DRAFT ENVIRONMENTAL IMPACT STATEMENT

SPACEX STARSHIP-SUPER HEAVY LAUNCH VEHICLE AT LAUNCH COMPLEX 39A

at the Kennedy Space Center, Merritt Island, Florida

Volume II, Appendix B.1, Part 1

August 2025

Federal Aviation Administration

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Appendix B *Regulatory Consultations*

This appendix provides regulatory consultation documentation for Endangered Species Act Section 7 consultation with the United States (U.S.) Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), Magnuson-Stevenson Fishery Conservation and Management Act consultation with the NMFS, National Historic Preservation Act (NHPA) Section 106 consultation with the Florida State Historic Preservation Officer (SHPO), U.S. Department of Transportation Act Section 4(f) consultation with officials with jurisdiction over affected properties, Coastal Zone Management Act consultation with the Florida Department of Environmental Protection, and Marine Mammal Protection Act Incidental Harassment Authorization with NMFS.

B.1 Endangered Species Act Section 7 Consultation (USFWS)

A Biological and Conference Assessment (BCA) was submitted to the USFWS on March 20, 2025.

The USFWS responded with a Request for Additional Information on April 11, 2025, to which the National Aeronautics and Space Administration (NASA) responded by providing responses to questions and a revised BCA on May 1, 2025. USFWS reviewed the revised BCA and did not have any additional questions or need for additional information. They deemed a complete consultation package retroactive to May 5, 2025, when the revised consultation package was opened and review by USFWS began. This revised BCA replaced the original BCA submitted to the USFWS on March 20, 2025; thus, only the Revised BCA is included in the Draft Environmental Impact Statement (EIS) appendix.

On June 6, 2025, the USFWS provided a Letter of Concurrence for select species ahead of the completion of the formal consultation. The June concurrence does not cover the following species and critical habitat currently undergoing formal consultation: eastern indigo snake (*Drymarchon couperii*), Florida scrub-jay (*Aphelocoma coerulescens*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), Kemp's ridley sea turtle (*Lepidochelys kempii*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), southeastern beach mouse (*Peromyscus polionotus niveiventris*), and the proposed green sea turtle critical habitat and loggerhead sea turtle critical habitat.

NASA provided the USFWS with an addendum to the BCA on June 12, 2025, to address changes in the action area associated with the range of potential Starship return to launch site trajectories.

Additional correspondence in this regard will be added to this section as the consultation process continues.

B.1.1 Biological and Conference Assessment Transmittal Letter

Akstulewicz, Kevin D. [US-US]

From: Hall, Patrice (KSC-SIE30)[redacted]
Sent: Thursday, March 20, 2025 9:59 AM
To: FW4FLESRegs@fws.gov; Myers, Brendan T
Cc: Brooks, James T. (KSC-SIE30); Baker, Nicholas M (FAA); Long, Eva (FAA); Hanson, Amy (FAA); Akstulewicz, Kevin D. [US-US]; Hiers, Stephanie D. [US-US]
Subject: EXTERNAL: Request to Initiate Formal Consultation Under Endangered Species Act, Section 7 for Starship-Super Heavy Launch and Landing Operations at Launch Complex-39A at the Kennedy Space Center (KSC)

Brendan,

The National Aeronautics and Space Administration (NASA) is evaluating the SpaceX proposal for Starship-Super Heavy Launch and Landing Operations at Launch Complex-39A at KSC. NASA and the Federal Aviation Administration (FAA) are evaluating the potential environmental effects of this action in an Environmental Impact Statement prepared pursuant to the National Environmental Policy Act.

In accordance with information required in 50 Code of Federal Regulations §402.14(c)(1), NASA is providing the Biological and Conference Assessment (BCA) which addresses potential effects on threatened and endangered species in the action area. NASA hereby requests initiation of formal consultation, pursuant to Section 7 of the Endangered Species Act (ESA). Effect determinations for the listed species and critical habitat in the action area are summarized in Table 6-1 of the BCA document.

The IPaC reports for the LC-39A Starship Super Heavy Operation BCA are in Appendix A of the document. Due to IPaC file size limits it was necessary to split up the Atlantic Ocean landings area into North, South, and Contingency, and split up the Pacific Ocean landings area into East, West, North, and South. We did not include IPaC reports for the Indian Ocean and portions of the Pacific Ocean that did not contain any federally listed species under USFWS jurisdiction. Below are project codes for the eight resulting project areas.

Project Code: 2025-0070940
Project Name: KSC LC39A Starship Super Heavy 1 psf/100 dB ASEL

Project Code: 2025-0071217
Project Name: KSC LC39A Starship Super Heavy (Atlantic Landings-North)

Project Code: 2025-0071227
Project Name: KSC LC39A Starship Super Heavy (Atlantic Landings-South)

Project Code: 2025-0071207
Project Name: KSC LC39A Starship Super Heavy (Contingency Landing 1psf)

Project Code: 2025-0071320
Project Name: KSC LC39A Starship Super Heavy (Pacific Landings-West)

Project Code: 2025-0071325
Project Name: KSC LC39A Starship Super Heavy (Pacific Landings-North)

Project Code: 2025-0071330
Project Name: KSC LC39A Starship Super Heavy (Pacific Landings-East)

1

Project Code: 2025-0071339
Project Name: KSC LC39A Starship Super Heavy (Pacific Landings-South)

The BCA document is too large to transmit by email and is available in Box at:
[redacted]

Please contact me to discuss any questions or concerns.

Best Regards,

Patrice

Patrice Hall
Environmental Protection Specialist
Environmental Management Branch
Spaceport Integration and Services
Mail Code: SI-E3
Kennedy Space Center, FL 32899
[redacted]

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B.1.2 Biological and Conference Assessment

FINAL

Biological and Conference Assessment

SPACEX STARSHIP-SUPER HEAVY LAUNCH AND LANDING OPERATIONS AT LAUNCH COMPLEX-39A

AT THE KENNEDY SPACE CENTER, MERRITT ISLAND, FLORIDA

Revised May 1, 2025

Federal Aviation Administration
Office of Commercial Space Transportation

Federal Aviation Administration

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Acronyms and Abbreviations

Acronym	Definition
§	Section
°C	degrees Celsius
°F	degrees Fahrenheit
ASEL	A-weighted sound exposure level
ASU	air separation unit
BCA	Biological and Conference Assessment
BDA	Blast Danger Area
BO	Biological Opinion
CANA	Canaveral National Seashore
CCSFS	Cape Canaveral Space Force Station
CFR	Code of Federal Regulations
CM	Conservation Measure
dB	decibel(s)
dBA	A-weighted decibels
DPS	distinct population segment
EA	Environmental Assessment
EMB	Environmental Management Branch
ES	Ecological Services
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FWS	Fish and Wildlife Service
g	an acceleration equal to the acceleration of gravity
INPS	invasive non-native plant species
IPaC	Information for Planning and Consultation
IRL	Indian River Lagoon
KSC	Kennedy Space Center
LC	Launch Complex
LCH_4	liquid methane
LN_2	liquid nitrogen
LOM	Lighting Operations Manual
LOX	liquid oxygen
LZ	Landing Zone
MINWR	Merritt Island National Wildlife Refuge
MOU	Memorandum of Understanding
MT	metric ton(s)
NASA	National Aeronautics and Space Administration
nm	nautical miles
NMFS	National Marine Fisheries Service
No.	Number
PBF	physical and biological feature
PCE	primary constituent element
psf	pounds per square foot
RTLS	return to launch site
SEL	sound exposure level
SpaceX	Space Exploration Technologies Corporation
U.S.	United States
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service

Chapter 1. Action

1.1 Introduction

The National Aeronautics and Space Administration (NASA) and Federal Aviation Administration (FAA) are evaluating Space Exploration Technologies Corporation's (SpaceX's) proposal for operation of the Starship-Super Heavy at Launch Complex (LC)-39A at the NASA Kennedy Space Center (KSC). NASA is the lead agency for this Proposed Action, which includes infrastructure construction, static fire tests, launches, landings, and daily operations at LC-39A; transport of supplies, personnel, and launch vehicles to LC-39A; expenditure of vehicles and components in the ocean; landings on droneships in the ocean; and transport of supplies and vehicles via barge. SpaceX must obtain a vehicle operator license from the FAA for Starship-Super Heavy launch and landing operations at LC-39A. The FAA action is the issuance of the vehicle operator license and subsequent renewals that are within the scope of this Biological and Conference Assessment (BCA).

In 2019, an informal Endangered Species Act (ESA) Section 7 consultation for Starship-Super Heavy at LC-39A was completed, allowing construction to begin on certain infrastructure at the site (USFWS, 2019a). Due to new species listings and critical habitat designations and multiple modifications to the original 2019 Proposed Action, NASA as the land management agency and the FAA as the licensing agency have determined that a new ESA Section 7 consultation with the United States Fish and Wildlife Service (USFWS) is needed to address the potential effects to federally listed species from Starship-Super Heavy operations at LC-39A. Thus, in accordance with Section 7 of the ESA of 1973, as amended (16 United States [U.S.] Code Section [§] 1531 et seq.), and 50 Code of Federal Regulations (CFR) Part 402, NASA and the FAA request initiation of a new formal Section 7 consultation for proposed SpaceX construction and operations activities at LC-39A and downrange landing areas.

This BCA, hereafter referred to as the LC-39A Starship BCA, analyzes the potential effects of the Starship-Super Heavy Launch program at KSC LC-39A on federally listed and proposed species and critical habitat under the jurisdiction of the USFWS. SpaceX's updated Proposed Action includes construction of a landing pad and additional launch infrastructure at LC-39A, an evolved launch vehicle design, a higher launch tempo, return to launch site (RTLS) booster and Starship recoveries, transport of vehicles and supplies via barges and trucks, landings on droneships in the ocean, and expenditure of vehicles and components in the ocean (covered in part in the 2025 National Marine Fisheries Service [NMFS] *Conference and Biological Opinion on SpaceX Starship-Super Heavy Increased Launch Cadence and Operations in the North Atlantic Ocean, Gulf of Mexico, North Pacific Ocean, South Pacific Ocean, and Indian Ocean Authorized by the Federal Aviation Administration* (NMFS, 2025)).

The following summaries provide information on consultations that will continue to be applicable for activities at LC-39A once Starship-Super Heavy activities begin (i.e., Master Plan sea turtle lighting requirements, Falcon launches/operations, Starship-Super Heavy infrastructure construction approved in 2019 consultation) and for facilities and infrastructure that will be associated with the Starship-Super Heavy operations (i.e., SpaceX Operational Area Facility, Roberts Road Operations Area).

Kennedy Space Center Master Plan, Center-Wide Operations Biological Opinion (BO) (Fish and Wildlife Service [FWS] Log Number [No.] 04EF1000-2016-F-0083) The USFWS determination for the 2016 KSC Center Master Plan BO was that adverse impacts to sea turtles would continue from lighting sources essential for human safety and national security at KSC, but the anticipated level of take (3 percent of hatchlings and 3 percent of adult nesting females) was “not likely to jeopardize the continued existence of Atlantic green *(Chelonia mydas*), Kemp’s ridley (*Lepidochelys kempii*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), or loggerhead (*Caretta caretta*) sea turtles and the action was not likely to destroy or adversely modify designated critical habitat” (USFWS, 2017). The Proposed Action will follow lighting requirements in the KSC Master Plan BO.

Kennedy Space Center SpaceX Starship and Super Heavy Program Informal Consultation (FWS Log No. 04EFI000-2019-I-1011). In 2019, NASA completed Section 7 consultation with the USFWS for the SpaceX Starship and Super Heavy Launch Vehicle at KSC LC-39A, evaluating potential construction and operations impacts on federally listed species and critical habitat from 24 annual launches of Starship-Super Heavy; landing of Starship at LC-39A, Landing Zone (LZ)-1 and LZ-2 at Cape Canaveral Space Force Station (CCSFS), and downrange on a floating platform; landing of Super Heavy downrange on a floating platform; and construction and operation of new launch-related infrastructure at LC-39A (USFWS, 2019a). NASA determined that there would be no effect on the following species: Lewton’s polygala (*Polygala lewtonii*), Carter’s mustard (*Warea carteri*), Atlantic marsh snake (*Nerodia clarkii taeniata*), rufa red knot (*Calidris canutus rufa*), and eastern black rail (*Laterallus jamaicensis jamaicensis*), which was a candidate species at the time of consultation. With the implementation of requirements from the *Standard Protection Measures for the Eastern Indigo Snake* (USFWS, 2021a), and adherence to the Prescribed Burn Memorandum of Understanding (MOU), KCA-4205 Revision C (SLD 45, USFWS, and KSC, 2025), the USFWS concurred with the determination of “may affect, but is not likely to adversely affect” for the Florida scrub-jay, wood stork (*Mycteria americana*), southeastern beach mouse (*Peromyscus polionotus niveiventris*), manatee (*Trichechus manatus*), and eastern indigo snake (*Drymarchon couperi*). The USFWS also stated that any potential adverse effects to sea turtles and the likelihood of “take” would be addressed by complying with KSC light requirements and BO 04EF1000-2016-F0083; the USFWS determined that proposed development within LC-39A would not jeopardize the continued existence of any sea turtle species.

Concurrence Letter from USFWS for SpaceX Falcon Launch Vehicles at Kennedy Space Center and Cape Canaveral Air Force Station (USFWS, 2020a). Note that Cape Canaveral Air Force Station is now known as Cape Canaveral Space Force Station (CCSFS). The USFWS concurred with the FAA determination of “may affect, not likely to adversely affect” for the following species from proposed construction and Falcon launch operations at KSC LC-39A and CCSFS LC-40: manatee, eastern indigo snake, and Florida scrub-jay, with the implementation of the conservation measures (CM) detailed in the concurrence letter. The USFWS exempted incidental take of nesting marine turtles associated with lighting under the KSC Center Master Plan BO (FWS Log No. 04EF1000-2016-F-0083); SpaceX agreed to implement the measures in the BO.

Kennedy Space Center SpaceX Operations and Florida Power and Light Solar Facility Biological Opinion (FWS Log No.: 04EF1000-2019-0193) (USFWS, 2019b). This BO addresses effects from the development and operation of the SpaceX Operational Area Facility and Florida Power and Light Photovoltaic Solar Facility. NASA made the determination of no effect for the piping plover (*Charadrius melodus*), roseate tern (*Sterna dougallii dougallii*), rufa red knot, and southeastern beach mouse. The potential impacts to sea turtles and loss of auxiliary habitat by Florida scrub-jays are addressed in separate BOs (FWS Log No. 04EF1000-2013-F-0194 and FWS Log. No. 04EF1000-2016-0083); KSC committed to following these BOs to address potential impacts from lighting and compensate for the loss of auxiliary Florida scrub-jay habitat. The BO includes an Incidental Take Statement for Florida scrub-jays and indigo snakes.

Kennedy Space Center SpaceX Roberts Road Operations Facility Biological Opinion-Amendment (FWS Log No.: 04EF1000-2019-0193/2023-0036318) (USFWS, 2024a): This amendment involves the development of up to an additional 100 acres of land north of the existing Roberts Road SpaceX Operations Area for office space and facilities in support of vehicle and payload processing, fabrication, storage, manufacturing, shipping, and receiving. NASA made no effect determinations for the piping plover, red knot, southeastern beach mouse, and West Indian manatee. The USFWS concurred with the NASA determination of “may affect, not likely to adversely affect” for the American alligator (*Alligator mississippiensis*), eastern black rail, eastern indigo snake, wood stork, sea turtles, and the proposed endangered tricolored bat (*Perimyotis subflavus*). Potential impacts to sea turtles and Florida scrub-jays have been analyzed in separate BOs (FWS Log No. 04EF1000-2013-F-0194, FWS Log. No. 04EF1000-2016-0083, and FWS Log No. 04EF1000-2019-0193); KSC committed to following these BOs to compensate for the loss of auxiliary Florida scrub-jay habitat and to address potential lighting impacts.

1.2 Background

The fully reusable Starship-Super Heavy launch vehicle system is planned to support missions to space stations in low-Earth orbit, the moon and Mars, and satellite payload missions. From 2020 to 2022, NASA awarded SpaceX an Artemis Human Landing System program contract and associated contract options to develop two Starship-based lunar landers and deliver them to the moon. The NASA-SpaceX contract also requires a series of Starship flight tests, including a flight demonstration of the Starship lunar lander to the surface of the moon. These flight tests and missions require extensive use of the Starship-Super Heavy vehicle to launch the lunar lander, as well as numerous Starship-based propellant tanker vehicles. These missions can occur independently from different launch sites. However, in support of Human Landing System SpaceX is proposing to launch Starship-Super Heavy from LC-39A and to land Super Heavy boosters and Starships at LC-39A following launch (RTLS). SpaceX’s proposal would provide an improved ability to reuse Super Heavy, which directly supports national space program priorities. By landing at the launch site, SpaceX can quickly begin post-flight vehicle processing.

Since the completion of the 2019 NASA Starship Environmental Assessment (EA) and ESA Section 7 consultation, SpaceX has undertaken infrastructure improvements at LC-39A (e.g., construction of a launch mount) (NASA, 2019; USFWS, 2019a). While the 2019 consultation is incorporated by reference, the effects of the proposed changes to Starship-Super Heavy concept of operations, including additional infrastructure and changes in launch vehicle design and launch tempo, are specifically analyzed in this BCA. SpaceX will apply for a Vehicle Operator License for LC-39A that would identify a proposed launch cadence consistent with that analyzed in this BCA.

1.3 Project Location

LC-39A is a NASA-owned, SpaceX-leased launch site located in Brevard County, Florida, on KSC property, approximately 3 miles east of NASA’s Vehicle Assembly Building (Figure 1-1; Figure 1-2). LC-39A currently supports Falcon 9 and Falcon Heavy launches. Following completion of the 2019 *Final Environmental Assessment for the SpaceX Starship and Super Heavy Launch Vehicle at KSC* and the associated ESA Section 7 consultation, SpaceX began developing additional capacity within the perimeter of LC-39A for future Starship-Super Heavy launch and landing operations (NASA, 2019; USFWS, 2019a). SpaceX would continue to launch Falcon missions at LC-39A while additional infrastructure is under construction and once the Starship-Super Heavy is operational.

Figure 1-1. Location of LC-39A

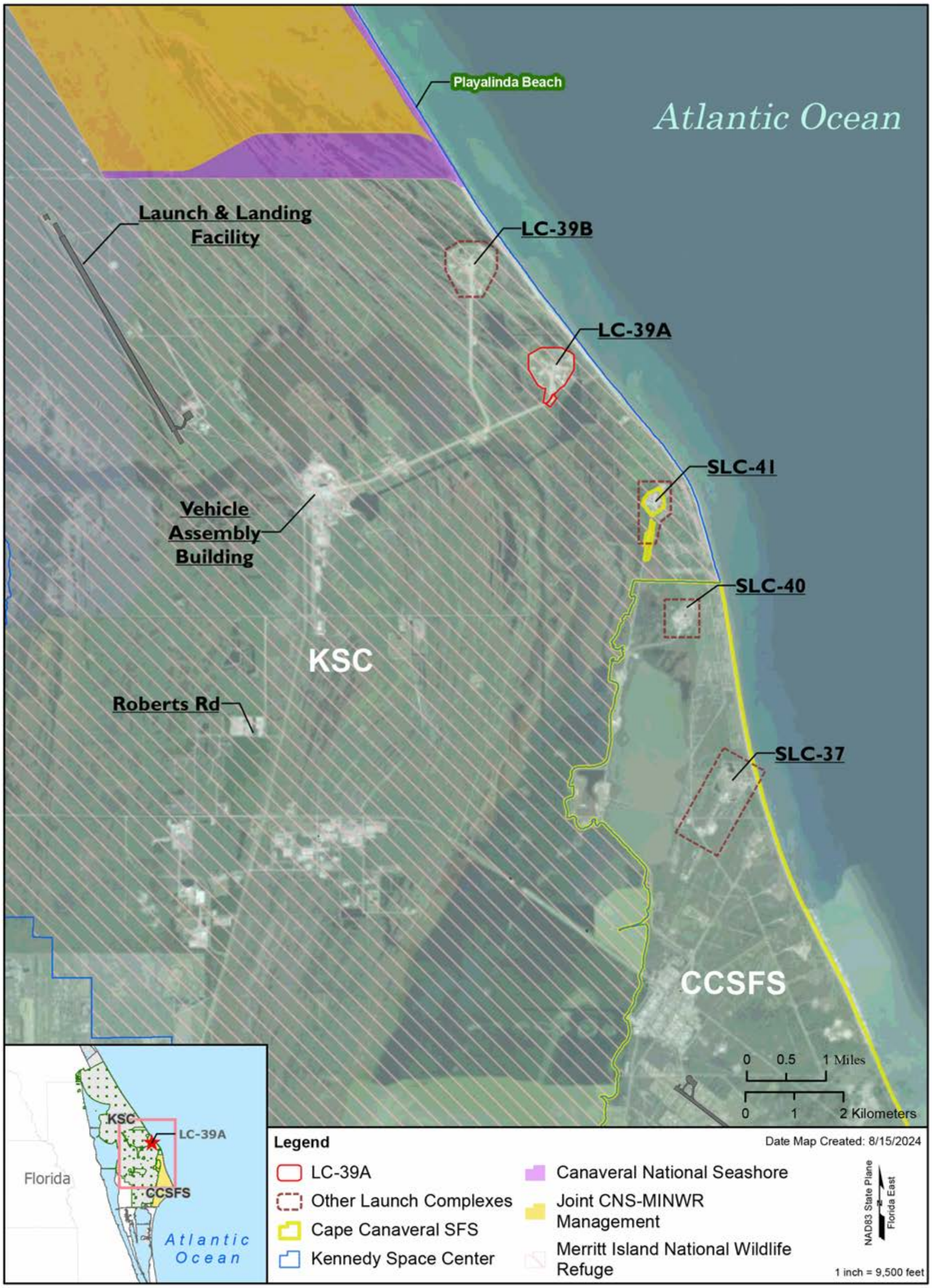

Figure 1-2. LC-39A and Select Other Launch Complexes and Space Launch Complexes at KSC and CCSFS

1.4 Project Description

SpaceX's Proposed Action includes Starship-Super Heavy launch and landing operations (up to 44 launches and 88 landings – 44 for each stage [Starship and Super Heavy] of the launch vehicle – per year) at LC-39A, to include ocean landings of Super Heavy in the Atlantic Ocean and Starship in the Atlantic, Pacific, and Indian Oceans. Starship and Super Heavy could land on floating platforms (referred to as "droneships") in the ocean. Infrastructure improvements at LC-39A are proposed to support launch and landing operations. A detailed discussion of the Proposed Action is provided in subsequent subsections.

1.4.1 Starship-Super Heavy Launch Vehicle

Starship-Super Heavy is composed of two stages: Super Heavy is the first stage (or booster), and Starship is the second stage (Figure 1-3). The fully integrated Starship-Super Heavy launch vehicle is expected to be up to 492 feet (150 meters) tall, depending on configuration, and approximately 30 feet in diameter. As designed, both stages are reusable, with any potential refurbishment actions taking place at SpaceX facilities at KSC (e.g., Roberts Road[1], LC-39A). Both stages are expected to have minimal post-flight refurbishment requirements; however, they may require periodic maintenance and upgrades.

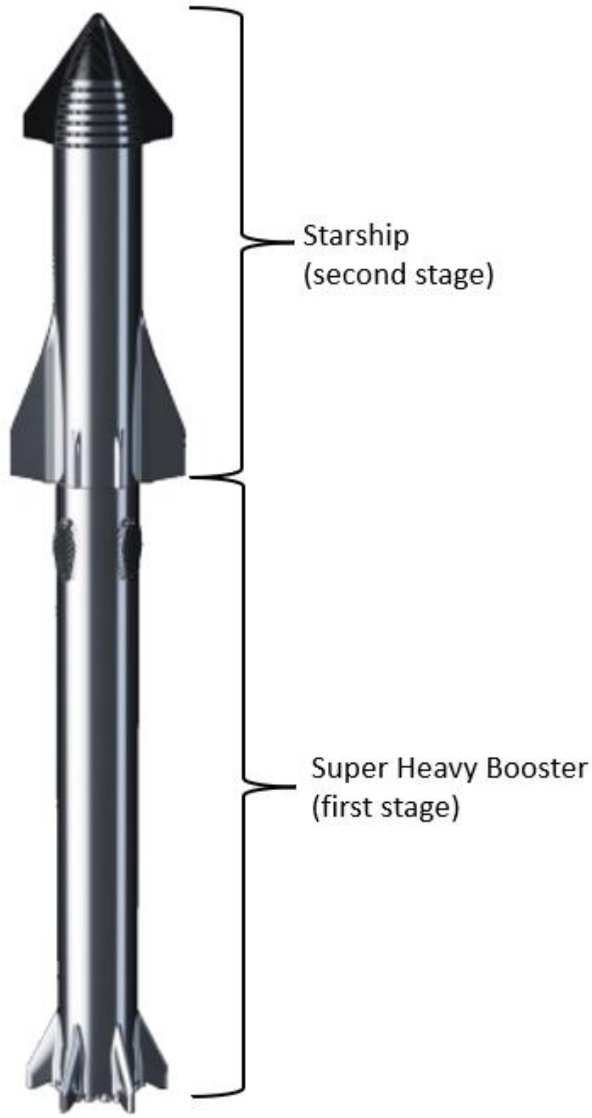

Figure 1-3. Starship-Super Heavy Launch Vehicle Design

[1] In addition to HangarX, the Roberts Road facility serves as SpaceX's payload fairing processing facility; current improvements underway (which are not part of this Proposed Action) would support Starship development plus integration and support of future Starship missions at KSC (NASA, 2024d).

As discussed in Section 1.2, *Background*, the Starship-Super Heavy launch vehicle has evolved since the 2019 NASA EA[2] and ESA Section 7 consultation. The proposed configuration consists of 35 Raptor engines for Super Heavy and 9 Raptor engines for Starship. The Raptor engine is powered by liquid oxygen (LOX) and liquid methane (LCH_4). Super Heavy is expected to hold up to 4,100 metric tons (MT) of propellant, and Starship is to hold up to 2,650 MT. Current maximum lift-off thrust of the Super Heavy launch vehicle is anticipated at 103 meganewtons[3]. Starship would have a maximum lift-off thrust of approximately 28 meganewtons. Launch propellant and commodities include liquid nitrogen (LN_2), water, gaseous oxygen, gaseous methane, gaseous nitrogen, helium, hydraulic fluid, LOX, and LCH_4.

1.4.2 Starship-Super Heavy Operations

1.4.2.1 Pre-Launch

Preflight operations could include ground testing activities, tanks testing, spin-prime tests, mission rehearsals (i.e., dry and wet dress rehearsals), and static fire engine tests. A dry dress rehearsal simulates launch day conditions where a full launch countdown is conducted but the vehicle is not fueled. A wet dress rehearsal is like a dry dress rehearsal, but the vehicle is fueled. This test allows the launch team to practice timelines and procedures used for launch and to identify potential issues. The goal of these operations is to verify that all vehicle and ground systems are functioning properly, as well as to verify that all procedures are properly written.

SpaceX could conduct tank tests and spin-prime tests prior to static fire or launch. If needed, proof tests could be performed to confirm the structural integrity of the launch vehicle tanks. Proof pressure tests are broken into two main categories: (1) pneumatic and (2) cryogenic. Pneumatic proof

PRE-LAUNCH ACTIVITIES

Tank Tests –

- Pressure testing to confirm structural integrity with appropriate factors of safety; do not release any propellant to the environment.

Spin-Prime Tests –

- Testing to verify the engine system is operational prior to static fire tests; vehicle engines are chilled, and pumps are spun to operating speed but are stopped prior to engine ignition.

Static Fire Engine Test –

- Test to verify engine control and performance; the launch vehicle engines are ignited for a short duration, generating a heat plume, then shut down.
- Conducted for both Starship and Super Heavy booster.

Dry Dress Rehearsal –

- Full launch countdown but the vehicle is not fueled.

Wet Dress Rehearsal –

- Full launch countdown but the vehicle is fueled.

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[2] The configuration analyzed in the 2019 EA consisted of 31 Raptor engines for the booster (Super Heavy) and 7 Raptor engines for Starship. The booster was proposed to hold up to 3,500 MT of propellant and Starship up to 1,500 MT of propellant. The maximum lift-off thrust was proposed at 62 meganewtons (NASA, 2019).

[3] One newton is equal to the force needed to move 1 kilogram of mass at a rate of 1 meter per second squared. One meganewton is equal to 1,000,000 newtons.

pressure testing consists of pressurizing the launch vehicle's tank with gaseous media (either helium, nitrogen, oxygen, or methane) and holding pressure for an extended duration. Cryogenic proof pressure testing consists of loading the tanks with a single propellant, typically LN_2 or LOX. The tanks are then pressurized to a predefined limit to confirm their structural integrity with appropriate factors of safety. These proof pressure tests do not release any propellant to the environment. Propellants are recycled back into the ground system tanks after the test is completed. Tank tests do not involve the mixing of explosive commodities and are designed to test an accepted safety limit; thus, they are not expected to explode or spread debris. Spin-prime tests verify the engine system is operational prior to static fire tests. During a spin-prime test, the vehicle engines are chilled, and pumps are spun to operating speed but are stopped prior to engine ignition.

Prior to launch operations, SpaceX could conduct static fire engine tests of both Starship and Super Heavy. Static fire testing is a standard industry practice to provide greater confidence in vehicle reliability and is performed widely across launch and test sites at the Eastern Range and at other facilities across the United States. The goal of a static fire engine test is to verify engine control and performance. During a static fire engine test, the launch vehicle engines are ignited for a short duration, generating noise and a heat plume, then shut down. Prior to a fully integrated Starship-Super Heavy launch, SpaceX would perform a Starship static fire engine test and a Super Heavy static fire engine test. It is possible but not expected that a static fire engine test could be attempted but is unsuccessful. If an engine test is unsuccessful, SpaceX would attempt another. A static fire test may be unsuccessful if one or more engine(s) fail to properly ignite or if other issues are identified with the vehicle or ground support equipment. Based on measurements taken during Starship-Super Heavy operations in Boca Chica, Texas, the plume at LC-39A is expected to reach 90 degrees Fahrenheit (°F) approximately 0.2 miles from the launch pad for static fire tests. SpaceX plans to conduct one static fire engine test per stage, per launch operation (i.e., two stages and 44 launches/year = 88 static fire tests). SpaceX may also reduce the cadence of the static fires of the Starship or Super Heavy vehicles, not requiring a static fire of each engine test per launch operation. Static fires would utilize the deluge system, with each event utilizing approximately 300,000 gallons of water. Static fires would be up to 15 seconds in duration and would only be conducted during the daytime. Cleared areas and roadblocks for the Blast Danger Area (BDA)[4] last about 3 hours per static fire event.

During preflight operations, SpaceX would connect the launch vehicle to ground systems. After an operation involving propellant (i.e., wet dress rehearsal and static fire engine test), SpaceX would transfer the propellant back to the commodity tanks. During Starship fuel loading for a static fire engine, gaseous methane could be released to the atmosphere or combusted; however, SpaceX intends to recapture methane where practicable. This release would be minimal, as the LCH_4 would be released as gaseous methane vented from the stage to maintain pressure, and it would be a very small percentage of the vehicle tank's propellant vented. It is standard practice for all launch vehicles to vent cryogenics to maintain pressure.

[4] The BDA is the safety zone associated with the potential for an anomaly on the launch pad. No personnel are allowed within the BDA. The closure area represents a bounding case, using the highest possible fuel volume as well as the highest possible LOX/methane yield.

Ground and airspace closures associated with pre-launch testing are intended to keep aircraft and the public out of a specific region throughout the time that a hazard may exist. The length of the window is primarily intended to account for the time needed for the operator to meet its mission objectives. The location and size of the closure area is defined to protect the public. Any required Canaveral National Seashore (CANA) or Merritt Island National Wildlife Refuge (MINWR) closures would be coordinated between SpaceX and the respective agency, National Park Service and/or USFWS. All closures, whether dictated by public safety concerns (i.e., the Range or the FAA require the closure) or due to visitor volumes exceeding capacity, would be temporary, lasting approximately 3 to 6 hours each time. BDAs are cleared and any necessary roadblocks are established around three hours prior to launch and dropped after launch. In the event of a scrub, cleared areas and roadblocks remain until propellant is offloaded, with the duration variable depending on the percentage of propellant loaded; however, the maximum duration would be about one hour. Because not all attempts load propellent before scrubbing and roadblocks are often dropped early in that case, for purposes of analysis in this BCA it is assumed an average of three hours of cleared BDAs and associated roadblocks per attempt.

The location and size of airspace closures for commercial space operations also vary with each mission type and are influenced by multiple factors, including vehicle hardware reliability. The size of airspace closures shrinks as reliability is established with results and analysis from each launch. For the initial launch of a new launch vehicle (e.g., Starship-Super Heavy), the hazard areas and associated airspace closures are bigger, to account for the increased risk of a vehicle failure relative to a mature rocket. Subsequent launches of that launch vehicle would include smaller hazard areas compared to the initial launch. The airspace closures for SpaceX pre-launch testing (tank tests, wet dress rehearsals, and static fire engine tests) would be localized to an area near the pad and may extend up to approximately 13,000 feet (4,000 meters) in altitude.

On Navigable Waters subject to U.S. authority, the U.S. Coast Guard (USCG) has broad authority to establish Limited Access Areas, which may include Safety and/or Security Zones, and Restricted Navigation Areas. The USCG publishes Notices to Mariners to inform the maritime community of temporary changes in condition, Limited Access Areas, Restricted Navigation Areas, and/or hazards on navigable waterways. Launches and reentries would be infrequent, of short duration, and scheduled in advance to minimize interruption to ship and boat traffic. Table 1-1 provides a summary of pre-launch and closure-related activities, and Figure 1-4 shows the potential access restriction areas for pre-launch, launch, and landing activities.

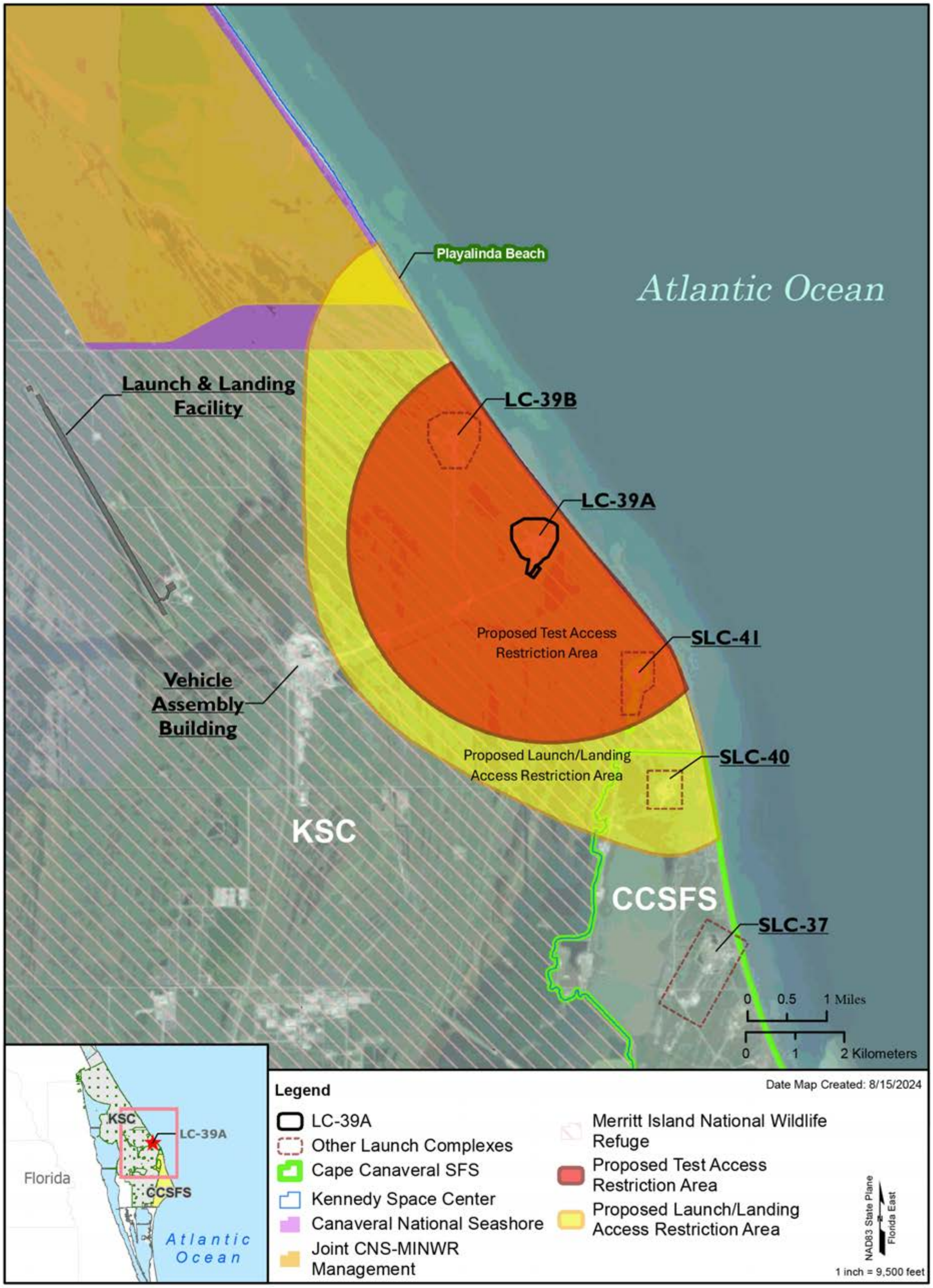


Figure 1-4. Potential Access Restriction Areas for Pre-Launch, Launch, and Landing Activities

Table 1-1. Summary of Pre-Launch and Closure-Related Activities

Action	Purpose	Start Time	End Time*
Establish check points and take down check points	Set up for launch and remove after launch. Commence monitoring of traffic flow.	T[1] – 6 to 12 hours	T + 5 to 30 minutes
Establish hard access control checkpoints	Restrict public access to BDA and limit access within the USCG LAA. (Same for Static Fire)	T – 3 hours	T + 5 to 30 minutes
USCG/other waterborne law enforcement on station	USCG and/or other local waterborne law enforcement sweep areas and limit (LAA) boating access. (Same for Static Fire)	T – 3 hours	T + 5 to 30 minutes
Security sweeps	Security sweeps responsible areas (e.g., beach, roads near launch site, rivers and creeks). Verify by video, UAV, or ATV as needed.	T – 2 hours	T – 1 hour 40 minutes
Trajectory sweeps	Verify with radar sweep.	T – 1 hour	T – 40 minutes
Close airspace	In accordance with agreed procedure, FAA Air Traffic Control closes appropriate commercial airspace. Airspace closures potentially affecting Special Use Airspace would be coordinated with the appropriate using agency (e.g., CCSFS, Patrick SFB).	T – 15 minutes	T + 5 to 30 minutes
Estimated Closure Time per Static Fire Engine Test (88/year) or Wet Dress Rehearsal (44/year) within BDA and LAA (up to approximately 13,500 feet [2.6 miles] from the center of LC-39A)		3 hours	
Estimated Total Annual Closure Time for Static Fire Engine Tests (88/year) and Wet Dress Rehearsals (44/year)		Approximately 396 hours	
Estimated Closure and Limited Access Time per Launch or Landing within the BDA/LAA (up to approximately 22,965 feet [4.4 miles] from the center of LC-39A)		Up to 3.5 hours	
Estimated Total Annual Closure and Limited Access Time for Launches (44) and Landings (88) within the BDA/LAA (50% between 7:00 a.m. – 10:00 p.m. and 50% between 10:00 p.m. – 7:00 a.m.)		Approximately 462 hours	
Estimated Total Annual Closure and Limited Access Time (44 launches / 88 landings / 88 static fire engine tests / 44 wet dress rehearsals)		Approximately 858 hours	

Notes: % = percent; ATV = all-terrain vehicle; BDA = Blast Danger Area; CCSFS = Cape Canaveral Space Force Station; FAA = Federal Aviation Administration; LAA = Limited Access Area; SFB = Space Force Base; UAV = unmanned aerial vehicle; USCG = United States Coast Guard.

* Does not apply to static fire or wet dress – all times assume nominal launch/landing sequence

[1] "T" implies the anticipated time of engine firing, with start and end times measured before (minus x hours or minutes) or after (plus x hours or minutes).

1.4.2.2 Launch

Starship-Super Heavy would launch from LC-39A up to 44 times per year and could occur at any time of day or night; for purposes of noise analysis, it is assumed that 22 launches would occur during the day (7:00 a.m. – 10:00 p.m.) and 22 launches would occur at night (10:00 p.m. – 7:00 a.m.) (Figure 1-5). During a launch, ignition of the Super Heavy booster Raptor engines would generate a heat plume. The plume would appear clear and consist of water vapor, carbon dioxide, carbon monoxide, hydrogen, methane, nitrogen oxides, and oxygen. The heat plumes and increased temperatures in this area would be temporary; they would only occur during engine ignition and would dissipate within minutes.

Figure 1-5. Proposed Starship-Super Heavy Launch Trajectories

A flame diverter or similar infrastructure (e.g., a water-cooled diverter) would be constructed to reduce potential effects due to the plume (a diverter can direct the plume upward, away from the ground). For LC-39A, SpaceX has only notional designs for a flame diverter; the notional design is a bifurcated diverter where the engines would be encased in the launch mount, which sits on top of the diverter. The two opposite sides of the rectangular diverter would be open and angled upwards. Deluge water (potable water) is released inside the launch mount to cool the mount and diverter as the launch occurs. SpaceX is anticipating that up to 400,000 gallons of deluge water would be used during each integrated launch. Based on measurements taken during Starship-Super Heavy operations in Boca Chica, Texas, the plume at LC-39A is expected to reach 90°F approximately 0.2 miles from the launch pad for launches and static fire tests. Launches would result in noise and vibration, and nighttime launches would require lighting.

As discussed for pre-launch activities (Section 1.4.2.1, *Pre-Launch*), closures associated with SpaceX launches and reentry would be necessary to protect the public. USCG or other local waterborne law enforcement sweep areas and limit boating access in the Limited Access Area; this would involve one boat per event. For a launch or reentry, the keep-out must typically begin at the time of launch and end when the mission has been completed, terminated, or cancelled. Airspace closures are immediately released once the mission has successfully cleared the area and no longer imposes a risk to the public. The actual duration of airspace closure is normally much less than the original planned closure, especially if the launch or reentry window is relatively long and the launch or reentry occurs at the beginning of the window. The location and size of airspace closures will also vary with each mission type and are influenced by multiple factors, including vehicle hardware reliability. For the initial launch of a new launch vehicle (e.g., Starship-Super Heavy), the hazard areas and associated airspace closures are bigger relative to a mature rocket, to account for the increased risk of a vehicle failure. Subsequent successful launches of that launch vehicle will include smaller hazard areas compared to the initial launch.

STARSHIP-SUPER HEAVY LAUNCHES

- Up to 44 launches/year (22 day/22 night)

SUPER HEAVY LANDINGS

- Up to 44/landings year (22 day/22 night)
  - Return to LC-39A (results in sonic boom)
  - Droneship in Atlantic Ocean (results in sonic boom)
  - Expended in Atlantic Ocean greater than 5 miles off the coast (sonic boom not heard on land)

1.4.2.3 Super Heavy and Starship Landings

Super Heavy Landings

Each Starship-Super Heavy orbital launch would include landing Super Heavy at LC-39A, downrange in the Atlantic Ocean on a droneship (mobile vessel not attached to the sea floor), or in the Atlantic Ocean, no closer than approximately 5 nautical miles (nm) off the coast within the Super Heavy Atlantic Ocean Landing Area depicted in Figure 1-6. For purposes of analysis, it is assumed that 22 landings would occur during the day (7:00 a.m. – 10:00 p.m.) and 22 landings would occur at night (10:00 p.m. – 7:00 a.m.). While it is acknowledged that there may be landings occurring in the ocean, the goal is for all landings to occur at LC-39A.

During flight, Starship's engines would start, most of Super Heavy's engines would cut off, and the booster would separate from Starship. Starship would continue to the desired orbit location, and Super Heavy would rotate and ignite to conduct the retrograde burn, which would place it in the correct angle to move the vehicle impact point to approximately its final target. Once Super Heavy is in the correct position, the engines would cut off. Super Heavy would then perform a controlled descent using atmospheric resistance to slow it down and guide it for a precise return to the tower at LC-39A, where it would be caught with the tower's arms. As Super Heavy slows down during its landing approach, a sonic boom would be generated. Once near the landing location, Super Heavy would ignite its engines to conduct a controlled landing. Based on measurements taken during Starship-Super Heavy operations in Boca Chica, Texas, the plume at LC-39A is expected to reach 90°F approximately 96 feet from the landing pad for both Starship and Super Heavy booster landings.

Super Heavy would land vertically at the catch tower at LC-39A or other landing location, such as a floating platform within one of the ocean landing areas, and go into an automated safing sequence wherein the engines shut down and any remaining LOX and methane would be offloaded to ground storage or released to the atmosphere (LCH_4 converts to gaseous form when it is released). If landing at the catch tower, another plume would be generated and the deluge system would be employed, utilizing approximately 68,000 gallons of water. Due to the risks to personnel, SpaceX is unable to reconnect the vehicle to ground systems when methane remains on the vehicle. In the future, SpaceX may recycle methane back into tanks, as technology and design develops.

While SpaceX intends Super Heavy to be fully reusable and to RTLS following operational flights, expending (i.e., not recovering) vehicles may be required; SpaceX anticipates this to be an infrequent occurrence given the goals of the reusable concept. Super Heavy could be expended in the Atlantic Ocean during the initial stages of launch operations at KSC if mission payload or desired orbit requirements would result in too little propellant remaining in Super Heavy to RTLS (Figure 1-6). This expenditure process would occur within several minutes after launch and Starship separates from the Super Heavy booster. An expended Super Heavy would break up above the ocean's surface or on impact with the ocean's surface, or it would sink. Some residual propellant would remain in an expended Super Heavy, and the impact would disperse settled remaining propellants and drive structural failure of the vehicle. The structural failure would allow the remaining propellant to mix, resulting in an explosive event upon impact with the ocean's surface.

SpaceX has a requirement to surveil the splashdown area before committing to launch and will stand down if the area cannot be confirmed clear of vessel traffic. A number of spotter aircraft, including drones, and surveillance vessels (or boats) are used during launch activities to ensure that designated hazard areas are clear of non-participating crafts. Combinations of radar, visual spotter aircraft, surface surveillance, and law enforcement vessels, may be deployed prior to launch. Most fixed-wing aircraft operate at altitudes of 15,000 feet (4,572 meters) but may drop to 1,500 feet (457 meters) to obtain a call sign visually from a non-participating vessel.

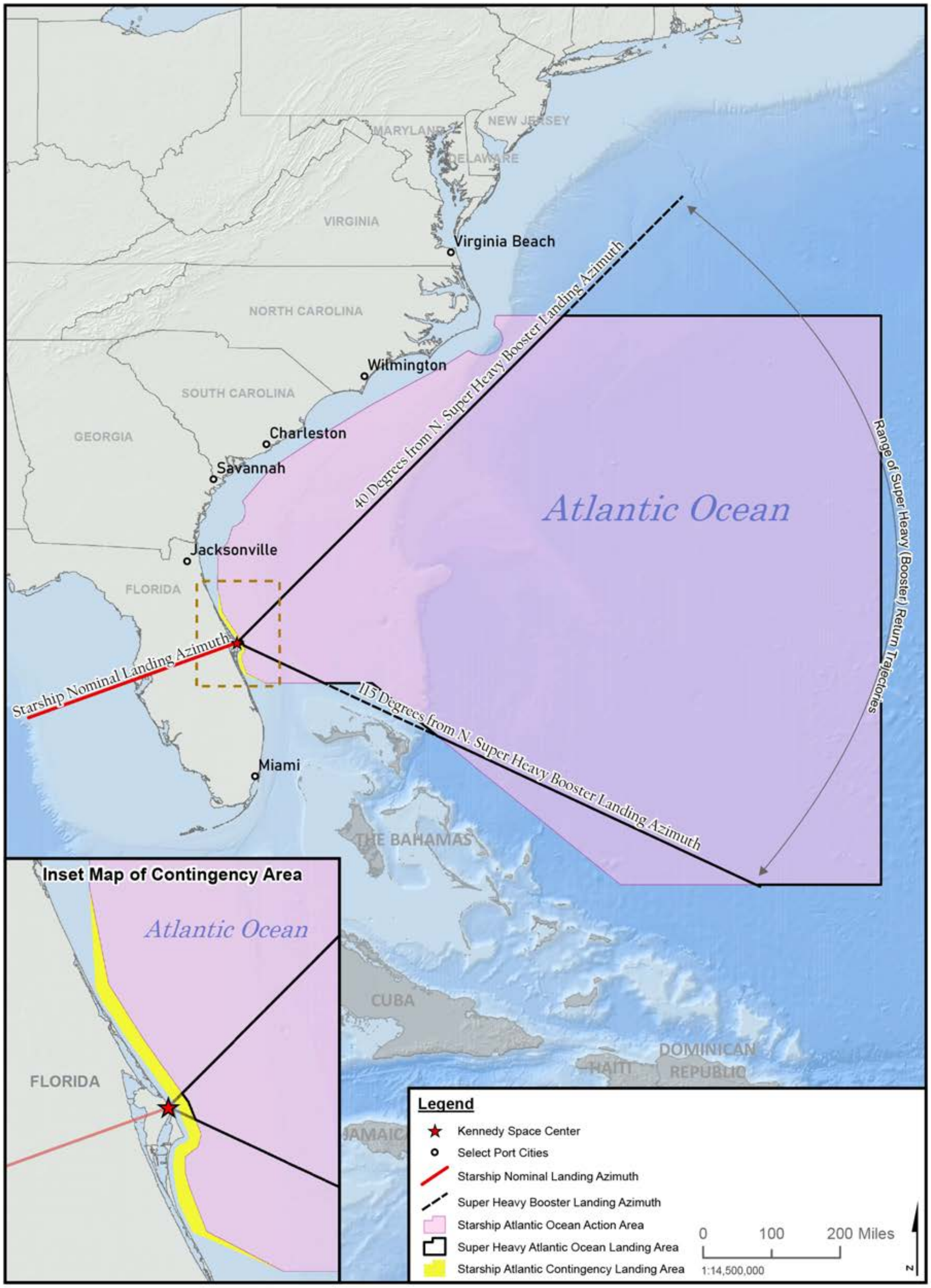


Figure 1-6. Proposed Starship and Super Heavy Landing Trajectories and Atlantic Landing Areas

Super Heavy could also conduct a soft water landing where the vehicle's engines would fire prior to impact with the ocean's surface, causing the vehicle to land vertically and intact. The vehicle would then take on water and sink on its own, be scuttled (purposefully sunk), or transported back to land. If recovered in the open ocean, via water landing or on a droneship (dimensions are unknown at this time; Starship-Super Heavy would employ a similar concept of operations to the Falcon offshore recovery model[5] but would likely require newer droneships), it would be delivered by vessel to Port Canaveral or the KSC turn basin and transported horizontally the remaining distance to the proposed launch site or other SpaceX facilities over the roadways.

Following Super Heavy landings at LC-39A, the vehicle may be transported from the landing pad to the adjacent launch mount or to one of SpaceX's production locations over the roadways for refurbishment. Any potential refurbishment actions would take place at SpaceX's facilities at the launch site or at other SpaceX facilities at KSC. No roadway improvements to support transportation are proposed as part of this Proposed Action. At this time, SpaceX does not anticipate a scenario where Super Heavy would launch from KSC and land at CCSFS and this is not addressed in this BCA.

STARSHIP LANDINGS

- Controlled descent (all result in sonic boom)
  - Return to LC-39A
  - Return to droneship in Atlantic Ocean
  - Pacific, Atlantic, Indian Ocean hard landing – terminal velocity impact with ocean surface; result in destruction of Starship
  - Pacific, Atlantic, Indian Ocean soft landing – allows ocean surface landing where vehicle is intact; Starship sinks or is scuttled
  - Debris is recovered if possible
- Uncontrolled descent
  - Starship breaks up during reentry in broad open ocean areas of Pacific or Indian Oceans
  - Debris is recovered if possible

Starship Landings

Starship could land at LC-39A, on a droneship in the high seas between 55 degrees south latitude and 55 degrees north latitude, or in the Atlantic Ocean (dimensions for the droneship are unknown at this time; Starship-Super Heavy would employ a similar concept of operations as the Falcon offshore recovery model[6] but would likely require newer droneships). In the Atlantic Ocean, SpaceX may land the Starship vehicle anywhere within the boundary of the Starship Atlantic Landing Area depicted in Figure 1-6. Proposed Starship and Super Heavy Landing Trajectories and Atlantic Landing Areas. However, part of the Starship Atlantic Landing Area consists of an Atlantic Contingency Landing Area, which is between 1 nm and 5 nm) from shore and runs 50 miles north and south of LC-39A (Figure 1-6). The remainder of the Atlantic landing area begins 5 or more nm from shore. Starship contingency landing operations could occur up to five times per year during the initial years of operation at KSC when something impedes use of the catch tower, there are issues with vehicle operating parameters, or other extenuating safety circumstances which prevent Starship RTLS landing operations at KSC. The proposed Starship nominal reentry trajectory is shown in Figure 1-6. The timeframe for recovery of Starship within the Atlantic Ocean

[5] https://newspaceeconomy.ca/2024/07/12/spacexs-offshore-recovery-fleet-enabling-reusable-rocketry/#:~:text=To%20recover%20Falcon%209%20payload,halves%20out%20of%20the%20water.

[6] https://newspaceeconomy.ca/2024/07/12/spacexs-offshore-recovery-fleet-enabling-reusable-rocketry/#:~:text=To%20recover%20Falcon%209%20payload,halves%20out%20of%20the%20water.

contingency landing area would be dependent upon the location of occurrence and the rapidity of the SpaceX recovery team's mobilization. Should Starship land in shallow waters, SpaceX would coordinate with the USCG to mitigate any potential navigable hazard until recovery is accomplished. SpaceX recovery personnel would follow standard salvage procedures in compliance with applicable state and Federal requirements for the salvage activity and perform an assessment of structural stability required to tow and stabilize Starship as it is returned to the Port. Recovery operations typically consist of one barge and a tug boat.

As shown in Figure 1-7, Starship would perform a controlled descent using atmospheric resistance to slow the vehicle down and guide it to its landing location. Guidance systems are used to maneuver the vehicle, and trajectories determine flight paths. As Starship slows down during its landing approach, a sonic boom would be generated. If landing at the catch tower, another plume would be generated and the deluge system would be employed, utilizing approximately 68,000 gallons of water. Following a successful landing, Starship would go into an automatic safing sequence (i.e., put the vehicle in a safe state). After Starship is in a safe state, a mobile hydraulic lift would raise Starship onto a transporter. If a Starship landing occurred downrange in the broad ocean area, it would be delivered by vessel to Port Canaveral or the KSC Turn Basin and transported the remaining distance to the proposed launch site or other SpaceX facilities over the roadways. Following Starship landings at the launch site, it would be transported from the landing pad to the adjacent launch mount or to one of SpaceX's production locations over the roadways for refurbishment. Any potential refurbishment actions would take place at SpaceX's facilities at the launch site or at other SpaceX facilities at KSC.

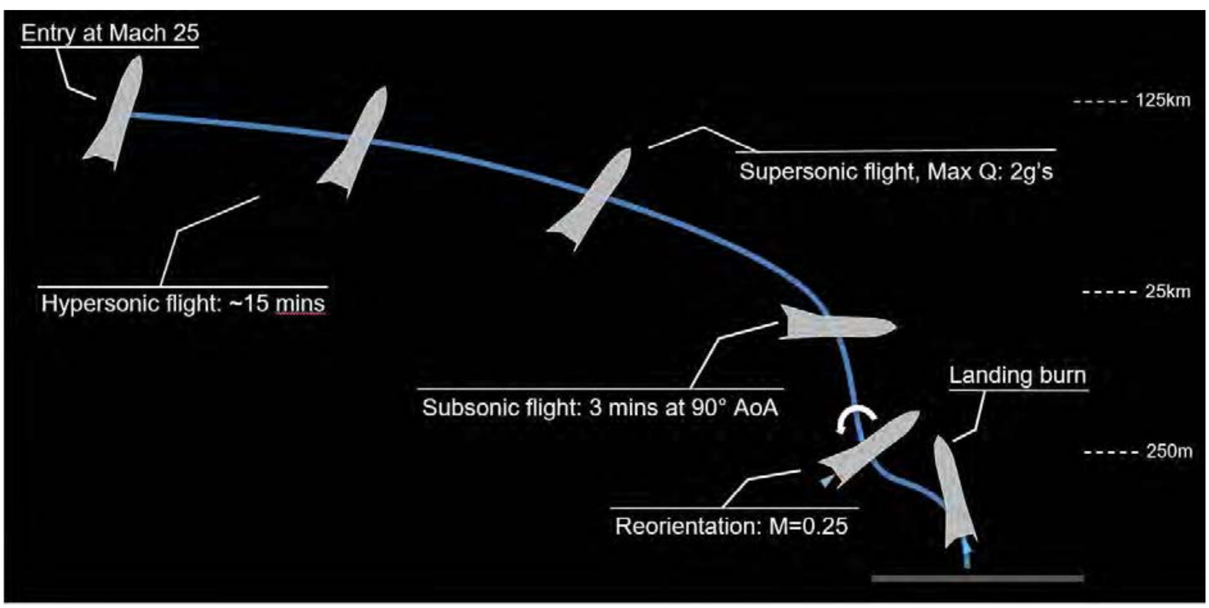
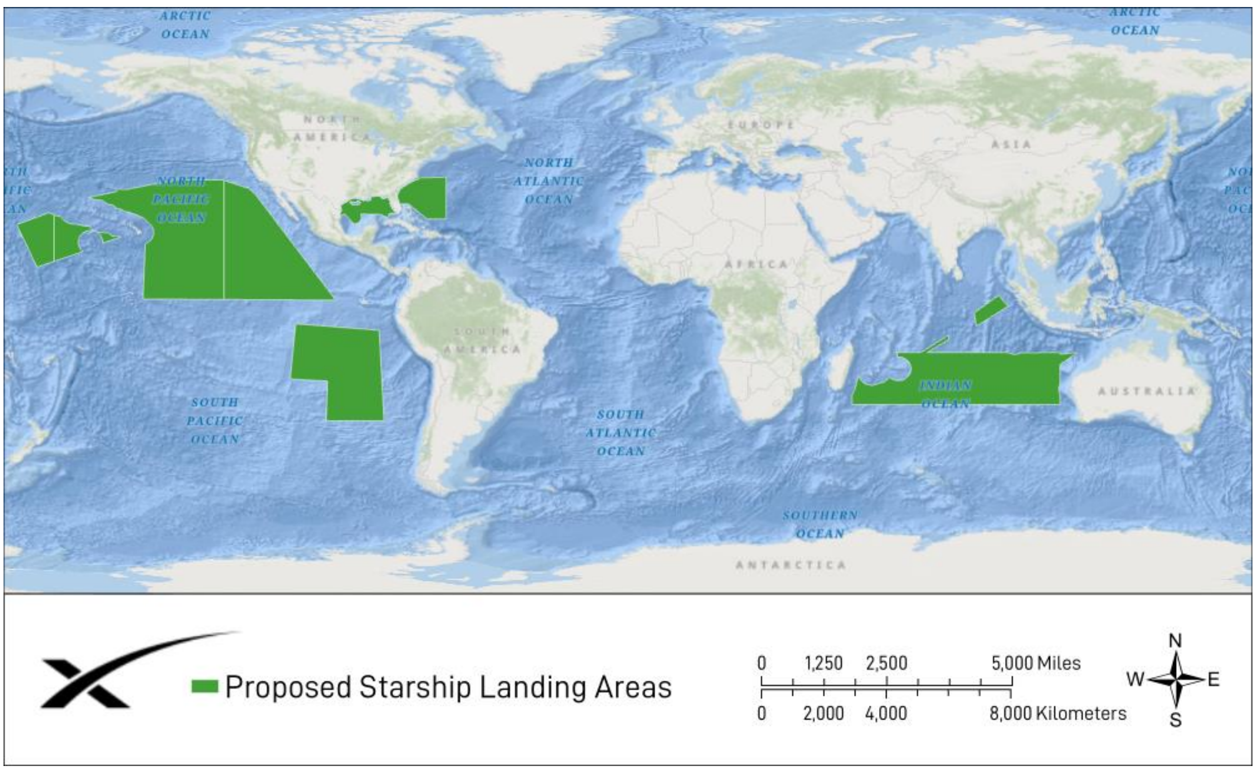


Figure 1-7. Proposed Starship Reentry and Landing

While SpaceX continues to prove accuracy and capability, SpaceX could require expending Starship during early program launches in the broad open ocean, as shown in Figure 1-8. SpaceX anticipates this to be an infrequent occurrence given the goals of the reusable concept. Starship could be expended in two different ways: a controlled descent that would result in Starship's intact impact with the ocean's surface (hard or soft landing) or an uncontrolled descent resulting in breakup during atmospheric reentry[7]. The timeframe between launch and expenditure (as well as location of expenditure) would vary, depending on mission requirements (e.g., the length of the mission, associated trajectories). If SpaceX assets are in the vicinity, an attempt would be made to recover Starship. SpaceX has a requirement to surveil the splashdown area before committing to launch and will stand down in the event the area cannot be confirmed clear of vessel traffic.

For uncontrolled descent, SpaceX could expend Starship through a breakup during atmospheric entry. Descent target areas would be in the broad open ocean shown in Figure 1-8. SpaceX expects most of the launch vehicle debris would sink because it is made of steel. Lighter items not made of steel, such as composite overwrapped pressure vessels, may float but are expected to eventually become waterlogged and sink. If large debris remains, SpaceX would coordinate with a party specialized in marine debris to survey the situation and sink or recover as necessary any large floating debris. SpaceX would coordinate with all land and water regulatory authorities, including the USCG and the State Department, prior to recovering debris to ensure it is recovered as expeditiously as possible.



Note: The Gulf of America Landing Area is not part of this Proposed Action.

Figure 1-8. Proposed Starship Ocean Landing Areas

Following an orbital landing, Starship would have remaining LOX and LCH_4 in the vehicle. Remaining LOX would be released to the atmosphere, and remaining LCH_4 would likely be released to the atmosphere or safely combusted. Due to risks to personnel, SpaceX is unable to reconnect the vehicle to ground systems when LCH_4 remains on the vehicle. In the future, SpaceX may recycle LCH_4 back into tanks, as technology and design develops.

[7] When Starship is not configured to survive atmospheric reentry (e.g., lack of sufficient propellant), Starship would tumble as it descends through the atmosphere and break apart at greater than 31 miles (50 kilometers) above ground level (based on telemetry data).

At this time, SpaceX does not anticipate a scenario where Starship would launch from KSC and land at CCSFS and this is not addressed in this BCA.

1.4.2.4 Trajectories

Starship-Super Heavy launch vehicle trajectories would be specific to each particular mission. Flight trajectories vary based on mission specifics such as desired payload orbit. Starship-Super Heavy launch azimuths would range from 40 degrees to 115 degrees, from a reference of due north at 0 degrees and due east at 90 degrees (see Figure 1-5). RTLS trajectories would be the same for the Super Heavy booster; however, RTLS for Starship would be from the southwest to northeast over central Florida as shown in Figure 1-6. Existing restricted airspace parameters would not need to be modified for Starship-Super Heavy operations.

1.4.2.5 Payloads

In general, payloads and their associated materials/fuels/volumes are mission dependent but would be like current commercial and government payloads analyzed in the *Environmental Assessment for Launch of NASA Routine Payloads* (NASA, 2011). Starship-Super Heavy program payloads would be like, but larger than, current and planned payloads launched on Falcon 9 or Falcon Heavy and range from 100,000 to 150,000 kilograms. Missions could include cargo and spacecraft flights to various orbits, the moon, Mars, and other destinations. SpaceX is also proposing to launch orbital propellant transfer missions, where Starship would carry propellant to refill orbital fuel depots. Payload volumes for Starship propellant tankers and depots could be as much as 2,650 MT; propellant is only carried in parts of the vehicle that are inherent to Starship's primary propulsion system. Crewed missions are not part of the Proposed Action.

Infrastructure Summary (Size is approximate)
Previously approved in 2019 NASA EA (already developed/under development): - LOX Farm (65,454 square feet [SF]) - Methane Farm (78,876 SF) - Launch Mount (36,568 SF) - Integration Tower (6,184 SF) - Evaporation/Retention Ponds (68,799 SF) - Vaporization Farm (9,650 SF) - Landing Zone (72,672 SF) - LN_2 Farm (13,342 SF) - Water Farm (17,955 SF) Included as part of this Proposed Action: - Air Separation Unit (222,071 SF) - Catch Tower (5,992 SF) - Deluge Pond (121,963 SF) - Liquefaction – includes natural gas pretreatment and methane liquefier (17,246 SF) - MegaPacks (34,979 SF) - Power Hub (28,998 SF) ***Total Square Footage: 800,647 SF***

1.4.3 LC-39A Infrastructure

A conceptual plan of proposed infrastructure improvements at LC-39A is shown in Figure 1-9 and described in the following sections. The figure shows facilities that were previously approved for construction (and currently under development) under the 2019 NASA EA, as well as those associated with this Proposed Action. Development would be limited to within the fence line of LC-39A. It is estimated that remaining construction would last up to 2 years. Launch activity may begin before construction activities for support facilities have been completed.

1.4.3.1 Super Heavy Catch Tower

SpaceX would construct an additional tower within the LC-39A fence line to support landing operations (Figure 1-9). While the integration tower used for launch could support Super Heavy landings, an additional landing tower would reduce launch pad refurbishment needed between each launch, providing a shorter turnaround period between launches and increasing the efficiency of launch operations. The catch tower would be approximately 480 feet (146 meters) tall and be similar in appearance to the existing integration tower.

