitments to the protection of its cultural resources. The ICRMP provides an inventory of cultural resources and a plan of action to identify, assess, manage, preserve, and protect these resources. It also includes a guide for impact analysis review and a set of standard operating procedures for ongoing cultural resource management activities. NASA follows stipulations identified in the ICRMP, existing memoranda of agreements, and the 2009 PA. During preparation of the 2013 NASA EA, which included Falcon 9 and Falcon Heavy launches from LC-39A, NASA determined its action would constitute an adverse effect on LC-39A (a historic property) in accordance with the 2009 PA and consulted the SHPO. The SHPO concurred with NASA's finding and noted that KSC has previously completed and will be following the appropriate mitigation stipulations identified in the 2009 PA. Prior to and during construction of the MST, SpaceX and NASA would comply with the 2009 PA and resolve any adverse effects to LC-39A in consultation with the SHPO.

The 2013 USAF SEA concluded that Falcon launch operations at LC-40 would not affect cultural resources because there are no historic properties located at or near LC-40. Similarly, the 2017 USAF SEA for Falcon Heavy first stage boost-back and landing at LZ-1 and LZ-2 concluded that Falcon booster landings at LZ-1 and LZ-2 would not affect historic properties and the SHPO concurred with that finding.

Based on SpaceX's estimate, up to six Falcon 9 launches per year could fly a southern trajectory. Thus, sonic booms could impact Florida up to twelve times per year—once during ascent and once during landing (see Figures 4-3 and 4-4 for the sonic boom footprint). Sonic booms are low-frequency impulsive noise events with durations lasting a fraction of a second. The majority of land within the APE is predicted to experience overpressures of less than 1 psf. An overpressure of 1 psf is similar to a clap of thunder. A narrow region north of Vero Beach with land area less than 3 square miles is predicted to receive overpressures greater than 2 psf. An area less than 0.01 square miles could experience a maximum overpressure of 4.6 psf. Based on the sonic boom modeling, no historic properties are expected to experience overpressures greater than 2 psf. Most of the APE would experience a boom of 0.25 psf, which is similar to distant thunder. Figures 4-3 and 4-4 show a common footprint in a portion of the region between the coast and Lake Okeechobee, and sonic booms could be experienced during both ascent and landing (i.e., up to a maximum of twelve times per year). Areas outside of this region would only experience sonic booms during either ascent or landing (i.e., up to a maximum of six times per year). During landings, sonic booms exhibit lower overpressure.

As noted in Section 4.5, in general, for well-maintained structures, the threshold for potential damage from sonic booms is 2 psf; below 2 psf, damage is unlikely. Therefore, the FAA does not expect any adverse effects to the historic structures within the APE. SpaceX would be responsible for resolving any structural damage caused by the sonic boom. Also, because sonic booms would occur up to a maximum of twelve times per year and would be similar to or less than the noise experienced during a clap of thunder in the majority of the APE, the FAA does not expect any adverse effects related to the setting of historic sites within the sonic boom APE. The FAA is currently conducting Section 106 consultation with the SHPO. The results of the consultation will be included in the Final EA.

4.6.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. As documented in the previous EAs and FAA FONSI, the No Action Alternative would not result in significant impacts to historical, architectural, archaeological, and cultural resources.

4.7. Department of Transportation Act Section 4(f)

A significant impact would occur if the action involves more than a minimal physical use of a Section 4(f) resource or constitutes a “constructive use” based on an FAA determination that the aviation project would substantially impair the Section 4(f) resource. Resources protected by Section 4(f) are publicly owned land from a public park, recreation area, or wildlife and waterfowl refuge of national, state, or local significance; and publicly or privately owned land from an historic site of national, state, or local significance. Substantial impairment occurs when the activities, features, or attributes of the resource that contribute to its significance or enjoyment are substantially diminished.

4.7.1. Proposed Action

4.7.1.1. Falcon 9 and Falcon Heavy Launches

For decades, the 4(f) properties located at KSC and CCAFS have been experiencing increased noise levels during launches taking place at CCAFS and adjacent KSC. Some of the launch vehicles, including the Space Shuttle, that have launched from CCAFS and KSC produced more thrust and thus louder noise than would occur under the Proposed Action. Due to the long history of these 4(f) properties experiencing noise from launches at CCAFS and KSC, the FAA has determined that Falcon launches would not substantially diminish the protected activities, features, or attributes of any of the Section 4(f) properties identified, and thus would not result in substantial impairment of the properties.

Section 4(f) properties located within the sonic boom footprints of a Falcon 9 polar launch or landing would be exposed to a sonic boom up to six times per year or up to 12 times per year if they are exposed to sonic booms during both ascent and landing. Section 4(f) properties within the sonic boom footprint include those NRHP-listed properties shown in Table 3-10. Other potential Section 4(f) properties within this sonic boom footprint include public parks, recreation areas, and wildlife management and conservation areas as described in Section 3.7.

Visitors at the Section 4(f) properties might experience a sonic boom at the time of a Falcon 9 polar launch and landing. Sonic booms are low-frequency impulsive noise events with durations lasting a fraction of a second. The majority of land within the sonic boom footprints is predicted to experience overpressures of less than 1 psf. An overpressure of 1 psf is similar to a clap of thunder. A narrow region north of Vero Beach with land area less than 3 square miles is predicted to receive overpressures greater than 2 psf during Falcon 9 ascent. An area less than 0.01 square miles could experience a maximum overpressure of 4.6 psf during Falcon 9 ascent. Most of the areas within the sonic boom footprints would experience a sonic boom of 0.25 psf, which is similar to distant thunder. Although some of the Section 4(f) properties include wildlife management and natural areas with typically quiet settings, this low magnitude of overpressure at only occasional times (maximum of twelve times per year) should not diminish the significance and enjoyment of these properties.

As noted in Section 4.5, in general, for well-maintained structures, the threshold for potential damage from sonic booms is 2 psf; below 2 psf, damage is unlikely. Therefore, the FAA does not expect any adverse effects to historic structures. SpaceX would be responsible for resolving any structural damage caused by the sonic boom. Also, because sonic booms would occur up to a maximum of twelve times per year and would be similar to or less than the noise experienced during a clap of thunder in the majority of the sonic boom footprint, the FAA has determined that Falcon 9 polar launches (including landings) would not substantially diminish the protected activities, features, or attributes of any Section 4(f) properties within the sonic boom footprint, and thus would not result in substantial impairment of the properties.

There is a possibility of temporary restricted access on sections of KSC managed by MINWR and CNS, as

have occurred for recent and past space programs. This is dependent upon the volume of visitor traffic and is not related to a public safety hazard from a launch. That is, past Falcon launch vehicle launches have not required closing MINWR or CNS from an FAA public safety perspective. Closures due to visitor volume are coordinated between KSC security, MINWR, and CNS by monitoring to ensure parking lot thresholds are not exceeded, and roadways allow for emergency egress for any form of emergency associated with large crowds. The closure would be temporary and would not cause more than a minimal disturbance to the enjoyment of the resource.

In summary, the Proposed Action would not constitute a physical or constructive use of Section 4(f) resources and therefore would not result in significant impacts to Section 4(f) properties.

4.7.1.2. Dragon Engine Testing and Payload Processing

This aspect of the Proposed Action does not occur on or near Section 4(f) properties and therefore would not be considered a constructive use of any Section 4(f) property and would not invoke Section 4(f) of the DOT Act.

4.7.1.3. Dragon Recovery and Fairing Drop Tests

Dragon recovery would not result in the physical use, direct taking, or temporary occupancy of Section 4(f) properties. As described in Section 4.5.1, Dragon landing would not be expected to produce a significant noise impact from sonic booms during Dragon-2 reentry. These booms would resemble a thunderclap that would be short in duration (only a few seconds) and would occur infrequently (up to seven times a year). Therefore, Dragon landings would not result in a use of a Section 4(f) property.

