Federal Aviation Administration

Draft Tiered Environmental Assessment for SpaceX Starship/Super Heavy Vehicle Increased Cadence at the SpaceX Boca Chica Launch Site in Cameron County, Texas

July 2024

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AGENCIES: Federal Aviation Administration (FAA), lead federal agency; the National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), the U.S. Coast Guard (USCG), and the National Aeronautics and Space Administration (NASA), cooperating agencies.

This tiered Environmental Assessment (EA) is submitted pursuant to the following: Section 102(2)(C) of the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. 4321, et seq.); Council on Environmental Quality NEPA-implementing regulations (40 CFR Parts 1500 to 1508); Section 4(f) of the Department of Transportation Act (49 U.S.C. § 303); Section 106 of the National Historic Preservation Act (16 U.S.C. § 470); Executive Order 11988, *Floodplain Management*; DOT Order 5650.2, *Floodplain Management and Protection*; and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*.

DEPARTMENT OF TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION: The FAA is evaluating SpaceX's proposal to increase the cadence of the Starship/Super Heavy launch program at the Boca Chica vertical launch area (VLA) in Cameron County, Texas. SpaceX must obtain new license or modification of their existing vehicle operator license from the FAA to operate Starship/Super Heavy. Issuing a permit or license is considered a major federal action subject to environmental review under NEPA. This tiered EA evaluates the potential environmental impacts of activities associated with the federal action of modifying SpaceX's vehicle operator license (see Section 2.2 for a more detailed description). The completion of the environmental review process does not guarantee that the FAA will issue a license modification to SpaceX for the Proposed Action. SpaceX's license application must also meet FAA safety, risk, and financial responsibility requirements per 14 CFR Chapter III. The FAA's Federal Action also includes the FAA's issuance of temporary airspace closures.

PUBLIC REVIEW PROCESS: In accordance with the applicable requirements, the FAA initiated a public review and comment period for the tiered EA. The 30-day public comment period begins on July 29, 2024 and ends on August 29, 2024.

CONTACT INFORMATION: Questions regarding the tiered EA can be addressed to Ms. Amy Hanson, Environmental Protection Specialist, Federal Aviation Administration, 1902 Reston Metro Plaza, Reston, VA 20190; project email address SpaceXBocaChica@icf.com.

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

Responsible FAA Official:

_____ Date: _____

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ACRONYMS AND ABBREVIATIONS

FAA	Federal Aviation Administration
AHAs	Aircraft Hazard Areas
APE	Area of Potential Effects
BCO	Biological Conference Opinion
BMP	Best Management Practice
CDNL	C-weighted Day-Night Average Noise Level
CFR	Code of Federal Regulations
CO	Carbon Monoxide
CO2e	Carbon Dioxide Equivalent
dB	Decibels
DNL	Day-Night Average Sound Level
DOD	Department of Defense
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
F	Fahrenheit
FONSI	Finding of No Significant Impact
GHG	Greenhouse Gas
IWG	The Interagency Working Group on the Social Cost of Greenhouse Gases
KSC	Kennedy Space Center
LaMax	Maximum A-Weighted Noise Level
LNG	Liquified Natural Gas
LOC	Letter of Concurrence
LOX	Liquid Oxygen
LRGV NWR	Lower Rio Grande Valley National Wildlife Refuge
MGD	Million Gallons Per Day
MMPA	Marine Mammal Protection Act
MT	Metric Tons
NAQS	National Ambient Air Quality Standards
NAS	National Aerospace System
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NHL	National Historic Landmark
NMFS	National Marine Fisheries Service
NOTAM	Notice to Air Missions
NOTMAR	Notice to Mariners
NOx	Oxides of Nitrogen
NPS	National Park Service
OSHA	Occupational Health and Safety Administration
PA	Programmatic Agreement
PEA	Programmatic Environmental Assessment
psf	Pounds Per Square Foot
psi	Pounds Per Square Inch
ROD	Record of Decision
SEL	Sound Exposure Level
SH4	State Highway 4
SHA	Ship Hazard Area
SpaceX	Space Exploration Technologies Corporation
SWCA	SWCA Environmental Consultants
SWPPP	Stormwater Pollution Prevention Plan
TCEQ	Texas Council on Environmental Quality
TCMP	Texas Coastal Management Plan
TGLO	Texas General Land Office
THC	Texas Historical Commission
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TXDOT	Texas Department of Transportation
U.S.C.	United States Code
USCG	Unites States Coast Guard
USFWS	United States Fish and Wildlife Service
UTRGV	University of Texas Rio Grande Valley
VLA	Vertical Launch Area
VSFB	Vandenberg Space Force Base
WR	Written Re-Evaluation

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1. INTRODUCTION

The Federal Aviation Administration (FAA) is evaluating Space Exploration Technologies Corporation's (SpaceX) proposal to increase the launch and landing cadence of the Starship/Super Heavy launch vehicle at its existing Boca Chica Launch Site in Cameron County, Texas. SpaceX must obtain a new or license modification from the FAA in order to launch and land Starship and Super Heavy, and to use associated launch systems at a higher cadence than analyzed in the 2022 *Final Programmatic Environmental Assessment for the SpaceX Starship/Super Heavy Launch Vehicle Program at the SpaceX Boca Chica Launch Site in Cameron County, Texas* (PEA; FAA 2022). The FAA considers the issuance or modification of a license to be a major federal action under the National Environmental Policy Act of 1969, as amended (NEPA; 42 United States Code [U.S.C.] 4321, et seq.), and the Council on Environmental Quality (CEQ) NEPA-implementing regulations (40 Code of Federal Regulations [CFR] parts 1500–1508) and requires an environmental review.

The FAA is the lead federal agency for this Environmental Assessment (EA), which is tiered from the 2022 Final Programmatic Environmental Assessment for the SpaceX Starship/Super Heavy Launch Vehicle Program at the SpaceX Boca Chica Launch Site in Cameron County, Texas (FAA 2022). This tiered EA evaluates the potential environmental impacts of activities associated with the federal action of modifying SpaceX's vehicle operator license (see Section 2.2 for a more detailed description). The completion of the environmental review process does not guarantee that the FAA will issue a license modification to SpaceX for the Proposed Action. SpaceX's license application must also meet FAA safety, risk, and financial responsibility requirements per 14 CFR Chapter III.

The affected environment and environmental impacts of Starship/Super Heavy operations at the Boca Chica Launch Site were analyzed in the 2022 PEA. The FAA issued a Mitigated Finding of No Significant Impact (FONSI) and Record of Decision (ROD) based on the 2022 PEA on June 13, 2022. Subsequent to that decision, the FAA issued a WR in April 2023 that evaluated additional information concerning SpaceX's Starship/Super Heavy ocean landings and launch pad detonation suppression system (FAA 2023a). In November 2023, the FAA issued a WR that evaluated additional information about the operation of the deluge system, the addition of a forward heat shield to the Starship/Super Heavy vehicle, and the expansion of the area of potential effects for cultural resources (November 2023 WR; FAA 2023b). In March of 2024, the FAA issued a FONSI based on an EA tiered from the PEA evaluating the potential environmental impacts of the Starship's proposed landings in the Indian Ocean (FAA 2024a).

The proposed launch operations analyzed in the 2022 PEA consisted of launch and landing activities: up to five annual Starship launches, up to five annual Super Heavy launches (with Starship attached as the second stage of the launch vehicle), up to ten annual Starship landings, and up to five annual Super Heavy landings.

SpaceX is proposing to modify the Starship/Super Heavy operations described in the 2022 PEA as detailed below.

1.1. Background

The FAA issued the 2022 PEA, which analyzed the potential environmental impacts of constructing launch-related infrastructure and operating the Starship/Super Heavy launch vehicle at the Boca Chica Launch Site. SpaceX's operations include launches originating from this site, as well as landings at this site, in the Gulf of Mexico, in the Pacific Ocean (near Hawaii), or in the Indian Ocean. The 2022 PEA analyzed up to

five annual Starship launches, up to five annual Super Heavy launches (with Starship attached as the second stage of the launch vehicle), up to ten annual Starship landings, and up to five annual Super Heavy landings.

Since the publication of the 2022 PEA, SpaceX has decided to no longer launch Starship by itself and has instead launched Starship/Super Heavy from the Boca Chica Launch Site in April and November 2023, and March and June 2024. While maturation of the vehicle has eliminated the need for suborbital test flights, SpaceX continues to iterate Starship/Super Heavy operations based on data collected through continued launches and attempted landings. Starship/Super Heavy is designed to be a fully reusable rocket capable of rapid flight rate (meaning minimal time between launches). Frequent launches and landings in the early phase of the program are critical in developing Starship/Super Heavy's rapid launch capability because it allows for iterative testing of the core design that supports a rapid flight rate. To achieve this need, SpaceX is proposing to increase the number of Starship/Super Heavy orbital launches and landing operations per year to continue to develop the vehicle's flight-rate capability.

This EA analyzes the impacts of the activities associated with SpaceX's proposal to increase launch and landing cadence. This EA tiers from the 2022 Final PEA, which analyzed the construction of the launch site and less frequent operations (including launches and landings) of the Starship/Super Heavy launch vehicle program in Boca Chica, Texas. The operations considered in this tiered EA include up to 25 annual Starship/Super Heavy orbital launches, up to 25 annual landings of Starship, up to 25 annual landings of Super Heavy, and vehicle upgrades. All launches considered in this tiered EA would originate from the Boca Chica Launch Site; landings could occur at this site, on a floating platform or expended in the Gulf of Mexico, in the Pacific Ocean (near Hawaii) and in the southeast Pacific, or in the Indian Ocean. Depending on the operational phase of the program, for landings at sea, both Starship and Super Heavy could have: (1) a hard landing at terminal velocity and break up on impact resulting in an explosive event at the surface of the water (2) a soft water landing and tip over and sink or explode on impact at the surface of the water and (3) breakup during reentry resulting in debris falling into the ocean. As mentioned previously, increased flight rate is critical to continually develop the core design of the launch vehicle, which is rapid reusability. The launch and landing operations analyzed in the 2022 PEA and in this tiered EA are summarized in Table 1.

Table 1 Comparison of Activities in the 2022 PEA and Current Proposed Action

Activity	2022 PEA Proposed Action	Current Proposed Action
Starship Static Fire Engine Test[a]	• 150 seconds	• 90 seconds (daytime)
Super Heavy Static Fire Engine Test[a]	• 135 seconds	• 70 seconds (daytime)
Starship Suborbital Launch	• 5 (4 daytime/1 nighttime)	• 0
Super Heavy Launch	• 5 (4 daytime/1 nighttime)	• 25 (24 daytime/1 nighttime)
Starship Landing	• 10 (2 daytime/8 nighttime) • Starship landing at the VLA, on a floating platform in the Gulf of Mexico or the Pacific Ocean, or expended in the Gulf of Mexico or Pacific Ocean	• 25 (24 daytime/1 nighttime) • Starship landing at the VLA, on a floating platform or expended in the Pacific Ocean or Indian Ocean

Activity	2022 PEA Proposed Action	Current Proposed Action
Super Heavy Landing	• 5 (4 daytime/1 nighttime) • Super Heavy landing at the VLA, on a floating platform in the Gulf of Mexico, or expended in the Gulf of Mexico	• 25 (24 daytime/1 nighttime) • No change in landing locations
Nominal Operational Access Restrictions	• SpaceX anticipates the proposed operations would require 500 hours of annual access restriction	• No change
Anomaly Response Access Restrictions	• If an anomaly occurred, SpaceX anticipates debris clean-up would require up to 300 hours of annual access restriction	• No change

Notes: [a] Static fire engine tests are an activity requiring a license from the FAA if the Autonomous Flight Termination System is functionally installed prior to the activity.
Daytime refers to 7:00 a.m. to 7:00 p.m., nighttime refers to 7:00 p.m. to 7:00 a.m.

1.2. Federal Agency Roles

1.2.1. Federal Aviation Administration

As the lead federal agency, the FAA is responsible for analyzing the potential environmental impacts of the Proposed Action. The Commercial Space Launch Act of 1984, as amended and codified at 51 U.S.C. 50901–50923, authorizes the Secretary of Transportation to oversee, license, and regulate commercial launch and reentry activities, and the operation of launch and reentry sites within the United States or as carried out by U.S. citizens. Section 50905 directs the Secretary to exercise this responsibility consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States. In addition, Section 50903 requires the Secretary to encourage, facilitate, and promote commercial space launches and reentries by the private sector. As codified at 49 CFR § 1.83(b), the Secretary has delegated authority to carry out these functions to the FAA Administrator.

The regulatory requirements pertaining to commercial launches and individual launch operators are described in 14 CFR Chapter III, Parts 400–460. SpaceX is the exclusive user of the Boca Chica Launch Site. Therefore, SpaceX is not required to apply for and obtain a launch site operator license for that site.

The FAA is also responsible for creating airspace closure areas in accordance with FAA Order 7400.2P, *Procedures for Handling Airspace Matters*, to ensure public safety.

1.2.2. Cooperating and Participating Agencies

The following agencies accepted the FAA's request to participate in the NEPA process as cooperating agencies due to their special expertise or jurisdiction by law over the launch facility or maritime environment: the National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), the U.S. Coast Guard (USCG), and the National Aeronautics and Space Administration (NASA). An agency has "special expertise" if it has statutory responsibility, agency mission, or related program experience regarding a proposal (40 CFR § 1508.1(nn).

The NPS provides special expertise with respect to historic properties, including National Historic Landmarks (NHLs) and National Historic Parks. The Palmito Ranch Battlefield NHL (referred to as the "NHL" in this EA) and the Palo Alto Battlefield National Historical Park are located approximately 3 and 19 miles, respectively, from the Boca Chica Launch Site. There are also other historic properties located near the launch site.

The USFWS provides special expertise with respect to threatened and endangered species and national wildlife refuges. There is suitable habitat, including federally designated critical habitat, for species listed under the Endangered Species Act (ESA) located near the Boca Chica Launch Site. The Lower Rio Grande Valley National Wildlife Refuge (LRGV NWR) is located adjacent to the launch site.

The USCG provides special expertise with respect to providing maritime safety and security during launch operations.

NASA provides special expertise with respect to potential environmental impacts from space launches and the operation of a launch site. NASA also has special expertise and interest in the operation of reusable suborbital and orbital launch vehicles through its programs, which are intended to help foster the development of the commercial reusable suborbital and orbital space transportation industry. Additionally, NASA uses Space Act Agreements and contracts, as well as competitions to promote technology development and demonstration. NASA's partnerships with commercial suppliers and private enterprises are expanding such that NASA may have a direct or indirect contribution to a commercial or government payload. For these reasons, NASA requested to be a cooperating agency in the development of this EA.

The FAA also invited the Texas Parks and Wildlife Department (TPWD), Texas Historical Commission (THC), Texas General Land Office (TGLO), and Texas Department of Transportation (TxDOT) to be participating agencies due to the location of the launch site relative to state-managed properties and due to special expertise of the agencies. These agencies participated in the NEPA process through activities such as attending project calls and reviewing and providing comments on administrative versions of this tiered EA.

1.3. Purpose and Need

The purpose of SpaceX's proposed action is to provide greater mission capability to NASA and the Department of Defense (DOD). SpaceX's activities would continue to fulfill the U.S. expectation that increased capabilities and reduced space transportation costs will enhance exploration (including within the Artemis and Human Landing System programs), support U.S. national security, and make space access more affordable. The Space Transportation section of the National Space Transportation Policy of 1994 addressed the commercial launch sector, stating that "assuring reliable and affordable access to space through U.S. space transportation capabilities is a fundamental goal of the U.S. space program." Additionally, the 2021 Space Priorities Framework's Mission states, "The United States will bolster the health and vitality of our space sectors – civil, commercial, and national security – for the benefit of the American people and leverage that strength to lead the international community in preserving the benefits of space for future generations" (White House 2021).

SpaceX's proposed action is needed to facilitate frequent launch and landing operations to allow iterative development of Starship/Super Heavy vehicles to achieve rapid launch capability and increase operational efficiency, capabilities, and cost effectiveness of the Starship/Super Heavy program. Satisfaction of these

needs benefit government and public interests and reduces operational costs. Public interests largely intersect with the government interests identified, including greater mission capability for space exploration and advancing reliable and affordable access to space which in turn advances the scientific and national security benefits of the U.S. space program as a whole. Demand for launch services has continued to increase over the past 20 years, and the space industry's growth projections indicate this will continue into the foreseeable future. By providing a reusable launch vehicle that returns to its launch site, the proposed action would reduce the cost of launch and increase efficiency, delivering greater access to space and enabling cost-effective delivery of cargo and people to the Moon and Mars. SpaceX's proposed action would satisfy requirements for more efficient and effective space transportation methods and continue the U.S. goal of encouraging activities by the private sector to strengthen and expand U.S. space transportation infrastructure.

1.4. Documents Incorporated by Reference

As indicated in 40 C.F.R. § 1501.12, agencies shall incorporate relevant material into environmental documents by reference when the effect is to cut down on bulk without impeding agency and public review of the action. Accordingly, the following documents are incorporated by reference:

- FAA. 2014a. Final Environmental Impact Statement SpaceX Texas Launch Site. Volume I, May 2014. (As incorporated by FAA. 2022).
- FAA. 2014b. Final Environmental Impact Statement SpaceX Texas Launch Site. Volume II-Appendices, May 2014. (As incorporated by FAA. 2022).
- FAA. 2022. Final Programmatic Environmental Assessment for the SpaceX Starship/Super Heavy Launch Vehicle Program at the SpaceX Boca Chica Launch Site in Cameron County, Texas. June. (Incorporates by reference FAA. 2014a and FAA. 2014b)
- FAA. 2023a. 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. Starship/Super Heavy Vehicle Ocean Landings and Launch Pad Detonation Suppression System. April.
- FAA. 2023b. 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. Starship/Super Heavy Deluge System Operation, Addition of a Forward Heat Shield Interstage, and Expansion of the Area of Potential Effects for Cultural Resources. November.
- FAA. 2024. Tiered Environmental Assessment for SpaceX Starship Indian Ocean Landings. March.
- NASA. 2019. Environmental Assessment for the SpaceX Starship and Super Heavy Launch Vehicle at Kennedy Space Center (KSC)
- NMFS (National Marine Fisheries Service). 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. January.

- NMFS. 2023a. Concurrence Letter for the Endangered Species Act Section 7 Consultation for FAA's Proposed Licensing of SpaceX Starship/Super Heavy Early Developmental Phase Launch and Reentry Operations for First Three Flights in the Gulf of Mexico and North Pacific Ocean. April.
- USFWS. 2022. Final Biological and Conference Opinion of the SpaceX Starship/Super Heavy Launch Vehicle Program at the Boca Chica Launch Site in Cameron County Texas.
- USFWS. 2023. Addendum to the 2022 Biological and Conference Opinion.

1.5. Other Licenses, Permits and Approval

The FAA has identified the following additional environmental approvals for SpaceX proposal, but others may be required.

- **Endangered Species Act (ESA).** In accordance with ESA Section 7, the FAA reinitiated consultation with USFWS and NMFS. NMFS concurred with the FAA's determination that the Proposed Action may affect, and is likely to adversely affect ESA-listed species and critical habitat under NMFS jurisdiction and conducted formal consultation with NMFS. The final EA will include the results of this consultation. The FAA determined the Proposed Action may affect and is likely to adversely affect ESA-listed species and critical habitat under USFWS jurisdiction and is conducting additional formal consultation with the USFWS. The final EA will include the results of this consultation. The prior Biological Conference Opinion (BCO) and 2023 Addendum to the BCO issued by USFWS, concluded the Proposed Action is not likely to jeopardize the continued existence of any federally listed species or adversely modify designated critical habitat. The prior BCO and Addendum contain Reasonable and Prudent Measures and associated Terms and Conditions to avoid, minimize, and mitigate the effects on listed species and critical habitat.

- **Magnuson-Stevens Fishery Conservation and Management Act.** The FAA determined there may be temporary adverse effects to Essential Fish Habitat (EFH), particularly in the event of launch failure involving the spread of debris. The FAA consulted NMFS regarding potential adverse effects to EFH, and NMFS provided Conservation Recommendations pursuant to 50 CFR § 600.920, which SpaceX and the FAA have agreed to implement as stated in the 2022 PEA and FONSI/ROD.

- **Marine Mammal Protection Act (MMPA).** The FAA evaluated the MMPA-protected marine mammals that have the potential to be disturbed during ocean landing operations. SpaceX would coordinate with NMFS prior to any landing activity that may impact species protected under MMPA. Additionally, SpaceX is coordinating with NMFS for an Incidental Harassment Authorization (IHA) for MMPA and, if deemed necessary by NMFS, will obtain an IHA prior to landing activities that may impact MMPA species.

2. DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

2.1. Proposed Action

The FAA's federal action is to modify SpaceX's existing vehicle operator license to authorize SpaceX's proposed action to increase the cadence of the Starship/Super Heavy launch program (see Section 1.1) at the Boca Chica vertical launch area (VLA) in Cameron County, Texas to up to 25 annual launches and 50

total annual landings (25 of the Starship and 25 of the Super Heavy), and make vehicle and operational upgrades identified below in Table 2. Up to one launch (of the total 25) would occur during nighttime hours from the VLA. SpaceX would also conduct up to 90 seconds of licensed daytime Starship static fire tests and 70 seconds of licensed daytime Super Heavy static fire tests a year. The federal action also includes the FAA's issuance of temporary airspace closures.

The following aspects of SpaceX's operations remain unchanged and are assessed by the existing environmental documentation supporting the program:

- Pre-flight Operations (Section 2.1.3.2 of the PEA)
- Nominal Operational Access Restrictions (Section 2.1.3.5 of the PEA)
- Personnel Levels (Section 2.1.3.6 of the PEA)
- Anomalies (Section 2.1.3.7 of the PEA)

The FAA's authority under the Commercial Space Launch Act only extends to licensed launch activities. Additional activities in and around the Boca Chica Launch Site, such as production and manufacturing, engine, stage, and tank testing that are not within the scope of the license and will occur regardless of whether a license is issued are not included in this analysis. The effects of such activities are considered as part of the environmental baseline and the cumulative effects analysis.

2.2. Launch Operations

Since the publication of the 2022 PEA, SpaceX has changed the location of Pad B within the VLA as described in the 2022 PEA. Figure 1 shows the new location of Pad B with Orbital Launch Mount 2. The Orbital Launch Mount 2 is a subset of the area described in the 2022 PEA as Pad B. SpaceX plans to expand the VLA into the full SpaceX owned parcel, as contemplated in the 2022 PEA, which will require permitting under Section 404 of the Clean Water Act in order to fill jurisdictional wetlands. Operations on Pad B for FAA-licensed activity would remain as previously analyzed in the 2022 PEA. SpaceX proposes to increase Starship/Super Heavy operations as described in Table 1. As Starship/Super Heavy continues to iterate towards rapid reusability, SpaceX is proposing potential launch vehicle modifications, including increasing thrust of both the Starship and Super Heavy vehicles that are pertinent to the impact analysis. Launch vehicle upgrades are summarized in Table 2.

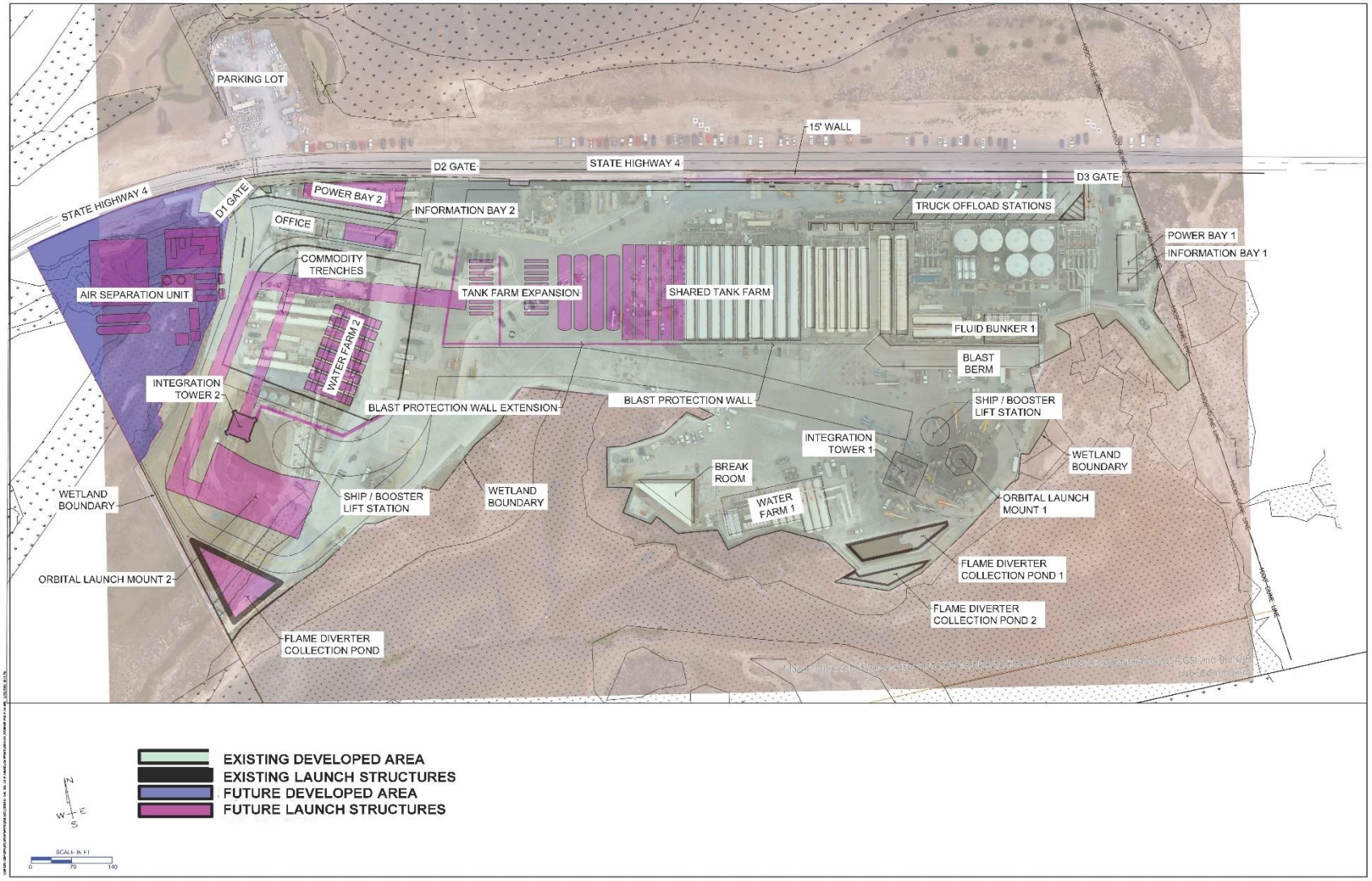

Figure 1 **Current Vertical Launch Area Layout**

Table 2. Launch Vehicle Specifications

Specification	2022 PEA Starship	2022 PEA Super Heavy	Upgraded Starship	Upgraded Super Heavy
Length (meters; m)	50	71	70	80
Diameter (m)	9	9	9	9
Number of Engines	6	37	9	35
Thrust	12 MN	74 MN	28.7 MN	103 MN
Propellant quantity (metric ton; MT)	1,500	3,700	2,650	4,100

As described in the 2022 PEA, Starship/Super Heavy missions would continue to include lunar and Mars missions and satellite payload missions. Approved trajectories would be based on specific launch vehicle performance and characteristics and would satisfy 14 CFR Part 400 regulations.

As Table 2 details, the upgrades to Starship/Super Heavy will increase the amount of thrust produced by the vehicle. The 2022 PEA assumed the heat plume generated from Starship/Super Heavy orbital launches would travel away from the existing Orbital Launch Mount 1 at the launch pad (described as Pad A in the 2022 PEA), with temperatures of about 300 degrees Fahrenheit (°F) reaching the edge of the VLA[1], 212°F approximately 0.3 mile from the launch mount, and temperatures reaching ambient temperature (90°F) approximately 0.6 mile from the launch mount.[2] The heat plumes and increased temperatures would only occur during engine ignition and dissipate within 30 to 60 seconds. However, the data collected from two flights showed the plume extending approximately 0.2 to 0.3 miles (SpaceX 2024a, 2024b), less than half of what was analyzed in the 2022 PEA. Additionally, SpaceX measured the temperature during the third launch event at five locations- 0.2, 0.4, 0.6, 0.8, and 1 mile from the launch mount. At 0.2 miles from the launch mount, a temperature change from ambient temperature (72°F)) to a maximum of 90°F was recorded 30 seconds after engine ignition and stayed at 90°F for five seconds before decreasing. No changes from ambient temperature were recorded at any other location. Conservatively assuming linear scaling of temperature from the increased thrust, based on the data recorded from flight 3, the heat plume would be anticipated to reach 90°F at 0.28 miles from the launch mount. Even with the increased thrust, SpaceX anticipates the plume to be less than what was analyzed in the 2022 PEA. However, this tiered EA retains the same assumptions as a conservative approach for this analysis.

SpaceX plans to add additional water tanks to the site to store the increased quantities of water, increasing the maximum volume of water from 361,000 gallons to 422,000 gallons, and would operate the deluge system during a Super Heavy landing at the VLA. SpaceX may use up to the maximum amount of deluge water per Super Heavy static fire, launch, or landing under the Proposed Action[3]. During a Super Heavy landing at the VLA, the deluge system would be reactivated and would run for approximately 30 seconds. At this time, Starship landings at the VLA are not anticipated to require deluge water. Brownsville Public Utilities Board is contemplating the installation of a public water line from Brownsville to Boca Chica that will remove trucks transporting water along State Highway 4 (SH 4). Site groundwater quality is unsuitable for use due to high levels of total dissolved solids (FAA 2022 pp.108). The additional volume is to facilitate

[1] For context, the existing launch mount is located approximately 125 feet from the edge of the VLA, and the new launch mount site is located approximately 150 feet from the existing edge of the VLA.

[2] These temperature and distance estimates do not consider a deluge system, which may decrease estimates.

[3] During flights two and three, during which the deluge system was operated, 180,0000 gallons of water was applied during each launch.

recycling of applied and recaptured water, provide water for cooling the launch mount deck after vehicle lift-off, and suppress sound. Refer to the Biological Assessment in Appendix A for additional analysis of the increase in trucks due to the Proposed Action.

SpaceX is not proposing any additional operational access restrictions as described in the 2022 PEA and would continue to adhere to the terms outlined in Section 2.1.3.5 of the 2022 PEA. In the beginning of the program, SpaceX estimated needing approximately 500 hours of temporary access restrictions annually for nominal operations. However, since the 2022 PEA, SpaceX has dramatically reduced the duration of operations and the number of access restrictions through engineering analysis and improvements. There has been an 85% reduction in the number of access restrictions from Flight 1 to Flight 3. Additionally, a majority of the testing that required access restrictions has been moved to SpaceX's Massey's Test Site, approximately 4 miles away from the VLA, and will not require SH 4 access restrictions from this location. SpaceX is expected to need less than 20 hours of access restrictions per launch campaign, including landings, but retains the same assumptions concerning access restrictions for a conservative analysis. Please refer to Section 3.2.6 for additional details.

2.3. Landings

SpaceX proposes to increase Starship/Super Heavy landings from up to 10 annual Starship landings and up to 5 annual Super Heavy landings to up to 25 Super Heavy landings and up to 25 Starship landings annually.

SpaceX plans to land the reusable Super Heavy and Starship back on land at the VLA or on floating platforms in the ocean. As SpaceX continues to develop the capability to perform a return to launch site landing of Super Heavy and the Starship, some vehicles may not be reused and are instead expended in the ocean in the following three conditions depending on the stage of development of the program:

1. Hard water landing at terminal velocity and break up on impact resulting in an explosive event at the surface of the water;

2. Soft water landing and tip over and sink or explode on impact at the surface of the water; or

3. In-flight breakup – Breakup during reentry resulting in debris falling into the ocean (up to 25 times per year of each vehicle stage).

Of the above scenarios, SpaceX anticipates no more than 20 explosive events at the surface of the water for each vehicle for the life of the program. These scenarios would occur within the first five years of the program.

SpaceX currently lands Super Heavy in the Gulf of Mexico and Starship in the Pacific Ocean (near Hawaii) and the Indian Ocean. SpaceX is proposing to expand the potential landing sites of Starship. Super Heavy would land on a droneship or continue to be expended in the Gulf of Mexico (Figure 2). Starship could land on a droneship (floating platform) or be expended in any of the four landing areas: the Indian Ocean (Figure 3), the Pacific Ocean (near Hawaii) and the northeast Pacific Ocean (Figure 4), or the southeast Pacific Ocean (Figure 5). The droneship operations and specifications were assessed in the 2022 PEA and 2022 NMFS consultation (NMFS 2022).

Since publication of the November 2023 WR, SpaceX is now proposing to jettison the forward heat shield between 1 and 400 kilometers offshore in the Gulf of Mexico. Once the forward heat shield interstage is

jettisoned from the vehicle, it stays fairly close to the vehicle until it enters the atmosphere, after which gradually drifts slightly away from the vehicle and is expected to typically land three to four km downrange of the landing location. It is anticipated that future improvements to the Starship/Super Heavy vehicles will enable SpaceX to no longer jettison the forward heat shield, therefore this action is anticipated to be temporary and is anticipated to take place approximately 20 times.

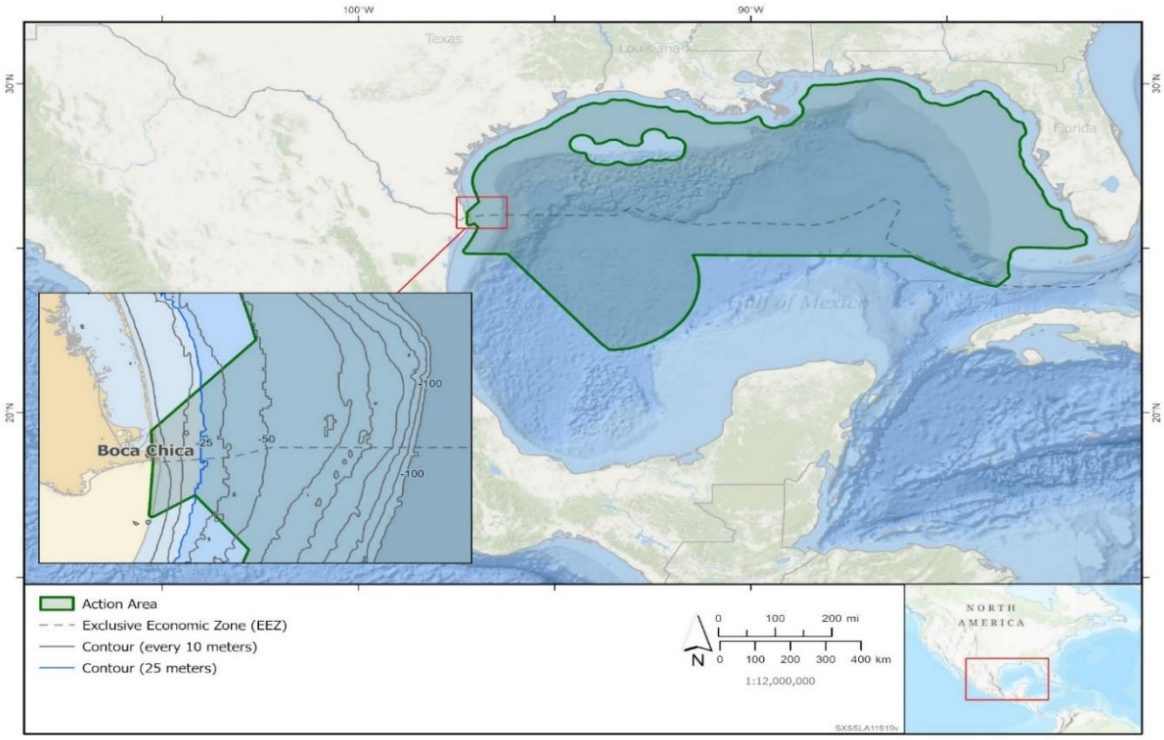

Figure 2 Gulf of Mexico Super Heavy Landing Area and Nominal Landing Location

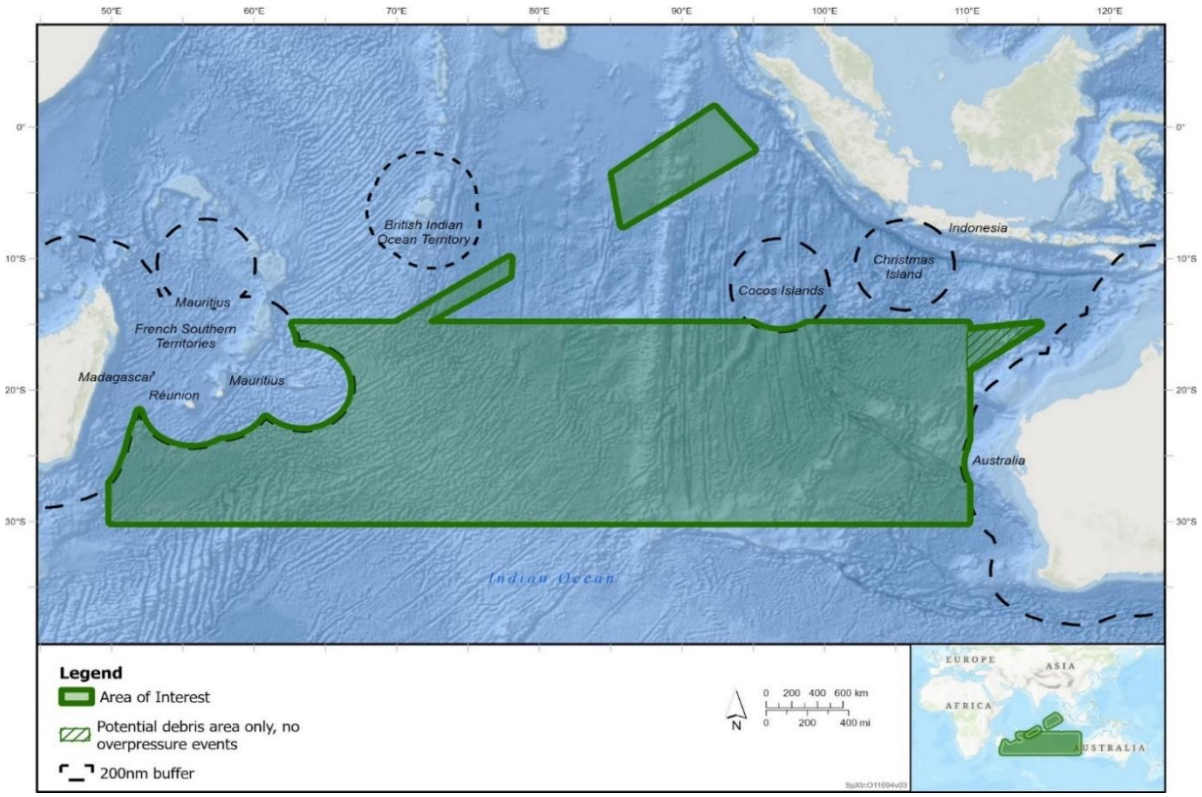

Figure 3 Indian Ocean Starship Landing Area

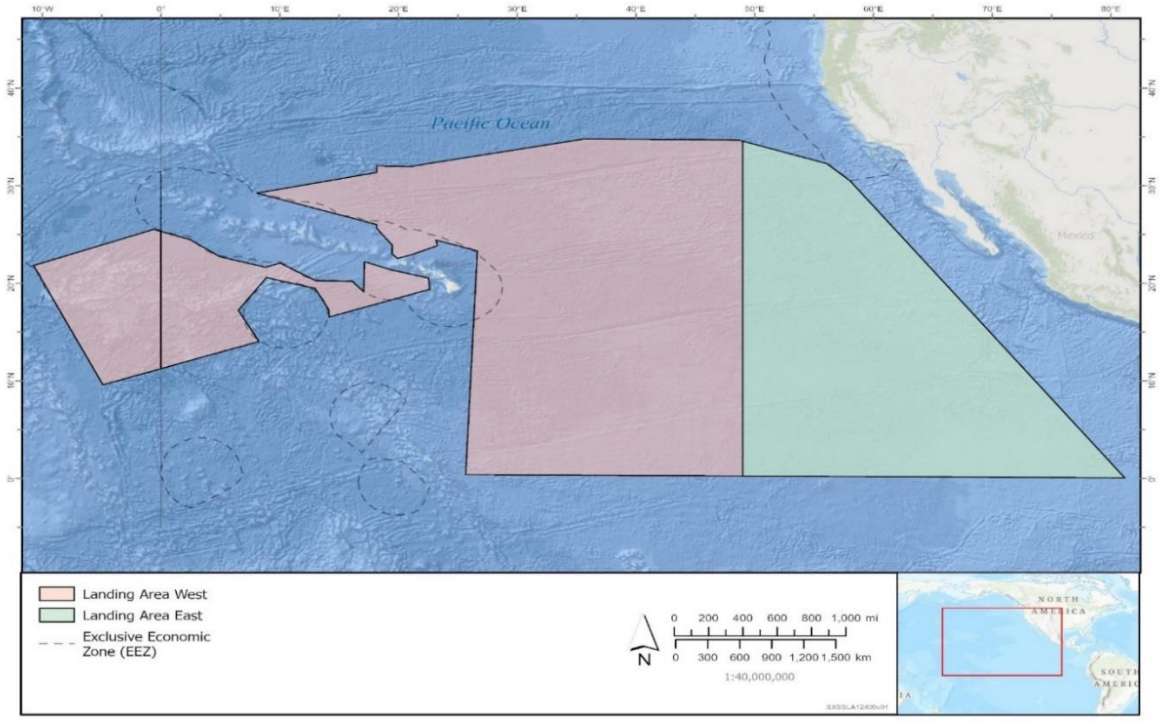

Figure 4 Northeast Pacific Starship Landing Area and Pacific Ocean (near Hawaii) Starship Landing Area