1.4.3.2 Propellant Generation

The Starship-Super Heavy Raptor engines are powered by LOX and LCH_4. SpaceX is proposing to construct onsite facilities for propellant generation and propellant storage, and storage tanks for LOX and LCH_4 are under construction as approved under the 2019 EA. Propellant generation facilities would be operated using natural gas and/or existing electrical power lines and “MegaPacks” (a large-scale rechargeable lithium-ion battery stationary energy storage product that can store up to 3.9 megawatt-hours of electricity). The current concept of operations is that commodities would be trucked to LC-39A to generate propellant. For the purposes of a “maximum use” analysis in this BCA, current estimates of the number of trucks per launch for commodities include 270 for LOX, 80 for LN_2, and 90 for LCH_4. At 44 launches per year, this equates to a total of 19,356 trucks per year. During a 12-hour period for operations occurring 365 days per year, this approximates to 53 trucks per day (or 4-5 trucks per hour). However, there could be more or fewer trucks per hour depending on launch frequency and specific commodity needs. There would be a pull-off for opposite flowing traffic with an estimated wait time of 5 minutes. Traffic following Starship-Super Heavy, cargo, and payloads to LC-39A would need to wait until arrival at LC-39A or pause to pass with an expected wait time of 15 minutes. Bulk storage of commodities would serve to also minimize the need for trucks over time. SpaceX would process natural gas brought to the site for propellant generation. A natural gas pretreatment system would remove impurities such as mercury, sulfur, water, carbon dioxide, and hydrocarbons heavier than methane from the natural gas to produce a stream of higher purity gaseous methane; impurities would be captured through a filtration system and managed according to KSC solid and hazardous waste requirements. Surplus natural gas would be used for process work and power generation or would boil off like a natural gas line venting. Natural gas systems typically have a venting mechanism (like in all propane tanks) to vent so it does not explode if under too much pressure; in industry this is called a relief valve.

In the future, natural gas would be supplied to LC-39A through a multi-user pipeline extending from the existing natural gas mainline on KSC. Florida City Gas is in the process of planning an underground pipeline extension at KSC to provide additional service; no details are currently available regarding specific location or timeframe. The extension of the pipeline would occur regardless of this Proposed Action. The natural gas pretreatment system would include a small amine treating unit for carbon dioxide removal, a scrub column to remove heavy hydrocarbons that would be up to 100 feet (30 meters) tall and 10 feet (3 meters) in diameter, and four to six smaller vessels approximately 6 feet (2 meters) in diameter and up to 30 feet (9 meters) tall.

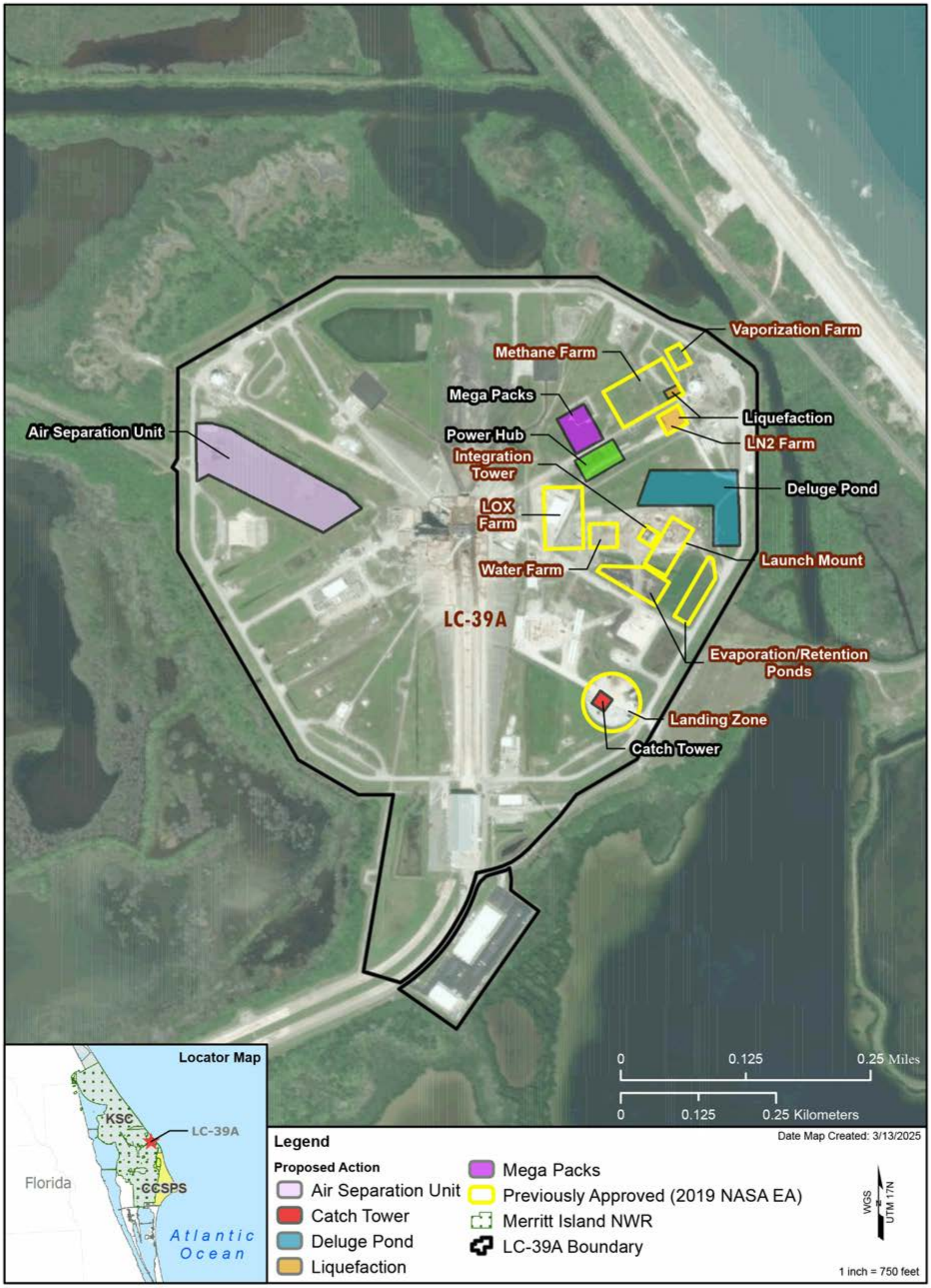


Figure 1-9. Proposed LC-39A Infrastructure

As part of the liquefaction process, SpaceX proposes to construct a methane liquefier to supercool pretreated natural gas into a liquid state for storage and transportation to the launch vehicle. The liquefier would use a compressor and turboexpanders to operate an inert gas refrigeration cycle with nitrogen or air to liquefy the methane in a primary heat exchanger. The natural gas pretreatment and liquefier together would be comprised of several structures each up to 65 feet (20 meters) tall. The methane liquefier would be cooled by a typical evaporative cooling tower, requiring up to 30 cubic meters per hour (approximately 9 cubic yards [8,000 gallons per hour]) of water (acquired through existing water pipelines) and producing up to 3 cubic meters per hour (800 gallons per hour) of wastewater, which would be captured by evaporation/retention ponds as identified in Figure 1-9.

SpaceX proposes to construct an air separation unit (ASU) within the LC-39A fence line to generate LN_2 and LOX to support launch activities. An ASU dehumidifies, liquefies, and separates air into its major components (oxygen and nitrogen). The liquid would then be transferred via pipeline to storage tanks at LC-39A. In addition to the primary oxygen and nitrogen liquid products, a waste nitrogen stream composed of rejected atmospheric gases would be produced (primarily nitrogen, oxygen, and argon) that would be vented back to the atmosphere; the amount to be vented is unknown. However, an ASU primarily emits only the air gases already present in the atmosphere, meaning its primary emissions are essentially “clean air” with minimal impurities, as the process primarily separates air into its constituent components like nitrogen and oxygen, with minimal additional emissions (European Industrial Gases Association, 2017).

The ASU would be cooled by a typical evaporative cooling tower, requiring approximately 75 cubic meters per hour (approximately 98 cubic yards [20,000 gallons] per hour) of water and producing approximately 7 cubic meters per hour (approximately 9 cubic yards [2,000 gallons] per hour) of wastewater. Water/wastewater would be managed in the same way as identified for the evaporative cooling tower as discussed previously. The ASU would be up to approximately 180 feet (55 meters) tall with supporting infrastructure up to approximately 60 feet (18 meters) tall. An onsite ASU reduces the need to transport nitrogen and oxygen to LC-39A from offsite via trucks as discussed previously.

Wastewater generated by the ASU and stormwater would be treated onsite via evaporation and retention ponds. Any residuals may be treated on-site, hauled off, or conveyed in a wastewater system that has capacity. On-site treatment could include but is not limited to methods such as membrane aerated biofilm reactors or other processes. Reclaimed wastewater could then be discharged on site via a stormwater pond, exfiltration trenches, infiltration basins, class V group 6 drainage wells, percolation/evaporation ponds, industrial evaporators, used for irrigation purposes or some other permitted method. If discharge would occur, SpaceX would acquire all necessary permits from the St. Johns River Water Management District. Utility work within LC-39A would occur to provide power and water to the system., with any new utility lines placed underground. As mentioned previously, up to 12 MegaPacks would be installed to support 24 MW/48 megawatt-hours of power generation. Existing commodity tanks would be used where practicable, and a 10,000-gallon aboveground storage tank would be constructed to store LN_2 for system purges. Propellant generation infrastructure location is shown in Figure 1-9.

1.4.3.3 Deluge and Diverter System

In general, the deluge system would apply a large amount of water to rapidly cool and create a barrier between the steel plate of the launch mount and rocket exhaust that would help to absorb sound energy and heat produced by the rocket engines and would allow the steel plate to be reused. It is expected that approximately 92 percent of the water would be vaporized by the heat of the rocket engines (FAA, 2023). Water delivery to the site would be by truck or pipeline as previously described and stored in tanks.

The deluge system and associated operational parameters are still in the design phase, and specific details are currently unknown. However, the diverter is expected to be bifurcated and divert the heat plume and exhaust vertically to reduce the radial extent of the plume, and deluge system components and operational parameters would likely include water containment, water storage, press tank (to push water through the system), a pumping system and piping network, and a control system and valves. SpaceX proposes to construct additional pond(s), if needed, to manage water associated with deluge and stormwater within LC-39A. Preliminary locations are shown in Figure 1-9. The deluge system would be activated during each ignition event on the orbital launch pad, including engine ignition tests and launches, and during landings. Each launch is associated with an estimated two static fire engine tests (one each for Starship and Super Heavy). Therefore, the deluge system may operate up to 220 times per year (44 static fires of Starship, 44 static fires of Super Heavy, 44 launches, 44 Starship landings, and 44 Super Heavy landings).

The deluge system would be activated immediately prior to an engine ignition or landing event, allowing water to flow from the storage tanks, through the piping network, and to the spray nozzles at the launch pad. Five seconds prior to ignition, water would begin discharging. Most of this preignition water would be captured by the containment structures. The amount of water applied during activation of the deluge system will differ depending on the type of ignition event. With estimates of 300,000 gallons per static fire event (88 total), 400,000 gallons per launch (44 total), and 68,000 gallons per landing (88 total), SpaceX estimates that up to 50 million gallons of water per year would be utilized for operations at the site (approximately 137,000 gallons per day); approximately 92 percent of deluge water utilized is vaporized during operations. SpaceX plans to reuse deluge water that is retained onsite (i.e., not evaporated). The system would pump and filter water from the deluge pond into storage tanks for reuse. In the event SpaceX is unable to reuse the deluge water, it may be hauled off site, discharged, or land applied. Prior to any discharge or land application, SpaceX would apply for any applicable Florida Department of Environmental Protection permits. All ponds would be lined to prevent percolation of contaminants into the groundwater and would be maintained and monitored by SpaceX. Berms would be built around the ponds to eliminate additional storm/rainwater inflow/outflow. No deluge water would enter the Banana River or adjacent waterbodies or wetlands.

During engine ignition of the Starship-Super Heavy, the surface of the pad flame diverter could experience a small amount of ablation (erosion of steel from the metal surface resulting from heat and force; considered common on metal launch infrastructure). The ablated steel would quickly recondense near the launch mount when exposed to the deluge water. The metal components of the steel could remain localized to the launch pad, captured in the deluge water and retained onsite, or dispersed in vapor. Per findings presented in the 2024 *Draft Tiered EA for SpaceX Starship/Super Heavy Vehicle Increased Cadence at the SpaceX Boca Chica Launch Site* in *Cameron County, Texas* (FAA, 2024), the amount of metal deposition from the vapor plume is expected to be minimal and monitoring would be conducted to ensure levels do not exceed accepted levels.

SpaceX would implement sampling protocols in accordance with an amended Multi-Sector General Permit for industrial stormwater from the Florida Department of Environmental Protection, and would remove water containing contaminants that exceed the water quality criteria and haul it to an approved industrial wastewater treatment facility. SpaceX would pump all other water not within permitting standards back to the water storage tanks for the deluge system.

1.4.4 Launch Vehicle Transport and Refurbishment

Fabrication, assembly, delivery, and integration of components would be as described in the 2019 EA and would occur at existing SpaceX facilities located on KSC and CCSFS[8]. Most manufacturing and assembly would occur at the SpaceX facility at Boca Chica, Texas, and Cidco Industrial Park, Cocoa, Florida. Starship or Super Heavy components would be delivered over roadways on a mobile transporter like the transports performed for Falcon. Large vehicle components would be transported by barge from the Port of Brownsville, Texas, utilizing the KSC Turn Basin to the Vehicle Assembly Building location, then via Crawlerway to LC-39A (Figure 1-10). Transport of supplies and vehicle components would involve approximately 40 barges per year transiting to the Turn Basin and five barges per year transiting to Port Canaveral. These are the same locations and processes utilized for current large vehicle transport (i.e., Falcon) and were used during the Shuttle Program.

Transport of Starship-Super Heavy and related components to and across KSC would generally occur as transport of rocket components currently does at KSC. This could include transport via barge or over land from SpaceX production sites, including Boca Chica, Texas, and Hawthorne, California, using standard transportation methods and routes. Any potential refurbishment actions would take place at SpaceX's facilities at KSC. Starship-Super Heavy would be transported from LC-39A to a SpaceX facility via SpaceX transporter over KSC roadways (Figure 1-11). At this time, no improvements to KSC infrastructure outside those previously identified for LC-39A are proposed. Improvements to KSC infrastructure that would support general SpaceX and other KSC operations were previously analyzed and approved through ESA Section 7 consultation (NASA, 2024a).

Similar processes would be followed for landings, recoveries, and salvage operations in the Atlantic Ocean. Planned landing and recovery operations for Super Heavies and Starships in the Atlantic landing area (greater than 5 nm offshore) would involve one droneship barge and one tug per vehicle per event. The droneship barge/tug would unload the vehicle at the Turn Basin, and the droneship barge would be docked at Port Canaveral. Contingency Starship salvage operations in the Atlantic (between 1 and 5 nm offshore) would involve one salvage barge and one tug per event. The salvage barge/tug would unload the Starship at the Turn Basin.

1.5 Kennedy Space Center Monitoring and Education Activities

This section describes the current monitoring and educational outreach conducted for federally listed species at KSC. Under the Proposed Action, NASA has committed to the continuation of the following educational efforts and species monitoring. These activities support recovery actions, such as population monitoring and research to improve the understanding of Florida scrub-jay distribution and abundance.

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[8] See Section 2.1, Page 12, of the *Final Environmental Assessment for the SpaceX Starship and Super Heavy Launch Vehicle at Kennedy Space Center (KSC) (https://netspublic.grc.nasa.gov/main/20190919_Final_EA_SpaceX_Starship.pdf)*

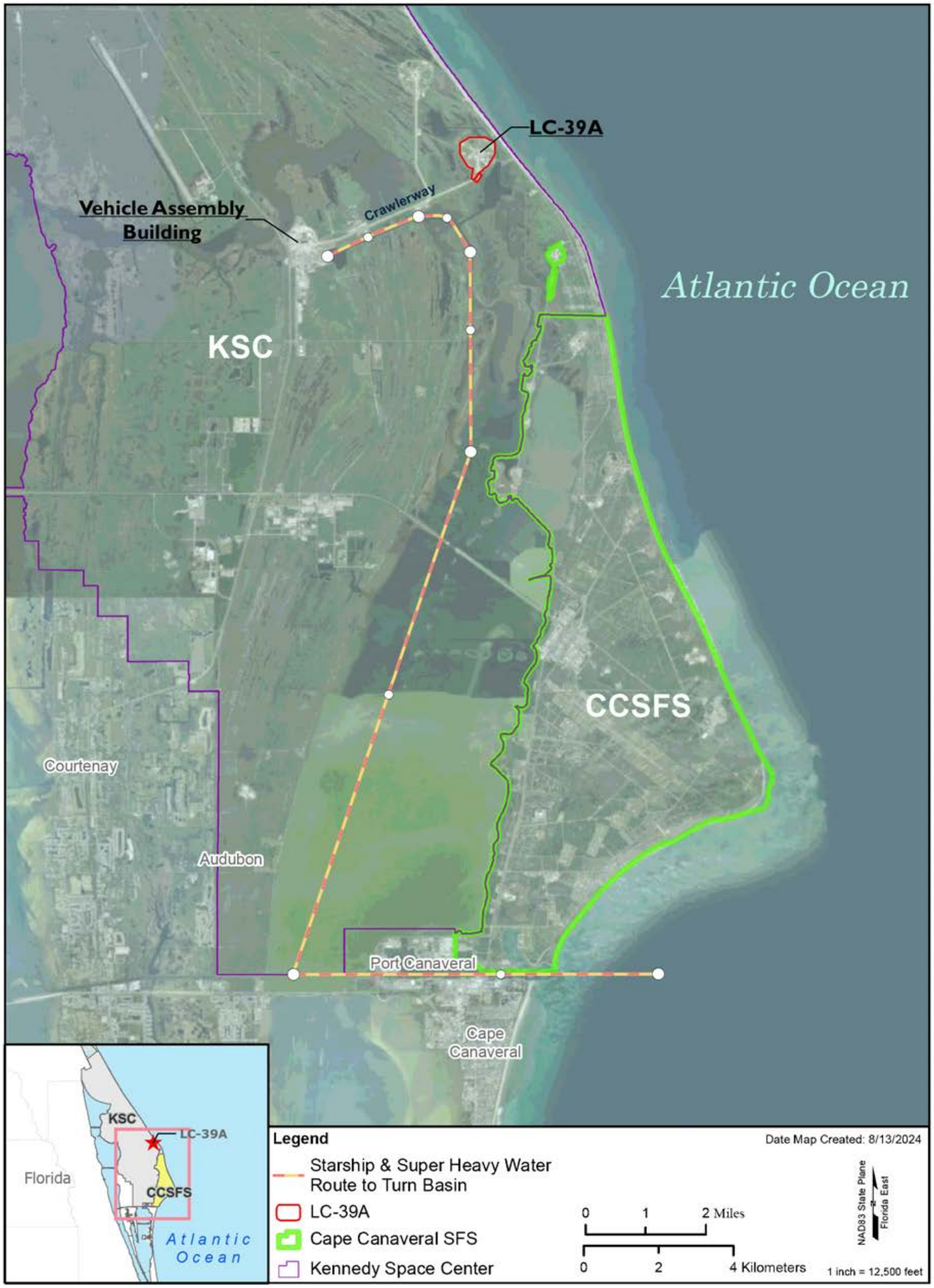


Figure 1-10. Barge Transport Routes

Figure 1-11. Land Transportation Routes at Kennedy Space Center

Florida Scrub-Jay

NASA implements the following monitoring for Florida scrub-jays at KSC:

- Territory mapping for all groups censused using an estimated 40-50 surveys primarily during April and May. Territories define the boundaries where recruitment, survival, and dispersal are measured.
- Color banding of immigrants and young within core populations with the goal of maintaining banding on 90 percent of the adult core population.
- Determination of family composition of Florida scrub-jays (birds by sex and breeding status) for each group once per month within current core populations.
- Determination of the number of juveniles in July using approximately 20-30 surveys within the core population.
- Identification of the habitat states of all potential territories (grid cells) within the focal Florida scrub-jay landscape using approximately 10-15 surveys. The occurrence of fire or mechanical cutting is recorded in potential territories each year allowing habitat quality monitoring of Florida scrub-jay habitat compensation areas and management actions.
- Opportunistic counts of Florida scrub-jay families in several focal landscapes where the number of families are estimated. These peripheral survey counts may be summarized once per year, if requested by the Environmental Management Branch (EMB) and MINWR, to reevaluate total population size and rank the importance of burn units.
- Support of the *Florida Scrub-Jay Compensation Plan* and associated BO and the Population Viability Analysis by collection of detailed habitat data on openings in scrub oak, vegetation height, and transitions between habitat states resulting from different management actions. Specific actions include:
    - Characterizing habitat quality in potential territories using fire history and Light Detection and Ranging (commonly known as LiDAR) if available.
    - Linking habitat management to long-term population sustainability.
    - Identifying actions needed to convert Florida scrub-jay territories from sinks to sources.
    - Developing maps that delineate openings in Florida scrub-jay core and support habitat for each year that suitable high-resolution imagery is available.

Southeastern Beach Mouse

NASA does not currently monitor for the southeastern beach mouse at KSC unless project-specific monitoring is required (e.g., shoreline restoration).

Manatees

NASA conducts systematic surveys of the distribution and abundance of Florida manatees in portions of the Indian River Lagoon (IRL) near and within NASA property, including Mosquito Lagoon, Banana Creek, and the KSC portion of the Banana River from State Road 528 North. During surveys, animal location, attribute information (e.g., behavior, number in-group, number of adults and calves), and environmental conditions are recorded. These quantitative data allow comparison of trends both seasonally and annually, and use patterns related to habitat features, such as depth and seagrass beds. NASA conducts four surveys by helicopter each year. The timing of surveys is determined in cooperation with EMB technical managers and local subject matter experts.

Eastern Indigo Snake

NASA does not currently monitor the eastern indigo snake at KSC; project-specific surveys are conducted as needed.

Sea Turtles

NASA and MINWR (through a cooperative agreement) conduct the following sea turtle monitoring for the 10 kilometer stretch of KSC beach within the secure area of the property, starting at the CCSFS northern boundary (kilometer 23) and extending to the northern terminus of the KSC secure/fenced area (kilometer 33). Nesting season surveys for KSC are performed daily from May through August by MINWR biologists in accordance with the Index Nesting Beach Survey protocols from the Florida Fish and Wildlife Conservation Commission, including a subsample of marked nests, as described by the Florida Fish and Wildlife Conservation Commission Nest Protocol Assessment. Details on nest success and the disorientation of marked nests are collected to identify sources and potential corrective measures for lighting that may impact nesting and hatchling sea turtles.

In addition to the MINWR information, KSC EMB conducts approximately six nighttime lighting surveys per sea turtle season. The survey identifies facilities that should meet compliance with proper lighting bulbs, fixtures, and timers, as outlined in each facility's Lighting Operations Manual (LOM). In 2024, 19 main support areas were visited during each lighting compliance survey. Facilities that are identified as non-compliant are classified into three groups, as follows:

1. Non-compliant but exempt due to operational safety constraints.
2. Non-compliant with potential for retrofit or upgrades in upcoming funding cycles.
3. Facilities that should meet compliance by having proper lighting bulbs and fixtures, timers, or the combination of both outlined in the *Exterior Light Management Plan*.

Starting in June 2020, the KSC survey route and reporting method was revised to exclude the facilities that have a LOM or were officially scheduled for retrofit. This streamlined reporting eliminates redundancy; however, observations for any such areas are still recorded. For facilities that are non-compliant, an "out of compliance" letter is sent to the facility manager after each survey.

Wading Birds

NASA currently conducts the following wading bird monitoring annually at KSC:

- Ten monthly aerial surveys annually of foraging habitat use in 13-25 impoundments
- Ten monthly ground surveys
- One nesting colony peak count by boat

- One nesting colony peak count by aerial survey

The foraging habitat use surveys document trends in foraging habitat use by wading birds (e.g., wood storks) within impounded salt marsh and estuarine edge habitats on KSC. The survey includes 20 impoundments, a large freshwater swale, and five sections of estuarine edge habitat along the shores of the Banana River, the Mosquito Lagoon, and the Indian River. The wading bird nesting colony surveys document trends in colonial nesting by wading birds on KSC.

<u>Educational Efforts</u>

NASA conducts educational outreach activities related to the protection and recovery of federally listed species. During sea turtle nesting season, NASA includes information in the KSC Daily News on why sea turtles need dark beaches and measures that employees can take. KSC also places “Lights Out for Sea Turtles” informational posters Center-wide and conducts webinars. Past KSC Sustainability webinars have discussed sea turtle management, prescribed burning and Florida scrub-jays, and other topics that affect listed species such as invasive species and runoff.

1.6 Prescribed Burning at KSC/MINWR

In accordance with the *Non-Reimbursable Interagency Agreement Between the National Aeronautics and Space Administration, John F. Kennedy Space Center, and the U.S. Department of the Interior, Fish and Wildlife Service for Use and Management of Property at the NASA, KSC, known as the Merritt Island National Wildlife Refuge*, (hereafter called the *KSC/MINWR Interagency Agreement*) the USFWS is responsible for conducting habitat and wildlife management activities at KSC, including prescribed burning, forest management, invasive and nuisance species management, water-level management, certain monitoring activities, and other programs deemed appropriate for fish and wildlife protection and enhancement (NASA and USFWS, 2024). The recently updated *Memorandum of Understanding between the Space Launch Delta 45, United States Fish and Wildlife Service, and John F. Kennedy Space Center for Prescribed Burning on Merritt Island National Wildlife Refuge, John F. Kennedy Space Center, and Cape Canaveral Space Force Station, Florida*, (hereafter called the *MOU for Prescribed Burning*) “establishes and defines a coordinated process through cooperative guidelines that allows USFWS to conduct prescribed burns on CCSFS and KSC while protecting personnel, infrastructure, and spaceflight hardware (SLD 45, USFWS, and KSC, 2025).”

1.6.1 KSC/MINWR Burn Planning and Preparation

Per the 2025 *MOU for Prescribed Burning*, USFWS burn preparation and planning responsibilities for fires at KSC/MINWR include:

- Identification of target burn units, burn preparation needs, acreage, and habitat goals for the year
- Completion and maintenance of burn preparations including disking, mowing, and/or mechanical cutting for burn opportunity availability
- Monitoring soils and vegetation moisture and composition maximum burn potential to meet goals and objectives

- Monitoring of range operations, launch schedule, and weather conditions to identify potential burn windows
- Once burn window is identified, notification of parties and mission partners of targeted burn units, back up units, tactical plans, and timing of burn operations

1.6.2 Notification and Coordination in Advance of a Burn

At least three business days in advance of a desired burn operation, MINWR must submit a prescribed burn notification to KSC. For prescribed burns located on KSC/MINWR, KSC Spaceport Integration reviews the planned burn targets, checks on constraints, and reviews burn buffers and GEOSIMS to determine if the scheduled burn targets are viable candidates. Spaceport Integration then communicates burn plans to tenant partners, NASA departments on KSC, and mission partners on CCSFS at least 3 days prior to the planned burn. These groups are invited to participate in the 0800 Operational Status Check meeting, where further discussions occur regarding the specifics of a planned burn each day, including the day of the burn. Anyone is allowed to bring up a dissenting opinion about a burn; the Prescribed Burn Working Group works to address their concerns and resolve any operational barriers to prescribed burning. KSC Leadership believes this MOU will better support prescribed burning, as reflected in Table 1-2, which provides definitions for critical days for launches and critical spaceflight hardware and payloads, as well as criteria for burning as related to the time until their transport/launch and the distance from smoke-sensitive facilities/launches. Note that in the 2025 MOU for Prescribed Burning, there are no prescribed burn restrictions related to non-critical payload transport or mating operations, and the burn buffer around smoke-sensitive facilities has been reduced to 0.5-mile, which greatly increases the opportunity to burn certain ecologically sensitive units to meet regulatory burn requirements.

Table 1-2. Burn Restrictions Related to Launches, Spaceflight Hardware and Payload Transport/Mating, and Contamination-Sensitive Facilities/Launch Sites

Definitions and Restrictions	Critical Day for Launch Operations	Non-Critical Day for Launch Operations	Critical Payload Transport/ Mating Operations(1)	Active Contamination-Sensitive Payload Processing Facilities and Launch Sites
Definition	• Crewed launch • Mission with critical spaceflight hardware or payload (NSA, NRO, GPS, NOAA, NASA, USSF) • Launch vehicle without Certified Autonomous Flight Safety System (AFSS)	• Uncrewed mission • Commercial payload mission • Launch vehicle with Certified AFSS	• Transport/mating for missions including, but not limited to: NSA, NRO, GPS, NOAA, NASA, USSF	• Processing facility currently occupied by smoke-sensitive critical spaceflight hardware/payload • Launch complex with rocket containing critical spaceflight hardware/ payload on the pad in advance of launch
Timing Restrictions	No prescribed burning within 12 hours of a targeted T-0 or launch window opening without the	Burning is permitted through T-0.	Any burning conducted within 48 hours of critical payload transport/ mating operations will be	Prescribed burning restrictions may be implemented to mitigate real-time changes to an active payload processing

Table 1-2. Burn Restrictions Related to Launches, Spaceflight Hardware and Payload Transport/Mating, and Contamination-Sensitive Facilities/Launch Sites

Definitions and Restrictions	Critical Day for Launch Operations	Non-Critical Day for Launch Operations	Critical Payload Transport/ Mating Operations(1)	Active Contamination-Sensitive Payload Processing Facilities and Launch Sites
	concurrence of the launch provider and their customer(s)		conducted with favorable weather, wind directions will be closely monitored for current and post weather conditions for smoke production, and extensive mop-up will be completed in an effort not to place smoke/remnant smoke directly on payload route or mating operations facilities.	or launch site's ability to protect against smoke or particulate contamination.
Distance Restrictions	Prescribed burn operations will be restricted to areas outside scheduled Flight Caution Area (FCA) roadblocks with favorable weather conditions. Outside the secured perimeter of KSC, Prescribed Burn Practitioners (PBP) will be allowed to burn with favorable weather conditions.	Prescribed burn operations will be restricted to areas outside scheduled FCA roadblocks with favorable weather conditions.	No burning to be conducted within scheduled roadblock/ hazard areas if established for mating operations.	PBP will not burn within a 0.5-mile radius unless favorable weather conditions exist and the PBP receives concurrence from the processing facility/ launch customer.

Notes: AFSS = Autonomous Flight Safety System; FCA = Flight Caution Area; GPS = Global Positioning System; KSC = Kennedy Space Center; NASA = National Aeronautics and Space Administration; NOAA = National Oceanic and Atmospheric Administration; NRO =National Reconnaissance Office; NSA = National Security Administration; PBP = Prescribed Burn Practitioners; T-0 = time at which a planned schedule of activties before a launch begins; USSF = U.S. Space Force.

[1] There are no prescribed burn restrictions related to non-critical payload transport or mating operations.

Source: Table developed from information contained in the *MOU for Prescribed Burning* (SLD 45, USFWS, and KSC, 2025).

1.6.3 Education and Agreements

Personnel from multiple KSC organizations continue efforts to educate NASA personnel, tenants, and other user groups on the why and how of prescribed fire. Spaceport Integration and the NASA Environmental Management Branch are the primary organizations disseminating fire information onsite, including general outreach as well as specific briefings to concerned organizations on how the subject burn is going to be conducted and the steps being taken to ensure that it is done safely with minimal impacts to missions and operations. Education efforts for these groups will continue, with a focus on the smoke prediction technologies KSC employs, as well as the importance of prescribed fire to reduce risks such as wildfires and failure to meet regulatory compliance requirements. Personnel from NASA, USFWS, and the USSF recently made a presentation entitled "Why We Burn" to over 200 attendees as part of the KSC Sustainability Speaker Series.

All new and renewed Space Act Agreements (which are written for commercial tenants) include language that tenants must cooperate with NASA and USFWS to coordinate prescribed burning activities at KSC. Tenants are responsible for constructing and upgrading facilities and providing the equipment and systems necessary to protect tenant property and flight hardware from smoke damage. Tenants must designate primary and alternate points of contact for burn coordination. Tenants shall not interfere in any way with the prescribed burning activities that occur on KSC property, including fire preparation activities.

Tenant agreements also include language regarding ESA Section 7 consultation requirements. By signing the lease, the tenant agrees to be fully responsible for meeting the requirements, terms, and conditions set forth in applicable BOs at the tenant's expense. The tenant must perform mitigations required by the BOs to offset impacts to federally listed species and their habitats due to tenant's activities.

1.7 Conservation Measures

As defined in the *Endangered Species Consultation Handbook* (USFWS and NMFS, 1998), CM "are actions to benefit or promote the recovery of listed species that are included by the Federal agency as an integral part of the proposed action. These actions will be taken by the Federal agency or applicant, and serve to minimize or compensate for project effects on the species under review. These may include actions taken prior to the initiation of consultation, or actions which the Federal agency or applicant have committed to complete in a Biological Assessment (BA) or similar document."

1.7.1 Natural Resources Training

These training requirements will be applicable for the duration of construction and operations activities, unless otherwise agreed to by NASA and USFWS-Ecological Services (ES). During development, the training will be provided to USFWS-ES for input.

CM 1. SpaceX will develop natural resources training for contractors and employees. Training will include, but not be limited to, the following topics:

- Instructions on implementing the conservation measures in this BCA and the terms and conditions from the resulting BO, as well as penalties for failure to follow these requirements
- Photos of listed species and their habitats, guidance on wildlife encounters (e.g., do not feed wildlife), and other relevant details, including the importance of dark beaches for sea turtles and prescribed fire for Florida scrub-jay habitat maintenance
- Instructions to immediately report the following to the KSC Duty Office and EMB: injured, dead, or sick wildlife (including road kills); wildlife utilizing buildings or infrastructure for roosting or nesting

- KSC Lighting restrictions (PLN-1210)
- Instructions on how to minimize the introduction and spread of invasive non-native plant species (INPS)
- Speed limits and restriction of vehicles to existing roads, parking areas, paved areas, and authorized construction sites
- Wildfire prevention measures
- Proper disposal of litter and garbage and securing of refuse containers

CM 2. Prior to beginning onsite activities (i.e., construction, operations) and annually thereafter, SpaceX will ensure that all personnel, including staff and contractors, receive the natural resources training. As new staff/contractors come on board, they will receive the training.

CM 3. NASA will continue educational outreach activities related to the protection and recovery of federally listed species (as described in Section 1.5, Kennedy Space Center Monitoring and Education Activities).

1.7.2 General Conservation Measures

These measures are applicable for the duration of construction and operations (e.g., daily operations; vehicle preparation, launches, landings), unless otherwise agreed to by NASA and USFWS-ES.

CM 4. To minimize adverse impacts from temporary and long-term lighting to federally listed species and designated critical habitat within the Action Area, SpaceX will update and follow the LC-39A LOM; the LOM will address applicable requirements for lighting associated with the Proposed Action, including measures for lighting minimization during sea turtle nesting season. SpaceX will submit an updated LC-39A LOM to NASA. NASA will coordinate review of the LOM with USFWS-ES. The LOM must be approved by NASA and USFWS-ES prior to operation of the Proposed Action.

CM 5. Like the beach light monitoring included in the *KSC Center Wide Operations BO*, NASA EMB and MINWR (through cooperative agreement) will monitor for lighting impacts on KSC beaches, take corrective actions (if feasible), and submit annual reports to USFWS-ES.

CM 6. SpaceX will work with NASA, MINWR, and USFWS-ES to develop a plan to implement noise and vibration monitoring at a sub-set of sea turtle nests in the vicinity of LC-39A such that site-specific operational conditions and any effects to sea turtle nests, eggs, and hatchlings can be documented and reported.

CM 7. Any construction project at KSC with the potential to affect protected species requires a biological survey prior to disturbances.

- If a gopher tortoise burrow is discovered within the LC-39A area prior to construction, it will be scoped with an infrared burrow camera. Tortoises will be removed from the burrow either by bucket trapping or excavation with a backhoe. Any discovered indigo snakes will be allowed to leave the site prior to collapsing the burrow. If relocation is necessary, the gopher tortoises and indigo snakes will be relocated in accordance with MINWR protocols.

- If southeastern beach mice or their burrows are observed during pre-construction surveys, NASA will contact the USFWS to determine if relocations are needed based on site conditions. Trapping would occur over three consecutive nights and a total of five nights using Sherman live traps set at 33-foot (10-meter) intervals throughout the vegetated portion of the proposed area to be disturbed by construction activities. Mice would be relocated to the dune east of LC-39A.

CM 8. Construction and operations activities will follow the 2024 *Standard Protection Measures for the Eastern Indigo Snake,* including displaying educational signs/posters, avoiding gopher tortoise burrows, and allowing indigo snakes to leave construction and operations areas unharmed. If an eastern indigo snake (alive, dead, or skin shed) is observed on the project site during construction activities, all such activities will cease until the established procedures are implemented, which includes notifying USFWS-ES (fw4flesregs@fws.gov) and NASA-EMB.

CM 9. To increase wildlife awareness and reduce road mortality for species such as indigo snakes, NASA will continue its coordination with MINWR to develop, install, and maintain wildlife crossing awareness signage on NASA property, particularly along rights-of-way for transportation routes associated with the Proposed Action.

CM 10. Red obstruction lighting for towers will comply with FAA Advisory Circular No. 70/7460-1M, Change 1 (AC 70/7460-1M Chg 1).

CM 11. To discourage protected birds and bats from roosting or establishing maternal colonies on LC-39A infrastructure, buildings, and equipment, SpaceX will incorporate measures such as visual fright devices.

CM 12. Consistent with current SpaceX wildlife management at LC-39A, if SpaceX identifies a listed species in a location where it may conflict with construction or operations at LC-39A, SpaceX will report the occurrence to NASA EMB. NASA EMB will contact MINWR to respond and determine the appropriate next steps, which can include trapping, translocation, removing the bird nest or bat roost, and/or excluding bats from facilities according to best management practices (per cooperative agreement). SpaceX will not remove bats, maternity roosts, bird nests, or other federally listed species before MINWR has evaluated the situation.

CM 13. Per the *KSC/MINWR Interagency Agreement* (NASA and USFWS, 2024) and within the constraints of sensitive payloads and mission operations described in the *2025 MOU for Prescribed Burning* (SLD 45, USFWS, and KSC, 2025), NASA and MINWR will continue to conduct management activities on NASA property at a level that maintains habitat for continued use by federally listed species. Activities will include but not be limited to prescribed burning, fire break maintenance, and invasive and nuisance species control (see Section 1.6, *Prescribed Burning at KSC and MINWR*).

CM 14. NASA and MINWR (through cooperative agreement) will continue to regularly monitor sea turtles, Florida scrub-jays, and manatees on NASA property using current protocols (see Section 1.5, *Kennedy Space Center Monitoring Activities*). SpaceX will continue to coordinate with NASA and MINWR to minimize interference from construction and operations at LC-39A with monitoring efforts for federally listed species.

CM 15. Using data collected per current monitoring protocols, NASA and SpaceX will assess potential changes in the distribution and abundance of sea turtles, Florida scrub-jays, and manatees on NASA property. As part of an adaptive management approach, NASA, SpaceX, SLD 45, and USFWS-ES will meet annually to review monitoring results and determine next steps (e.g., continue or modify monitoring, reinitiate consultation, reduce or terminate monitoring).

CM 16. If southeastern beach mouse monitoring is determined necessary per the Incidental Take Statement, NASA and SpaceX, in collaboration with USFWS-ES and SLD 45, will develop a monitoring plan to assess impacts to the abundance and distribution of southeastern beach mice in the vicinity of LC-39A. As part of an adaptive management approach, NASA, SpaceX, SLD 45, and USFWS-ES will meet annually to review monitoring results and determine next steps (e.g., continue or modify monitoring, reinitiate consultation, reduce or terminate monitoring).

CM 17. To minimize the potential for negative interactions with manatees, SpaceX barge/boat operations will follow the following manatee protection measures, which are primarily applicable for Proposed Action operations within IRL and within 1 mile offshore in the Atlantic Ocean, 50 miles north and south of LC-39A.

- SpaceX will provide a dedicated observer (e.g., biologist or person other than the watercraft operator that can recognize manatees) that is responsible for surveying for manatees with the aid of binoculars during all in-water activities, including transiting estuarine and marine waters for surveillance or for transport of supplies, boosters, spacecraft, or other launch-related equipment or debris.
- When a manatee is sighted, the observer will alert the vessel operators to maintain a minimum distance of 50 feet from the animal. Boats will make all efforts to avoid passing over a submerged manatee. If the vessel is not able to avoid passing over a submerged manatee, the engine will be placed in idle until the animal is clear of the area. The engine will be placed in idle only if navigation and safe operation of the vessel can be maintained. If safe operation and navigation of the vessel cannot be maintained with the engine in an idle position, the vessel will operate at the lowest possible speed to maintain navigation and safe operation while reducing potential effects to manatees.
- Vessels will follow routes of deep water and previously established and maintained channels or basins whenever possible.
- Within the IRL, personnel will restrict boat speeds to 10 knots or less outside of the channel in areas where manatees are observed.
- Vessels will operate at "no wake/idle" speeds while near the dock unless human safety considerations dictate otherwise.

CM 18. NASA and SpaceX will document any incidents of injury or death of a federally listed species and report them to the USFWS-ES within 24 hours.

Chapter 2. Action Area

ESA regulations (50 CFR §402.02) define the Action Area as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The Action Area includes: (1) LC-39A, (2) area surrounding LC-39A that would be exposed to traffic, launch plumes, noise, and sonic booms (construction, operational, and launch and landing noise), (3) area in the Atlantic Ocean where Super Heavy boosters and Starship vehicles might land or be expended, (4) area in the Pacific Ocean where Starship vehicles might land or be expended, and (5) area in the Indian Ocean where Starship vehicles might be expended. Note that the landing area in the Indian Ocean and some of the landing areas in the Pacific Ocean are not analyzed in this BCA because no ESA species protected under USFWS jurisdiction are present, as verified in Information for Planning and Consultation (IPaC) searches. The following sections discuss the factors considered in determination of each portion of the Action Area.

2.1 LC-39A and Surrounding Area

Construction Area and Launch and Landing Plumes

Construction would be limited to inside the perimeter fence of LC-39A (Figure 2-1). The plumes generated from Starship-Super Heavy static fire tests and launches would travel away from the launch pad, with an estimated vapor plume extent of up to approximately 0.2 miles and temperatures expected to reach ambient temperature (90°F) by 0.2 miles from the pads (Figure 2-1). For Starship and Super Heavy landings, the estimated vapor and heat plume extent is approximately 96 feet from the landing pad (Figure 2-1).

Propulsion/Engine Noise

Noise disturbances are expected from construction, operational, and launch noise. Different organisms are typically most sensitive to sounds within a limited frequency range and hence will perceive sounds with different frequency spectra differently, even if the sound levels are identical. Noise studies tailored to human health and safety typically weight noise intensities to the human hearing spectrum in a process known as A-weighting. A-weighted decibel (dBA) values are not necessarily appropriate for analysis of wildlife impacts given that species perceive noise differently; for example, high-frequency echolocating bats will have drastically different frequency sensitivities than humans. However, most noise monitoring and studies are geared toward the human environment and are reported in dBA. It may be difficult to find comparative metrics in unweighted decibels. Humans and many species of terrestrial wildlife also do not perceive very low frequency sound, which is a substantial component of launch noise. Therefore, use of unweighted estimates could potentially inflate the analysis of impacts beyond those that would realistically occur.

A noise descriptor/metric for noise effects on wildlife has not been universally adopted, but some research indicates sound exposure level (SEL)[9] is the most useful predictor of responses (FRA, 2012). Much of the research has lacked systematic documentation of the source noise event. Many studies report "sound levels" without specifying the frequency spectrum or duration. A notable exception is a study

[9] SEL values represent the total sound energy of noise event in terms of an equivalent event which only lasts 1 second, providing a consistent comparison basis for sound events of differing durations.

sponsored by the Department of the Air Force that identifies SEL as the best descriptor for response of domestic turkey poults to low-altitude aircraft overflights (Bradley et al., 1990). This study identifies a threshold of response for disturbance of domestic turkeys (100 percent rate of crowding) as an A-weighted SEL (ASEL) of 100 decibels (dB). Another report questions whether an A-weighted sound level used in the SEL for aircraft overflights is appropriate for animals since their hearing differs from humans (Manci et al., 1988). However, because no weighting has been established for representing the hearing characteristics of wild animals, the A-weighted sound level continues to be used.

Sonic Booms

Sonic booms are thunder-like noises that people and animals hear when launch vehicles travel faster than the speed of sound. These high amplitude, impulsive noises are typically quantified in terms of their overpressure, or increase in pressure over atmospheric conditions, as traditional noise metrics do not adequately capture the full array of energetic effects of sonic booms.

An overpressure of 1 pounds per square foot (psf) has been perceived as similar to a clap of thunder (Rylander, 1974). An overpressure of 1 psf is equivalent to a C-weighted[10] SEL of 102 C-weighted decibels. Most sonic boom studies on animals were conducted between 1960 and 1990 due to interest in commercial supersonic travel and generally focused on 1 to 2 psf sonic booms which are typical of aircraft. The scant available information suggests that sonic booms below 1 psf elicit little to no noticeable startle reaction from receptor species (Epsmark, 1972). More pronounced startle reactions have been observed at the 1 psf threshold in some species of birds (Ellis et al., 1991) and mammals (Rylander, 1974), although it is important to note that reactions vary widely based on the species in question.

Summary

Based on the above, NASA delineated the portion of the Action Area surrounding LC-39A as the combination of the outermost predicted (modeled) ASEL 100 dB contour for engine noise (including static fires, launches, and landings) and the outermost predicted (modeled) 1 psf contour for overpressure events. (Figure 2-2). This area encompasses all areas expected to be affected by construction activities, daily operations, heat and vapor plumes, lighting vehicle traffic, boat/barge traffic, and events with smaller noise and sonic boom footprints. Note that ocean landings are addressed separately in Section 2.2, *Atlantic Ocean*, Section 2.3, *Pacific Ocean*, and Section 2.4, *Indian Ocean*.

[10] C-weighting is a frequency weighting that measures the impact of loud noises on the human ear. C-weighting is used for peak sound pressure measurements, such as measuring impulse noise.

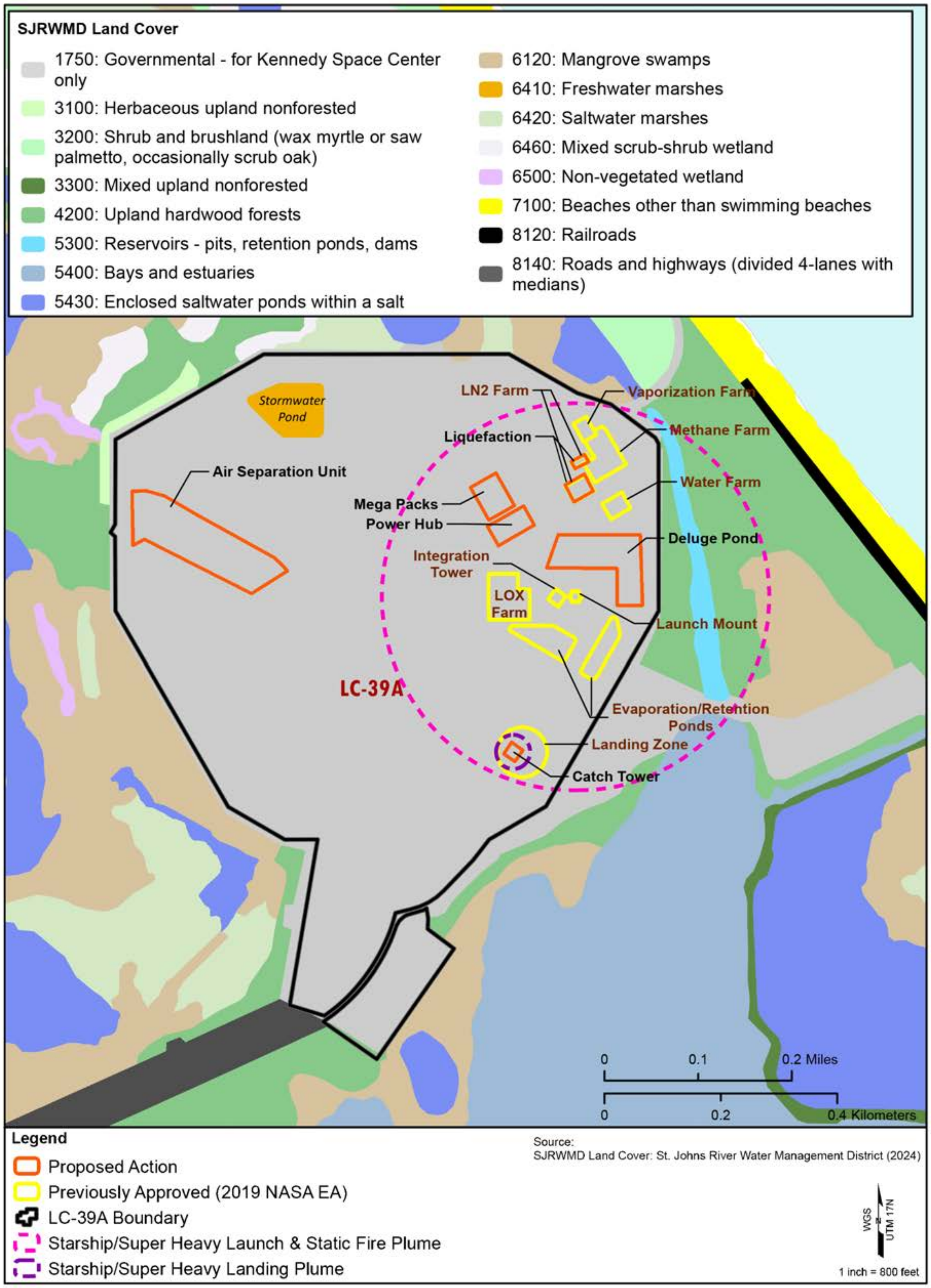


Figure 2-1. St. Johns River Water Management District Land Cover for LC-39A Construction and Plume Areas

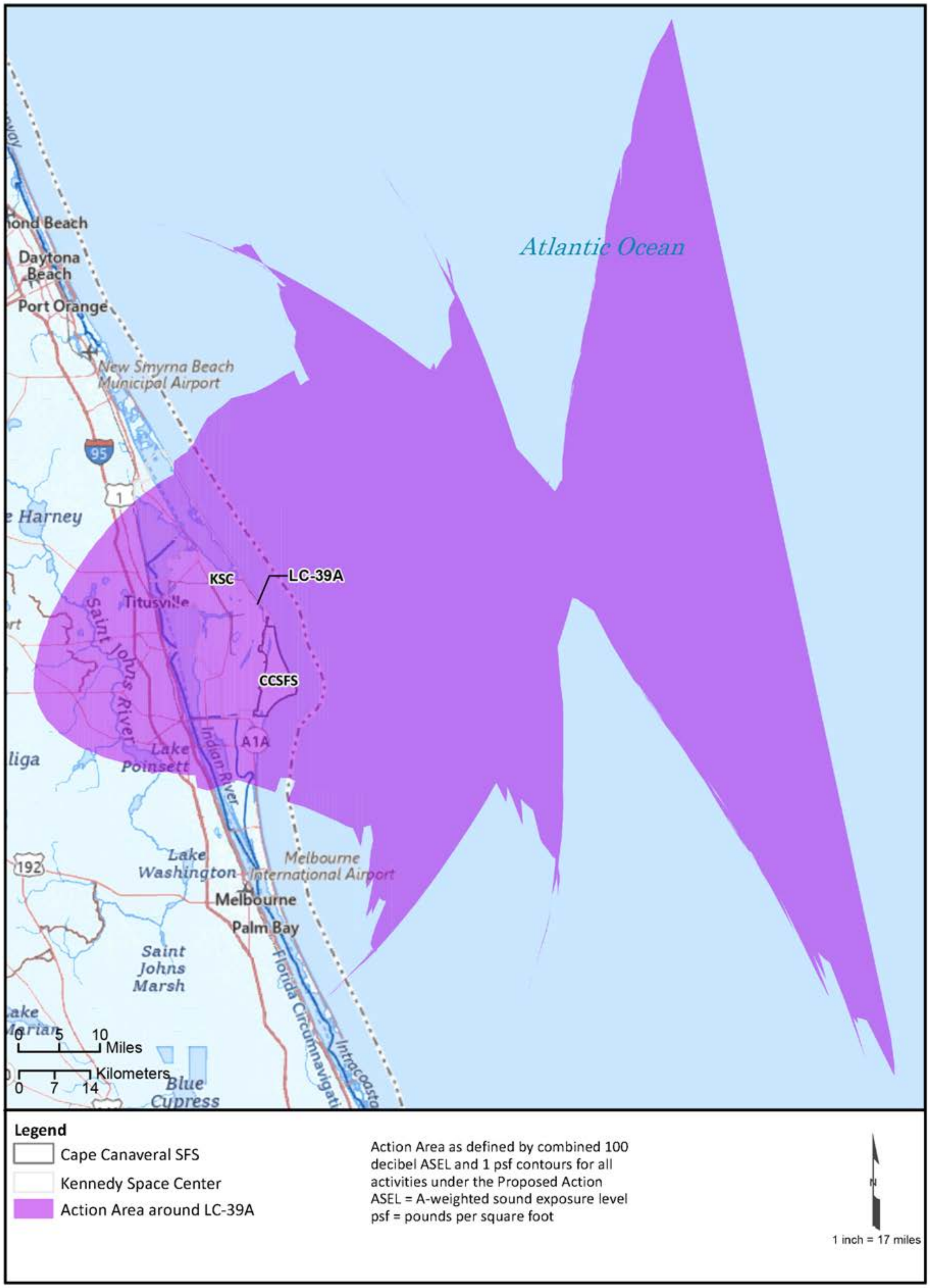


Figure 2-2. LC-39A and Surrounding Area: Combined 1 psf/100 dB ASEL Contour

2.2 Atlantic Ocean

The Atlantic landings area includes the portion of the Atlantic Ocean where Starship vehicles and Super Heavy boosters may be expended or land on droneships (Figure 1-6); this landing area comes no closer than within 5 nm of the U.S. coastline. The Super Heavy landing area extends in a triangle from LC-39A, as the Super Heavy would return within the arc of the 40-degree and 115-degree azimuths (Figure 1-6). The Starship contingency landing area includes an additional area from 1 nm to 5 nm offshore for 50 miles north and south of LC-39A (Figure 1-6**)**. The Starship contingency landing area (including the 1 psf overpressure contour) encompasses noise and overpressure effects from Starship contingency landings (Figure 2-3). Noise and ASEL effects from Super Heavy Atlantic landings are encompassed within the 1 psf/100 dB ASEL contour surrounding LC-39A (Figure 2-2). The Atlantic landing area and Starship contingency landing area would encompass potential lighting and direct physical impacts associated with Atlantic landings and boat/barge traffic.

2.3 Pacific Ocean

The Pacific landing area includes multiple areas of the Pacific Ocean where Starship vehicles may be expended (Figure 1-8). IPaC searches reported listed species under USFWS jurisdiction only within certain portions of the Pacific landing area. The Pacific landing area would encompass potential noise, overpressure, lighting, and direct physical impacts associated with Starship landings and boat/barge traffic.

2.4 Indian Ocean

The Indian Ocean landing area includes the portion of the Indian Ocean where Starship vehicles may be expended (Figure 1-8). IPaC searches did not report any listed species under USFWS jurisdiction for this area, thus the Indian Ocean landing area is not discussed further in this BCA.

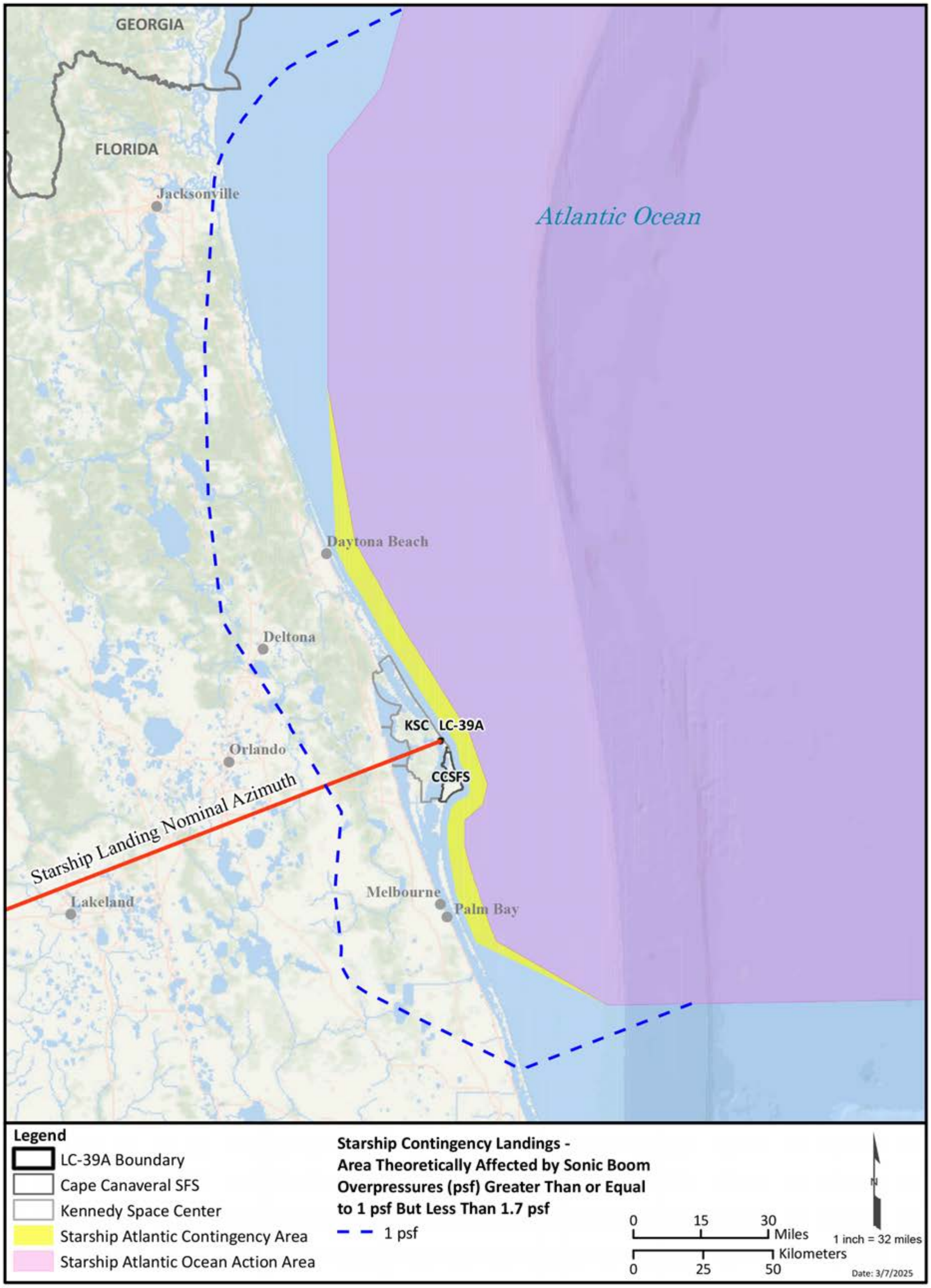


Figure 2-3. Starship Atlantic Contingency Landing Area and 1 psf Contour

Chapter 3. Status of the Species and Critical Habitat

3.1 Official Species and Critical Habitat Lists

The USFWS's IPaC system was queried in March 2025, for the areas affected by the Proposed Action. Due to the large extent of the ocean landing areas, they had to be split into multiple reports to meet the IPaC size limitations. The resulting official species and critical habitat lists are available in Appendix A, *Information for Planning and Consultation (IPaC) Reports*. Table 3-1 includes the ESA-listed and proposed species that may occur within the Action Area around LC-39A, as well as proposed and designated critical habitat (Figure 2-2). Table 3-1 includes a column for the Area around LC-39A within the 1 psf/100 dB ASEL, as well as columns for these following two areas within that: (1) LC-39A footprint (area where construction activities will occur) and (2) the plume area (area affected by plume vapor/heat). Table 3-2 includes the ESA-listed species that may occur within the Atlantic and Pacific landings areas (Figure 1-6 and Figure 1-8) and Table 3-3 includes species that may occur within the Starship contingency area 1 psf contour (Figure 2-3).

Table 3-1. Species and Critical Habitat Noted in IPaC Lists for LC-39A, Plume Area, and the 1 psf/100 dB ASEL Area Around LC-39A

Common Name (Scientific Name)	Federal Status	LC-39A Footprint	Plume Area	1 psf/100 dB ASEL Area Around L-39A
Birds				
Black-capped petrel (*Pterodroma hasitata*)	Endangered	-	-	X
Crested caracara (*Caracara plancus audubonii*) [Florida Distinct Population Segment]	Threatened	X	X	X
Eastern black rail (*Laterallus jamaicensis jamaicensis*)	Threatened	X	X	X
Everglade snail kite (*Rostrhamus sociabilis plumbeus*)	Endangered	X	X	X
Florida scrub-jay (*Aphelocoma coerulescens*)	Threatened	X	X	X
Piping plover (*Charadrius melodus*)	Threatened	-	-	X
Red-cockaded woodpecker (*Dryobates borealis)*	Threatened	-	-	X
Rufa red knot (*Calidris canutus rufa*)	Threatened	X	X	X
Whooping crane (*Grus americana*)	Threatened (NEP)	-	-	X
Wood stork (*Mycteria americana*)	Threatened (delisting proposed)	-	-	X
Insects				
Monarch butterfly (*Danaus plexippus*)	Proposed Threatened	X	X	X

Table 3-1. Species and Critical Habitat Noted in IPaC Lists for LC-39A, Plume Area, and the 1 psf/100 dB ASEL Area Around LC-39A

Common Name (Scientific Name)	Federal Status	LC-39A Footprint	Plume Area	1 psf/100 dB ASEL Area Around L-39A
Mammals				
Florida panther (*Puma [= Felis] concolor coryi*)	Endangered	-	-	X
Puma (*Puma [= Felis] concolor,* all subspecies except *coryi*)	Threatened (S/A)	-	-	X
Southeastern beach mouse (*Peromyscus polionotus niveiventris*)	Threatened	X	X	X
Tricolored bat (*Perimyotis sublavus*)	Proposed Endangered	-	-	X
West Indian manatee (*Trichechus manatus*)	Threatened	X	X	X
Plants				
Beautiful pawpaw (*Deeringothamnus pulchellus*)	Endangered	-	-	X
Carter's mustard (*Warea carteri*)	Endangered	X	X	X
Lewton's polygala (*Polygala lewtonii*)	Endangered	X	X	X
Papery whitlow-wort (*Paronychia chartacea*)	Threatened	-	-	X
Pigeon wings (*Clitoria fragrans*)	Threatened	-	-	X
Pygmy fringe-tree (*Chionanthus pygmaeus*)	Endangered	-	-	X
Rugel's pawpaw (*Deeringothamnus rugelii*)	Endangered	-	-	X
Sandlace (*Polygonella myriophylla*)	Endangered	-	-	X
Reptiles				
American alligator (*Alligator mississippiensis*)	Threatened (S/A)	-	-	X
American crocodile (*Crocodylus acutus*)	Threatened	-	-	X
Atlantic salt marsh snake (*Nerodia clarkia taeniata*)	Threatened	X	X	X
Eastern indigo snake (*Drymarchon couperi*)	Threatened	X	X	X
Green sea turtle (*Chelonia mydas*) [North Atlantic Ocean DPS]	Threatened	X	X	X
Hawksbill sea turtle (*Eretmochelys imbricata*)	Endangered	X	X	X
Leatherback sea turtle (*Dermochelys coriacea*)	Endangered	-	-	X
Loggerhead sea turtle (*Caretta caretta*) [Northwest Atlantic Ocean DPS]	Threatened	-	-	X

Table 3-1. Species and Critical Habitat Noted in IPaC Lists for LC-39A, Plume Area, and the 1 psf/100 dB ASEL Area Around LC-39A

Common Name (Scientific Name)	Federal Status	LC-39A Footprint	Plume Area	1 psf/100 dB ASEL Area Around L-39A
Critical Habitat				
Rufa red knot	Proposed	-	-	X
West Indian manatee	Final and Proposed	-	X	X
Green sea turtle	Proposed	-	-	X
Loggerhead sea turtle	Final	-	-	X

Notes: - = not listed in IPaC report for this area; ASEL = A-weighted sound exposure level; dB = decibels; DPS = distinct population segment; IPaC = Information for Planning and Consultation; LC = Launch Complex; NEP = non-essential experimental population; psf = pounds per square foot; S/A = Similarity of Appearance.
Sources: See Appendix A, *Information for Planning and Consultation (IPaC) Reports.*

Table 3-2. Species Noted in IPaC Lists for Atlantic Landings (>5 nm offshore) and Pacific Landings Areas

Common Name (Scientific Name)	Federal Status	Atlantic Landings Action Area[1]	Pacific Landings Action Area
Birds			
Band-rumped storm-petrel (*Hydrobates castro*) (Hawaii Distinct Population Segment)	Endangered	-	X
Bermuda petrel (*Pterodroma cahow*)	Endangered	X	-
Black-capped petrel (*Pterodroma hasitata*)	Endangered	X	-
Hawaiian petrel (*Pterodroma sandwichensis*)	Endangered	-	X
Newell's shearwater (*Puffinus newelli*)	Threatened	-	X
Roseate tern (*Sterna dougallii dougallii*)	Endangered	X	-
Short-tailed albatross (*Phoebastria albatross*)	Endangered	-	X

Notes: > = greater than; - = not listed in IPaC report for this area; IPaC = Information for Planning and Consultation; nm = nautical miles.
[1] The western boundary of the Atlantic Landings Area begins 5 nm offshore from the United States coastline.
Sources: See Appendix A, *Information for Planning and Consultation (IPaC) Reports.*

Table 3-3. Species and Critical Habitat Noted in IPaC List for Atlantic Starship Contingency Landings Area 1 psf Contour

Common Name (Scientific Name)	Federal Status
Birds	
Black-capped petrel (*Pterodroma hasitata*)	Endangered
Crested caracara (*Caracara plancus audubonii*) (Florida Distinct Population Segment)	Threatened
Eastern black rail (*Laterallus jamaicensis jamaicensis*)	Threatened
Everglade snail kite (*Rostrhamus sociabilis plumbeus*)	Endangered
Florida grasshopper sparrow (*Ammodramus savannarum floridanus*)	Endangered
Florida scrub-jay (*Aphelocoma coerulescens*)	Threatened

Table 3-3. Species and Critical Habitat Noted in IPaC List for Atlantic Starship Contingency Landings Area 1 psf Contour

Common Name (Scientific Name)	Federal Status
Piping plover (*Charadrius melodus*)	Threatened
Red-cockaded woodpecker *(Dryobates borealis*)	Threatened
Rufa red knot (*Calidris canutus rufa*)	Threatened
Whooping crane (*Grus americana*)	Threatened (NEP)[1]
Wood stork (*Mycteria americana*)	Threatened (delisting proposed)
Crustacean	
Black Creek crayfish (*Procambarus pictus*)	Proposed Endangered
Insects	
Monarch butterfly (*Danaus plexippus*)	Proposed Threatened
Mammals	
Anastasia Island beach mouse (*Peromyscus polionotus phasma*)	Endangered
Florida bonneted bat (*Eumops floridanus*)	Endangered
Florida panther (*Puma [= Felis] concolor coryi*)	Endangered
Puma (*Puma [= Felis] concolor,* all subspecies except *coryi*)	Threatened (S/A)
Southeastern beach mouse (*Peromyscus polionotus niveiventris*)	Threatened
Tricolored bat (*Perimyotis sublavus*)	Proposed Endangered
West Indian manatee (*Trichechus manatus*)	Threatened
Plants	
Beautiful pawpaw (*Deeringothamnus pulchellus*)	Endangered
Carter's mustard (*Warea carteri*)	Endangered
Etonia rosemary*(Conradina etonia*)	Endangered
Fragrant prickly-apple (*Cereus eriophorus* var. *fragrans*)	Endangered
Lakela's mint (*Dicerandra immaculata*)	Endangered
Lewton's polygala (*Polygala lewtonii*)	Endangered
Okeechobee gourd (*Cucurbita okeechobeensis okeechobeensis*)	Endangered
Papery whitlow-wort (*Paronychia chartacea*)	Threatened
Pigeon wings (*Clitoria fragrans*)	Threatened
Pygmy fringe-tree (*Chionanthus pygmaeus*)	Endangered
Rugel's pawpaw (*Deeringothamnus rugelii*)	Endangered
Sandlace (*Polygonella myriophylla*)	Endangered
Tiny polygala (*Polygala smallii*)	Endangered
Reptiles	
Atlantic salt marsh snake (*Nerodia clarkia taeniata*)	Threatened
American alligator (*Alligator mississippiensis*)	Threatened (S/A)
American crocodile (*Crocodylus acutus*)	Threatened
Eastern indigo snake (*Drymarchon couperi*)	Threatened
Green sea turtle (*Chelonia mydas*)	Threatened
Hawksbill sea turtle (*Eretmochelys imbricata*)	Endangered
Leatherback sea turtle (*Dermochelys coriacea*)	Endangered
Loggerhead sea turtle (*Caretta caretta*)	Threatened
Critical Habitat	
Rufa red knot	Proposed
Piping plover	Final
Florida bonneted bat	Final
West Indian manatee	Final and Revised Proposed

Table 3-3. Species and Critical Habitat Noted in IPaC List for Atlantic Starship Contingency Landings Area 1 psf Contour

Common Name (Scientific Name)	Federal Status
Green sea turtle	Proposed
Loggerhead sea turtle	Final

Notes: IPaC = Information for Planning and Consultation; NEP = non-essential experimental population; psf = pounds per square foot; S/A = Similarity of Appearance.