4.7.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. As documented in the previous EAs and FAA FONSI, the No Action Alternative would not result in significant impacts to Section 4(f) properties.

4.8. Biological Resources

This section addresses impacts on biological resources from SpaceX's proposed activities, including Falcon 9 and Falcon Heavy launch and landing operations, and Dragon reentry and recovery. These types of impacts and impact mechanisms have been addressed in previous EAs (USAF 2017a, 2014, 2016, 2016a; NASA 2013) and are briefly summarized in this section, with a focus on the potential impacts from SpaceX's proposed increased launch frequencies at KSC and CCAFS. Biological resources impacts would be significant if the USFWS or NMFS determines that the action would be likely to jeopardize the continued existence of a federally listed threatened or endangered species, or would result in the destruction or adverse modification of federally designated critical habitat. The FAA has not established a significance threshold for non-listed species. Factors to consider for non-listed include whether the action would have the potential for:

- A long-term or permanent loss of unlisted plant or wildlife species, i.e., extirpation of the species from a large project area;
- Adverse impacts to special status species (e.g., state species of concern, species proposed for listing, migratory birds, bald and golden eagles) or their habitats;
- Substantial loss, reduction, degradation, disturbance, or fragmentation of native species' habitats or their populations; or

- Adverse impacts on a species' reproductive success rates, natural mortality rates, non-natural mortality (e.g., road kills and hunting), or ability to sustain the minimum population levels required for population maintenance.

4.8.1. Proposed Action

4.8.1.1. Terrestrial Habitats and Wildlife

The biological resources data and analyses from previous EAs for the Falcon 9 and other recent launch programs are applicable to the Proposed Action, and a significant impact on terrestrial vegetation and wildlife occurring in the study area would not be expected. The effects on local vegetation from 14 Delta, 20 Atlas, and 8 Titan launches from CCAFS have been mapped, and there was temporary near-field damage from fire and heat post-launch (Schmalzer 1998). Such impacts have also been experienced during past Falcon 9 launches. The proposed increase in Falcon 9 and Falcon Heavy launches would be expected to have similar consequences. The Falcon vehicles use the same liquid fuels (LOX and RP1) as the Delta, Atlas, and Titan rockets, so there is very little to no acid or particulate deposition anticipated that would permanently damage surrounding vegetation. Impacts to vegetation are anticipated to be minimal, and therefore, minimal for wildlife occupying the area.

Besides the changes in habitat structure from fire and heat in small areas adjacent to the launch pads, the other potential impact expected for wildlife would be from increased frequency of noise from launches, landings, and static fire tests. Wildlife in the study area would be exposed to noise generated by the engines during takeoff and landing events, as well as sonic booms generated during first stage boost-back and landing. The number of Falcon 9 and Falcon Heavy launches is predicted to increase from a current 24 launches per year to 70 launches per year by 2025 (Table 2-2). Monitoring scrub-jay behavior after Delta, Atlas, and Titan launches found no apparent impacts from noise, but these data were for a combined 42 launches over a time period of 2 ½ years (16 launches per year) (Schmalzer et al. 1998). Monitoring associated with the Space Shuttle program (135 launches over 30 years or 4.5 launches per year) found that there was an initial flight response from birds in the vicinity, but no long-term impacts were observed (NASA 2014). Nesting wood storks were documented flying off active nests, but would typically return within 4 minutes. No significant adverse effects to wildlife have been reported from recent SpaceX launch operations.

More annual launches increases the rate of disturbance as well as the chances that a noise-induced startle response at a critical time in the nesting cycle could occur. A startle response from nesting birds can result in broken eggs, or cause young flightless birds to jump out of a nest. Repeated nest failures can eventually trigger desertion of a nesting area. There are no mitigation measures currently available to reduce the chances of noise-induced startle responses. Although there would be an increased launch frequency under the Proposed Action, noise from launch events is not expected to result in a long-term or permanent loss of wildlife species or adverse impacts on species' reproductive success rates.

Construction of the MST at LC-39A would not affect wildlife habitat. All construction would occur on previously developed areas. Noise during construction would be temporary and not affect wildlife populations at KSC. In summary, the Proposed Action would not result in significant impacts on general wildlife species.

4.8.1.2. Marine Habitats and Wildlife

As described in previous NEPA analyses (USAF 2007, 2013, 2016a, 2016b) and ESA Section 7 consultations with NMFS (NMFS 2016, 2017, 2018a, 2018b), significant impacts on marine habitats and species from SpaceX's reentry and recovered operations are unlikely.

Potential impacts on marine habitats and wildlife from Falcon vehicle launches and Dragon splashdowns

relate to reentry sonic booms and the open ocean splashdowns of the Falcon booster or Dragon, associated fairings, parachute components, expendable radiosondes, and weather balloons. Impacts could include direct strikes to an animal, entanglement with parachute or parafoil lines and material, the ingestion of pieces of latex weather balloons and exposure to sonic boom. These potential impacts are fully described by NMFS as part of FAA's 2017 ESA Section 7 consultation (NMFS 2017) that addressed SpaceX's landing and recovery operations in the Atlantic and Pacific Oceans (and Gulf of Mexico). The same impact mechanisms and effects described and assessed as part of the 2017 NMFS consultation are applicable to non-protected species. The consultation concluded with NMFS concurring that SpaceX's landing and recovery operations would be unlikely to adversely affect federally listed threatened and endangered species. Based on the same reasoning, it is unlikely that non-protected marine wildlife would be adversely affected and that the effects from an increased number of landing and recovery operations would be negligible. The following paragraphs provide a summary of the potential impacts on marine wildlife from the NMFS 2017 consultation (see Appendix B).

Given the low frequency of the Dragon Capsule's reentry, splashdown and recovery operations and the fact that marine wildlife, marine mammals, and special status species spend the majority of their time submerged as opposed to on the surface, it is extremely unlikely they would be impacted (e.g., struck) by a Dragon splashdown. The capsule would remain on the surface throughout splashdown and recovery operations. Direct strikes by falling debris and the splashdown of the spacecraft are discounted as extremely unlikely for all species of concern, fish, sea turtles, and marine mammals. This is also due to the small size of the components as compared to the vast open ocean. The relative availability of these animals at the ocean surface, spatially and temporally, combined with the low frequency of the proposed action, reduce the likelihood of impacts to extremely low. Additionally, there are no known interactions with any of these species after decades of similar rocket launches.

Fairing recovery operations occur in the vast action area in deep open ocean waters, 300–500 nautical miles from shore. Fairing recovery operations could also include waters off the coast of the Bahamas, Cuba, Jamaica, and Haiti. SpaceX expects to recover both halves of the nose fairing and main portions of the parafoils. Unrecovered portions would sink rapidly. The drogue parachute begins to sink within one minute of splashdown and is estimated to have sunk to a depth of 1,000 feet within 46 minutes while the parafoil would sink to similar depths within one to two hours. These small fragments are not expected to resuspend to a level where they would be encountered by species, once resting on the ocean floor.

Marine mammals and sea turtles could potentially ingest unrecovered debris (e.g., parachute materials, radiosondes). However, for reasons explained above regarding sink rates and limited opportunities for such encounters by marine turtles and marine mammals, ingestion is deemed so low as to be discountable. Ingestion by various listed fish species were also considered during the 2017 consultation. Interaction with fairing halves, radiosondes, or parachutes was deemed very unlikely. Fish within the action area are expected to be in water depths beyond the ranges of effect for most actions resulting in highly unlikely interactions. Weather balloons which burst at altitude and shred were evaluated and should only be available for exposure to these protected species in the upper portion of the water column for a matter of weeks. Given the expected fate and size of the weather balloon shreds, accidental ingestion is not anticipated to occur.

Marine species entanglement with parachutes, parafoils and lines from the Falcon 9 fairing is unlikely due to rapid sink rates reducing time at the surface for any interaction. The Dragon main parachutes, which remain at the surface longer, are generally recovered by SpaceX. In the few cases main or drogue parachutes might not be recovered, they are not expected to remain at the surface for more than a few hours. In addition, the infrequency of the splashdowns and recovery actions renders the probability of interactions highly unlikely for turtles, seals/sea lions, and other marine mammals.