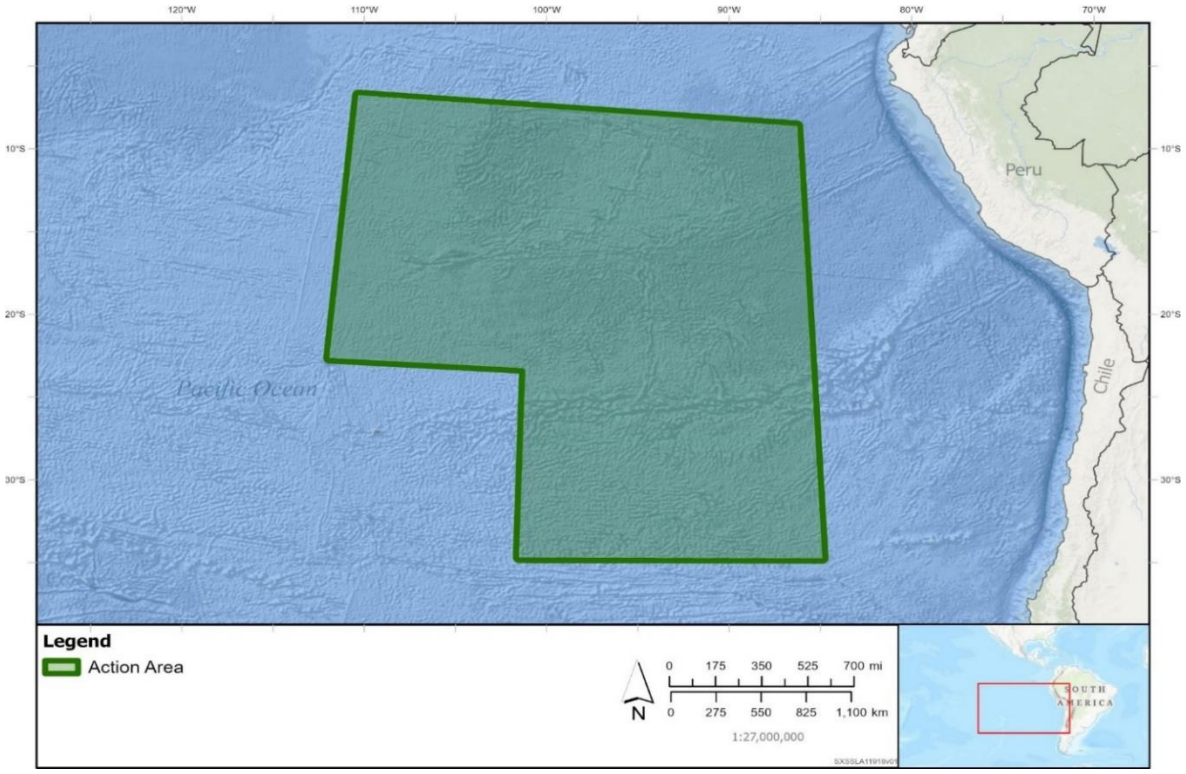

Figure 5 Southeast Pacific Starship Landing Area

Consistent with the 2022 PEA, landings that occurred downrange on a floating platform would continue to be delivered by barge to the Port of Brownsville and transported the remaining distance to the Boca Chica Launch Site over roadways.

Under the Proposed Action, remaining propellant on both Starship and Super Heavy would increase over the amounts previously assessed. Up to approximately 101 metric tons (MT) of residual propellant is projected to remain on the Starship launch vehicle for downrange landing, including expenditures. Up to approximately 74 MT of residual propellant is projected to remain on the Super Heavy vehicle for downrange landing, including expenditures.

2.4. Airspace Closures

In Section 2.1.3.5 of the 2022 PEA, the FAA concluded that the Proposed Action would not require the FAA to alter the dimensions (shape and altitude) of the airspace to accommodate the then Proposed Action, comprising 5 suborbital launches, 5 orbital launches, and 10 reentries annually. The FAA also concluded in 2022 that temporary closures of existing airspace may be necessary to ensure public safety during the proposed operations. As of the date of this Draft EA, SpaceX has implemented the 2022-contemplated Proposed Action twice in 2023 and twice in 2024. The FAA temporarily closed airspace to permit these operations.

The FAA Air Traffic Organization Space Operations Office completed a generic National Aerospace System (NAS) impact analysis in accordance with the FAA "Notice of Updated Factors for Optimizing Use of the National Aerospace System," dated April 13, 2023. This analysis was generic because SpaceX has yet to

identify potential dates for its launch and landing operations. However, based on past practice, the FAA concluded that it would similarly expect to close existing airspace to permit SpaceX to launch or land the Starship/Super Heavy vehicles contemplated in this Proposed Action.

SpaceX proposes to increase the number of launch and reentry operations at the Site as set forth in Section 2.1. The FAA Air Traffic Organization Space Operations Office uses the Aircraft Hazard Area information (described in Section 2.1.3.5 of the 2022) to produce an airspace management plan, which describes the launch/reentry information and analyzes the effects of each operation on airspace efficiency, capacity, and any other associated impacts to the National Aerospace System from each licensed launch and reentry operation and is disseminated to the operators and various impacted ATO facilities. This information helps the FAA determine whether the proposed launch or reentry (programmatically or individually) would result in an unacceptable limitation on air traffic. If that were the case, the FAA would work with the operator to identify appropriate mitigation strategies, such as shortening the requested launch/reentry window, shifting the launch/reentry time if possible. The FAA may also approve fewer launch or reentry operations, shorter launch and reentry windows, dates for such operations that fall outside of prioritize operations with a national security purpose, or require shorter launch and retry windows or only approve launch or reentry dates that fall outside of seasonal travel patterns. The FAA often provides data to launch operators to avoid operations during days with high aviation traffic volume and identifies times with minimal impact to the NAS, such as overnight hours between 2:00 a.m. and 9:00 a.m. CT. FAA acknowledges, however, that while these operating windows would minimize disruption to the NAS, they are likely to increase disruptions to the non-traveling public in the vicinity of the proposed launch or landing operations and increase the potential likelihood that FAA's approval of the proposal would result in significant noise impacts. See Section 3.2.3 for more information.

The FAA manages the airspace for all users. While in prior analyses, including Section 2.1.3.5 of the 2022 PEA, FAA concluded that most commercial space launch operations result in minor or minimal impacts on commercial and private users of airspace, the FAA has analyzed the impact expected to occur with the Proposed Action and has determined, based on data obtained from the 4 launches that occurred from the Boca Chica, TX launch site, that these disruptions would be more than minor or minimal. Temporary closure of airspace would be expected to result in rerouted traffic patterns for aircraft to avoid these AHAs.

2.5. Waterway Closures

All landing operations would comply with necessary notification requirements, including issuance of NOTMARs by the USCG, as defined in agreements required for a vehicle operator license issued by the FAA. A NOTMAR provides a notification regarding a temporary hazard within a defined area (a Ship Hazard Area [SHA]) to ensure public safety during proposed operations. A NOTMAR itself does not alter or close shipping lanes; rather, the NOTMAR provides a notification regarding a temporary hazard within a defined area to ensure public safety during the proposed operations.

2.6. Selection Standards and Criteria

The FAA's authority with respect to SpaceX's license application is stated in Section 1.2.1. SpaceX's purpose and need are identified in Section 1.3. CEQ defines "reasonable alternatives" as those "that are

technically and economically feasible and meet the purpose and need for the proposed action." (40 C.F.R. §1508.1(hh)). To meet the purpose and need of the Starship/Super Heavy launch program, SpaceX presented to the FAA certain criteria that the action alternatives must meet. FAA reviewed and approves the use of these criteria:

1. Ability to meet necessary launch rate/frequency demanded by DOD and NASA contractual obligations by 2025, including the Human Landing System and Rocket Cargo contracts.

2. Ability to support both low Earth orbit and geostationary transfer orbit trajectories. To reach these trajectories, the launch site must have the ability to support launches towards the east to avoid a "dogleg," a bent trajectory which severely compromises the performance to orbit.

3. Location must be at a low latitude in order to maximize the payload mass that the launch vehicle can place into orbit.

4. Ability to provide geographic diversity from existing or proposed launch facilities in Florida to diversify risk and operations. Geographical diversity is necessary to allow the program to continue to operate/exist/provide capability if one site is disabled (e.g., terrorist attack, natural disaster, vehicle anomaly). SpaceX must diversify risk and operations by operating from multiple locations located in different geographic regions.

2.7. Alternatives Considered but Eliminated from Further Analysis

Using the criteria above, SpaceX dismissed Vandenburg Space Force Base (VSFB) based on criteria 2 and 3. SpaceX also evaluated its existing facilities at KSC, a new launch site on CCSFS, and the Boca Chica Launch Site, for reasonableness. However, SpaceX dismissed these launch sites from detailed review based on the following reasons.

- Existing Facilities on CCSFS (LC-39A): The existing launch pad at LC-39A does not currently support the technological improvements that are required for continued development of the Starship/Super Heavy development program and would need to undergo upgrades as well as the FAA/NASA NEPA process prior to operation of the site. The FAA published a Notice of Intent to prepare an EIS on May 10, 2024. Additionally, If LC-39A was not available due to a hurricane, fire, anomaly, or other event, SpaceX would require another location to ensure the Starship/Super Heavy program can continue to operate, including from the required trajectories and latitudes, as outlined above.

- New Launch Site on CCSFS (SLC-37 or SLC-50): SLC 37 is under lease agreement until the end of 2024 by a third party. SLC-50 is currently undeveloped. Either of these sites would need to undergo the FAA/Department of the Air Force NEPA process, design, and development to accommodate construction of a Starship/Super Heavy launch and landing pad. The FAA would have to issue an Environmental Impact Statement (EIS) prior to establishing lease agreements for SpaceX from the U.S. Space Force. It is anticipated that it would take until late 2025 for the Department of the Air Force to issue a ROD. Thus, SpaceX could not begin constructing until late 2025 and would need meet the criteria listed above for the Proposed Action.

2.8. No Action Alternative

Under the No Action Alternative, the FAA would not modify a license to SpaceX to allow for increased launch and landing cadence from the Boca Chica launch site. As assessed in the 2022 PEA and subsequent Written Re-evaluations (WR), SpaceX could conduct up to five annual Starship and up to five annual Super Heavy launches (with Starship attached as the second stage of the launch vehicle), up to ten annual Starship landings, and up to five annual Super Heavy landings. The Starship/Super Heavy launch vehicles would not be modified and would remain the same as assessed in the 2022 PEA.

Under the No Action Alternative, there would be no new impacts on the environmental impact categories analyzed in this EA. The no-action alternative provides the basis for comparing the environmental consequences of the Proposed Action.

3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.1. VLA

The VLA is located on SpaceX-owned land in Cameron County, Texas, near the cities of Brownsville and South Padre Island. The site is located in a sparsely populated coastal area adjacent to the Gulf of Mexico, characterized by marsh and barrier island plant communities, shallow open water, algal flats, and unvegetated tidal flats. The VLA is surrounded by Boca Chica State Park and is adjacent to the LRGV NWR. The larger area includes several private and public industries, including the SpaceX production and manufacturing facility, the Port of Brownsville, liquified natural gas (LNG) facilities at the Port of Brownsville, the City of Port Isabel, San Roman Wind Farm, and developments on South Padre Island. Boca Chica Village includes support infrastructure such as housing, restaurants, and offices used in connection with SpaceX's production and manufacturing facility near Boca Chica Village, as well as some private houses not affiliated with SpaceX.

For almost all environmental resource categories, the affected environment near the VLA remains the same as discussed in the 2022 PEA. While the number of orbital launches and landings authorized by the license would change, the spatial extent of impacts from each orbital launch/landing would generally be the same as in the 2022 PEA. The geographic extent of modeled noise contours did slightly increase under the Proposed Action due to the increase in thrust and updated modeling for sonic booms caused by landings at the VLA; the impact on this extended noise area is incorporated into resource analyses as applicable.

3.2. Issues Evaluated in this EA

The analysis in this tiered EA is focused on the environmental impact categories with the potential to be affected by an increase in launch cadence, and changes to the launch vehicles, including: air quality; biological resources (terrestrial and marine wildlife); climate; cultural resources; Department of Transportation Section 4(f); hazardous materials; land use; natural resources and energy supply; noise and noise-compatible land use; socioeconomics, environmental justice, and children's health; visual resources; and water resources. There are no potential impacts that could affect farmlands or wild and scenic rivers; therefore, these environmental impact categories are not analyzed in this EA.

3.2.1. Air Quality

Air quality impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA and would not be significant. The 2022 PEA concluded that operational activities would not significantly impact air quality. Based on emission estimates under the scenario considered in the 2022 PEA, emissions of oxides of nitrogen (NOx) and carbon monoxide (CO) were both found to be under the conformity de minimis threshold. Additionally, Cameron County, Texas, was at the time designated as being in attainment for all criteria pollutants. As a result, the project as proposed in the 2022 PEA would not have been subject to a conformity analysis had emissions of any criteria pollutant exceeded the de minimis threshold. Based on the estimated emission rates, it was determined that the project would not contribute to an exceedance of the National Ambient Air Quality Standards (NAAQS). The Texas Commission on Environmental Quality (TCEQ) has adopted the NAAQS as promulgated by the U.S. Environmental Protection Agency (EPA). As a result, no Texas ambient air quality standards were expected to be exceeded by the project.

A comparison of estimated emissions associated with the Proposed Action to the 2022 PEA, as well as a comparison to the conformity de minimis thresholds are provided in Table 3.

Table 3. Proposed Action Emission Rates Compared to 2022 PEA Emission Rates

Emission Generating Activity	2022 PEA Estimated Emissions (tons/year)		Proposed Action Estimated Emissions (tons/year)		Difference of Proposed Action Estimated Emissions vs 2022 PEA Estimated Emissions (tons/year)	
	CO	NOx	CO	NOx	CO	NOx
Starship/Super Heavy Launches	6.60	14.37	34.99	76.22	28.39	61.85
Starship Suborbital Launches	0.93	2.02	0	0	-0.93	-2.02
Starship Landings	0.65	1.41	2.42	5.27	1.77	3.86
Super Heavy Landings	0.68	1.48	3.39	7.38	2.71	5.90
Starship Static Test Fires	1.35	2.95	1.04	2.28	-0.31	-0.67
Super Heavy Static Test Fires	5.75	12.52	3.16	6.88	-2.59	-5.64
Total	**15.96**	**34.75**	**45.00**	**98.03**	**29.04**	**63.28**
Conformity de minimis Threshold	100	100	100	100	100	100

* Emission estimates in the 2022 PEA were based on up to five (5) Starship/Super Heavy launches, five (5) Starship suborbital launches, ten (10) Starship landings, five (5) Super Heavy landings, 150 seconds of Starship static test fires, and 135 seconds of Super Heavy static test fires. Additionally, Starship emissions were estimated assuming that it would employ up to six (6) raptor engines, and Super Heavy was expected to be equipped with up to 37 Raptor engines. The Proposed Action includes up to twenty-five (25) Starship/Super Heavy launches, twenty-five (25) Starship landings, twenty-five (25) Super Heavy landings, 90 seconds of Starship static test fires, and 70 seconds of Super Heavy static test fires. Additionally, the number of engines per vehicle is being increased to up to nine (9) Raptor engines on the Starship and decreased to thirty-five (35) Raptor engines on the Super Heavy.

Estimated emission rates for CO and NOx are below the de minimis thresholds, with estimated rates of 45 and 98 tons per year of CO and NOx, respectively. Ambient air quality in Cameron County remains relatively unchanged since 2022, with the county still being designated as being in attainment for all criteria pollutants. As a result, general conformity is not applicable to the Proposed Action.

According to the 2020 Annual Emission Inventory (EPA 2023a), total emissions for Cameron County totaled 47,424.7 and 4,829.2 tons per year for CO and NOx, respectively. Emission estimates indicate that the increase in emissions due the Proposed Action would account for approximately 0.1% of CO emissions

and 0.21% of NOx emissions on an annual basis. The Proposed Action is not expected to contribute to an exceedance of the NAAQS.

Hazardous air pollutants from mobile sources, known as mobile source air toxics, are described in the 2022 PEA. Sources of mobile source air toxics would be similar to those assessed in the 2022 PEA, including from vehicles and non-road equipment. The vessels and boat used during SpaceX's operations would likely vary in age and have a range of emission controls. SpaceX anticipates that recovery equipment and vehicles would be operated for approximately five days for each launch with a recovery and would produce negligible ambient pollutant emissions in a widely dispersed area. Hazardous air pollutants from the combustion of fossil fuel, which is the cause of emissions from mobile sources, are emitted in quantities anywhere from one to three orders of magnitude less than criteria pollutant emissions from these sources. Because of the small scale of the emissions and the context of the minimal mobile source operations required by the Proposed Action, hazardous air pollutant emissions are not considered for the mobile sources in this analysis but are considered for ground processing activities.

The Federal Highway Administration considers projects to have a low potential for effect for mobile source air toxics when design year traffic is below 140,000 – 150,000 vehicles per day (Federal Highway Administration 2023). The increase in truck traffic associated with the Proposed Action would be substantially lower than these volumes, and Cameron County is an attainment area for all pollutants (EPA 2023). This project would not result in meaningful increases in mobile source air toxic impacts. Moreover, EPA regulations for vehicle engines and fuels will cause overall mobile source air toxic emissions to decline significantly over the next several decades. Accordingly, emissions from vehicular traffic would have low potential effects from mobile source air toxics and are not assessed quantitatively.

Similar to the 2022 PEA, it is expected that airspace restrictions linked to the Proposed Action could lead to increased emissions from aircraft due to rerouting and greater fuel consumption. Any resulting aircraft departure delays from impacted airports would be of short duration. Consequently, any increase in emissions from aircraft kept on the ground would likely be insubstantial. Moreover, it is probable that grounded planes would not keep their engines running during anticipated delays, further reducing potential emissions. Hence, it is not anticipated that these increased emissions would be significant, and they would not surpass the NAAQS standards for any specific pollutants. Emissions from rerouted aircraft would take place above 3,000 feet (within the mixing layer) and are unlikely to influence the surrounding air quality.

During all landing attempts, SpaceX expects residual Liquid Oxygen (LOX) and methane to remain on Starship during descent and landing. Unlike other launch vehicle propellants and fuels, LOX and methane are not hazardous air pollutants and residual LCH4 and LOX would be vented to the atmosphere following the landing. After landing and safing, the breakover fixture assembly (controlled supported drop from vertical to horizontal) of the Starship would commence. Because of the small scale of the emissions and the context of the minimal mobile source operations required by the Proposed Action, air pollution emissions are not expected to have a significant impact on Air Quality.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant air quality impacts.

3.2.2. Climate

Climate impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA. The PEA determined that greenhouse gas (GHG)

emissions would not be considered significant and would not contribute to any appreciable addition of GHGs into the atmosphere. Similarly, GHG emissions associated with the Proposed Action would not be considered to be significant or contribute to any appreciable addition of GHGs into the atmosphere. A summary of the carbon dioxide equivalent (CO2e) emission rates associated with the Proposed Action compared to the 2022 PEA is provided in Table 4.

Table 4. Proposed Action GHG Emission Rates Compared to 2022 PEA GHG Emission Rates

Summary Table	2022 PEA CO2e Total (metric tons)	Proposed Action CO2e Total (metric tons)	Increase in Emissions Over 2022 PEA (metric tons/year)
Starship Launches[1]	393	0	-393.00
Starship/Super Heavy Launches	16,650	58,450	47,781
Starship Landings	273	928	750
Super Heavy Landings	573	1,300	859
Starship Static Test Fires	573	401	-131
Super Heavy Static Test Fires	2,430	1,212	-1,094
Methane Venting	23,000	35,051	9,157
Total	**43,892**	**97,342**	**56,928**

[1] The Proposed Action is not seeking authorization for suborbital Starship launches, where the 2022 PEA authorized up to five a year (FAA 2022). This resulted in a net decrease in emissions for this activity.