[1] The western boundary of the Atlantic Starship Contingency Area begins 1 nautical mile offshore from the United States coastline.

Sources: See Appendix A, *Information for Planning and Consultation (IPaC) Reports.*

Although the IPaC list did not include the federally endangered Kemp's ridley sea turtle (*Lepidochelys kempii*), this BCA includes the Kemp's ridley because this species is known to nest within the Action Area.

3.2 No Effect Determinations

In consideration of the best available science, NASA has determined that the official species list includes certain species that either do not or are not expected to occur in the Action Area. In other cases, a species would not be exposed to effects of the action due to the type of habitat that they occupy, or the physical and biological features (PBFs) for the critical habitat would not be affected by the Proposed Action. Per the rationale provided in Table 3-4, these species and critical habitats will not be carried forward for additional discussion.

Table 3-4. Species and Critical Habitat Eliminated from Detailed Analysis Due to No Effect

Common Name (Scientific Name)	Rationale for No Effect Determination
Animal Species	
Whooping crane	The USFWS has determined that nonessential experimental populations are not necessary for the continued existence of a species. Due to issues with survival and reproduction, cranes are no longer released to central Florida Experimental Population (Non-Essential) and cranes from this population are rarely observed in Florida (FWC, 2025a). Thus, the whooping crane is not expected to occur in the Action Area and the Proposed Action would have no effect on this species.
Black Creek crayfish	This proposed species lives in streams and is restricted to northeastern Florida in the Lower St. Johns River Basin (USFWS, 2025a). Infrequent Starship contingency landing overpressure levels of 1 psf would not transmit underwater where this crayfish lives; thus, the Proposed Action would have no effect on this species.
Florida panther	The Florida panther breeding population is limited to south Florida, below the Caloosahatchee River (FWC, 2024a). Because this extremely rare, transient species is unlikely to occur within the Action Area during the short duration of a test, launch, or landing event, the Proposed Action would have no effect on the Florida panther.
Puma	This species is listed due to similarity of appearance to the federally protected Florida panther. This transient species is unlikely to occur within the Action Area during the short duration of a test, launch, or landing event.
American alligator	This species is locally abundant and is only listed due to similarity of appearance to the federally listed American crocodile. Because the Action Area is outside of the range of the American crocodile, effects to the American alligator are not considered further in this BCA.

Table 3-4. Species and Critical Habitat Eliminated from Detailed Analysis Due to No Effect

Common Name (Scientific Name)	Rationale for No Effect Determination
American crocodile	Currently the northern extent of the species range is Satellite Beach and Melbourne Beach, which are south of the Action Area (USFWS, 2022a). The Proposed Action would have no effect on the American crocodile.
Plant Species	
Beautiful pawpaw	This species was not listed on IPaC reports as known or expected to be on or near the areas where there would be potential for effects from construction and launch/landing plumes (e.g., crushing, heat damage). While this plant was listed on the IPaC report for the wider area affected by the 100 dB ASEL/1 psf contour, launch and landing noise and overpressure would have no effect on this species.
Carter's mustard	Current known distribution is limited to the Central Florida Ridge; populations of Carter's mustard previously documented in Brevard County are now considered extirpated (USFWS, 2021b), which is outside of the Action Area. The Proposed Action would have no effect on this species.
Etonia rosemary	These species were not listed on IPaC reports as known or expected to be on or near the areas where there would be potential for effects from construction and launch/landing plumes (e.g., crushing, heat damage). While they were listed on the IPaC report for the wider area affected by the 100 dB ASEL/1 psf contour, launch and landing noise and overpressure would have no effect on these species.
Fragrant prickly-apple	
Lakela's mint	
Lewton's polygala	Current known distribution is limited to the Central Florida Ridge (USFWS, 2021c), which is outside of the Action Area. The Proposed Action would have no effect on this species.
Okeechobee gourd	These species were not listed on IPaC reports as known or expected to be on or near the areas where there would be potential for effects from construction and launch/landing plumes. While these plants were listed on the IPaC report for the wider area affected by the 100 dB ASEL/1 psf contour, launch and landing noise and overpressure would have no effect on these species.
Papery whitlow-wort	
Pigeon wings	
Pygmy fringe-tree	
Rugel's pawpaw	
Sandlace	
Tiny polygala	
Critical Habitat	
Piping plover critical habitat	The primary constituent elements listed for wintering piping plover critical habitat include intertidal beaches and flats (between annual low tide and annual high tide) and associated dune systems and flats above annual high tide that support foraging, roosting, and sheltering tide (66 Federal Register 36038). The only elements of the Proposed Action that would overlap piping plover critical habitat are noise and overpressures from Starship contingency ocean landings; these would have no effect on the primary constituent elements of piping plover critical habitat.
Rufa red knot critical habitat (proposed)	The PBFs listed for rufa red knot proposed critical habitat include: beaches and tidal flats for foraging; upper beach areas for roosting, preening, resting, and/or sheltering; ephemeral and/or dynamic coastal features, ocean vegetation deposit or surf-cast wrack, intertidal peat banks, and features landward of the beach that support foraging or roosting; and artificial habitat mimicking natural conditions or maintaining the six PBFs listed previously (86 Federal Register 37410, 88 Federal Register 22530). Proposed critical habitat for overwintering red knots is present on portions of MINWR, KSC, and CANA, as well as other coastal areas within the larger Action Area overlapped by rocket noise and sonic booms. Proposed critical habitat is located 0.22 miles from the closest construction and 0.30 and 0.43 miles from the launch and landing pads, respectively. Thus, there would be no effect to red knot proposed critical habitat from construction or plumes and noise, sonic booms,

Table 3-4. Species and Critical Habitat Eliminated from Detailed Analysis Due to No Effect

Common Name (Scientific Name)	Rationale for No Effect Determination
	and lighting associated with the Proposed Action would also have no effect on rufa red knot proposed critical habitat.
Florida bonneted bat critical habitat	The PBFs listed for Florida bonneted bat critical habitat include: habitats with sufficient darkness that provide for roosting and rearing of offspring (live or dead trees and snags); foraging habitat with sufficiently dark open areas in or near areas of high insect concentrations (e.g., near waterbodies/wetlands); dynamic disturbance regime (e.g., fire, hurricanes) that maintains and regenerates forest habitat; habitat diversity and structural connectivity; and a subtropical climate with conditions that support normal behavior, successful reproduction, and rearing of offspring (89 Federal Register 16624). The only element of the Proposed Action that would overlap Florida bonneted bat critical habitat is overpressure from Starship contingency ocean landings; this would have no effect on the primary constituent elements of Florida bonneted bat critical habitat.
Manatee critical habitat	When critical habitat was designated for the West Indian manatee in 1977, the listing did not specify PBFs essential to the conservation of the species, just geographic areas (42 Federal Register 47840–47845). The 2024 proposed revision of manatee critical habitat (89 Federal Register 78134) includes updated proposed areas of critical habitat, and specifies the following PBFs for the Florida manatee subspecies of the West Indian manatee: (1) areas of water warmed by natural processes (e.g., spring discharges, passive thermal basins) that have either reliable thermal quality throughout the winter (i.e., having at least a medium thermal quality as defined by the *Florida Manatee Warm-Water Habitat Action Plan*) or that have established manatee use throughout the winter each year (see the *Florida Manatee Warm-Water Habitat Action Plan*); and (2) areas supporting emergent, submerged, or floating aquatic vegetation within 18.6 miles (30 kilometers) of the natural warm-water sources described previously or another established winter manatee aggregation areas (i.e., power plants with established manatee use). Current critical habitat for the manatee includes most of the waters in the IRL system, as well as some of the nearshore Atlantic Ocean waters of the Action Area. The proposed revision of critical habitat for the Florida manatee includes most of the waters in the IRL system but no longer includes nearshore waters in the Atlantic Ocean. The footprint of the plume overlaps 3.21 acres of critical habitat, but only 0.51 acres of the proposed revised critical habitat is within the plume area. The vapor/heat plumes from static fire tests, launches, and landings would be diverted upwards and would not affect surrounding waters. The Proposed Action would implement requirements for construction and operations, such as sediment control measures and spill prevention/containment procedures, and deluge water and stormwater would be contained onsite. Thus, plumes and water runoff would have no effect on manatee critical habitat and noise, sonic booms, and lighting from the Proposed Action would also have no effect on current designated manatee critical habitat or the revised proposed critical habitat.

Notes: ASEL = A-weighted sound exposure level; CCSFS = Cape Canaveral Space Force Station; CANA = Canaveral National Seashore; dB = decibel(s); ft = foot; FWC = Florida Fish and Wildlife Conservation Commission; IPaC = Information for Planning and Consultation; KSC = Kennedy Space Center; LC = Launch Complex; m = meter; MINWR = Merritt Island National Wildlife Refuge; PBF = physical and biological feature; psf = pounds per square foot; USFWS = United States Fish and Wildlife Service.

3.3 Status of the Species and Critical Habitat

This section provides status summaries for the federally listed and proposed listed species and critical habitat areas potentially affected by the Proposed Action; information on their occurrence within the action area is provided in Section 4.3, *Environmental Baseline for Species and Critical Habitats*. For more information regarding these species and the factors affecting their conservation status, please refer to proposed and final listing determinations, recovery plans, status of the species assessments, and 5-year reviews available at https://ecos.fws.gov/ecp/ (Environmental Conservation Online System). Maps showing species locations are provided in Section 5.3, *Effects to Species and Critical Habitat*.

3.3.1 Audubon's Crested Caracara

The threatened Audubon's crested caracara occurs in south-central Florida, the southwestern United States, and Central America. The species prefers wet prairies with cabbage palms but may also utilize wooded areas with saw palmetto, scrub oaks, cypress, and pastures. Caracaras are non-migratory, occupying home ranges year-round. This large raptor primarily feeds on carrion, reptiles, amphibians, mammals, eggs, and other birds. In Florida, eggs have been found from September to April, with breeding season peaking around January to March (FWC, 2024b). The Audubon's crested caracara is 1 of 68 species included in the *South Florida Multi-Species Recovery Plan* (USFWS, 1999). The 5-year review (USFWS, 2009) indicates that population trends are not available, but that declines are likely based on habitat effects. The primary threat to this species is habitat loss, degradation, and fragmentation.

3.3.2 Band-Rumped Storm-Petrel

The endangered band-rumped storm-petrel is known to breed on the islands of Hawaii, Kauai, Lanai, and Lehua. These petrels regularly forage in the waters around Niihau, Kauai, and Hawaii Islands, in concentrations of a few birds up to as many as 100 birds, where they possibly await nightfall before coming ashore to breeding colonies (USFWS, 2021d). Adults also forage for small fish, squid, and crustaceans in the open ocean. Band-rumped storm-petrels show a strong attraction to light sources, including artificial lights. The storm-petrel is included in the *Recovery Plan for 50 Hawaiian Archipelago Species* (USFWS, 2022b). Habitat damage from invasive species is the primary threat to this species. The 5-year review (USFWS, 2021d) indicates there are currently declines in both populations and individuals within populations.

3.3.3 Bermuda Petrel

The endangered Bermuda petrel is a seabird species that nests in burrows on a few islets of Bermuda from October to June (Cornell University, 2025). Outside of the breeding season, individuals may forage over large areas of the North Atlantic Ocean, from areas offshore of the eastern United States (South Carolina to Maine) and Canada to western Europe. Bermuda petrels feed on small fish, squid, and other marine invertebrates near the ocean surface. The species, once thought to have been hunted to extinction, currently has an estimated total population of 425 to 450 birds (USFWS, 2024b). Known and potential threats to the species include flooding that may damage or destroy the few nesting areas, nest predation by non-native species, toxic substances (e.g., pesticides), human disturbance, artificial lighting, plastic ingestion, and offshore wind and oil/gas development.

3.3.4 Black-Capped Petrel

This endangered pelagic seabird uses terrestrial habitats only for nesting, which is limited to one island in the Caribbean, Hispaniola. These petrels spend most of their lives over the open sea, traveling long distances to foraging areas in the western Atlantic Ocean, southern Caribbean basin, and the northern Gulf of America. As described in the *Species Status Assessment* (USFWS, 2023a), primary offshore habitat is mostly, but not exclusively, over water with depths of 200–2,000 meters (900–6,562 feet). Most known offshore occurrences are near Caribbean islands and along the western edge of the Gulf Stream (southern Florida to the U.S. mid-Atlantic region). Off Florida, petrels occur over shallower waters and nearer to shore than in the mid-Atlantic region. The offshore region from southern Florida to North Carolina is the only marine area where regular and sizable concentrations of the species occur, making this area important for their survival. Black-capped petrels forage primarily at night and during early morning hours, and mostly in flocks, consuming baitfish and invertebrates. The primary threat to this species is nesting habitat loss and degradation. Other threats include human predation at nesting sites, invasive animal species, and artificial lighting (petrels use moonlight and starlight for nocturnal navigation). The current overall status of the species is considered "fairly low" (USFWS, 2023a).

3.3.5 Eastern Black Rail

The threatened eastern black rail is a small, cryptic marsh bird that occurs in salt, brackish, and freshwater wetlands, preferring areas of dense herbaceous vegetation for cover. Plant structure (vegetative cover that allows movement under the canopy) is more important than plant species composition. This bird rarely is spotted in flight, instead running for short distances along the ground. Individuals forage among marsh vegetation for invertebrates and seeds of aquatic plants. In Florida, nesting season typically extends from May to September, with nests established on the ground in clumps of vegetation where water levels are lower than nest height (USFWS, 2019c). The primary threat to this species is habitat fragmentation, alteration, and conversion. Additional threats include altered hydrology, land management issues, pollutants, disease, altered food webs and predation, and human disturbance (USFWS, 2025b). Results of the Species Status Assessment indicate an overall declining population trend for the eastern black rail, with future extirpation from some currently occupied areas likely (USFWS, 2019c). The *Recovery Outline for the Eastern Black Rail* was published in 2021 (USFWS, 2021e).

3.3.6 Everglade Snail Kite

The endangered Everglade snail kite feeds almost exclusively on apple snails found in sparsely vegetated lake shores or marshes (FWC, 2024c). Peak nesting for this mid-sized raptor occurs between February and July, but they may nest throughout the year. A recovery plan was prepared in 1999 and amended in 2019 (USFWS, 2019d). The 5-year review (USFWS, 2023b) states that from the 1960s to the 1980s, distribution in Florida was mostly limited to the Everglades. However, abundance has since increased and snail kites have expanded to northern Florida (e.g., Paynes Prairie State Park near Gainesville). Little information on population status is available outside of Florida.

3.3.7 Florida Grasshopper Sparrow

The federally endangered Florida grasshopper sparrow is known to occur only in remnant areas of south-central Florida (Highlands, Okeechobee, Osceola, and Polk Counties) (USFWS, 2023d). Occurrence coincides with only a very small portion of the Action Area. Habitat for this species consists of relatively large tracts of treeless prairie that are maintained by frequent fire (USFWS, 2019h). The species population has declined substantially in the last three decades. Habitat availability is not thought to be a primary limiting factor in recovery. Nest predation by native animals and the introduced fire ant (*Solenopsis invicta*) appears to be the major threat to the Florida grasshopper sparrow.

3.3.8 Florida Scrub-Jay

The threatened Florida scrub-jay, the only bird species endemic to Florida, inhabits sand pine and xeric oak scrub and scrubby flatwoods interspersed with patches of bare sand or light herbaceous vegetation. Frequent fire is an important element in maintaining appropriate Florida scrub-jay habitat by reducing shrub height and increasing these open spaces. This type of patchy habitat allows the Florida scrub-jay to survey a large area for predators, while also providing refuge and forage resources. The Florida scrub-jay forages mostly on or near the ground, primarily consuming insects but also plant food such as acorns. These birds are non-migratory and permanently territorial, with nesting occurring from March through June (USFWS, 2019e). Territory size averages about 25 acres, and territory availability is apparently a limiting factor in population growth. Although Florida scrub-jays may use the same territory and nest site in consecutive years, they may also build a new nest or modify the existing one from year to year based on factors such as the condition of the previous nest, changes in vegetation, and other environmental considerations. Most juveniles remain in their natal territory for at least 1 year (and sometimes up to 6 years) as helpers before dispersing to become breeders. The primary threat to this species is habitat loss, degradation, and fragmentation. Strike mortality is also a threat along high-speed roads because these birds may forage on road shoulders and rights-of-way. Florida scrub-jays have declined to less than 10 percent of their historical numbers and are considered extirpated from several counties. The Florida scrub-jay 5-year review (USFWS, 2020b) concluded that some populations have continued to decline since listing under the ESA, but the species remains secure on many conservation-managed lands. The USFWS has prepared a recovery plan (USFWS, 2019e) and Species Status Assessment (USFWS, 2019f) for the Florida scrub-jay.

3.3.9 Hawaiian Petrel

Breeding colonies of the endangered Hawaiian petrel are found only in remote or high elevation areas on the islands of Maui, Molokai, Hawaii, Lanai, and Kauai. Adults spend most of their time at sea, and do not start breeding until they are about six years old (USFWS, 2022c). The 1983 *Hawaiian Dark-rumped Petrel and Newell's Manx Shearwater Recovery Plan* was amended in 2019 to include the Hawaiian petrel (USFWS, 2019g). Threats to the species include powerline collisions, artificial light attraction, predation by introduced and feral species, and invasive plants. The most recent 5-year review (USFWS, 2022c) indicated that population trends are generally unknown, but that most of the threats to the species remain. An exception is implementation of effective predator control at several breeding sites.

3.3.10 Newell's Shearwater

The threatened Newell's shearwater nests in difficult-to-find burrows on the slopes and cliffs of Kauai, with additional small colonies on Maui, Molokai, and Hawaii Island. The shearwater only forages at sea and can pursue prey to over 150 feet deep (USFWS, 2024c). The USFWS prepared a recovery plan for this species in 1983 (USFWS, 1983). Threats to the Newell's shearwater include powerline collisions, artificial light attraction, predation by introduced and feral species, and invasive plants. As described in the most recent 5-year review (USFWS, 2024c), severe population declines occurred in the 1990s and 2000s. The population has generally stabilized since that time but remains at a greatly reduced level with no evidence of increase.

3.3.11 Piping Plover

The piping plover, listed as threatened under the ESA, migrates seasonally between breeding habitat in the central and eastern United States and Canada and nonbreeding (winter) habitat along the U.S. Gulf and Atlantic Coasts (July to May). Most winter sightings occur near or within designated winter critical habitat. Overwintering piping plovers forage for invertebrates in exposed, wet sand in beach and estuarine shoreline areas such as wash zones, intertidal ocean beachfronts, wrack lines, washover passes, mud and sand flats, ephemeral ponds, and salt marshes. Plovers also use adjacent areas in dunes, debris, and sparse vegetation for sheltering (USFWS, 2020c). Threats to this species include habitat loss and degradation, human disturbance (particularly at breeding sites), predation, and mortality from wind turbines. The USFWS published a recovery plan for the Atlantic Coast population of the piping plover in 1996 (USFWS, 1996). The most recent 5-year review (USFWS, 2024d) indicates that, for individuals of the breeding range of the Atlantic coast population, population growth has occurred overall but none of the recovery criteria have yet been met.

3.3.12 Red-Cockaded Woodpecker

The federally threatened red-cockaded woodpecker has a patchy distribution in several southern states, and it occurs throughout Florida in areas with suitable habitat. Nesting and roosting habitat consists of open pine woodlands and savannahs containing large, old pines (USFWS, 2022d). Foraging habitat generally consists of mature pines with an open canopy, a sparse hardwood and/or pine midstory, and abundant native bunchgrass and forb groundcovers. The primary threat to the red-cockaded woodpecker is habitat alteration and fragmentation, including forest removal and fire suppression. Due to restoration activities and improved forestry practices, most red-cockaded woodpecker populations are currently stable or increasing (USFWS, 2022d).

3.3.13 Roseate Tern

The federally endangered northeastern North American population of the roseate tern tends to forage over coastal waters within 3 to 15 miles (5 to 25 kilometers) of their breeding colonies, but some breeding and post-breeding roseate terns may forage greater distances offshore. Roseate terns may travel over 30 miles (50 kilometers) during chick provisioning flights to feeding areas and have been documented up to 60 miles (100 kilometers) offshore (USFWS, 2020d). The USFWS has prepared recovery plans for the northeastern population (USFWS, 1998) and Caribbean population (USFWS, 1993a). Threats to this species include habitat destruction and modification, predation, food availability, and disturbance. The most recent 5-year review (USFWS, 2022e) indicates that abundance estimates for the Caribbean population (which breeds from Florida to the West Indies) are unknown, although the number of breeding pairs has decreased in some areas.

3.3.14 Rufa Red Knot

The federally threatened rufa red knot nests mostly above the Arctic Circle during summer and migrates south in winter (September to May). Although many individuals migrate to South America, some winter in coastal areas of the southern United States, including areas along Florida's Atlantic and Gulf Coasts. The U.S. Atlantic coast from Florida to North Carolina is a well-known stopover area, particularly during northward migration. Coastal habitats generally include exposed ocean-front and bay-front intertidal sediments, including dynamic features such as sand spits, islets, shoals, and sandbars. Typical nonbreeding foraging habitat consists of coastal mudflats, tidal zones, open sandy beaches, and mangrove-dominated shorelines, where these shorebirds are usually found feeding on invertebrates (especially hard-shelled mollusks) near the water's edge. Red knots roost near their foraging areas in supratidal areas with open vistas (USFWS, 2023c). The Species Status Assessment report identifies primary threats to the rufa red knot as loss of breeding and nonbreeding habitat, predation on breeding grounds, reduced prey availability throughout the nonbreeding range, and increasing frequency of mismatches in the timing of the annual migratory cycle relative to favorable food and weather conditions (USFWS, 2020e). Red knots are thought to have been severely depleted by hunting in the 1800s but have at least partially recovered. The Species Status Assessment report (USFWS, 2020e) and latest 5-year review (USFWS, 2021f) indicate the wintering population in the southeastern United States is stable but not increasing.

3.3.15 Short-Tailed Albatross

Breeding colonies for the endangered short-tailed albatross are known to exist on Torishima Island, the Senkaku Islands, Ogasawara Islands, and Midway Atoll. This species appears to use surface scavenging as a primary foraging strategy, with squid being its preferred prey (USFWS, 2020f). The recovery plan for this species identifies exploitation, which no longer occurs, as the major cause of population decline (USFWS, 2008a). Secondary threats include the potential for volcanic eruption at the main breeding site, incidental catch in commercial fisheries, ingestion of plastics, pollutant contamination, and predation and habitat damage by non-native species. Populations are increasing in some areas and the most recent 5-year review (USFWS, 2020f) concludes that, if current trends continue, the species could be considered for downlisting from endangered to threatened.

3.3.16 Wood Stork

The Southeast United States distinct population segment (DPS) of the wood stork (*Mycteria americana*) has been proposed for delisting due to recovery (Federal Register Volume 88, No. 31, February 15, 2023, 9830–9850). Their distribution includes the southeastern coastal plain, with breeding in Florida, Georgia, North Carolina, and South Carolina. These large colonial breeders forage in freshwater and estuarine wetlands and other shallow water habitats and build their nests in trees or on islands surrounded by water, typically in mixed hardwood swamps and cypress domes (February to June). The USFWS published a recovery plan for this species in 1986 (USFWS, 1986). The primary threats identified for U.S. wood storks include habitat loss, conversion, and degradation. The 5-year review (USFWS, 2007) indicated the Southeast U.S. breeding population of the wood stork is increasing and expanding its overall range, and the Species Status Assessment (USFWS, 2021g) states that expansion is expected to continue.

3.3.17 Monarch Butterfly

The monarch butterfly was proposed for listing as a threatened species in December of 2024 (89 Federal Register 100662–100716). At the southern end of their breeding range in North America (i.e., parts of Florida, the Gulf Coast, California), non-migratory monarchs remain year-round. The eastern and western North American populations migrate long distances to their respective overwintering sites in Mexico and California. During breeding and migration (spring through fall), adults require a diversity of blooming nectar resources. They specifically require milkweed for oviposition and larval feeding. The temperature range within which monarchs can develop is 53°F (12 degrees Celsius [°C]) to 91°F (33°C) (USFWS, 2024e). The monarch Species Status Assessment (USFWS, 2024e) identifies primary threats as habitat changes, and insecticide use. Although North American migratory populations fluctuate naturally, available data suggest overall population declines in overwintering sites.

3.3.18 Florida Bonneted Bat

The federally endangered Florida bonneted bat is a large bat species that occurs in central and south Florida, generally from just south of Orlando to Miami in coastal and interior areas (USFWS, 2025c). This species is very rare throughout its range, with only a few nursery roosts documented in the state (FWC, 2025b). Florida bonneted bats are found in forest, wetland, open water, and residential areas. They forage at night on flying insects in a variety of open habitats. These bats roost singly or in groups of over 50 individuals in natural cavities of pines and other types of trees, and in artificial cavities such as bat houses and under roofing tiles. Breeding activity peaks in April but occurs year-round. The primary threat to this species is habitat destruction, fragmentation, and modification due to development and agriculture. Additional threats include small population size, slow reproduction, and restricted range. In 2018, the USFWS prepared a recovery outline to support development of a recovery plan (USFWS, 2018). The population trend is unknown but ongoing threats could potentially slow recovery.

3.3.19 Anastasia Island Beach Mouse

The federally endangered Anastasia Island beach mouse is mostly restricted to Anastasia Island, Florida (St. Johns County) (FWC, 2025c). Mice that were reintroduced in suitable habitat north of Anastasia Island are currently surviving in very low numbers. The species would therefore coincide with only a very small part of the Action Area. Habitat for this species generally consists of sand dunes vegetated by sea oats and other salt-tolerant species of vines and grasses, as well as interior scrub environments (USFWS, 2025d). They dig burrows, typically on the sloping side of dunes at the base of vegetation, which are used for food storage and refuge. This nocturnal species feeds at night on seeds of sea oats and beach grasses, as well as invertebrates. Breeding typically peaks between November and early January but may occur year-round. Mortality rates are high. The primary threat to the Anastasia Island beach mouse is habitat loss and fragmentation due to development. Other threats include hurricanes and predation by feral and free-ranging animals. The most recent 5-year review indicates the species' status is stable, although populations can fluctuate seasonally and annually (USFWS, 2019i). The USFWS initiated a 5-year status review for multiple species, including the Anastasia Island beach mouse, in May 2023 (88 Federal Register 30324). The USFWS published the *Recovery Plan for the Anastasia Island Beach Mouse and Southeastern Beach Mouse* in 1993 (USFWS, 1993b).

3.3.20 Southeastern Beach Mouse

The federally threatened southeastern beach mouse has a restricted range along the Atlantic Coast, currently occurring on CCSFS, KSC/MINWR, and CANA, with relict populations at Sebastian Inlet State Recreation Area and New Smyrna dunes. The Canaveral Complex population (which contains several subpopulations) is considered the core population. The southeastern beach mouse occupies primary and secondary frontal sand dunes vegetated by sea oats and other salt-tolerant species of vines and grasses, as well as scrub dunes and interior scrub environments. They utilize the scrub adjacent to these dunes for digging their burrows, which are generally found on the sloping side of a dune at the base of vegetation and are used for refuge, nesting, and food storage (USFWS, 2019j). Periodic fires help to maintain optimal scrub habitat. The nocturnal southeastern beach mouse feeds at night on seeds (dune and scrub plants) and invertebrates. Foraging activity decreases with increasing light levels (moonlight or artificial lights). Breeding typically peaks in fall and winter but may occur year-round. Reproduction and mortality rates are high for this species. The primary threat to the southeastern beach mouse is habitat loss and fragmentation. Other identified threats include shoreline armoring, artificial lighting, vehicular/foot traffic, and free-roaming cat predation. The most recent 5-year review indicates the species' status is stable (USFWS, 2019j). The USFWS initiated a 5-year status review for multiple species, including the southeastern beach mouse, in June 2024 (89 Federal Register 48437). The USFWS published the *Recovery Plan for the Anastasia Island Beach Mouse and Southeastern Beach Mouse* in 1993 (USFWS, 1993b).

3.3.21 Tricolored Bat

The tricolored bat is proposed for listing by the USFWS as endangered throughout its range, which covers much of the central and eastern portion of the United States, including all of Florida. Massive population declines throughout this species' range have been mainly attributable to a fungus that causes white-noise syndrome, though the fungus has not been found in Florida. This species forages at night on small insects over waterways and forest edges, typically around treetop level. Tricolored bats form small maternity colonies during the summer in tree foliage or man-made structures, giving birth in May or June. During the winter, they hibernate in caves and mines; however, in the South where caves are less common, they may also overwinter in culverts, tree cavities, and other abandoned artificial structures (USFWS, 2021h). The Species Status Assessment identifies white-nose syndrome as the primary threat to this species (USFWS, 2021h). Additional threats include direct contact with wind energy turbines and habitat loss.

3.3.22 West Indian Manatee

West Indian manatees utilize estuarine, marine, and freshwater habitats, typically seeking out areas with warm water during cold periods (i.e., deep water areas, springs, industrial plant discharge water). Manatees use a wide variety of freshwater, estuarine, and marine habitats for feeding, drinking, traveling, resting, thermoregulation, and other behaviors. Individuals typically travel along the edges of vegetation beds in or near channels, and sometimes along coastal beaches. Manatees are often found in canals, creeks, embayments, and lagoons, especially near the mouths of rivers. While manatees may migrate over a large area during the spring and summer, they return to these warm water sites for the fall and winter.

Distribution in Florida is therefore mostly limited to the Florida peninsula during cold months. Calving is typically highest in the spring; however, mating activity and calving may occur at any time of year. Calves remain with the mother for 2 to 3 years, maturing at 3 to 5 years old. Manatees feed on submerged, emergent, and floating vegetation (i.e., sea grasses) within freshwater, estuarine, and marine habitats (USFWS, 2024f).

In January 2025, the USFWS proposed to list the two subspecies of the West Indian manatee under the ESA: the Florida manatee (*Trichechus manatus latirostris*) and the Antillean manatee (*Trichechus manatus manatus*) (90 Federal Register 3131). The USFWS proposed to list the Florida manatee as threatened and the Antillean manatee as endangered. Associated revisions to critical habitat were proposed in 2024 (89 Federal Register 78134). The 2001 recovery plan (USFWS, 2001) identified vessel strikes as the most significant threat to the species. Additional threats include habitat loss and alteration (e.g., loss of seagrass and other vegetation), direct mortality from water control structures, harmful algal blooms, and entanglement in debris. Unusually cold water temperature is also a cause of manatee mortality. The population has increased significantly in Florida over the past 30 years but has declined in most of the proposed Antillean subspecies' range (USFWS, 2025e). Although neither a 5-year review nor a Species Status Assessment has been prepared for the manatee, the information in the Federal Register notices regarding subspecies listing and critical habitat revision may be considered to represent a 5-year review (USFWS, 2024f).

3.3.23 Atlantic Salt Marsh Snake

The federally threatened Atlantic salt marsh snake appears to be restricted to Volusia County, Florida (FWC, 2025d; USFWS, 2019k), and therefore coincides with only a small portion of the Action Area. Habitat for this snake consists of coastal salt marshes and mangrove swamps, including tidal flats and shallow tidal creeks and pools (from brackish to fully saline) (USFWS, 2025f; FWC, 2025d). Habitat may contain black mangroves and grasses such as glasswort (*Salicornia), Spartina,* and *Juncus*. This species is most active at night. The most recent 5-year review indicates the population trend for this species in unknown (USFWS, 2019k). The USFWS prepared a recovery plan in 1993 (USFWS, 1993c).

3.3.24 Eastern Indigo Snake

The threatened eastern indigo snake is found within the southeastern portion of the United States, often in association with areas where gopher tortoises occur. This large snake uses a wide variety of upland and wetland habitats; usage can vary seasonally. Indigo snakes move long distances and have very large home ranges, ranging from several hundred to several thousand acres. Indigo snakes utilize below-ground shelter sites for refuge, feeding, breeding, and nesting. During the winter, indigo snakes may be found occupying gopher tortoise burrows (USFWS, 2019l). The primary threat to the species is habitat destruction, modification, and fragmentation. Additional threats include direct mortality from people, predation, and vehicle strikes. The most recent 5-year review was published in 2024 (USFWS, 2024g), and the USFWS published a revised *Recovery Plan for the Eastern Indigo Snake* in 2019 (USFWS, 2019m). The eastern indigo snake is rare throughout its range and populations are considered extirpated in numerous areas. The 2019 Status Assessment Report indicates the overall current population resiliency is medium to low (USFWS, 2019l).

3.3.25 Sea Turtles

Sea turtles inhabit tropical and temperate regions of the Atlantic, Pacific, and Indian Oceans. They make long migrations between foraging areas and nesting beaches, where they typically nest between the high tide line and the dune front (NMFS and USFWS, 2023) (81 Federal Register 20058). Most sea turtle species nest at night; however, the Kemp's ridley usually nests during the day. Hatchlings of all species emerge from their nests almost exclusively at night. They use light cues to find the ocean; ambient light from the open sky creates a relatively bright horizon compared to the dark silhouette of the dune and vegetation landward of the nest (in the absence of artificial inland lighting). Substrate characteristics that are thought to be important for embryonic development and survival consist of moderate slope, modest temperature fluctuation, and adequate humidity. The green, loggerhead, and leatherback sea turtles nest regularly on Atlantic Coast beaches of Florida, including areas adjacent to KSC. Most nests are deposited from June to September (green turtle), May to August (loggerhead turtle), and April to June (leatherback turtle) (CANA, 2024). Kemp's ridley sea turtles primarily nest along the Gulf of America coast. Kemp's ridley nesting is documented near KSC, but it is considered rare (NASA, 2020). Hawksbill sea turtle nesting in the continental United States is restricted to Southeast Florida and, therefore, does not coincide with the Action Area. Threats to sea turtle species in general include fisheries bycatch, loss and degradation of nesting and foraging habitats, harvest of turtles and eggs for consumption (in some areas of the world), entanglement in marine debris, and vessel strikes (NOAA Fisheries, 2025). Status and recovery documents for each species are listed below.

Green sea turtle. Separate recovery plans have been prepared for Atlantic and Pacific Ocean populations of the green sea turtle. NMFS and the USFWS published the recovery plan for Atlantic populations in 1991 (NMFS and USFWS, 1991). The most recent 5-year review, published in 2007 (NMFS and USFWS, 2007), indicated that populations in the western Atlantic Ocean were stable or increasing.

Hawksbill sea turtle. Separate recovery plans have been prepared for the U.S. Pacific Ocean population and populations in all other U.S. waters. NMFS and the USFWS published the recovery plan for the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of America in 1993 (NMFS and USFWS, 1993). The most recent 5-year review, published in 2013, (NMFS and USFWS, 2013a) indicated that various populations were increasing, decreasing, or stable at that time. However, population trends were not provided for Florida beaches.

Kemp's ridley sea turtle. NMFS and the USFWS published the *Bi-National Recovery Plan for the Kemp's Ridley Sea Turtle* in 2011 (NMFS and USFWS, 2011). The most recent 5-year review was published in 2015 (NMFS and USFWS, 2015); NMFS and the USFWS initiated an updated 5-year status review for the Kemp's ridley turtle in 2021 (86 Federal Register 34228).

Leatherback sea turtle. Separate recovery plans have been prepared for the U.S. Pacific Ocean population and populations in all other U.S. waters. NMFS and the USFWS published the recovery plan for the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of America in 1992 (NMFS and USFWS, 1992). The most recent 5-year review, published in 2013 (NMFS and USFWS, 2013b), indicated that most populations in the Atlantic Ocean were stable or increasing, and that nesting along Florida beaches specifically was increasing.

Loggerhead sea turtle. Separate recovery plans have been prepared for U.S. Pacific Ocean and Northwest Atlantic Ocean populations. NMFS and the USFWS published the *Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle* in 2008 (NMFS and USFWS, 2008). The most recent 5-year review, published in 2023 (NMFS and USFWS, 2023), indicates that the Northwest Atlantic Ocean DPS is stable.

3.3.26 Sea Turtle Critical Habitat (Final and Proposed)

Green Sea Turtle Critical Habitat (Proposed)

In 2023, the USFWS proposed to designate new areas of nesting beach critical habitat for threatened and endangered DPSs of the green sea turtle (88 Federal Register 46376).

The USFWS has identified terrestrial areas that support natural coastal processes, as well as localized areas where habitat supports important green turtle nesting or basking areas, as PBFs for the species. These features are as follows:

> *(1) Extra-tidal or dry sandy beaches from the mean high-water line—the line on a chart or map that represents the intersection of the land with the water surface at the elevation of mean high water line—to areas of beach landward of the mean high-water line and which contain the characteristics described herein. These beaches include:*
>
> > *(a) Habitat for green turtles to transit across beaches and for nest placement that includes: (i) relatively unimpeded wet and dry sand or nearshore access areas from the ocean to the beach for nesting females and from the beach to the ocean for both post-nesting females and hatchlings and (ii) drier sand areas located above mean high water in the supralittoral zone to avoid being inundated frequently by high tides.*
> >
> > *(b) Sand substrate that (i) allows for suitable nest construction, (ii) is suitable for facilitating gas diffusion conducive to embryo development, (iii) can develop and maintain temperatures and a moisture content conducive to embryo development, and (iv) allows for emergence of hatchlings from eggshells, through sand substrate to the beach surface.*
>
> *(2) Nesting beach habitat with sufficient darkness such that nesting turtles are not deterred from emerging onto the beach and hatchlings and post-nesting females can orient to the sea.*
>
> *(3) Natural coastal processes or artificially created or maintained habitat mimicking natural conditions. This includes artificial habitat types that mimic natural conditions described in PBFs 1 and 2 above for beach access, nest site selection, nest construction, egg deposition and incubation, and hatchling emergence and movement to the sea.*

Loggerhead Sea Turtle Critical Habitat (Final)

Designated critical habitat for the loggerhead sea turtle Northwest Atlantic Ocean DPS under USFWS jurisdiction includes nesting beach habitat along portions of the Gulf of America and Atlantic Ocean coastlines (79 Federal Register 39856).

The USFWS has determined that the following PBFs are essential for the loggerhead sea turtle Northwest Atlantic Ocean DPS:

> *PBF 1—Sites for breeding, reproduction, or rearing (or development) of offspring*
>
> *PBF 2—Habitats protected from disturbance or representative of the historical, geographic, and ecological distributions of the species*

The USFWS further determined that the terrestrial primary constituent elements (PCEs) specific to the DPS are the extra-tidal or dry sandy beaches from the mean high-water line to the toe of the secondary dune, consisting of four components:

> *PCE 1—Suitable nesting beach habitat that has (a) relatively unimpeded nearshore access from the ocean to the beach for nesting females and from the beach to the ocean for both post-nesting females and hatchlings and (b) is located above mean high water to avoid being inundated frequently by high tides.*
>
> *PCE 2—Sand that (a) allows for suitable nest construction, (b) is suitable for facilitating gas diffusion conducive to embryo development, and (c) is able to develop and maintain temperatures and a moisture content conducive to embryo development.*
>
> *PCE 3—Suitable nesting beach habitat with sufficient darkness to ensure nesting turtles are not deterred from emerging onto the beach and hatchlings and post-nesting females orient to the sea.*
>
> *PCE 4—Natural coastal processes or artificially created or maintained habitat mimicking natural conditions.*

Chapter 4. Environmental Baseline

4.1 Environmental Setting

Much of the Action Area around LC-39A is under Federal management, including KSC (NASA), CCSFS (Department of the Air Force), MINWR and St. Johns National Wildlife Refuge (USFWS), and CANA (National Park Service). The Action Area also overlays portions of the IRL system and Atlantic Ocean, as well as developed areas to the south, west, and north of these Federal lands (Figure 1-1**).** The small portion of KSC's land area that is actively used to support space mission operations includes developed facility sites, roads, lawns, maintained rights-of-way, and undeveloped operational areas that are dedicated safety zones around existing facilities or are held in reserve for planned and future expansion. The remaining acreage at KSC is either undeveloped area outside of the operational areas, submerged lands, wetlands, or areas administered by the USFWS (MINWR) or National Park Service (CANA). Land uses at neighboring CCSFS are similar to those at KSC. Wetlands are prevalent at KSC, MINWR, and CCSFS, including freshwater marshes, hardwood and mixed swamps, maritime hammocks, estuarine and palustrine scrub-shrub wetlands, saltwater marshes, and mangrove swamps. The predominant upland communities are oak-palmetto scrub and pine flatwoods, with mowed ruderal herbaceous areas around developed areas and rights-of-way.

LC-39A, a SpaceX-leased launch site located on KSC, currently supports Falcon 9 and Falcon Heavy launches (Figure 1-2). As described in the 2019 *Final EA for the SpaceX Starship and Super Heavy Launch Vehicle at KSC*, SpaceX is developing a site within the perimeter of LC-39A for future Starship-Super Heavy launch operations (NASA, 2019). At LC-39A, land cover has been highly disturbed since the 1950s and currently consists of infrastructure (launch pad, roads, support structures, and buildings), shallow freshwater retention ditches, and mowed grass. Additional information on the existing conditions within the portions of the Action Area closest to LC-39A is available in the KSC Environmental Resources Document, Space Launch Delta 45 Integrated Natural Resources Management Plan, MINWR Comprehensive Conservation Plan, and the CANA Final General Management Plan/EIS (NASA, 2020; USSF, 2023; USFWS, 2008b; National Park Service, 2014).

The predominant land cover category within the 1 psf/100 dB ASEL contour around LC-39A is bays and estuaries, followed by residential, freshwater marshes, commercial and services, lakes, mixed wetland hardwoods, and highways (SJRWMD, 2024). The IRL system makes up a large portion of the area within the 1 psf/100 dB ASEL contour, consisting of the Mosquito Lagoon, Banana River, and Indian River. Most of the non-Federal lands along the shorelines of the IRL system and the Atlantic Ocean are residential and commercial development. The St. Johns River and adjacent St. Johns River Water Management District Conservation Areas and the St. Johns National Wildlife Refuge cover much of the western portion of the area within the 1 psf/100 dB ASEL contour, with vast areas of emergent and forested wetlands, as well as upland areas of oak scrub and pine flatwoods. The *Upper St. Johns River Surface Water Improvement and Management Plan* and the St. Johns National Wildlife Refuge Comprehensive Conservation Plan provide additional information on the types of habitats and wildlife that occur within the western portion of the area within the 1 psf/100 dB ASEL contour (SJRWMD, 2007; USFWS, 2011).

See the ESA Section 7 consultation Amendment 2 document associated with Starship Super Heavy operations at Boca Chica, Texas, for descriptions of the environmental setting at the Atlantic and Pacific landing action areas (USFWS, 2022f).

4.2 Activities Considered as Part of the Environmental Baseline

This section provides an overview of the activities considered as part of the environmental baseline. Per 50 CFR §402.02, the environmental baseline includes "the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process," as well as impacts from "Federal agency activities or existing Federal agency facilities that are not within the agency's discretion to modify."

The natural landscape of KSC and CCSFS is interspersed with launch complexes, buildings, roads, ditches, canals, sight lines, impoundments, and runways. Past fire exclusion, orange grove drainage systems, and INPS have altered vegetative communities. The primary activities that have affected listed species are land clearing, construction, launch and landing operations, exterior lighting, surface water discharges, and hazardous waste and hazardous materials. Past and present State and private actions also have affected federally listed species, including development, roads, bridges, docks, wastewater treatment plants, septic tanks, shoreline armoring, and other human activities (e.g., recreation, boat traffic).

Natural resources management activities at KSC, CCSFS, MINWR, and CANA include prescribed fire, INPS control, nuisance species control, habitat restoration, and endangered species management to improve the health of native species and habitat. On CCSFS, improvements to the management of scrub have increased the amount of habitat used by the Florida scrub-jay and possibly the indigo snake and the southeastern beach mouse. KSC continues to make progress in reducing light use through development and implementation of LOMs for launch complexes and facilities. Recent dune construction and improvements at KSC provide some abatement to disorientation risks by screening direct line-of-sight to the facilities and associated lighting, as well as improving habitat for the southeastern beach mouse.

While the Action Area does have thousands of acres of undeveloped land, the maintenance of existing facilities and infrastructure, as well as future construction, launches, and daily operations for activities that have already undergone formal or early Section 7 consultation, will affect the environmental baseline in some areas. State and private actions contemporaneous with this consultation, such as construction associated with development, roads, and bridges, are also part of the environmental baseline. These activities and facilities are likely to result in noise and human disturbance, habitat destruction and degradation, collisions/ strikes, lighting, and INPS spread, among other effects (Table 4-1). Appendix B, *Consultations*, provides a list of formal consultations with proposed actions that either have continuing effects, have not yet been completed, or have not started and, thus, may have impacts that overlap with the Starship-Super Heavy Proposed Action.

Table 4-1 provides an impact overview for the activities considered as part of the environmental baseline in the Action Area.

Table 4-1. Impact Overview for Activities Considered as Part of the Environmental Baseline

Organization	Activity Type	Impacts
Kennedy Space Center, Cape Canaveral Space Force Station	Facility and infrastructure construction and maintenance; land clearing; daily operations	Noise, sonic boom, vibration, and human disturbance Habitat destruction/degradation Lighting Collisions/strikes Hazardous materials INPS spread
	NASA, SpaceX, United Launch Alliance, Blue Origin, and other launch operator tests, launches, landings, and daily operations	
	Natural resources management	Habitat improvement
Merritt Island National Wildlife Refuge, Canaveral National Seashore, St. Johns National Wildlife Refuge	Facility and infrastructure construction and maintenance; daily operations	Noise and human disturbance Habitat destruction/degradation Lighting Collisions/strikes Hazardous materials INPS spread
	Past mosquito impoundment construction and current maintenance (MINWR only)	Habitat destruction/degradation
	Natural resources and recreation management	Habitat improvement
State and Private	Commercial and residential construction; infrastructure construction and maintenance; dredging; daily activities; past mosquito impoundment construction and current maintenance	Noise and human disturbance Habitat destruction/degradation Lighting Collisions/strikes Hazardous materials INPS spread

Notes: INPS = invasive non-native plant species; MINWR = Merritt Island National Wildlife Refuge; NASA = National Aeronautics and Space Administration; SpaceX = Space Exploration Technologies Corporation.

Table 4-2 lists the annual baseline and proposed action levels of launches, static fire tests, and landings at KSC and CCSFS for programs with completed ESA Section 7 consultations plus the Proposed Action.

Table 4-2. Baseline and Proposed Action Launches, Landings, and Static Fire Tests at KSC and CCSFS

Baseline Annual Operations (1 September 2023 – 31 August 2024)						
Event	**Facility**	**Complex**	**Vehicle/Program**	**Day**	**Night**	**Total**
Launch	KSC	LC-39A	SpaceX Falcon 9	10.2	6.8	17
		LC-39A	SpaceX Falcon Heavy	1.8	1.2	3
	CCSFS	SLC-37	ULA Delta IV Heavy	1	0	1
		SLC-40	SpaceX Falcon 9	37.2	24.8	62
		SLC-41	ULA Atlas V 501 (0 SRBs)	1	0	1
		SLC-41	ULA Atlas V N22 (2 SRBs)	1	0	1
		SLC-41	ULA Atlas V 551 (5 SRBs)	1	1	2
		SLC-41	ULA Vulcan VC2S	0	1	1
			Total Launches	**53.2**	**34.8**	**88**
Landing	CCSFS	LZ-1/LZ-2	SpaceX Falcon 9 Booster	4.2	2.8	7
		LZ-1/LZ-2	SpaceX Falcon Heavy Booster	3.6	2.4	6
			Total Landings	**7.8**	**5.2**	**13**
Static Fire	KSC	LC-39A	SpaceX Falcon 9	10.2	6.8	17
		LC-39A	SpaceX Falcon Heavy	1.8	1.2	3
	CCSFS	SLC-40	SpaceX Falcon 9	37.2	24.8	62
			Total Static Fire Tests	**49.2**	**32.8**	**82**

Table 4-2. Baseline and Proposed Action Launches, Landings, and Static Fire Tests at KSC and CCSFS

Proposed Action Annual Operations (includes other actions with completed consultations)						
Event	**Facility**	**Complex**	**Vehicle/Program**	**Day**	**Night**	**Total**
Launch	KSC	LC-39A	Starship	22	22	44
		LC-39A	SpaceX Falcon 9	0	36	36
		LC-39A	SpaceX Falcon Heavy	0	5	5
		LC-39B	NASA Space Launch System	0.6	0.4	1
		LC-48N	NASA SCLV	32.5	19.5	52
		LC-48S	NASA SCLV	32.5	19.5	52
	CCSFS	SLC-14	Stoke Nova	5	5	10
		SLC-16	Relativity Terran R	18	6	24
		SLC-20A	SCLV	4.2	1.8	6
		SLC-20B	MCLV	12.6	5.4	18
		SLC-36	Blue Origin New Glenn Launch	10	2	12
		SLC-40	SpaceX Falcon 9 Launch	0	70	70
		SLC-41	ULA Atlas V 551 (5 SRBs)	6.25	3.75	10
		SLC-41	ULA Vulcan VC6S	13	7	20
		SLC-46	Liquid Propellant Vehicle	7.5	4.5	12
		SLC-46	Solid Propellant Vehicle	7.5	4.5	12
			Total Launches	**171.6**	**212.4**	**384**
Landing	KSC	LC-39A	Starship Spacecraft RTLS	22	22	44
		LC-39A	Super Heavy Booster RTLS	22	22	44
	CCSFS	LZ-1/2	SpaceX Falcon Booster	0	54	54
		LZ-1/2	SpaceX Falcon Heavy Booster	0	5	5
			Total Landings	**44**	**103**	**147**
Static Fire	KSC	LC-39A	Starship	22	22	44
		LC-39A	Super Heavy Booster	22	22	44
		LC-39A	SpaceX Falcon 9	0	36	36
		LC-39A	SpaceX Falcon Heavy	0	5	5
		LC-48N	NASA SCLV	32.5	19.5	52
		LC-48S	NASA SCLV	32.5	19.5	52
	CCSFS	SLC-11	Blue Origin BE-4 Engine Testing	108	0	108
		SLC-14	Stoke Nova	10	0	10
		SLC-16	Relativity Terran R Static Fire	18	6	24
		SLC-16	Relativity Terran R Stage MDC Hot Fire	10	4	14
		SLC-20A	SCLV Static Fire	4.2	1.8	6
		SLC-20A	SCLV Acceptance Test	4.2	1.8	6
		SLC-20B	MCLV Static Fire	12.6	5.4	18
		SLC-20B	MCLV Acceptance Test	12.6	5.4	18
		SLC-36	Blue Origin New Glenn Static Fire	10	2	12
		SLC-40	SpaceX Falcon 9 Static Fire	0	70	70
			Total Static Fire Tests	**298.6**	**220.4**	**519**

Notes: BE-4 = Blue Engine 4; CCSFS = Cape Canaveral Space Force Station; KSC =Kennedy Space Center; LC = Launch Complex; MDC = Mission Duty Cycle; NASA = National Aeronautics and Space Administration; RTLS = return to launch site; SCLV = Spacecraft and Launch Vehicle; SLC = Space Launch Complex; SpaceX = Space Exploration Technologies Corporation; SRB = solid rocket booster; ULA = United Launch Alliance.

4.3 Environmental Baseline for Species and Critical Habitat

Locations of known and potential habitat, as well as designated and proposed critical habitat, within the Action Area around LC-39A are provided in the figures of Chapter 5, *Effects of the Action*.

4.3.1 Audubon's Crested Caracara

Crested caracaras are present in Florida in relatively small, isolated populations and are year-round residents. Brevard County is the northern limit for the Audubon's crested caracara (FWC, 2024b). KSC personnel have observed caracaras at LC-39B and along the beach road between KSC and CCSFS in recent years and they have been documented on CCSFS (USSF, 2023). These birds have high site fidelity, so the presence of adults likely indicates a breeding territory; however, nesting has not been confirmed. The caracara's preferred habitat of wet prairies with cabbage palms is not present close to LC-39A, but the caracara is expected to occur in the wider Action Area affected by rocket noise and sonic booms.

4.3.2 Band-Rumped Storm-Petrel

The band-rumped storm-petrel breeds on the Hawaiian Islands, which are just outside of the portions of the Pacific Landings Area that are south and east of the islands and forages within or travels through the Pacific Landings Area.

4.3.3 Bermuda Petrel

The Bermuda petrel nests in burrows on a few islets of Bermuda; otherwise, individuals live on the open ocean. This species forages in deeper waters within the Atlantic Landings Area.

4.3.4 Black-Capped Petrel

The black-capped petrel is known to breed on one island – Hispaniola; otherwise, it lives on the open ocean. This species is expected to forage in deeper waters within the Atlantic Landings Area and may be a transient visitor to nearshore portions of the Action Area. However, no observations of the black-capped petrel have been made at KSC, MINWR, CCSFS, or CANA.

4.3.5 Eastern Black Rail

Available records from 2011 to 2016 indicate no eastern black rail breeding was observed in Brevard County (USFWS, 2019c), but black rail breeding has been documented at the St. Johns NWR in recent years. During bird surveys at MINWR impoundments from 1984 to 1985, black rails were infrequently sighted within emergent vegetation along the edges of open water (Breininger & Smith, 1990). Breeding season call surveys were conducted at KSC/MINWR in 2022 at route locations determined by Geographic Information System analysis and consultation with USFWS experts (NASA, 2023). Prior to the breeding season (March through July), survey routes, each consisting of multiple playback stations, were established in five areas with suitable habitat. Each route was surveyed two to four times (15 total surveys) from March to July, with most surveys lasting about 2 hours. Black rails were detected three times during the breeding season in the Black Point area (10.7 miles from LC-39A) and near Buck Creek on the west shore of the Banana River (7.4 miles from LC-39A).

Eastern black rail surveys have not been conducted in the LC-39A area. Although suitable black rail habitat is not present within LC-39A, suitable intertidal marshes and emergent wetlands are present in the vicinity of LC-39A and within the larger Action Area affected by rocket noise and sonic booms.

4.3.6 Everglade Snail Kite

The Everglade snail kite is primarily found in central and south Florida (FWC, 2024c). No snail kite habitat is present at LC-39A. Due to its limited diet consisting primarily of apple snails found in sparsely vegetated lake shores or marshes, which are not common in the Action Area, the kite would only be incidentally present within the Action Area affected by launch noise and sonic booms.

4.3.7 Florida Grasshopper Sparrow

The Florida grasshopper sparrow is known to occur only in remnant areas of south-central Florida (Highlands, Okeechobee, Osceola, and Polk Counties) (USFWS, 2023d). Suitable habitat for the Florida grasshopper sparrow is present only near the edge of the Starship Atlantic Contingency landings 1 psf contour.

4.3.8 Florida Scrub-Jay

The Action Area contains the second largest contiguous population of Florida scrub-jays in the species' range. Together, CCSFS, KSC, CANA, and MINWR are estimated to have more than 20,000 acres of potentially suitable scrub-jay habitat; however, numbers have declined by more than 50 percent since 1987, and the population continues to decline (NASA, 2024b). KSC has a potential population size of 700 breeding pairs, but the population is currently less than half this number. At KSC, the core habitat zone represents habitat of greatest importance to the scrub-jay population; the support habitat zone has lesser importance, although it is necessary for connecting population cores and providing a population with high persistence probabilities. Auxiliary habitat is of lower habitat quality regardless of management history.

At CCSFS, there are approximately 8,400 acres of scrub habitat potentially suitable for Florida scrub-jays based on estimated acreages for oak scrub, disturbed oak scrub, coastal strand, and disturbed coastal strand habitats. The scrub acreage is divided into three categories: good, fair, and poor (USSF, 2023). In the *Biological Assessment for the Falcon Operations at Space Launch Complex 40, Cape Canaveral Space Force Station,* Figure 10 shows the Florida scrub-jay survey data from 2016 to 2023 for CCSFS, including the number of individuals observed and scrub-jay census years (USSF, 2024).

Figure 4-1 and Figure 4-2 provide Florida scrub-jay data for KSC, MINWR, and CCSFS from 1995 to 2022/2023.

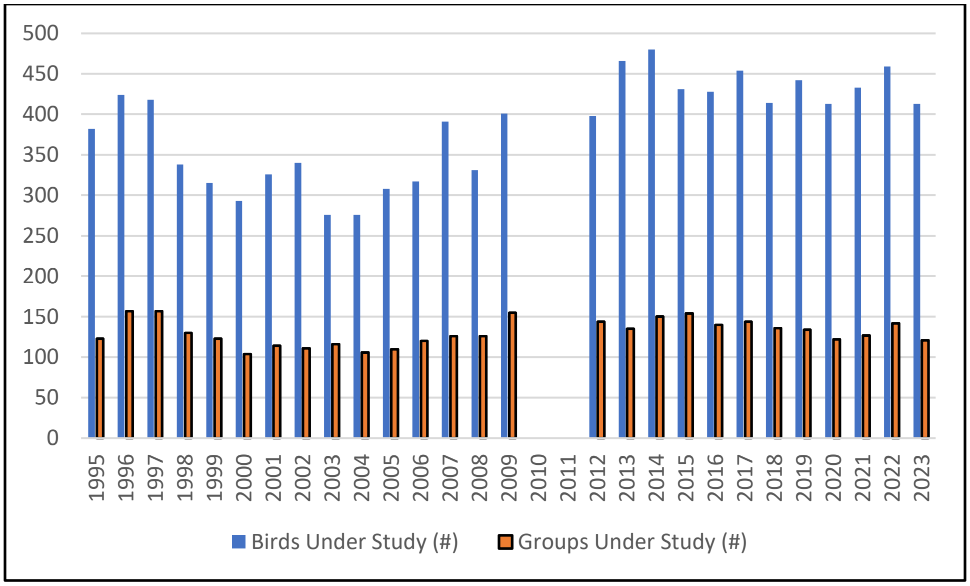


Figure 4-1. Florida Scrub-Jay at CCSFS: Number of Birds and Groups Under Study (1995 to 2023)

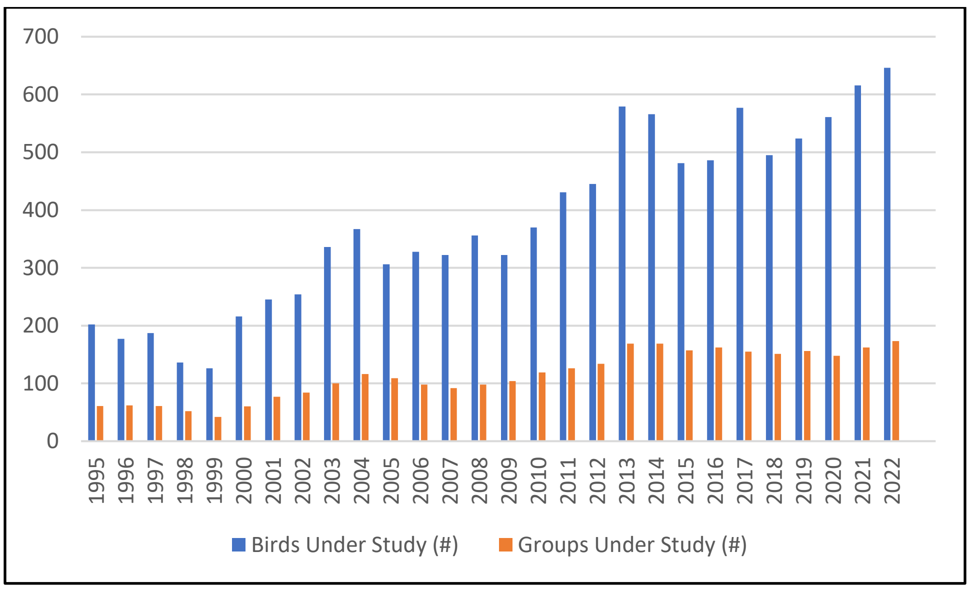


Figure 4-2. Florida Scrub-Jay at KSC/MINWR: Number of Birds and Groups Under Study (1995 to 2022)

Monitoring of color-banded scrub-jay populations on KSC began in 1987 and showed that territory sizes averaged 10 hectares (25 acres) (Breininger et al., 1995). KSC supports the state's second-largest population of Florida scrub-jays, which has declined by more than 50 percent since 1987 and has continued to decline (NASA, 2025a). Most habitat on KSC remains suboptimal (short, closed-medium, tall mix). It has not recovered from habitat degradation during the fire-suppression period and is about half its potential carrying capacity. Changing the amount or quality of habitat outside of focal scrub areas makes little difference to Florida scrub-jay population viability and may actually negatively affect recruitment by drawing helpers away from the best areas.

Historically, Florida scrub-jay monitoring was conducted near pads LC-39A and LC-39B, but this monitoring was discontinued as the areas were viewed as “sinks” and monitoring and management efforts were focused in areas with greater potential for recovery.

For the Proposed Action, the closest Florida scrub-jay territory core habitat is 0.86 miles from the nearest construction and 1.32 miles and 1.27 miles from the launch and landing pads, respectively.

4.3.9 Hawaiian Petrel

The Hawaiian petrel breeds on the Hawaiian Islands, which are just outside of the Pacific Landing Action Areas that are south and east of the islands and is known to forage within or travel through the Pacific Landing Action Areas.

4.3.10 Newell’s Shearwater

The Newell’s shearwater breeds on the Hawaiian Islands, which are just outside of the Pacific Landing Action Areas that are south and east of the islands and is known to forage within or travel through the Pacific Landing Action Areas.