In the event of failure there could be a potential impact on marine species as the spacecraft and launch vehicle debris would fall into the ocean areas. Debris would include the liquid propellant, which is considered a negligible hazard because virtually all hazardous materials would be consumed in the destruct action, dispersed in the air, and only structural debris remains could strike the water. In a destruct action, the Dragon spacecraft or launch vehicle may survive to impact the water essentially intact, presenting some potential for habitat impact. Any unspent hypergolic propellants, which are toxic to marine organisms, would be of concern, however this potential is extremely low as described in USAF (2007, 2014, and NMFS 2017).

As described in Section 4.5, sonic booms created by launches and Dragon reentry near CCAFS/KSC intercept the ocean surface more than 40 miles offshore over the open Atlantic Ocean. Due to the low magnitude of the boom during reentry, and the substantial attenuation of a sonic boom at the air/water interface, coupled with exponential attenuation with water depth, the sonic boom would not result in impacts to marine species beneath the surface. The only impact expected may be a startle-type response as described in USAF (2000a) and NMFS (2017). Sonic booms are infrequent, and marine species in the ocean's surface waters are present in low densities. The spring and fall northern right whale migration would place periodic groups of whales along the Atlantic coastline but rarely more than 5 miles off shore. Even though the frequency of sonic booms would increase slightly based on the increased in launch-landing cycles between 2020 and 2025, the actual sonic boom event associated with landings would remain relatively infrequent and are not expected to negatively affect the survival of any marine species (USAF 2014, NMFS 2017).

4.8.1.3. Protected Species and Habitat

4.8.1.3.1. Terrestrial Species

Based on the previous EAs, no mortality would be expected from future Falcon launches of any of the protected wildlife species potentially occurring in the study area. These previous analyses also concluded that overall impacts to these species are expected to be minimal (USAF 2007, 2013, and NASA 2013). No anomalies were observed in the behavior of scrub-jays after Delta, Atlas, or Titan launches, implying no noise-related effects (Schmalzer 1998). However, these data were gathered for fewer launches than are anticipated to occur in the future, and also did not take into account additional noise from static fire tests or sonic booms. Repeated startle responses from sudden noises during the bird nesting season could potentially cause reduced reproductive success. No mitigation measures are available to reduce this potential. Monitoring via remote cameras of select species such as Florida scrub-jays and bald eagles during the nesting season could help determine if a problem exists and quantify the severity.

No observable, measurable rocket impacts occurred for southeastern beach mice at KSC during studies of this species during the space shuttle program.

Regarding nesting and hatchling sea turtles, USFWS Biological Opinions have been in place for many years at CCAFS and KSC to ensure proper measures are taken to protect this light sensitive species from exterior operational lights. Light operations manuals have been in place for all launch pads and are updated with as new information becomes available for best practices. Proper lighting controls are expected to manage this issue, but it is evaluated by NASA, USAF, and USFWS on a regular basis with nest monitoring and lighting compliance surveys.

The FAA is currently conducting ESA section 7 consultation with the USFWS to address potential effects to ESA-listed species (see Appendix B). The results of this consultation will be presented in the Final EA.

4.8.1.3.2. Marine Species

As determined in earlier environmental assessments of the Falcon 9 and similar programs (USAF 2007,

2013, 2014, 2017; NASA 2013), no adverse impacts are expected for protected marine species or critical habitats under the proposed action. The FAA consulted NMFS under ESA Section 7(a)(2) for SpaceX landing and recovery operations. The consultations resulted in letters of concurrence (NMFS 2017, 2018a, 2018b; Appendix B). NMFS reviewed all of the information between June and September of 2017 and concurred with the FAA's determination that the SpaceX landing and recovery operations in the Atlantic and Pacific Oceans (and Gulf of Mexico) are not likely to adversely affect threatened or endangered species or adversely modify designated critical habitat. The FAA reinitiated consultation with NMFS for SpaceX landing and recovery operations after the giant manta ray and oceanic whitetip shark were listed as threatened under ESA. The NMFS concurred with FAA's determinations that SpaceX's landing and recovering operations would not likely adversely affect these two species (NMFS 2018a, 2018b; see Appendix B).

The FAA reinitiated consultation again with NMFS during preparation of this EA to account for the expanded action area associated with polar missions (see Appendix B for correspondence). A detailed description of impacts to federally listed species can be found in Appendix B. The results of the consultation with NMFS will be presented in the Final EA.

4.8.1.3.3. Critical Habitat

The study area does not contain terrestrial critical habitat. NMFS's previous evaluation of SpaceX's launch and recovery operations (NMFS 2016, 2017, 2018a, 2018b) resulted in the conclusion that all potential effects of open-water landings to listed species and critical habitat are discountable, insignificant, or beneficial, and concurred with FAA, USAF, and NASA's determination that the Proposed Action is not likely to adversely affect critical habitat. The FAA has determined that polar launches (including landings) would have no effect on critical habitat.

4.8.2. Summary

Given that 1) the FAA expects the USFWS and NMFS will determine the Proposed Action would not jeopardize the continued existence of a federally listed threatened or endangered species, and would not result in the destruction or adverse modification of federally designated critical habitat, and 2) none of the factors to consider for non-listed species would result, the Proposed Action is not expected to result in significant impacts on biological resources. The Final EA will document the conclusion of the ESA consultations with the USFWS and NMFS.

4.8.3. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. Under the No Action Alternative, SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS at a launch rate as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. The No Action Alternative would not jeopardize the continued existence of a federally listed threatened or endangered species or result in the destruction or adverse modification of federally designated critical habitat, and therefore would not result in significant impacts on biological resources.

4.9. Coastal Resources

The FAA has not established a significance threshold for coastal resources. However, the FAA has identified factors to consider when evaluating the context and intensity of potential environmental impacts on coastal resources. Factors to consider include whether the action would have the potential to:

- Be inconsistent with the relevant state coastal zone management plan(s);

- Impact a coastal barrier resources system unit (and the degree to which the resource would be impacted);
- Pose an impact to coral reef ecosystems (and the degree to which the ecosystem would be affected);
- Cause an unacceptable risk to human safety or property; or
- Cause adverse impacts to the coastal environment that cannot be satisfactorily mitigated.

4.9.1. Proposed Action

Operations and launch and landing activities for the Falcon vehicles at LC-39A, LC-40, LZ-1, and LZ-2 would take place in the coastal zone, which is the entire State of Florida, similar to other vehicle launches. Falcon first stage landings on the drone ship would be no closer than approximately 10 nautical miles from shore, but could be located several hundred miles offshore in the Atlantic Ocean. Payload fairing landing and recovery would take place no closer than 5 nautical miles offshore.

Dragon landing operations and recovery activities would occur in deeper waters at least 5 nautical miles off the Atlantic or the Pacific coasts. The recovery vessel would remain in deep waters during the transport of the recovered Dragon to Port Canaveral, a CCAFS-based wharf facility, or a commercially available wharf on the Pacific Coast.

Landing and recovery operations would not take place in intertidal areas, salt marshes, estuaries, and coral reefs. Dragon is designed to conduct precision landings. National Marine Sanctuaries and NWRs in the Gulf of Mexico and the Pacific Ocean would be avoided. Any coral reefs occurring in the study area would be avoided during planning of the landing location for each Dragon mission and operations.

Aside from the construction of the MST at LC-39A (an existing launch facility), the Proposed Action does not include any coastal construction or seafloor disturbing activities and would be consistent with commonly occurring Atlantic and Pacific Ocean maritime operations. Spacecraft processing for the Falcon 9 and its payloads would be the same as currently performed. No impacts are expected from Falcon payload processing operations. All materials and procedures would remain essentially the same.