GHG emissions due to truck traffic (including from construction and transport of commodities and water) would not result in meaningful increases in GHGs. Moreover, EPA regulations for vehicle engines and fuels will cause overall vehicle GHG emissions to decline significantly over the next several decades. Accordingly, GHG emissions from truck traffic would have low potential effects from mobile source air emissions and are not assessed quantitatively.

The Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) is comprised of multiple U.S. federal agencies which estimate the social cost of greenhouse gases. This metric assigns a monetary value to the long-term damages caused by the emission of carbon dioxide, methane, and nitrous oxide emissions, considering their impacts on climate change, public health, ecosystems, and the economy. The IWG published the "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990" in 2021. Table 5 provides the social cost of GHGs for the Proposed Action over ten years based on the Interim Estimates under Executive Order 13990. The social cost of carbon from the Proposed Action would be offset by the benefits of the program, including the economic and job creation benefits of U.S. competitiveness in the global launch market and the enabling of new business opportunities in space that will be made possible by those same advancements in space access. Additionally, in order to support efforts to increase the affordability of the program, SpaceX plans to continue developing technology to recycle and otherwise minimize releases of greenhouse gases.

Table 5. Social Cost of GHGs Based on Interim Estimates Under Executive Order 13990

Year	Social Cost of CO2 per metric ton (3% discount rate)
2024	$55
2025	$56
2026	$57
2027	$58
2028	$60
2029	$61
2030	$62
2031	$63
2032	$64
2033	$65
2034	$66

It is important to note that the FAA has not set a significance threshold for climate, nor has it pinpointed specific factors to consider when determining the significance of GHG emissions. Currently, there are no universally accepted methods to determine significance for commercial space launch projects due to their minimal contribution to global GHG emissions. As such, FAA guidance will evolve in line with the maturing science or if new federal mandates are introduced. To provide context, the Proposed Action's annual GHG emission rates are compared to the annual GHG emission rates for the world, the United States, and the state of Texas in terms of CO2e in Table 6.

Table 6. Proposed Action GHG Emission Rates Compared to 2022 PEA GHG Emission Rates

Summary Table	Annual CO2e Emission Rates (metric tons/year)
World[1]	3.29×10^{10}
United States[2]	5.75×10^{9}
State of Texas[2]	7.92×10^{8}
Total Proposed Action Increase in CO2e Emissions	**97,342**

[1] International Energy Agency 2022.

[2] EPA 2023b. Values presented here represent gross CO2e values for the reporting year 2021.

Based on the values presented in Table 6, the Proposed Action would account for less than 0.0003% of worldwide GHG emissions, approximately 0.002% of US GHG emissions, and approximately 0.012% of the State of Texas GHG emissions, on an annual basis.

Airspace closures associated with the Proposed Action would lead to increased emissions from airplanes. This is mainly because planes would need to take pre-established alternative flight routes, which themselves are assessed by the FAA under NEPA. This would result in the usage of more fuel. Increases in GHG emissions would result from the additional fuel usage. While rerouting would be a short-lived scenario for affected planes, the emissions from each launch, considering the number of planes impacted, would not be substantial enough to notably influence the climate. Additionally, since the 2022 PEA,

airspace closures are becoming more efficient. SpaceX and the FAA have also established a corridor approach for aircraft during Starship/Super Heavy launches that keeps more air routes open, so that less aircrafts are rerouted.

Based on the above findings, the data and analyses are consistent with those discussed in the 2022 PEA, and the Proposed Action would not result in significant impacts to climate change.

3.2.3. Noise and Noise-Compatible Land Use

Noise and noise-compatible land use impacts, taking into account the new information related to the Proposed Action, would be different than those discussed in the 2022 PEA. The 2022 PEA contemplated the noise associated with Starship/Super Heavy orbital launches and landings, ultimately determining that no residents or members of the public would experience noise above Occupational Safety and Health Administration's (OSHA's) 115-dBA threshold[4] for the maximum A-weighted noise contours during an orbital launch and there was no significant risk of structural damage (See Section 3.5.4 of the PEA). A discussion of other noise data affected by the Proposed Action associated with static fire engine tests, launches, landings, and potential for structural damage is provided below, and an updated Noise Assessment for the Proposed Action is provided in Appendix B.

3.2.3.1. Static Fire Engine Tests

The 2022 PEA evaluated a scenario where Starship and Super Heavy static fire engine tests would occur with up to 6 and 37 engines, respectively. The 2022 PEA found that the Maximum A-Weighted Noise Level (L_{Amax}) 90 dB contour for a Starship static fire engine test would extend approximately 2.5 miles to the west of the launch site, while the Sound Exposure Level (SEL) 90 dBA contour would extend approximately 7 miles to the west of the launch site, including some populated areas of Port Isabel and South Padre Island. The L_{Amax} 90 dB contour for a Super Heavy static fire engine test would extend approximately 4 miles to the west of the launch site, while the SEL 90 dBA contour would extend approximately 10 miles to the west of the launch site. Contours extended further to the east of the launch site due to sound propagation over water, though no human noise receptors are present in that direction. The 2022 PEA determined that intermittent and temporary static fire tests would not result in significant noise impacts.

Updated static fire engine testing noise modeling results for the increased thrust of the Raptor engines indicate that the 90 dB L_{Amax} contours would increase slightly, while the SEL contours would decrease due to improvements in modeling. The modeling indicates that the 90 dB L_{Amax} contour for a Starship static fire engine test would extend approximately 3.5 miles to the west of the launch site, an increase of about 1 mile, while the SEL 90 dBA contour would extend approximately 6 miles to the west of the launch site, a decrease of about 1 mile. The updated noise modeling results also indicate that the L_{Amax} 90 dB contour for a Super Heavy static fire engine test would extend approximately 4.5 miles to the west of the launch site, an increase of approximately 0.5 miles, while the SEL 90 dBA contour would extend approximately 8 miles to the west of the launch site, a decrease of approximately 2 miles. The Proposed Action would slightly increase the area located within the 90 dB L_{Amax} contours to include additional area near the VLA. Though the noise levels would increase slightly from the increase in thrust, the noise from static fires

[4] Chapter 11 of the FAA Order 1050.1F Desk Reference (FAA 2024b) states the FAA should evaluate whether the Occupational Safety and Health Administration (OSHA) hearing damage criteria from 29 CFR § 1910.95 and the National Academy of Sciences' guidelines for structural damage (National Academy of Sciences 1977) may be exceeded for a project. Guidelines on permissible noise exposure limits from OSHA (OSHA 2020) are designed to protect human hearing from long-term, continuous exposures to high noise levels and aid in the prevention of noise-induced hearing loss.

would continue to be infrequent due to the limited duration of these tests and it is not anticipated that the Proposed Action would result in significant noise impacts. The 2022 PEA determined there would be no significant impacts due to noise from static fires. SpaceX is proposing to reduce licensed static fire time for both Starship and Super Heavy, resulting in less frequent impacts described in the 2022 PEA.

3.2.3.2. Launch (Takeoff) Noise

The 2022 PEA found that the higher L_{Amax} contours (100–140 dBA) extended up to approximately 7 miles from the launch site. Portions of South Padre Island, Port Isabel, Laguna Vista, eastern Brownsville, and eastern Tamaulipas, Mexico, were anticipated to experience L_{Amax} levels of 90-100 dBA. During daytime operations with background noise levels ranging from 50 to 60 dBA, residents of Brownsville and Harlingen were modeled to perceive launch noise levels reaching 70 to 90 dBA. 2022 PEA SEL contour levels also ranged from 90 dBA to 150 dBA for each orbital launch. If the same launch occurs during the night, when background levels are lower than during the day (e.g., below 40 dB to 50 dB range), these residents may notice launch noise levels that exceed 60 dB. A prevailing onshore or offshore breeze may also influence noise levels in these communities. The 100 dBA SEL contour extended west into Brownsville and south into Tamaulipas, Mexico, while the 90 dBA SEL contour extended further west and north into Harlingen and Raymondville, and further southwest into Tamaulipas, Mexico.

The 90 dBA L_{Amax} contour for launch operations in the 2022 PEA overlapped Brazos Island State Park, Boca Chica State Park, portions of the NHL, parts of the LRGV NWR, Isla Blanca Park on South Padre Island, and Boca Chica Village. Isla Blanca Park is not within the access restriction area and visitors at Isla Blanca Park during a launch were expected to experience close to 100 dBA during an orbital launch and closer to 90 dBA during a suborbital launch. Due to the intermittent and temporary nature of noise level resulting from launches, however, noise impacts were deemed to be not significant.

Following the launches of the Starship/Super Heavy from Boca Chica, SpaceX collected noise data which was used to verify and improve the noise modeling efforts completed in the 2022 PEA. The data collected showed the modeling results were within the predicted modeling results in the 2022 PEA.

Updated noise modeling for the Proposed Action, which includes vehicle thrust increase, indicates that the higher L_{Amax} contours (100–140 dBA) would extend up to approximately 8 miles from the launch site. Port Isabel, parts of South Padre Island, and parts of Tamaulipas, Mexico are expected to experience L_{Amax} levels of 100 to 110 dBA, while Laguna Vista and parts of eastern Brownsville are expected to experience L_{Amax} levels of 90 to 100 dBA. The rest of South Padre Island and parts of Tamaulipas, Mexico, are expected to experience L_{Amax} levels of 90 to 100 dBA.

Proposed Action SEL contour levels range from 90 dBA to 150 dBA for each orbital launch. The 2022 PEA determined that the 100 dBA SEL contour from launches would extend approximately 45 miles from the launch site, while the 90 dBA SEL contour would extend approximately 25 miles from the launch site. Under the Proposed Action, the 100 dBA SEL contour is anticipated to extend approximately 8 miles west into Brownsville and south into Tamaulipas, Mexico, while the 90 dBA SEL contour is anticipated to extend further west and north into Harlingen, and further southwest into Matamoros, Mexico, to a total of approximately 15 miles from the launch site. Due to improved accuracy of the dBA SEL modeling, the contours for the Proposed Action are smaller than those analyzed in the 2022 PEA, accordingly, significant noise impacts are not expected. Although the frequency of noise impacts is higher than what was presented in the 2022 PEA, an increase from 10 launch events to 25 launches would still be considered intermittent, temporary, and infrequent over the course of a year. As stated above, no residents or

members of the public will experience noise above OSHA's 115-dbA threshold during an orbital launch. Accordingly, significant noise impacts are not expected.

3.2.3.3. Landings

The 2022 PEA presented modeled sound levels for Super Heavy booster and Starship landings at the VLA during orbital missions. For Super Heavy landings, Port Isabel was modeled to experience an approximately 90 dB L_{Amax}, and the southern portion of South Padre Island was modeled to experience approximately 90–95 dBA. All other populated areas were modeled to experience 90 dBA or below. For Starship orbital landings at the VLA, the 2022 PEA indicated that a portion of Port Isabel and the southern part of South Padre Island would experience 90 dB L_{Amax}. Residents of Brownsville were expected to possibly hear noise levels above 60 dBA, but noise during offshore Super Heavy or Starship landing events was not expected to be noticed by residents along the coast.

Based on the Proposed Action's updated noise modeling for Super Heavy landings at the VLA, the southern portions of Port Isabel and South Padre Island are expected to experience between a 90 and 100 dB L_{Amax}. All other populated areas are expected to experience 90 dBA or below. For Starship landings, the 90 dB L_{Amax} contour extends about 6 miles from the VLA. Residents of Port Isabel may hear Starship landing events above 60 dB, particularly during nighttime landings. The 115 dB Lamax contour, which is used as a conservative limit for hearing conservation, is located approximately 1 mile from the landing pad and does not contain private residences. Although the updated modeling indicates that landings would be slightly louder than modeled in the 2022 PEA, these differences would be small and would not be meaningfully noticeable. The noise from landings would be short in duration. As described in the 2022 PEA, noise from landings is expected to last approximately one minute, with the peak exposure for a single location lasting approximately 20 seconds. The Super Heavy booster would land approximately 10 minutes after launch, and the timing of Starship landings would vary based on the mission. The noise between launches and landings would be spread out over time, and landing noise would not result in significant impacts.

3.2.3.4. Cumulative Noise

For the Proposed Action, cumulative noise levels were estimated for projected launch, landing, and static fire test operations at the VLA using the Day-Night Average Sound Level (DNL) metric. FAA's threshold of project-related noise change is measured in DNL. This calculation does not include noise from sonic booms from landing events. Cumulative noise from sonic booms is discussed in 3.2.3.5 below. Noise from nighttime landings receives a DNL 10 dBA penalty. DNL is intended to measure the effect of cumulative sound on humans and accounts for the time of day during which the noise occurs, how long the noise lasts, how loud it is, and the frequency with which it occurs. For the Proposed Action, the DNL 65 contour for the Proposed Action is located within about 4 miles of the VLA entirely in areas that are unpopulated, except for Boca Chica Village. SpaceX would enforce the access restriction area during launch operations, as discussed in the 2022 PEA (FAA 2022 Section 2.1.3.5). Thus, no visitors or village residents would be present at noise sensitive areas within the 4-mile radius and the proposed project changes would not result in significant noise impacts.

3.2.3.5. 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. A sonic boom trace is an impulsive event that lasts for less than 300 milliseconds. A sonic boom is generated during vehicle ascent, but it would not impact land areas. A sonic boom would also be generated during orbital Starship/Super Heavy launches and Starship and Super

Heavy landings as the vehicle approaches the landing location. SpaceX used PCBOOM to estimate single event sonic boom levels during Starship and Super Heavy descent. SpaceX's sonic boom analysis via PCBOOM is located in Appendix B. Sonic boom modeling contours are approximate and actual exposure at any particular location or time during a sonic boom event can vary depending on a number of different atmospheric, physical, and operational parameters.

Starship/Super Heavy Orbital Launches

Sonic boom impacts from Starship/Super Heavy launches are consistent with the information contained within the 2022 PEA, Section 3.5.4.6.

Super Heavy Booster Landings

Updated sonic boom modeling for the booster landings under the Proposed Action predict overpressure events of 15 psf and 21 psf in areas located within the area where only SpaceX personnel are allowed during launches (public hard checkpoint[5]). Boca Chica Village is within the public hard checkpoint, which is evacuated during launch/landing activities. The predicted overpressure for the area surrounding the public hard checkpoint indicate overpressure events up to 15 psf, with contours extending just beyond the U.S. / Mexico Border[6]. Predicted overpressure levels at the southern portion of South Padre Island and Port Isabel, Tarpon Bend, as well as northeast regions of Tamaulipas, Mexico would be expected to reach 10 psf. The 6 psf sonic boom contour is predicted to extend approximately 10 miles from the launchpad, and encompass portions of South Padre Island, all of Port Isabel, Laguna Heights, and portions of Laguna Vista. Portions of northeastern Tamaulipas, Mexico, including La Burrita and El Conchillal, would also be encompassed in the 6 psf sonic boom contour. The 4 psf boom contour is expected to extend approximately 15 miles from the launchpad, and would encompass northern portions of South Padre Island, Laguna Vista, eastern portions of Brownsville, and La Bartolina and El Huisachal in Tamaulipas, Mexico. The 2 psf sonic boom contour is predicted to extend approximately 28 miles, and would overlap Laguna Atascosa, Los Fresnos, Brownsville; and in Mexico, Matamoros and San José. The 1 psf sonic boom contour is predicted to extend approximately 27 miles, and would impact Rio Hondo, San Benito, as well as Santa Adelaida, La Venada, and San José in Mexico.

[5] The public hard checkpoint is located at State Highway 4 and Richardson Avenue. Only SpaceX personnel and FAA launch support personnel are able to pass this checkpoint.

[6] Because the FAA is required to analyze transboundary impacts, areas in Mexico are also considered in the analysis.

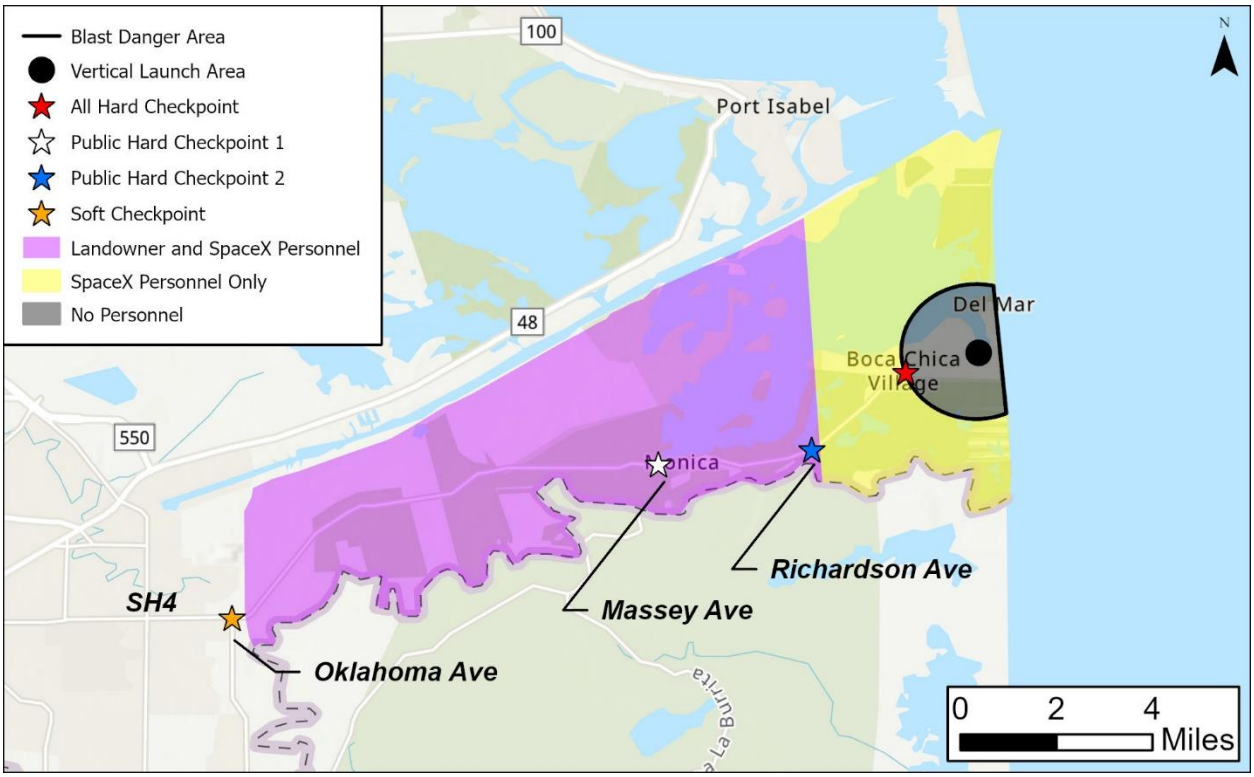

Figure 6 Access Restriction Area

Starship Landings

For Starship landings at the VLA, the 2022 PEA predicted overpressure levels ranging from 1.2 to 2.2 psf. The 2.2 psf contour was estimated to be offshore and not impact land. Overpressures between 2 and 1 psf were predicted to impact the southern part of South Padre Island. For the Proposed Action, sonic booms are predicted to range between 4 psf and less than 1 psf. The 4 psf sonic boom is predicted to occur on southernmost part of South Padre Island and the jetty at Boca Chica Beach. The 2 psf contour is predicted to reach portions of South Padre Island, as well as Port Isabel, Boca Chica, and northeast portions of Tamaulipas, Mexico. The 1 psf contour is predicted to extend approximately 24 miles, and impact Brownsville, South Padre, Port Isabel, Laguna Heights, Laguna Vista, and other south Texas communities, as well as El Huisachal and Rancho Santa Isabel in Mexico.

In general, sonic booms in the 0.2 to 0.3 psf range could be heard by someone who is expecting them and listening for them, but usually would not be noticed. Sonic booms of 0.5 psf are more likely to be noticed, and sonic booms of 1.0 psf and above are certain to be noticed (1 psf is similar to a clap of thunder). Sonic booms of 1 to 2 psf are produced by supersonic aircraft flying at normal operating altitudes. The location of maximum overpressure from a sonic boom would vary with weather conditions, it is unlikely that any given location would experience the maximum estimated level of overpressure more than once over multiple events. Impacts to human health are not anticipated, tests have shown exposure to up to 100 psf sonic booms with no adverse consequences (Benson 2013, Maglieri 2014).