4.3.11 Piping Plover

Overwintering piping plover occur in shoreline areas of the Action Area, including portions of MINWR, KSC, CCSFS, and CANA. No piping plover habitat is within the construction area, but there is potential piping plover overwintering habitat located 0.12 miles from the closest construction and 0.17 and 0.13 miles from the launch and landing pads, respectively, so piping plovers are expected to seasonally occur within the Action Area.

4.3.12 Red-Cockaded Woodpecker

Suitable mature pine habitat required by red-cockaded woodpeckers is not present near LC-39A and is very limited within the 1 psf/100 dB ASEL contour around LC-39A. The 2022 *Red-cockaded Woodpecker Species Status Assessment* (USFWS, 2022g) shows no red-cockaded woodpecker populations within the 1 psf/100 dB ASEL contour around LC-39A, and only one red-cockaded woodpecker population within the Starship Contingency 1 psf contour, located south of Palm Bay (St. Sebastian River Preserve State Park). The Species Status Assessment ranks this population’s resilience (13 active clusters) as very low (USFWS, 2022g).

4.3.13 Roseate Tern

Roseate terns occur in offshore areas off the coast of North Carolina and South Carolina. They are likely to occur within the Atlantic Landings Area.

4.3.14 Rufa Red Knot

Overwintering red knots occur in shoreline areas of the Action Area, including portions of MINWR, KSC, CCSFS, and CANA. The larger Action Area around LC-39A where there would be impacts from rocket noise and sonic booms overlaps areas of potential red knot habitat. No red knot habitat is within the construction area, but there is potential red knot overwintering habitat located 0.12 miles from the closest construction and 0.17 and 0.13 miles from the launch and landing pads, respectively, so red knots are expected to seasonally occur within the Action Area.

4.3.15 Short-Tailed Albatross

The short-tailed albatross breeds on Midway Atoll, just north of the Pacific Landing Action Areas and is known to forage within or travel through the Pacific Landing Action Areas.

4.3.16 Wood Stork

There are no known nesting colonies or core foraging habitat for the wood stork within 4 miles of LC-39A. However, the wider Action Area does overlap with core foraging habitat for known nesting colonies, and the wood stork has been documented at KSC and CCSFS (USSF, 2023; NASA, 2020). The closest wood stork foraging habitat is located over 5 miles from the construction area and the launch and landing pads.

4.3.17 Monarch Butterfly

Monarch butterflies have been sighted within the Action Area, including at KSC. These may be some of the monarchs from eastern North America that appear to migrate through Florida to Cuba and the Yucatán Peninsula. The non-migratory populations of monarchs in Florida are assumed to be further south than the Action Area around LC-39A.

4.3.18 Anastasia Island Beach Mouse

Suitable habitat for the Anastasia Island beach mouse is present only within the Starship Atlantic Contingency landings 1 psf contour, and its range is limited to St. Johns County, Florida.

4.3.19 Florida Bonneted Bat

The federally endangered Florida bonneted bat is a large bat species that occurs in central and south Florida, generally from just south of Orlando to Miami in coastal and interior areas (USFWS, 2025c). Therefore, the species would likely only coincide with the Action Area in a small portion of the northeastern portion of its range.

4.3.20 Southeastern Beach Mouse

Studies and surveys have been done on the southeastern beach mouse population on KSC since the 1970s. Populations appear to have remained stable over the years, likely due to the continuity of the habitat (CANA/KSC/MINWR/CCSFS) that allows recolonization when subpopulations are extirpated by natural events such as hurricanes and other storms. In a study conducted on KSC between 2003 and 2005, capture rates of beach mice in coastal dune areas were good, but they were less than those experienced further south on CCSFS where the expanse of suitable habitat is much wider. Medium- to high-quality habitat is available for the southeastern beach mouse within the coastal dune/strand areas of CCSFS, as well as in interior oak scrub sites and in buildings. Near Land Management Unit 40 at CCSFS, there is a large and healthy population of the southeastern beach mouse residing in coastal dune/strand and disturbed oak scrub communities (USSF, 2023). At the shoreline dune restoration area near KSC LC-39A and LC-39B, the southeastern beach mouse moved into the area within 4 months of vegetation planting.

The 2025 *Population Viability Analysis for the Southeastern Beach Mouse* (Traylor-Holzer & Lacy, 2025) includes information on the known extant southeastern beach mouse populations—the Canaveral Complex population, which is the core southeastern beach mouse population, and the Smyrna Dunes Park population, a small, isolated population located north of the Canaveral Complex. The Canaveral Complex population extends 72 kilometers from the Port Canaveral entrance channel north to the northern reaches of CANA. The availability of inland habitat varies along this stretch, with substantial suitable connected inland habitat at CCSFS (southern 30 kilometers), some suitable inland habitat at KSC (central 10 kilometers), and little to no suitable inland habitat at CANA (northern 30 kilometers). Traylor-Holzer and Lacy (2025) cited recent work on CANA and KSC that documented a seasonal pattern of higher beach mouse densities in spring and winter, with a high density in dune habitat of approximately 3.6 mice/acre and estimated at approximately 1.2 mice/acre in inland habitat.

No potential beach mouse habitat (per spatial data provided by KSC) is located within the construction area or plume area, but there is potential habitat located 0.15 miles from the closest construction and 0.23 and 0.39 miles from the launch and landing pads, respectively.

4.3.21 Tricolored Bat

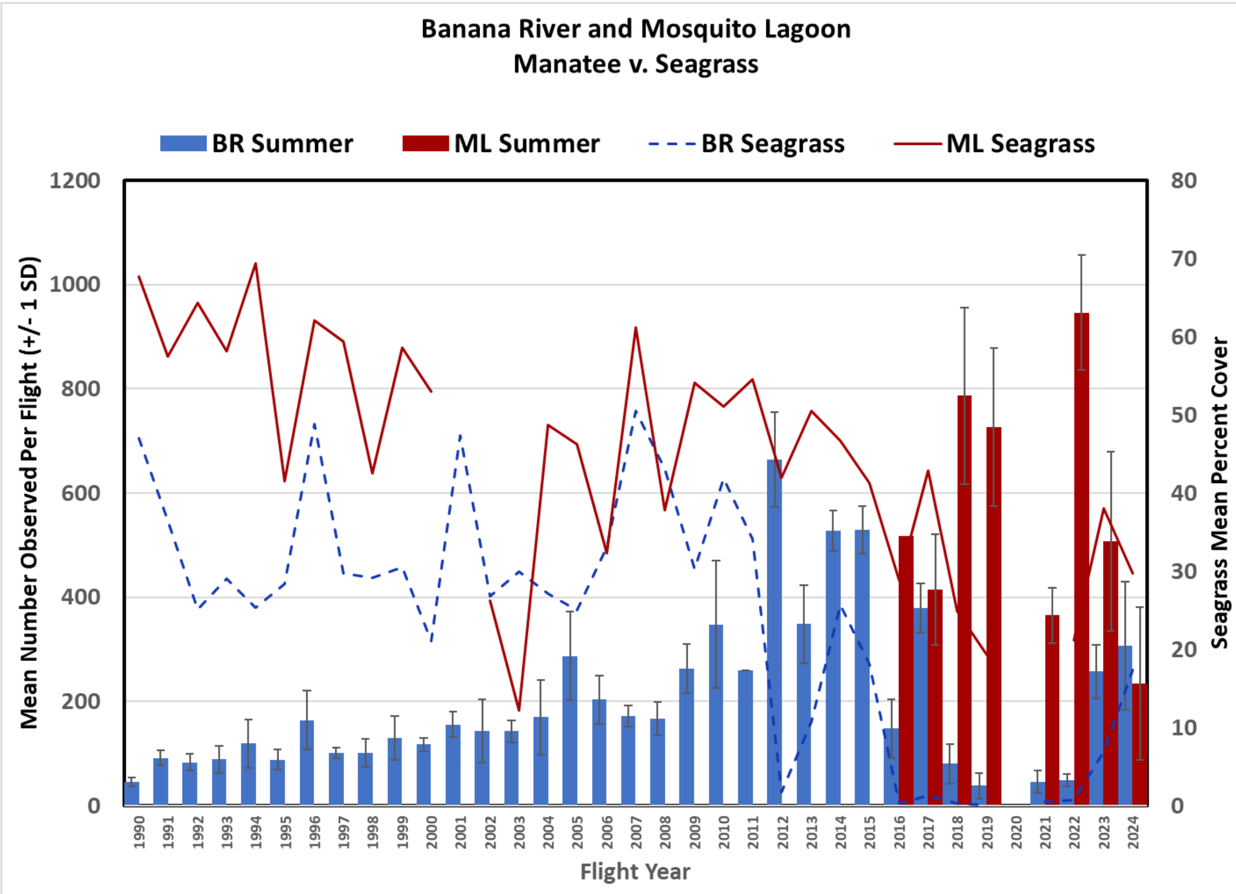
The tricolored bat is known to occur in within the Action Area, and acoustic surveys conducted in 2019 detected tricolored bats at various locations on CCSFS (USSF, 2023). Roost locations on KSC, MINWR, and CCSFS are unknown, but the species is expected to roost within the Action Area that may be affected by noise and sonic booms.

4.3.22 West Indian Manatee

Manatees are present year-round in the Action Area, except for brief periods of cold weather. During the spring each year, as much as 25 percent of the total U.S. manatee population can be found within the waters immediately surrounding KSC, MINWR, and CCSFS property (NASA, 2020). The upper Banana River, managed by NASA and MINWR, is closed to the public for safety and security measures, and is a sanctuary for manatees, which covering the majority of the KSC boundary within the Banana River. This is an area of particular emphasis for cautious boat operations; all motorized boat traffic, except for NASA mission-essential activities, is precluded from entering the sanctuary.

Seagrass is the major source of forage for manatees. Between 2009 and 2019, several large, persistent algal blooms reduced water clarity and quality in the IRL, negatively impacting seagrass growth and distribution. The acreage of seagrasses in the KSC portion of the Banana River dropped from over 12,000 acres in 2009 to less than 400 acres in 2019 (NASA, 2024c). The 2023 KSC seagrass transect surveys documented a marked increase in seagrass occurrence and percent cover in the KSC portions of the Banana River and Mosquito Lagoon compared to the limited presence of submerged aquatic vegetation since 2016. Reductions in bloom activity and clearer water due to water quality improvements are likely responsible for the increases in seagrasses.

In the early 1990s, on average fewer than 100 manatees were documented per flight in the Banana River but numbers were steadily increasing into the hundreds until 2016 when numbers dropped to under 200. In 2018, manatee abundance in the Banana River reached a 28-year low (average of 81 manatees per flight). During this period, manatee mortality rates in the IRL were the highest documented in decades; hundreds of manatees died of apparent starvation. Concurrently, as manatee numbers declined in the Banana River, large numbers of manatees were observed in the Mosquito Lagoon, where manatee numbers have been traditionally low. Since 2023, manatees have begun returning to the Banana River to levels observed prior to the seagrass die-off in 2015 and 2016. This increase is most likely related to the increase in seagrass in both areas (Figure 4-3).



Source: NASA (2025b). Blue bar = mean number of manatees per flight with +/- 1 standard deviation (SD) for Banana River; red bar = mean number of manatees per flight with +/- 1 SD for Mosquito Lagoon. Lines = trends in mean percent cover of seagrass (red for Banana River, blue for Mosquito Lagoon). Note: No surveys conducted in summer 2020.

Figure 4-3. Seagrass and Manatee Trends during Summer Surveys in Banana River and Mosquito Lagoon

Table 4-3 presents the number of manatees observed during 2024 surveys. In 2024, the highest counts overall and for each lagoon occurred in late winter and spring. The highest count of 949 manatee occurred on the 25 April 2024 survey (NASA, 2025b). The numbers decreased during the summer months as manatees moved throughout the region. The numbers increased in late summer and fall as manatees returned to the area.

Table 4-3. Number of Manatees Observed During 2024 Surveys of Banana River and Mosquito Lagoon

Survey Date	Season	Banana River	Mosquito Lagoon	Total Observed
1/30/2024	Winter	119	93	212
2/23/2024	Winter	227	616	843
3/21/2024	Spring	420	363	783
4/25/2024	Spring	507	442	949
5/16/2024	Spring	270	127	397
6/18/2024	Summer	223	85	308
7/10/2024	Summer	186	156	342
8/15/2024	Summer	444	419	863
8/29/2024	Summer	376	279	655
9/19/2024	Fall	218	226	444

Source: NASA (2025b).

Manatee habitat is located 0.07 miles from the closest construction and is 0.17 and 0.13 miles from the launch and landing pads, respectively. The footprint of the plume overlaps 3.21 acres of critical habitat.

4.3.23 Atlantic Salt Marsh Snake

Per the 5-year review for the Atlantic Salt Marsh Snake, the status of this snake is unknown, but it appears to be restricted to coastal portions of Volusia County, Florida (USFWS, 2019n). Thus, the entire range of the Atlantic salt marsh snake is contained within the 1 psf contour around the Starship Atlantic Contingency landing area.

4.3.24 Eastern Indigo Snake

Suitable habitat for the indigo snake does occur within the Action Area, with occasional sightings and road kills. The last confirmed observation of an eastern indigo snake on CCSFS was in 2004, but an unconfirmed, yet reliable, observation was made in December 2023. A 2018 herpetological survey did not result in any observations, but a roadkill eastern indigo snake was observed that year approximately 0.5 mile north of the KSC-CCSFS boundary. From 1998 to 2002, in a study funded by a private wildlife foundation with support from NASA and the USFWS, more than 70 eastern indigo snakes were captured from throughout Brevard County and radio-tracked (Breininger et al., 2011).

These documented observations support the assertion that it is reasonably certain that indigo snakes occur within the Action Area.

4.3.25 Sea Turtles

Sea turtle monitoring at CCSFS and KSC started in the 1980s. The Atlantic shoreline within the Action Area provides nesting habitat for loggerhead sea turtles, green sea turtles, and leatherback sea turtles, with infrequent nesting by Kemp’s ridley sea turtles and hawksbill sea turtles.

CANA, KSC, and CCSFS beaches consistently support high nest densities each year during nesting season (May through October). KSC, CANA, and CCSFS together provide over 67 kilometers (47.6 miles) of contiguous federally owned nesting beach. On the 10 kilometers (6.2 miles) of KSC secured beach, roughly 1,000 loggerhead nests generally are deposited annually, while green sea turtle nesting typically alternates low and high nesting numbers from one year to the next (e.g., with less than 50 nests one year and close to 1,000 nests the following year) (NASA, 2020). Leatherback nests are found in relatively low numbers each year, with rare nesting by Kemp's ridley sea turtles.

Table 4-4 provides sea turtle nesting data for Brevard County, Florida, from 2018 to 2022. Figure 4-4 and Figure 4-5 provide sea turtle nesting data for KSC and CCSFS from 1983/1986 to 2023.

Table 4-4. Sea Turtle Nesting Data for Brevard County, Florida, 2018–2022

	2018	2019	2020	2021	2022
Loggerhead	23,294	27,814	26,991	22,554	31,623
Green	1,598	25,609	12,203	15,281	17,464
Leatherback	38	98	98	95	143

Source: FWC Fish and Wildlife Research Institute Statewide Nesting Beach Survey Program (https://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals/).

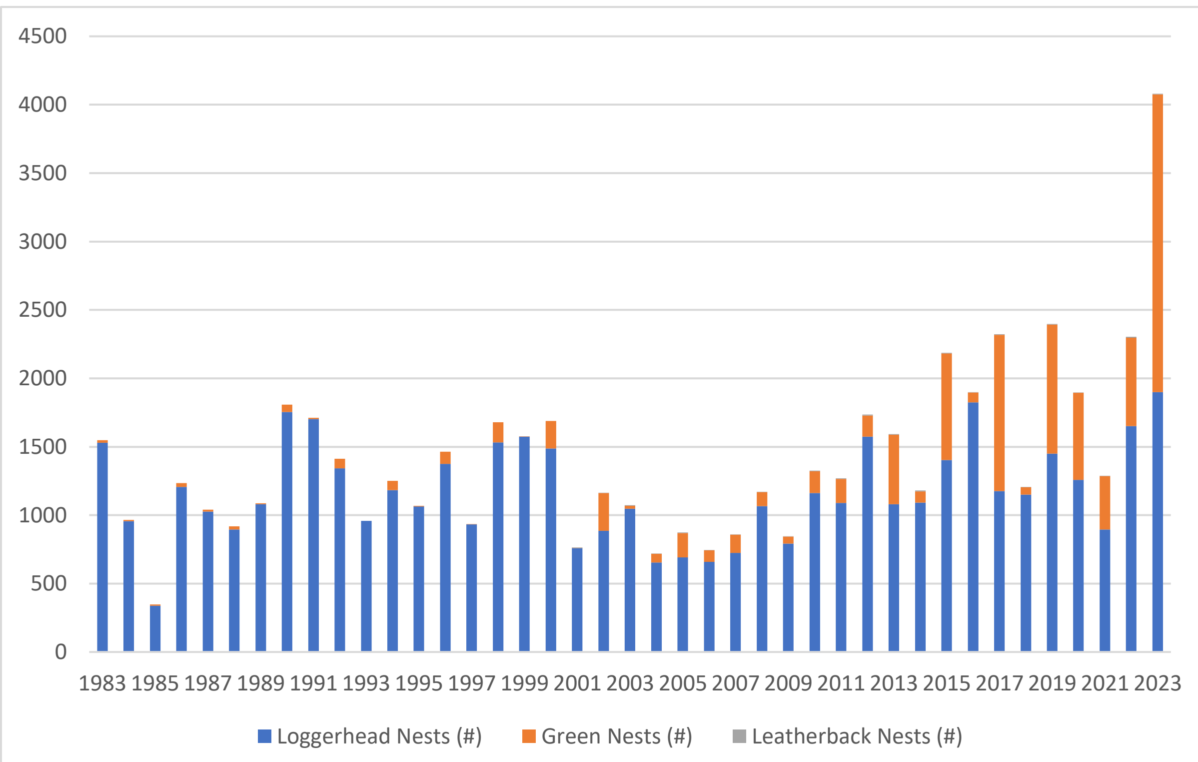


Figure 4-4. Sea Turtle Nests at KSC Security Beach (1983 to 2023)

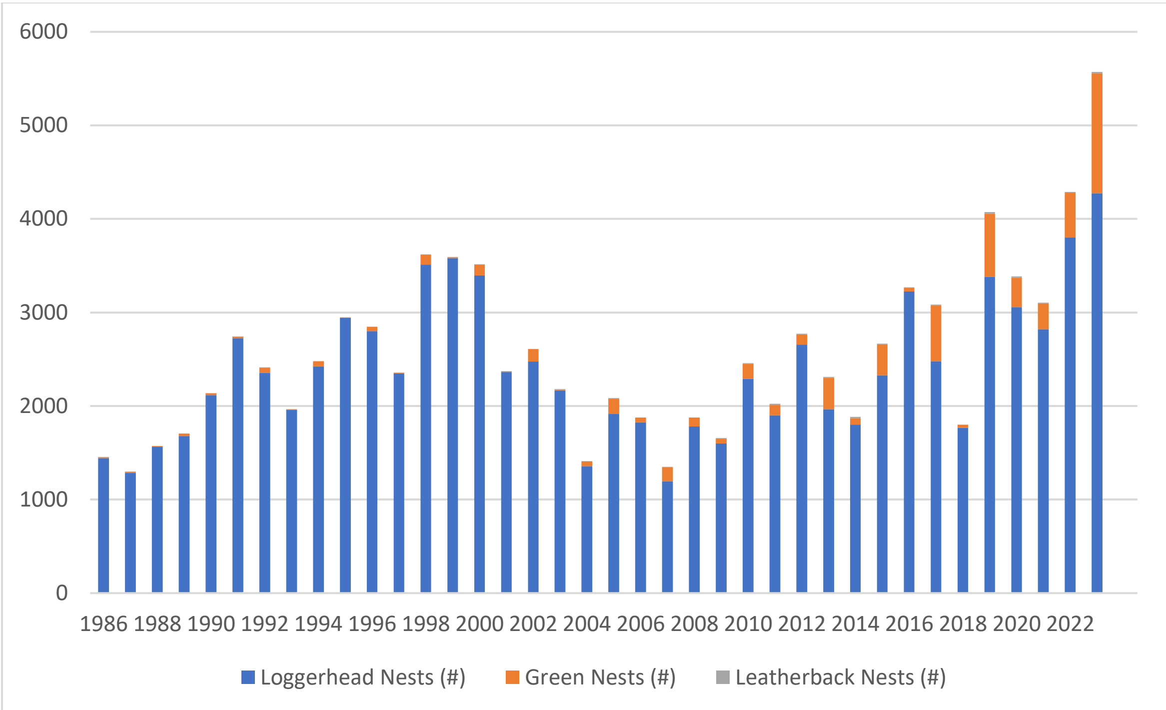


Figure 4-5. Sea Turtle Nests at CCSFS (1986 to 2023)

The 11-kilometer stretch of the KSC Security Beach has been monitored for sea turtle nesting activity annually since 1983, beginning at the KSC/CCSFS boundary and extending north to the KSC Eagle 4 observation tower and the southern extent of CANA. Kilometer sections and KSC facilities near the coast are shown in Figure 4-6. The kilometer section numbers shown this figure correspond to the segment below or south of the designation. LC-39A is directly centered on the kilometer 30 section, which is closest to the location of proposed Starship-Super Heavy operations at KSC.

Loggerhead nesting within the KSC Security Beach has shown large year to variability and several population peaks and troughs over 41 years of monitoring, with an overall increasing trend. Looking at the last 10 years, after the end of the Space Shuttle program and roughly corresponding with the beginning of SpaceX's Falcon 9 program at LC-39A, loggerhead nesting along the entire KSC Security Beach has increased at a rate of about twice the rate (R=0.074) as observed over the entire 41-year period. Green turtle nesting, which was almost discountable in 1983 has increased exponentially at the KSC Security Beach since monitoring began (Figure 4-4). Nesting was bimodal for many years with alternating "high" and "low" years, with periods of deviation from this pattern from roughly 2004 to 2012 and from 2019 to 2023. Loggerhead and green sea turtle nesting within the kilometer 30 beach section adjacent to LC-39A show similar trends to those for the overall Security Beach, recording an increasing trend during both analysis periods (41 and 10 years).

Figure 4-6**. KSC Security Beach Sea Turtle Nesting Survey Kilometer Stations and Adjacent Facilities**

Sea turtle nesting success is measured as the percentage of emergences or "crawls" resulting in egg deposition (i.e., nesting). Aside from the physiological and behavioral factors determining when sea turtles emerge from the ocean to nest, nesting success can be influenced by several external factors including nesting habitat condition, predation pressure (predator interactions), human disturbance from direct interaction and artificial light use, and even monitoring observer bias. For the KSC Security Beach, the long-term data suggest loggerhead nesting success has decreased by about 13 percent for this period, while crawl data collected from the previous 10 years indicates nesting success for both species was flat during that period (Figure 4-7). As is the case within the entire KSC Security Beach, nesting success analyzed from the long-term within kilometer 30 also shows a decreasing trend for both loggerhead and green sea turtles. However, when crawl survey data from the last 10 years is considered, nesting success with kilometer 30 shows a slight increase during that period for both species (Figure 4-8).

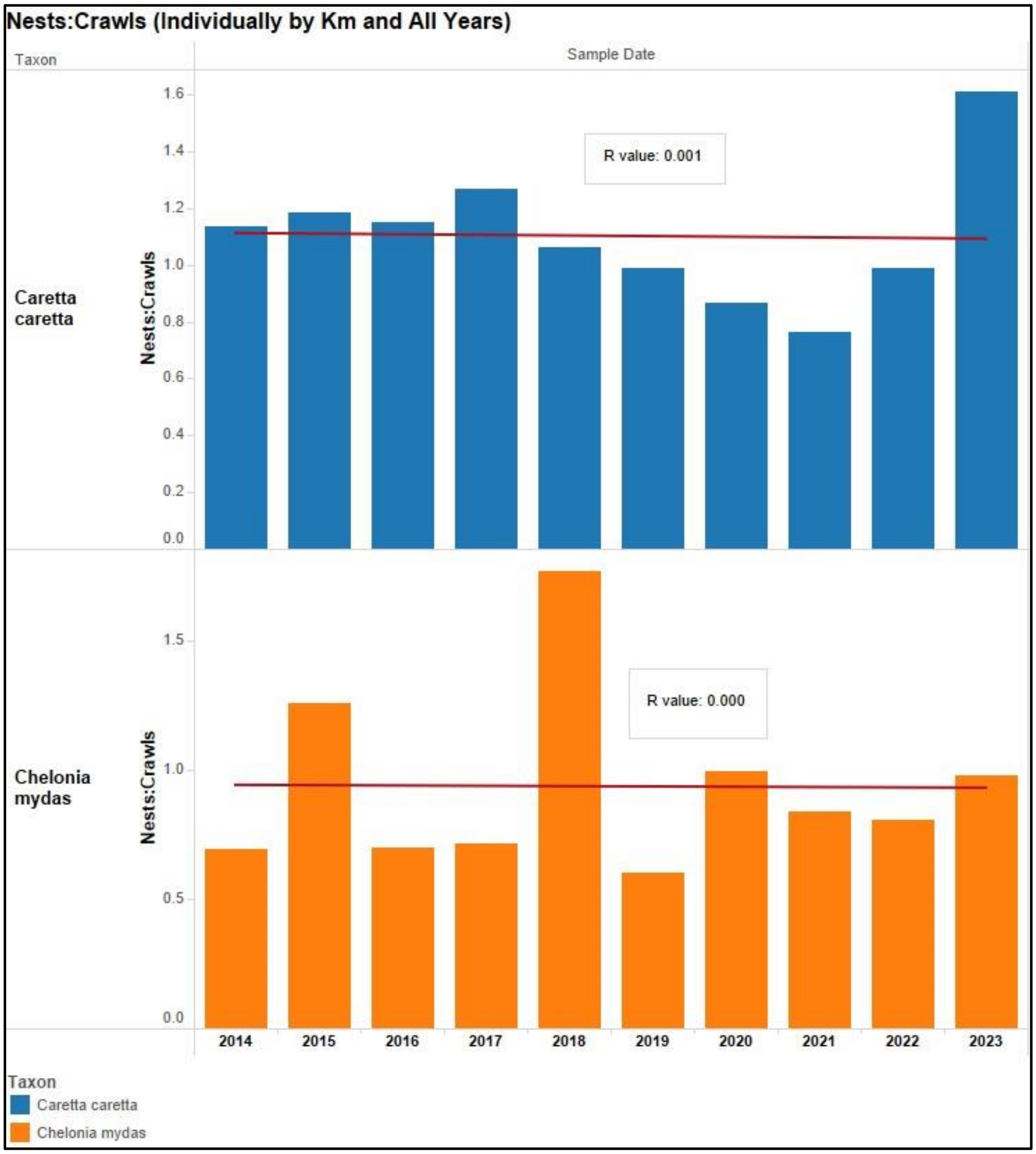


Figure 4-7**. Nesting Success along KSC Security Beach for Loggerhead (top) and Green (bottom) Sea Turtles, 2014 to 2023**

There are many factors external to KSC operations that determine sea turtle populations and nesting output recorded each year on the KSC Security Beach. Because KSC beaches have remained relatively untouched by development and no KSC operations directly inhibit sea turtle nesting activities, it is highly unlikely that fluctuations (temporal or spatial) in observed nesting totals are related to KSC and its operations. However, it is widely accepted that conservation and sea turtle management activities such as predator control programs conducted for the past 40-years along the contiguous Federal properties comprised of CSSFS, KSC/MINWR, and CANA have been a contributing factor in recovery of sea turtle populations nesting on these beaches.

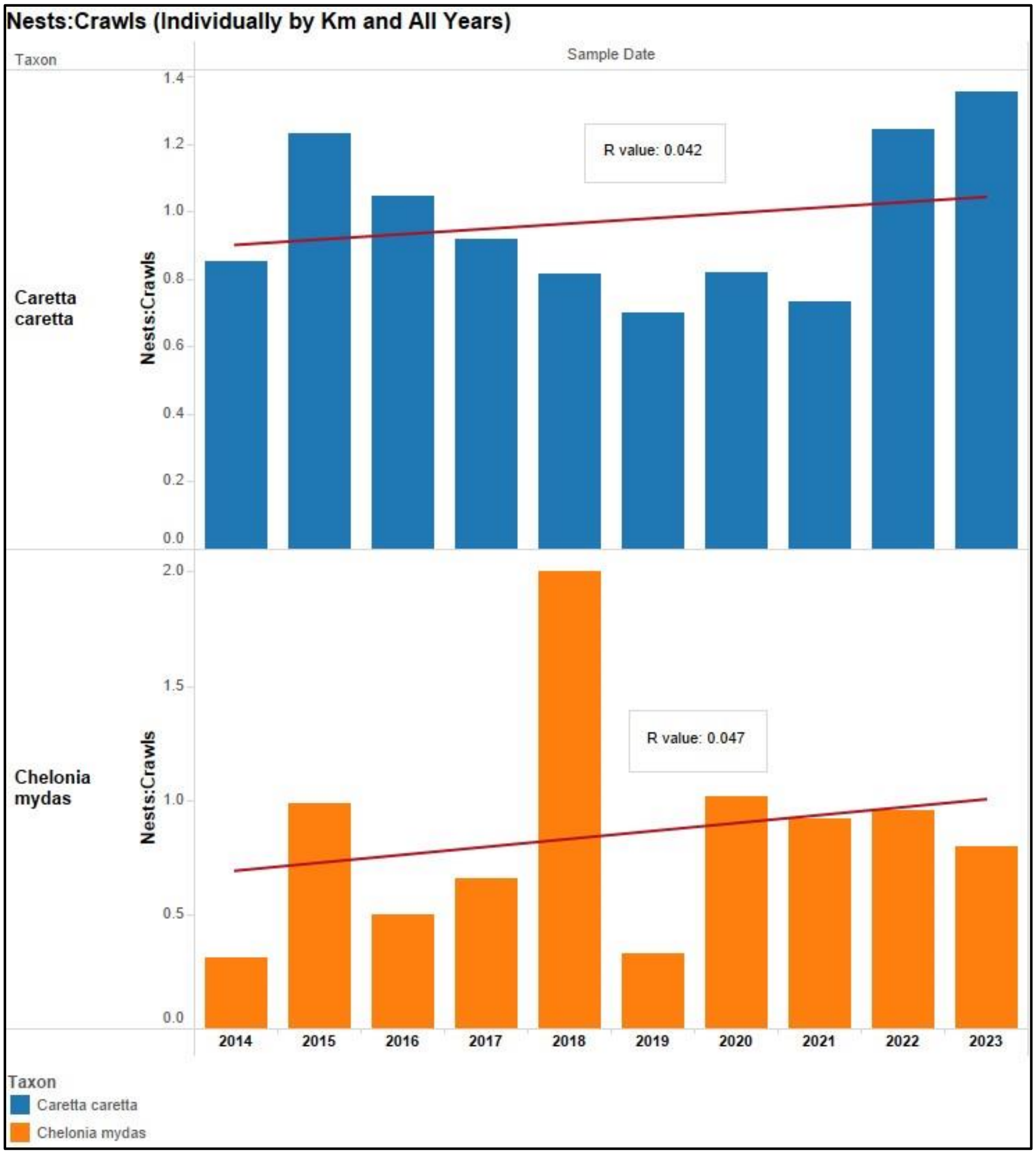


Figure 4-8. Nesting Success within Kilometer Section 30 of KSC Security Beach for Loggerhead (top) and Green (bottom) Sea Turtles, 2014 to 2023

Changes in nesting success over time can be an indication of human impacts, most easily observed from coastal construction projects such as beach nourishment that directly affect nesting habitat quality. Crawl data from the KSC Security Beach suggests there has been some reduction in sea turtle nesting success since initial monitoring commenced in 1983, most notably between 1987 and 2005 during the bulk of Space Shuttle Program at KSC. During this period there was also significant retreat of the beach and loss of dunes which increased visibility of artificial lighting on the nesting beach. It is also likely that narrowing beaches and escarpments resulting from erosion events reduced availability of suitable nesting habitat leading to more abandoned nesting attempts than typical. More recently, nesting success appears to be stable and in the case of kilometer 30 near Pad A, slightly increasing. Although it is difficult to know exactly why sea turtle nesting success is no longer in decline, the period of improvement does coincide with construction of the KSC inland dune system (completed between 2011 and 2021) which has improved adjacent nesting beach conditions. However, further analysis would be necessary to test the relationship between dune construction and nesting success. Increased efforts by NASA to regulate artificial lighting use and reduce impacts at KSC may have also contributed to nesting success improvement.

Based on nest surveys at CCSFS from 1986 through 2022, the average annual number of loggerhead turtle nests is 2,332 with a record number of loggerhead nests (3,804) in 2022 (USSF, 2023). From 1986 to 2022, the number of green sea turtle nests deposited on CCSFS beaches ranged from 4 to 675, with an annual average of 128 green sea turtle nests. The 2019 nesting season had a record high of 675 green sea turtle nests at CCSFS (USSF, 2023). From 1986 to 2022, the highest number of leatherback nests observed in any given year on CCSFS was 15 (in 2019); however, many years there are no leatherback nests and only 157 leatherback nests have been documented on CCSFS since surveys began. The hawksbill sea turtle has not been documented nesting on CCSFS (USSF, 2023). In 2015, two Kemp's ridley nests were recorded at CCSFS, both by the same female. This is the only time that a Kemp's ridley has been observed nesting on CCSFS and it is not expected to recur with any regularity (USSF, 2023).

Sea turtle nesting habitat is located 0.22 miles from the closest construction and is 0.31 and 0.46 miles from the launch and landing pads, respectively. No nesting habitat is within the plume or construction area.

4.3.26 Sea Turtle Critical Habitat (Final and Proposed)

Nesting critical habitat has been designated for the loggerhead sea turtle and proposed for the green sea turtle on portions of the Atlantic beaches within the Action Area, including CANA, MINWR, and KSC. Per the 2004 amendments to the ESA, as a Department of Defense property being managed under an Integrated Natural Resources Management Plan, CCSFS is exempt from critical habitat designations.

Green Sea Turtle Critical Habitat (Proposed)

The 1 psf contours around LC-39A and the Starship Contingency Area overlap areas of proposed critical habitat for nesting green sea turtles (88 Federal Register 46572). The previous section (Section 4.3.25, *Sea Turtles*) describes lighting conditions on the beaches near LC-39A. Green sea turtle proposed critical habitat is located 0.22 miles from the closest construction and is 0.31 and 0.46 miles from the launch and landing pads, respectively. No proposed critical habitat is within the plume or construction area.

Loggerhead Sea Turtle Critical Habitat (Final)

The 1 psf contours around LC-39A and the Starship Contingency Area overlap areas of loggerhead sea turtle nesting critical habitat (79 Federal Register 39856). The previous section (Section 4.3.25, *Sea Turtles*) describes lighting conditions on the beaches near LC-39A. Loggerhead critical habitat is located 0.22 miles from the closest construction and is 0.31 and 0.46 miles from the launch and landing pads, respectively. No loggerhead critical habitat is within the plume or construction area.

Chapter 5. Effects of the Action

5.1 Analysis Approach

This section analyzes potential effects to federally listed and proposed species and critical habitat resulting from the Proposed Action, including the consequences of other activities that are not part of the Proposed Action but are caused by the action. Per 50 CFR §402.02, a consequence is caused by the proposed action "if it would not occur but for the proposed action and it is reasonably certain to occur." Some effects of the action may occur later in time or may include consequences occurring outside the immediate area involved in the action.

Effect determinations were based on the following definitions:

- **May Affect, Not Likely to Adversely Affect** – the appropriate determination of effects on the species are expected to be insignificant, discountable, or completely beneficial. **Insignificant effects** should never reach the scale where take occurs. **Discountable effects** are those that are extremely unlikely to occur. **Beneficial effects** – concurrent positive effects without any adverse effects. Based on best judgment, a person would not (1) expect discountable effects to occur or (2) be able to meaningfully detect, measure, or evaluate insignificant effects.
- **May Affect, Likely to Adversely Affect** – the appropriate determination if any adverse effect may occur to listed species due to the proposed action, and the effect is not discountable, insignificant, or beneficial.

The ESA and associated regulations define take, harm, and harass as follows:

- **Take** means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct" (ESA §3(19)).
- **Harm** is defined as "an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering." (50 CFR §17.3)
- **Harass** is defined as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering." (50 CFR §17.3)

NASA identified potential stressors associated with proposed construction and operations based on previous consultations and various species recovery plans. Effects analyses utilized species survey and monitoring data, scientific articles, and data collected in association with launch operations at Starbase in Boca Chica, Texas; Vandenberg Space Force Base in California; Wallops Flight Facility in Virginia; and KSC and CCSFS in Florida. Effects from proposed activities within the Action Area were evaluated based upon (1) an understanding of the vehicles, methods, and equipment that would be used during construction and operations at LC-39A, (2) knowledge of the potential for such vehicle, methods, and equipment to disturb listed species and their habitats, and (3) awareness of the types of effects that have resulted from similar actions in the past. Section 5.2, *Stressors Associated with the Proposed Action*, provides an overview of these threats, and Section 5.3, *Effects to Species and Critical Habitat*, discusses the effects analysis and determinations for ESA-listed species and critical habitat within the Action Area.

5.2 Stressors Associated with the Proposed Action

Table 5-1 provides an overview of the stressors associated with the Proposed Action and the species and critical habitats potentially affected. Table 5-2 provides an overview of the frequency, duration, and timing of activities associated with the Proposed Action.

Table 5-1. Stressors Associated with the Proposed Action and Species and Critical Habitat Potentially Affected

Stressor	Source and Spatial Extent of Impact	Species/ Critical Habitat Potentially Affected
Vegetation Disturbance/ Destruction	Construction: • Vehicles, equipment, and personnel: within LC-39A boundary Operations: • Plumes: up to 0.2-mile radius around launch pad	Manatee Southeastern beach mouse Monarch butterfly
Noise and Visual Stimuli	Construction: • Vehicles, equipment, and personnel: within and around LC-39A, and along roads Operations: • Vehicles, equipment, and personnel: within and around LC-39A, and along roads • Facilities operation: within and around LC-39A • Static fire tests: varies by species • Launches: varies by species • Landings: varies by species • Landings at sea: varies by species	Audubon's crested caracara Eastern black rail Everglade snail kite Florida scrub-jay Piping plover Red-cockaded woodpecker Red knot Seabird species Wood stork Anastasia Island beach mouse Manatee Southeastern beach mouse Tricolored bat Indigo snake Sea turtle species
Vibrations	Construction: • Vehicles, equipment, and personnel: within and around LC-39A Operations: • Vehicles, equipment, and personnel: within and around LC-39A • Facilities operation: within and around LC-39A • Static fire tests: currently unknown • Launches: currently unknown • Landings: currently unknown	Audubon's crested caracara Eastern black rail Everglade snail kite Florida scrub-jay Piping plover Red knot Manatee Southeastern beach mouse Tricolored bat Indigo snake Sea turtle species

Table 5-1. Stressors Associated with the Proposed Action and Species and Critical Habitat Potentially Affected

Stressor	Source and Spatial Extent of Impact	Species/ Critical Habitat Potentially Affected
Sonic Booms	Operations: • Launches: varies by species (offshore) • Landings: varies by species • Landings at sea: varies by species (offshore)	Audubon's crested caracara Eastern black rail Everglade snail kite Florida grasshopper sparrow Florida scrub-jay Piping plover Red-cockaded woodpecker Red knot Seabird species Wood stork Manatee Anastasia Island beach mouse Southeastern beach mouse Florida bonneted bat Tricolored bat Indigo snake Sea turtle species
Strikes/ Collisions	Construction: • Vehicles, equipment: LC-39A, roads to LC-39A Operations: • Supply and commodities trucks: LC-39A, roads to LC-39A • Daily vehicle traffic: LC-39A, roads to LC-39A • Launches: launch trajectory • Landings at LC-39A: landing trajectory • Landings at sea/droneship: landing trajectory • Barges/boats: nearshore, channels, ports, Banana River, Turn Basin	Audubon's crested caracara Eastern black rail Everglade snail kite Florida scrub-jay Piping plover Red knot Seabird species Monarch butterfly Manatee Southeastern beach mouse Tricolored bat Indigo snake Sea turtle species
Deluge Water and Vapor Cloud	Operations: • Launches: Heat/vapor plume: 0.2-mile radius around launch pad • Static Fire Tests: vapor cloud: 0.2-mile radius around launch pad • Landings at LC-39A: vapor cloud: 96-foot radius around landing pad • Landings at sea/droneship: 96-foot radius around landing area	Audubon's crested caracara Eastern black rail Everglade snail kite Piping plover Red knot Manatee

Table 5-1. Stressors Associated with the Proposed Action and Species and Critical Habitat Potentially Affected

Stressor	Source and Spatial Extent of Impact	Species/ Critical Habitat Potentially Affected
Plumes	Operations: • Launch plume: 0.2-mile radius around launch pad • Static Fire Test plume: 0.2-mile radius around launch pad • Landing plume (LC-39A): 96-foot radius around landing pad • Landing plume (at sea/droneship): 96-foot radius around landing area	Audubon's crested caracara Eastern black rail Everglade snail kite Piping plover Red knot Seabird species Manatee
Artificial Lighting	Construction: • Work lighting: within and around LC-39A Operations: • Facilities operation: within and around LC-39A • Static fire tests: varies by species • Launches: varies by species • Landings: varies by species • Landings at sea/droneship: varies by species	Audubon's crested caracara Eastern black rail Everglade snail kite Florida scrub-jay Seabird species Southeastern beach mouse Tricolored bat Sea turtle species Loggerhead nesting critical habitat (final) Green sea turtle nesting critical habitat (proposed)
Hazardous Materials	Construction: • Vehicles, equipment: LC-39A Operations: • Supply and commodities trucks: LC-39A • Launches: launch trajectory • Landings at LC-39A: landing trajectory • Landings at sea/droneship: landing trajectory • Barges/boats: channels, ports, Turn Basin	Seabird species Manatee
Invasive Species Introduction	Construction: • Vehicles, equipment: LC-39A Operations: • Supply and commodities trucks: LC-39A, roads to LC-39A • Daily vehicle traffic: LC-39A, roads to LC-39A	Southeastern beach mouse Indigo snake
Restricted Access for Management and Monitoring	Operations: • Static fire tests: varies by event • Launches: varies by event • Landings: varies by event	Florida scrub-jay Southeastern beach mouse Indigo snake Sea turtle species Manatee

Note: LC = Launch Complex.

Table 5-2. Frequency, Duration, and Timing of Proposed Activities

Activity	Frequency	Duration	Timing
Vehicles, equipment, and personnel (construction)	Daily	Noise: Up to 24 hours/day, 7 days a week for 1-2 years Lighting: Temporary work lighting[1] may be required at night for indeterminate periods of time	Primarily daytime
Vehicles, equipment, and personnel (daily operations/ maintenance)	Daily	Noise: Low levels up to 24 hours/day, 7 days a week; Lighting: Some permanent lighting year-round; Temporary work lighting[1] may be required at night for indeterminate periods of time Length of the action	Primarily daytime, with intermittent periods of increased nighttime activity
Activities at LC-39A associated with launch events-preparations and post-flight processing (typically 3-4 days/event)	Up to 44 times a year	Noise: Increased levels 3-4 days around a launch Lighting: 3-4 days around a launch, increased lighting[1] may be required 24 hours/day for security/safety Length of the action	Primarily daytime, but periods of increased nighttime activity also occur with launch preparations; Assume half of launch events may occur during sea turtle season (May through October).
Static fire test (Starship)	Up to 44 times a year	Flame light: 15 seconds Noise: 15 seconds Plume: less than 5 minutes	Any time of day or night; for analysis, assumed 22 daytime (7:00 a.m. – 10:00 p.m.) and 22 nighttime (10:00 p.m. – 7:00 a.m.). Assume half of launch events may occur during sea turtle season (May through October).
Static fire test (Super Heavy)	Up to 44 times a year	Flame light: 15 seconds Noise: 15 seconds Plume: less than 5 minutes	Assumed 22 daytime and 22 nighttime and that half of launch events may occur during sea turtle season (May through October).
Starship-Super Heavy launch	Up to 44 times a year	Flame light: less than 1 minute Noise: 1-2 minutes Sonic boom (at sea): millisecond Plume: less than 5 minutes	Assumed 22 daytime and 22 nighttime and that half of launch events may occur during sea turtle season (May through October).
Landing at LC-39A (Starship)	Up to 44 times a year	Flame light: less than 1 minute Noise: 1 minute Sonic boom: millisecond Plume: less than 5 minutes	Assumed 22 daytime and 22 nighttime and that half of launch events may occur during sea turtle season (May through October).
Landing at LC-39A (Super Heavy)	Up to 44 times a year	Flame light: less than 1 minute Noise: 1 minute Sonic boom: millisecond Plume: less than 5 minutes	Assumed 22 daytime and 22 nighttime and that half of launch events may occur during sea turtle season (May through October).

Table 5-2. Frequency, Duration, and Timing of Proposed Activities

Activity	Frequency	Duration	Timing
Starship landing in Atlantic Contingency area (1-5 nm offshore)	Assumed up to 4/year	Flame light: less than 1 minute Noise: 1 minute Sonic boom: millisecond Plume: less than 5 minutes	Any time of day or night
Starship landing in Atlantic, Pacific, Indian Ocean (>5 nm offshore)	Assumed 2 a year	Flame light: less than 1 minute Noise: 1 minute Sonic boom: millisecond Plume: less than 5 minutes	Any time of day or night
Super Heavy landing in Atlantic (>5 nm offshore)	Assumed 5 a year	Flame light: less than 1 minute Noise: 1 minute Sonic boom: millisecond Plume: less than 5 minutes	Any time of day or night
Barge, droneship (at-sea landings)	Assumed 11 a year	Assumed 12-hour period	Any time of day or night
Barge transport of supplies/vehicle parts	Assumed 40 barges/year to Turn Basin; 5 a year to Port Canaveral	Varies	Primarily daytime docking
Boats (clearing, surveillance)	Up to 132 times a year	3 to 3.5 hours per static fire, launch, landing event	Any time of day or night

Notes: > = greater than; LC = Launch Complex; nm = nautical mile.
[1] Temporary lighting may include the use of mobile light towers and/or temporary use of permanent lighting fixtures.

5.2.1 Vegetation Disturbance or Destruction

Vegetation effects associated with construction would be limited to inside the perimeter fence of LC-39A. Approximately 9.9 acres of governmental land cover (i.e., paved areas and mowed grass) would be replaced by the catch tower, pond, ASU, MegaPacks, power hub, and liquification facility (Table 5-3 and Figure 2-1).

The area of potential vegetation disturbance from launch and landing plumes is expected to be limited to a 0.2-mile radius around the launch pad; the area affected by the 96-foot radius landing plume around the landing pad is entirely contained within the launch plume area. While much of this area would be concrete, there would be the potential for disturbance to some vegetated areas from launch and landing events; most of these areas are low-quality wildlife habitat and in some locations are infested with INPS such as Brazilian pepper (Table 5-3 and Figure 2-1).

Table 5-3. Land Cover Types within Tower/Pond/Facilities Footprint, LC-39A, Launch Plume, and Landing Plume

Land Cover Type	Tower/Pond/ Facilities Footprint[1] (acres)	LC-39A (acres)	Launch Plume (acres)	Landing Plume[2] (acres)
Governmental – KSC	9.89	170.54	67.21	0.66
Upland hardwood forest	0	0.04	12.65	0

Table 5-3. Land Cover Types within Tower/Pond/Facilities Footprint, LC-39A, Launch Plume, and Landing Plume

Land Cover Type	Tower/Pond/ Facilities Footprint[1] (acres)	LC-39A (acres)	Launch Plume (acres)	Landing Plume[2] (acres)
Reservoirs – pits, retention ponds, dams	0	0	3.74	0
Bays and estuaries	0	0	1.19	0
Mangrove swamps	0	0.18	1.00	0
Freshwater marshes	0	2.45	0	0
Saltwater marshes	0	0.03	0	0
Roads/highways	0	0.0.1	0	0
Total	**9.89**	**173.25**	**85.79**	**0.66**

Notes: LC = Launch Complex; KSC = Kennedy Space Center.

[1] Area includes footprint of catch tower, deluge pond, air separation unit, MegaPacks, power hub, and liquification facility. Total construction footprint of 659,441 square feet (approximately 20 acres) will be contained within the LC-39A fence line.

[2]The landing plume area is entirely contained within the launch plume area.

Source: SJRWMD Land Cover (SJRWMD, 2024).

5.2.2 Noise and Visual Stimuli

The Proposed Action will expose federally listed species to the noise and visual disturbance of multiple activities, including construction; daily operations; and rocket tests, launches, and landings. Animal species are expected to exhibit a wide variety of responses to the noise and visual stimuli associated with these activities. The degree of disturbance can be affected by the type of noise generated, the proximity to the noise source, duration of the sound, frequency of events, the species, and the history of exposure to noise events by individuals of a species. Because some species are more sensitive than others and vary in their responses, it can be difficult to generalize or to draw conclusions across species. Often the effects of noise are mixed with other variables (e.g., predators, weather, ground-based disturbance), making it challenging to determine actual noise effects on population size or population growth (Bowles, 1995) or as an ultimate factor in limiting productivity of a certain nest, area, or region (Smith et al., 1988).

Noise effects on wildlife are classified in three ways. First, effects can be direct, such as the masking of biologically relevant sounds or, in relatively rare cases, physiological changes to the auditory system. Eardrum rupture and temporary or long-term hearing loss are direct physiological changes to the auditory system that are generally only associated with noises of long duration and/or extremely high intensity. The risk of hearing loss also depends on the species' hearing sensitivities and the intensity of the noise at various frequencies. Secondly, noise impacts may include non-auditory effects such as stress and hypertension; behavioral changes; interference with mating or reproduction; and impaired ability to obtain adequate food, cover, or water. The third type of effects are the result of other effects and include population decline and habitat loss.

As many animal species use sound to communicate, detect prey, and avoid predation, increased noise levels can reduce the distance and area over which animals can perceive important acoustic signals. Such secondary effects of noise vary widely with species; environmental variables; and the types, durations, and sources of noise (Manci et al., 1988). The potential for external noise to mask these important signals is of greater concern for continuous noise sources (e.g., compressors, busy highways) than for intermittent, brief noise exposures such as that resulting from launches, landings, and tests. However, even brief activities can mask signals and may cause certain individuals to cease communications temporarily.

A general reaction in animals from exposure to loud noise and/or sudden movement in their field of vision is the startle response. A startle response can include behavioral responses (e.g., flying away) and physiological changes (e.g., elevated heart rate). The intensity and duration of the startle response appear to depend on the species, whether it is a group or an individual, and whether there have been previous exposures (Erbe & Thomas, 2002). Factors that can affect the type and degree of wildlife responses to construction and operations noise include the proximity, speed, size, and noise level of the equipment/rocket; wind direction, speed, and local air turbulence; landscape structures (e.g., vegetative cover); and whether the animals are in the breeding or nesting phase.

The startle reaction is a natural response that helps animals avoid predators; however, if the behavioral component of the startle is uncontrolled, this panic response can result in injury (e.g., breaking of limbs) or mortality. Responses can range from flight, trampling, stampeding, jumping, or running to simply alerting or moving the head in the apparent direction of the noise source. Startle effects are most likely to occur from a visible activity close to the animal that involves the sudden onset of a high level of noise. The literature indicates the intensity and duration of the startle response typically decreases with the number and frequency of exposures (DAF, 1994), but individuals that do not acclimate may startle upon each exposure. Wildlife habituation to intermittent sounds can be gradual and possibly more limited than to regular exposures.

Isolated noise events have the potential to result in nest abandonment and reduced reproductive success for some animals, including both migratory and resident species. Manci and others reported a reduction in reproductive success in some songbirds after exposure to low-altitude jet overflights (Manci et al., 1988). According to a recent study, some species exhibit an increase in sensitivity to overflights during harsh weather conditions (van der Kolk et al., 2020). Models of shorebird fitness impacts from raptor and human disturbance found that the birds could be disturbed up to 1 to 1.5 times per hour before their fitness was reduced in winters with abundant food and mild weather, but they could be disturbed only up to 0.2 to 0.5 times per hour when food was scarce and the weather was severe (Goss-Custard et al., 2006).

While the duration of tests, launches, and landings is relatively brief, the combination of the visual and auditory effects could cause physiological responses due to fear or panic in addition to the behavioral responses. Examples of physiological responses to noise include increased hormonal production and increased heart rate. Increased heart rates, which are an indicator of excitement or stress, occur naturally as a response to predation. Thus, each test, launch, or landing may not, in and of itself, be detrimental. However, the threshold for the frequency at which harmful effects may occur would vary by species. Although the relationship between physiological effects and species interactions with their environments has not been thoroughly studied, the limited literature suggests the degree of physiological response in wildlife species may lessen over time with repeated exposure to launch, landing, and test noise.

Transmission of in-air sound into water is highly dependent on the altitude of the source and the angle at which the sound encounters the water surface (DoN, 2018). Sound is transmitted into water primarily within a narrow area (cone of about 13 degrees from vertical) below the source. At greater angles, the water surface acts as a reflector and allows very little sound to enter the water column. At low altitudes, sound levels reaching the water surface are higher, but the transmission area is smaller. As the sound source gains altitude, sound reaching the water surface diminishes, but the transmission area increases.

When exposed to in-air noise, aquatic species typically show a slight startle response at most (Manci et al., 1988).

Facility Noise from Proposed Action

Operation of the ASU/liquefaction facilities would generate noise with similar characteristics to noise generated by other industrial facilities at LC-39A (e.g., LOX farm, methane farm, vaporization farm, LN_2 farm, water farm) that were analyzed in the 2019 NASA EA and found to have no significant noise impacts. Noise levels associated with similar facilities employing large compressors and other loud components generate noise levels of approximately 40 dBA at a distance of 1 mile (https://novascotia.ca/nse/ea/bear-head-energy/bhe-ea-registration-appendix-e.pdf). Exact noise levels experienced outside the boundaries of LC-39A would depend on specific layout and equipment specifications of the plant within the designated facility footprints, which are not known at this time. Air inlets and exhaust vents would incorporate silencers to reduce exterior noise levels, and where practicable, loud equipment (e.g., compressors) would be enclosed within structures.

Rocket Engine Noise from the Proposed Action

The 2025 *Starship Noise Assessment for Flight and Test Operations at KSC LC-39A* Appendix C, *Noise Modeling Report*, contains detailed explanations of noise metrics and maps showing modeled noise contours. The noise metric relevant to analysis of potential effects of the Proposed Action to federally listed species is SEL. This composite metric represents both the level of a sound and its duration. The two main characteristics of individual time-varying noise events such as launches are a sound level that changes throughout the event and a period during which the event is heard. SEL provides a measure of the total acoustic energy transmitted to the listener during the event, but it does not directly represent the sound level heard at any given time. For example, during launch, SEL would include both the maximum noise level and the lower noise levels produced during onset and recess periods of the launch. Mathematically, it represents the sound level of a constant sound that would, in one second, generate the same acoustic energy as the actual time-varying noise event.

RNOISE was used to estimate the noise contours for static fire tests, Starship orbital launches, Super Heavy booster landings, and Starship descent/landings (Appendix C**,** *Noise Modeling Report*). Static fire engine tests typically occur 1 to 3 days prior to launch and last up to 15 seconds per event; noise in excess of 100 dB ASEL from these events would be limited primarily to KSC, MINWR, and the Atlantic Ocean. Engine noise produced during launches would last a few minutes at most at a single location, with the highest noise levels occurring for less than a minute; launch noise in excess of 100 dB ASEL would be generated across KSC, CCSFS, MINWR, and CANA, as well as portions of the Atlantic Ocean, IRL, and surrounding lands. Landing noise exceeding 100 dB ASEL would impact a much smaller area of KSC, CCSFS, MINWR, CANA, IRL, and the Atlantic Ocean. Super Heavy landing noise follows launch and associated launch engine noise by approximately 5 to 7 minutes; Starship landing locations and times between launches and landings would vary based on mission objectives.

The test, launch, and landing events at LC-39A would generate noise centered either at the launch pad or landing pad, attenuating outward until the noise environment returned to ambient levels. The modeled ASEL around the LC-39A launch or landing pad, as applicable, for each event is provided below:

- Starship static fire test: 140 dB ASEL

- Super Heavy static fire test: 140 dB ASEL
- Launch: 140 dB ASEL
- Starship landing: 140 dB ASEL
- Super Heavy landing: 140 dB ASEL

The maximum extent of the 100 dB ASEL contour from the LC-39A launch or landing pad, as applicable, for each event is provided below:

- Starship static fire test: 3.7 miles over land; 11.8 nm over the Atlantic
- Super Heavy static fire test: 5 miles over land; 17.1 nm over the Atlantic
- Launch: 17.6 miles over land; 16.1 nm over the Atlantic
- Starship landing: 3.9 miles over land; 4.8 nm over the Atlantic
- Super Heavy landing: 8.1 miles over land; 9.3 nm over the Atlantic

Current ASELs

Because ASEL is an integrated metric, no modeled ASEL "baseline" is possible. Instead, information on ASELs from current launches is presented for comparison. In the 2020 Falcon Launches at KSC and CCSFS EA, much of MINWR, KSC, CANA, and CCSFS were modeled to be affected by ASELs greater than 100 dB from Falcon 9 and Falcon Heavy launches, in some areas exceeding 110 dB ASEL (FAA, 2020). For Falcon 9, the 100 dB and 110 dB ASEL contours are expected to remain almost entirely on KSC and CCSFS property. For Falcon Heavy, while the 110 dB ASEL contour is expected to remain within the CCSFS and KSC boundaries, Merritt Island and parts of Titusville are expected to be exposed to ASELs higher than 100 dB. The 100 dB ASEL launch contours for Falcon 9 and Falcon Heavy launches from LC-39A also extend approximately 20 miles into the Atlantic Ocean. Currently there are no Falcon booster landings at LC-39A, but booster landings at LZ-1 and LZ-2 at CCSFS were modeled to expose portions of the Action Area to noise exceeding 110 dB ASEL; the ASEL at LC-39A was modeled at approximately 100 dB from these booster landings (FAA, 2020).

5.2.3 Vibrations

Some energy from launches, landings, and static fire tests, as well as from some construction and maintenance equipment, will manifest as vibrations. Due to an interest in the potential for ground vibrations in dune habitats to affect wildlife, vibration levels were recorded during the March 14, 2024, Starship-Super Heavy launch at Boca Chica, Texas. Data were collected from accelerometers (i.e., ground vibration monitors) placed in the dunes roughly 0.25 miles to the east of the launch pad at depths of 1 foot and 3 feet below ground surface. Acceleration at 1 foot depth measured 0.728 g (an acceleration equal to the acceleration of gravity) to 1.025 g (7.14 to 10.05 feet per second squared), while the sensors at 3 feet deep had maximum responses below 0.1 g (0.981 feet per second squared). Elevated acceleration lasted a total of approximately 30 seconds. The Peak Particle Velocity of just over 1 inch per second had a dominant vertical direction that dissipated quickly (SpaceX, 2024). No biological data were collected in concert with these measurements, so they serve only as indicators of potential substrate response.

The vibrations associated with static fire tests and landings would last only a few seconds, and less than a minute for launches, but they can add to species disturbance. Species reactions would vary depending on their proximity to the construction or operation activity. Some animals may freeze, startle, or temporarily avoid the area, while some individuals may permanently abandon nests, roosting sites, and foraging areas. Depending on frequency and duration, vibrations may result in physiological impacts to certain species and could also harm incubating eggs (i.e., cracks, addling). However, this is difficult to assess due to the limited availability of scientific data on vibration impacts on animals in the wild. Potential burrow collapses are also of concern, but the exact conditions that might cause a collapse are unclear at this time.

5.2.4 Sonic Booms

A sonic boom is the sound associated with the shock waves created by a vehicle traveling through the air faster than the speed of sound. Overpressure is the force left after a sonic boom. A sonic boom trace is an impulsive event that lasts for less than 300 milliseconds. Acoustic energy in the air does not effectively cross the air/water interface; most of the noise is reflected off the water surface. Overpressures from sonic booms are not expected to affect species underwater.

Due to the typical co-occurrence of noise, vibrations, and sonic boom overpressures, it can be difficult to separate effects, but startle responses are likely, particularly during initial exposures to sonic booms. Responses also can be hard to predict because the degree of disturbance can vary based on species, number of exposures, time of day, and other factors. Some animals may vacate their nests either temporarily or permanently, leaving eggs or young exposed to the weather or predators. Sonic booms may also reduce foraging efficiency and feeding time, interrupt communication, interfere with predator/prey detection, and cause animals to avoid the area.

Birds appear to be more affected behaviorally by sonic booms than mammals and, in response to sonic booms, have been seen to fly, run, or crowd (Manci et al., 1988). A study of low-level military jet aircraft and mid- to high-altitude sonic booms documented noticeable alarm in peregrine falcons, which demonstrated crouching and rare flushing from the perch or nest (Ellis et al., 1991). The study also noted that negative responses became rarer and peregrine falcons potentially became habituated to the jets.

Sonic Booms from the Proposed Action

Estimates of sonic booms (overpressure of high energy impulsive sound) produced during launches and landings at LC-39A were modeled using PCBoom; static fire tests do not produce sonic booms. During launches, sonic booms exceeding 15 psf would be generated over the Atlantic Ocean, approximately 34 nm offshore; they would not affect land areas. Each Super Heavy landing and Starship landing would generate a separate sonic boom, typically slightly after peak landing noise. During descent, sonic boom overpressures exceeding 1.5 psf and 20 psf may be generated by Starship and Super Heavy landings, respectively, in the vicinity of the LC-39A landing pad (see Appendix C**,** *Noise Modeling Report*). Overpressure levels for the Starship landings would attenuate outward in all directions. The maximum extent of the 1 psf contour from the LC-39A landing pad or offshore in the Atlantic Ocean, as applicable, for each event is provided below:

- Launch: no sonic boom over land; sonic boom is 34 to 56 nm offshore over the Atlantic Ocean
- Starship landing: 29.6 miles over land; 21.4 nm over the Atlantic Ocean

- Super Heavy landing: 24.2 miles over land; 46.5 nm over the Atlantic Ocean

For ocean landings, a Super Heavy landing on a droneship would produce a sonic boom of up to 8 psf. During descent, when Starship is supersonic, a sonic boom of up to 2 psf would be generated.

Current PSF Levels

In the 2020 Falcon Launches at KSC and CCSFS EA, the overpressure levels for Falcon landings in the vicinity of the landing pad at CCSFS ranged from 2.0 to 2.7 psf. Overpressure levels in the areas adjacent to KSC and CCSFS were predicted to be between 0.5 to 1.0 psf, and offshore overpressure levels were predicted to be up to 4.6 psf (FAA, 2020).

5.2.5 Strikes and Collisions

Due to the poor quality of available habitat, wildlife is sparse within the busy LC-39A Complex, but injury or mortality due to vehicle or equipment strikes is possible, both at the construction sites and on roads to LC-39A, particularly for small and less mobile species. Construction traffic and personnel traffic during future operations would be as described in the 2019 EA. The additional traffic to provide commodities and water would involve an average of approximately 53 heavy-duty trucks during a 12-hour period (or 4-5 trucks per hour), 7 days a week, with more or fewer trucks per hour depending on launch frequency and specific commodity needs. Most animals would likely avoid the roadways and the LC-39A area due to the noise and disturbance associated with traffic, construction, daily operations, and launch preparations. Additionally, most of the traffic from construction and operations would occur during daylight hours.

The construction of new structures could pose a potential collision risk for birds. According to the USFWS, collision hazards for birds depend on several factors related to the bird, infrastructure, and location. Collision mortality typically increases with structure height. At night, birds can be attracted to lighted structures resulting in collisions, entrapment, excess energy expenditure, and exhaustion; during the day, birds may collide with glass windows that are either clear or that reflect the landscape. The Proposed Action involves the construction of several tall structures, but they do not include glass windows and would be comprised of opaque surfaces, which are of less risk regarding bird collisions. Potential effects from tower lighting would be reduced by implementing lighting practices for minimizing disorienting effects on migratory birds, to the greatest extent possible.

Strikes from launch vehicles are possible in the vicinity of LC-39A, potentially injuring or killing affected animals. Given the amount of noise and human activity in the vicinity of LC-39A during launch preparations, most animals would be expected to avoid the area until the level of disturbance decreased after operations were completed, minimizing the chances of a strike.

Potential manatee strikes are also of concern due to increased barge/boat traffic associated with the transport of supplies and vehicle components, as well as droneship barges and tugs bringing Starship and Super Heavy vehicles back to the Turn Basin and Port Canaveral after ocean landings. Observation of standard manatee protection measures and speed limit requirements within the Banana River would serve to limit the potential for manatee strikes.

5.2.6 Deluge Water and Vapor Cloud

Deluge ponds at LC-39A would contain the spraying deluge water within the fence line where no listed species occur, so no deluge water would reach nearby estuarine waters. Suspended debris in the water or cloud is unlikely as most of LC-39A is either paved or ruderal vegetation and the flame diverters will direct the water and cloud upward instead of directly outward across the ground's surface. Thus, effects from suspended debris to listed species and their habitats are considered discountable. Although most animals would likely avoid the LC-39A area due to the noise and disturbance associated with operations, the several seconds of disturbance associated with spraying water may affect the behavior of individual animals in the immediate area as they are startled and compelled to cease their prior activity (e.g., foraging, resting, grooming, evading potential predators) to move away from the disturbance. Ultimately, however, this response may benefit these individuals if they move further away from the most intense parts of the plume.

At LC-39A, the deluge system may be operated up to 220 times annually for Starship-Super Heavy static fire engine tests, launches, and landings at LC-39A, with a potential vapor cloud deposition area of up to 0.2 miles from the launch pad (Table 5-3 and Figure 2-1). Because the engines of the Starship-Super Heavy use LOX and LCH_4 as propellants, rather than solid rocket boosters like Space Shuttle vehicles, no metals are produced from propellent combustion. During engine ignition, a small amount of mechanical erosion of steel from the surface of the metal pad flame deflector would occur, but it would quickly recondense near the launch mount when exposed to deluge water. Sampling conducted at Boca Chica for the second and third Starship-Super Heavy flights showed negligible results for stainless steel components in all air, soil, and deluge water results (FAA, 2024).