The Florida State Clearinghouse previously determined that SpaceX's Falcon launch operations in Florida are consistent with the state's coastal management program (NASA 2013, USAF 2013). To facilitate SpaceX's compliance with the state's coastal management program for the proposed increase in annual operations, the FAA has submitted this Draft EA to the Florida State Clearinghouse for review. The Final EA will include any comments received from the Clearinghouse review. No significant coastal resource impacts are expected.

4.9.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. Under the No Action Alternative, SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS at a launch rate as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. The No Action Alternative would be consistent with Florida's and California's coastal management programs and would not result in significant impacts on coastal resources.

4.10. Water Resources

This section addresses impacts to surface water and groundwater resources. Determination of water resource impacts is based on an analysis of the potential for activities to affect surface water or groundwater quality as defined by applicable laws and regulations. Considered in this analysis is activity-

related introduction of contaminants into surface water or groundwater resources. The Proposed Action does not involve physical alterations or disturbances of overland surface water flows and groundwater recharge. Potential impacts to water quality could occur; however, most of these potential impacts would be avoided and minimized through Clean Water Act compliance (e.g., NPDES permits). A significant impact to surface waters would occur if the action exceeded water quality standards established by federal, state, local, and tribal regulatory agencies; or contaminated the public drinking water supply such that public health may be adversely affected. A significant impact to groundwater would occur if the action would exceed groundwater quality standards established by federal, state, local, and tribal regulatory agencies; or contaminate an aquifer used for public water supply such that public health may be adversely affected.

4.10.1. Proposed Action

4.10.1.1. Falcon 9 and Falcon Heavy Launch Operations

Falcon 9 and Falcon Heavy launch operations include launches, landings, and associated activities. These impacts have been addressed in previous EAs and are briefly summarized here.

There is potential for an inadvertent discharge of industrial wastewater (deluge water) into nearby jurisdictional waters of the United States in the event of an overflow of the deluge water system at LC-40. It is highly unlikely that the maximum discharge of deluge water would occur with a deluge basin capacity of 160,000 gallons. The USAF 2013 EA found launching of the Falcon 9 would not be expected to significantly impact water resources. Since the 2013 EA, SpaceX has improved the industrial wastewater and now recycles approximately 75,000 gallons back into the system after launch. Any remaining water is collected in a wastewater pond.

Operations at LC-39A would have minimal impacts on the surface water quality. Surface waters at the launch complex would drain to existing swales within the pad perimeter. Stormwater runoff generated from the launch pad drains to various manmade grassed swales that radiate from the pad. The grassed swales discharge via culverts to a swale that runs parallel to the perimeter access road. The perimeter access road swale discharges to receiving waters on the periphery of the site. Launch deluge and pad washdown water at LC-39A flows down two concrete flumes into east and west treatment tanks. These tanks have a net lined holding capacity of 704,146 gallons. No chemicals are used for treatment of the wastewater. It is allowed to settle and attenuate pH over time in the containment tanks before being land applied to a 2.2-acre bermed disposal area operated as a spray field, as authorized by Florida Department of Environmental Protection.

The launch exhaust cloud formed from the exhaust plume and evaporation and subsequent condensation of deluge water could affect surface water drainage from the launch complexes. The exhaust cloud would consist largely of steam with insignificant amounts of hazardous materials from LOX and RP-1 propellants. The temporary and minimal volume of water condensing from the exhaust cloud would not result in significant impacts to surface water quality.

Potential impact to surface waters of the Indian River Lagoon or the Atlantic Ocean of a failed landing from spilled fuel, if not consumed by combustion or contained inside the tank, would be relatively minor. Residual RP-1, approximately 400 gallons, would be expelled into the ocean upon impact and dissipate within hours.

Construction of the MST at LC-29A would not impact the existing stormwater infrastructure. The construction would occur on previously developed and existing concrete surfaces.

In summary, less than significant impacts on surface waters are expected during Falcon launch operations or from payload processing. All materials and procedures would remain essentially the same

as those analyzed in previous EAs. Even with an increased number of launches, implementing procedures already in place and adhering to NPDES permit conditions would avoid and minimize water quality impacts.

4.10.1.2. Dragon Reentry and Recovery

Several aspects of the Proposed Action are potential sources of water quality pollutants. Dragon landing operations along with recovery vessel and RHIB activities are evaluated for the possible release of contaminants and hazardous constituents into ocean waters. A full discussion of hazardous materials, solid waste, and pollution prevention is presented in Sections 3.11 and 4.11. Dragon propellant storage is designed to retain residual propellant, so any propellant remaining in the capsule is not expected to be released into ocean waters. The capsule has multiple system redundancies in place in the event it is damaged upon reentry and/or splashdown that help to prevent unanticipated releases. If any propellant were to be released, it would rapidly disperse and does not represent a source of substantial environmental degradation to water quality.

Recovery vessel and RHIB operations have the potential to release small amounts of oil and gas into the water. However, vessel operations would be conducted in accordance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), which prohibits certain discharges of oil, garbage, and other substances from vessels. The Proposed Action is therefore not expected to have a significant impact on ocean water resources in the Atlantic or Pacific.

4.10.1.3. Dragon Engine Testing and Payload Processing

Wastewater from Dragon and routine payload processing would be processed through existing wastewater handling and treatment systems at CCAFS. The Proposed Action falls within the scope of existing water discharge permit definitions. There would be a negligible impact on surface water or groundwater.

4.10.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. As documented in the previous EAs and FAA FONSIs, the No Action Alternative would not result in significant impacts on water resources.

4.11. Hazardous Materials, Solid Waste, and Pollution Prevention

The FAA has not established a significance threshold for Hazardous Materials, Solid Waste, and Pollution Prevention; however, the FAA has identified factors to consider in evaluating the context and intensity of potential environmental impacts. Factors to consider that may be applicable to hazardous materials, solid waste, and pollution prevention include, but are not limited to, situations in which the action would have the potential to:

- Violate applicable federal, state, tribal, or local laws or regulations regarding hazardous materials and/or solid waste management;
- Involve a contaminated site (including, but not limited to, a site listed on the National Priorities List). Contaminated sites may encompass relatively large areas. However, not all of the grounds within the boundaries of a contaminated site are contaminated, which leaves space for siting a facility on non-contaminated land within the boundaries of a contaminated site. An EIS is not necessarily required. Paragraph 6-2.3.a of FAA Order 1050.1F allows for mitigating impacts below significant levels (e.g., modifying an action to site it on non-contaminated grounds within

a contaminated site). Therefore, if appropriately mitigated, actions within the boundaries of a contaminated site would not have significant impacts;

- Produce an appreciably different quantity or type of hazardous waste;
- Generate an appreciably different quantity or type of solid waste or use a different method of collection or disposal and/or would exceed local capacity; or
- Adversely affect human health and the environment

4.11.1. Proposed Action

4.11.1.1. Falcon 9 and Falcon Heavy Launches

Since all applicable federal, state, county, NASA, and USAF rules and regulations would continue to be followed for the proper storage, handling, and usage of hazardous materials under the continued Falcon Launch Vehicle Program, less than significant impacts on hazardous materials management are expected under the Proposed Action. There would be no changes for fuel handling procedures. The only changes would entail loading additional, more dense RP-1 into the Falcon launch vehicles and more propellant deliveries to the launch facilities throughout the year.

The processing of launch vehicles at LC-39A and LC-40 requires the use of hazardous materials and results in the production of hazardous wastes. Impacts due to use of large quantities of hazardous materials and creation of large quantities of hazardous waste would be measurable but would be reduced through appropriate management and conservation measures. All hazardous materials would continue to be handled and disposed of per the requirements established by OSHA (Hazardous Materials) and per the Hazardous Materials Contingency Plan developed for the Falcon Launch Vehicle Program. SpaceX has implemented proper handling procedures for payloads containing hypergolic fuels. During Falcon program launch operations, hazardous and solid waste would be handled and disposed of in a manner consistent with the guidelines established by NASA as outlined in Kennedy NASA Procedural Requirement 8500.1 and USAF rules and regulations. There would also be contingency plans for responding to and minimizing the effects of spills. All hazardous material releases to air, water, soil, and pavement at KSC must be reported per the requirements in KDP-KSC-P-3008 and CCAFS. With the proper procedures and safeguards in place, it is not expected that soil or groundwater contamination would be caused by operational activities at the Proposed Action sites.