Cumulative Day-Night Level

Noise exposure from sonic booms that exceeds the significance threshold of C-weighted day-night average noise level (CDNL) 60 dBC for impulsive noise sources (equivalent to DNL 65 dBA) is a significant impact (FAA 2020, FAA 2022). To determine the significance of sonic boom exposure on surrounding communities, the FAA converted psf data to CDNL. The FAA uses CDNL to assess cumulative annoyance from impulsive noise like sonic booms, while using other metrics to evaluate hearing loss and other noise-related health effects (FAA 2024b). Given unique characteristics of commercial space operations, the FAA's guidance recommends that other supplemental noise metrics may also be used in conjunction with DNL "to describe and assess noise effects for commercial space operations" (FAA 2024b). The FAA does not use these supplemental metrics to make decisions. Rather, the FAA has established a system of noise measurement that comprises a single, core decision-making metric, the A-weighted DNL. Under FAA Order 1050.1F, significant noise impacts would occur if the Proposed Action would increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dBA noise contour, or that will be exposed at or above the DNL 65 dB level due to a DNL 1.5 dB or greater increase in noise exposure, when compared to the No Action alternative for the same timeframe. FAA's NEPA implementing policies and procedures did not exempt commercial space transportation from this threshold. See FAA Order 1050.1F at Exhibit 4-1. Until the FAA revises its noise policy, all actions including commercial space transportation actions, are subject to this metric and significance threshold.[7]

Noise-sensitive areas are within the 60 dB CDNL contour within the US. Noise sensitive areas within the 60 dB CDNL would experience significant noise impacts under the FAA's current 60 dB CDNL significance threshold.

[7] The FAA determined that changes in transportation use, public expectations, and technology warrant a review of its civil aviation noise policy. On January 13, 2021, the FAA published in the Federal Register a notice entitled, "*Review of FAA Aircraft Noise Policy and Research Efforts: Request for Input on Research Activities to Inform Aircraft Noise Policy"*,86 FR 2722, which described the FAA's noise research portfolio and a first of its kind nationally scoped survey that updated FAA's understanding of the dose-response relationship between exposure to aircraft noise and community annoyance (Neighborhood Environmental Survey or NES). FAA also requested input on the FAA's research activities that would inform the FAA's noise policy and would inform the future direction of the FAA noise research portfolio. The NES showed that a higher percentage of people were "highly annoyed" by aircraft noise across all levels of noise exposure that were studied. In addition to setting forth the FAA noise policy and research efforts, this Notice described the results of research into the societal benefits and costs of noise mitigation measures. On May 1, 2023, the FAA published in the Federal Register a notice entitled "*Request for Comments on the Federal Aviation Administration's Review of the Civil Aviation Noise Policy, Notice of Public Meeting.*" In this notice, the FAA announced that it intends to consider how changes to the FAA civil aviation noise policy may better inform agency decisions and the types of impacts FAA considers in making decisions (e.g., community annoyance, certain types of adverse health impacts highly correlated with aviation noise exposure). The FAA requested suggestions of potential improvements to how the FAA analyzes, explains, and presents changes in exposure to civil aviation noise. 88 FR 26641. In this notice, the FAA specifically sought public comments on whether it should establish noise thresholds for low-frequency events, such as those associated with the launch and reentry of commercial space transportation vehicles authorized by the FAA Office of Commercial Space Transportation, which metrics should be used to establish these noise thresholds, and the appropriate noise exposure level to define the threshold of significant noise impacts. As part of this policy review, FAA is also examining the body of scientific and economic literature to understand how aviation noise correlates with annoyance as well as environmental, economic, and health impacts. The FAA is also evaluating whether any of these impacts are statistically significant and the metrics that may be best suited to disclose them. Until this policy development process is concluded, the FAA will continue to rely on DNL to make decisions regarding the significance of potential noise impacts. In this Draft EA, the FAA is not seeking comment on whether and how its noise policy should be revised. Rather, the FAA seeks comments on its analysis of the impacts associated with the Proposed Action and potential for significance under the FAA's existing noise threshold set forth in FAA Order 1050.1F at Exhibit 4-1.

The FAA and SpaceX continue to review the sonic boom report to evaluate the potential for operational modifications, including the possible combinations of daytime and nighttime operations that could result in lower CDNL levels and minimize disruptions to the NAS. The FAA and SpaceX are considering available operational and other mitigation measures, including a potential reduction in the total number of operations and/or an adjustment to the daytime and nighttime operations, to ensure that cumulative sonic boom noise does not exceed significance thresholds. The FAA will consider all relevant data, public comments, and applicable requirements before reaching a conclusion in the Final EA.

As described in the 2022 PEA, SpaceX will implement their public notification plan to educate the public and announce when a launch or landing event would occur. Announcements of upcoming Starship/Super Heavy launches and landings would serve to warn people about these noise events. The plan would involve issuing statements to news outlets and law enforcement so that when noise is heard, the public would understand what has occurred. Sonic booms from Starship landings could occur days or weeks after the launch mission however, these booms are substantially less noisy than Super Heavy landings.

3.2.3.6. Structural Damage Potential

Based on the updated noise modeling for the Proposed Action, the 140 dB L_{max} contour[8] for launch events would extend approximately 1.2 miles to the west and to the north, consistent with what was analyzed in the 2022 PEA. There are no third-party structures in the 150-dB contour, and with the exception of the two historical resources assessed in the 2022 PEA, there are no third-party structures in the 140 dB contour. Additionally, the historical resources have been stabilized since the publication of the 2022 PEA to protect the resources against vibrations from launch operations and the vibration monitoring reports for Flight 1-3 have shown no damage to structural resources. Consistent with the 2022 PEA, Boca Chica Village would be contained within the 130 dBA L_{max} contour, which extends approximately 3.5 miles. Port Isabel, South Padre Island, and Tamaulipas, Mexico are predicted to be within the 120 dB L_{max} contour, with the southeastern part of Laguna Vista being within this contour as well. This contour extends approximately 9.5 miles, slightly further than the 8 miles analyzed in the 2022 PEA. The entirety of Brownsville and most of Matamoros, Mexico would be contained within the 111 dBA L_{max} contour, which extends approximately 22.5 miles, compared to the 19 miles in the 2022 PEA. Although recent modeling predicted that noise contours would extend slightly further than predicted in the 2022 PEA, no structural damage or significant impact to third-party structures is anticipated.

For sonic booms, at approximately 2 psf there is a 1/10,000 probability of breakage for a large window, and at approximately 4 psf there is a 1/10,000 probability of breakage for a small window (USACE 1989). At 6 psf, audibility is effectively guaranteed. Laboratory and field testing shows that pre-damaged or poor condition windows could possibly exhibit progression of damage over multiple exposures to this magnitude of boom (Higgins 1965). At 10.0 psf the likelihood of superficial (e.g., plaster, bric a brac) damage and window damage becomes more plausible but is generally still expected to be very low probability and predominantly due to poor existing conditions such as pre-cracked, pre-stressed, older and weakened, or poorly mounted windows (Benson 2013, White 1972, Fenton 2016, Maglieri 2014). Finally, SpaceX presents sonic boom exposures up to 21 psf for booster landings. This represents a threshold where prevailing literature indicates window breakage becomes possible for standard condition windows, though the prediction of specific window breakage still depends on size, age, orientation, surrounding structure, and other effects (NOAA 2019, Maglieri 2014). The areas that would be exposed to this level are generally limited and would be evacuated during launch and when reentering vehicles

[8] As indicated in the 2022 PEA, there is consensus that damage becomes improbable below 140 dB. See Fenton and Methold 2016.

may fly supersonic at the lowest altitude before landing. Please refer to the Appendix B Noise Assessment for additional information on sonic booms.

FAA requires SpaceX to maintain insurance in the event a sonic boom results in claims of structural damage. Property owners may contact SpaceX directly to submit claims and evidence in support of the damage claim. Based on data measured during the April, November 2023, and March 2024 Starship/Super Heavy test flights, and summarized in the vibration monitoring reports, extrapolation of launch data suggests that peak responses should remain below a widely used damaging threshold of 2 inches per second for most well-maintained structures beyond 0.7 miles from the VLA (U.S. Bureau of Mines 1989). Additionally, the analysis found that the increased launch cadence in the Proposed Action would not pose a substantial concern for fatigue for most residential and commercial buildings beyond 0.7 miles of the VLA. In accordance with the 2022 PEA, the PA, and the SpaceX Boca Chica Vibration Monitoring Plan, SpaceX would continue to monitor the launch vibrations for a total of 5 orbital launches at various locations 2, 3, 5, and 8 miles from the VLA to confirm that vibration does not pose a risk of structural damage.

3.2.4. Visual Resources

Visual resource impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA except for the additional proposed nighttime launches. The PEA determined that the most impactful effect on visual resources would be associated with nighttime launches, which would result in increased light emissions during those events.

Nighttime launches would decrease from one orbital and one suborbital under the 2022 PEA, to up to one nighttime launch under the Proposed Action. This would result in decreased frequency of Proposed Action impacts on nighttime views as identified in the 2022 PEA. Additionally, SpaceX has increased the efficiency of vehicle preparations, and thus the amount of lighting on a per launch basis has decreased, and overall impacts are anticipated to remain similar to those assessed in the 2022 PEA. Effects from nighttime launch events would be lessened through conformance with the conditions and mitigation, including following the Lighting Management Plan. This Plan includes minimizing spot lights when not launching and directing light downward, low, and using amber lights to the greatest extent possible. Therefore, the Proposed Action would result in less frequent impacts on nighttime views compared to the 2022 PEA, the type and magnitude of impacts associated with the single proposed nighttime launch event was considered in the 2022 PEA.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant visual resource impacts.

3.2.5. Cultural Resources

Cultural resource impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA. The PEA determined that the area of potential effects (APE) was a 10-mile area centered on the VLA and encompassed where ground-disturbing activities and/or engine noise levels up to 120 decibels (dB) were predicted to be experienced.

As explained in the PEA, the FAA made a finding of *adverse effect* for the following 17 historic properties (i.e., historic sites, objects, structures, and buildings), because they could experience visual, auditory, and vibration effects or falling debris from an anomaly directly striking the historic properties that could diminish their integrity: Alta Vista Apartments; Former Bahia Mar and Bahia Grande Condominiums;

Charles Champion Building; Del Mar; Long Island Swing Bridge; Palmetto and Cypress Bridge Pilings ; Palmetto Pilings Historical Marker; Palmito Ranch Battlefield NHL; Point Isabel Coast Guard Building; Point Isabel Lighthouse and THC Marker; Port Isabel Cemetery; Port Isabel Firemen's Hall; Queen Isabel Inn; Queen Isabella Memorial Causeway; Sea Island Resort Hotel; Former Ship Café Building; and the White Sands Motel (FAA 2022:78–79). It was noted in the PEA that the Palmetto and Cypress Bridge Pilings and Palmetto Pilings Historical Marker would potentially be most affected (i.e., potentially physically damaged) by high noise levels and the associated vibrations caused by vehicle launches.

To resolve these adverse effects, the FAA, THC, NPS, USFWS, TPWD, the Advisory Council on Historic Preservation, and SpaceX executed a Programmatic Agreement (PA) in April 2022 that stipulated the process for minimizing and mitigating adverse effects for these 17 historic properties. With the resolution of adverse effects on historic properties, the Proposed Action documented in the PEA would not result in significant impacts on historical, architectural, archaeological, or cultural resources. The following measures were identified in the PA to avoid, minimize, or mitigate adverse effects associated with auditory and vibration effects and/or falling debris from an anomaly directly striking the historic properties (FAA 2022:85–86):

- Implementing measures to reduce noise levels generated by construction equipment;
- Implementing measures to minimize noise from truck (construction, tanker, concrete, water, delivery) traffic;
- Conducting a vibration monitoring program to gather data on the effects of launches on the Palmetto Pilings Historical Marker, Palmetto Pilings, Port Isabel Lighthouse, and at the 2-, 3-, and 8-mile distances from the VLA. The program will also include a structural assessment from vibration data to assess any impacts and address any structural damage given any impact from launch operations.
- If an anomaly affects a historic property, SpaceX will hire a qualified professional to make recommendations for restoration of the historic property. Upon review and approval, SpaceX will hire a qualified professional to restore the historic property.
- An Unanticipated Discoveries Plan was prepared to outline the processes to be followed in the event previously unknown cultural resources or human remains are discovered during construction or operation of the Proposed Action.

No additional visual impacts from the Proposed Action would result in a change to the 10-mile APE used in the 2022 PEA. Additionally, the modeled 120 dB contour for the Proposed Action stays within the APE evaluated in the 2022 PEA. With regard to the 120-dB contour, the Starship and Super Heavy static fire test contours would extend up to approximately 3 miles and 6 miles, respectively, from the VLA, while the Starship/Super Heavy launch contours would extend up to approximately 9.5 miles from the VLA.

The Proposed Action would not include construction for launch operations beyond the boundary analyzed in the 2022 PEA; therefore, there would be no changes regarding the avoidance, minimization, or mitigation recommendations for the previously recorded historic properties in the 2022 PEA.

In accordance with the 2022 PEA, the PA, and the SpaceX Boca Chica Vibration Monitoring Plan, SpaceX's contractor STRAAM monitored the April and November 2023, and March 2024 launch events and all vibration minimizing measures described above were in place. STRAAM individually monitored the Palmetto Pilings 1936 Centennial Marker (Historic Marker), Palmetto and Cypress Bridge Pilings site (the Pilings), and the Port Isabel Lighthouse, including the replica Fresnel Lens. In addition, ground vibration

monitors were placed 2, 3, 5 and 8 miles from the launch pad. The vibration monitoring determined that the majority of the energy transmitted by the launch was distributed through the air and not through the ground. Although the sensor on the Historic Marker appeared to only record background noise and may have malfunctioned, no damage was observed to the structure following the launch. STRAAM determined that the mitigation efforts implemented at the Pilings worked, no damage was visible to the structures and elevated vibration thresholds were not triggered on the monitors. The overall dynamic signature of the Lighthouse and the Lens were both unchanged after the launch. The level of energy measured at the Lighthouse during launch was small and did not excite the Lighthouse to damaging levels. The response of the Lens during the launch was very similar to the response of the dome, indicating that the lens protection was successful in mitigating free motion of the lens. Finally, ground motion at the Lighthouse was minimal, and similar to the vibration intensity caused by normal truck traffic in the area. No damage to the Lighthouse was observed. The PEA and FONSI/ROD determined the Proposed Action may have adverse effects to historic properties, but determined adverse effects would be resolved through the PA. The vibration monitoring program demonstrates conformance to the Starship/Super Heavy program evaluated in the FONSI/ROD, consistent with the findings in the PEA and FONSI/ROD regarding potential damage due to vibration, there would be no significant impacts due to vibration.

SpaceX also continues to mitigate impacts to cultural resources by implementing other mitigation measures established in the 2022 PEA and the 2022 PA. For example, the Historical Context Report has been reviewed by the agency consulting parties in accordance with the PA during development and is scheduled to be finalized in mid-2024. SpaceX has worked with a qualified firm to develop the Scope of Work for the Level Historic American Landscapes Survey in coordination with the FAA, which was provided to the consulting parties for review and comment on October 27, 2023 in accordance with the PA. SpaceX submitted the final scope of work to the FAA on December 14, 2023 and anticipates starting the project in 2024.

SpaceX is not proposing any additional access restrictions that would impact visitation to the cultural resources. No additional effects to cultural resources would result from the Proposed Action beyond those described in the 2022 PEA and analyzed above. The avoidance, minimization, or mitigation recommendations in the PA (as currently stands or modified under this EA, if applicable) would continue to be implemented.

Although the Proposed Action would result in increased sonic boom levels from landings at the VLA, the sonic booms would not result in significant impacts to cultural resources. Noise due to sonic booms from Super Heavy landings at the VLA would increase from up to 15 psf in the 2022 PEA to within the 21 psf contour in this EA. Although overpressure levels would increase, as described in Section 3.2.3.5, the sonic booms are not predicted to cause structural damage to cultural resources within the APE. The two resources located within the 21 psf contour are the Cypress Bridge Pilings and Palmetto Pilings Historical Marker. The Palmetto Pilings Historical Marker had foundations reset in 2022 by THC and SpaceX, and the Cypress Bridge Pilings and Palmetto Pilings Historical Marker would continue to remain braced surrounding launch events to prevent damage due to elevated vibration, as agreed to by the consulting parties to the 2022 Programmatic Agreement.

The Faro Bagdad Lighthouse, approximately 3 miles south of the VLA in Bagdad, Tamaulipas Mexico, is located within the 10 psf contour. As described in the PEA, at 10.0 psf the likelihood of superficial (e.g., plaster, bric a brac) damage and window damage becomes more plausible but is generally still expected to be very low probability and predominantly due to poor existing conditions such as pre-cracked, pre-stressed, older and weakened, or poorly mounted windows (Benson 2013, White 1972, Fenton 2016,

Maglieri 2014). Structural damage to this lighthouse is not anticipated due to the concrete makeup of the structure.

FAA requires SpaceX to maintain insurance in the event a sonic boom results in claims of structural damage. Property owners may contact SpaceX directly to submit claims and evidence in support of the damage claim.

Based on the above findings, consistent with the data and analyses that were discussed in the 2022 PEA, the Proposed Action would not result in significant impacts to cultural resources.

3.2.6. Department of Transportation Act Section 4(f)

Updated sonic boom information for the Proposed Action is being analyzed by the FAA for potential Section 4(f) impacts and will be compared to those discussed in the 2022 PEA. At this time, the FAA has not made any preliminary determinations regarding the significance of these impacts. The analysis is being conducted in accordance with FAA Order 1050.1F and any findings will be documented in the Final EA. The FAA will explain if any conclusions differ from those presented in the 2022 PEA and will disclose if it conducted any additional consultations. Until this analysis is complete, it is premature to draw conclusions about the potential significance of the impacts. The FAA will consider all relevant data, public comments, and applicable requirements before reaching a conclusion in the Final EA.

The 2022 PEA determined that the study area for Section 4(f) is the 90 dB L_{Amax} noise contour for Starship/Super Heavy orbital launch operations. Protected Section 4(f) resources include public parks, recreation areas, wildlife or waterfowl refuges of national, state, or local significance, and land of an historic site of national, state, or local significance. Following the 90 dB L_{Amax} contour, the 2022 PEA identified 26 publicly owned parks, recreation areas, and refuges, and 17 historic properties. In the 2022 PEA, the FAA determined that the Proposed Action:

- would not result in the use of any Section 4(f) properties through permanent incorporation.
- would have no *constructive use* of historic properties, Boca Chica State Park, Brazos Island State Park, the LRGV NWR, the South Bay Coastal Preserve, Isla Blanca Park, Laguna Atascosa National Wildlife Refuge, Trail Park, and Laguna Madre Nature Trail under Section 4(f) resulting from visual effects.
- would have no *constructive use* under Section 4(f) due to temporary access restrictions from launch operations or anomalies.
- would have no *constructive use* under Section 4(f) due to noise from launch or daily operational activities.
- would have no *constructive use* of historic properties, the Isla Blanca Park, Laguna Atascosa National Wildlife Refuge, or Laguna Madre Nature Trail from vibrations or sonic booms for launch operations under Section 4(f).
- would constitute a use under Section 4(f) for temporary occupancy of some historic properties and Boca Chica State Park and Brazos Island State Park resulting from anomalies, but any such impacts are expected to be *de minimis*.

The Proposed Action would not change limits on access restrictions for launch operations or in the event of an anomaly. Since the first launch in April 2022, SpaceX has increased the efficiency of launch operations and reduced the projected duration of access restrictions on a per operation basis. The 2022

PEA assumed approximately 100 hours of access restrictions for each orbital launch event and 500 hours of access restrictions annually. For the April 20, 2023 launch, there were approximately 24.5 access restriction hours for the launch, and 48 hours of access restriction for anomaly response activities. For the second test flight on November 18, 2023, there were approximately 10.5 access restriction hours for launch and none for anomaly response activities. Although the number of orbital launches and landings would increase under the Proposed Action, the total duration of access restrictions would still not exceed 500 hours annually. As the number of launches increases, the reliability of the vehicle would increase and the risk of an anomaly would be below what was described in the 2022 PEA. No additional hours of anomaly-related access restrictions beyond the 300 analyzed in the 2022 PEA are proposed. SpaceX would continue to implement mitigation measures for access restrictions as described in the 2022 PEA. Therefore, the FAA has determined that the increase in operational activities would not constitute a *constructive use* due to temporary access restrictions of these Section 4(f) properties.