5.2.7 Plumes

The plumes generated from Starship-Super Heavy static fire tests and launches are anticipated to extend no further than 0.2 miles from the launch pad, with temperatures expected to reach ambient temperature (90°F) by 0.2 miles from the launch pad. Due to the limited number of engines used during landings, the expected distance to ambient temperature from the landing catch tower is only 96 feet, which is contained completely within the paved landing zone. Habitat loss and degradation may occur from static fire tests and launches, with the greatest potential for damage near the launch pad. Most of the areas within the 0.2-mile radius plume are either developed or mowed, but some natural habitats may be damaged by elevated temperatures within the plume (Table 5-3 and Figure 2-1). For any nests established within the 0.2-mile radius of the launch pad where exhaust may extend, there would be the potential for damage or destruction of eggs, as well as injury or death of adults and young due to thermal stress. However, most animals would likely avoid the area due to the noise and disturbance associated with launch preparations, and no federally listed species are known to nest within this area.

5.2.8 Artificial Lighting

Artificial lighting sources would include construction lighting; buildings and equipment used during daily operations; safety, security, and work lighting during launch preparations; barge/boat lighting; and engine ignitions. Launch operations require additional lighting to ensure the protection and safety of SpaceX personnel and hardware. Leading up to a launch, spotlighting may illuminate the launch vehicle at LC-39A for several days. Additional lighting would also be employed during landings, both at LC-39A and in the ocean. Under non-launch conditions, brighter lights (typically metal halide) would be turned off or reduced. Dring standard (non-launch) ground support operations, daily operations would require varying levels of artificial lighting 7 days a week, throughout the year; however, these routine operations do not require engine ignition or bright spotlighting.

Artificial lighting at night at LC-39A has the potential to affect sea turtles during nesting season, as well as bats, southeastern beach mice, and other animals who may be disturbed or disoriented by the lights. Artificial lighting may cause temporary or permanent abandonment of nesting, roosting, and foraging areas by birds, bats, southeastern beach mice, and other nocturnal animals. Some listed species may suffer from increased predation from this lighting, while others may be able to more easily locate their prey. Tower lighting has the potential to disorient birds and bats, causing them to circle the lights to exhaustion or to fly into the lights. Depending on the time of year, night lighting could affect light-based cues used by hatching sea turtles. Newly hatched sea turtles orient toward light sources when crawling to the sea. Consequently, if there are man-made light sources coming from inland sources, they may mistakenly crawl landward instead of toward the sea, resulting in mortalities from predators or from becoming too dry. Man-made lighting can also disturb nesting adult sea turtles.

5.2.9 Hazardous Materials

Hazardous materials used during construction and operations would include, but not be limited to, diesel fuel, gasoline, and propane to fuel the construction equipment; hydraulic fluids, oils, and lubricants; welding gases; paints; solvents; adhesives; and batteries. An accidental release of hazardous materials (e.g., equipment fuel spill) could affect individual ESA-listed species if they were exposed to the contaminant, which could cause injury, sickness, or death. However, hazardous materials handling management procedures will be required during construction and operations; thus, releases should be rare and limited in scope.

In accordance with the Clean Water Act, SpaceX would continue to operate under the construction stormwater discharge permit, and the Stormwater Pollution Prevention Plan would be updated prior to the commencement of new construction activities. Every outdoor storage area where hazardous materials are proposed to be stored or staged during construction would be identified in the Stormwater Pollution Prevention Plan and inspected on a recurring basis during the construction phase and until the permit is terminated.

Starship-Super Heavy launch operations would require the use and storage of hazardous materials for launches as well as for routine maintenance and flight support activities. Most of these materials would be stored as near to their point of use as possible to minimize the potential for accidental spills to occur. The hazardous materials storage tanks would be located within secondary containment designed to hold at least 110 percent of the tank's maximum volume. The main propellants used for launch operations, LOX and $LCH_{4,}$ are both gaseous at room temperature and, thus, would not contaminate vegetation or habitats if released. SpaceX's Spill Prevention, Control, and Countermeasure Plan would be revised in accordance with the Clean Water Act requirements included in 40 CFR Part 112 to outline proper management and spill response procedures for changes in the oils and fuels stored at the site. Hazardous wastes would be managed onsite in accordance with applicable Federal, state, and local regulations.

Expended vehicles may involve explosions that scatter debris or release hazardous materials. Responses to such events may include activities to retrieve debris or contain and remediate spills, which could temporarily disturb foraging.

5.2.10 Invasive Species Introduction

Construction activities may introduce or spread INPS from equipment, fill, or landscaping materials. These introductions can degrade habitats by altering native species composition and structure. To minimize the potential for INPS spread, construction equipment from off location would be cleaned prior to use at KSC, and only certified weed-free landscaping and fill material would be used.

5.2.11 Restricted Access for Management and Monitoring

Launch-related closures may restrict access for natural resources management (e.g., prescribed burning, wetland restoration, feral hog control). The primary species of concern for continued monitoring at KSC, MINWR, CCSFS, and CANA are Florida scrub-jays and sea turtles. Other species that are monitored at varying frequencies include manatees, eastern black rails, red knots, piping plovers, and southeastern beach mice. KSC, MINWR, and CCSFS recently updated their *MOU for Prescribed Burning*, which lays out conditions and constraints for prescribed burning (SLD 45, USFWS, and KSC, 2025). In the 2025 *MOU for Prescribed Burning*, there are no prescribed burn restrictions related to non-critical payload transport or mating operations, and the burn buffer around smoke-sensitive facilities has been reduced to 0.5-mile; these updates greatly increase the opportunity to burn certain ecologically sensitive units to meet regulatory burn requirements. SpaceX understands it is its responsibility to protect payloads/space flight hardware from smoke associated with prescribed burning or wildfires, and will properly maintain and operate clean rooms and/or processing facilities in accordance with established industry clean room standards to allow for prescribed burns to be conducted.

5.3 Effects to Species and Critical Habitat

Within the Action Area, zones of impact for individual species were determined by considering each species' sensitivity to all facets of the Proposed Action based on existing data and studies on the effects of noise, sonic booms, vibrations, and vapor plumes on the species and their habitats. Existing species monitoring data, survey reports, and databases were reviewed to assess the potential occurrence, distribution, and habitat use of federally listed species within the broader Action Area.

As previously discussed, the most widespread stressors associated with the Proposed Action are noise and sonic booms. Noise and sonic booms may induce startle and alert reactions in individuals, with responses varying based largely upon individual circumstances and psychological factors. It is, therefore, difficult to generalize the anticipated behavioral reactions to various noise and overpressure levels across species. Available studies and data, as well as personal observations by qualified biologists in the field, were used as the basis for determining what levels were likely to induce a response. Since in most cases no directly applicable studies exist, reasonable conclusions were deduced from similar species and by examining evidence of impacts from other types of noise (e.g., aircraft noise, other space vehicle launch noise), as applicable.

Table 5-4 provides the distance from the construction area, launch pad, and landing pad to the closest federally listed species and critical habitat.

Table 5-4. Distance from the Construction Area, Launch Pad, and Landing Pad to the Nearest Listed Species and Critical Habitat

	Distance to nearest habitat from:		
	Construction Area (miles)	Launch Pad (miles)	Landing Pad (miles)
Territories			
Florida scrub-jay territory (core)	0.86	1.32	1.27
Potential Habitat			
Southeastern beach mouse	0.15	0.23	0.39
Piping plover (overwintering)	0.12	0.17	0.13
Rufa red knot (overwintering)	0.12	0.17	0.13
Wood stork (foraging habitat)	5.13	5.32	5.15
Final Critical Habitat			
West Indian manatee	0.07	0.17	0.13
Loggerhead sea turtle (nesting)	0.22	0.31	0.46
Proposed Critical Habitat			
Green sea turtle (nesting)	0.22	0.31	0.46
Rufa red knot (overwintering)	0.22	0.30	0.43

5.3.1 Audubon’s Crested Caracara

As discussed in Section 5.2.2, *Noise and Visual Stimuli*, noise and visual disturbances associated with construction and operations may startle birds or cause them to avoid the area. As Brevard County is the northern limit for the range of the threatened Audubon’s crested caracara (FWC, 2024b), any individuals present in the Action Area would likely be transitory, not nesting. The effort required for a disturbed bird to fly to another area to forage or rest would be minimal and any effects associated with dispersing are expected to be insignificant. Additionally, it is extremely unlikely that a caracara would be present during the limited window for launch activities, so impacts from plumes or launch vehicle strikes are considered discountable.

Small numbers of Audubon’s crested caracara have been documented foraging but not nesting within the Action Area, which is just north of their expected northern range. Although individuals present at the time of static fire tests, launches, or landings could be disturbed by noise, vibrations, lighting, and/or sonic booms depending on their proximity to these activities, any temporarily alterations in feeding and sheltering would not significantly disrupt normal caracara behavioral patterns. Given the apparent rarity of caracaras within the Action Area and the low probability of an individual to be present at the time of a launch event, effects to caracaras from the Proposed Action are extremely unlikely to occur and are considered discountable. Thus, NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the caracara.

5.3.2 Eastern Black Rail

There is a lack of suitable black rail habitat at and near the launch and landing areas, so the potential for black rails to be affected by any ground-disturbing construction activities or plumes is very low, but noise and visual disturbance from tests, launches, and landings may cause temporary disturbance, and possibly brief stress, due to interrupted breeding, foraging, or roosting.

The effort required for a disturbed bird to fly to another area to forage or rest would be minimal and any effects associated with dispersing are expected to be insignificant. Due to the rare occurrence of this species within the Action Area, and the low probability of one occurring close to LC-39A at the time of a test, launch, or landing event, NASA considers the effects of the Proposed Action on the eastern black rail to be discountable.

Suitable habitat for the eastern black rail is present within the Action Area, and recent surveys on KSC/MINWR have detected black rail calls in some of these areas. Although individuals present at the time of static fire tests, launches, or landings could be disturbed by noise, vibrations, lighting, and/or sonic booms depending on their proximity to these activities, any temporarily alterations in feeding and sheltering would not significantly disrupt normal rail behavioral patterns. No suitable black rail habitat is present near the launch area, and there is a low probability that an individual rail would be present at the time of a launch event, so effects to eastern black rails from the Proposed Action are extremely unlikely to occur and are considered discountable. NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the eastern black rail.

5.3.3 Everglade Snail Kite

The portion of the Action Area around LC-39A is outside of the Everglade snail kite's normal range, which is primarily Central and South Florida (FWC, 2024c). The snail kite is not known to roost or breed within the Action Area around LC-39A, and it is unlikely to be transiting the area during the short duration of a test, launch, or landing event. Thus, NASA considers the effects of the Proposed Action to be discountable for the Everglade snail kite. Additionally, the effort required for a disturbed bird to fly to another area to forage or rest would be minimal and any effects associated with dispersing are expected to be insignificant.

The Everglade snail kite is unlikely to be transiting the area during the short duration of a test, launch, or landing event when potential noise, vibrations, and/or sonic booms could disrupt feeding or sheltering. Effects to Everglade snail kites from the Proposed Action are extremely unlikely to occur and are considered discountable. NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the Everglade snail kite.

5.3.4 Florida Grasshopper Sparrow

Florida grasshopper sparrows are not present within the portion of the Action Area affected by construction or operations at and around LC-39A. Due to the infrequent nature of contingency landings and the large area over which they may occur (100 miles of coastline), there is only a small probability of this species being exposed to overpressures of approximately 1 psf from Starship Atlantic Contingency landings.

Suitable habitat for the Florida grasshopper sparrow is present only near the edge of the Starship Atlantic Contingency landings 1 psf contour. Any exposed individuals may temporarily alter feeding, breeding, or sheltering, but would not suffer significant disruption in normal behavioral patterns. Effects to the Florida grasshopper sparrow from the Proposed Action are extremely unlikely to occur and are considered discountable. NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to Florida grasshopper sparrow.

5.3.5 Florida Scrub-Jay

The closest Florida scrub-jay core and support territories to the areas of construction are 0.9 miles and 0.4 miles away, respectively (Table 5-4). Due to the distance from the construction area, associated noise, vibrations, and lighting are not likely to cause measurable reactions in Florida scrub-jays, and vehicle strikes are not anticipated as construction-related traffic routes do not traverse scrub-jay habitat.

A small area of Florida scrub-jay auxiliary habitat is present near the edge of the 0.2-mile radius launch plume. Auxiliary habitat is of lower quality and would not support scrub-jays without a great deal of management investment, so no direct impacts to scrub-jays are expected from the plume. Lighting associated with nighttime launches, landings, and static fire tests would be focused on the vehicle or other components within LC-39A, but would indirectly extend into areas that would otherwise be dark. Light produced by launch, landing, and static fire plumes would be visible at night in some areas of Florida scrub-jay habitat. However, due to the relatively low number of nighttime launches and distance of Florida scrub-jay habitat from the pads (resulting in diminished light levels), light-related disturbance to this diurnal species would be discountable.

The closest Florida scrub-jay core territory to the launch and landing pads is 1.3 miles to the northwest (Table 5-4). During static fire tests, launches, and landings, scrub-jay territories at KSC/MINWR and CCSFS would be exposed to noise levels up to 130 dB ASEL, 140 dB ASEL, and 130 dB ASEL, respectively (Figure 5-1 through Figure 5-7). Table 5-5 provides acreages of Florida scrub-jay core habitat that would be exposed to the various levels of noise. During Super Heavy landings, most scrub-jay territories at KSC/MINWR and CCSFS would be exposed to sonic boom overpressures of at least 1 psf, with some core territories exposed to overpressures up to over 20 psf (Figure 5-8 through Figure 5-11). Table 5-6 provides acreages of Florida scrub-jay core habitat that would be exposed to the various levels of overpressure.

Static fire engine tests typically occur 1 to 3 days prior to launch, with associated noises lasting less than 15 seconds. Landing noise follows launch and associated launch engine noise by 5 to 10 minutes for the Super Heavy, but no landing noise timeframe can be determined for Starship. Each sonic boom event would last a fraction of a second. There would be up to 44 of each of the following annually: Starship tests, Super Heavy tests, launches, Super Heavy landings, and Starship landings.

As discussed in Section 5.2.2, *Noise and Visual Stimuli*, and Section 5.2.4, *Sonic Booms*, noise and sonic booms associated with static fire tests, launches, and landings may startle birds, potentially resulting in interruption of foraging, breeding, nesting, or roosting (Kight et al., 2012; Ortega, 2012). Such disturbances could also cause a Florida scrub-jay to flush from the nest, leaving eggs or young vulnerable to predation or dehydration. In some cases, adults may damage eggs during their startle response. Individuals that flush from a protected or concealed area may be more vulnerable to predation. Noise and vibration may also cause elevated stress levels. Stress responses may cause effects such as suppression of the immune system (Slabbekoorn et al., 2018).

Table 5-5. Florida Scrub-Jay Core Habitat at KSC, MINWR, and CCSFS Exposed to Greater than 100 dB ASEL from the Proposed Action at LC-39A

Events at LC-39A	Acres affected[1]					
	100-110 dB ASEL	110-115 dB ASEL	115-120 dB ASEL	120-130 dB ASEL	130-140 dB ASEL	>140 dB ASEL
Starship-Super Heavy launch	11,222	3,695	4,239	3,309	381	0
Starship static fire test	1,885	206	94	0	0	0
Super Heavy static fire test	4,852	536	215	117	0	0

Table 5-5. Florida Scrub-Jay Core Habitat at KSC, MINWR, and CCSFS Exposed to Greater than 100 dB ASEL from the Proposed Action at LC-39A

Events at LC-39A	Acres affected[1]					
	100-110 dB ASEL	110-115 dB ASEL	115-120 dB ASEL	120-130 dB ASEL	130-140 dB ASEL	>140 dB ASEL
Super Heavy landing[2]	7,096	2,367	706	346	0	0
Starship landing	2,539	232	109	0	0	0

Notes: > = greater than; ASEL = A-weighted sound exposure level; BCA = Biological and Conference Assessment; CCSFS = Cape Canaveral Space Force Station; dB = decibels; KSC = Kennedy Space Center; LC = Launch Complex; MINWR = Merritt Island National Wildlife Refuge.

[1]Data for Florida scrub-jay core habitat outside of KSC, MINWR, and CCSFS was not available at the time of BCA development.

[2]Super Heavy nominal landing was used as the representative landing, as it would expose the greatest amount of Florida scrub-jay core habitat to the highest ASELs.

Table 5-6. Florida Scrub-Jay Core Habitat at KSC, MINWR, and CCSFS Exposed to Greater than 1 psf Overpressure from the Proposed Action at LC-39A

Events at LC-39A	Acres affected[1]					
	1-2 psf	2-4 psf	4-6 psf	6-10 psf	10-20 psf	>20 psf
Starship-Super Heavy launch	Sonic boom over the Atlantic Ocean does not affect land					
Starship static fire test	No sonic boom					
Super Heavy static fire test						
Super Heavy landing[2]	21	2,420	7,304	8,303	4,519	167
Starship landing	23,954	0	0	0	0	0

Notes: > = greater than; BCA = Biological and Conference Assessment; CCSFS = Cape Canaveral Space Force Station; KSC = Kennedy Space Center; LC = Launch Complex; MINWR = Merritt Island National Wildlife Refuge; psf = pounds per square foot.

[1]Data for Florida scrub-jay core habitat outside of KSC, MINWR, and CCSFS was not available at the time of BCA development.

[2]Super Heavy landing at 40 degrees was used as the representative landing, as it would expose the greatest amount of Florida scrub-jay core habitat to the highest overpressure levels.

At Vandenberg Space Force Base where there has been an increase in Falcon 9 launches starting in 2021, a statistical analysis was conducted to investigate the relationship between western snowy plover (*Charadrius nivosus nivosus)* abundance and productivity and the increased launch frequency (USSF, 2025). While the analysis did identify a significant location-specific relationship between *breeding population count* and *modeled engine noise* (p-value < 0.001), suggesting that western snowy plovers may be selecting habitat further from launch activities to reduce exposure to overpressure and noise associated with launches, the analysis did not find a significant relationship between snowy plover *hatch rate* and launch-related disturbances (p-values = 0.751 and 0.738 for *overpressure exposure* and *modeled engine noise*, respectively), or between *fledge rate* and launch-related disturbances (p-values = 0.148 and 0.815 for *overpressure exposure* and *modeled engine noise*, respectively) (USSF, 2025). To date, this presents the best available science on launch effects to an avian species, particularly with respect to hatch rates and fledge rates. Unlike western snowy plovers, Florida scrub-jays are very territorial, and they require specific habitat conditions, so they are less likely to relocate. It is unknown if this would affect hatch or fledge rates.

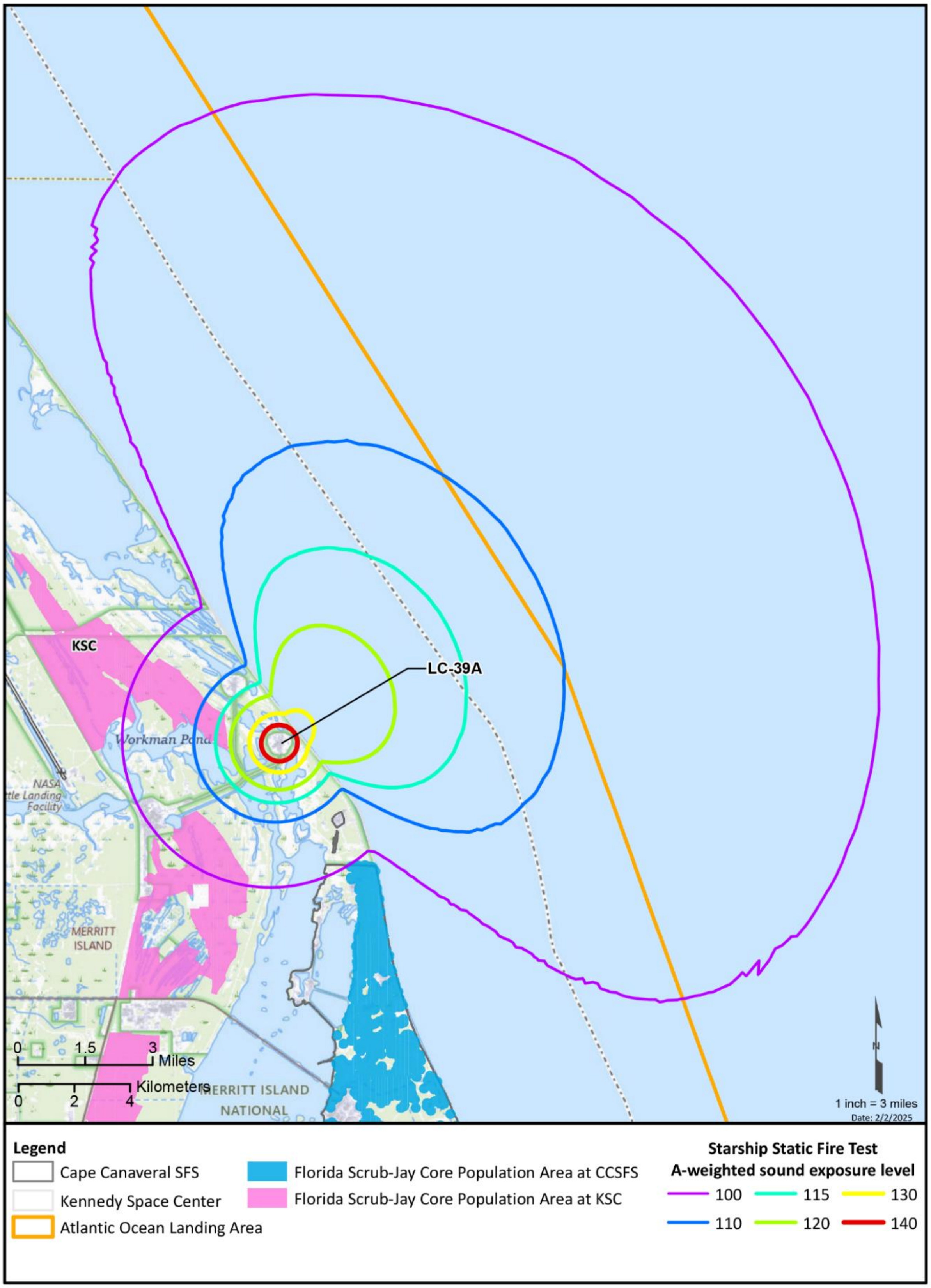


Figure 5-1. Florida Scrub-Jay Habitat in Relation to Starship Static Fire Test Noise Contours (ASEL)

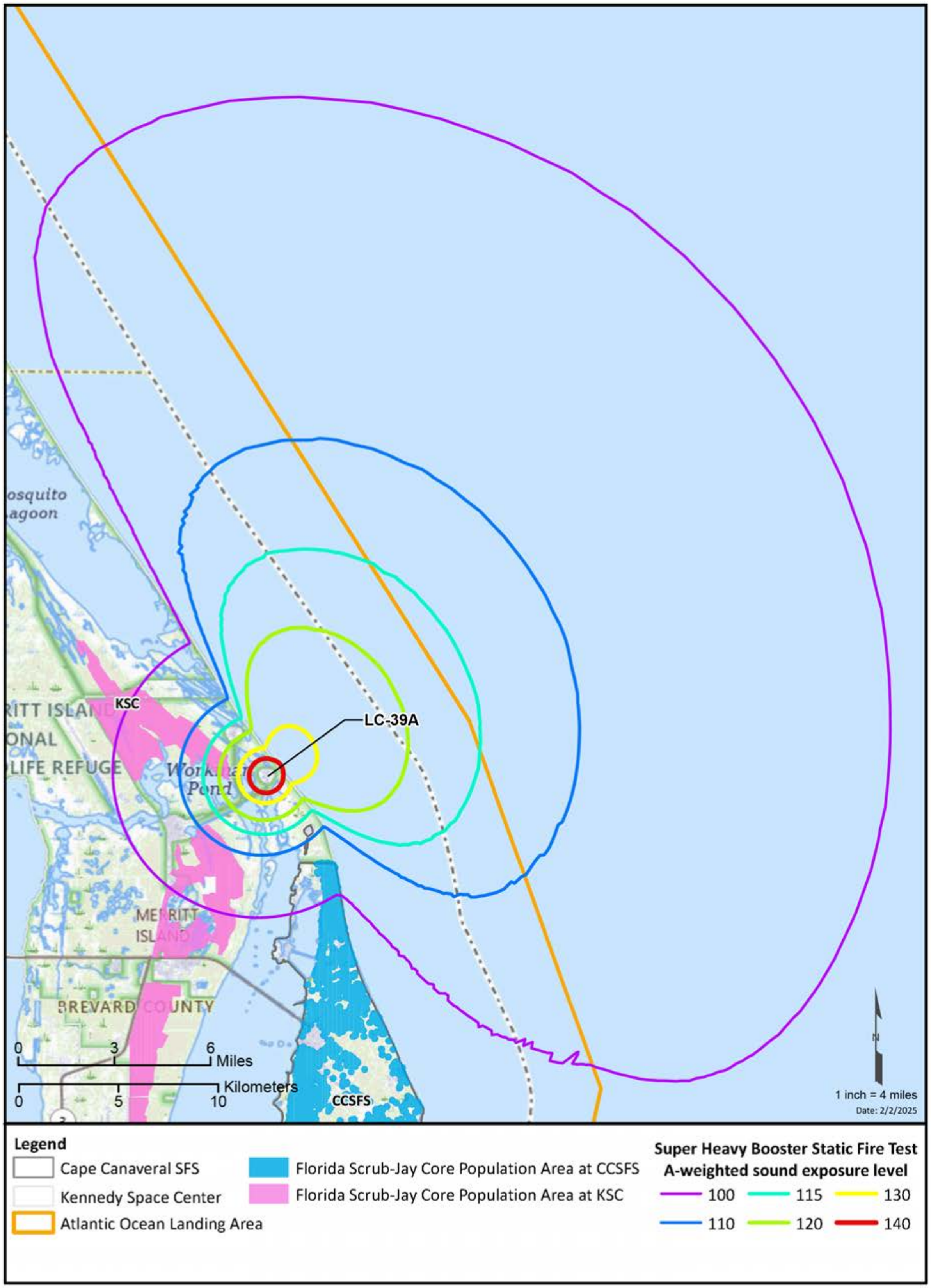


Figure 5-2. Florida Scrub-Jay Habitat in Relation to Super Heavy Static Fire Test Noise Contours (ASEL)

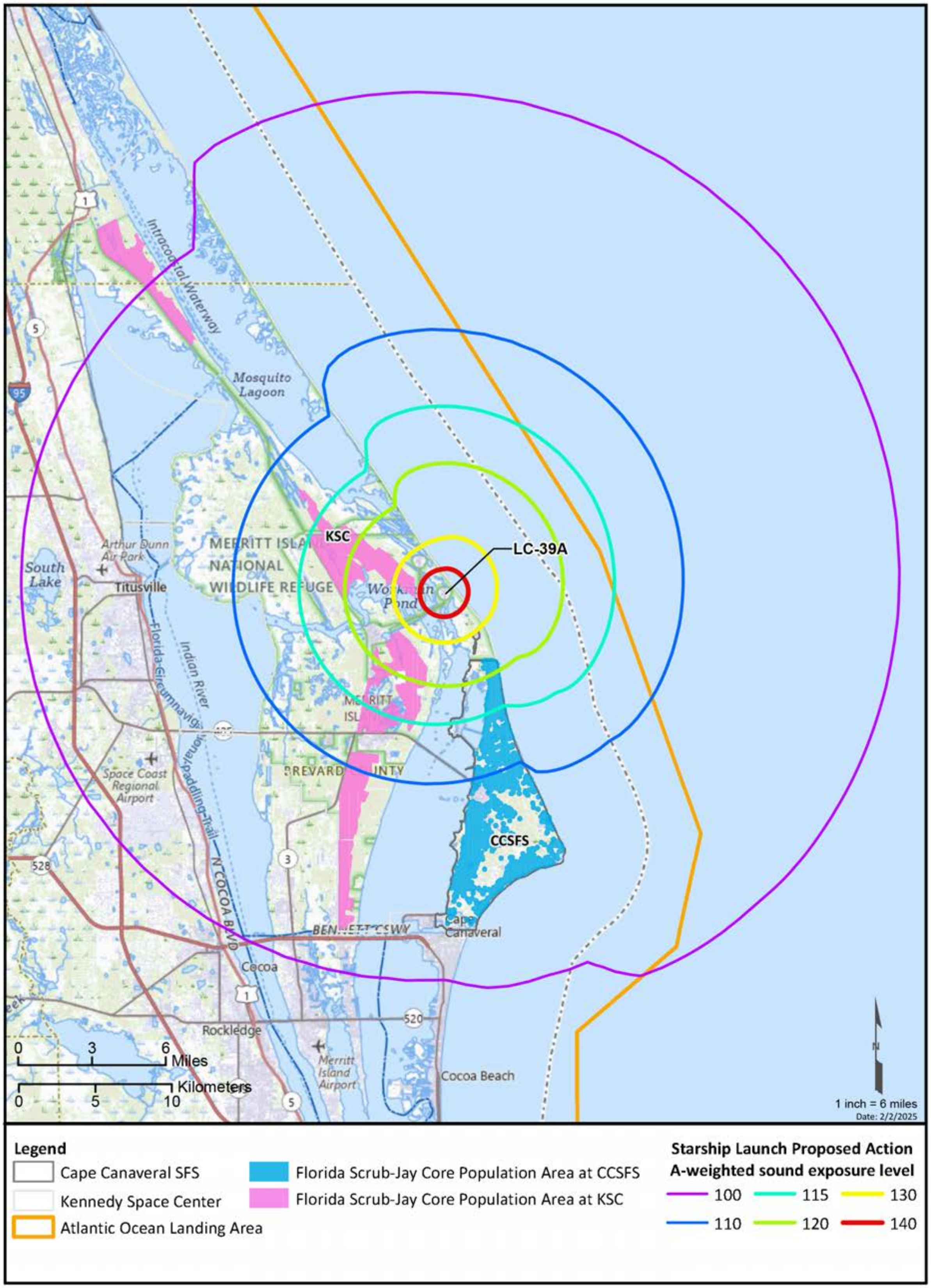


Figure 5-3. Florida Scrub-Jay Habitat in Relation to Launch (Nominal Heading) Noise Contours (ASEL)

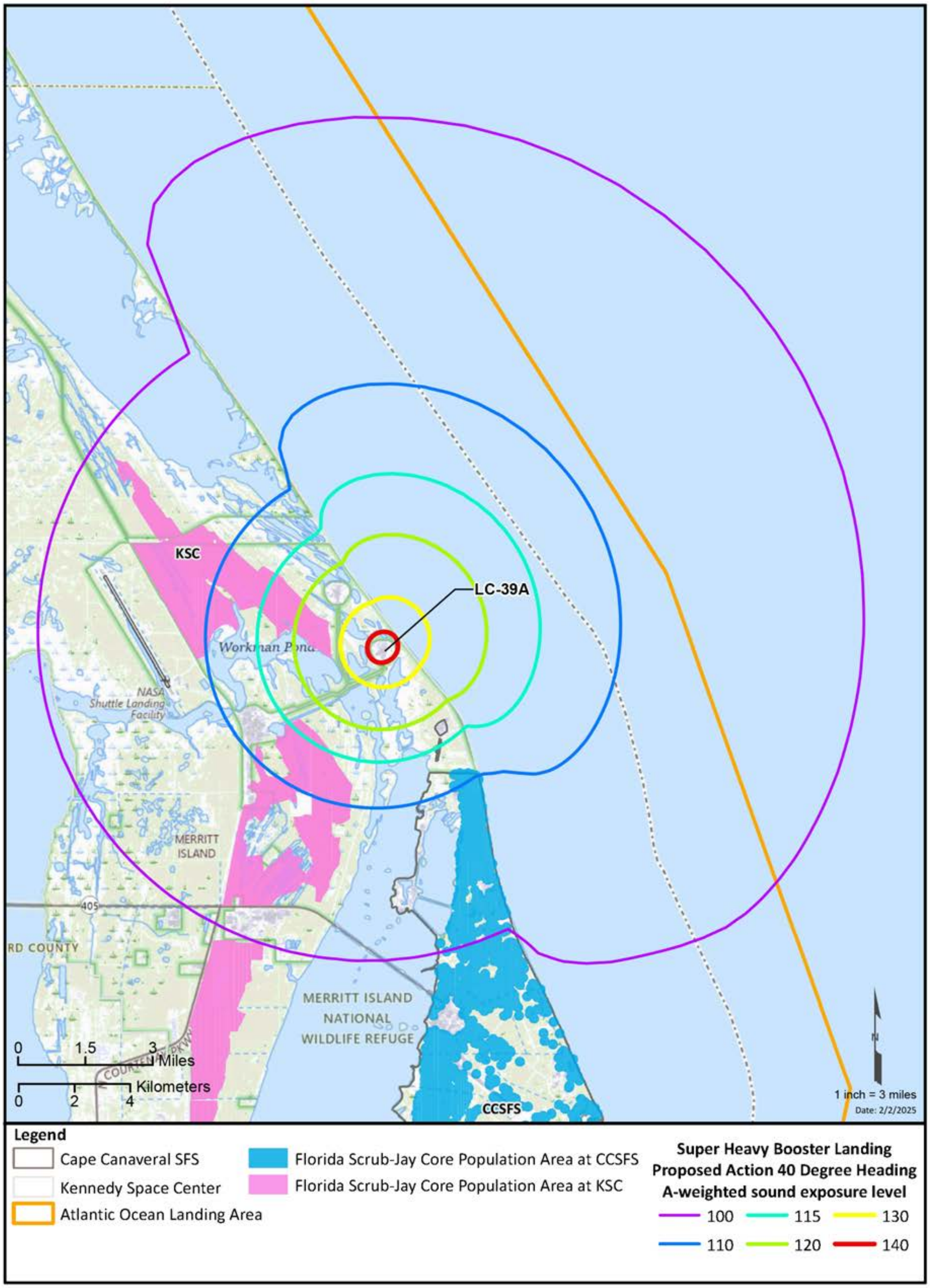


Figure 5-4. Florida Scrub-Jay Habitat in Relation to Super Heavy Landing (40 Degree Heading) Noise Contours (ASEL)

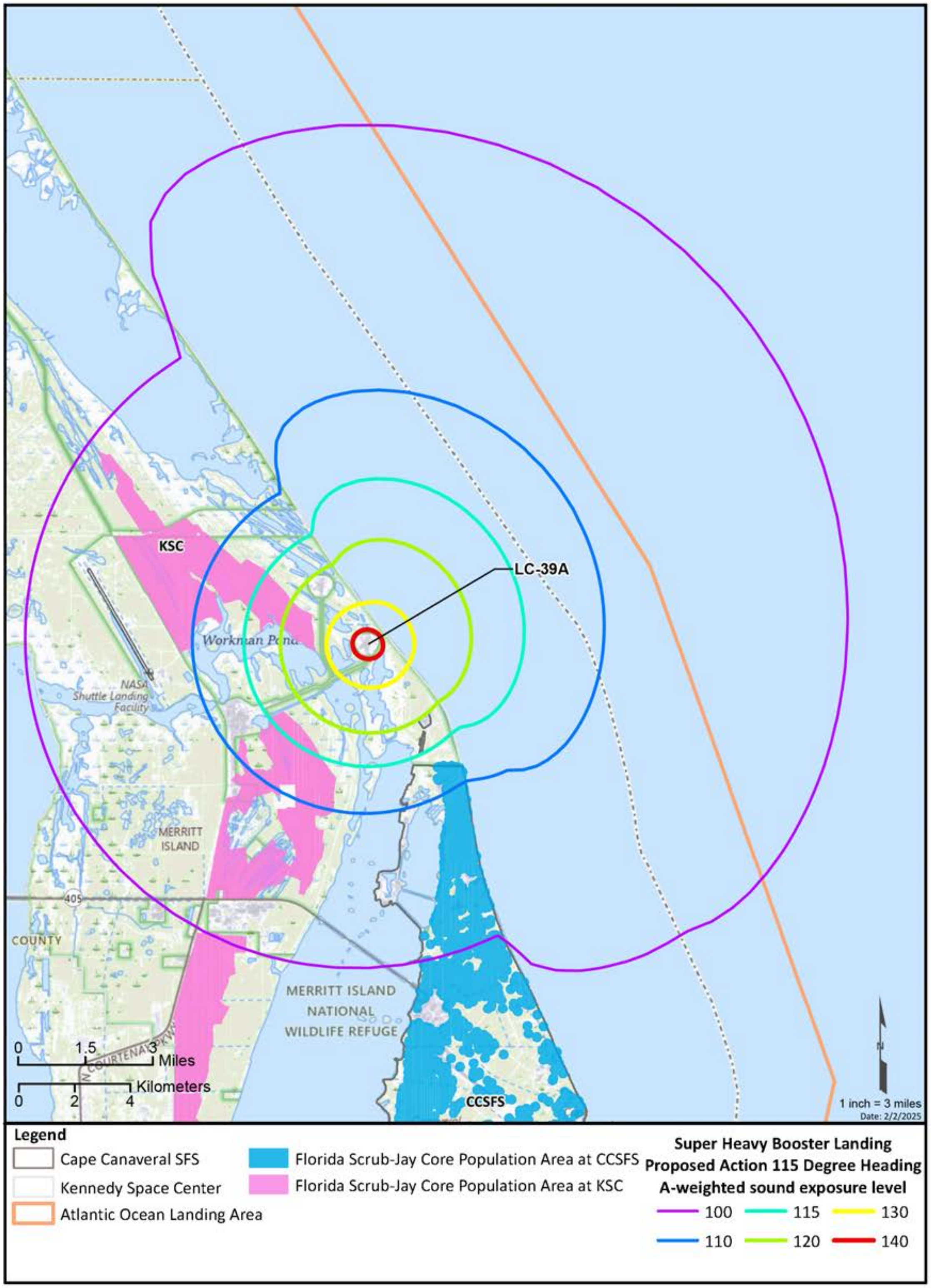


Figure 5-5. Florida Scrub-Jay Habitat in Relation to Super Heavy Landing (115 Degree Heading) Noise Contours (ASEL)

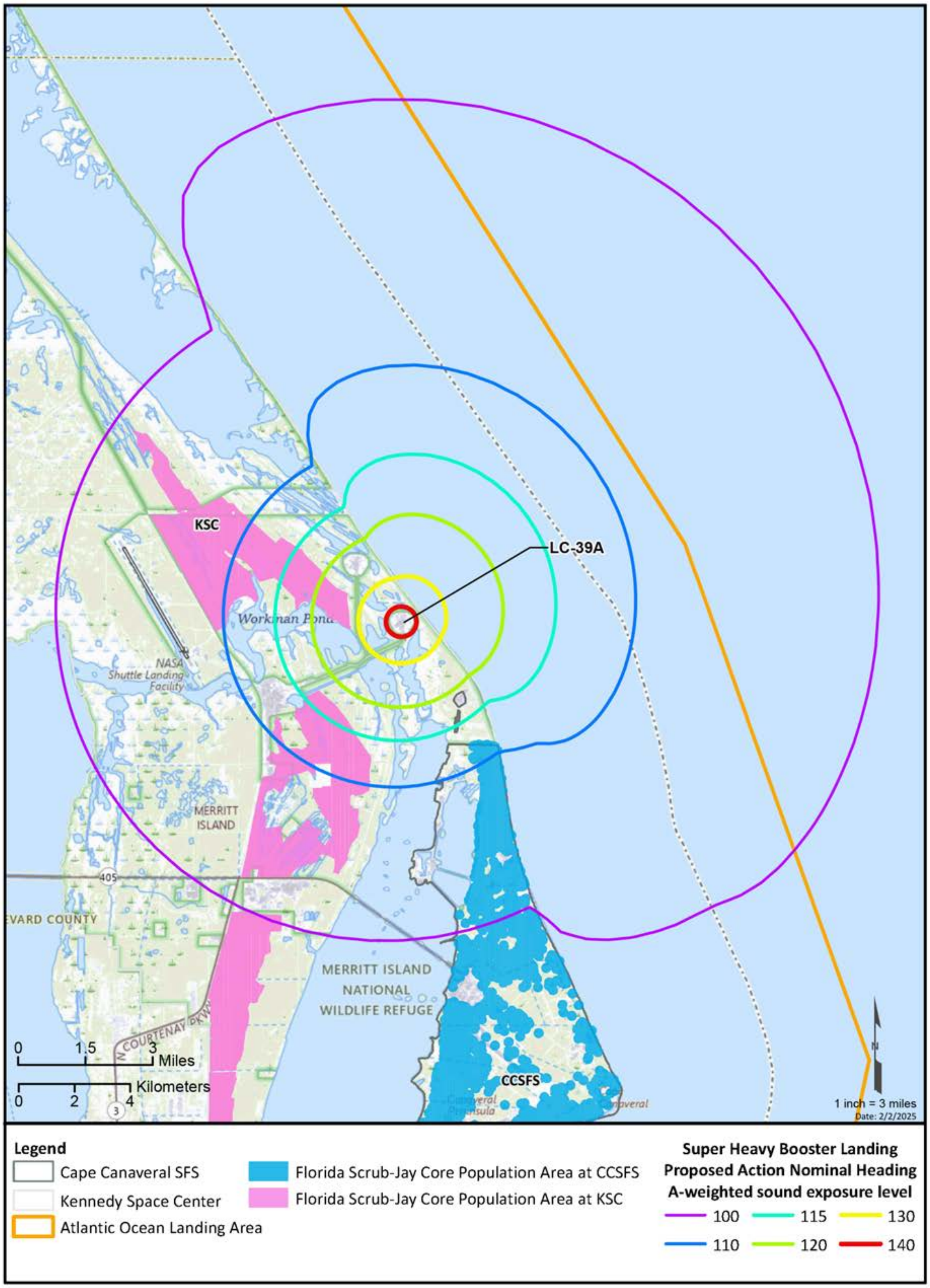


Figure 5-6. Florida Scrub-Jay Habitat in Relation to Super Heavy Landing (Nominal Heading) Noise Contours (ASEL)

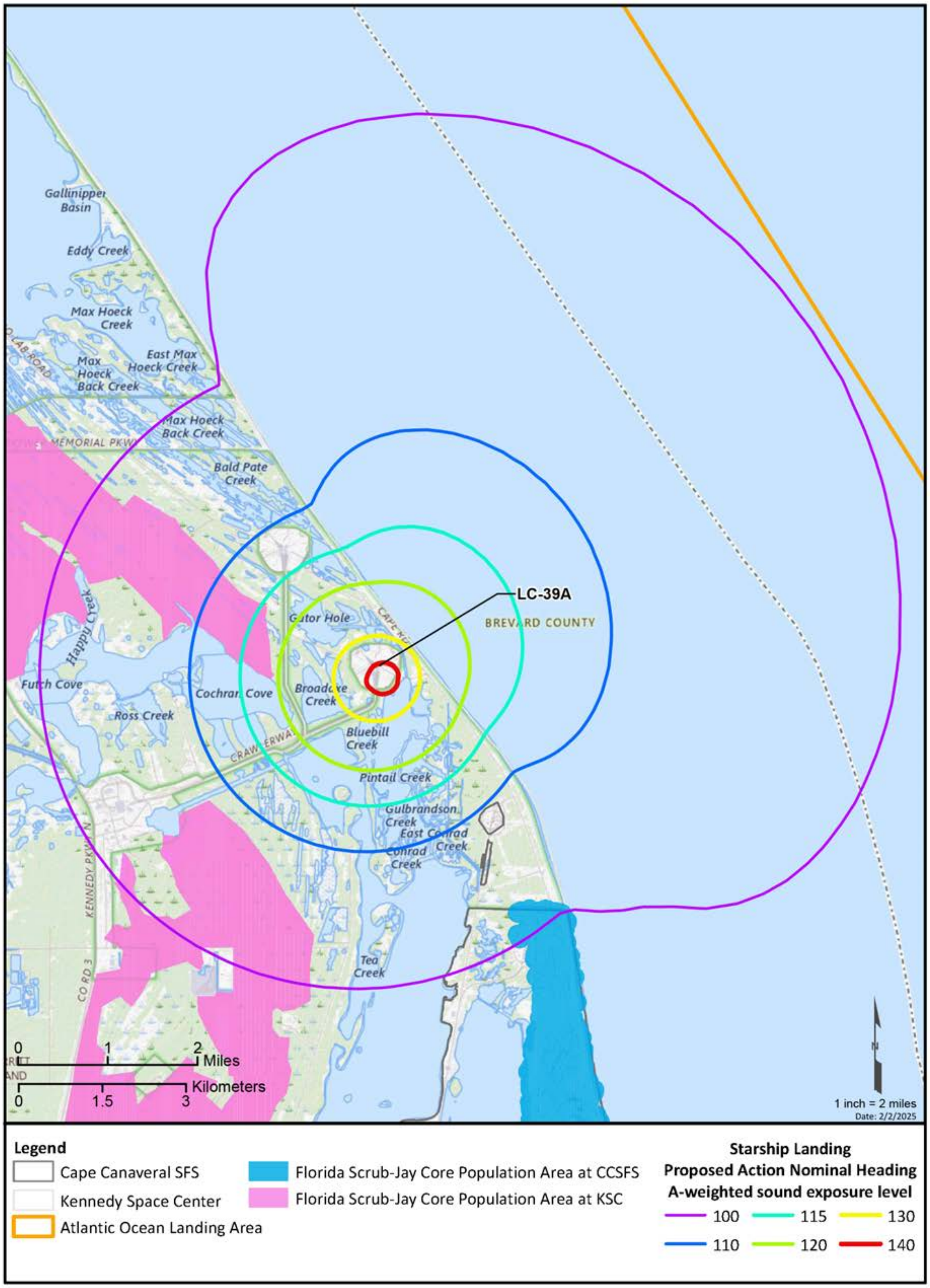


Figure 5-7. Florida Scrub-Jay Habitat in Relation to Starship Landing (Nominal Heading) Noise Contours (ASEL)

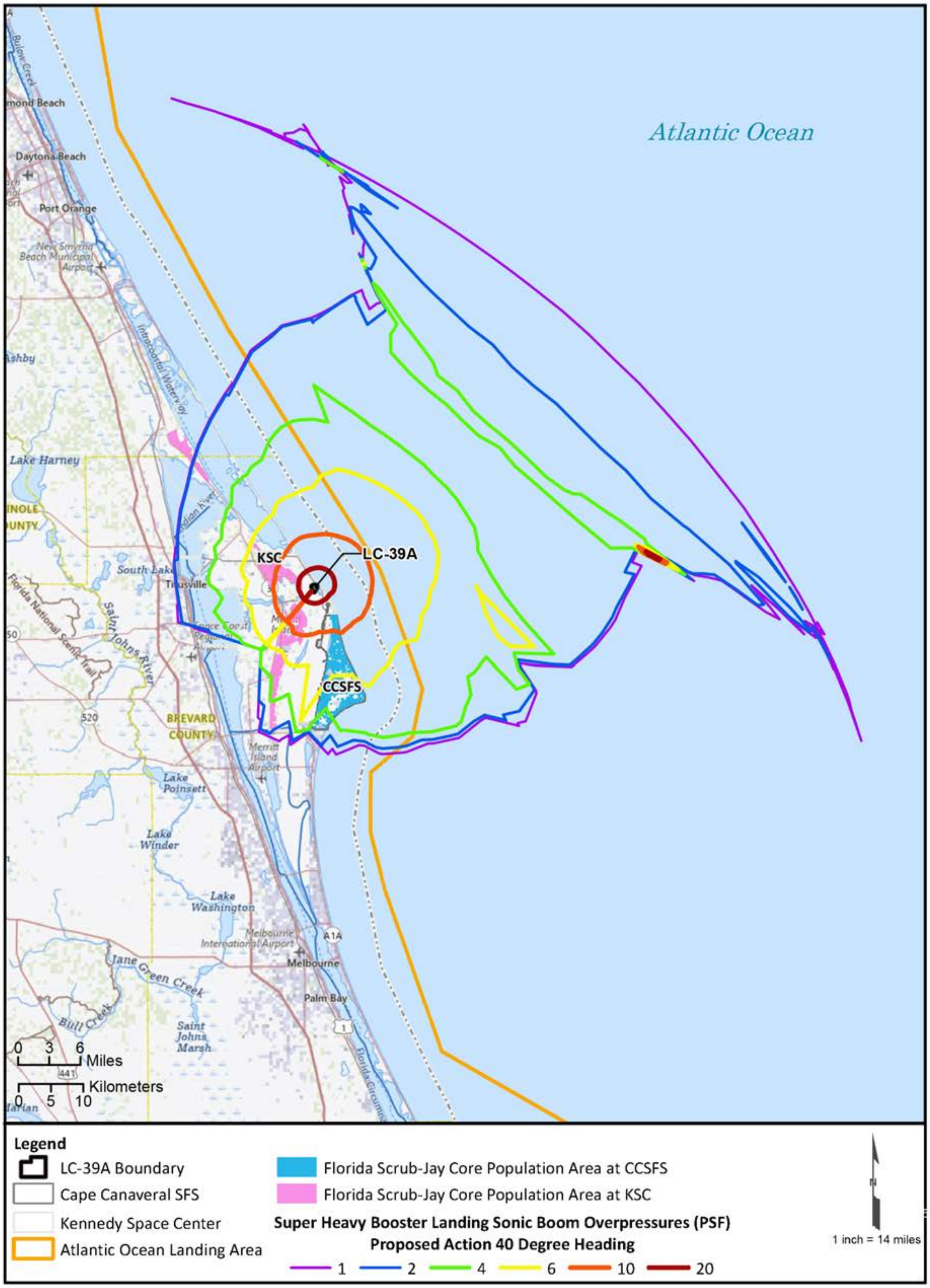


Figure 5-8. Florida Scrub-Jay Habitat in Relation to Super Heavy Landing (40 Degree Heading) Sonic Boom Overpressure Contours

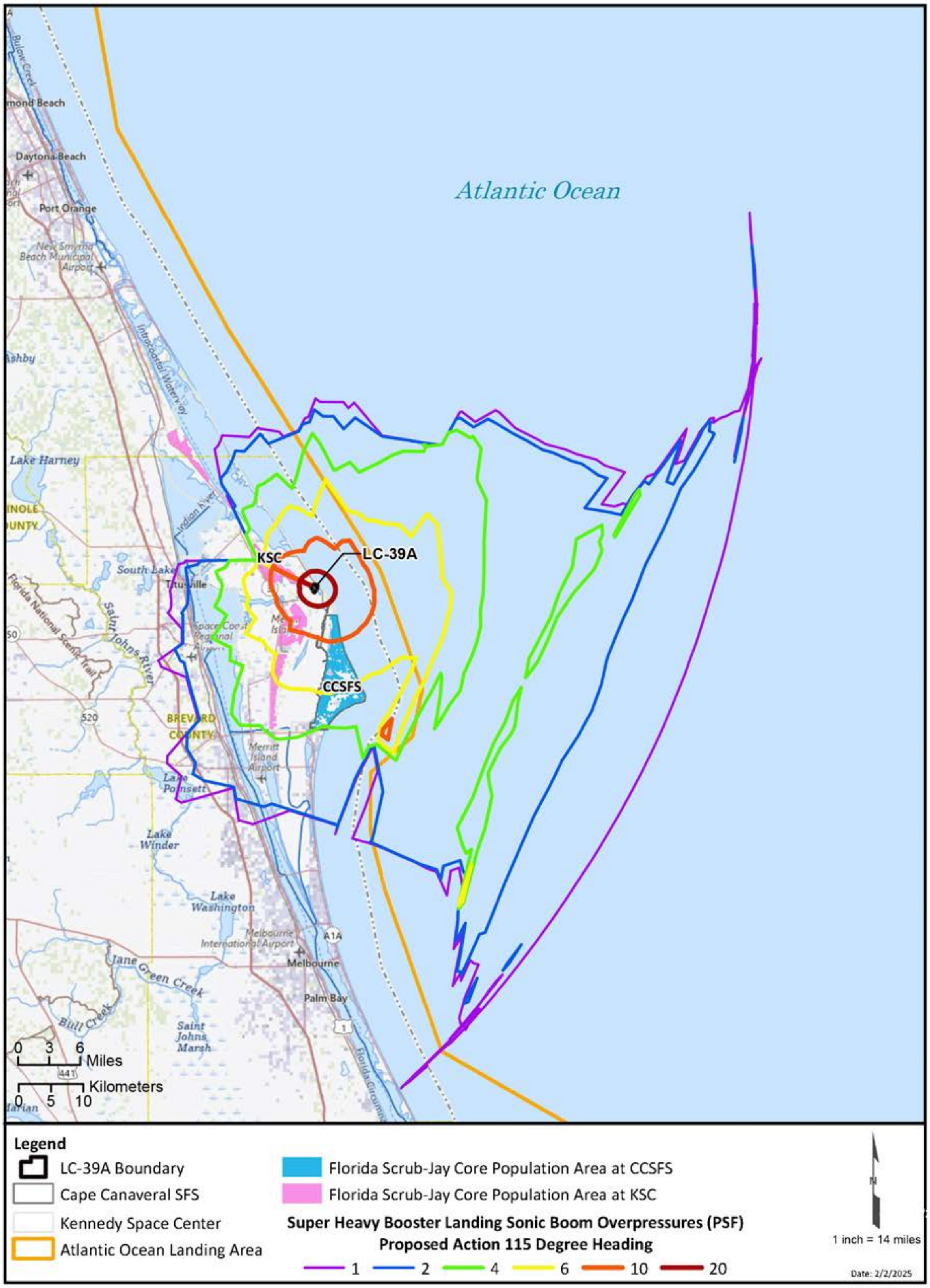


Figure 5-9. Florida Scrub-Jay Habitat in Relation to Super Heavy Landing (115 Degree Heading) Sonic Boom Overpressure Contours

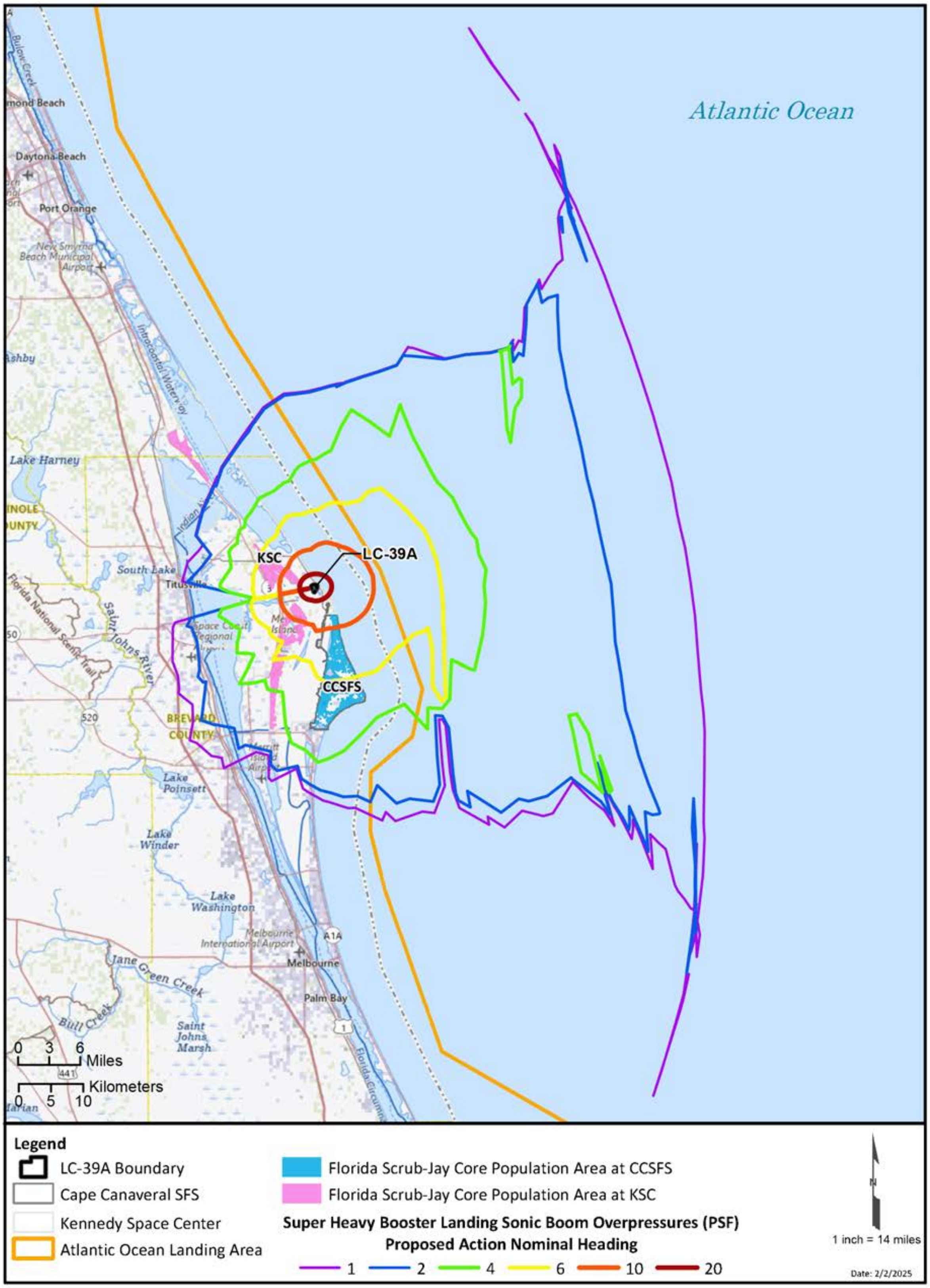


Figure 5-10. Florida Scrub-Jay Habitat in Relation to Super Heavy Landing (Nominal Heading) Sonic Boom Overpressure Contours

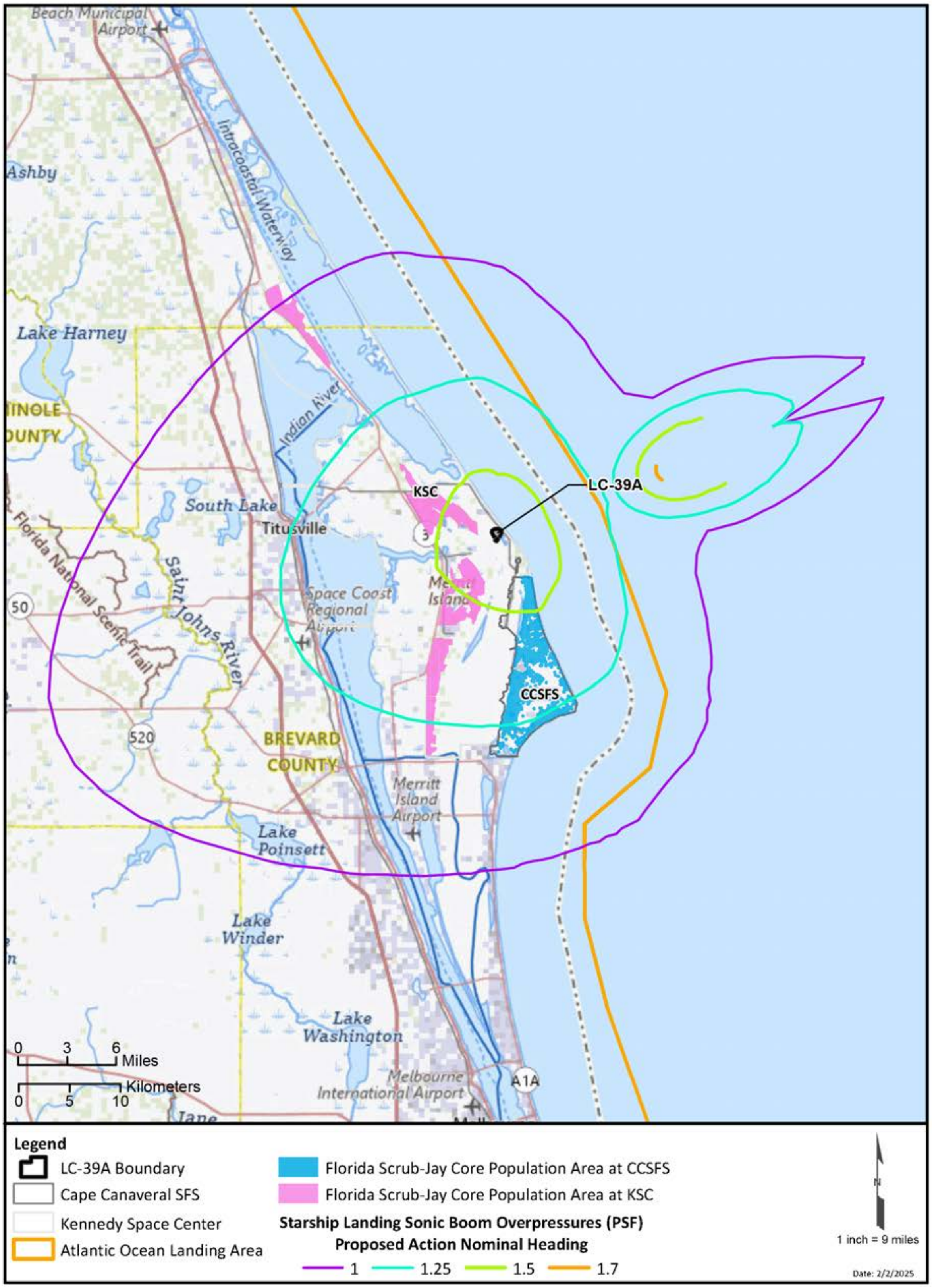


Figure 5-11. Florida Scrub-Jay Habitat in Relation to Starship Landing (Nominal Heading) Sonic Boom Overpressure Contours

Any decreases in the ability to burn habitat for the fire-dependent Florida scrub-jay, especially in the Happy Creek and Schwartz Road population cores, would negatively affect the viability of these birds, particularly foraging and breeding activities. Launch-related closures could also affect the ability to conduct monitoring for Florida scrub-jays. As described in Table 1-1 and shown in Figure 1-4, closures would be limited to the smallest area possible and for the shortest time possible while still maintaining safety. While there may be limited access to certain areas on a periodic basis, there would be periods between closures that would allow burning and monitoring to occur. SpaceX operations are not limited by smoke, so the only blocks of time not available for burns are the closures for safety immediately around the static fire, launch, and landing periods. If burn conditions are right, burns on launch days would be possible. Similarly, once safety closure areas are open, monitoring could occur immediately.

The Florida scrub-jay has been documented nesting, foraging, and roosting within the Action Area, with core habitat 0.9 miles from the nearest construction area and 1.3 miles from the launch and landing pads at LC-39A. No suitable nesting or foraging habitat is located within the 0.2-mile area around the launch pad, so heat impacts to Florida scrub-jays from launches and landings are not expected. Individuals present at the time of static fire tests, launches, or landings could be disturbed by noise, vibrations, lighting, and/or sonic booms depending on their proximity to these activities, with potential for alterations in breeding, feeding, and sheltering. Thus, NASA has made the determination of **may affect, likely to adversely affect**, for the Proposed Action with respect to the Florida scrub-jay.

5.3.6 Piping Plover

Piping plovers may overwinter within the Action Area, but no critical habitat is present and plovers do not breed within the Action Area. As discussed in the Section 5.2.2, *Noise and Visual Stimuli*, noise and visual disturbances associated with construction and operations may startle birds or cause them to avoid the area. Near the outer edge of the plume, potential habitat for the piping plover is present, but the likelihood of plovers transiting the area during the brief period when there would be potential heat effects is low, making it extremely unlikely that they would be exposed to the heat plumes from tests, launches, or landings, which are limited to a 0.2-mile radius around the pads (Figure 5-12). Monitoring at Boca Chica has not recorded any dead or injured piping plovers following Starship and Super Heavy launch events (FAA, 2024).It is unknown how various noise and overpressure levels may affect piping plover hearing ability, but NASA expects that any individuals in the vicinity would exhibit a startle response (i.e., take flight) during tests, launches, and landings, with brief alterations in feeding and sheltering, but returning to normal behavior shortly thereafter (Figure 5-13). Noise exposure time would last only a few minutes per launch and less for static fire tests and landings. Sonic boom impacts last milliseconds. Due to their transitory nature and rarity in the Action Area, the probability of noise- or overpressure-related effects to piping plovers would be low; such effects are deemed discountable.

The occurrence of overwintering piping plover near LC-39A is rare, but they have been documented within the Action Area. While individuals present at the time of static fire tests, launches, or landings could be disturbed by noise, vibrations, lighting, and/or sonic booms depending on their proximity to these activities, any temporary alterations in feeding and sheltering would not significantly disrupt normal piping plover behavioral patterns. Potential piping plover foraging habitat is present near the launch area, but the probability that an individual plover would be present close enough to the pad at the time of a launch event to be affected by the plume is low. Overall effects to piping plovers from the Proposed Action would be considered insignificant. Thus, NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the piping plover.