While the amount of waste per launch would remain approximately the same, due to increased frequency of launches, there would be a corresponding increase in hazardous material being used (refer to Table 2-2 for planned launch frequency). SpaceX would comply with all applicable rules and regulations for each launch, thereby minimizing the potential for impacts related to hazardous materials.

All hazardous materials would continue to be handled and disposed of per the requirements established by OSHA (Hazardous Materials), RCRA and per the Hazardous Materials Contingency Plan developed for the Falcon 9 and Heavy Launch Vehicle Program. Approximately 2,800 pounds or less of RP-1 fuel may remain on-board each returning first stage vehicle. After removing the legs, the vehicles would be transported shortly after landing to another SpaceX facility for processing activities including maintenance and cleaning. Since all applicable federal, state, county, and USAF rules and regulations would continue to be followed for the proper storage, handling, and usage of hazardous materials under the Falcon Launch Vehicle Program, less than significant impacts for hazardous materials management are expected from Falcon landing operations.

4.11.1.2. Dragon Engine Testing and Payload Processing

The approximate quantities of materials that would be used during processing of a routine payload spacecraft would remain the same as past and current operations. Facilities at LC- 40 and LC-39A have been permitted to process hypergolic propellants and would continue operating under those permit requirements for any hypergolic propellants and waste products. Payload processing would increase between years 2020 and 2025, similar to the rate discussed above for launches. SpaceX would implement processes to reduce the incremental use of these materials per launch so that overall increase would be moderate.

The hazardous materials used to process routine payload spacecraft could potentially generate hazardous waste. SpaceX would continue operating in accordance with existing requirements. No Class I ODSs would be used in the payload processing facilities.

Operation of the proposed Dragon processing buildings at Area 59 would be managed in the same fashion as other processing facilities at CCAFS. Fuel volumes and subsequent safety arcs would be approved by USAF safety prior to operations beginning. SpaceX has implemented proper handling procedures for payloads containing hypergolic fuels at LC-40. Since all applicable federal, state, and local regulations would continue to be followed for the proper storage, handling, and usage of hazardous materials under its Falcon Launch Vehicle Program, no significant impacts due to hazardous materials management are expected.

Dragon engine testing and payload processing is expected to generate much less solid waste than a launch of a Falcon 9 vehicle. Examples of solid waste may include cardboard packaging, wood, rag material, plastic and aluminum bottles and cans. The Proposed Action at the Area 59 processing facility would therefore not have a significant impact on CCAFS's solid waste management.

4.11.1.3. First-Stage Booster and Dragon Reentry and Recovery

The recovered first-stage boosters that would be brought by barge to the Port and wharf areas could contain small amounts of RP-1, hydraulic fluid, and some explosives. Dragon could contain up to 20 percent of the maximum propellant load (approximately 300 pounds) of MMH propellant when recovered. MMH is a strong irritant which may damage eyes and cause respiratory tract damage. Repeated exposure to lower concentrations may cause toxic damage to liver and kidneys as well as anemia. In addition, the EPA classifies MMH as a probable human carcinogen. MMH is also flammable and could spontaneously ignite when exposed to an oxidizer.

Operation and maintenance of vessels, vehicles and equipment used for booster and Dragon recovery operations would generate small quantities of hazardous wastes. These wastes would include, at a minimum, empty containers, spent solvents, waste oil, spill cleanup materials (if used), unused explosives, and lead-acid batteries.

Hazardous Materials and Wastes

As described in the 2007 EA (USAF 2007), SpaceX would be responsible for identifying, containing, labeling, and accumulating the hazardous wastes in accordance with all applicable federal, state, and local regulations. It is not anticipated that Proposed Action would increase hazardous waste production. Operations supporting the Dragon recovery operations could use a small amount of products containing hazardous materials, including POLS, paints, solvents, oils, lubricants, acids, batteries, and chemicals. In particular, the Dragon may contain approximately 20 percent of the maximum propellant load upon splashdown, including MMH. If human error (e.g., not following procedures, not wearing protective clothing, or not donning breathing equipment) occurs during capsule recovery, exposure of personnel to toxic propellant vapors may result. This would give some level of short-term adverse health impact and

an incremental increase in the chance of the exposed individual developing cancer. However, continued implementation of existing handling and management procedures for hazardous materials and hazardous wastes would limit the potential for impacts.

Management of hazardous materials is the responsibility of each individual or organization and is regulated under RCRA (40 CFR 260-280) and Rule 62-730. Hazardous materials and wastes would be handled in accordance with applicable federal, state, and local environmental and public and occupational health and safety regulations. Safeguards, including multiple system redundancies in case of damage upon reentry, are in place to minimize the release of toxic chemicals in the environment, and rapid emergency response plans would ensure that accidental spills would be cleaned up quickly. No significant impacts from hazardous materials or hazardous waste management are expected from the Proposed Action.

Solid Waste

Solid wastes would be placed in covered receptacles until disposed of off-site to minimize accidental entry into marine waters or contact with stormwater and prevent offsite deposition from wind. Solid wastes would be salvaged or recycled to the maximum extent practicable and the remaining solid waste disposed of in appropriately permitted landfills. With the implementation of appropriate handling and management procedures, solid wastes generated as a result of recovery operations would have no significant impacts to the environment.

Pollution Prevention

Hazardous materials, substances and wastes used and generated as part of recovery operations would be collected, stored, and disposed of using practices that minimize the potential for accidental releases or contact with storm or marine water and in accordance with applicable spill prevention plans, RCRA and OSHA regulations. All accidental releases of polluting substance would be responded to quickly and appropriate clean up measures would be implemented in accordance with applicable laws to minimize impacts to the environment. The Dragon has been designed to perform pinpoint landings to avoid collisions with existing structures in the Gulf of Mexico and to avoid release of hazardous materials and pollutants. To avoid collision with marine vessels, to further ensure public and environmental safety, a NOTMAR would be issued 3-6 days prior to reentry, splashdown and recovery efforts. As a result, recovery operations would have no significant impacts to the environment with regards to pollution.

4.11.1.4. MST Construction

MST construction activities would use small quantities of hazardous materials, which would result in generation of small volumes of hazardous wastes. Hazardous materials that are expected to be used are common to construction activities and include diesel fuel and gasoline to power the construction equipment, hydraulic fluids, oils and lubricants, welding gases, paints, solvents, adhesives, and batteries. Appropriate hazardous material management techniques would be followed to minimize their use and waste disposal. The construction contractors would make all reasonable and safe efforts to contain and control any spills or releases that may occur. All hazardous material releases to air, water, soil, and pavement at KSC must be reported per the requirements in KDP-KSC-P-3008, Hazardous Materials Emergency Response. Compliance with hazardous material and waste management regulations and adherence to guidelines established by NASA as outlined in Kennedy NASA Procedural Requirement 8500.1 would avoid or minimize impacts from construction activities.

4.11.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and

Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. SpaceX's Falcon launch vehicle program requires the use of hazardous materials and the generation of solid waste. As documented in the previous EAs and FAA FONSI, the No Action Alternative would not result in significant impacts related to hazardous materials, solid waste, and pollution prevention.

4.12. Natural Resources and Energy Supply

The FAA has not established a significance threshold for natural resources and energy supply. However, the FAA has identified a factor to consider when evaluating the context and intensity of potential environmental impacts on natural resources and energy supply. Aspects to consider include situations in which the action would have the potential to cause demand to exceed available or future supplies of these resources.