During operations, the Proposed Action would include increased launch cadence and increased thrust, which would increase the 90 dB L_{Amax} contour from the contour assessed in the 2022 PEA by approximately 2 miles for launches and 1 mile for landings. No additional 4(f) resources were identified within modeled noise contours, however additional parts of the Laguna Atascosa National Wildlife Refuge and of the LRGV NWR would be exposed to the 90 dB L_{Amax} contour. A quiet setting was noted as an important attribute to both these wildlife refuges. However, noise effects would be intermittent and short-term in duration (minutes). At all other times, the quiet setting of the Section 4(f) properties would persist. Therefore, the FAA determined that noise from operational activities would not constitute a *constructive use* of these Section 4(f) properties.

The FAA is evaluating whether there would be significant impacts to 4(f) resources within the 60 CDNL contour. See Section 3.2.3 for more information on the 60 CDNL contour.

The Proposed Action would also result in a small increase in noise levels from increased commodity and water truck trips. It is anticipated that the Proposed Action would increase vehicle traffic and human presence from an estimated 6,000 total trucks per year in the 2022 PEA to 23,771 trucks under the Proposed Action. The location and timing of these trips would be as described in the 2022 PEA and would not constitute a *constructive use* of affected Section 4(f) properties due to their intermittent nature and rapid noise attenuation over distance. This would represent approximately 5 additional trucks along SH4 an hour if trucks operate 12 hours per day.

The FAA is ensuring SpaceX continues to mitigate impacts to Section 4(f) resources by means including but not limited to: issuing notifications in accordance with its Access Restriction Notification Plan, collaborating with USFWS to meet environmental education goals, collaboration with Fishing's Future (an organization dedicated to bringing youth closer to nature), implementing the SpaceX Lighting Management Plan, and undertaking research on restoration of algal flats with Texas A&M University. SpaceX continues to implement existing measures to reduce noise levels generated by construction equipment and from truck traffic.

As described above, the reliability of the vehicle would increase as more launches occur and the risk of an anomaly would be below what was described in the 2022 PEA. In the unlikely event of an anomaly, impacts resulting from debris from anomalies would continue to be *de minimis*. SpaceX would continue to implement the measures specified in the Memorandum of Agreement with TPWD described in the 2022 PEA to mitigate and restore any impacts from anomalies at Boca Chica State Park, Brazos Island State Park, and other TPWD land. Therefore, the FAA has determined that the increase in operational activities would constitute a *de minimis* impact due to temporary occupancy of Section 4(f) properties.

Based on the above findings, consistent with the data and analyses that were discussed in the 2022 PEA, the Proposed Action would not result in significant impacts to 4(f) properties.

3.2.7. Water Resources (including Wetlands, Floodplains, Surface Waters, Groundwater, Ocean Waters)

Taking into account the new information related to the Proposed Action, water resource impacts would be comparable to those discussed in the 2022 PEA.

As a requirement of the Texas Pollutant Discharge Elimination System (TPDES) permit administered through TCEQ, SpaceX maintains its facility Construction and Industrial Stormwater Pollution Prevention Plan (SWPPP), which also includes a Spill Prevention, Control, and Countermeasures Plan and Hazardous Materials Management Plan, in addition to typical SWPPP best management practices (BMPs), while conducting all FAA-permitted or -licensed operations. Under the Proposed Action, SpaceX would continue to adhere to these plans to reduce the potential for adverse impacts to water resources. Implementation of BMPs identified in the Project's current SWPPP would prevent or minimize indirect impacts from erosion and sedimentation to the nearby surface water bodies. The Spill Prevention, Control, and Countermeasures Plan and Hazardous Materials Management Plan would also be implemented to minimize the potential for accidental releases of polluting substances from equipment and would require that material handling and spill response BMPs be implemented at the VLA to prevent the potential contamination of groundwater.

As described in the November 2023 WR of the 2022 PEA, SpaceX installed steel plates over the launch pad foundation. These features are designed to prevent the potential of a pad breakup and associated debris and dust. The steel plates include a water-cooling element (i.e., deluge system) that would be activated to protect the steel plates during a launch event and allow reusability of the steel plates. The deluge system would not be needed for landings at the VLA.

The Proposed Action would increase the volume of deluge water used annually; however, all water would be managed in accordance with the TPDES Multi-Sector General Permit, which authorizes the discharge of stormwater associated with industrial activity and specific non-stormwater discharges. Retention ponds would continue to capture launch pad water and would continue to be lined to prevent potential percolation of contaminants into the groundwater. Retention ponds would continue to be maintained and monitored by SpaceX in accordance with TCEQ's Texas Surface Water Quality guidance.[9]

The operation of the deluge system would apply a maximum of approximately 422,000 gallons per operation (booster static fire or launch). Although the quantity of deluge water evaluated for each launch would increase, the number of licensed Super Heavy static fires per launch would decrease as the program matures over time. Most of the water would be collected in the containment structures or vaporized, although the specific amount in either volume or relative percentage is unknown and may vary across ignition events. For the purposes of this analysis, SpaceX assessed the deluge operations to date in order to estimate that approximately 316,500 gallons of water would be vaporized during engine ignition, 17,600 gallons would be detained at the VLA, and approximately 87,900 gallons is assumed to be dispersed outside the constructed portion of the VLA as overland sheet flow, push out, or condensation. The water that would be dispersed outside the constructed area would mainly be from the water that is released prior to engine ignition and the water released after engine shutdown or launch. It is estimated

[9] Texas Administrative Code, Title 30 Environmental Quality, Part 1 Texas Commission on Environmental Quality, Chapter 307: Texas Surface Water Quality

that 17% of the total water would be used prior to engine ignition, 75% would be used during the launch, and 8% would be used post-launch.

Although approximately 87,900 gallons of the deluge water may leave the paved area of the VLA per operation, it is not expected that this water will cause significant impacts to water resources. An average summertime thunderstorm at Boca Chica would deposit more water over the projected 0.6 mile radius impact area than any single or all combined activations of the deluge system. Brownsville receives about 27 inches of rain a year on average (National Weather Service 2023). The operation of the deluge system and detonation suppression system combined would be roughly equivalent to a rainfall event of 0.004 inch across the area of the 0.6-mile heat/vapor plume area occurring two times per month on average. Since the amount of water that is anticipated to reach the mudflats from a maximum of the operation of the deluge system Is expected to be less than significant in comparison to an average summer rainfall event, this amount of water would be unlikely to alter the habitat and cause adverse alterations to water resources.

As described in the November 2023 WR, during engine ignition of the Starship/Super Heavy, surfaces of the steel infrastructure could experience ablation. 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. Samples were collected in the soil, air, and deluge water for components of stainless steel (chromium and zinc) following Flight 2 and Flight 3 and showed negligible results for stainless steel components in all soil, air, and deluge water results (SpaceX 2024c, 2024d). The Proposed Action is anticipated to continue to have negligible impacts to soil, air, and water during launch operations from potential ablation.

As analyzed in the Biological Assessment, the amount of liquid water that would escape the VLA during each use of the deluge system would be equivalent to a rainfall of 0.004 inch across the impact area, annually, the estimated cumulative discharge of 4,395,000 gallons of liquid water through use of the deluge system would be the equivalent of an additional 0.22 inch of rain if distributed across the impact area. Therefore, the operational changes presented in this EA would not alter existing wetlands or floodplains beyond what was analyzed in the 2022 PEA and the impacts would not be significant. Additionally, the changes would not result in dewatering or drawdown from adjacent areas, as deluge water would continue to be brought in from off-site. Furthermore, it is anticipated that most deluge water would be vaporized during the launch sequence, and not have adverse effect on the adjacent floodplain or oceanic waters.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant water resource impacts.

3.2.8. Biological Resources

Biological impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA. The 2022 PEA defined the action area for biological resources by the 1 psf contour for Super Heavy landing sonic booms, which extended 13 miles from the VLA. The action area in this tiered EA has been expanded based on updated noise modeling for the proposed vehicle modifications based on the 1 psf Super Heavy sonic boom. The 1 psf contour extends approximately 20 to 27 miles from the VLA over land, and approximately 33 miles over water. Accordingly, an updated official species list, updated environmental baseline descriptions, and updated cumulative activities are provided in the documentation being consulted with USFWS, and are summarized below.

3.2.8.1. Terrestrial Habitat and Wildlife

The 2022 PEA noted that operational activities have potential to impact terrestrial habitats and wildlife due to the presence of structures, lighting, vehicle traffic and presence of humans, launch related noise and vibration impacts, exhaust/heat plumes, and anomalies.

The Proposed Action would increase vehicle traffic and human presence from an estimated 6,040 total trucks per year in the 2022 PEA to 23,771 trucks under the Proposed Action to haul commodities and water to the site. However, SpaceX would continue to implement mitigation measures identified in the PEA, such as operating an employee shuttle to reduce the number of project-related vehicles, to minimize traffic impacts to wildlife, and limiting water truck deliveries to daytime hours to the extent practicable.

Maximum noise levels generated from launches would extend roughly 1 mile further (from 7 miles to 8 miles) from the launch site than anticipated in the 2022 PEA due to the proposed Super Heavy thrust increase (Appendix B). Additionally, the frequency of the noise events would increase from up to five suborbital launches and five orbital launches annually to as many as 25 launches annually. Noise from launches last approximately 3 minutes per launch and would occur approximately 25 times per year. Noise from landings, up to 50 per year, would be substantially less noticeable and would last seconds. The 90 dB l_{Amax} contour extends about 6 miles from the VLA. The 115 dB l_{Amax} contour, which is used as a conservative limit for hearing conservation, is located approximately 1 mile from the landing pad (Appendix B). During launch activities, noise would cause wildlife to be temporarily displaced or disturbed. However, due to the temporary and intermittent nature of these noise sources, wildlife would be expected to resume normal behavior shortly after a launch operation is complete. Sonic booms caused by the landing of Starship and Super Heavy vehicles would occur up to 25 times each per year (50 total). As described in Section 3.2.3.5, Starship sonic booms are predicted to reach up to 4 psf, with the 1 psf contour extending approximately 24 miles. Super Heavy sonic booms are predicted to reach up to 21 psf, with the 1 psf contour extending approximately 20 to 33 miles over land or water. Significant impacts to wildlife due to sonic booms are not anticipated. NASA (2003) reported that sonic boom overpressure events generating between 20 and 144 psf have been experienced by humans without injury. A 1991 study funded by the U.S. Air Force found that chicken eggs, when exposed to sonic booms of 17 to 19 psf for a duration of 9 days, did not develop cracks or deviations (Bowles et al. 1991). Numerous other studies also cite sonic booms of varying intensity as having no detrimental effect on wildlife (Maglieri et al. 2014). The increased frequency of sonic booms is not expected to cause a notable difference from the impacts described in the 2022 PEA, including a startle response, species specific defensive behaviors, and orienting responses. Therefore, direct physical injury or death of wildlife from sonic booms are not anticipated. SpaceX would continue to conduct biological monitoring pre- and post-launch to evaluate avian species and vegetation changes due to SpaceX activities.

Under the Proposed Action, heat plume temperatures within the immediate VLA and 0.6-mile radius could injure or cause mortality to individual animals or lead to vegetation changes, including loss of plant community structure, reduction in total cover, and replacement of same native species with weed species. These temperatures would be short-lived (heat plume would dissipate within minutes) and would not be expected to permanently damage the vegetation. Infrequent launches and quick dissipation of heat is not anticipated to affect species at the population level. Following the April 20, 2023 test flight, vegetation monitoring conducted of the 0.6-mile area surrounding the launchpad in accordance with the May 2022 Biological Conference Opinion and the SpaceX Biological Monitoring Plan found minimal damage to vegetation, primarily consisting of sand and debris (Raba Kistner 2023a). A small fire burned approximately 3.5 acres of upland vegetation south of the launchpad (Hicks and Contreras 2023). Based

on the vegetation recovery from past fires in the area documented to date, habitat function and ecosystem services should return to pre-burn levels within one to two growing seasons (Hicks and Contreras 2023). Following the launchpad improvements detailed in the November 2023 WR, similar damage to the launchpad is not expected and has not been observed in the two launches since, which will prevent dispersal of sand and debris during launch activities. The second flight in November 2023 resulted in minimal amounts of sand deposited immediately east of the VLA (Raba Kistner 2023b), no signs of damage from heat, and no fires. No dead or injured animals were detected by monitoring following either launch (Raba Kistner 2023c, Raba Kistner 2023d). The third flight in March 2024 resulted in two small brush fires, and a small amount of debris was deposited north of the VLA. An area approximately 0.1 acres was burned in a dry grassy area approximately 0.4 miles northwest of the launch mount. A second fire approximately 0.25 acres in area occurred in a dry grassy region approximately 0.15 miles south of the launch mount. No dead or injured ESA-listed species were observed. Post-fire assessments have been conducted after each fire by experts at the University of Texas Rio Grande Valley, and the assessments have concluded that impacts to wildlife are similar to those which would occur from a prescribed burn in comparable habitat (Hicks and Contreras 2019, 2022, 2023, 2024). Further, the experts concluded that mortality of wildlife due to rapid temperature increases at burned sites during the onset of launch also seems unlikely (Hicks and Contreras 2024). Because of this, although fires have occurred following the orbital test flights, these fires would not be anticipated to cause significant impacts to biological resources at the proposed increased cadence. Additionally, as the area is regularly subject to high winds, it is not anticipated that sand deposits from engine ignition events will cause significant impacts to the area from the proposed increased cadence. Additionally, the use of the deluge system will continue to minimize these impacts by suppressing dust and potential brush fires. The analysis in the 2022 PEA used a conservative assumption for potential impacts to biological resources from the heat of the plume. Based on the data from the first three test flights, it is expected that the impacts from each launch event would be substantially less than those analyzed in 2022 (SpaceX 2024a, 2024b).

Following the fourth test flight on June 6, 2024, the Coastal Bend Bays & Estuaries Program documented a “thick cloud of dust and small debris” pushed out from the engine thrust during Test Launch #4 and a pea-sized piece of concrete debris damaged a camera lens (LeClaire and Newstead 2024). This report suggests that a “gravel plume” that moves up to pea-sized particles of mud, sand, gravel, and similar materials with enough force to damage shorebird eggs extends at least 0.3 miles from the VLA. A gravel plume was not previously analyzed in the 2022 PEA but is considered in detail in the Biological Assessment. Incidentally, the game camera footage also documented adult nesting shorebirds moving away from nesting areas near the VLA in advance of the noise, activity, and heat/vapor/gravel plumes generated by launch activity and quickly returned to areas exposed to these plumes following a launch.

Additionally, SpaceX would continue to conduct the biological monitoring required in the 2022 BCO and 2022 PEA. SpaceX has deployed avian biologists from SWCA Environmental Consultants (SWCA) with experience monitoring for coastal shorebirds to implement monthly surveys (starting in July 2022) as part of the SpaceX Biological Monitoring Plan. Trend analysis of the avian monitoring data collected by UTRGV from 2015 to 2021 found little to no evidence of meaningful trends, either increasing or decreasing, in the number of birds observed through time. SWCA’s survey data from July 2022 to June 2023 are consistent with the natural, varied cycles of the target species (SWCA 2023). Additional years of data collection will likely allow for a more definitive conclusion regarding whether there are any trends in abundance that are not the result of background variation or sampling issues. Only one aplomado falcon has been observed several miles away from the VLA since surveying began in 2015.

Annual vegetation monitoring in accordance with the 2022 BCO and 2022 PEA has taken place near the VLA, tracking the composition and extent of three different habitat types that are present adjacent to the VLA: low-lying and unvegetated mudflats, a transition zone of halophytic vegetation, and short "hind dunes" (referred to in the monitoring reports as "Bare", "Transition", and "Dune" communities). The monitoring also tracks encroachment ("creep") of vegetation at the transition between the unvegetated mudflats and halophytic salt flats. The vegetation monitoring report published in 2021 by University of Texas Rio Grande Valley (UTRGV) was previously evaluated in the May 2022 BCO and for the 2022 PEA. Since then, results from the 2022 vegetation monitoring were completed. The results show that between 2021 and 2022, plant cover within different habitat types was highly variable. There was a 57% decrease in total live plant cover in mudflats (from 1.87% to 0.80%) and a 20% decrease in transition plots (from 17.57% to 13.97%); however, live plant cover changed little in dune plots (from 26.2% to 26.4%), and there was a 20% increase in creep plots (from 15.7% to 18.8%). This was the lowest plant cover observed in mudflat and transition plots since 2018, and, for transition plots, this represents a continuing decrease in plant cover. Creep plots also exhibited a gradual increase in plant cover. UTRGV identified two possible alternative explanations regarding the observed differences between plant communities in the different monitoring zones: It is possible that some of the observed differences could be explained by additional factors that have not been quantified or analyzed, such as proximity to the road or differences in elevation. Much of the variation observed over the past 7 years of monitoring has been within the range of natural variability, but some changes attributable to land use change near launch pad have also been observed (UTRGV 2023). The monitoring to date has not detected increased vegetation in the mudflat monitoring plots. Additionally, as detailed above, the maximum of the operation of the deluge system is expected to be less than significant in comparison to an average summer rainfall event, this amount of water would be unlikely to alter the habitat and cause adverse alterations to water resources. Consistent with the PEA, SpaceX plans to eventually expand the VLA and develop the area south of the existing pad boundary.

The Proposed Action includes 25 annual launches with up to one launch occurring during the night. This would represent a decrease in nighttime launches, thus evaluations previously made in the 2022 PEA are still conservative and lighting impacts from nighttime operations would remain short in duration. Effects from this proposed single nighttime launch would be tempered through conformance with the Lighting Management Plan, and SpaceX would continue to monitor lighting at the VLA according to the SpaceX Light Monitoring Plan during sea turtle nesting season.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant terrestrial habitat and wildlife impacts.

3.2.8.2. Terrestrial ESA-Listed Species and Critical Habitat

Terrestrial ESA-listed species and critical habitat impacts under the Proposed Action would be similar to those impacts described in the 2022 PEA. In accordance with Section 7 of the ESA, the FAA conducted consultation with the USFWS as part of the 2022 PEA. The FAA determined that the 2022 PEA may affect and is likely to adversely affect ESA-listed species and critical habitat under USFWS jurisdiction and conducted formal consultation with the USFWS. The USFWS issued a BCO, which concluded the 2022 PEA Proposed Action is not likely to jeopardize the continued existence of any federally listed species or adversely modify designated critical habitat. The BCO contained Reasonable and Prudent Measures and associated Terms and Conditions to avoid, minimize, and mitigate the effects on listed species and critical habitat.

Following issuance of the 2022 BCO, the FAA reinitiated formal consultation with USFWS on September 1, 2023 regarding the effects of operating a deluge and detonation suppression system, an updated environmental baseline within the action area and the April 20 launch and mishap, a newly listed species, and a newly proposed endangered species. The USFWS issued Reinitiation #1 of Interagency Consultation on November 14, 2023 (BCO Reinitiation #1), which serves as a Final BCO Addendum. The Addendum concluded that the November 2023 WR Proposed Action is not likely to jeopardize the continued existence of any federally listed species or adversely modify designated critical habitat, and that additional incidental take would not be reasonably certain to occur.

The Proposed Action would not introduce any additional construction-related effects at the VLA that are outside the scope of impacts analyzed in the 2022 PEA and the USFWS BCO (FAA 2022) to ESA-listed species.

Table 7 provides a summary of operation-related stressors or threats previously considered under the 2022 PEA and USFWS BCO that would still apply under the Proposed Action. No new threats or stressors were identified. Additional Proposed Action analysis for key stressors/threats is provided in Table 7.

This tiered EA evaluates potential impacts to six species of shorebirds that were not evaluated in the 2022 PEA, due to expansion of the action area under the Proposed Action. The black-capped petrel (*Pterodroma hasitata*), Band-rumped storm-petrel (*Oceanodroma castro*), Hawaiian petrel (*Pterodroma sandwichensis*), Newell's shearwater (*Puffinus auricularis newelli)*, Roseate tern (*Sterna dougallii*), and Short-tailed albatross (*Phoebastria albatrus*) are evaluated in Section 3.2.8.2. The Cactus Ferruginous Pygmy-owl (newly listed as threatened) and tricolored bat (proposed endangered listing) have been added to this EA due to change in listing/nomination status. In accordance with ESA Section 7, the FAA reinitiated consultation with the USFWS on May 6, 2024. The FAA determined the Proposed Action may affect and is likely to adversely affect ESA-listed species and critical habitat under USFWS jurisdiction and is conducting formal consultation with the USFWS. The final EA will include the results of this consultation.