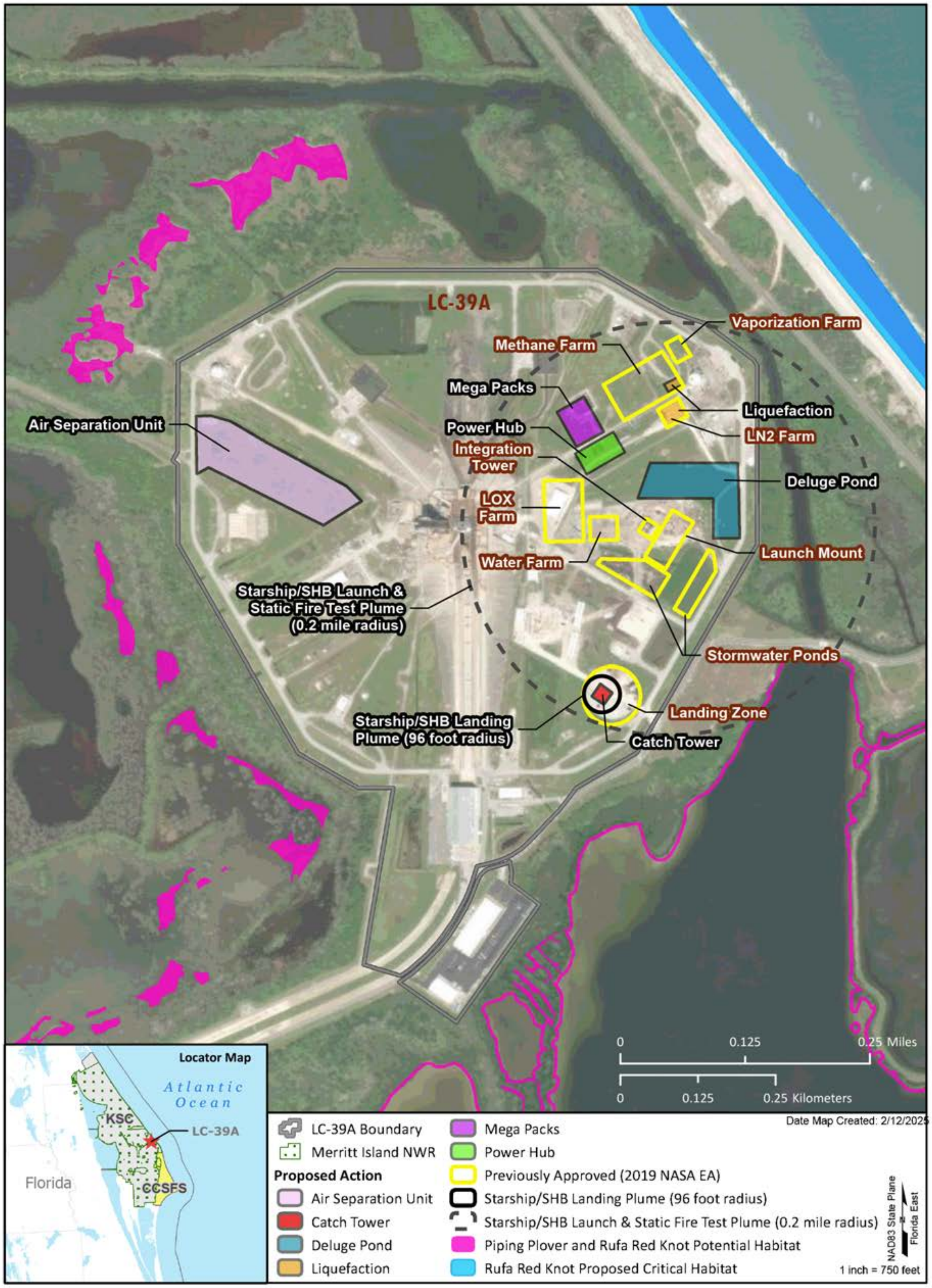


Figure 5-12. Potential Piping Plover and Rufa Red Knot Habitat in Relation to Construction Areas and Launch and Landing Plumes

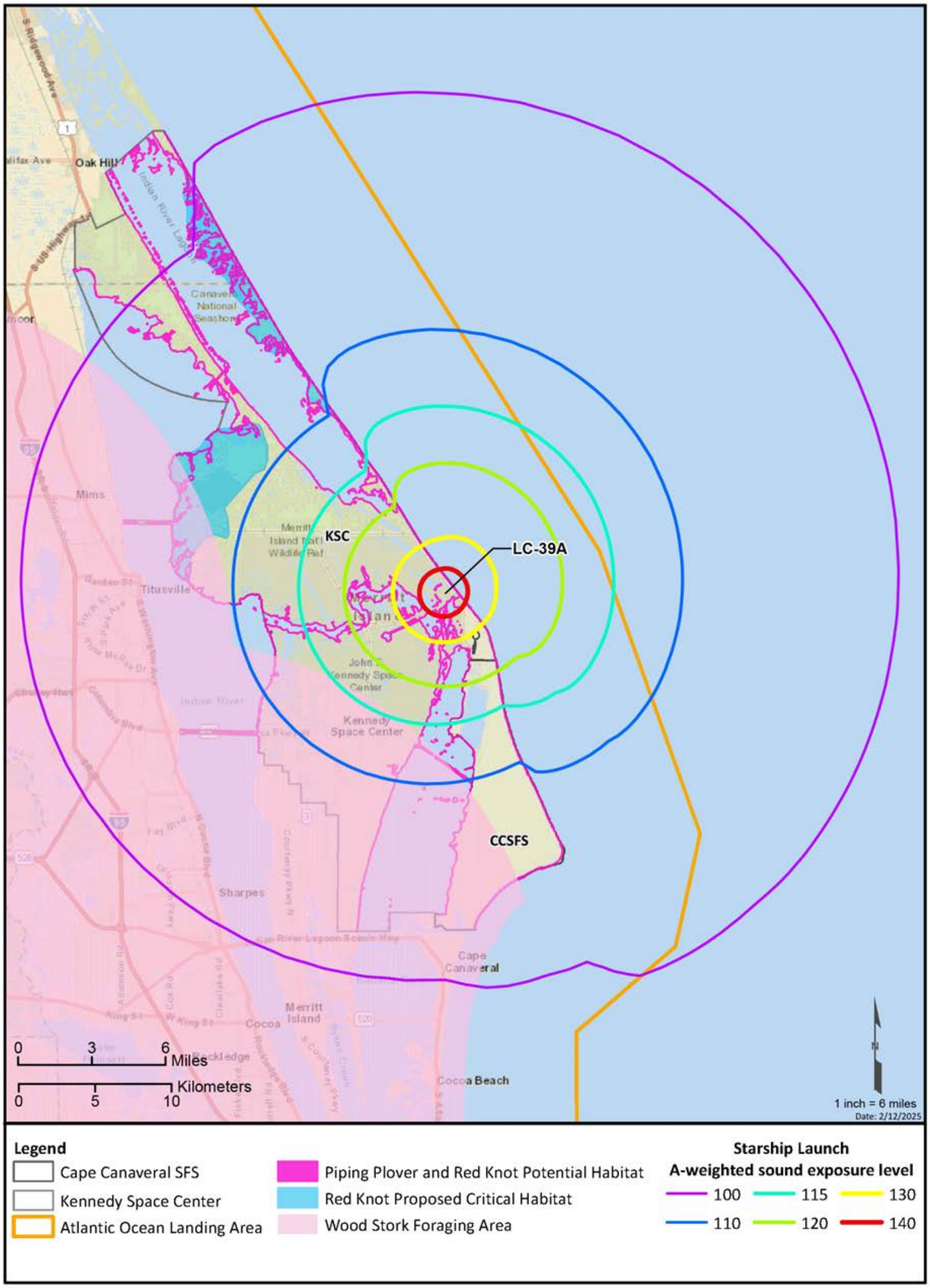


Figure 5-13. Potential Piping Plover, Red Knot, and Wood Stork Habitat in Relation to Launch Noise Contours (ASEL)

5.3.7 Red-Cockaded Woodpecker

No red-cockaded woodpeckers are present within the 1 psf/100 dB ASEL contour around LC-39A, so there would be no effects from plumes, strikes, vegetation damage, or lighting. The one small red-cockaded woodpecker population within the Starship Contingency 1 psf contour, located south of Palm Bay (St. Sebastian River Preserve State Park). Due to the infrequent nature of contingency landings and the large area over which they may occur (100 miles of coastline), there is only a small probability of this species being exposed to overpressures of approximately 1 psf from Starship Atlantic Contingency landings.

Any exposed individuals may temporarily alter feeding, breeding, or sheltering, but would not suffer significant disruption in normal behavioral patterns. Effects to these beach mice from the Proposed Action are extremely unlikely to occur and are considered discountable. NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the red-cockaded woodpecker.

5.3.8 Rufa Red Knot

Rufa red knots overwinter in the Action Area, but they do not breed within the Action Area. Construction activities at LC-39A would occur approximately 0.2 miles from red knot proposed critical habitat (Table 5-4). As discussed in Section 5.2.2, *Noise and Visual Stimuli*, noise and visual disturbances associated with construction and operations may startle birds or cause them to avoid the area. Near the outer edge of the plume, potential habitat for the red knot is present, but the likelihood of red knots transiting the area during the brief period when there would be potential heat effects is low, making it extremely unlikely that they would be exposed to the heat plumes from tests, launches, or landings which are limited to a 0.2-mile radius around the pads (Figure 5-12). Monitoring at Boca Chica has not recorded any dead or injured red knots following Starship and Super Heavy launch events (FAA, 2024).

It is unknown how various noise and overpressure levels may affect red knot hearing ability, but NASA expects that any individuals in the vicinity would exhibit a startle response (i.e., take flight) during tests, launches, and landings, returning to normal behavior shortly thereafter (Figure 5-13). If present within the Action Area, exposure time would last only a few minutes per launch and less for static fire tests and landings. Table 5-7 and Table 5-8 provide acreages of red knot proposed critical habitat that would be exposed to various noise levels. Due to their transitory nature, the probability of noise- or overpressure-related impacts to red knots are considered discountable.

Table 5-7. Rufa Red Knot Proposed Critical Habitat Exposed to Greater than 100 dB ASEL from the Proposed Action at LC-39A

Events at LC-39A	Acres affected						
	100-110 dB ASEL	110-115 dB ASEL	115-120 dB ASEL	120-130 dB ASEL	130-140 dB ASEL	140-150 dB ASEL	>150 dB ASEL
Starship-Super Heavy launch	13,035	91	34	34	20	22	0
Starship static fire test	34	9	6	7	16	0	0
Super Heavy static fire test	49	12	9	11	9	10	0

Table 5-7. Rufa Red Knot Proposed Critical Habitat Exposed to Greater than 100 dB ASEL from the Proposed Action at LC-39A

Events at LC-39A	Acres affected						
	100-110 dB ASEL	110-115 dB ASEL	115-120 dB ASEL	120-130 dB ASEL	130-140 dB ASEL	140-150 dB ASEL	>150 dB ASEL
Super Heavy landing[1]	93	24	14	19	24	0	0
Starship landing	30	11	7	21	0	0	0

Notes: > = greater than; ASEL = A-weighted sound exposure level; dB = decibels; LC = Launch Complex.

[1]Super Heavy landing at 40 degrees was used as the representative landing, as it would expose the greatest amount of rufa red knot proposed critical habitat to the highest ASELs.

Table 5-8. Rufa Red Knot Proposed Critical Habitat Exposed to Greater than 1 psf Overpressure from the Proposed Action at LC-39A

Events at LC-39A	Acres affected					
	1-2 psf	2-4 psf	4-6 psf	6-10 psf	10-20 psf	>20 psf
Starship-Super Heavy launch	Sonic boom over the Atlantic Ocean does not affect land					
Starship static fire test	No sonic boom					
Super Heavy static fire test						
Super Heavy landing[1]	74	8,854	4,346	56	47	36
Starship landing	13,388	0	0	0	0	0

Notes: > = greater than; ASEL = A-weighted sound exposure level; LC = Launch Complex; psf = pounds per square foot.

[1]Super Heavy landing at 40 degrees was used as the representative landing, as it would expose the greatest amount of rufa red knot proposed critical habitat to the highest overpressure levels.

Overwintering red knots have been documented in the Action Area, and specifically at KSC, MINWR, and CCSFS. Although individuals present at the time of static fire tests, launches, or landings could be disturbed by noise, vibrations, lighting, and/or sonic booms depending on their proximity to these activities, any temporarily alterations in feeding and sheltering would not significantly disrupt normal red knot behavioral patterns. Red knot foraging habitat is present near the launch area, but the probability that an individual red knot would be present close enough to the pad at the time of a launch event to be affected by the plume is low. Overall effects to red knots from the Proposed Action would be considered discountable Thus, NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the rufa red knot.

5.3.9 Seabirds in the Atlantic

Foraging individuals could be exposed to and subsequently startled by launch, static fire, and landing activities at LC-39A, or ocean landings and expenditures associated with Atlantic landings and expenditures (Figure 5-14). If foraging within the 100 dB ASEL/1 psf contour around LC-39A, the black-capped petrel, Bermuda petrel, and roseate tern may be exposed to noise, sonic booms, and light from launch, static fire, and landing activities. However, these species typically remain over 20 miles offshore, so such effects would be discountable.

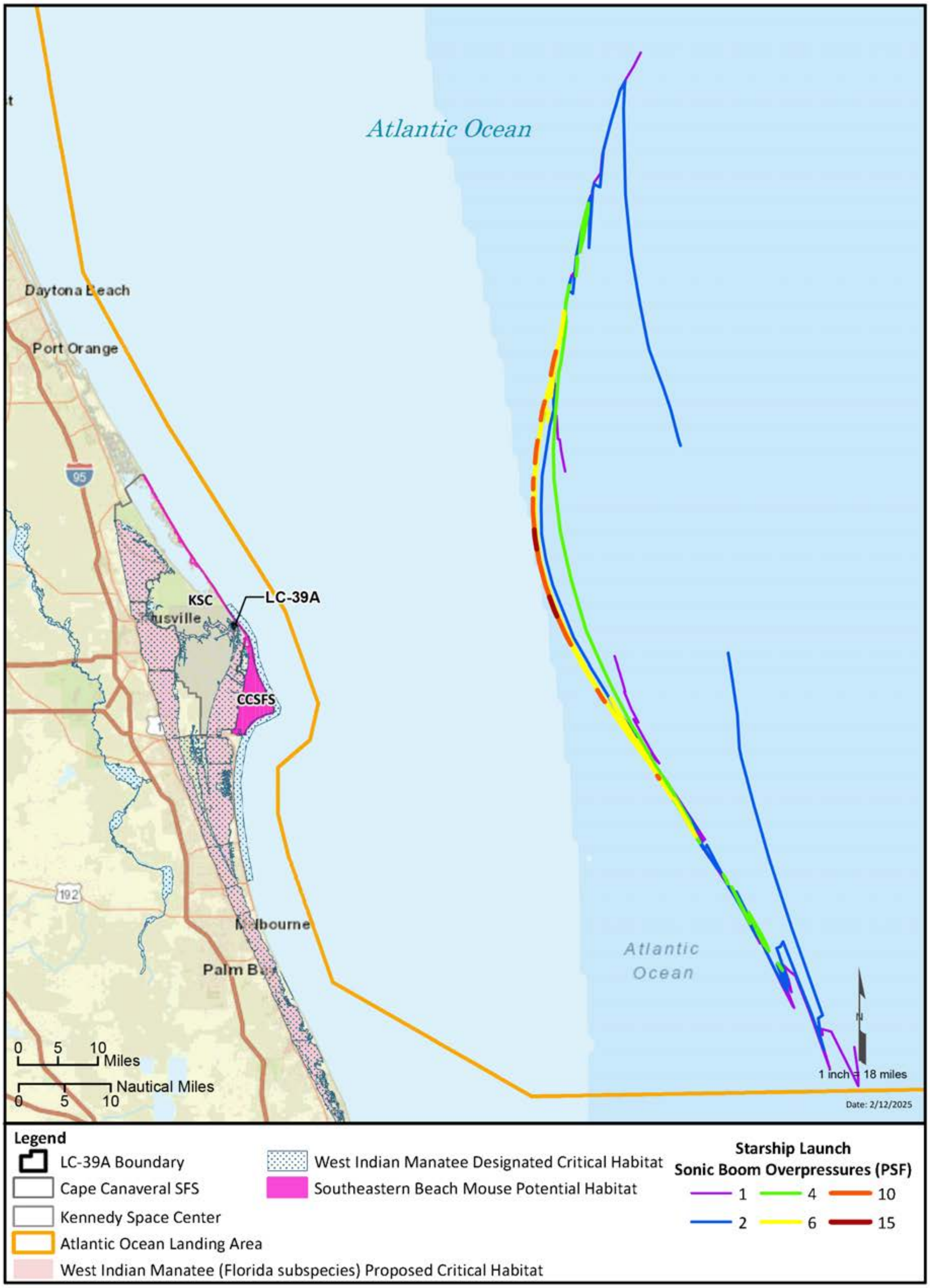


Figure 5-14. Atlantic Ocean Landing Area in Relation to Launch (Nominal Heading) Sonic Boom Overpressure Contours

Petrels have been shown to be attracted to lights on ships and platforms at sea as they forage at night (Troy et al., 2013), and any attraction toward platforms or ships where a rocket is to land could increase the chance of the birds being injured from the heat/vapor plume. However, the number of birds attracted to the light is expected to be low, given the distance that the platform or ship is to be stationed offshore and the fact that most observed fallout from light occurs on land, near populated areas (Troy et al., 2013). During the day, it is not expected that the lights would have any effect on seabirds; however, birds may still forage or rest on or around ships or platforms, as they are known to do around offshore oil and gas platforms (Rodriguez et al., 2019). It is not expected that the landing noise or overpressure would affect seabirds, as they would flush from the area as the vehicle lands and continue to forage elsewhere.

The open ocean around the landing platform or droneship would be exposed to heat and vapor plumes. As a landing is initiated, any birds that are resting on the platform or foraging around the platform could be exposed to the heat and vapor plume created by the landing. However, the birds would be expected to flush in advance of the heat and vapor plume, avoiding physical injury. As seabirds that are adapted to flying long distances, these species would not be expected to encounter any long-term adverse effects induced by infrequent flushing from the landings. It is also not expected that there would be a high density of birds resting or foraging around the landing platform or droneship, due to the distance from their breeding areas.

Expended vehicles may involve explosions that scatter debris or release hazardous materials. Responses to such events may include activities to retrieve debris or contain and remediate spills, which could temporarily disturb foraging. However, it is not expected that landings in the Atlantic landing zone would result in such events; thus, the potential for impacts from hazardous materials or debris to seabirds is discountable.

The black-capped petrel, Bermuda petrel, and roseate tern have been documented in the Atlantic Landings Area. Although individuals present at the time of static fire tests, launches, and landings could be disturbed by noise, lighting, and sonic booms (launches and landings only) depending on their proximity to these activities, any temporary alterations in feeding and sheltering would not significantly disrupt normal behavioral patterns. Additionally, the probability that an individual bird would be present close enough to the droneship or area where a vehicle was expended at the time of landing to be affected by the plume or any hazardous materials or debris is low. Overall effects to seabirds from the Proposed Action would be considered discountable. Thus, NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the black-capped petrel, Bermuda petrel, and roseate tern.

5.3.10 Seabirds in the Pacific

Band-rumped storm-petrels, Hawaiian petrels, Newell' shearwaters, and short-tailed albatrosses foraging in the Pacific landing areas could be exposed and subsequently startled by landings and other activities associated with Starship expenditures. As with seabirds in the Atlantic (Section 5.3.9, *Seabirds in the Atlantic*), the number of birds attracted to the boat lighting is expected to be low, given the distance that the platform or ship is to be stationed from the Hawaiian Islands and the fact that most observed fallout from light occurs on land, near populated areas (Troy et al., 2013). During the day, it is not expected that the lights would have any effect on seabirds; however, birds may still forage or rest on or around ships or platforms. It is not expected that the landing noise or overpressure would affect seabirds, as they would flush from the area as the vehicle lands and continue to forage elsewhere.

As a landing is initiated, any birds that are foraging platforming the area could be exposed to the heat and vapor plume created by the landing. However, the birds would be expected to flush in advance of the heat and vapor plume, avoiding physical injury. As discussed in Section 5.3.9**,** *Seabirds in the Atlantic*, there is unlikely to be a high density of birds resting or foraging due to the distance from land, where a vast majority of these birds nest and roost. Thus, flushings due to landings would be infrequent and impacts would be discountable.

Expended vehicles may involve explosions that scatter debris or release hazardous materials. Responses to such events may include activities to retrieve debris or contain and remediate spills, which could temporarily disturb foraging. However, it is not expected that landings in the Pacific landing zone would result in such events; thus, the potential for impacts from hazardous materials or debris to seabirds is discountable.

The band-rumped storm-petrel, Hawaiian petrel, Newell's shearwater, and short-tailed albatross have been documented in the Pacific Landings Area. Although individuals present at the time of landings could be disturbed by noise, lighting, and sonic booms depending on their proximity to these activities, any temporary alterations in feeding and sheltering would not significantly disrupt normal behavioral patterns. Additionally, the probability that an individual bird would be present close enough to the area where a vehicle was expended to be affected by the plume or any hazardous materials or debris is low. Overall effects to seabirds from the Proposed Action would be considered discountable. Thus, NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the band-rumped storm-petrel, Hawaiian petrel, Newell's shearwater, and short-tailed albatross.

5.3.11 Wood Stork

No wood stork colonies are present within the Action Area, but wood stork foraging habitat is present within portions of the Action Area to the west and south of KSC, approximately 5 miles from LC-39A, as well as areas within the 1 psf contour for the Starship Atlantic Contingency landing area. Due to the distance from foraging habitat, construction activities, lighting, vibrations, and plumes at LC-39A are not likely to impact wood storks, but noise and sonic booms from operations may temporarily disturb or displace wood storks, interrupting roosting and reducing foraging efficiency for brief periods of time (Figure 5-13).

Suitable foraging habitat for the wood stork is present within the Action Area. Although individuals present at the time of static fire tests, launches, or landings could be disturbed by noise and/or sonic booms depending on their proximity to these activities, any temporary alterations in feeding and sheltering would not significantly disrupt normal wood stork behavioral patterns. The closest documented foraging habitat is over 5 miles from the launch site, and the probability that an individual stork would be present close enough to the pad at the time of a launch event to be affected by the plume, vibrations, or lighting is low. Overall effects to wood storks from the Proposed Action would be considered insignificant and discountable. NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the wood stork.

5.3.12 Monarch Butterfly

The monarch butterfly may be exposed to heat, lighting, human presence, and vibration impacts from the Proposed Action, and a small area of potential low-quality habitat may be degraded due to exposure to the heat and vapor plume. However, the preferred habitat of monarch butterflies includes areas with milkweed, which would not be common in the habitat types at and around LC-39A where construction and the plume may have effects (0.2-mile radius around the launch pad). The probability that a monarch butterfly would be present within the plume and be affected by elevated temperatures during a launch is very low; such effects are considered discountable. Potential lighting and vibration effects to butterflies are unknown, but activity in their proximity may cause them to move to other areas for feeding, breeding, or sheltering. Such movements would not significantly disrupt normal monarch behavioral patterns.

The monarch butterfly is present within the Action Area and has been documented at KSC. Although individuals present at the time of static fire tests, launches, or landings could be disturbed by activity, vibrations, or lighting, depending on their proximity, any temporary alterations in feeding and sheltering would not significantly disrupt normal monarch behavioral patterns. The probability that a monarch would be present close enough to the pad at the time of a launch event to be affected by the plume is low. Overall effects to monarchs from the Proposed Action would be considered insignificant and discountable. NASA has made the determination of **not likely to jeopardize** for the Proposed Action with respect to the proposed monarch butterfly.

5.3.13 Anastasia Island Beach Mouse

Suitable habitat for the Anastasia Island beach mouse is present only within a portion of the Starship Atlantic Contingency landings 1 psf contour. This species is not present within the portion of the Action Area affected by construction or operations at and around LC-39A, so there would be no effects from plumes, strikes, vegetation damage, or lighting. Due to the infrequent nature of contingency landings and the large area over which they may occur (100 miles of coastline), there is only a small probability of this species being exposed to overpressures of approximately 1 psf from Starship Atlantic Contingency landings.

Any exposed individuals may temporarily alter feeding, breeding, or sheltering, but would not suffer significant disruption in normal behavioral patterns. Effects to these beach mice from the Proposed Action are extremely unlikely to occur and are considered discountable. NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the Anastasia Island beach mouse.

5.3.14 Florida Bonneted Bat

Florida bonneted bats are not present within the portion of the Action Area affected by construction or operations at and around LC-39A. Due to the infrequent nature of contingency landings and the large area over which they may occur (100 miles of coastline), there is only a small probability of this species being exposed to overpressures of approximately 1 psf from Starship Atlantic Contingency landings.

Suitable habitat for the Florida bonneted bat is present only near the edge of the Starship Atlantic Contingency landings 1 psf contour. Any exposed individuals may temporarily alter feeding, breeding, or sheltering, but would not suffer significant disruption in normal behavioral patterns. Effects to these bats from the Proposed Action are extremely unlikely to occur and are considered discountable. NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the Florida bonneted bat.

5.3.15 Southeastern Beach Mouse

Any southeastern beach mice in proximity to LC-39A may be subjected to noise, vibrations, lighting, and human presence associated with construction activities. All construction activities will be limited to within the LC-39A fence line, which is approximately 0.2 miles from the nearest southeastern beach mouse habitat (Figure 5-15). The southeastern beach mouse has not been documented within the boundaries of LC-39A through biological surveys. Any beach mice present would be susceptible to injury and mortality through crushing by construction equipment. Construction projects with the potential to affect protected species require biological surveys prior to disturbance. If southeastern beach mice or their burrows were observed during these surveys, NASA would contact the USFWS to determine if relocations are needed based on site conditions. Trapping would occur over three consecutive nights and a total of five nights using Sherman live traps set at 33-foot (10-meter) intervals throughout the vegetated portion of the proposed area to be disturbed by construction activities. Mice would be relocated to the dune east of LC-39A.

Although this would decrease the potential for physical impacts, relocation may lead to increased densities in already occupied habitat that could affect breeding, feeding, and sheltering opportunities. Construction would occur primarily during daylight hours when the nocturnal southeastern beach mouse is typically resting within its burrow, which would provide a degree of protection from these disturbances. However, an unknown amount of noise and vibrations could reach the southeastern beach mouse in its burrow, disrupting sleep and other activities such as caring for young. For any construction that continued after dusk, associated lighting, noise, and vibrations could disrupt southeastern beach mouse foraging behaviors and increase their exposure to predators.

With the combination of the fencing around LC-39A, the developed condition of most of the site, and the general noise associated with construction and daily operations, it is unlikely that the southeastern beach mouse would occur within any of the construction areas. They are more likely to be encountered on roads leading to LC-39A. Environmental training provided to all LC-39A personnel and contractors would include photos of the federally listed species that may be seen in the Action Area, as well as instructions to allow these animals to move away from the road or area before resuming activities. Section 1.7, *Conservation Measures*, discusses the measures that would minimize the chance of vehicle collisions with federally listed species.

The closest southeastern beach mouse habitat to the launch and landing pads is 0.2 miles and 0.4 miles, respectively, to the northeast (Table 5-4). By the time plumes associated with launches, static fire tests, and landings reach southeastern beach mouse habitat, they will have returned to ambient temperature (Figure 5-15). Potential effects to the southeastern beach mouse from the plumes would be discountable.

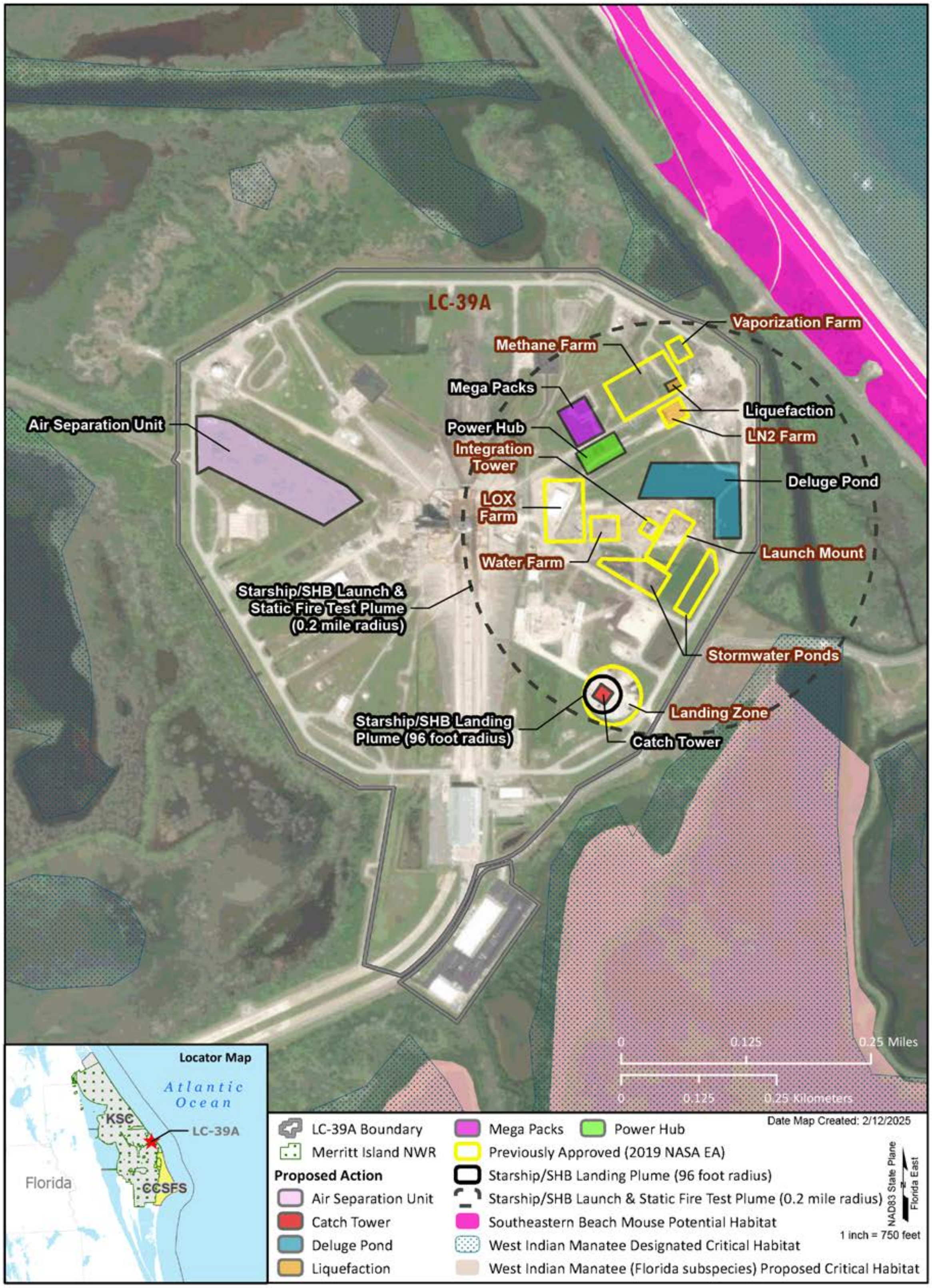


Figure 5-15. Southeastern Beach Mouse and Manatee Habitat in Relation to Construction Areas and Launch and Landing Plumes

During launches, southeastern beach mouse habitat at KSC, MINWR, CANA, and CCSFS would be exposed to noise levels of up to 150 dB (Figure 5-16 through Figure 5-22). Table 5-9 provides acreages of potential southeastern beach mouse habitat exposed to various noise levels. During Super Heavy landings, most southeastern beach mouse habitat at KSC, MINWR, CANA, and CCSFS would be exposed to sonic boom overpressures of at least 1 psf, with some southeastern beach mouse habitat exposed to overpressures over 20 psf (Figure 5-14 through Figure 5-26). Table 5-10 presents the acreages of southeastern beach mouse habitat that would be exposed to various levels of overpressure during landings at LC-39A.

Table 5-9. Southeastern Beach Mouse Potential Habitat at KSC, MINWR, CANA, and CCSFS Exposed to Greater than 100 dB ASEL from the Proposed Action at LC-39A

Events at LC-39A	Acres affected[1]						
	100-110 dB ASEL	110-115 dB ASEL	115-120 dB ASEL	120-130 dB ASEL	130-140 dB ASEL	140-150 dB ASEL	>150 dB ASEL
Starship-Super Heavy launch	12,282	2,193	583	486	96	46	2
Starship static fire test	273	41	20	23	26	3	0
Super Heavy static fire test	594	128	44	34	21	22	0
Super Heavy landing[2]	2,259	295	165	102	49	0	0
Starship landing	356	55	30	48	2	0	0

Notes: > = greater than; ASEL = A-weighted sound exposure level; BCA = Biological and Conference Assessment; CANA = Canaveral National Seashore; CCSFS = Cape Canaveral Space Force Station; dB =decibels; KSC = Kennedy Space Center; LC = Launch Complex; MINWR = Merritt Island National Wildlife Refuge.

[1]Data for potential southeastern beach mouse habitat outside of KSC, MINWR, CANA, and CCSFS was not available at the time of BCA development.

[2]Super Heavy landing at 115 degrees was used as the representative landing, as it would expose the greatest amount of southeastern beach mouse habitat to the highest ASELs.

Table 5-10. Southeastern Beach Mouse Potential Habitat at KSC, MINWR, CANA, and CCSFS Exposed to Greater than 1 psf Overpressure from the Proposed Action at LC-39A

Events at LC-39A	Acres affected[1]					
	1-2 psf	2-4 psf	4-6 psf	6-10 psf	10-20 psf	>20 psf
Starship-Super Heavy launch	Sonic boom over the Atlantic Ocean does not affect land					
Starship static fire test	No sonic boom					
Super Heavy static fire test						
Super Heavy landing[2]	76	325	6,843	6,948	1,244	137
Starship landing	15,655	0	0	0	0	0

Notes: > = greater than; BCA = Biological and Conference Assessment; CANA = Canaveral National Seashore; CCSFS = Cape Canaveral Space Force Station; KSC = Kennedy Space Center; LC = Launch Complex; MINWR = Merritt Island National Wildlife Refuge; psf = pounds per square foot.

[1]Data for potential southeastern beach mouse habitat outside of KSC, MINWR, CANA, and CCSFS was not available at the time of BCA development.

[2]Super Heavy landing at 115 degrees was used as the representative landing, as it would expose the greatest amount of southeastern beach mouse habitat to the highest overpressure levels.

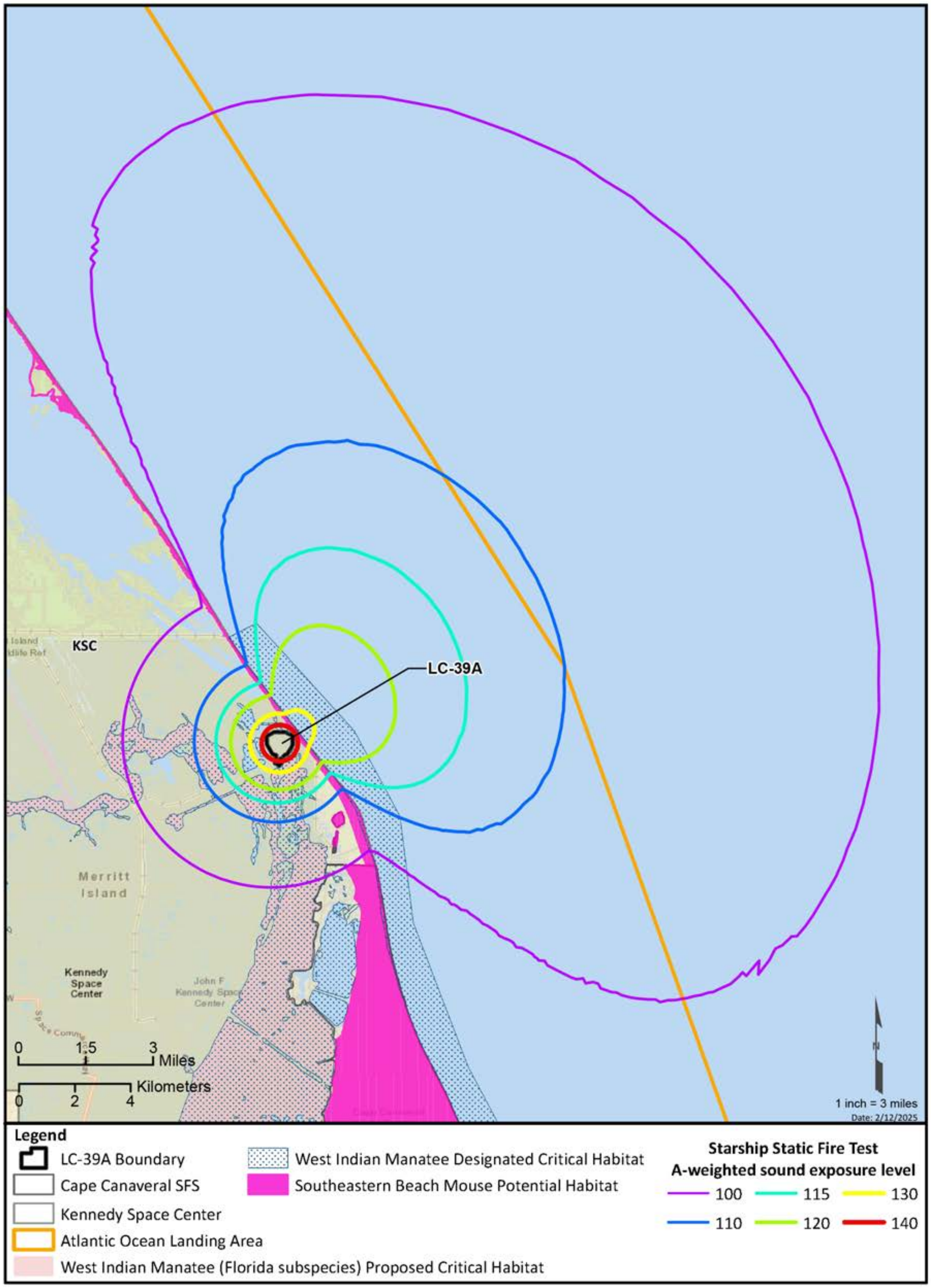


Figure 5-16. Southeastern Beach Mouse and Manatee Habitat in Relation to Starship Static Fire Test Noise Contours (ASEL)

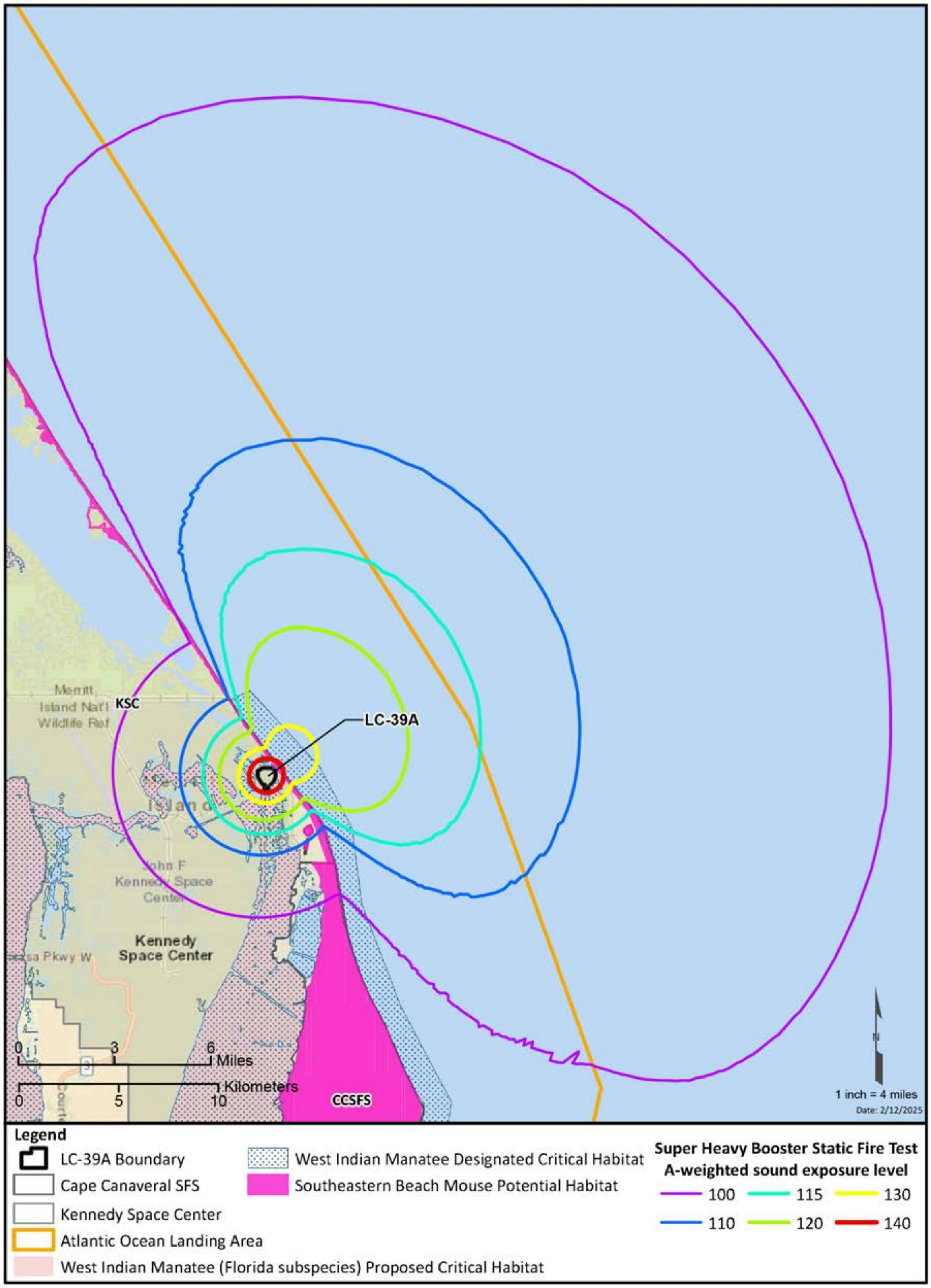


Figure 5-17. Southeastern Beach Mouse and Manatee Habitat in Relation to Super Heavy Static Fire Test Noise Contours (ASEL)

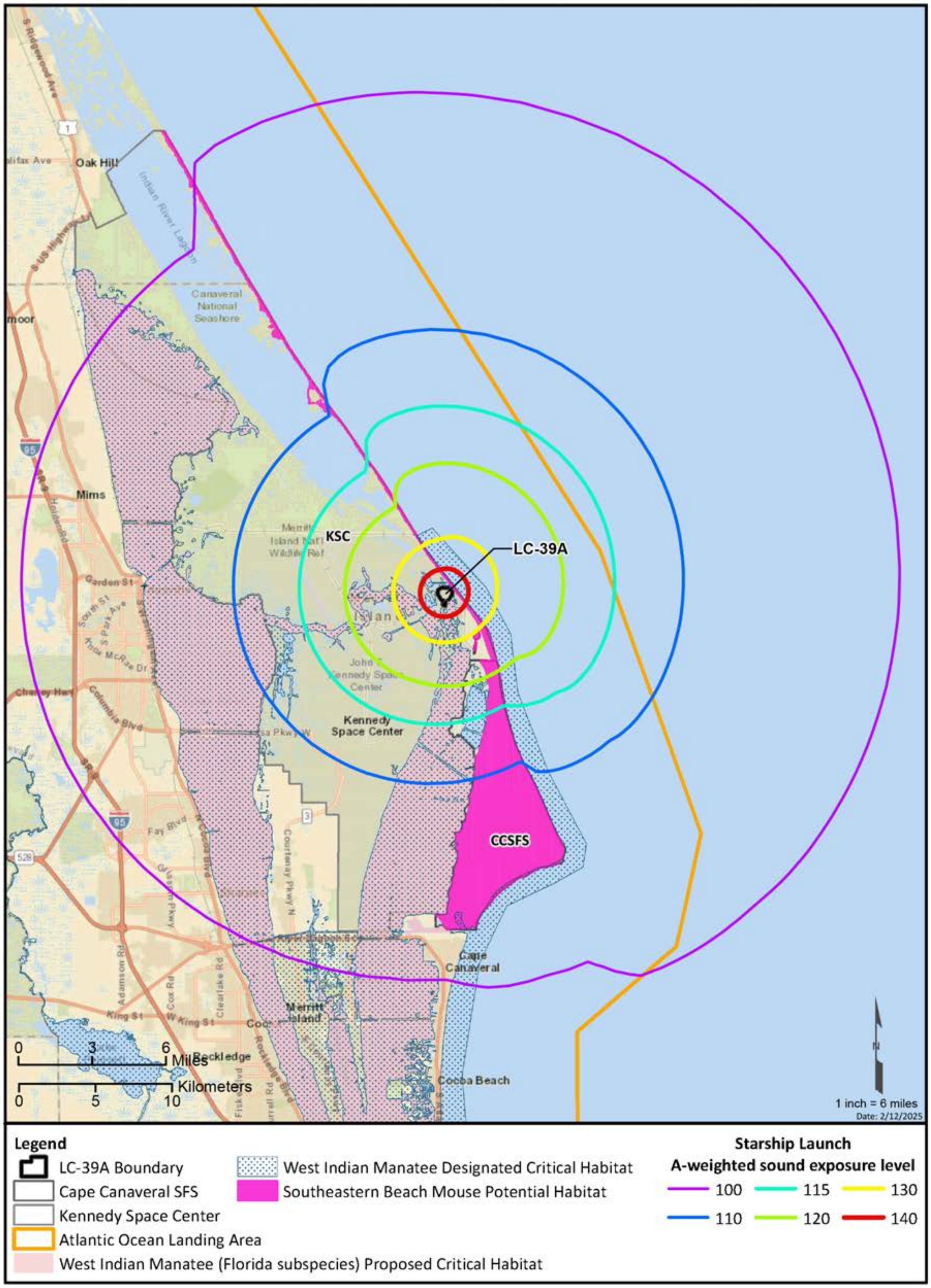


Figure 5-18. Southeastern Beach Mouse and Manatee Habitat in Relation to Launch(Nominal Heading) Noise Contours (ASEL)

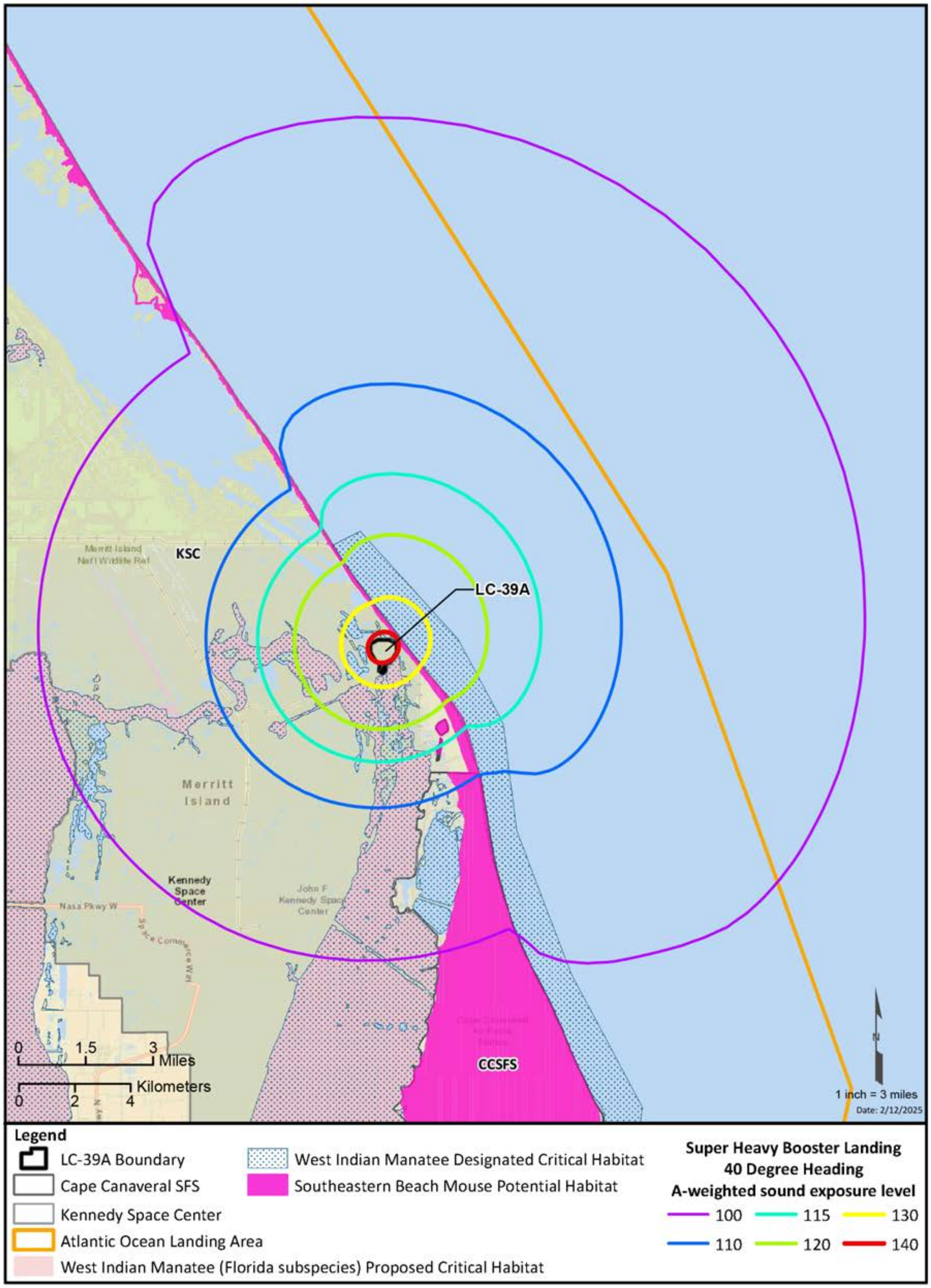


Figure 5-19. Southeastern Beach Mouse and Manatee Habitat in Relation to Super Heavy Landing (40 Degree Heading) Noise Contours (ASEL)

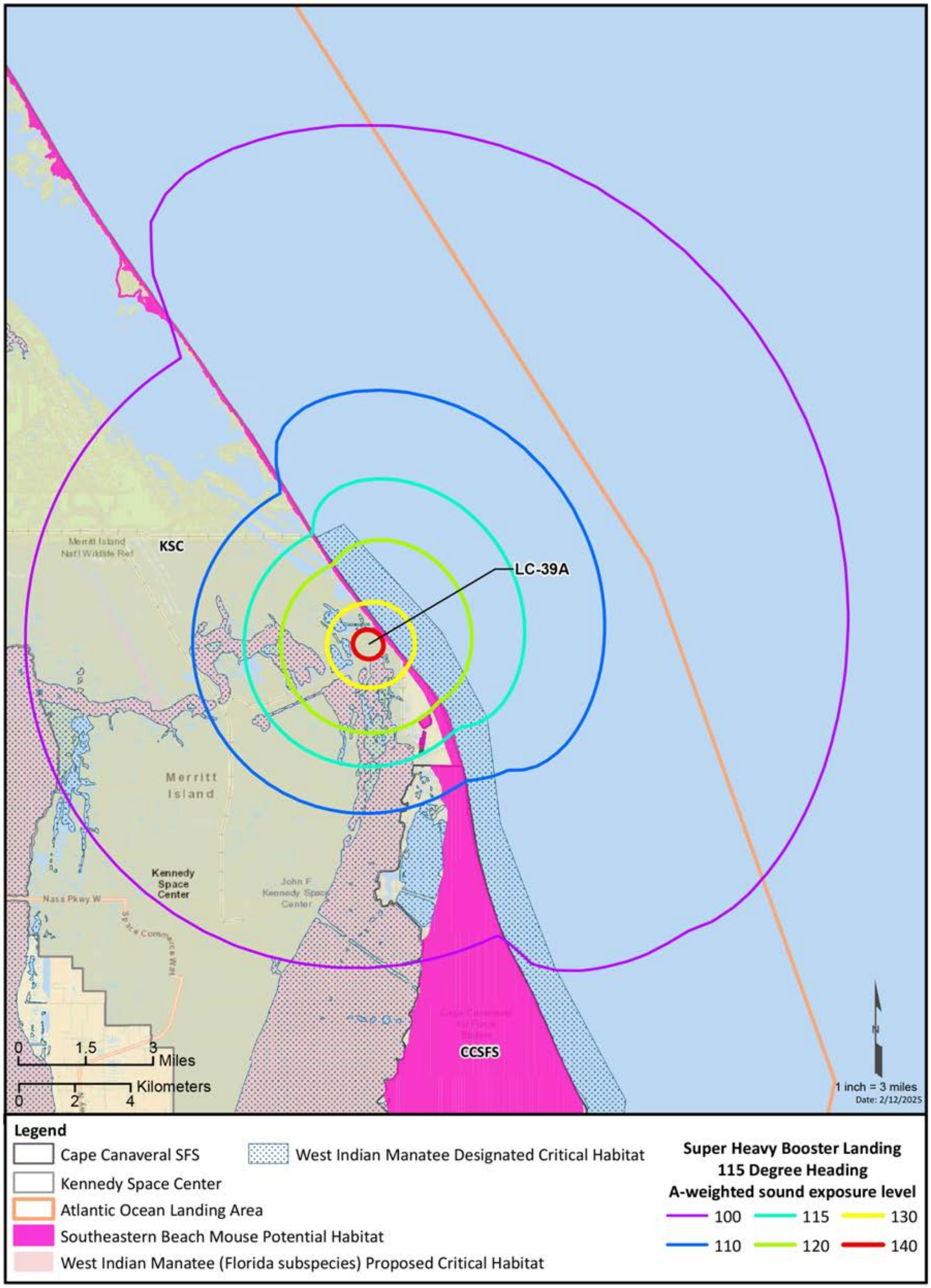


Figure 5-20. Southeastern Beach Mouse and Manatee Habitat in Relation to Super Heavy Landing (115 Degree Heading) Noise Contours (ASEL)

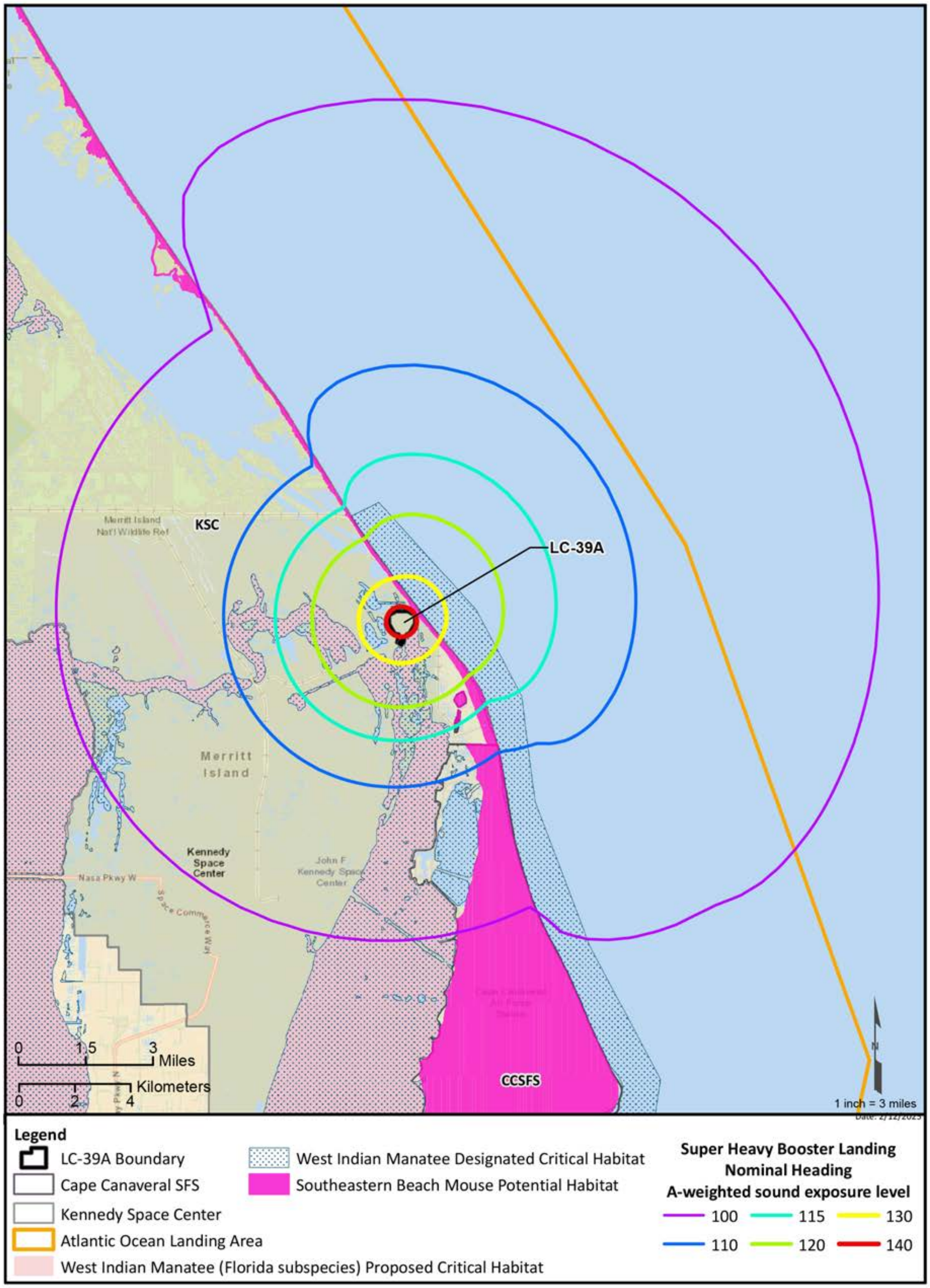


Figure 5-21. Southeastern Beach Mouse and Manatee Habitat in Relation to Super Heavy Landing (Nominal Heading) Noise Contours (ASEL)

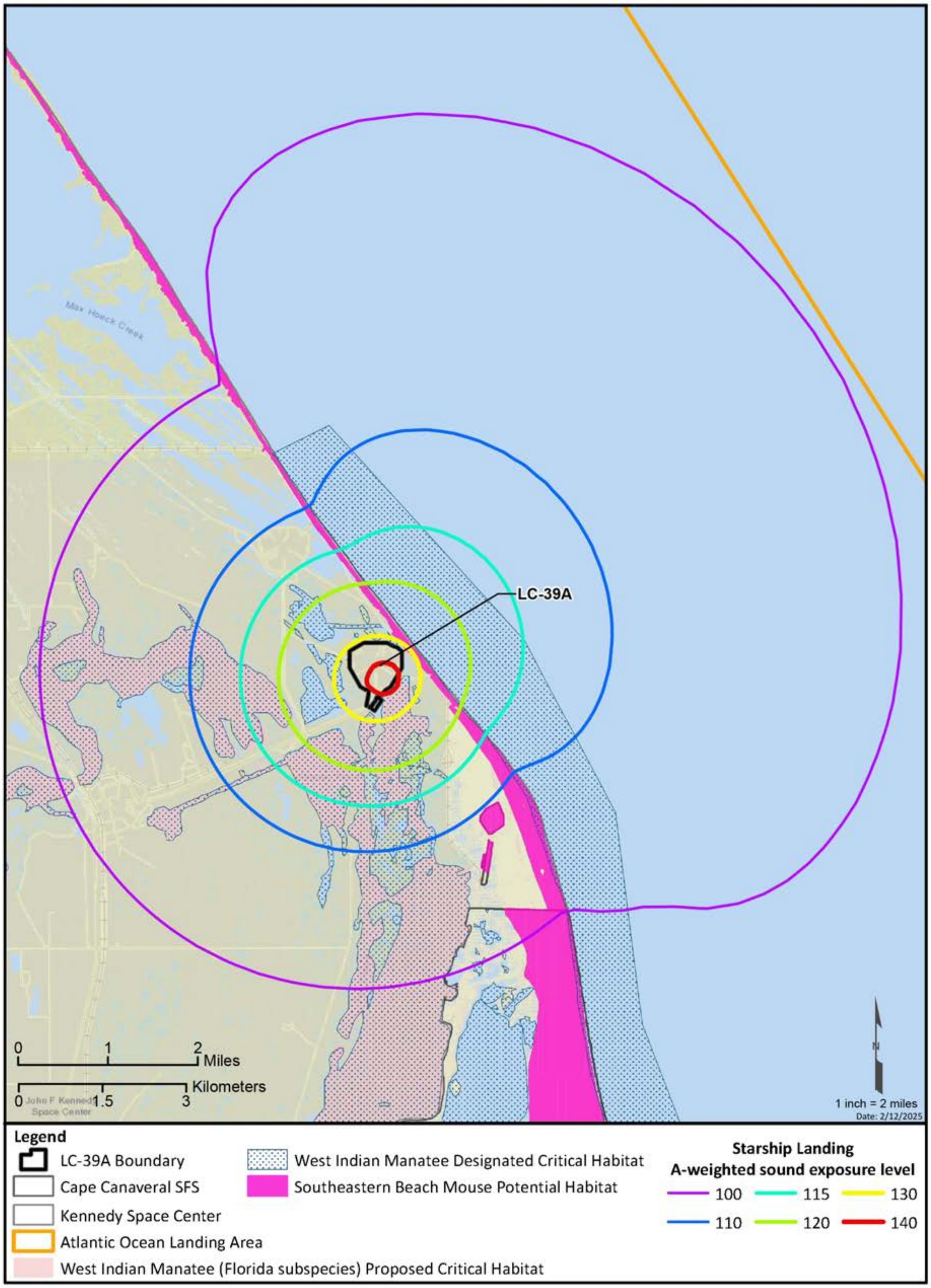


Figure 5-22. Southeastern Beach Mouse and Manatee Habitat in Relation to Starship Landing (Nominal Heading) Noise Contours (ASEL)

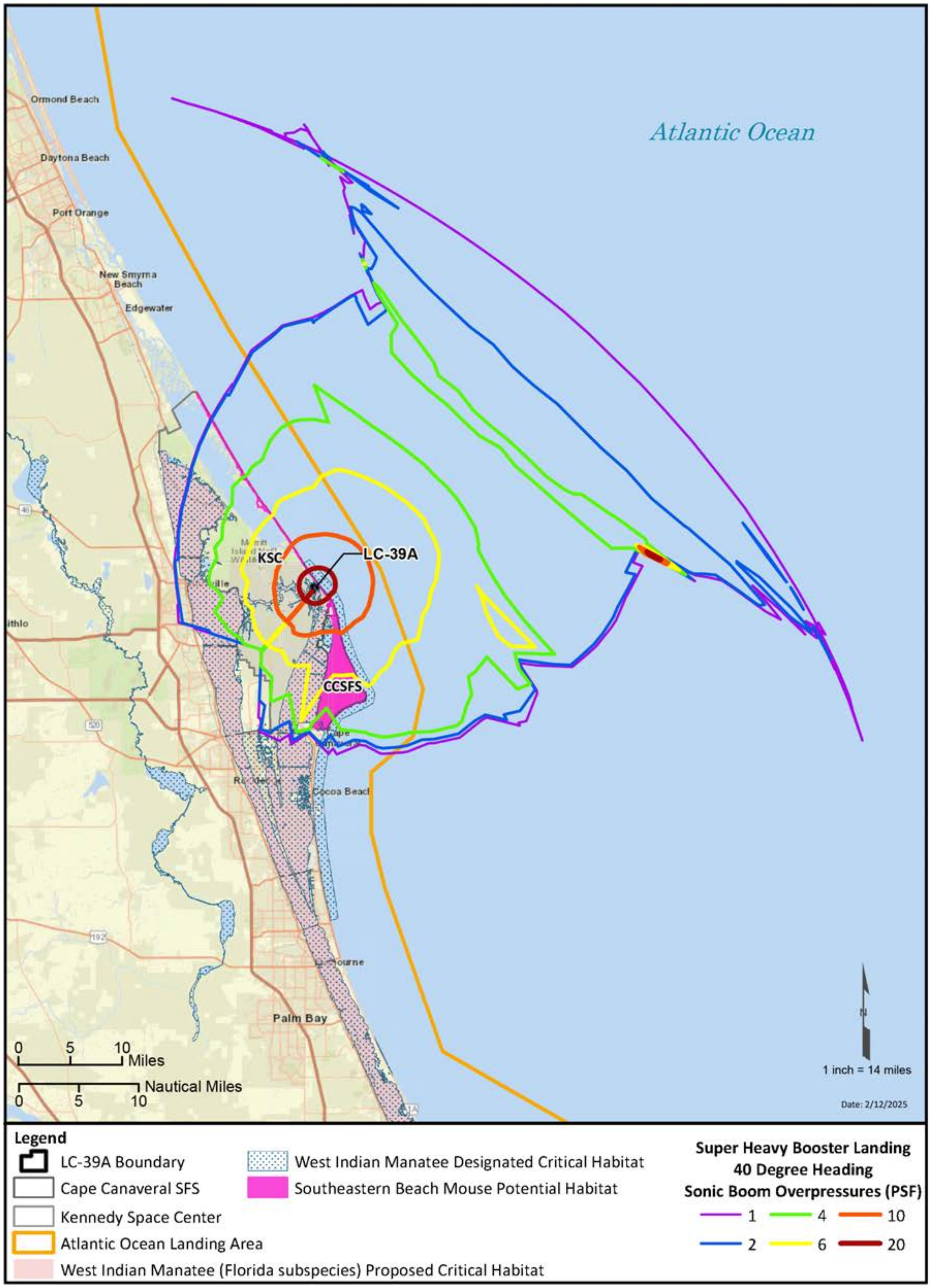


Figure 5-23. Southeastern Beach Mouse and Manatee Habitat in Relation to Super Heavy Landing (40 Degree Heading) Sonic Boom Overpressure Contours