4.12.1. Proposed Action

The demands of the Proposed Action on infrastructure at KSC and CCAFS has been analyzed in previous NEPA documents (NASA 2013; USAF 2013, 2017a) and are summarized here.

The current potable and non-potable water supply to LC-40 was designed to support the Titan IV launch vehicle program and can handle Falcon vehicle launch requirements. Since only one vehicle will be in preparation for launch on each pad at any given time, Falcon program reliance on the water supply would be relatively small with no significant impact expected.

Electrical power capabilities at LC-40 were also designed to support the Titan IV launch program. The Falcon launch program electrical power needs are less than that of the Titan program and would not be a significant impact on availability of electrical power. Similarly, impacts to electricity, natural gas, and communications infrastructure at KSC would be minimal. These utilities and services are currently available in the vicinity of Proposed Action sites and minimal additional demands on these services would be readily absorbed.

Ground support and construction activities are anticipated to have minimal impacts on current potable water resources and electricity on KSC. These utilities are currently available at LC-39A and are expected to be able to absorb the additional demands of Falcon launch operations. Therefore, the proposed action would not have significant impacts on water supply or electrical power capabilities.

Recovery operations would require the use of fuel for the recovery vessel, RHIB and helicopter. Reentry operations would require the use of hypergolic fuels for deorbit. The demand for both types of fuel would be met without difficulty. The Proposed Action is not expected to significantly increase demand or use of natural resources and energy supply and therefore would not result in significant impacts.

4.12.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. There would be no new effects on natural resources and energy supply as a result of the No Action Alternative.

4.13. Socioeconomics

The FAA has not established significance thresholds for socioeconomics. However, the FAA has identified factors to consider when evaluating impacts. For socioeconomics, the factors to consider are whether the Proposed Action would have the potential to:

- Induce substantial economic growth in an area, either directly or indirectly (e.g., through establishing projects in an undeveloped area);
- Disrupt or divide the physical arrangement of an established community;
- Cause extensive relocation when sufficient replacement housing is unavailable;
- Cause extensive relocation of community businesses that would cause severe economic hardship for affected communities;
- Disrupt local traffic patterns and substantially reduce the levels of service of roads serving an airport and its surrounding communities; or
- Produce a substantial change in the community tax base.

4.13.1. Proposed Action

The Proposed Action involves additional operations related to launch and landing and does not involve substantial construction or development. Launch operations have moderate economic benefits, including increased demand in the workforce, higher revenues, and increased per capita income. While the population under the poverty threshold may not directly benefit through employment and income, it may indirectly benefit as regional economic health is improved through the proposed increase in commercial space exploration activity.

The Proposed Action does not involve onshore activities that could adversely affect economic activity and income, employment, population and housing, and public services and social conditions. Up to ten Dragon recoveries per year would occur at Port Canaveral, or a CCAFS-based wharf facility (such as Poseidon Wharf), and four recoveries at Port of Los Angeles. Issuing a notice to mariners for the short term avoidance of the splashdown and recovery area for ten splashdown and 27 landing operations per year.

SpaceX would continue to use its existing workforce for launch, landing, and recovery activities. The Proposed Action would not significantly affect the local housing market and would not negatively affect the local economy.

In summary, the Proposed Action would not result in significant socioeconomic impacts on the region.

4.13.2. No Action Alternative

Under the No Action Alternative, the FAA would not modify existing SpaceX licenses or issue new licenses to SpaceX for launch operations discussed in Section 2.1. Under the No Action Alternative, SpaceX would continue Falcon 9 and Falcon Heavy launch operations at KSC and CCAFS at a launch rate as analyzed in previous NEPA and environmental reviews and in accordance with FAA licenses. The No Action Alternative would not result in significant impacts to Socioeconomics.

5. CUMULATIVE IMPACTS

CEQ NEPA-implementing regulations define a cumulative impact as the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR § 1508.7). According to CEQ (1997b), “each resource, ecosystem and human community must be analyzed in terms of its ability to accommodate additional effects, based on its own time and space parameters.” Therefore, a cumulative impacts analysis normally will encompass geographic boundaries beyond the immediate area of the Proposed Action, and include past, present, and reasonably foreseeable future actions, in order to capture these additional impacts.

5.1. Projects Considered for Potential Cumulative Effects

Future development and activities that may occur at or near the launch and landing sites were researched and considered. Projects planned at CCAFS, Port Canaveral, and KSC, including Exploration Park and the Visitor Complex, are discussed in the following paragraphs. Many of these actions involve federal agency agreements or funding and have already had NEPA documents prepared or would be required to go through NEPA coordination and documentation. Because Dragon recovery on the west coast would have minor impacts, such that when combined with other past, present, or reasonably foreseeable future actions at the Port of Los Angeles would not meaningfully contribute to cumulative impacts, this aspect of the Proposed Action is not discussed in this chapter.

The future land use plan for KSC promotes the most efficient use of land area resources balanced with an understanding of development suitability and capacity. KSC’s transition to a multi-user spaceport advocates compatible relationships between adjacent land uses, encourages infill development, and preserves environmentally sensitive areas (NASA 2017). Current actions at KSC include Exploration Ground Systems (EGS) leading the center's transformation from a historically government-only launch complex to a spaceport with activity involving government and commercial vehicles alike. The program's primary objective is to prepare the center to process and launch the next-generation vehicles and spacecraft designed to achieve NASA's goals for space exploration.

LC-39B is under the process of redevelopment for the Space Launch System (SLS) rocket and Orion spacecraft. The pad was returned to a clean design after removal of the Fixed Service Structure. This will allow multiple types of vehicles to launch from LC-39B arriving at the pad with service structures on the mobile launch platform rather than custom structures on the pad. NASA has announced LC-39B would be available to commercial users during times when it is not needed by SLS. Northrop Grumman plans to integrate the Omega rocket at NASA’s Vertical Assembly Building and launch from LC-39B (Northrop Grumman 2019).

KSC’s newest launch pad, designated 39C, is designed to accommodate Small Class Vehicles. Located in the southeast area of the LC-39B perimeter, this new concrete pad measures about 50 feet wide by about 100 feet long. Launch Pad 39C will serve as a multi-purpose site allowing companies to test vehicles and capabilities in the smaller class of rockets, making it more affordable for smaller companies to break into the commercial spaceflight market. As part of this capability, NASA’s Ground Systems Development and Operations Program developed a universal propellant servicing system, which can provide liquid oxygen and liquid methane fueling capabilities for a variety of small class rockets.

With the addition of Launch Pad 39C, KSC can offer the following processing and launching features for

companies working with small class vehicles (maximum thrust up to 200,000 pounds):

- Processing facilities – i.e. Vehicle Assembly Building
- Vehicle/payload transportation (KAMAG, flatbed trucks, tugs, etc.) from integration facility to pad
- Launch site
- Universal propellant servicing system (LOX, liquid methane)
- Launch control center/mobile command center options

KSC is in the process of constructing LC-48 as a multi-use launch complex for Small Class Launch vehicles. This launch complex would be located approximately 6,500 feet southeast of LC-39A and 5,220 feet north of LC-41. Development could also include construction of a Horizontal Integration Facility, Manufacturing and Refurbishment Facility, and Vertical Landing Facility near the launch complex, on other undeveloped areas at KSC, in an area sited for industrial use, on CCAFS, or elsewhere off Center property.

Increased flight operations at the SLF would involve construction of new facilities and increased flight operations at the SLF in the following broad categories: commercial spaceflight program and mission support aviation, aviation test operations including unmanned aerial vehicles, airborne research and technology development and demonstration, parabolic flight missions, testing and evaluation of experimental spacecraft, ground based research and training, and development and demonstration of future supersonic passenger flight vehicles. To take full advantage of the capabilities of the SLF, new construction would occur at both the south-field and mid-field sites.