Table 7. Potential Effects to ESA-Listed Species and Critical Habitat Based on Stressors/Threats Associated with the 2022 Proposed Action compared to the Proposed Action

Stressor or Threat	PEA Proposed Action Potential Effect on Species	Proposed Action Potential Effect on Species	Species Potentially Affected
Visual presence and noise from launches (including landings)	Disturbance to species from noise depends on 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. For instance, vehicular traffic can mask bird calls (such as alarm calls) and inhibit breeding birds to find mates and to defend territories. Sudden noise events, such as sonic booms, can cause birds to abandon nests or roosts which may increase the potential for predation. Noise events associated with construction and operations (including launches and landings) are generally thought to result in short-term behavioral responses which may be considered harassment, but sustained noise events may render habitat unusable.	The EA Proposed Action involves more frequent launches and landings. This frequency would amount to 25 Starship/Super Heavy launches and 50 landings annually (25 Starship landings and 25 Super Heavy landings). Additionally, the number of noise events generated by launch operations would increase from 10 to 25 and would still last minutes. The number of noise events generated by landing operations would increase and would less than a minute. Based on the still relatively intermittent launch frequency, short duration of launch and landing events, however, the Proposed Action is not expected to significantly affect any listed species due to the little to no evidence of the launch activity impacting trends to the species.	Piping plover (T) Red knot (T) Northern aplomado falcon (E) Eastern black rail (T) Cactus Ferruginous Pygmy-owl (T) Jaguarundi (E) Ocelot (E) Tricolored bat (PE) Green sea turtle (T) Hawksbill sea turtle (E) Kemp's ridley sea turtle (E) Leatherback sea turtle (E) Loggerhead sea turtle (T) Black-capped petrel (E) Band-rumped storm-petrel (E) Hawaiian petrel (E) Newell's shearwater (E) Roseate tern (E) Short-tailed albatross (E)
Rocket heat plume	Due to the infrequency of launches and quick dissipation of heat plumes, the plumes are not anticipated to cause significant effects on ESA-listed species or their habitat.	Ignition of the Starship/Super Heavy rocket engines would have the maximum plume heat of any other ignition events at the VLA. Temperatures at the VLA generated by the heat plume would reach about 300°F. Within an approximate 0.3-mile radius surrounding the VLA, the temperatures would reach about 212°F and within an approximate 0.6-mile radius, the temperatures would reach an ambient temperature of 90°F. Any ESA-listed species located within the 0.6-mile radius of the heat plume may be injured or subject to mortality. However, noise associated with the pre-launch operations and the engines is expected to drive individuals to disperse from the area prior to exposure to the heat plume. Some pre-launch activities, such as the use of drones, or cryogenic venting could trigger the startle response of birds and other animals, allowing additional dispersal time. The operation of the deluge system also has been shown to reduce these temperatures and	Piping plover (T) Red knot (T) Northern aplomado falcon (E) Eastern black rail (T) Jaguarundi (E) Ocelot (E) Green sea turtle (T) Hawksbill sea turtle (E) Kemp's ridley sea turtle (E) Leatherback sea turtle (E) Loggerhead sea turtle (T) Black-capped petrel (E)

Stressor or Threat	PEA Proposed Action Potential Effect on Species	Proposed Action Potential Effect on Species	Species Potentially Affected
		produce steam and condensate that would be rapidly cooled as it travels through the air. Therefore, although launch cadence would increase, launches would still occur infrequently and each event would be intermittent and temporary in nature. Proposed Action activities would be consistent with launch, landing, and testing events already occurring at the site. As such, the species that frequent the area have likely experienced this disturbance. Additionally, temperatures recorded during flight 3 indicate that the 2022 PEA analysis conservatively estimated the size of the heat plume, and that temperature was ambient (90°F) at 0.2 miles from the launch mount. It is not anticipated that the increased thrust will cause the heat plume to extend beyond the 0.6-mile radius area assessed. The increased mission cadence will increase the frequency that the open ocean around the landing platform or droneship is 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. Piping plovers and red knots regularly or occasionally use habitat within the gravel plume area for foraging and resting. The noise and activity associated with engine ignition likely cause piping plovers or red knots that may be close to the VLA to flush prior to the creation of the gravel plume. This behavioral response would likely prevent physical injury or death from the gravel plume. To date, no piping plovers or red knots have been found dead or injured following testing of the Starship and Super Heavy launch vehicles. Since piping plovers and red knots do not breed in Texas, no immobile eggs or chicks would be present in the vicinity of the VLA, and none would be exposed to the potentially harmful effects of the gravel plume.	Band-rumped storm-petrel (E) Hawaiian petrel (E) Newell's shearwater (E) Roseate tern (E) Short-tailed albatross (E)
Launch related closures	The 2022 PEA states that SpaceX estimates its operations that require restricting public access to protect public safety would require up to 500 hours annually. An additional 300 hours would be needed for anomaly response closure hours. Launch-related access restrictions during sea turtle nesting season could impact the ability of sea turtle patrol personnel to locate nests and collect eggs for off-site incubation. Launch-related access restrictions could also impact researchers and National Wildlife Refuge staffs' ability to conduct bird and vegetation surveys.	Areas in the vicinity of the Boca Chica Launch Site would require temporary access restrictions due to the Proposed Action. The number of closure hours for licensed activities and anomaly response would be the same as the PEA and are not anticipated to generate new impacts.	Piping plover (T) Red knot (T) Green sea turtle (T) Hawksbill sea turtle (E) Kemp's ridley sea turtle (E) Leatherback sea turtle (E) Loggerhead sea turtle (T)

Stressor or Threat	PEA Proposed Action Potential Effect on Species	Proposed Action Potential Effect on Species	Species Potentially Affected
Night lighting	Lighting on beaches may disrupt hatchling emergence from sea turtle nests. The PEA assumed 20% of annual operations would occur at night.	The Proposed Action would launch primarily during daylight hours (7:00 a.m. and 7:00 p.m.). Up to one launch could occur at night under the Proposed Action. During nighttime launch activity, SpaceX would require bright spotlighting for short durations when illuminating the launch vehicle. Lighting at night can disorient or interrupt the nesting process nocturnally nesting species of sea turtles. All sea turtle nests detected on Texas beaches are collected, and the eggs are incubated in facilities and therefore the likelihood of eggs not collected hatching at the same time a night launch occurs is low. Inappropriate lighting may also result in abandonment of roosting areas by terrestrial birds, however this displacement is temporary. Piping plovers and Red knots do not breed in Boca Chica, TX. Aplomado falcons are not known to nest within the vicinity of the VLA. Therefore, lighting effects would not impact nesting of the ESA species.	Piping plover (T) Red knot (T) Northern aplomado falcon (E) Green sea turtle (T) Hawksbill sea turtle Kemp's ridley sea turtle (E) Leatherback sea turtle (E) Loggerhead sea turtle (T)
Lighting on Landing Platforms and Drone Ships	N/A	Seabirds may be attracted to lights on ships and platforms at sea as they forage at night, and any attraction towards 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 from the Hawaiian Islands. During the day, it is not expected that the lights would have any effect on sea birds.	Black-capped petrel (E) Band-rumped storm-petrel (E) Hawaiian petrel (E) Newell's shearwater (E) Roseate tern (E) Short-tailed albatross (E)
Hazardous materials	During operations, there is the potential for spills of hazardous materials. The likelihood that an ESA-listed species would come into contact of a hazardous material during a spill is low given SpaceX's immediate clean-up response.	Under the Proposed Action, there is potential for spills of hazardous materials. The likelihood that an ESA-listed species would come into contact with a hazardous material during a spill would continue to be low, however, given SpaceX's immediate clean-up response.	Green sea turtle (T) Hawksbill sea turtle (E) Kemp's ridley sea turtle (E) Leatherback sea turtle (E) Loggerhead sea turtle (T)
Ground vibrations	There is a potential for ground vibrations that occur during launches and landings to disturb nesting turtles and birds and potentially impact eggs. These vibrations from rocket launches could frighten nesting sea turtles, causing them to abandon their nesting attempt. The likelihood of significant disturbance is low, however, given the short-term, infrequent nature of vibration impacts; vibrations from launch operations would only last a few minutes.	Under the Proposed Action, the likelihood of significant disturbance would still be low given the short-term, infrequent nature of vibration impacts. The Proposed Action increased launch schedule may increase the likelihood of this occurrence; however, the events would still relatively infrequent (about once to twice a month) for only a few minutes. The operation of the deluge system may also mitigate some of the vibration and sound impacts. The current minimization measures taken by SpaceX to reduce impacts are being implemented through coordination with Sea Turtle, Inc. to conduct surveys daily during sea turtle nesting season and immediately prior to a launch. Hatched sea turtles are then brought back to Boca Chica	Piping plover (T) Red knot (T) Northern aplomado falcon (E) Eastern black rail (T) Jaguarundi (E) Ocelot (E) Green sea turtle (T) Hawksbill sea turtle (E) Kemp's ridley sea turtle (E)

Stressor or Threat	PEA Proposed Action Potential Effect on Species	Proposed Action Potential Effect on Species	Species Potentially Affected
		beach and released. These measures would continue to occur under the Proposed Action.	Leatherback sea turtle (E) Loggerhead sea turtle (T)
Increased traffic and human presence	Vehicle traffic during daily operations from SpaceX operations personnel could potentially increase the likelihood of wildlife being killed by a collision with a vehicle. In addition, traffic and human presence could cause wildlife to avoid the area. The area is already trafficked by humans, and to date, monitoring has not shown any documented "take" of ESA-listed species due to vehicle strikes involving SpaceX.	The Proposed Action would increase the number of truck trips for transport of propellant and water to the Project. Although jaguarundis are known to be diurnal, ocelots are active around sunset and sunrise, with activity continuing during the night. The ongoing increase in traffic and human presence would likely cause wildlife to avoid areas near SH 4. However, the area already experiences frequent human and vehicle activity, and to date, monitoring has not shown any "take" of ESA-listed species due to vehicle strikes involving SpaceX. SpaceX would also continue to implement environmental protection operation measures as discussed in Section 2022 PEA and November 2023 WR. Some of the operational measures include education plans for personnel on the potential for vehicle collision with ocelots and jaguarundis, encouragement for personnel to use employee shuttle, speed limits of 25 miles per hour at the VLA with restrictions to operated vehicles only in existing paved and dirt roads and parking, and water truck delivery limited to daylight hours as practicable.	Piping plover (T) Red knot (T) Northern aplomado falcon (E) Eastern black rail (T) Jaguarundi (E) Ocelot (E)
Habitat loss (including critical habitat)	Direct loss of habitat reduces a species ability to reproduce, find food, find shelter, and survive.	The operation of the deluge system has the potential to change surrounding habitat however, water would be retained to the greatest extent possible.	Piping plover (T) Red knot (T) Northern aplomado falcon (E) Eastern black rail (T) Jaguarundi (E) Ocelot (E) Green sea turtle (T) Hawksbill sea turtle (E) Kemp's ridley sea turtle (E) Leatherback sea turtle (E) Loggerhead sea turtle (T)
Anomaly	An anomaly in which a Starship/Super Heavy test operation, launch, or landing fails could result in impacts including debris and fire, which could injure or cause mortality to wildlife species adjacent to the launch pad or within areas impacted by debris. Fires are unlikely and, consistent with monitoring to date, are not expected to cause a significant impact on any species.	The April 2023 WR included the installation of a fire suppression system to prevent the risk of a fire on the launch pad. This fire suppression system would continue to be operated as part of the Proposed Action. The operation of the deluge system evaluated in the November 2023 WR would reduce the dissemination of debris directly surrounding the launch pad and help with fire suppression. The Proposed Action to increase the frequency of launches at the VLA, is not expected to	Piping plover (T) Red knot (T) Northern aplomado falcon (E) Eastern black rail (T) Jaguarundi (E) Ocelot (E) Green sea turtle (T) Hawksbill sea turtle (E)

Stressor or Threat	PEA Proposed Action Potential Effect on Species	Proposed Action Potential Effect on Species	Species Potentially Affected
		increase the probability of an anomaly occurring due to the increase in reliability and capability of the vehicle that occurs with each successful launch, proposed measures discussed above would continue in the help mitigate the potential impacts to an unlikely event of an anomaly to ESA-listed species or critical habitat.	Kemp's ridley sea turtle (E) Leatherback sea turtle (E) Loggerhead sea turtle (T)
Increased boat traffic	A potential increase in boat traffic during launch days could increase the potential for seagrass beds to be disturbed from rotor wash and therefore result in a decrease in a food source for the manatee. In addition, the risk to manatees from boat strikes would increase.	Boaters are not permitted to be in the Gulf at Boca Chica Beach or near the landing locations in the oceans. The Proposed Action would not alter boating activity in the Project vicinity.	West Indian manatee (T)

Notes: (T)= Endangered species action status of threatened
(E)= Endangered species action status of endangered
(PE) = Proposed Endangered

In accordance with the FONSI/ROD, SpaceX would continue to coordinate with Sea Turtle, Inc. prior to the launch-related access restrictions of State Highway 4 and Boca Chica Beach to ensure any discovered eggs could be accessed by Sea Turtle, Inc. and removed from the beach prior to launch. For the first three launches of Starship/Super Heavy, no sea turtle eggs were discovered during Sea Turtle Inc.'s surveys on April 19, 2023 (during sea turtle nesting season) or on November 18, 2023 (outside of sea turtle nesting season), or March 14, 2024 (before sea turtle nesting season).

Accordingly, consistent with the data and analyses contained in the 2022 PEA, and pending consultation, it is anticipated that the Proposed Action would not result in significant impacts to terrestrial ESA-listed species and critical habitat.

3.2.8.3. Marine Resources

Federally Listed Species and Critical Habitat

Marine ESA-listed species and critical habitat impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA.

As described in the 2022 PEA, the FAA completed a programmatic ESA consultation with the NMFS for launch and reentry operations in the marine environment (NMFS 2022) and included analysis of launches at Boca Chica TX and landing of the Starship at the VLA, downrange in the Gulf of Mexico or in the Pacific Ocean. Super Heavy could land at the VLA or downrange in the Gulf of Mexico. NMFS concurred with the FAA's determination that the activities presented in the programmatic consultation would not adversely affect ESA-listed marine species or designated critical habitat. A programmatic letter of concurrence (LOC) was issued (2022 LOC; NMFS 2022).

Following the issuance of the 2022 NMFS LOC, the FAA initiated formal consultation with NMFS to evaluate additional information provided by SpaceX regarding Starship and Super Heavy planned descents during the first launch. Specifically, the consultation evaluated Starship's planned landing and Super Heavy's planned soft water landing, more clearly defined the existing launch profile for Starship and Super

Heavy ocean landings, and evaluated the expansion of the potential area for Starship's ocean landing location. On April 14, 2023, NMFS provided a letter of concurrence for the FAA's determination of may affect, but is not likely to adversely affect ESA-listed species and designated habitat when considering this additional information (2023 LOC; NMFS 2023).

In February of 2024, the FAA requested informal consultation with NMFS for Starship reentry operations in the Indian Ocean. The consultation evaluated the potential for up to a total of ten nominal operations, including up to a maximum of five overpressure events from Starship intact impact and up to a total of five reentry debris or soft water landings in the Indian Ocean, until March 2025. On March 7, 2024, NMFS provided a letter of concurrence for the FAA's determination of may affect, but is not likely to adversely affect ESA-listed species and designated habitat when considering this additional information (NMFS 2024).

The NMFS LOCs identified potential stressors to ESA-listed species due to 2022 PEA activities. These potential stressors, which would still apply under the Proposed Action, include the following:

- impact by fallen objects: spacecraft, rocket parts, radiosonde;
- exposure to hazardous materials;
- exposure to sonic booms (overpressure) and impulse noise generated during spacecraft reentry or stage landings in the ocean;
- ship strike; and
- harassment by aircraft overflight.

Impacts by fallen objects and hazardous materials under the Proposed Action would remain highly unlikely to occur and thus discountable, as the amount of material or debris would not increase per landing, but only the frequency at which the landings occur. There may be residual propellent on board during splashdown, however a spacecraft's propellant storage is designed to retain residual propellant, so any propellant remaining in the spacecraft is not expected to be released into the ocean. In an unlikely event the propellant tank ruptures on impact, the propellant would evaporate or be quickly diluted and buffered by seawater. As stated in the LOC, the chance for ESA-listed marine species to be exposed to the residual propellants from a splashdown or launch failure is extremely low and therefore discountable. Under previous consultations, NMFS concluded that hazardous material exposure to ESA-listed marine mammals, sea turtles, and fish in the action area may affect, but are not likely to adversely affect these animals. SpaceX would still implement the avoidance and minimization measures presented in the 2022 LOC and the 2022 PEA to minimize encounters with ESA-listed species.

As presented in the 2022 and 2023 LOC, studies use an impulsive noise threshold value of 12 pounds per square inch (psi) for a harassment risk to marine mammals and sea turtles. To produce the 12 psi in the water, there needs to be nearly 900 psf at the water surface, assuming excellent coupling conditions. NMFS also noted that it is very difficult to create sonic booms that even approach 50 psf. Furthermore, the 2022 LOC states that ESA-listed marine mammals and sea turtles could be exposed to the overpressures from sonic booms in the air when they are surfacing for air; however, the chances of both events happening at same time (i.e., species surfacing and a sonic boom occurring) is extremely unlikely, especially considering the length of a sonic boom is less than one second. The previous consultation and letter of concurrence references a maximum overpressure of 2.2 psf would be generated, therefore, the 2022 LOC determination that exposure to sonic booms and impulse noise would not affect marine species

due to little energy transferring into water as a result of sonic booms (FAA 2017) and the highly unlikeliness of impacts to surfacing species is likely still valid, even with the increase in launch cadence.

For the sea birds, foraging individuals could be exposed and subsequently startled by engine noise and/or sonic booms associated with ascent and landing, or by noise associated with downrange booster and fairing recovery. The black-capped petrel is the only species out of these six seabirds that ranges close enough to the VLA to be exposed to launch activities. However, this species has not been recorded during monitoring efforts and does not typically come inland, so launch activities are not expected to have an adverse effect. Species that are drawn in by light may have a higher risk of injury depending on lighting of landing platforms and droneships. Petrels, storm-petrels, and shearwaters, including Newell's shearwater and band-rumped storm-petrel, 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 towards 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 from the Hawaiian Islands and the fact that most observed fallout from light occurs on land, near populated areas (Troy et al. 2013). The increased mission cadence will increase the frequency that the open ocean around the landing platform or droneship is 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.

The 2023 LOC evaluated the potential effects of an explosive event near the ocean's surface for Starship's landing in the Pacific Ocean. NMFS evaluated the potentially affected area within which ESA-listed marine species could be harassed. Data on the abundance and distribution of the species in the potentially affected area was evaluated to quantitatively analyze potential impacts. The number of ESA-listed marine species was expected to be less than one, and NMFS concurred with the FAA's findings that the Proposed Action may affect, but was not likely to adversely affect ESA-listed species or critical habitats.

The March 2024 LOC evaluated the potential effects of Starship/Super Heavy operations in the Indian Ocean. Using a similar evaluation, it was determined that the number of ESA-listed marine species was expected to be less than one, and NMFS concurred with the FAA's finding that the Proposed Action may affect, but was not likely to adversely affect ESA-listed species or critical habitats.

The FAA is currently consulting with NMFS regarding the Proposed Action increases in overpressure events due to the overall increase in frequency of landings and the jettison of the heat shield. The FAA reinitiated consultation with NMFS for the Proposed Action that may affect, and is likely to adversely affect ESA-listed species and critical habitat under NMFS jurisdiction. The results of this consultation will be disclosed in a new LOC and the Final EA. Any terms and conditions identified in the LOC by NMFS will be adopted and implemented to minimize or avoid impacts to ESA-listed marine species and critical habitat. MMPA impacts are determined through the IHA process with NMFS. SpaceX is currently consulting with NMFS regarding potential impacts to MMPA species for issuance of an IHA.

As a species that spends most of its life at sea, the potential exists, although unlikely, for overpressure events associated with the Proposed Action to impact individual black-capped petrels. However, foraging flocks of black-capped petrels are generally no larger than 65 birds (USFWS 2023), making the likelihood of an overpressure event directly impacting a black-capped petrel in the large landing areas exceedingly unlikely and discountable.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, and pending consultation and the issuance of a new LOC and IHA, it is anticipated that the Proposed Action would not result in significant impacts to ESA-listed marine species and critical habitat.

Essential Fish Habitat

EFH impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA.