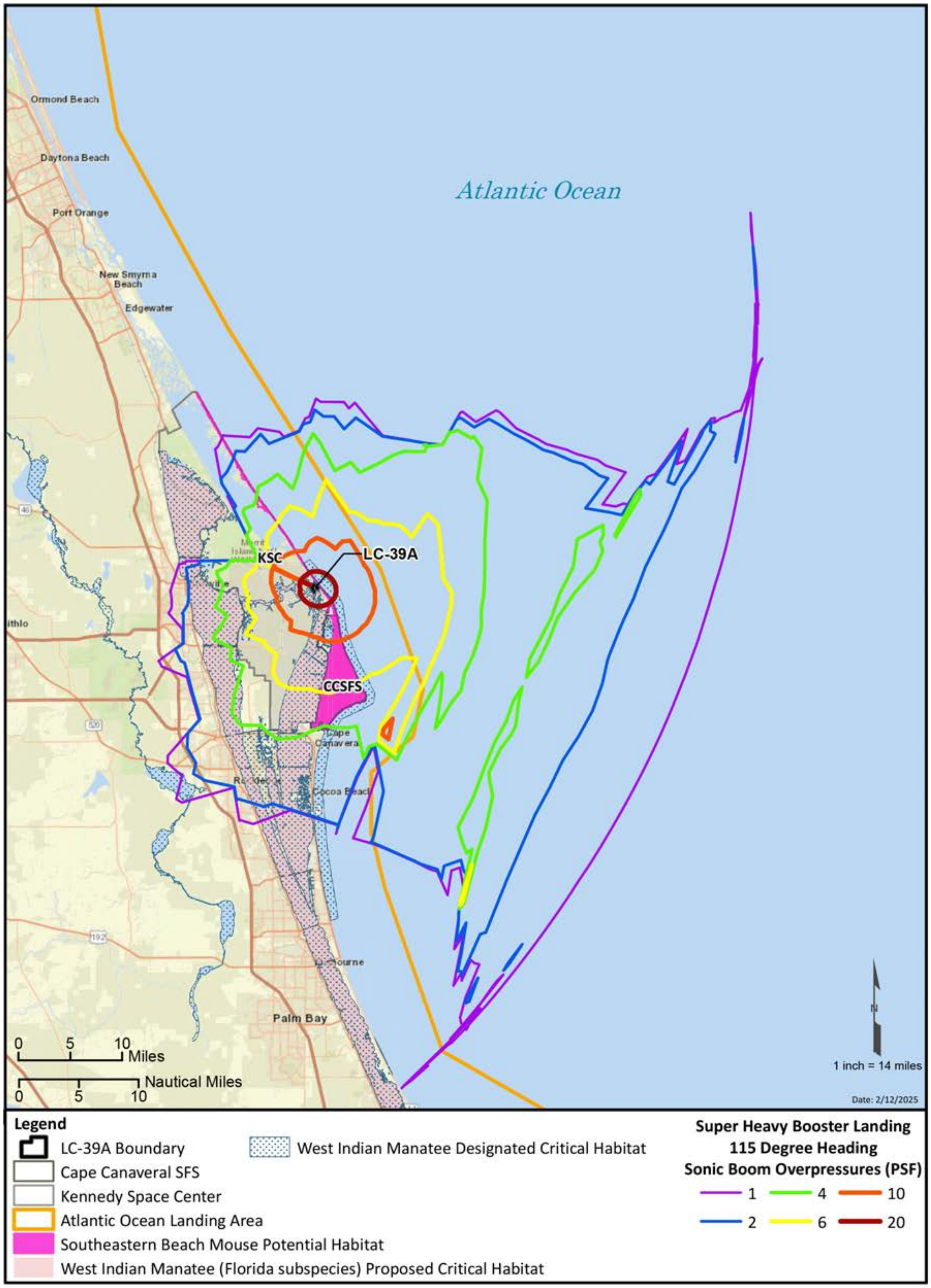


Figure 5-24. Southeastern Beach Mouse and Manatee Habitat in Relation to Super Heavy Landing (115 Degree Heading) Sonic Boom Overpressure Contours

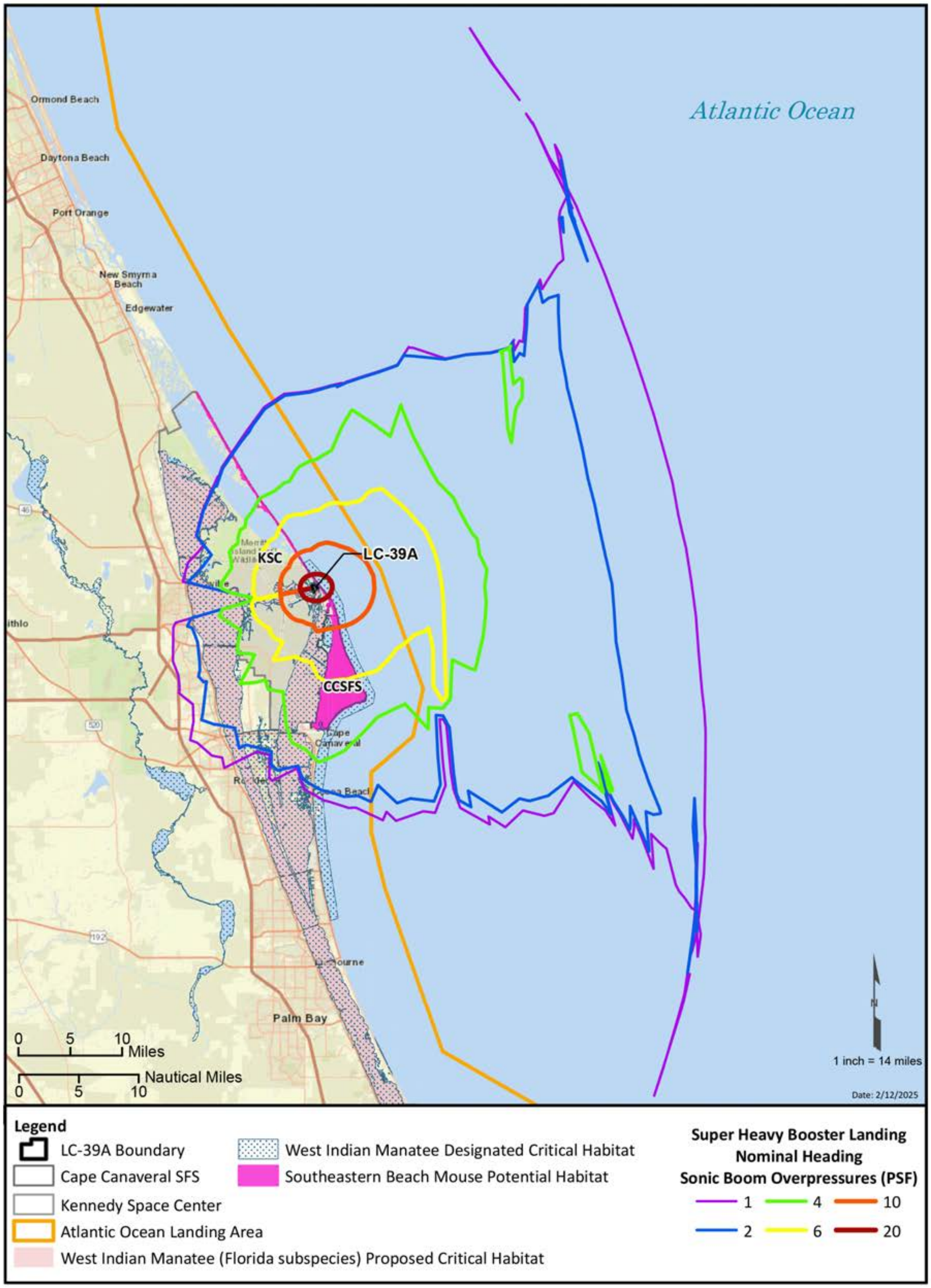


Figure 5-25. Southeastern Beach Mouse and Manatee Habitat in Relation to Super Heavy Landing (Nominal Heading) Sonic Boom Overpressure Contours

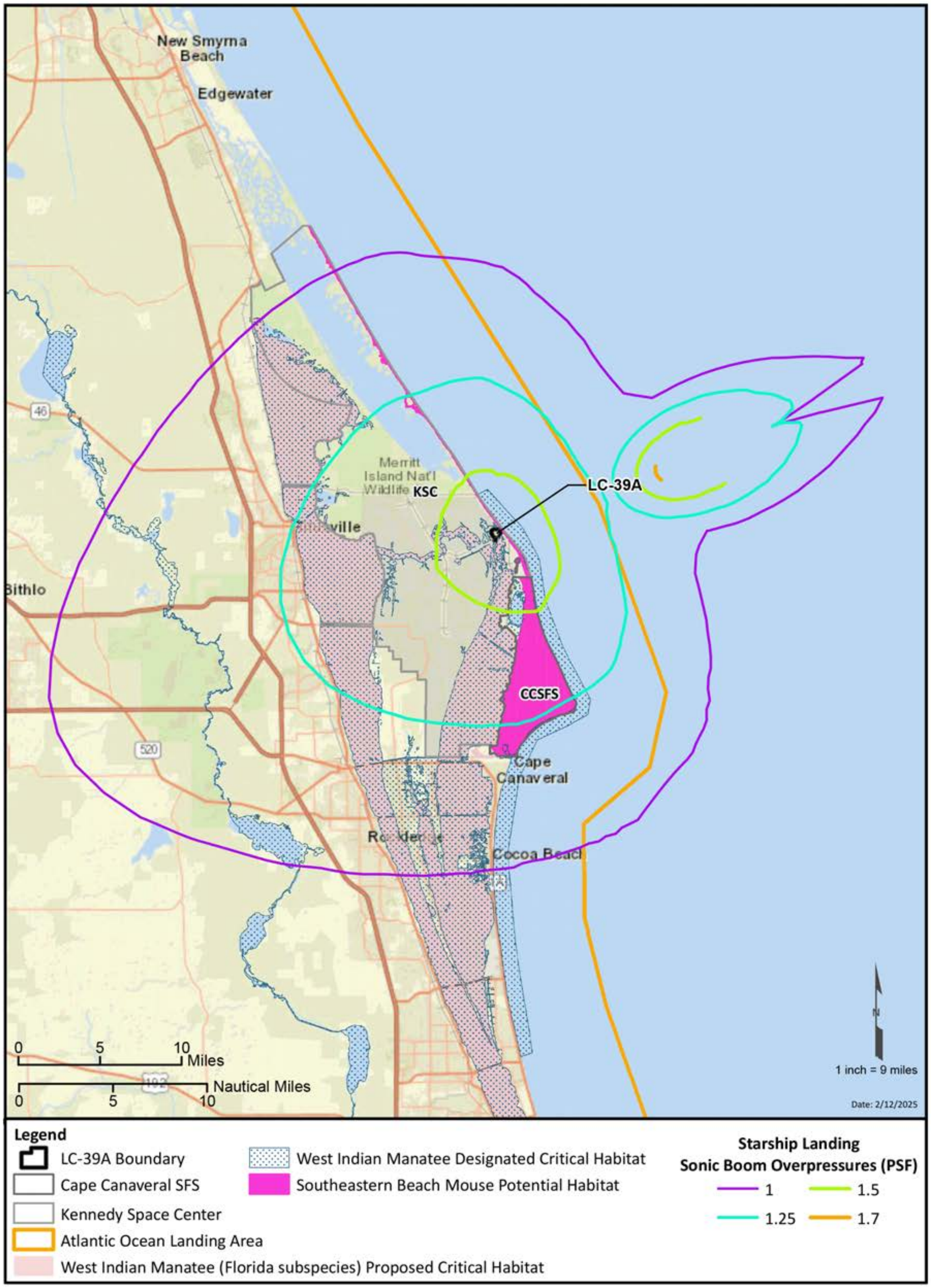


Figure 5-26. Southeastern Beach Mouse and Manatee Habitat in Relation to Starship Landing (Nominal Heading) Sonic Boom Overpressure Contours

Noise, sonic booms, vibration, and lighting associated with operations are likely to disturb or displace the southeastern beach mouse, and in some cases may make them more vulnerable to predation. In addition, mice in general (particularly pregnant mice) may be physiologically affected by substrate vibration (Carman et al., 2008; Reynolds et al., 2018). Although retreat to their burrows may reduce exposure to most stressors, such retreat may reduce breeding success, foraging efficiency, and rest and feeding time, particularly when the disturbances are at night, since the southeastern beach mouse is nocturnal.

As stated in Appendix A, *Summary of Available Literature Regarding the Effects of Noise Exposure on Rodents*, of the 2024 *Biological Assessment for the Reactivation of Space Launch Complex 14 at Cape Canaveral Space Force Station, FL,* studies focused on noise stimuli and southeastern beach mice are absent from the scientific literature, so studies on other rodent species must be used as surrogates. Short duration, episodic, high-intensity sound exposure studies are largely lacking, particularly with field studies that evaluated behavioral responses in rodents. In one study, rats exposed to 104 dB showed evidence of change in the area of the brain where much of the processing of auditory information occurs (Szczepaniak & Møller, 1996). Stimulation of this part of the brain is associated with tinnitus (i.e., ringing sound). Tinnitus could potentially cause an increased susceptibility to predation, as hearing is generally important for small mammal predator avoidance. In another study, rats exposed to noise at 104 dB showed evidence of altered response in a certain type of neuron (Goble et al., 2009). Mice exposed to noise of 123 dB in a laboratory setting experienced hearing loss and impaired spatial learning and memory (Liu et al., 2016).

There are currently no existing studies on the effects of substrate vibration and burrow collapse for the southeastern beach mouse specifically. One vibration study for the San Bernardino kangaroo rat (*Dipodomys merriami parvus*) involved constructing artificial burrows 5 to 10 feet from haul roads and measuring sand and soil collapse into the burrows. The study found that vibrations induced by truck haul traffic do not pose risks to the stability of San Bernardino kangaroo rat burrows at distances of 5 to 10 feet from the edge of the road (Barneich, 2004). Studies related to oil and gas exploration have documented burrow collapse for kangaroo rats and pygmy rabbits as a result of vibrations (Wilson, 2011; Cypher et al., 2012). It is expected that southeastern beach mice inhabiting areas near the launch and landing pads may be exposed to vibrations produced by launch, static fire, and landing activities and that burrow collapse is possible from the vibrations, although the potential for collapse is unknown. The nearest southeastern beach mouse potential habitat is shown in Figure 5-15. The effect of burrow collapse on southeastern beach mouse may range from a minor energetic cost in rebuilding the burrow to increased exposure to avian predators to loss of individuals if young are buried below the soil.

Exact density estimates are not available for the southeastern beach mouse, but Traylor-Holzer and Lacy (2025) calculated density estimates in the Action Area to be 1.2 mice per acre in inland habitat and 3.6 mice per acre in dune habitat. The estimates in Table 5-11 were calculated using this density range and the modelled acreages affected by up to 100 dB ASEL and 1 psf from static fire tests, launches, and landings (Table 5-9 and Table 5-10).

Table 5-11. Estimated Numbers of Southeastern Beach Mice at KSC, MINWR, CANA, and CCSFS Potentially Exposed to Greater than 1 psf Overpressure and/or 100 dB ASEL from Proposed Action

Events at LC-39A	Exposed to >1 psf (# beach mice)	Exposed to >100 dB ASEL (# beach mice)	Maximum Annual Number of Potential Exposures
Starship-Super Heavy launch	NA	18,825 to 56,477	44
Starship static fire test	NA	463 to 1,390	44

Table 5-11. Estimated Numbers of Southeastern Beach Mice at KSC, MINWR, CANA, and CCSFS Potentially Exposed to Greater than 1 psf Overpressure and/or 100 dB ASEL from Proposed Action

Events at LC-39A	Exposed to >1 psf (# beach mice)	Exposed to >100 dB ASEL (# beach mice)	Maximum Annual Number of Potential Exposures
Super Heavy static fire test	NA	1,012 to 3,035	44
Super Heavy landing	18,619 to 55,857	3,214 to 9,641	44
Starship landing	18,786 to 56,358	589 to 1,768	44

Notes: > = greater than; # = number; ASEL = A-weighted sound exposure level; CANA = Canaveral National Seashore; CCSFS = Cape Canaveral Space Force Station; dB = decibels; KSC = Kennedy Space Center; LC = Launch Complex; MINWR = Merritt Island National Wildlife Refuge; NA = not applicable, psf = pounds per square foot.

The estimated number of southeastern beach mice potentially exposed to greater than 100 dB ASEL from launches would be between 18,825 and 56,477 mice, up to 44 times a year (Table 5-11). Mice in closer proximity to LC-39A would also experience noise greater than 100 dB ASEL up to 88 times per year from static fire tests and 88 times a year from landings (Table 5-11). Overpressures exceeding 1 psf from landings (up to 88 annually) may affect between 18,619 and 56,358 southeastern beach mice. Mice exposed to the highest noise levels are likely to be the same individuals exposed to the greatest overpressures. These individuals are expected to exhibit varying degrees of alterations in feeding, sheltering, and breeding, and potential abandonment of territories, with resulting reductions in physical condition and reproduction.

Lighting associated with nighttime launches, landings, and static fire tests would be focused on the vehicle or other components within LC-39A, but would also extend into areas that would otherwise be dark. The southeastern beach mouse is a nocturnal species that relies on darkness to forage and avoid predation. Previous research indicates that beach mice tend to shift their behavior and forage less during times of full moon or when exposed to artificial lighting (Bird et al., 2004; Falcy & Danielson, 2013).

Southeastern beach mice have been documented in the Action Area, and specifically at KSC, MINWR, CANA, and CCSFS. Although known southeastern beach mouse habitat is present near the launch area (0.26 miles away), the probability that an individual mouse would be present close enough to the pad at the time of a launch event to be affected by the plume is low; most mice would likely retreat to their burrows due to noise and activity associated with launches. Individuals present at the time of static fire tests, launches, or landings could be disturbed by noise, vibrations, lighting, human presence, and/or sonic booms depending on their proximity to these activities. Lighting from operations may make the nocturnal foraging southeastern beach mouse more vulnerable to predators, resulting in injury or death. Due to the limited extent of their habitats, they may not be able to move to new locations to avoid impacts from construction and operations, so alterations in feeding and sheltering may result in significant disruption to normal behavioral patterns. Thus, NASA has made the determination of **may affect, likely to adversely affect**, for the Proposed Action with respect to the southeastern beach mouse.

5.3.16 Tricolored Bat

No direct effects to tricolored bat habitat from construction or plumes would occur as no suitable habitat for tricolored bats is present at LC-39A or within the 0.2-mile launch plume area. Bats are primarily active between dusk and dawn, thus the potential for noise and sonic boom impacts to affect tricolored bat behaviors, cause stress responses, and mask acoustic signals is greater at night. Most insect-eating bat species in Florida generally forage from near treetop level to within a few feet of the ground surface or water surface, so the insectivorous tricolored bat is not anticipated to occur regularly within the open areas around LC-39A. Additionally, bats tend to avoid lit areas, further reducing the likelihood of tricolored bats occurrence close to the launch area.

Suitable habitat for the tricolored bat is present within the Action Area, and recent surveys on CCSFS have detected tricolored bat calls in some areas. Although individuals present at the time of static fire tests, launches, or landings could be disturbed by noise, vibrations, lighting, and/or sonic booms depending on their proximity to these activities, any temporarily alterations in feeding, breeding, and sheltering would not significantly disrupt normal tricolored bat behavioral patterns. No tricolored bat habitat is present near the launch area, and there is a low probability that an individual tricolored bat would be present at the time of a launch event, so effects to these bats from the Proposed Action are extremely unlikely to occur and are considered discountable. NASA has made the determination of **not likely to jeopardize** for the Proposed Action with respect to the proposed tricolored bat.

5.3.17 West Indian Manatee

LC-39A construction and operational activities would occur approximately 0.1 miles from manatee critical habitat, so runoff from the site is a concern due to potential water quality effects (Figure 5-15). Excess sedimentation or other pollutants could result in physiological effects (e.g., respiration) to species or could destroy or degrade habitats necessary for breeding, foraging, and resting. As is standard practice, construction contractors would implement requirements in construction permits, stormwater permits, and spill prevention plans to prevent such effects. NASA expects that any accidental release of hazardous materials would affect a limited area and that SpaceX's immediate clean-up response would avoid or minimize effects on species and habitat. SpaceX personnel and associated contractors would be required to comply with appropriate hazardous materials handling and management procedures. These measures would prevent erosion and stormwater transport of sediments and hazardous substances into surrounding terrestrial and estuarine habitats. Water deluge will be contained in ponds within the boundaries of LC-39A and will be regularly monitored for harmful substances.

The Starship-Super Heavy launch and landing pads would be located approximately 0.17 miles and 0.13 miles from manatee habitat, respectively, and the launch plume extends over 3.2 acres of manatee habitat southeast of LC-39A. Deluge water would be captured and treated onsite, and the plume would be diverted upwards, so would not affect water temperatures. Per findings presented in the 2024 *Draft Tiered EA for SpaceX Starship/Super Heavy Vehicle Increased Cadence at the SpaceX Boca Chica Launch Site* in *Cameron County, Texas* (FAA, 2024), the amount of metal deposition from the vapor plume is expected to be minimal and monitoring would be conducted to ensure levels do not exceed accepted levels. The likelihood of manatees being present in the small portion of manatee habitat at the edge of the potential plume during the brief period of potential plume effects is low (Figure 5-15).

Sound is primarily transferred from air to water in a narrow cone, and, outside of this area, most sound is reflected off the water's surface; therefore, underwater noise would be detectable in only a small area. Manatees may be exposed to noise and/or overpressure when they surface to breathe or engage in other behaviors such as feeding and resting. The potential for an individual animal to be at the surface at the same time a static fire test, launch, or landing occurred would be low, although the overall probability is increased due to the presence of multiple animals that could surface at different times. Affected animals could startle and react behaviorally. The potential for and degree of reactions would be greatest in estuarine areas adjacent to LC-39A (Figure 5-16 through Figure 5-22). However, launch/landing/test noise duration would be brief (seconds to minutes).

As discussed in the *Programmatic Concurrence Letter for Launch and Reentry Vehicle Operations in the Marine Environment and Starship/Super Heavy Launch Vehicle Operations at SpaceX's Boca Chica Launch Site* (NMFS, 2022), previous research indicates that the sonic boom harassment risk for submerged marine mammals is associated with an overpressure level substantially greater than levels that would be produced during Super Heavy landings (Figure 5-14 through Figure 5-26). Therefore, potential noise and overpressure effects would be limited to animals at and very near the water surface.

There is potential for barges and other boats transiting between Port Canaveral and the Turn Basin to strike manatees (Figure 5-27). However, while there have been injured and dead manatees reported in the KSC portion of the Banana River, NASA is not aware of any boat or barge strikes resulting in serious injury or death being directly attributed to KSC operations. Due to the intermittent nature of use of the Turn Basin, it is difficult to determine a current annual average number of vessels, but the Proposed Action would result in a definite increase in vessel traffic (Table 5-2). Annually, there may be up to 40 more barges carrying supplies/vehicle components and 11 more barges/tugs bringing Starship and Super Heavies back to the Turn Basin. These barges would follow the conservation measures identified in Section 1.7, *Conservation Measures*, including the presence of manatee observers. Potential effects to manatees from barges, surveillance boats (approximately 132 per year), and recreational boats present in the Action Area during a launch event would additionally be minimized by the required speed limits in the IRL.

Manatees have been documented in the Action Area, and specifically around KSC, MINWR, CANA, and CCSFS. At times manatees have been present in the three acres of waters near LC-39A at the furthest potential extent of the plume, but the probability that an individual manatee would be out of the water where it could be affected by the heat is extremely low. Similarly, manatees spend most of their time under water, so the probability of a manatee with its head out of the water such that it would be exposed to high noise levels and a sonic boom would be low. Although individuals present at the time of static fire tests, launches, or landings could be disturbed by noise, vibrations, lighting, and/or sonic booms depending on their proximity to these activities, any temporarily alterations in feeding, breeding, and sheltering would not significantly disrupt normal behavioral patterns. With implementation of conservation measures for barges and boat traffic (e.g., speed limits, observers), strike potential would be minimal. Overall effects to manatees from the Proposed Action would be considered discountable and insignificant. Thus, NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the manatee.

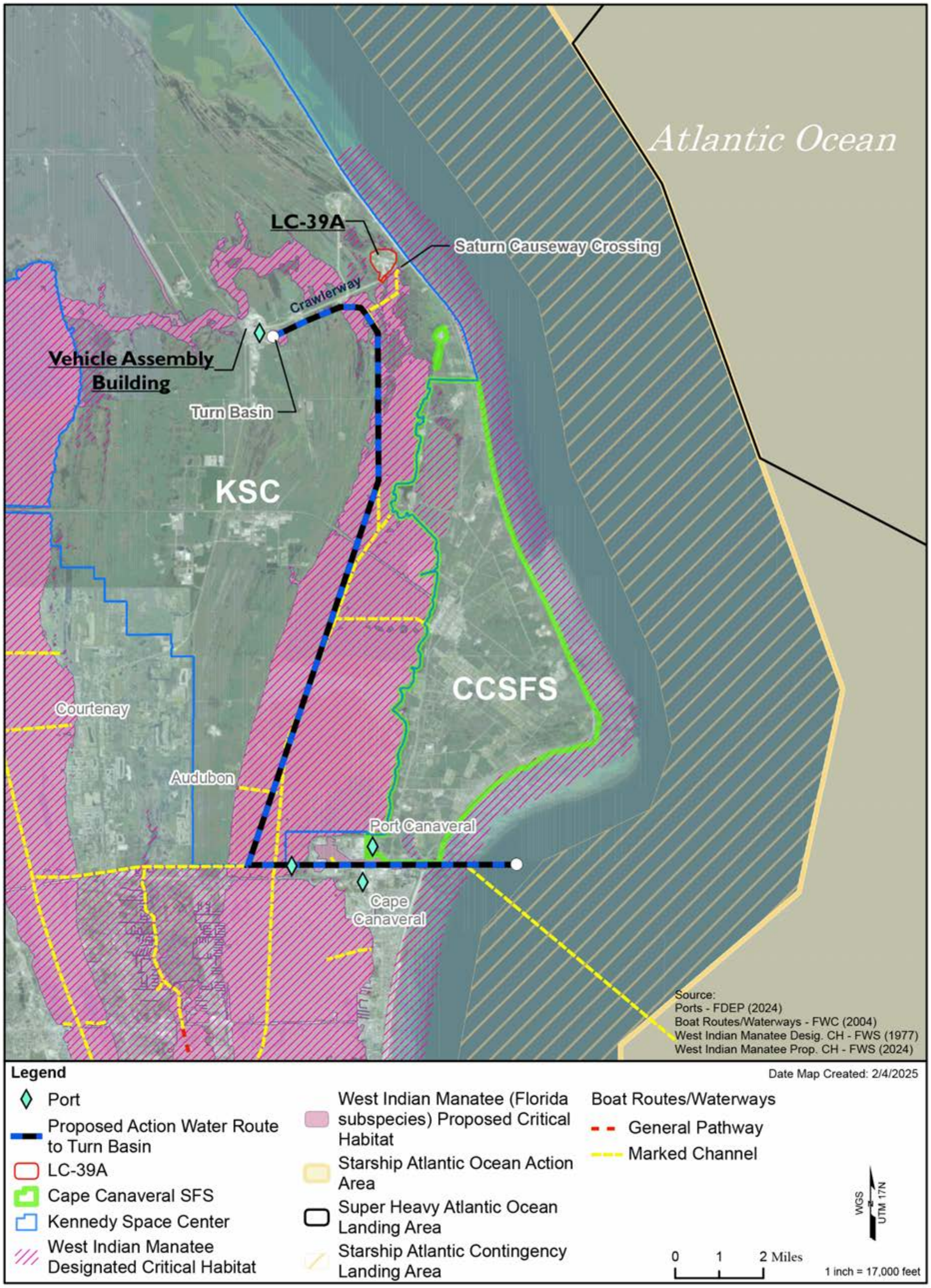


Figure 5-27. Turn Basin, Boat Routes, Ports, Shipment Area for Starship and Super Heavy

5.3.18 Atlantic Salt Marsh Snake

The Atlantic salt marsh snake is not present within the portion of the Action Area affected by construction or operations at and around LC-39A, so there would be no effects from plumes, strikes, vegetation damage, or lighting. The snake is present within the Starship Atlantic Contingency landings 1 psf contour. However, due to the infrequent nature of contingency landings and the large area over which they may occur (100 miles of coastline), there is only a small probability of this species being exposed to overpressures of approximately 1 psf from Starship Atlantic Contingency landings. Any exposed individuals may temporarily alter feeding, breeding, or sheltering, but would not suffer significant disruption in normal behavioral patterns.

Effects to these snakes from the Proposed Action are extremely unlikely to occur and are considered discountable. NASA has made the determination of **may affect, not likely to adversely affect**, for the Proposed Action with respect to the Atlantic salt marsh snake.

5.3.19 Eastern Indigo Snake

With the combination of the fencing around LC-39A, the developed condition of most of the site, and the general noise associated with construction and daily operations, it is unlikely that indigo snakes would occur within any of the construction areas. Any snakes exposed to construction noise could experience stress (Bogan, et al., 2024), but noise levels causing such effects would extend only a short distance. They are more likely to be encountered on roads leading to LC-39A. Environmental training provided to all LC-39A personnel and contractors would include photos of the federally listed species that may be seen in the Action Area, as well as instructions to allow these animals to move away from the road or area before resuming activities. Section 1.7, *Conservation Measures*, discusses the measures that would minimize the chance of vehicle collisions with federally listed species.

SpaceX will implement the *Standard Protection Measures for Eastern Indigo Snakes* to minimize potential impacts during construction. Construction personnel will be educated on the protections for the indigo snake and instructed that if an indigo snake is encountered during construction activities, it must be allowed to safely move out of the project area. The KSC Natural Resources Manager will be notified immediately of any sightings. If any gopher tortoise burrows are encountered during construction, they would be scoped before collapsing to ensure that the tortoise and any potential indigo snakes would not be entombed during the collapse of refugia habitat. Due to the potential for injury or death from vehicle and equipment traffic to and from the site, personnel and contractors associated with construction activities and daily operations would be informed of the potential for encountering indigo snakes on roadways. However, sightings of eastern indigo snakes at KSC are rare and the likelihood of a strike is low.

Enge and Wood (2002) found no correlation between traffic volume and snake mortality (on roads) rates during a study involving 1,022 daily searches to document all observed snake mortality on roads in a central Florida study area between June 1998 and December 2001. During this study, searches occurred on 79 percent of available days during the study period and one juvenile eastern indigo snake was found dead on a road. The study also found that eastern indigo snakes were one of four large snake species proportionally trapped three times more frequently within intact habitats on public lands than they were found on roads in fragmented areas (Enge & Wood, 2002).

The Species Status Assessment for the Eastern Indigo Snake (USFWS, 2019l) does not identify noise, light, or vibration as stressors for this species. However, wildlife species, including reptiles, may experience a startle or stress response when exposed to such disturbances. One study found that a lizard species exposed to intermittent, high-amplitude noise (e.g., aircraft flyovers) exhibited a stress response and altered foraging behavior (Kepas et al., 2023) Increases in anthropogenic disturbance, including noise, likely causes elevated stress responses for eastern indigo snakes (Bogan, et al., 2024). The increased stress can result in immunosuppression. Some study results suggest indigo snakes subjected to ongoing anthropogenic disturbance could be more susceptible to disease. During an eastern indigo snake translocation effort, most snakes captured within an area exposed to anthropogenic noise were affected by a protozoan pathogen (USFWS, 2024g). Conversely, in a survey of free-ranging snakes, including eastern indigo snakes, this pathogen was not detected in areas unaffected by intense anthropogenic disturbance, including noise (O'Hanlon et al., 2023). Any such impacts would be short term and intermittent. Any indigo snakes in the vicinity of LC-39A currently would be exposed to such effects every few days to weeks from current Falcon operations at the site. However, under the Proposed Action, exposures would increase by up to 220 events (static fire tests, launches, landings) annually. Elevated stress responses and immunosuppression may result from this increase in anthropogenic disturbance, leading to sickness or death.

Within the Action Area, the eastern indigo snake is reasonably certain to occur within scrub, coastal grassland, coastal strand, beach dune, ruderal areas, and some wetland areas (USFWS, 2019l). Per data provided by NASA, KSC, MINWR, and CANA provide approximately 66,758 acres of potential indigo snake habitat. Per the *Reactivation of Space Launch Complex-14 Biological Opinion* (2024), CCSFS contains an estimated 10,351 acres of potential eastern indigo snake habitat. The Peninsular Florida average male home range is 369 acres and 121 acres for females (Bauder et al., 2016). Assuming all potential indigo snake habitat at KSC, MINWR, CANA, and CCSFS was maximally occupied, and that the average home ranges apply to the Action Area, up to 846 eastern indigo snakes (209 males and 637 females) could be exposed per launch. However, as so few indigo snakes have been documented at these Federal properties, it is unlikely that such high numbers actually are present.

Although sightings are rare, the eastern indigo snake has been documented in the Action Area, specifically at KSC where there has been the documented crushing and death of an indigo snake on KSC by a vehicle. Although individuals present at the time of static fire tests, launches, or landings could be disturbed by noise, vibrations, lighting, and/or sonic booms depending on their proximity to these activities, any temporarily alterations in feeding, breeding, and sheltering would not significantly disrupt normal indigo snake behavioral patterns. There is a low probability that an individual indigo would be present within 0.2 miles of the launch pad at the time of a launch event, so effects heat impacts to the indigo snake from the Proposed Action are extremely unlikely to occur. However, given the past instance of an indigo snake death due to a vehicle impact and potential effects due to Thus, NASA has made the determination of **may affect, likely to adversely affect**, for the Proposed Action with respect to the indigo snake.

5.3.20 Sea Turtles

The potential for effects to nesting sea turtles would be limited to the months of May through October (i.e., sea turtle nesting and hatching season). Construction activities at LC-39A would occur approximately 0.2 miles from loggerhead sea turtle nesting designated critical habitat and green sea turtle nesting proposed critical habitat (Table 5-4 and Figure 5-28).

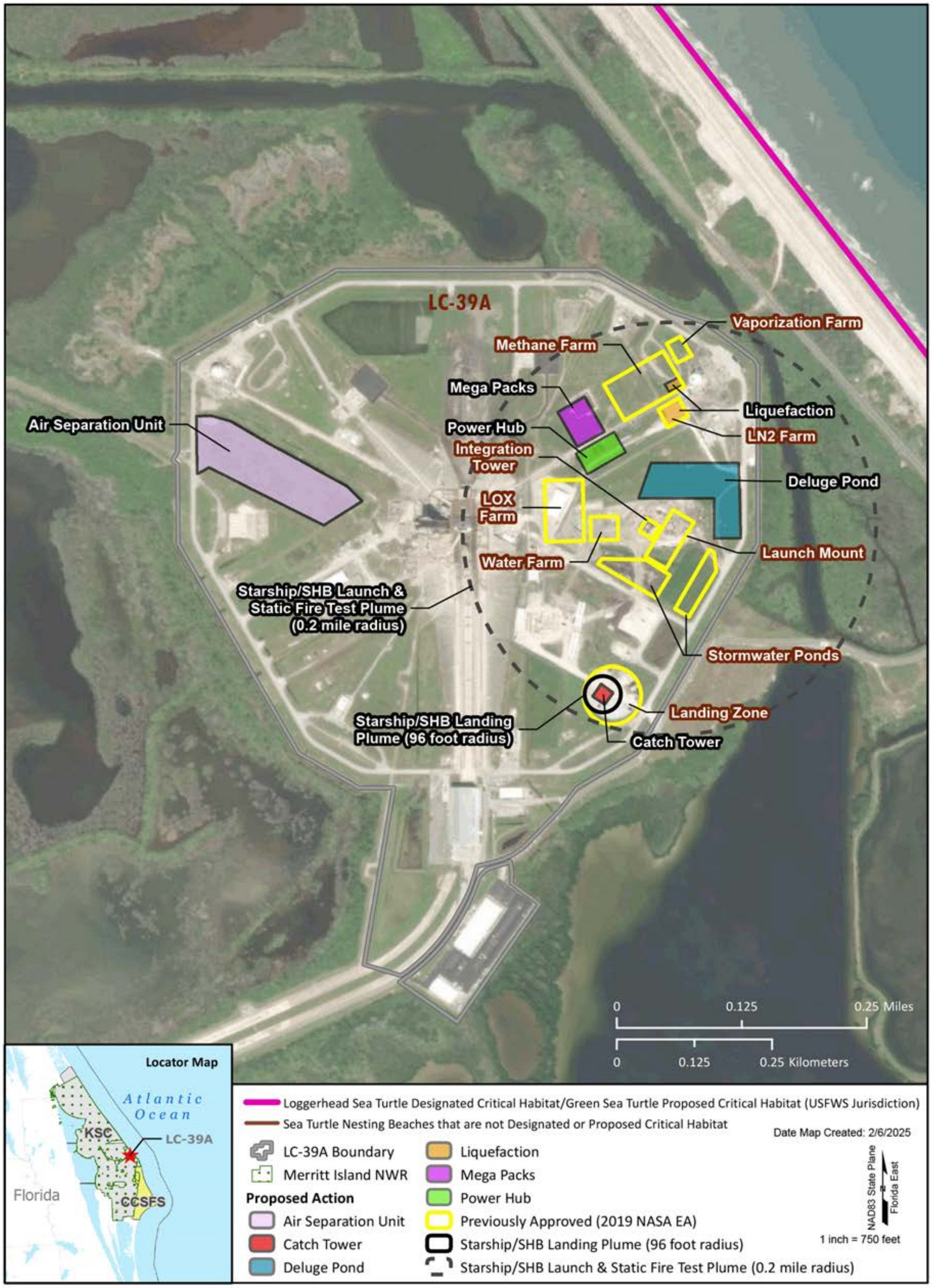


Figure 5-28. Sea Turtle Nesting Habitat in Relation to Construction Areas and Launch and Landing Plumes

Construction would occur primarily during daylight hours, but lighting, vibrations, and noise associated with any construction that continued after dusk could disrupt nesting sea turtles that emerge in proximity to LC-39A and disorient hatchlings, reducing nesting success and hatchling survival. Dunes and vegetation located between LC-39A and the beach do block some of the light, but lighting from multiple tall structures at the sites, as well as other exterior lighting would reach the beach. SpaceX will work with NASA to update the LC-39A LOM to minimize lighting impacts to the greatest extent possible while still maintaining security and safety. The beach is monitored during nesting season to identify disorientation events. These data are communicated to environmental managers at KSC to ensure compliance with the incidental take authorization from the USFWS. Because construction will not occur within nesting beach habitat, will be intermittent and temporary, will employ sea turtle friendly lighting to the extent possible, and is not expected to materially increase the levels of activity, noise, and lighting to which turtles are currently exposed in the Action Area, potential construction impacts to sea turtles are expected to be discountable.

Almost all sea turtle nesting and hatching occurs at night, so nighttime operations from May through October are the primary concerns for effects to sea turtles within the Action Area. Nighttime lighting, noise, vibrations, and sonic booms may deter females from nesting (i.e., false crawls) or interrupt nesting, and artificial lighting may result in the disorientation of hatchlings. These disturbances may reduce nesting success and hatchling survival. The combined noise, vibrations, and lighting associated with a nighttime static fire test, launch, or landing event is likely to disturb any adult or hatchling sea turtles present on the beach in the vicinity of LC-39A. Any restrictions preventing early morning sea turtle patrol monitoring during nesting season may result in missed nests and associated future protections (Table 1-1 and Figure 1-4). This also would affect long-term monitoring data accuracy.

Per Section 4.3.25, *Sea Turtles*, analysis of sea turtle crawl observations recorded immediately adjacent to LC-39 A (kilometer 30) from both before and after Falcon 9 program occupancy shows no discernable effects to sea turtle nesting from operations at Pad A. Additionally, monitoring of marked nests by MINWR since the beginning of the Falcon 9 launch program has not documented any disorientation events for hatchling or adult sea turtles from lighting associated with LC 39A. Further, no disorientation has been documented along the entire KSC Security Beach since the 2020 nesting season. However, the number of night operations will increase under the Proposed Action (up to 22 of each of the following at night annually: Starship tests, Super Heavy tests, launches, Super Heavy landings, and Starship landings), and the number of nights with lighting will increase under the Proposed Action, with an average of three nights per launch event, for up to 44 launch events, for a total of 132 nights. There would also be brief, but intense light from the nighttime static fire tests (up to 44), launches (up to 22), and landings (up to 44) themselves.

Sea turtle habitat is outside the 0.2-mile radius of the estimated extent of heat and vapor cloud effects associated with static fire tests, launches, and landings (Figure 5-28). The closest sea turtle nesting habitat to the launch and landing pads is 0.3 miles and 0.5 miles to the northeast, respectively, so air will return to ambient temperatures prior to reaching sea turtle habitat.

During static fire tests, launches, and landings sea turtle habitat at KSC, CANA, and CCSFS would be exposed to noise levels of up to 150 dB ASEL (Figure 5-29 through Figure 5-35). Table 5-12 provides the mileages of sea turtle nesting habitat that would be exposed to the various noise levels. During Super Heavy landings, most sea turtle nesting habitat at KSC, CANA, and CCSFS would be exposed to sonic boom overpressures of at least 1 psf, with some nesting habitat exposed to overpressures of over 20 psf (Figure 5-36 through Figure 5-40). Table 5-13 provides the mileages of sea turtle nesting habitat that would be exposed to the various overpressures from landings at LC-39A. There would be up to 22 of each of the following at night annually: Starship tests, Super Heavy tests, launches, Super Heavy landings, and Starship landings.

Table 5-12. Sea Turtle Nesting Beaches and Nesting Critical Habitat Exposed to Greater than 100 dB ASEL from the Proposed Action at LC-39A

Events at LC-39A	Total miles of nesting beaches affected (miles of critical habitat affected)[1]						
	100-110 dB ASEL	110-115 dB ASEL	115-120 dB ASEL	120-130 dB ASEL	130-140 dB ASEL	140-150 dB ASEL	>150 dB ASEL
Starship-Super Heavy launch	21.3 (10.4)	5.3 (2.8)	3.6 (2.1)	4.2 (3.8)	2.3 (2.3)	1.7 (1.7)	0
Starship static fire test	3.8 (3.8)	1 (1)	0.7 (0.7)	1 (1)	0.9 (0.9)	0	0
Super Heavy static fire test	5.2 (4.2)	1.4 (1.4)	1 (1)	1.3 (1.3)	0.9 (0.9)	0.5 (0.5)	0
Super Heavy landing[2]	8.0 (4.4)	2.6 (2.6)	1.7 (1.7)	2.1 (2.1)	1.8 (1.8)	0	0
Starship landing	3.6 (3.6)	1.1 (1.1)	0.9 (0.9)	1.7 (1.7)	0	0	0

Notes: > = greater than; ASEL = A-weighted sound exposure level; dB = decibels; LC = Launch Complex.

[1]Loggerhead sea turtle nesting critical habitat (final) and green sea turtle nesting critical habitat (proposed) cover the same area.

[2]Super Heavy landing at 40 degrees was used as the representative landing, as it would expose the greatest amount of sea turtle nesting habitat to the highest ASELs.

Table 5-13. Sea Turtle Nesting Beaches and Nesting Critical Habitat Exposed to Greater than 1 psf Overpressure from the Proposed Action at LC-39A

Events at LC-39A	Total miles of nesting beaches affected (miles of critical habitat affected)[1]					
	1-2 psf	2-4 psf	4-6 psf	6-10 psf	10-20 psf	>20 psf
Starship-Super Heavy launch	Sonic boom over the Atlantic Ocean does not affect land					
Starship static fire test	No sonic boom					
Super Heavy static fire test						
Super Heavy landing[2]	2.3 (2.2)	12.8 (4.2)	9.7 (3.4)	7.8 (3.4)	6.3 (3.9)	3.5 (3.5)
Starship landing	42.5 (22.3)	0	0	0	0	0

Notes: > = greater than; LC = Launch Complex; psf = pounds per square foot.

[1]Loggerhead sea turtle nesting critical habitat (final) and green sea turtle nesting critical habitat (proposed) cover the same area.

[2]Super Heavy landing at 115 degrees was used as the representative landing, as it would expose the greatest amount of sea turtle nesting habitat to the highest overpressure levels.

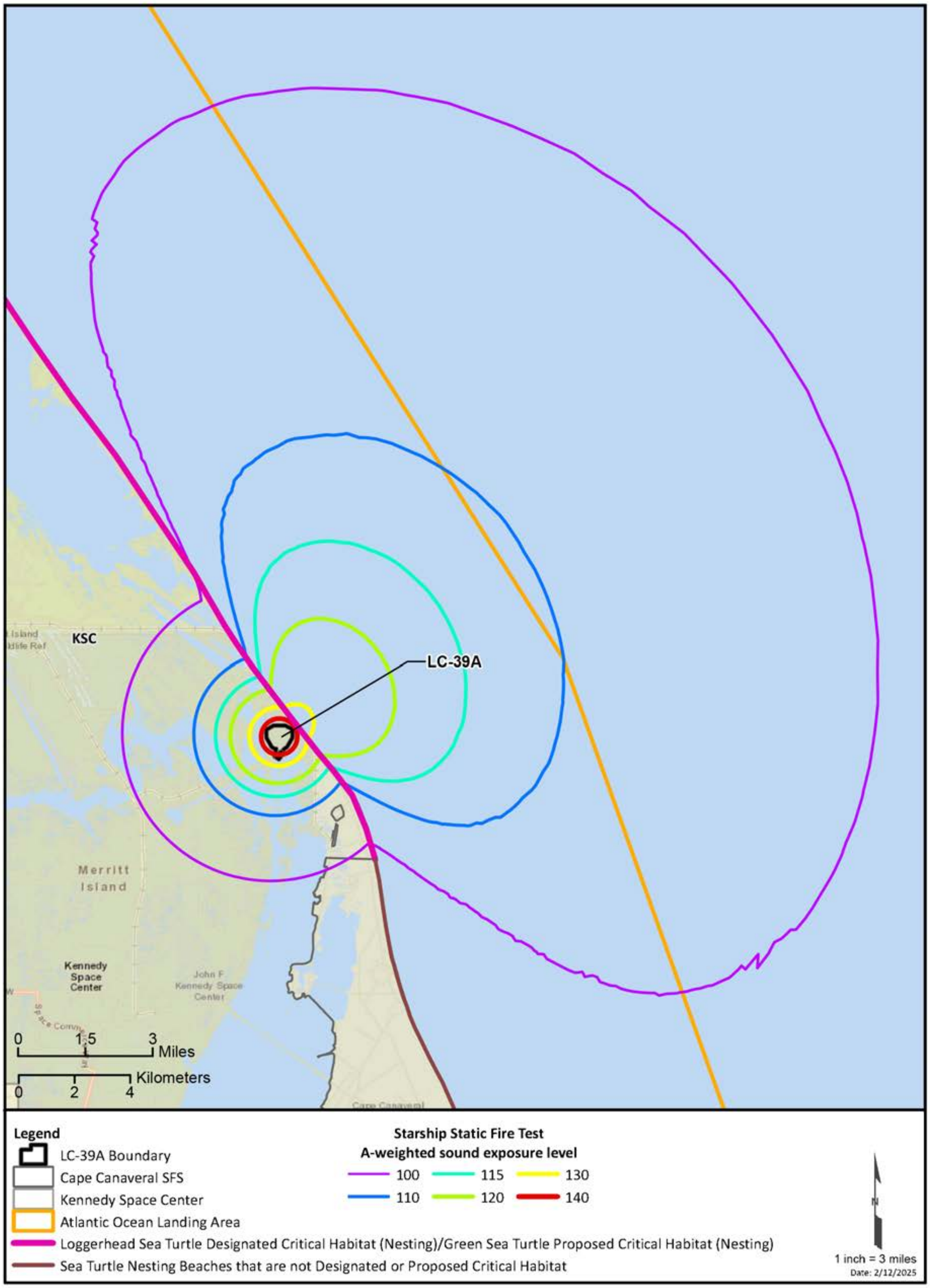


Figure 5-29. Sea Turtle Nesting Habitat in Relation to Starship Static Fire Test Noise Contours (ASEL)

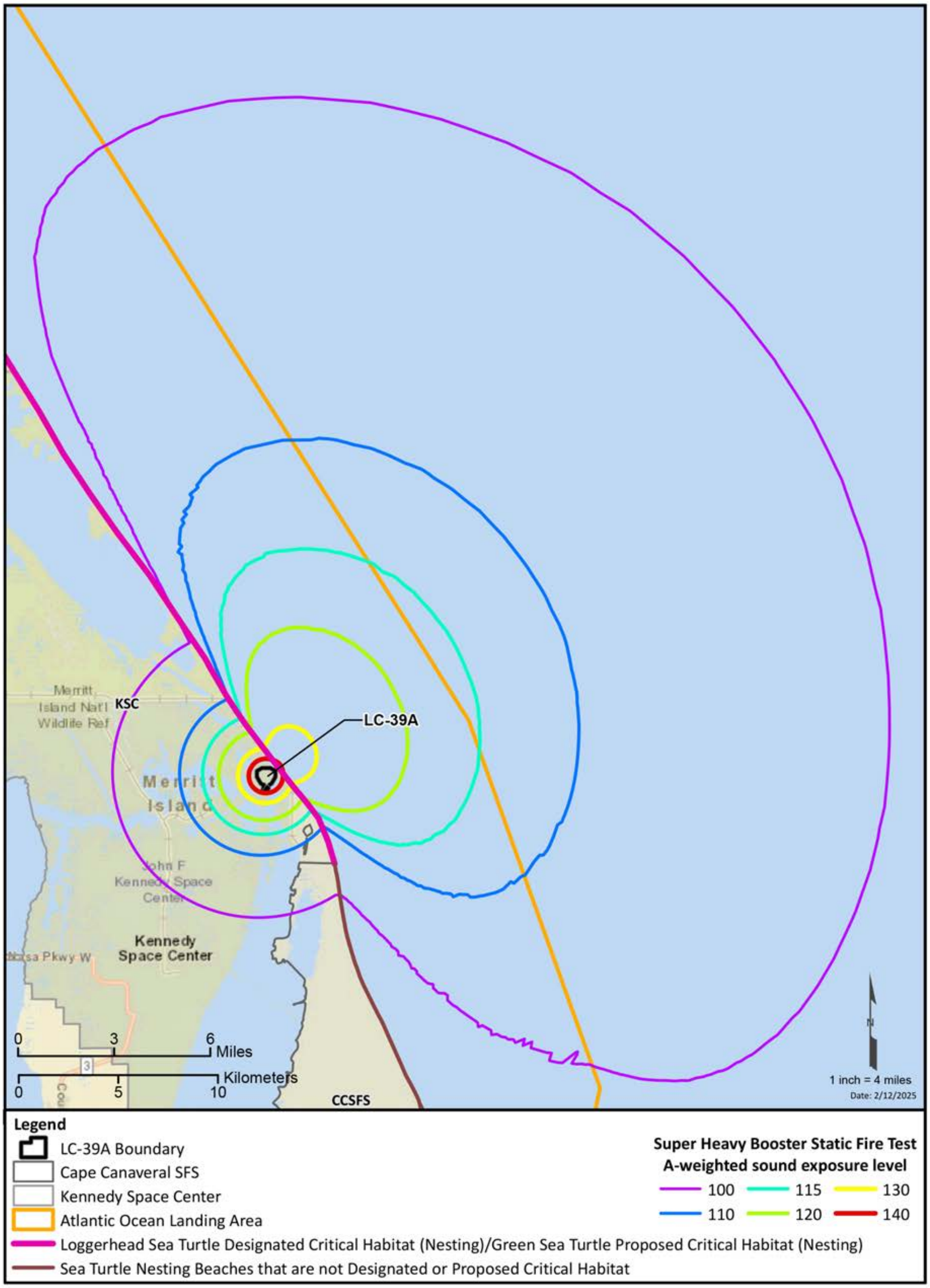


Figure 5-30. Sea Turtle Nesting Habitat in Relation to Super Heavy Static Fire Test Noise Contours (ASEL)

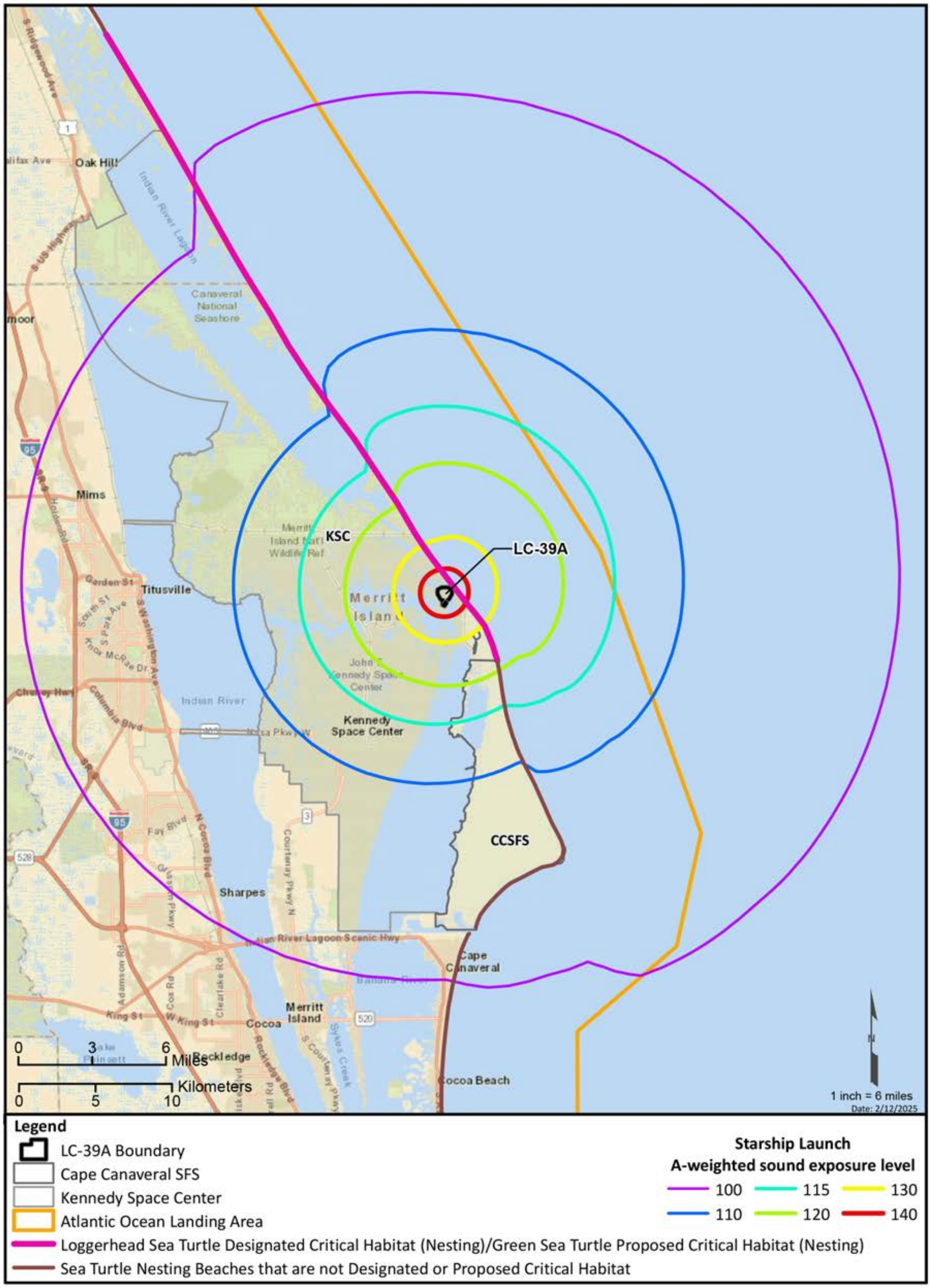


Figure 5-31. Sea Turtle Nesting Habitat in Relation to Launch (Nominal Heading) Noise Contours (ASEL)

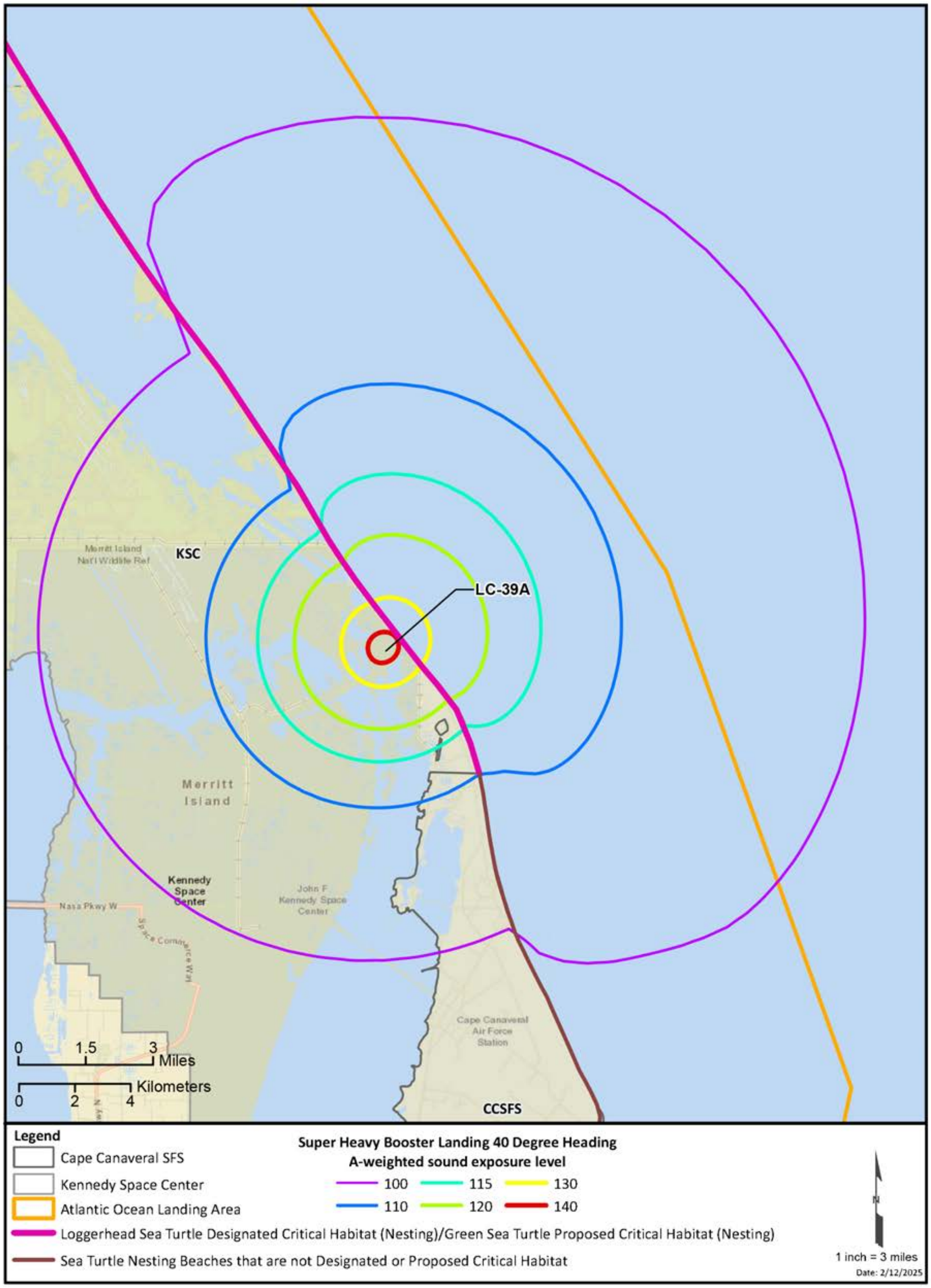


Figure 5-32. Sea Turtle Nesting Habitat in Relation to Super Heavy Landing (40 Degree Heading) Noise Contours (ASEL)

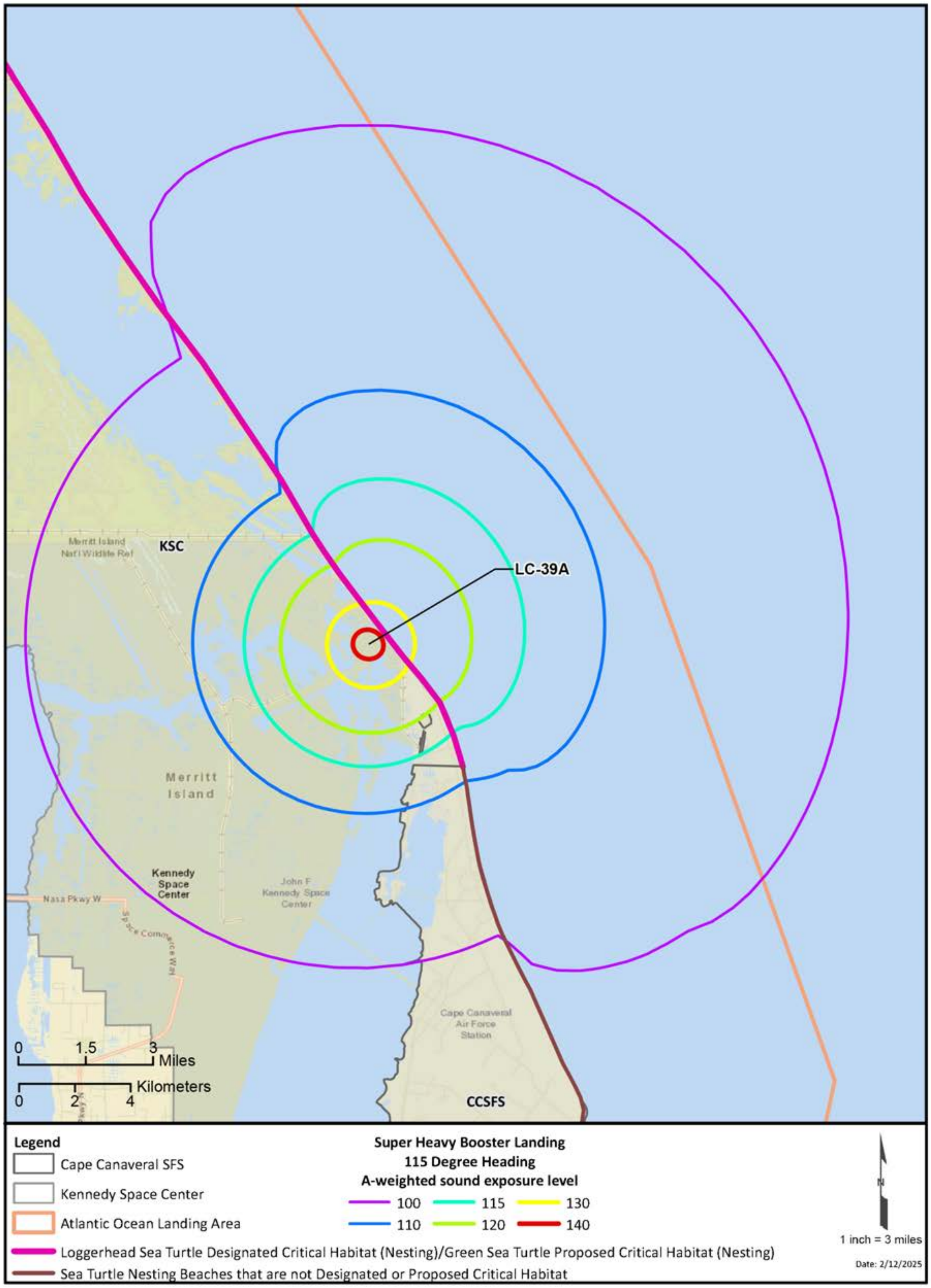


Figure 5-33. Sea Turtle Nesting Habitat in Relation to Super Heavy Landing (115 Degree Heading) Noise Contours (ASEL)

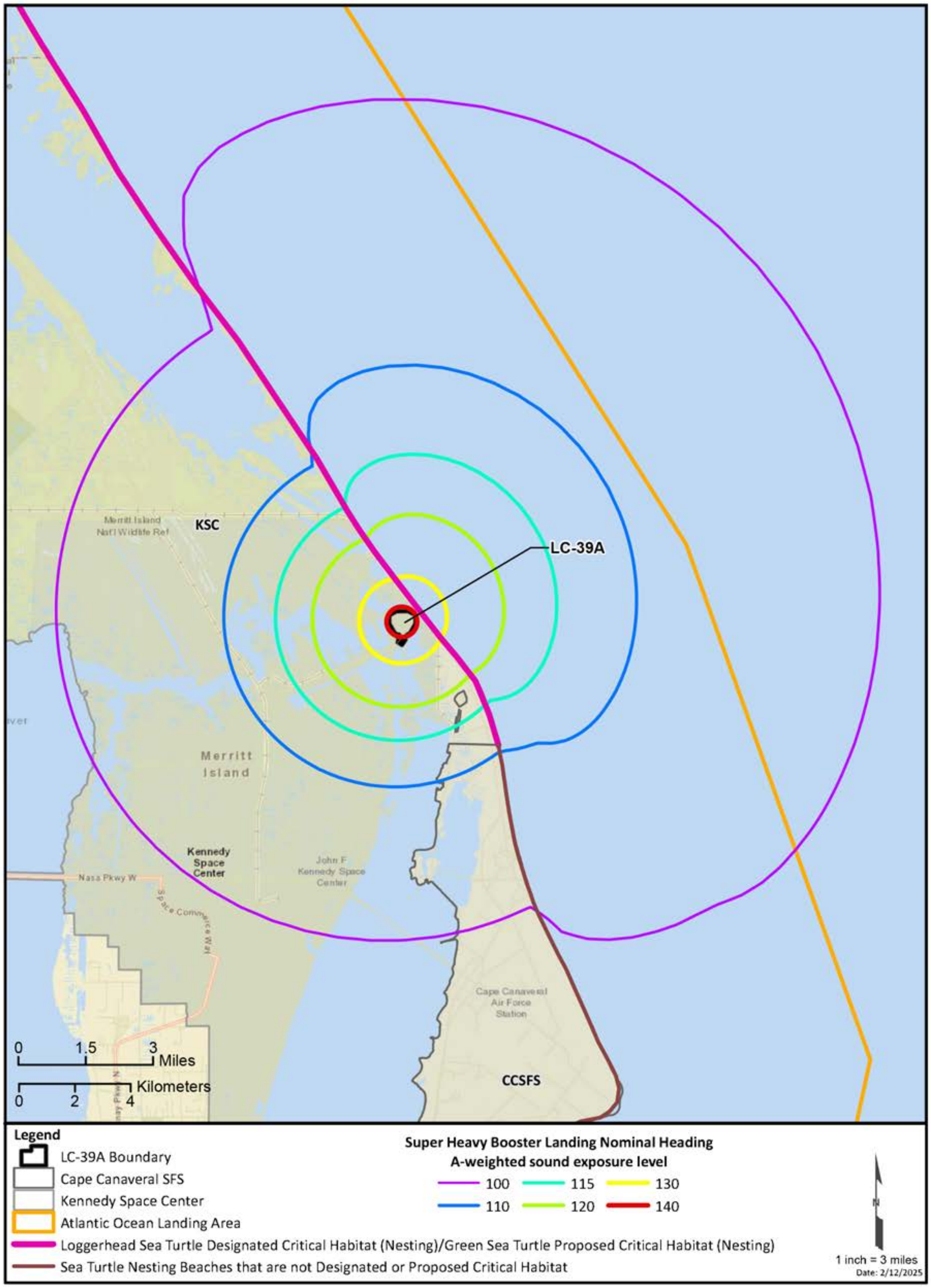


Figure 5-34. Sea Turtle Nesting Habitat in Relation to Super Heavy Landing (Nominal Heading) Noise Contours (ASEL)