Virgin Galactic's space tourism spinoff company, Virgin Orbit, has developed LauncherOne to serve the small-satellite industry. LauncherOne is a two-stage, expendable, LOX/RP-1 rocket that launches from a dedicated 747-400 carrier aircraft named Cosmic Girl. It may operate from multiple locations including KSC. LauncherOne will be capable of placing a 661-pound payload into a sun-synchronous orbit and a 992-pound payload into an equatorial orbit. LauncherOne will be able to launch polar and sun-synchronous missions from approximately 50 miles off the west coast of Los Angeles, California, and a similar distance off the east coast of Cape Canaveral, Florida, for equatorial missions (Virgin Orbit 2017).

SpaceX is proposing to expand operations to include launch of the Starship/Super Heavy (in development) from LC-39A. The fully reusable rocket system is being developed by SpaceX to take humans and cargo to Earth orbit and beyond, including to the Moon and Mars. The launch vehicle is comprised of two stages using LOX and liquid methane (LCH₄) as propellant. SpaceX intends to eventually launch the Starship/Super Heavy approximately 24 times per year. The Starship/Super Heavy would include Lunar and Mars missions, satellite payload missions, and human spaceflight. NASA issued a FONSI based on the EA in September 2019.

The CCAFS/PAFB Installation Development Plan aligns the future vision for CCAFS and PAFB with the priority of achieving short- and long-term sustainability of the installation. The 45th Space Wing Mission Statement is "One team...delivering assured space launch, range, and combat capabilities for the Nation" with a vision of becoming the "World's Premier Gateway to Space" (USAF 2017b). Future development would be guided by sustainability, and increases in launch tempo and associated support activities would occur sustainably and compatibly with the efficient use of land and energy, the conservation of natural resources and the safe operation of launch vehicles and processing facilities. New facilities and launch complexes would be developed as to minimize any potential impact or compatibility with current facilities and the environment.

Blue Origin is in the process of constructing an Orbital Launch Site at LC-11 and LC-36 on CCAFS. The facility would support testing of rocket engines, integration of launch vehicles, and launches of liquid fueled, heavy-lift class orbital vehicles.

Space Florida holds an FAA Launch Site Operator License for LC-46. This allows Space Florida to offer the site for launches of solid and liquid propellant launch vehicles to launch operators for several types of vertical launch vehicles. The proposed launch vehicles and their payloads would be launched into low earth orbit or geostationary orbit. All vehicles are expected to carry payloads, including satellites (FAA 2008). Orbital ATK plans to launch the Minotaur IV rocket from LC-46.

The short-term forecast for CCAFS and KSC includes launches from LC-37B, LC-39A, LC-40, LC-41, and LC-46. LC-37 is used to launch communications and global positioning system (GPS) satellites aboard the Delta IV launch vehicle. A Delta IV Medium launched a communications satellite in March of 2017. Launches from LC-39A to date include launches of the SpaceX Falcon 9 for ISS resupply missions, a U.S. Government National Reconnaissance Office (NRO) intelligence satellite, and various communications satellites. The maiden launch of the Falcon Heavy occurred on February 6, 2018. On September 7, 2017 the USAF X-37B mission was launched on a Falcon 9 from LC-39A.

LC-41 is currently used by United Launch Alliance for Atlas V launches. A USAF payload was launched from LC-41 in January 2017. An Orbital ATK unmanned resupply Cygnus spacecraft was flown from LC-41 to the ISS in April 2017. Additional launches in 2017 included communications satellites, a National Reconnaissance Office intelligence satellite, and an early warning missile detection system.

USAF is currently preparing an EA to assess the environmental impacts of a Real Property transfer, via license, of 214 acres of land, to include LC-20 at CCAFS and all facilities contained thereon, to Space Florida. Space Florida would develop and sublicense the 214 acres to meet current and future commercial, national, and state space transportation requirements through the expansion and modernization of space transportation facilities within Space Florida's Cape Canaveral Spaceport territories to include areas within CCAFS. A draft or final EA has not been published.

USAF is also planning to prepare an EA to assess the environmental impacts of a Real Property transfer of LC-16 to Relativity for launch operations. Relativity would conduct demolition activities and construct new facilities at LC-16 to support its launch operations. A draft or final EA has not been published.

United Launch Alliance is developing the Vulcan Centaur launch vehicle to provide a more versatile and cost competitive space launch vehicle while maximizing the use of existing space launch infrastructure. The Vulcan Centaur will contain a larger diameter booster tank than the Atlas V, use new BE-4 booster engines that consume liquid oxygen and liquid natural gas for the first stage, multiple solid rocket motor configurations. United Launch Alliance plans to launch the Vulcan Centaur vehicle from LC-41. Vulcan Centaur Program modifications will occur at LC-41, the Vertical Integration Facility and the Solid Motor Assembly and Readiness Facility.

A Minotaur IV rocket was launched from LC-46 in August 2017. This was the first launch of an Orbital ATK Minotaur rocket from CCAFS. The mission launched a surveillance satellite for the USAF.

The Canaveral Harbor or Port Canaveral is a man-made, deepwater port located on the barrier island north of the City of Cape Canaveral. Cruise ship activity continues to increase with additional homeport ships including some of the largest in the world. Port Canaveral is currently the world's second busiest cruise port for multi-day embarkation. With more travelers taking to the water and new cruise ships continuing to be built, the Port's cruise industry is set to expand even further. Recent developments include the new Cruise Terminal One, and multi-million dollar renovations to Cruise Terminals Five,

Eight, and Ten. Carnival, Disney, Royal Caribbean, and Norwegian Cruise lines all sail out of Port Canaveral.

Port Canaveral continues to develop facilities and capacity to become a premier cargo port. The first quarter of 2017 saw significant increases in vehicle, slag, salt and petroleum imports. New cargo services in 2016 include Blue Stream, a weekly container service connecting Central Florida with Europe, Central America and the Caribbean. In 2016 an auto processing company AutoPort opened a 14.7-acre terminal for new vehicles arriving at the docks.

5.2. Cumulative Impact Analysis

In accordance with FAA Order 1050.1F and the CEQ NEPA-implementing regulations, the FAA analyzed the potential cumulative impacts on those impact categories discussed in Chapter 4. Cumulative impacts result from the incremental effect of an action when added to other past, present, and reasonable foreseeable future actions, regardless of the proponent undertaking these actions. Minimal or negligible impacts from individual projects may, over a period of time, become collectively significant. Past, current, and future launch vehicle processing operations at KSC and CCAFS, along with present and future actions occurring on a regional basis, must be considered when evaluating cumulative impacts.

Under the No Action Alternative, there would be no change in baseline conditions for the resources evaluated in this EA. No new cumulative impacts are expected.

5.2.1. Land Use

The Proposed Action would not result in land use impacts. The Proposed Action would not change the existing use of the launch facilities. The Proposed Action would not change the fire management program activities in the area surrounding LC-39A and LC-40. Therefore, the Proposed Action, when combined with other past, present, and reasonably foreseeable future actions, would not result in cumulative impacts on land use.

5.2.2. Visual Effects (including Light Emissions)

Under the Proposed Action, rockets would be visible in the sky more often and there could be greater instances of nighttime lighting. All operations at KSC and CCAFS must comply with Light Management Plans to minimize the amount of sky glow and avoid or minimize effects to nesting sea turtles. All future projects at KSC and CCAFS will have to comply with this lighting requirement. Therefore, the Proposed Action, when combined with other past, present, and reasonably foreseeable future actions, is not expected to result in significant cumulative visual effects.

5.2.3. Air Quality

KSC, CCAFS, and Brevard County are in an “attainment” area and the operational emissions for the Proposed Action represent an extremely small percentage of the Brevard County regional emissions and would not cause an exceedance of any NAAQS. The past, present, and reasonably foreseeable future actions with the potential to affect air quality are presented in the previous section. As discussed in Chapter 4, the Proposed Action would result in temporary air emissions during a launch operation. It should be noted that each launch operation would separately, avoiding simultaneously combining impacts associated with exhaust plumes from more than one vehicle at a time.

Air emissions from other projects summarized above would be localized and short term in nature except for launch operations at KSC and CCAFS, and shipping activity at Port Canaveral which are anticipated to continue. Long-term emissions from the projects are not expected to increase. Air emissions from the Proposed Action when combined with other past, present, or reasonably foreseeable future actions would not result in an exceedance of any NAAQS and therefore would not result in significant cumulative air quality impacts.

5.2.4. Climate

The total direct and indirect impacts resulting from the launch, landing, and recovery activities would be limited to small increases in GHG emissions and therefore would not have a significant impact to cumulative GHG emissions or climate change. The small quantity of GHG emissions from the Proposed Action alone would not cause appreciable global warming that would lead to climate changes. However, these emissions would increase GHG concentration in the atmosphere, and, in combination with past, present, and reasonably foreseeable future emissions from all other sources, contribute incrementally to climate change.

5.2.5. Noise and Noise-Compatible Land Use

Short-term increases in the noise levels received in the community from the Proposed Action are not anticipated to be significant. Long-term noise levels for the proposed launch (including landing) activities for the Falcon 9 and Falcon Heavy are not expected to surpass the significance thresholds for impacts. Sonic booms generated by most (non-polar) launch events would impact the ocean surface beyond 30 miles off the coast and would not be audible on land; therefore, these sonic booms would not produce any significant impacts in the surrounding areas. A sonic boom would impact parts of Florida during a polar mission. The majority of the areas impacted would experience an overpressure of around 0.25 psf, which is similar to distant thunder.

The past, present, and reasonably foreseeable future actions with the potential to affect noise are presented in the previous section. Launch frequencies are anticipated to remain fairly constant when comparing past and future launch manifests and incorporating the Proposed Action. As Starship/Super Heavy launches gradually increase over time to 24 launches per year, the number of Falcon launches would decrease. All past and future launches have or will result in short-term and temporary increases in noise levels. It should also be noted that each launch would or has occurred separately, avoiding combining noise related impacts from more than one launch at a time. As a result, the overall cumulative effect of other past, present, and reasonably foreseeable future actions from noise is considered minor and less than significant. When considered with other past, present, and foreseeable future actions, the Proposed Action would not result in significant cumulative noise impacts.

5.2.6. Historical, Architectural, Archaeological, and Cultural Resources

The FAA's undertaking does not involve construction. In previous consultations with the SHPO, the SHPO has determined that launches (including landings) at KSC and CCAFS would not adversely affect historic properties. The FAA is in the process of consulting the SHPO for potential effects to historic properties from Falcon 9 polar launches (including landings) (the only aspect of the FAA's undertaking that has not been previously reviewed by the SHPO). No adverse effects to historic properties are expected.

The past, present, and reasonably foreseeable future actions with the potential to affect cultural resources are presented in the previous section. Launch frequencies are anticipated to remain fairly constant when comparing past and future launch manifests and incorporating the Proposed Action. As Starship/Super Heavy launches gradually increase over time to 24 launches per year, the number of Falcon launches would decrease. All past and future launches have or will result in short-term and temporary increases in noise levels. The overall cumulative effect of other past, present, and reasonably foreseeable future actions from noise is considered minor and less than significant. When considered with other past, present, and foreseeable future actions, the Proposed Action is not expected to result in significant cumulative impacts on historical, architectural, archaeological, or cultural resources.

5.2.7. Department of Transportation Act Section 4(f)

The Proposed Action would contribute to the annual number of times launch noise is received in

MINWR and CNS and by other Section 4(f) properties. Also, the Proposed Action would contribute to the annual number of times that sections of KSC managed by MINWR and CNS are temporarily restricted due to visitor volumes. Closures due to visitor volume are coordinated between KSC security, MINWR, and CNS by monitoring to ensure parking lot thresholds are not exceeded, and roadways allow for emergency egress for any form of emergency associated with large crowds. Closures are temporary and do not cause more than a minimal disturbance to the enjoyment of the resource.

Given their proximity to the launch facilities at KSC and CCAFS, MINWR and CNS (and other 4(f) properties in the study area; see Section 3.7) have been experiencing launch noise for decades. Due to the long history of these Section 4(f) properties experiencing noise from launches at CCAFS and KSC, the FAA has determined the Proposed Action, when combined with other past, present, and reasonably foreseeable future actions, would not substantially diminish the protected activities, features, or attributes of any Section 4(f) property, and thus would not result in substantial impairment of the properties. The FAA has made the same determination for 4(f) properties within the sonic boom footprint of a Falcon 9 polar launch (including landing). Therefore, the Proposed Action would not result in significant cumulative impacts on Section 4(f) properties.

5.2.8. Biological Resources

Although the Proposed Action and other concurrent projects may disturb wildlife, the disturbance would be temporary and wildlife would continue to use habitat in the study area. The short and infrequent operation would not be expected to have residual effects past each operation. Compliance with the measures specified in ESA consultations and implementation of environmental protection measures would minimize impacts to special-status species. Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts to biological resources.

5.2.9. Coastal Resources

The Proposed Action is not expected to result in impacts on coastal resources. Therefore, the Proposed Action would not contribute to cumulative impacts on coastal resources. The Florida State Clearinghouse previously determined that SpaceX's Falcon launch operations in Florida are consistent with the state's coastal management program. The FAA has submitted this Draft EA to the Florida State Clearinghouse for review. The Final EA will include any comments received from the Clearinghouse review.

5.2.10. Water Resources

Cumulative impacts to water resources could occur if concurrent projects were to inadequately address water resources in the study area. Compliance with all state and federal regulations and implementation of proper management of materials and wastes would minimize impacts to water resources. Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts to water resources.

5.2.11. Hazardous Materials, Solid Waste, and Pollution Prevention

Falcon launch operations would use products containing hazardous materials, including paints, solvents, oils, lubricants, acids, batteries, surface coating, cleaning compounds, propellants, chemicals, and other hazardous material payload components. However, continued implementation of existing handling and management procedures for hazardous materials, hazardous wastes, and solid wastes generated during the operation of the vehicles would limit the potential for impacts.

The past, present, and reasonably foreseeable future actions with the potential to affect hazardous materials and hazardous waste are presented in the previous section. Numerous types of hazardous

materials are used to support the missions and general maintenance operations at CCAFS and KSC. Management of hazardous materials is the responsibility of each individual or organization and is regulated under RCRA (40 CFR 260-280) and Rule 62-730. As a result, the overall cumulative effect of other past, present, and reasonably foreseeable future actions from hazardous materials and waste are considered minor and less than significant. When considered with other past, present, and foreseeable future actions, it is not anticipated that the Proposed Action would contribute a noticeable incremental impact from hazardous materials and waste.

5.2.12. Natural Resources and Energy Supply

The Proposed Action would involve the consumption of fuel, oil, and lubricants for launch, landing, and recovery operations. Any impacts to electrical service would occur within KSC and result in relatively small cumulative impacts to regional service providers. Potable water supply could become more limited. Future operations and personnel could implement water conservation measures and evaluate alternative water sources in order to minimize impacts on this resource. The commitment of energy and natural resources to implement the Proposed Action in conjunction with past, present, and reasonably foreseeable future actions is not anticipated to be excessive in terms of region-wide usage; cumulative impacts to natural resources and energy supply would not be significant.

5.2.13. Socioeconomics

The Proposed Action with the addition of added economic activity would result in a minor but positive impact to the local economy. The past, present, and reasonably foreseeable future actions with the potential to affect socioeconomics are presented in the previous section. The Spaceport (KSC and CCAFS) is Brevard County's major employer. The presence of these employers causes a chain of economic reactions throughout the local region and nearby counties. These actions have or will have a positive influence on socioeconomics, through contributions to the local economy. As a result, the overall cumulative effect of the Proposed Action when combined with other past, present, and reasonably foreseeable future actions on socioeconomics is considered beneficial but less than significant.

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