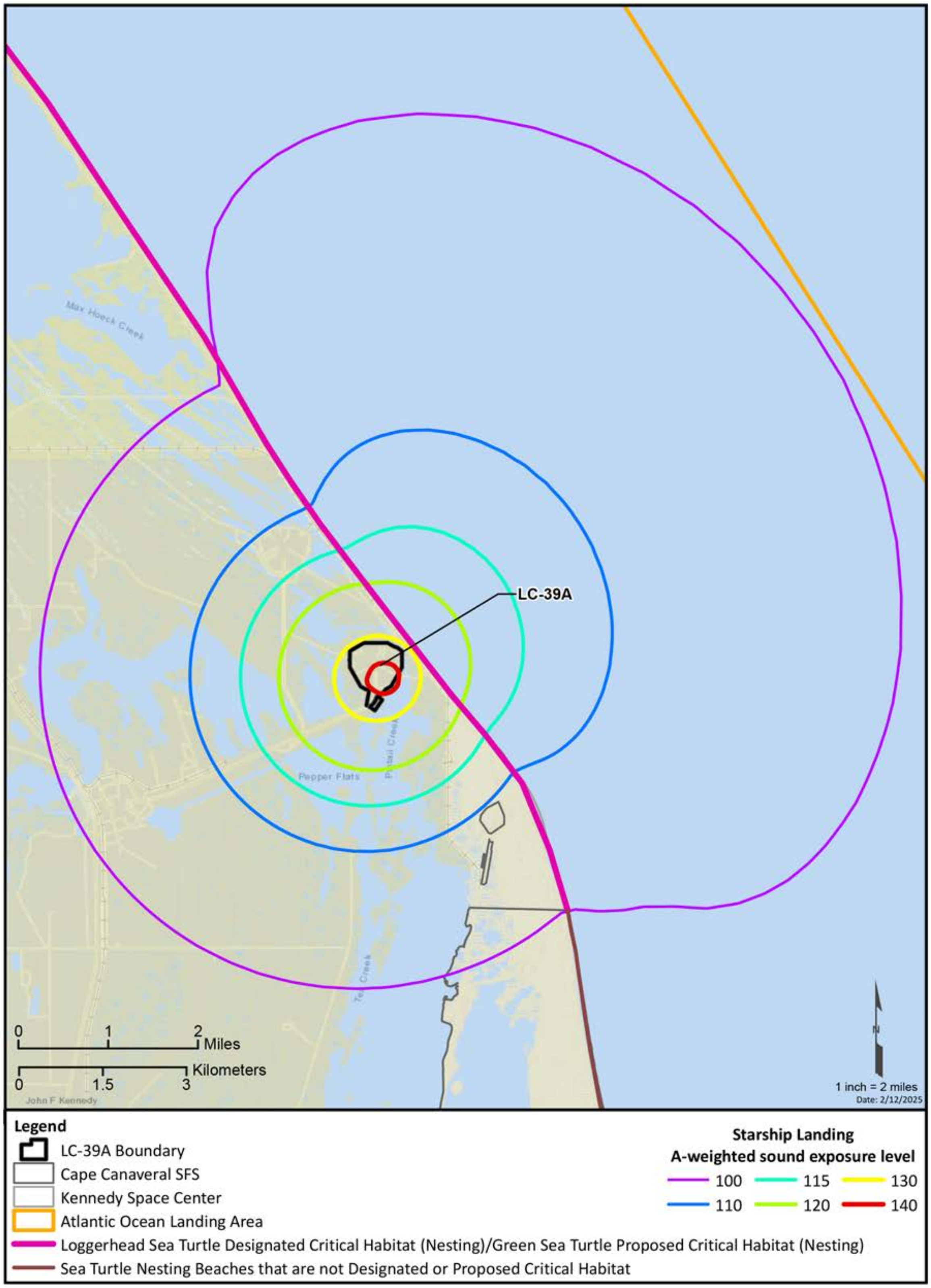


Figure 5-35. Sea Turtle Nesting Habitat in Relation to Starship Landing (Nominal Heading) Noise Contours (ASEL)

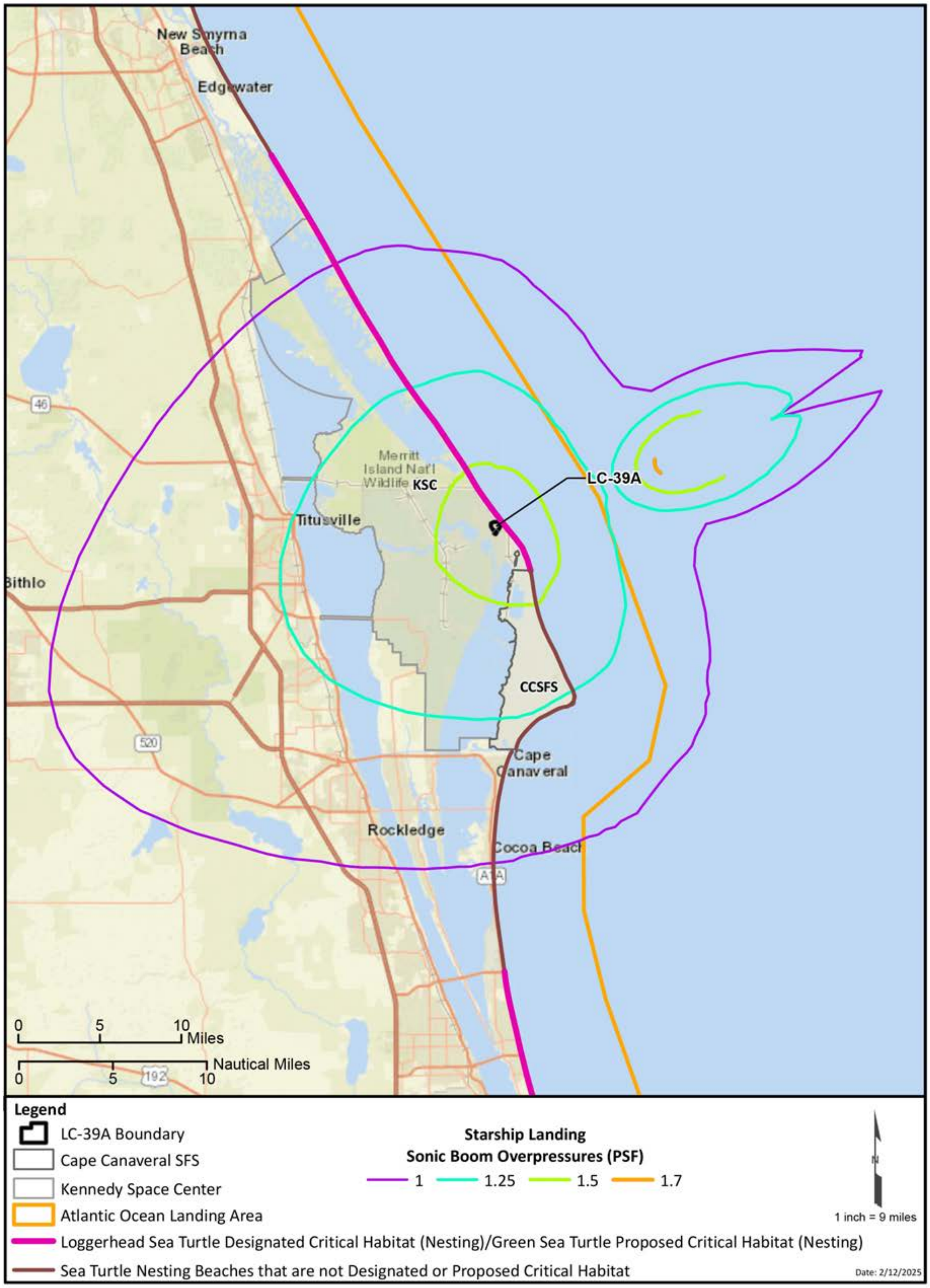


Figure 5-36. Sea Turtle Nesting Habitat in Relation to Launch (Nominal Heading) Sonic Boom Overpressure Contours

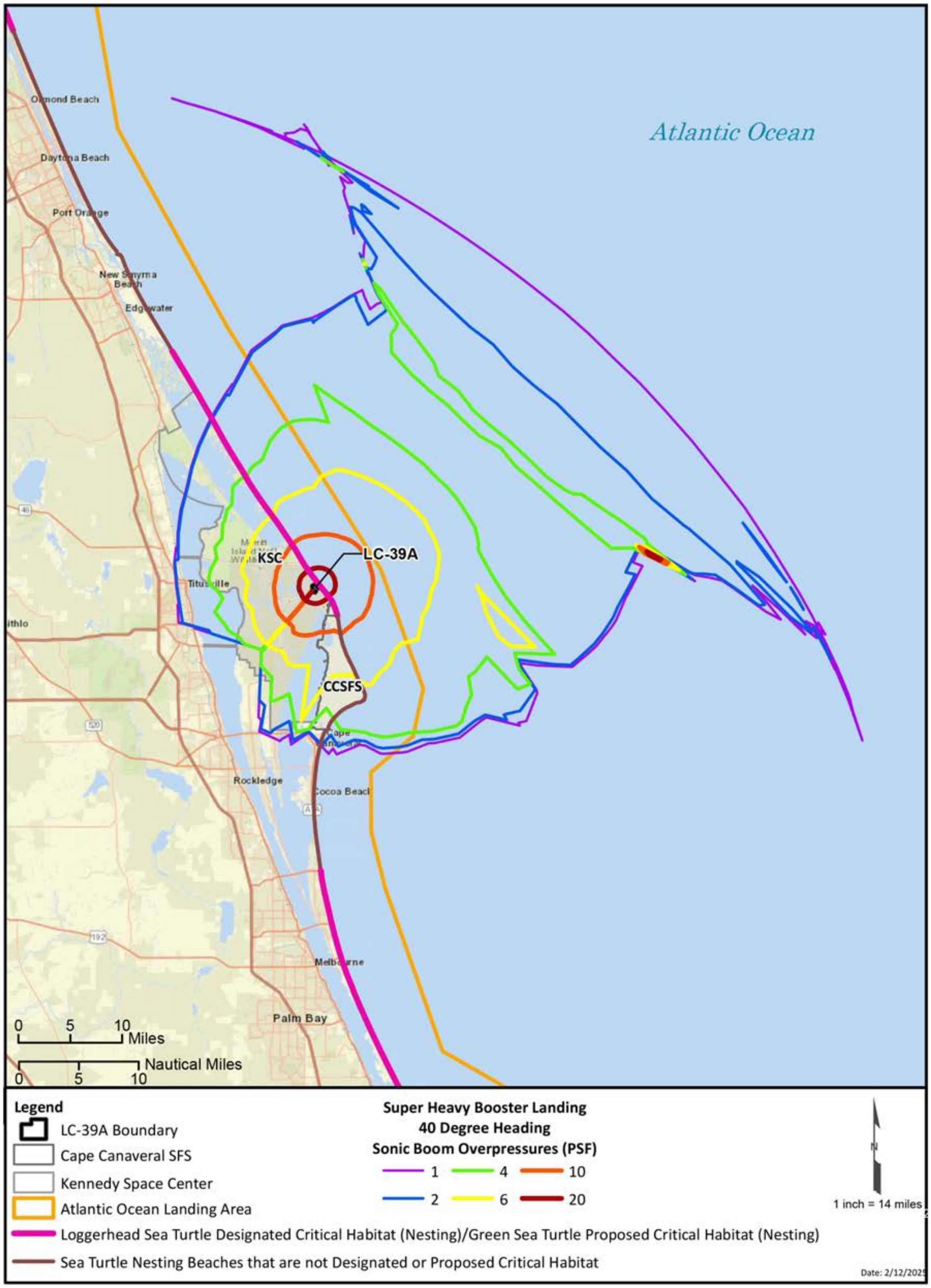


Figure 5-37. Sea Turtle Nesting Habitat in Relation to Super Heavy Landing (40 Degree Heading) Sonic Boom Overpressure Contours

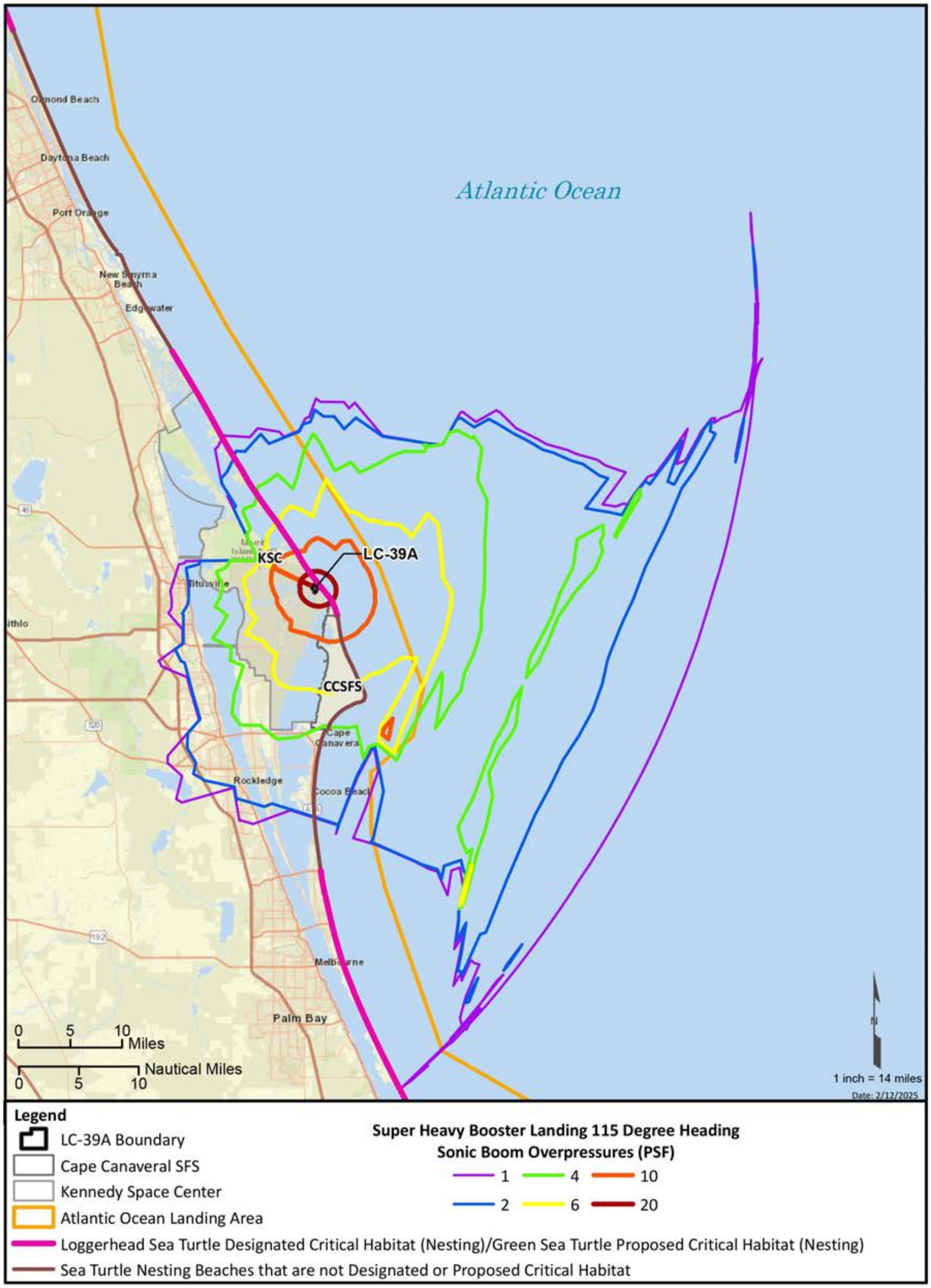


Figure 5-38. Sea Turtle Nesting Habitat in Relation to Super Heavy Landing (115 Degree Heading) Sonic Boom Overpressure Contours

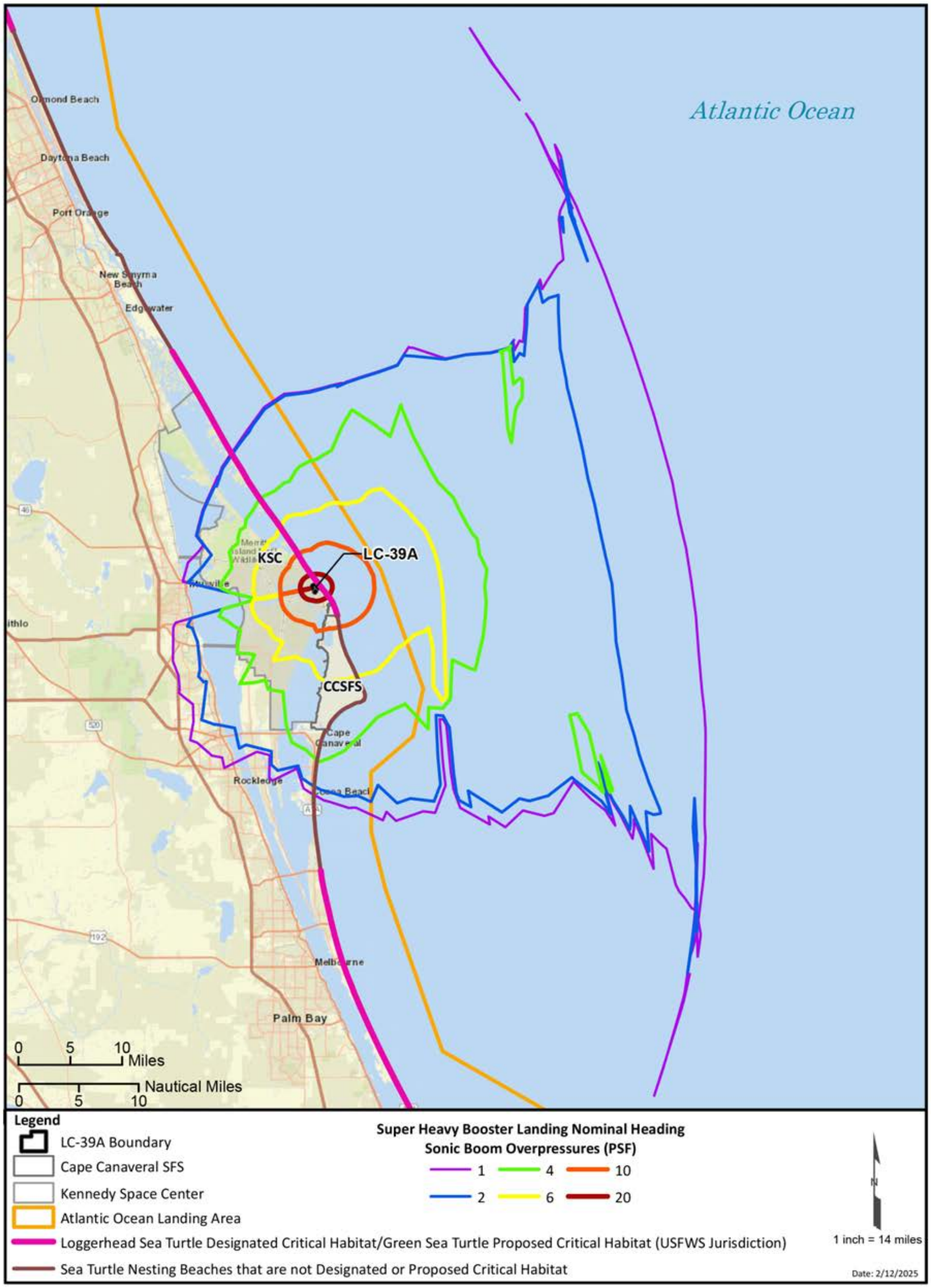


Figure 5-39. Sea Turtle Nesting Habitat in Relation to Super Heavy Landing (Nominal Heading) Sonic Boom Overpressure Contours

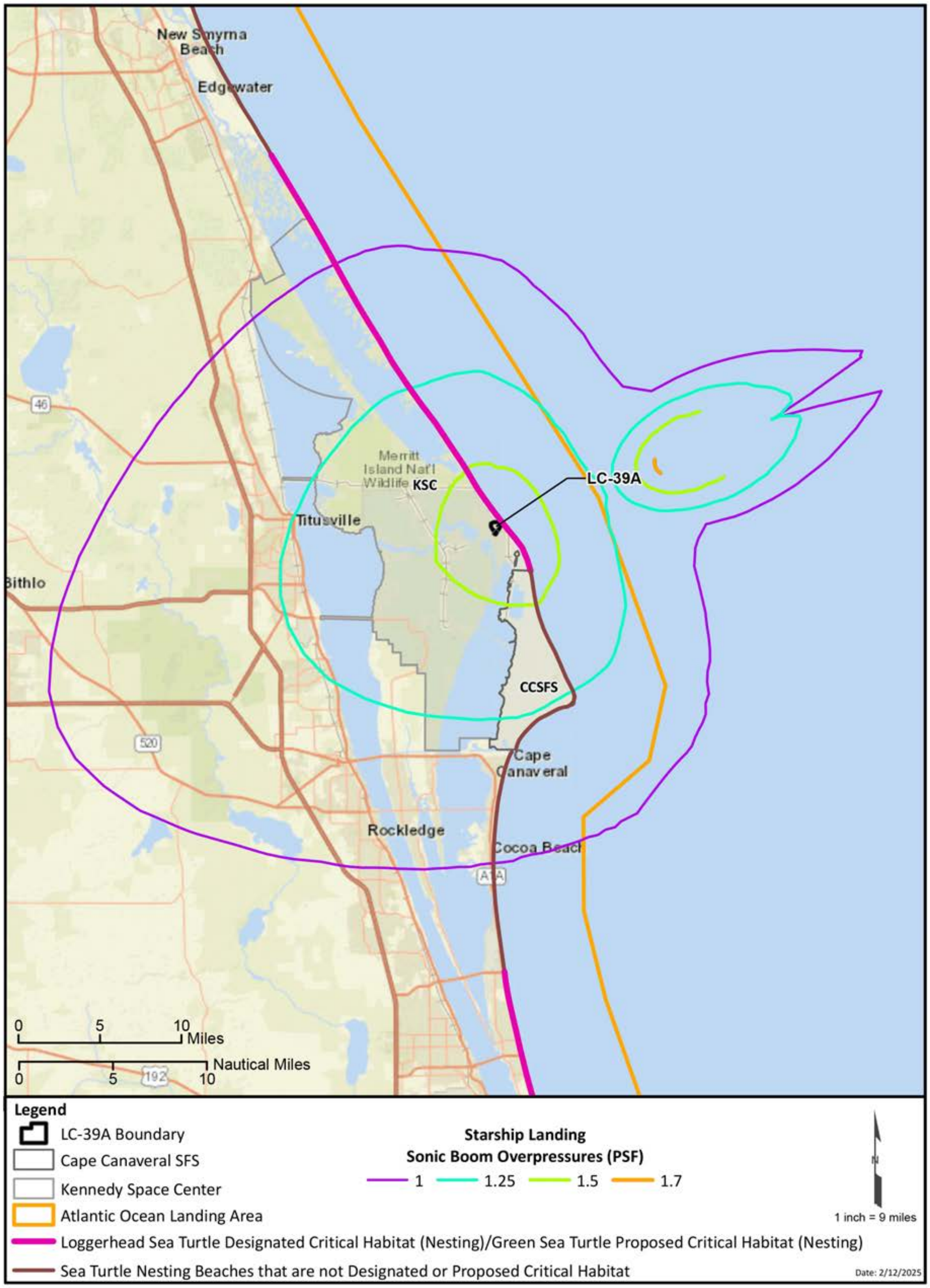


Figure 5-40. Sea Turtle Nesting Habitat in Relation to Starship Landing (Nominal Heading) Sonic Boom Overpressure Contours

Although sea turtle nests in the Action Area are regularly exposed to vibration from launches, the magnitude of disturbance associated with the Super Heavy is likely to be greater, and the number of annual exposures to vibration would increase. There are currently no studies on the effects of noise-induced vibration on sea turtle nests, eggs, or hatchlings in the nest. Potential negative effects of ground vibrations on sea turtle eggs could range from minor decreases in hatchling fitness to congenital malformations to egg failure. Vibrations could result in physiological effects that interfere with the ability of hatchlings to reach the water (e.g., sensory disorientation). Vibrations also might collapse nests or solidify sand around nests, which could affect hatchling emergence. Shannon and others (1994) documented strong effects from vibrations on chicken embryonic development (e.g., congenital malformations) and mortality, as well as increasing mortality with increasing magnitude of exposure; they cited amplitude, frequency, amplitude transmission, and timing of the exposure as factors associated with negative effects to the chicken embryos. A study of loggerhead sea turtle nest relocations found that eggs relocated within the first 12 hours of deposition had a hatch success rate of 79 to 90 percent, while mid-incubation relocations resulted in a success rate of 53 percent (Ahles & Milton, 2016). The study results, along with the results of nest relocations in general, indicate that some amount of movement (i.e., vibration) can be tolerated by sea turtle eggs. However, these results suggest that the timing of egg movement is likely to influence sea turtle hatch success rate and Shannon and others (1994) showed that the degree of effects to developing chicken embryos was affected by the timing of exposure. Given the degree of unknowns regarding vibration effects on sea turtle nests, eggs, and hatchlings in the nest, SpaceX will work with NASA and MINWR to determine an appropriate monitoring approach to evaluate potential vibration effects to sea turtle nests in the vicinity of LC-39A.

Sea turtles have been recorded nesting in the Action Area, including along KSC, MINWR, CANA, CCSFS and adjacent Atlantic beaches. Known sea turtle nesting habitat is present as close as 0.31 miles from the launch pad and 0.46 miles from the landing pad; this is outside of the 0.2-mile radius of the plume, so there would be no heat impacts to sea turtles. Noise, vibrations, and sonic booms from static fire tests, launches, and landings could frighten nesting turtles and cause them to abandon their nesting attempts; frighten or disorient hatchlings and reduce hatchling survival; or adle eggs or degrade sand conditions around nests, thus reducing hatchling emergence. Lighting could cause adult females to false crawl or hatchlings to become disoriented and reduce nesting success/hatchling survival. On launch days during sea turtle nesting season, sea turtle nest patrol personnel may be unable to access the beach, thereby missing a sea turtle nesting event, affecting the accuracy of long-term monitoring data. NASA has determined the Proposed Action **may affect, and is likely to adversely affect**, the loggerhead, green, leatherback, hawksbill, and Kemp's ridley sea turtles.

5.3.21 Sea Turtle Critical Habitat (Designated and Proposed)

No construction or operational activities would occur within loggerhead sea turtle nesting critical habitat or green sea turtle nesting proposed critical habitat, but lighting associated with nighttime construction or operations could affect these nesting habitats. Essential features of these critical habitats are beaches that are sufficiently dark so that nesting turtles are not deterred from emerging, and post-nesting turtles and hatchlings orient to the sea. Dunes and vegetation would block some light from LC-39A, but lighting associated with tall structures (e.g., the catch tower); non-sea turtle-friendly lighting that may be required for safety or security; and light produced during nighttime launches, landings, and static fire tests could be visible from the beach on some nights. SpaceX will work with NASA to update the LC-39A LOM to minimize lighting impacts to the greatest extent practicable. The beach is monitored during nesting season to identify disorientation events. These data are communicated to environmental managers at KSC to ensure compliance with the incidental take authorization from the USFWS in the KSC Center Master Plan BO regarding lighting effects on sea turtles (USFWS, 2017). The Proposed Action would negatively affect one of the essential features of loggerhead critical habitat and green sea turtle proposed critical habitat (i.e., sufficiently dark beaches) within this portion of their range. Contingency landings have the potential to infrequently affect light levels within sea turtle designated and proposed nesting critical habitat shown in Figure 5-41. Overall, some degree of lighting or sky glow from the Proposed Action would be visible from certain portions of sea turtle designated and proposed nesting critical habitat for multiple nights each year.

Proposed critical habitat for green sea turtles is present in the Action Area, including at KSC, MINWR, and CANA. No critical habitat is present within the construction area at LC-39A or within the 0.2-mile radius around the launch pad that would be affected by the plume, so no direct physical impacts from heat or construction-related sand disturbance would occur to green sea turtle critical habitat. Lighting from construction, daily operations, launch-related security and safety lighting, and light from the launches and landings themselves, are likely to adversely affect critical habitat by affecting the PBF regarding a sufficiently dark beach for nesting. SpaceX will reduce the amount of artificial lighting that reaches the beaches through measures included in their updated LOM for LC-39A, but some degree of adverse effects to critical habitat will still occur. Thus, NASA has made the determination of **no destruction or adverse modification**, for the Proposed Action with respect to green sea turtle proposed critical habitat.

Critical habitat for loggerhead sea turtles is present in the Action Area, including at KSC, MINWR, and CANA. No critical habitat is present within the construction area at LC-39A or within the 0.2-mile radius around the launch pad that would be affected by the plume, so no direct physical impacts from heat or construction-related sand disturbance would occur to loggerhead critical habitat. Lighting from construction, daily operations, launch-related security and safety lighting, and light from the launches and landings themselves, are likely to adversely affect critical habitat by affecting the PBF regarding a sufficiently dark beach for nesting. SpaceX will reduce the amount of artificial lighting that reaches the beaches through measures included in their updated LOM for LC-39A, but some degree of adverse effects to critical habitat will still occur. Thus, NASA has made the determination of **may affect, likely to adversely affect**, for the Proposed Action with respect to loggerhead sea turtle critical habitat.

5.4 Cumulative Effects

Cumulative effects are defined in 50 CFR §402.02 as “those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the Action Area of the Federal action subject to consultation.” As previously discussed, much of the land within the Action Area consists of Federal properties; future projects on these Federal properties and other projects requiring Federal permits would require separate consultation pursuant to Section 7 of the ESA and, thus, are not included in this cumulative effects analysis.

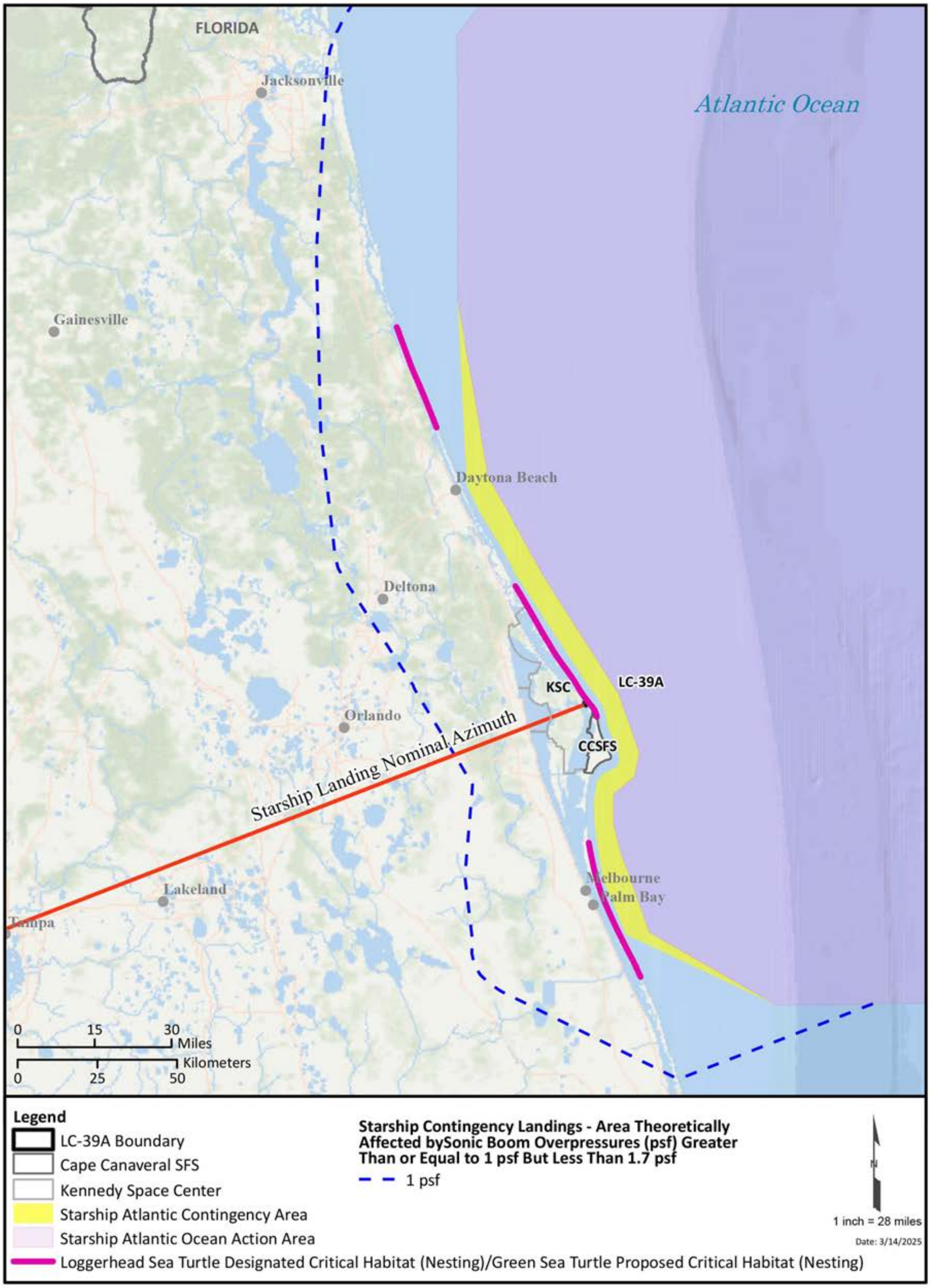


Figure 5-41. Sea Turtle Nesting Critical Habitat in Relation to Starship Atlantic Contingency Area 1 psf Overpressure Contour

A thorough review of publicly available databases and planning documents was made of the Action Area to identify future State and private activities that, when combined with the Proposed Action, may result in cumulative effects to the listed species and critical habitat addressed in this BCA with **Likely to Adversely Affect** determinations. Input also was solicited from SpaceX, the FAA, and NASA.

No projects were identified that meet the criteria of being both reasonably foreseeable and exclusively a State or private activity that did not require any type of Federal permit. Therefore, according to the definition of cumulative effects in 50 CFR §402.02, there would be no cumulative effects to the Florida scrub-jay, southeastern beach mouse, eastern indigo snake, or any sea turtle species within the Action Area beyond those analyzed in this BCA.

Chapter 6. Effect Determinations

6.1 Effect Determinations for Species and Critical Habitat

Table 6-1 lists the overall effect determinations for federally listed and proposed species and critical habitat resulting from the Proposed Action. “No effect” determinations are listed in Table 3-4.

Table 6-1. Effect Determinations for Federally Listed and Proposed Species and Critical Habitat

Species/Critical Habitat	Effect Determinations
Audubon’s crested caracara	May Affect, Not Likely to Adversely Affect
Band-rumped storm-petrel	May Affect, Not Likely to Adversely Affect
Bermuda petrel	May Affect, Not Likely to Adversely Affect
Black-capped petrel	May Affect, Not Likely to Adversely Affect
Eastern black rail	May Affect, Not Likely to Adversely Affect
Everglade snail kite	May Affect, Not Likely to Adversely Affect
Florida grasshopper sparrow	May Affect, Not Likely to Adversely Affect
Florida scrub-jay	May Affect, Likely to Adversely Affect
Hawaiian petrel	May Affect, Not Likely to Adversely Affect
Newell’s shearwater	May Affect, Not Likely to Adversely Affect
Piping plover	May Affect, Not Likely to Adversely Affect
Red-cockaded woodpecker	May Affect, Not Likely to Adversely Affect
Roseate tern	May Affect, Not Likely to Adversely Affect
Rufa red knot	May Affect, Not Likely to Adversely Affect
Short-tailed albatross	May Affect, Not Likely to Adversely Affect
Wood stork	May Affect, Not Likely to Adversely Affect
Monarch butterfly (proposed threatened)	Not Likely to Jeopardize
Anastasia Island beach mouse	May Affect, Not Likely to Adversely Affect
Florida bonneted bat	May Affect, Not Likely to Adversely Affect
Southeastern beach mouse	May Affect, Likely to Adversely Affect
Tricolored bat (proposed endangered)	Not Likely to Jeopardize
West Indian manatee	May Affect, Not Likely to Adversely Affect
Atlantic salt marsh snake	May Affect, Not Likely to Adversely Affect
Eastern indigo snake	May Affect, Likely to Adversely Affect
Green sea turtle	May Affect, Likely to Adversely Affect
Hawksbill sea turtle	May Affect, Likely to Adversely Affect
Kemp’s ridley sea turtle	May Affect, Likely to Adversely Affect
Leatherback sea turtle	May Affect, Likely to Adversely Affect
Loggerhead sea turtle	May Affect, Likely to Adversely Affect
Loggerhead sea turtle critical habitat	May Affect, Likely to Adversely Affect
Green sea turtle critical habitat (proposed)	No Destruction or Adverse Modification

Notes: ESA = Endangered Species Act; USFWS = United States Fish and Wildlife Service.

*Proposed species and critical habitat are not protected by the ESA and do not trigger ESA Section 7 consultation. However, NASA has evaluated the effects of the action on the proposed tricolored bat and monarch butterfly, as well as green sea turtle proposed critical habitat, and seeks USFWS concurrence with these determinations through a voluntary informal conference process. If the species becomes listed or the critical habitat designated in the future, reinitiation of consultation may be required.

6.2 Conclusion

The FAA or NASA will notify the USFWS if any of the actions considered in this BCA are modified or if additional information on listed species becomes available, as a reinitiation of consultation may be required. If impacts to listed species occur beyond what has been considered in this assessment, the USFWS will be notified immediately to determine further actions, including reinitiation of consultation.

Chapter 7. References

Ahles, N., & Milton, S. (2016). Mid-Incubation Relocation and Embryonic Survival in Loggerhead Sea Turtle Eggs. *The Journal of Wildlife Management, 80*(3), 430-437. doi:10.1002/jwmg.1023

Barneich, J. A. (2004). Two Case Histories of Blast- & Traffic-Induced Vibrations on the Stability of Burrows of Endangered Sensitive Ground Dwelling Animals. *International Conference on Case Histories in Geotechnical Engineering 10*, (p. Paper No. 4.14).

Bauder et al. (2016). Bauder, J. M., Breininger, D. R., Bolt, M. R., Legare, M. L., Jenkins, C. L., ... & McGarigal, K. Seasonal variation in eastern indigo snake (Drymarchon couperi) movement patterns and space use in peninsular Florida at multiple temporal scales. *Herpetologica, 72*(3), 214-226.

Bird et al. (2004). Bird, B. L., Branch, L. C., & Miller, D. L. Effects of Coastal Lighting on Foraging Behavior of Beach Mice. *Conservation Biology, 18*(5), 1435–1439.

Bogan, et al. (2024). Bogan Jr, J. E., O'Hanlon, B. M., Steen, D. A., Horan, T., Taylor, R., Mason, A. K., ... & Elmore, M. Health assessment of free-ranging eastern indigo snakes (Drymarchon couperi) from hydrologic restoration construction sites in south Florida, USA. *The Journal of Wildlife Diseases, 60*(1), 39-51.

Bowles, A. E. (1995). Responses of Wildlife to Noise. In R. L. Gutzwiller (Ed.), *Wildlife and Recreationists: Coexistence Through Management and Research.* Washington D.C.: Island Press.

Bradley et al. (1990). Bradley, F., Book, C., & Bowles, A. E. *Effects of Low-Altitude Aircraft Overflights on Domestic Turkey Poults*. Report No. HSD-TR-90-034. U.S. Air Force Systems Command, Noise and Sonic Boom Impact Technology Program.

Breininger et al. (1995). Breininger, D. R., Larson, V. L., Duncan, B. W., Smith, R. B., Oddy, D. M., & Goodchild, M. F. Landscape patterns of Florida scrub jay habitat use and demographic success. *Conservation Biology, 9*(6), 1442-1453.

Breininger et al. (2011). Breininger, D. R., Bolt, M. R., Legare, M. L., Drese, J. H., & Stolen, E. D. Factors influencing home-range sizes of eastern indigo snakes in central Florida. *Journal of Herpetology, 45*(4), 484-490.

Breininger, D. R., & Smith, R. B. (1990). Waterbird use of coastal impoundments and management implications in east-central Florida. *Wetlands, 10*, 223-241.

CANA. (2024). *Sea Turtle Monitoring*. Retrieved from Canaveral National Seashore, National Park Service: https://www.nps.gov/cana/learn/nature/sea-turtle-monitoring.htm.

Carman et al. (2008). Carman, R. A., Jue, D. A., & Glickman, G. M. Vibration effects on laboratory mice during building construction. *The Journal of the Acoustical Society of America, 123*(5), 36-70.

Cornell University. (2025). *Bermuda petrel*. Retrieved from Cornell University, eBird: https://ebird.org/species/berpet.

Cypher et al. (2012). Cypher, B. L., Saslaw, L. R., Van Horn Job, C. L., Westall, T. L., & Madrid, A. Y. *Kangaroo rat population response to seismic surveys for hydrocarbon reserves*. California State University.

DAF. (1994). *Air Force Position Paper on Effects of Aircraft Overflights on Large Domestic Stock.* Department of the Air Force.

DoN. (2018). *Atlantic Fleet Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement.* Department of the Navy.

Ellis et al. (1991). Ellis, D. H., Ellis, E. H., & Mindell, D. P. Raptor Responses to Low-level Jet Aircraft and Sonic Booms. *Environmental Pollution, 74*, 53-83.

Enge, K. M., & Wood, K. N. (2002). A pedestrian road survey of an upland snake community in Florida. *Southeastern Naturalist, 1*(4), 365-380.

Epsmark, Y. (1972). Behavior reactions of reindeer exposed to sonic booms. *Deer, 2*(7), 800-802.

Erbe, C., & Thomas, J. (2002). *Exploring Animal Behavior Through Sound: Volume 1.* Switzerland: Springer Nature.

European Industrial Gases Association. (2017). *Environmental Impacts of Air Separation Units.* Brussels: Doc 94/17, revision of Doc 94/11.

FAA. (2020). *Final Environmental Assessment and Finding of No Significant Impact for SpaceX Falcon Launches at Kennedy Space Center and Cape Canaveral Air Force Station.* Federal Aviation Administration.

FAA. (2023). *Written Re-evaluation of the 2022 Final Programmatic Environmental Assessment for the SpaceX Starship/Super Heavy Launch Vehicle Program at the Boca Chica Launch Site in Cameron County Texas. November.*

FAA. (2024). *Draft Tiered Environmental Assessment for SpaceX Starship/Super Heavy Vehicle Increased Cadence at the SpaceX Boca Chica Launch Site in Cameron County, Texas. July.*

Falcy, M., & Danielson, B. (2013). A complex relationship between moonlight and temperature on the foraging behavior of the Alabama beach mouse. *Ecology, 94*(11), 2632–2637. doi:10.1890/13-0426.1

FRA. (2012). *High-Speed Ground Transportation Noise and Vibration.* Washington, DC: Federal Railroad Administration, U.S. Department of Transportation. DOT/FRA/ORD-12/15. Retrieved from https://railroads.dot.gov/sites/fra.dot.gov/files/fra_net/2680/20120220_FRA_HSR_NV_Manual_FINAL_102412.pdf.

FWC. (2024a). *Florida Panther Program: Description and Range.* Florida Fish and Wildlife Conservation Commission.

FWC. (2024b). *Crested Caracara (Caracara cheriway).* Florida Fish and Wildlife Conservation Commission.

FWC. (2024c). *Everglade Snail Kite (Rostrhamus sociabilis plumbeus).* Florida Fish and Wildlife Conservation Commission.

FWC. (2025a). *Florida's Whooping Cranes*. Retrieved from Florida Fish and Wildlife Conservation Commission: https://myfwc.com/research/wildlife/birds/whooping-crane/information/.

FWC. (2025b). *Florida Bonneted Bat*. Retrieved from Florida Fish and Wildlife Conservation Commission: https://myfwc.com/wildlifehabitats/profiles/mammals/bats/florida-bonneted-bat/.

FWC. (2025c). *Anastasia Island Beach Mouse*. Retrieved from Florida Fish and Wildlife Conservation Commission: https://myfwc.com/wildlifehabitats/profiles/mammals/land/anastasia-island-beach-mouse/.

FWC. (2025d). *Atlantic Salt Marsh Snake*. Retrieved from Florida Fish and Wildlife Conservation Commission: https://myfwc.com/wildlifehabitats/profiles/reptiles/snakes/atlantic-salt-marsh-snake/.

Goble et al. (2009). Goble, T. J., Møller, A. R., & Thompson, L. T. Acute high-intensity sound exposure alters responses of place cells in hippocampus. *Hearing Research, 253*(1-2), 52–59.

Goss-Custard et al. (2006). Goss-Custard, J. D., Triplet, P., Sueur, F., & West, A. D. Critical thresholds of disturbance by people and raptors in foraging wading birds. *Biological Conservation, 127*(1), 88-97.

Kepas et al. (2023). Kepas, M. E., L. O. Sermersheim, S. B. Hudson, A. J. J. Lehmicke, S. S. French, & L. M. Aubry. Behavior, stress and metabolism of a parthenogenic lizard in response to flyover noise. *Frontiers in Amphibian and Reptile Science, 1*, 1129253.

Kight et al. (2012). Kight, C. R., Saha, M. S., & Swaddle, J. P. Anthropogenic Noise is Associated with Reductions in the Productivity of Breeding Eastern Bluebirds (Sialia sialis). *Ecological Applications, 22*(7), 1989-1996. doi:https://doi.org/10.1890/12-0133.1

Liu et al. (2016). Liu, L., Shen, P., He, T., Chang, Y., Shi, L., Tao, S., ... & Wang, J. Noise induced hearing loss impairs spatial learning/memory and hippocampal neurogenesis in mice. *Scientific Reports, 6*(1), 20374. doi:10.1038/srep20374

Manci et al. (1988). Manci, K. M., Gladwin, D. N., Villella, R., & Cavendish, M. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis. Ft. Collins, CO: U.S. Fish and Wildlife Service National Ecology Research Center.

NASA. (2011). *Environmental Assessment for Launch of NASA Routine Payloads. August.*

NASA. (2019). *Final Environmental Assessment for the SpaceX Starship and Super Heavy Launch Vehicle at Kennedy Space Center (KSC).*

NASA. (2020). *Environmental Resources Document, John F. Kennedy Space Center.* National Aeronautics and Space Administration.

NASA. (2023). *Annual Report for the Black Rail Survey Project.*

NASA. (2024a). *Biological Opinion for the Kennedy Space Center SpaceX Roberts Road SpaceX Operations Facility, FWS Log #: 04EF1000-2019-0193 / 2023-0036318.*

NASA. (2024b). *Using Florida Scrub-Jay habitat quality and demography to inform management decisions, KSC, 2023 Annual Update Report.*

NASA. (2024c). *Seagrass Trends in the Banana River and Mosquito Lagoon at Kennedy Space Center, Florida, Annual Summary 2023.* NEMCON Environmental Monitoring (Unpublished Report).

NASA. (2024d). *Final Supplemental Environmental Assessment for the Roberts Road SpaceX Operations Area Expansion & Supporting Infrastructure on Kennedy Space Center.*

NASA. (2025a). *Florida Scrub-Jay Habitat Quality and Demography to Inform Management Decisions. NASA Environmental and Medical Contract Annual Summary Report for 2024 (unpublished).*

NASA. (2025b). *Monitoring the Distribution and Abundance of Florida Manatees (Trichechus mantatus latirostris) in Kennedy Space Center Waters Using Aerial Surveys.* NASA Environmental and Medical Contract Annual Summary Report for 2024 (unpublished report).

NASA and USFWS. (2024). *Non-Reimbursable Interagency Agreement Between NASA, John F. Kennedy Space Center, and the U.S. Department of the Interior, Fish and Wildlife Service for Use and Management of Property at the NASA, KSC, known as the Merritt Island National Wildlife Refuge.* National Aeronautics and Space Administration and United States Fish and Wildlife Service.

National Park Service. (2014). *Final General Management Plan/Environmental Impact Statement for Canaveral National Seashore, Florida.*

NMFS. (2022). *Programmatic Concurrence Letter for Launch and Reentry Vehicle Operations in the Marine Environment and Starship/Super Heavy Launch Vehicle Operations at SpaceX's Boca Chica Launch Site, Cameron County, TX.* Silver Spring, MD: National Marine Fisheries Service.

NMFS. (2025). *Conference and Biological Opinion on SpaceX Starship-Super Heavy Increased Launch Cadence and Operations in the North Atlantic Ocean, Gulf of Mexico, North Pacific Ocean, South Pacific Ocean, and Indian Ocean Authorized by the Federal Aviation Admin.* National Marine Fisheries Service.

NMFS and USFWS. (1991). *Recovery Plan for U.S. Population of Atlantic Green Turtle, Chelonia mydas.* National Marine Fisheries Service. Washington, DC: National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS and USFWS. (1992). *Recovery Plan for Leatherback Turtles, Dermochelys coriacea, in the U.S. Caribbean, Atlantic, and Gulf of Mexico.* National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS and USFWS. (1993). *Recovery Plan for the Hawksbill Turtle, Eretmochelys imbricata.* National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS and USFWS. (2007). *Green Sea Turtle (Chelonia mydas) 5-Year Review: Summary and Evaluation.* National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS and USFWS. (2008). *Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (Caretta caretta).* National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS and USFWS. (2011). *Bi-National Recovery Plan for the Kemp's Ridley Sea Turtle (Lepidochelys kempii).* National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS and USFWS. (2013a). *Hawksbill Sea Turtle (Eretmochelys imbricata) 5-Year Review: Summary and Evaluation.* National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS and USFWS. (2013b). *Leatherback Sea Turtle (Dermochelys coriacea) 5-Year Review: Summary and Evaluation.* National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS and USFWS. (2015). *Kemp's Ridley Sea Turtle (Lepidochelys kempii) 5-Year Review: Summary and Evaluation.* National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS and USFWS. (2023). *Loggerhead Sea Turtle (Caretta caretta) Northwest Atlantic Ocean DPS 5-Year Review: Summary and Evaluation.* National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NOAA Fisheries. (2025). *Sea Turtles*. Retrieved from National Oceanic and Atmospheric Administration Fisheries: https://www.fisheries.noaa.gov/sea-turtles.

O'Hanlon et al. (2023). O'Hanlon, B. M., J. E. Bogan, J. C. Godwin, M. Hoffman, L. L. Smith, H. C. Chandler, & B. L. Talley. Cryptosporidium serpentis surveillance in free-ranging snakes to inform a reintroduction strategy for the eastern indigo snake (Drymarchon couperi). *Journal of Wildlife Diseases, 59*(1), 176-180.

Ortega, C. (2012). Effects of Noise Pollution on Birds: A Brief Review of Our Knowledge. *Ornithological Monographs No. 74*, 6-22. Retrieved from https://doi.org/10.1525/om.2012.74.L6.

Reynolds et al. (2018). Reynolds, R. P., Yao, L., Garner, A., & Norton, J. N. Vibration in mice: A review of comparative effects and use in translational research. *Animal Models and Experimental Medicine, 1*, 116-124.

Rodriguez et al. (2019). Rodriguez, A., Arcos, J. M., Bretagnolle, V., Dias, M. P., Holmes, N. D., Louzao, M., ... & Chiaradia, A. Future directions in conservation research on petrels and shearwaters. *Frontiers in Marine Science, 6*, 94.

Rylander, R. (1974). The sonic boom—Effects on humans. *Sozial-und Präventivmedizin (International Journal of Public Health), 19*(3), 217-220.

Shannon et al. (1994). Shannon, S. G., Moran, A. W., & Mason, K. T. *Effect of Vibration Frequency and Amplitude on Developing Chicken Embryos. U.S. Army Aeromedical Research Laboratory Report No. 95-1.* Fort Rucker, AL: United States Army Aeromedical Research Laboratory.

SJRWMD. (2007). *Upper St. Johns River Basin Surface Water Improvement and Management (SWIM) Plan.* St. Johns River Water Management District.

SJRWMD. (2024). Land Cover Land Use 2020 Geospatial Open Data. St. Johns River Water Management District.

Slabbekoorn et al. (2018). Slabbekoorn, H., Dooling, R. J., & Popper, A. N. Man-made sounds and animals. In H. Slabbekoorn, *Effects of anthropogenic noise on animals* (pp. 1–22). Springer.

SLD 45, USFWS, and KSC. (2025). *Memorandum of Understanding between Space Launch Delta 45, U.S. Fish and Wildlife Service, and John F. Kennedy Space Center for Prescribed Burning on Merritt Island National Wildlife Refuge, Kenndedy Space Center, and Cape Canaveral Space Force Station.* KCA-4205 Rev C.

Smith et al. (1988). Smith, D. G., Ellis, D. H., & Johnston, T. H. Raptors and Aircraft. *Proceedings of the Southwest Raptor Management Symposium. National Wildlife Federation Technical Series 11*, 360-367. Washington, D.C.: R. L Glinski, B. Gron-Pendelton, M. B. Moss, M. N. LeFranc, Jr., B. A. Millsap, & S. W. Hoffman (Eds.).

SpaceX. (2024). *Vibration Monitoring Report--Draft Dune Data, Starship Super Heavy Launch March 14, 2024.*

Szczepaniak, W., & Møller, A. (1996). Evidence of neuronal plasticity within the inferior colliculus after noise exposure: a study of evoked potentials in the rat. *Electroencephalography and clinical Neurophysiology, 100*(2), 158–164.

Traylor-Holzer, K., & Lacy, R. C. (2025). *Population Viability Analysis for the Southeastern Beach Mouse (Peromyscus polionotus niveiventris).* Apple Valley, MN: IUCN Conservation Planning Specialist Group.

Troy et al. (2013). Troy, J. R., Holmes, N. D., Veech, J. A., & Green, M. C. *Using observed seabird fallout records to infer patterns of attraction to artificial light*. San Marcos, TX: Texas State University. Endangered Species Research.

USFWS. (1983). *Hawaiian Dark-Rumped Petrel and Newell's Manx Shearwater Recovery Plan.* U.S. Fish and Wildlife Service.

USFWS. (1986). *Wood Stork Recovery Plan.* U.S. Fish and Wildlife Service.

USFWS. (1993a). *Recovery Plan, Caribbean Roseate Tern (Sterna dougallii).* U.S. Fish and Wildlife Service.

USFWS. (1993b). *Recovery Plan for the Anastasia Island Beach Mouse (Peromyscus polionotus phasma) and Southeastern Beach Mouse (Peromyscus polionotus niveiventris).* Department of the Interior. Atlanta, GA: U.S. Fish and Wildlife Service.

USFWS. (1993c). *Recovery Plan, Atlantic Salt Marsh Snake (Nerodia clarkii taeniata).* U.S. Fish and Wildlife Service.

USFWS. (1996). *Piping Plover (Charadrius melodus) Atlantic Coast Population Revised Recovery Plan.* U.S. Fish and Wildlife Service.

USFWS. (1998). *Roseate Tern Northeastern Population Recovery Plan.* U.S. Fish and Wildlife Service.

USFWS. (1999). *South Florida Multi-Species Recovery Plan.* U.S. Fish and Wildlife Service.

USFWS. (2001). *Florida Manatee Recovery Plan, Third Revision.* U.S. Fish and Wildlife Service.

USFWS. (2007). *Wood stork (Mycteria americana) 5-Year Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2008a). *Short-Tailed Albatross Recovery Plan.* U.S. Fish and Wildlife Service.

USFWS. (2008b). *Merritt Island National Wildlife Refuge Comprehensive Conservation Plan.* U.S. Fish and Wildlife Service.

USFWS. (2009). *Florida Population of the Audubon's Crested Caracara (Polyborus plancus audubonii) = Northern Crested Caracara (Caracara cheriway) 5-Year Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2011). *St. Johns National Wildlife Refuge Comprehensive Conservation Plan.* U.S. Fish and Wildlife Service.

USFWS. (2017). *USFWS Biological Opinion for the Kennedy Space Center Master Plan.* Jacksonville, FL: U.S. Fish and Wildlife Service.

USFWS. (2018). *Recovery Outline for Florida Bonneted Bat (Eumops floridanus).* U.S. Fish and Wildlife Service.

USFWS. (2019a). *Section 7 Concurrence Letter for Kennedy Space Center SpaceX Starship and Super Heavy Program.*

USFWS. (2019b). *Kennedy Space Center SpaceX Operations and Florida Power and Light Solar Facility Biological Opinion (FWS Log No.: 04EF1000-2019-0193).* U.S. Fish and Wildlife Service.

USFWS. (2019c). *Species Status Assessment for the Eastern Black Rail (Laterallus jamaicensis jamaicensis).*

USFWS. (2019d). *Recovery Plan for the Endangered Everglade Snail Kite, Amendment 1.* U.S. Fish and Wildlife Service.

USFWS. (2019e). *Recovery Plan for the Florida Scrub Jay (Aphelocoma coerulescens).*

USFWS. (2019f). *Species Status Assessment, Florida Scrub-Jay (Aphelocoma coerulescens).* U.S. Fish and Wildlife Service.

USFWS. (2019g). *Amendment to the Hawaiian Dark-rumped Petrel and Newell’s Manx Shearwater Recovery Plan Amendment.* U.S. Fish and Wildlife Service.

USFWS. (2019h). *Florida Grasshopper Sparrow Recovery Plan, Revision 1.* U.S. Fish and Wildlife Service.

USFWS. (2019i). *Anastasia Island Beach Mouse (Peromyscus polionotus phasma) 5-Year Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2019j). *Southeastern Beach Mouse (Peromyscus polionotus niveiventris) 5-Year Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2019k). *Atlantic salt marsh snake (Nerodia clarkii taeniata) 5-Year Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2019l). *Species Status Assessment (SSA) Report for the Eastern Indigo Snake (Drymarchon couperi).* Atlanta, GA: U.S. Fish and Wildlife Service.

USFWS. (2019m). *Recovery Plan for the Eastern Indigo Snake, First Revision.* Atlanta, GA: U.S. Fish and Wildlife Service.

USFWS. (2019n). *Atlantic Salt Marsh Snake Five-Year Review: Summary and Evaluation.*

USFWS. (2020a). *Concurrence Letter from USFWS for SpaceX Falcon Launch Vehicles at Kennedy Space Center and Cape Canaveral Air Force Station.* U.S. Fish and Wildlife Service.

USFWS. (2020b). *Florida Scrub-Jay (Aphelocoma coerulescens) 5-Year Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2020c). *Piping Plover (Charadrius melodus) 5-year Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2020d). *Roseate Tern Northeastern North American Population (Sterna dougallii dougallii) 5-Year Review.* U.S. Fish and Wildlife Service.

USFWS. (2020e). *Species Status Assessment Report for the Rufa Red Knot (Calidris canutus rufa), Version 1.1.* U.S. Fish and Wildlife Service.

USFWS. (2020f). *Short-tailed Albatross (Phoebastria albatrus) 5-Year Review.* U.S. Fish and Wildlife Service.

USFWS. (2021a). *Standard Protection Measures for the Eastern Indigo Snake.* U.S. Fish and Wildlife Service.

USFWS. (2021b). *Carter's Mustard Five-Year Review: Summary and Evaluation.*

USFWS. (2021c). *Lewton's Polygala Five-Year Review: Summary and Review.*

USFWS. (2021d). *Band-rumped storm-petrel (Oceanodroma castro) Hawai'i Distinct Population Segment: 5-Year Review.* U.S. Fish and Wildlife Service.

USFWS. (2021e). *Recovery Outline for the Eastern Black Rail (Laterallus jamaicensis jamaicensis).* U.S. Fish and Wildlife Service.

USFWS. (2021f). *Rufa Red Knot (Calidris canutus rufa) 5-Year Review: Summary and Evaluation.* Galloway, NJ: U.S. Fish and Wildlife Service.

USFWS. (2021g). *Species Status Assessment Report for the Wood Stork (Mycteria americana).* U.S. Fish and Wildlife Service.

USFWS. (2021h). *Species Status Assessment Report for the Tricolored Bat (Perimyotis sublavus).* U.S. Fish and Wildlife Service.

USFWS. (2022a). *American Crocodile Five-Year Review: Summary and Evaluation.*

USFWS. (2022b). *Recovery Plan for 50 Hawaiian Archipelago Species.* U.S. Fish and Wildlife Service.

USFWS. (2022c). *Hawaiian petrel (Pterodroma sandwichensis) 5-year Review.*

USFWS. (2022d). *Species Status Assessment Report For the Red-cockaded Woodpecker (Picoides borealis) Version 1.4.* U.S. Fish and Wildlife Service.

USFWS. (2022e). *Roseate Tern Caribbean Population (Sterna dougallii dougalii) Status Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2022f). *Biological Opinion for SpaceX Starship/Super Heavy Launch Vehicle Program at the SpaceX Boca Chica Launch Site, Cameron County, Texas.*

USFWS. (2022g). *Species status assessment report for the red-cockaded woodpecker (Picoides borealis). Version 1.4.* Atlanta, GA: U.S. Fish and Wildlife Service.

USFWS. (2023a). *Black-capped Petrel (Pterodroma hasitata) Species Status Assessment Report, v. 1.3.*

USFWS. (2023b). *Everglade Snail Kite (Rostrhamus sociabilis plumbeus) 5-Year Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2023c). *USFWS Recovery Plan for the Rufa Red Knot (Calidris canutus rufa).*

USFWS. (2023d). *Florida grasshopper sparrow (Ammodramus savannarum floridanus) Status Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2024a). *Kennedy Space Center SpaceX Roberts Road Operations Facility Biological Opinion-Amendment (FWS Log Number: 04EF1000-2019-0193 / 2023-0036318).* U.S. Fish and Wildlife Service.

USFWS. (2024b). *Cahow or Bermuda Petrel (Pterodroma cahow) 5-Year Status Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2024c). *ʻAʻo (Newell's shearwater, Puffinus newelli) 5-year Review.*

USFWS. (2024d). *Piping Plover (Charadrius melodus) 5-Year Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2024e). *Monarch Butterfly (Danaus plexippus) Species Status Assessment Report, version 2.3.*

USFWS. (2024f). *West Indian Manatee (Trichechus manatus)*. Retrieved from U.S. Fish and Wildlife Service Environmental Conservation Online: https://ecos.fws.gov/ecp/species/4469#lifeHistory.

USFWS. (2024g). *Eastern Indigo Snake (Drymarchon couperi) 5-Year Status Review: Summary and Evaluation.* U.S. Fish and Wildlife Service.

USFWS. (2025a). *Black Creek Crayfish*. Retrieved from U.S. Fish and Wildlife Service: https://www.fws.gov/species/black-creek-crayfish-procambarus-pictus.

USFWS. (2025b). *Eastern Black Rail*. Retrieved from U.S. Fish and Wildlife Service: https://www.fws.gov/species/eastern-black-rail-laterallus-jamaicensis-jamaicensis.

USFWS. (2025c). *Florida Bonneted Bat*. Retrieved from U.S. Fish and Wildlife Service: https://www.fws.gov/species/florida-bonneted-bat-eumops-floridanus.

USFWS. (2025d). *Anastasia Island beach mouse (Peromyscus polionotus phasma)*. Retrieved from U.S. Fish and Wildlife Service: https://ecos.fws.gov/ecp/species/5522.

USFWS. (2025e). *Manatee*. Retrieved from U.S. Fish and Wildlife Service: https://www.fws.gov/species/manatee-trichechus-manatus.

USFWS. (2025f). *Atlantic salt marsh snake (Nerodia clarkii taeniata)*. Retrieved from U.S. Fish and Wildlife Service: https://ecos.fws.gov/ecp/species/7729.

USFWS and NMFS. (1998). *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act.* U.S. Fish and Wildlife Service and National Marine Fisheries Service.

USSF. (2023). *Space Launch Delta 45 (SLD 45) Integrated Natural Resources Management Plan (INRMP).* U.S. Space Force.

USSF. (2024). *Biological Assessment for the Falcon Operations at Space Launch Complex 40, Cape Canaveral Space Force Station.* United States Space Force.

USSF. (2025). *Draft Statistical Analysis for Vandenberg Western Snowy Plover.* United States Space Force. Prepared for Space Launch Delta 30, Vandenberg Space Force Base, California. March.

van der Kolk et al. (2020). van der Kolk, H., Krijgsveld, K. L., Linssen, H., Diertens, R., Dolman, D., Jans, M., ... & Van de Pol, M. Cumulative energetic costs of military aircraft, recreational and natural disturbance in roosting shorebirds. *Animal Conservation, 23*(4), 359-372.

Wilson, T. (2011). Effects of seismic exploration on pygmy rabbits. *Natural Resources and Environmental Issues, 17*(1), 43-46.