As described in the 2022 PEA, in the event of a failure, there could be potential impact on marine species and EFH if launch vehicle debris falls into the ocean. The Starship/Super Heavy launch vehicle would sink but would not result in permanent changes to physical parameters (temperature, salinity, oxygen concentration, etc.) of the water column. The 2022 PEA also determined that amount of propellant, metals, and other substances that could leach or dissolve into the water column or substrate after the launch vehicle sinks to the ocean floor, would be minimal, as the spacecraft's propellant storage is designed to retain residual propellant, so any propellant remaining in the spacecraft is not expected to be released into the ocean. In an unlikely event the propellant tank ruptures on impact, the propellant would evaporate or be quickly diluted and buffered by seawater. As part of NMFS consultation during the 2022 PEA, NMFS provided the two following Conservation Recommendations pursuant to 50 CFR §600.920, which SpaceX and the FAA agreed to implement:

- Conservation Recommendation 1: Prior to any in-water work (i.e., debris recovery or sinking), SpaceX would ensure all ballast and vessel hulls do not pose a risk of introducing new invasive species and that project implementation would not increase abundance of invasive species present at the project site. SpaceX would sanitize any equipment that has been previously used in an area known to contain invasive species prior to its use for project activities.
- Conservation Recommendation 2: The FAA would coordinate with NMFS in the case of a launch failure and any vessel grounding to determine if consultation re-initiation is appropriate.

The new Proposed Action would increase the number of Starship/Super Heavy vehicle launches, but as the number of launches increases, the reliability of the vehicle would increase and the risk of an anomaly would remain the same as described in the 2022 PEA. The probability of an expended vehicle impacting EFH would remain negligible. SpaceX expects fuel onboard the launch vehicle to be consumed during vehicle breakup, as well as all residual propellant, which would combust. Any remaining structural debris would be made of inert materials and are not anticipated to affect water quality and EFH. SpaceX would also continue to either sink or recover any large floating debris, as necessary, and implement previous NMFS Conservation Recommendations.

As discussed under marine ESA-listed species, single event impulse noise levels and sonic booms would not affect marine species or EFH, as little energy is transferred into the water column as a result of these events (FAA 2017). As the likelihood of creating a sonic boom in excess of 50 psf remains highly unlikely, the increase in launch cadence would not alter noise impacts to species with designated EFH.

Based on the above findings, consistent with the data and analyses that were discussed in the 2022 PEA, the Proposed Action would not result in significant impacts to EFH.

3.2.9. Land Use

Land use impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA. The PEA determined that impacts to land use from launch related operations were not anticipated because the Proposed Action would not violate any local land use plans or zoning ordinances. Additionally, the planned uses under the PEA were deemed consistent with current land uses.

Proposed Actions considered in this EA would occur within SpaceX's property boundary and therefore would not change compatibility with zoning ordinances or land use plans. Beach and beach access point restrictions would still be subject to an existing Memorandum of Agreement between Cameron County and TGLO, which delineates the circumstances under which the County is authorized to conduct access restrictions to protect public health and safety during spaceflight activities. SpaceX's Roadway Closure Traffic Control Plan and access restriction text message service would also continue to be utilized to ensure safety and security during launch operations. Licensed access restrictions would not change under the Proposed Action and would continue to be limited to 500 hours per year for operations plus 300 hours per year to address anomalies.

Transport of Starship/Super Heavy, cargo, and payloads to the VLA would continue to occur on SH4, which is the only road leading to the VLA. If either stage of the launch vehicle were recovered downrange, SpaceX would deliver it by barge to the Port of Brownsville and transport it the remaining distance to the VLA over roadways. Although the Proposed Action could increase the frequency of transport due to an increase in launches and landings, transport of rocket components and payloads over this stretch of SH 4 is currently a common occurrence. Additionally, the increase in landing-related transports would be negligible compared to annual average daily traffic counts on SH 4 closest to the site, which were 2,473 in 2022 (TXDOT 2023). The additional transports could cause some road delays on SH 4 and may slow visitor's access to Boca Chica Beach and other resources in the area. SpaceX will continue to notify the public of planned delays on SH 4 through updates to the Cameron County website's "Temporary and Intermittent State Highway 4 Road Delay" updates (Cameron County 2024) and through variable message signs posted along SH 4.

Impacts to state owned submerged lands and offshore oil and gas leases would not change; SpaceX would continue to notify and coordinate with leaseholders and oil and gas operators prior to launches and landings. Risks associated with debris and hazardous materials are addressed below, in the Hazardous Materials, Solid Waste, and Pollution Prevention section.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant land use impacts.

3.2.10. Hazardous Materials, Solid Waste, and Pollution Prevention

Hazardous materials, solid waste, and pollution prevention impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA. The 2022 PEA found that no substantial volumes of hazardous materials would require disposal and the potential for impacts would be limited through the implementation of appropriate handling and management procedures for hazardous materials.

Under the Proposed Action, hazardous materials transportation, storage, and disposal would continue to occur in a manner consistent with applicable federal, state, and local environmental, public, and occupational health and safety regulations.

Transportation of commodities containing hazardous materials (LOX, methane, liquid nitrogen) would increase under the Proposed Action (from 3,850 to 18,421 trucks per year). The transport of hazardous materials would have the potential to result in accidental spills that could adversely impact soil, surface water, and groundwater adjacent to transportation routes. However, SpaceX has appropriate plans in place to address accidental spills or releases of hazardous materials (e.g., Spill Prevention, Control, and Countermeasures Plan). In the case of a reportable spill or the discovery of previously unknown contaminants that exceed a reportable threshold, SpaceX would stop work and contact the National Response Center. If the reportable spill occurs within tidal waters, SpaceX would also notify the TGLO. SpaceX would treat or remove soils adversely affected by spills in accordance with applicable federal and state regulations.

Propellent (LOX and methane) quantities used for launch vehicles would also increase from 1,500 MT to a total of 2,650 MT for Starship and from 3,700 MT to 4,100 MT for the Super Heavy vehicle. However, most of the hazardous materials would be consumed prior to landing. Although the Proposed Action would increase the number of launches and landings that occur at the site, the probability of a launch anomaly that releases debris and hazardous materials would decrease. Any launch anomalies would be subject to the guidance, policies, and protocols regarding hazardous material incidents and associated emergency response described in SpaceX's Anomaly Response Plan. SpaceX would respond to any accidental releases of polluting substances quickly and implement appropriate clean-up measures in accordance with applicable laws to minimize impacts to the environment, per PEA mitigation measures.

During engine ignition the surface of the pad flame deflector could experience a small amount of ablation. Ablation is the mechanical erosion of steel from the surface of the metal as result of exposure to heat and force and is considered a common consequence of activities on metal launch infrastructure. The ablated steel would be minimal and would quickly recondense near the launch mount when exposed to the deluge water. The increased mission profile would increase the cumulative amount of metal that may be ablated and subsequently deposited outside the VLA. SpaceX would continue to conduct contaminant sampling in accordance with the November 2023 WR and BCO Reinitiation #1. Sampling conducted from the second and third flights of Starship/Super Heavy showed negligible changes from baseline contaminant levels. All of the soil sample results registered below the Texas-specific soil background concentrations[10] for pre- and post-launch sampling events. There were no evident trends between the pre- and post-launch. Water samples collected following the second and third flights showed results for all tested analytes that remain well below the Standard for Industrial Multi-Sector General Permit Numeric Effluent Limits (TCEQ 2016). Additionally, hexavalent chromium was non-detectable before and after the launch. SpaceX will continue to conduct contaminant monitoring and provide the results to the FAA and USFWS. Baseline data will be compared to future monitoring data to confirm that no deposition and or/accumulation or potential contaminants is occurring, and no significant changes from baseline levels are expected (SpaceX 2024c, 2024d). As required in the BCO Reinitiation #1, sampling will occur after every launch beginning in 2023, twice a year after a launch in 2024, and potentially quarterly the following 3 years depending on the findings of the monitoring.

SpaceX would continue to salvage or recycle solid waste to the maximum extent practicable and dispose of the remaining solid waste in appropriately permitted landfills. In 2022, the nearby Seabreeze landfill

[10] 30 TAC §350.51(m)

had approximately 28,826,044 remaining tons of capacity and had an estimated 22 remaining years of operational capacity (TCEQ 2023).

A launch anomaly could result in debris and hazardous materials being distributed in the immediate area of the landing site. If any anomalies occurred during the landing event SpaceX would respond to all accidental releases of polluting substances quickly and implement appropriate cleanup measures in accordance with applicable laws to minimize impacts to the environment. Starship would have approximately 34 gallons of hydraulic fluid. In the event of an anomaly, hydraulic fluid may remain contained in the vehicle, ignite, or be released. Remaining hazardous materials such as propellant, ordnance, or chemicals would be transported back to SpaceX in accordance with DOT regulations for transport of hazardous substances.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant hazardous materials, solid waste, and pollution prevention impacts.

3.2.11. Natural Resources and Energy Supply

Natural resources and energy supply impacts, taking into account the new information related to the Proposed Action, would be comparable to those discussed in the 2022 PEA.

3.2.11.1. Natural Resources

The primary natural resource of concern for the Proposed Action is water. The 2022 PEA evaluated potential impacts to groundwater quality, municipal water supply, and aquifer draw down. The PEA concluded the Proposed Action would have minimal impact to the groundwater quality, the demand placed on municipal water supplies would not be significant, and aquifer drawdown could range up to 0.6 feet after 20 years.

The Proposed Action would not alter the potential for impacts to groundwater quality and should not alter rates of potential 20-year aquifer drawdown. It would, however, increase the water required for Super Heavy static fires and launches by approximately 10,270,000 gallons annually. As reported in the 2022 PEA, actual municipal water use for the city of Brownsville was 20.8 million gallons per day (MGD) in 2018 and is projected by the Texas Water Development Board to be 36.8 MGD in 2030, with total municipal capacity from the Rio Grande at 47.5 MGD. Thus, even if the demand for municipal water increased 10,270,000 gallons per year, or 0.03 MGD, the increase would be approximately 0.1% of the City's 2018 usage and well within the current and projected capacity for the City of Brownsville.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant natural resource impacts.

3.2.11.2. Energy Supply

The 2022 PEA evaluated impacts associated with 1) demand for electricity, 2) demand for diesel and gasoline to fuel ground equipment, and 3) demand for the various propellant fuels and commodities required for launches and static fire tests. The PEA determined:

- The use of power from the existing on-site solar energy farm, along with the proposed expansion of the solar farm and additional battery system would minimize impacts to the electric power supply.

- The PEA determined that demand for diesel and gasoline would not adversely impact the balance of diesel and gasoline supply and demand in the highly industrialized Rio Grande Basin.

The Proposed Action would not change these conclusions. Since the publication of the 2022 PEA, the Magic Valley Electric Coop installed a line that extends from Brownsville east to Boca Chica Beach. This power line provides additional power to users east of Brownsville, including test and launch operations at the VLA.

With respect to demand for various propellant fuels, the Starship has a propellant capacity of 2,650 MT and the Super Heavy has a propellant capacity of 4,100 MT. The estimated demand for propellant for launches estimated in the PEA amounted to approximately 33,500 MT. The increased launch events and propellant capacity would increase the total propellant to 168,750 MT, which would be an increase of 135,250 MT annually[11]. Regional and national supplies of propellants and commodities are not expected to be impacted by this increase. Annual production of oxygen in the U.S. was approximately 10,993 million kg, or 11.0 million MT, in 2019 (EPA 2023c), so the increase would represent 1.1% of domestic production. LCH_4 is a more purified form of LNG that is in large supply in the U.S., which exported 6,903 billion cubic feet of LNG, or 141.7 million MT, in 2022 (U.S. Energy Information Administration 2023). The increased demand for LCH_4 would be less than 0.01% of the amount of LNG produced for export per year in the U.S. There are large markets in the U.S. for LOX and LCH_4 and therefore the relatively minor increased demand would not likely adversely affect prices or supplies at the regional or national level.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant energy supply impacts.

3.2.12. Socioeconomics, Environmental Justice, and Children's Environmental Health and Safety Risks

3.2.12.1. Socioeconomics

The 2022 PEA determined that Project activities would not adversely affect existing economic activity, income, employment, population, housing, sustenance, public services, and/or social conditions. Specific PEA findings included the following:

- Launch operations may result in economic benefits to the local area, including increased labor demand, higher revenues for local businesses, and an overall increased per capita income.
- While the population living under the poverty threshold may not benefit through direct employment, individuals may indirectly benefit as regional economic activity is stimulated by the increase in space exploration-related employment and purchases.
- Impacts on property values and quality of life would be difficult to assess due to the large number of variables that can influence these topics. Negative impacts on home values or quality of life associated with noise, traffic, and lighting conditions near the launch facilities could potentially be offset by increased demand in the area created by employment opportunities at the site.
- Airspace closures would not result in the closure of any public airport or severely restrict the use of the surrounding airspace so as to prevent access to an airport for an extended period of time.

[11] With the Raptor engine's 3.6:1 mixture ratio by weight of LOX to LCH_4 the total increased demand for LOX and LCH_4 would be roughly 37,200 MT and 10,300 MT respectively.

The Proposed Action would not materially change the expected number of operational personnel, expenditures, or taxes and so would not change expected impacts to economic activity, income, employment, population, sustenance, public services, and/or social conditions.

Although the increased launch cadence would incrementally increase noise and traffic in the Project area, a review of estimated home values using the Zillow Home Value Index (Zillow 2023), in the ten years from 2014 to 2023 showed that the change in estimated home prices in the Boca Chica zip code (78521) were similar to the change for Cameron County, with increases in home values estimated at 73.6% and 67.4% respectively. No obvious trend has emerged to indicate either an increase in home values associated with the higher demand from employment and development in the area or a decrease in home values associated with proximity to the launch area. While it is important to note that average estimated home values in the zip code do not capture potential impacts to specific properties, these data do suggest that facility operation has not resulted in systematic property value reductions.

Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant socioeconomic impacts.

3.2.12.2. Environmental Justice

The 2022 PEA identified environmental justice populations in the study area of Cameron and Willacy Counties and noted the proportion of minority and low-income populations in the counties were substantially higher than in the state of Texas. These populations were identified as being subject to some unavoidable impacts from 1) increased noise, 2) traffic, 3) lighting during nighttime operations, and 4) intermittent and temporary access restrictions to Boca Chica Beach. However, the PEA found that these impacts would be minimized by following FAA, OSHA, Department of Transportation, and state requirements and guidelines, as well as the mitigation measures identified to limit access restrictions.

The Proposed Action would change noise, traffic, nighttime operations, and access restrictions relative to the 2022 PEA as follows:

1. The 2022 PEA already contemplated the noise associated with Starship/Super Heavy orbital launches and landings. The Proposed Action would increase the frequency of these launch events from fewer than 10 annually to as many as 25 annually.

2. Additional daily truck trips would be required to meet the increased demand for commodities (e.g. rocket propellant) and water. It is not anticipated that these increases in daily trucks trips would likely alter the expected traffic conditions along SH 4 or at the site.

    a. An estimated 18,421 additional truck trips per year would be required to bring in propellant. This equates to an increase of approximately 40 trucks every day accessing the site via SH 4.

    b. An estimated 3,800 truck trips per year would be required to bring water for the deluge system. This equates to an increase of approximately 4.5 truck per day.

3. Nighttime operations would decrease from one suborbital and one orbital launch event per year to up to one nighttime launch event.

4. The total number of launch events would increase from 10 to as many as 25 annually and the total number of landings would increase from 15 to as many as 50. The maximum annual number of

hours (500) in which access to affected public parks (e.g. Boca Chica Beach, as identified in Section 3.15.4.2 of the 2022 PEA) would be restricted would remain the same.

1. Noise due to sonic booms for Super Heavy landings at the VLA would increase from up to 15 psf in the 2022 PEA to within the 21 psf contour in this EA. Additionally, the 1 psf contour (similar to a clap of thunder) for sonic booms for Super Heavy landings would increase from approximately 13 miles to approximately 20 to 33 miles. The 60 db CDNL contour would extend approximately 6 miles from the VLA.

As described in the 2022 PEA, SpaceX will implement their public notification plan to educate the public and announce when a launch or landing event would occur. The plan would involve issuing statements to news outlets and law enforcement so that when noise is heard, the public would understand what has occurred. The Proposed Action would have some unavoidable impacts to local residents that do not rise to a level of significance, from increased traffic, lighting during nighttime operations, and intermittent and temporary access restrictions to Boca Chica Beach. These impacts would be minimized by following all appropriate FAA, OSHA, DOT, and state requirements and guidelines, as well as the mitigation measures identified in the 2022 PEA.

Based on the information presented for community characteristics in Section 3.15.3.2 of the 2022 PEA and the updated sonic boom information in this EA there would be no disproportionate impacts on environmental justice populations due to significant noise impacts.

Based on the information provided above, the Proposed Action would not result in significant impacts on environmental justice populations. Further, the FAA will continue providing Spanish translations of vital project-related documents and information, and oral interpretation services for public meetings, or by request, in the future.

3.2.12.3. Children's Environmental Health and Safety Risks

The 2022 PEA determined that risks to children's environmental health and safety would be limited since the Project is located in a sparsely populated area with no children living in the only nearby residential area and no public schools within 6 miles.

The 2020 U.S. Decennial Census (U.S. Census Bureau 2020) shows less than five children living in the census blocks immediately adjacent to the launch site, which includes a radius of over 2 miles. The Ad Astra School, a private school started by SpaceX, is the nearest school and is located approximately 6 miles from the launch site. Since publication of the 2022 PEA, more SpaceX employees have moved into area with their children. Children would not be near the VLA during launch or landing operations. The school is located within the 60 dB CDNL contour, however, the school is closed during launch/landing activities.

Noting that the 2022 PEA already contemplated the risks posed by orbital launches (i.e., Starship with the Super Heavy rocket attached) the only new consideration relates to the unexpected creation of a dust plume that affected communities when SpaceX conducted its first launch of Starship with the Super Heavy rocket attached on April 20, 2023, the effect of increased traffic, and the effect of increased noise.

- As noted in the preceding section, corrective actions and launch pad modifications made by SpaceX are expected to prevent similar dust impacts in the future.
- As noted in the preceding section, an additional 65 truck trips per day along SH 4 would not represent a material change in the previously contemplated traffic volume.

- As noted in the preceding section, the 2022 PEA already contemplated the noise associated with Starship/Super Heavy orbital launches and landings. An increase in these noise events would not fundamentally change children's environmental health concerns or safety risks.

Thus, risks to children's environmental health and safety would be comparable to those discussed in the 2022 PEA. Accordingly, consistent with the data and analyses contained in the 2022 PEA, the Proposed Action would not result in significant risk to children.

3.2.13. Coastal Resources

The Proposed Action is subject to the regulations set forth by the Coastal Barrier Resources Act (16 U.S.C. § 3501 et seq.) and the Coastal Zone Management Act (16 U.S.C. § 1451Ŧ1466). The State of Texas, through the TGLO, exercises its authority to implement the Texas Coastal Management Plan under the Coastal Zone Management Act through 31 Texas Administrative Code §501.3. As discussed in the PEA, TGLO stated they would not conduct a consistency review because the Proposed Action is not a listed activity and is not subject to review under the Texas Coastal Management Plan. As the activity type has not changed, no additional consistency review is needed.

The 2022 PEA concluded that no significant impacts to coastal resources would occur, as no coastal construction or seafloor disturbing activities would take place, and any downrange landings would occur no closer than 19 miles offshore. The Proposed Action includes downrange landings no closer than 5 nautical miles offshore and the jettison of the heat shield no closer than 1 nm offshore. Landing and recovery operations, including the jettisoned heat shield would not take place in intertidal areas, salt marshes, estuaries, or coral reefs. As an applicant of the FAA-license, SpaceX is responsible for coordinating with the TGLO to ensure its activities are consistent with the TCMP. However, the proposed activity is not included on the states "Listed Activities Subject to CZMA Review" and does not require further coordination with TGLO. No further analysis in this EA is warranted.

3.3. Cumulative Impacts

Analyses of potential cumulative impacts considers "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR § 1508. 1(g)(3) (2022). SpaceX projects identified include the Starfactory construction at SpaceX's production and manufacturing area, housing developments in Boca Chica Village and at Rio East and West (located near State Highway 4 and Richardson Avenue), vehicle engineering testing at SpaceX's property known as Massey's, and construction of a water and other utility lines from Brownsville to the Boca Chica along State Highway 4.

3.3.1.1. Air Quality

Cumulative impacts on air quality from past, present, and future actions near the VLA would be less than significant. The VLA is located in Cameron County which is in an attainment area for all pollutants (EPA 2023). The operational emissions for the Proposed Action represent an extremely small percentage of the Cameron County regional emissions and would not cause an exceedance of any NAAQS. The Proposed Action would result in temporary air emissions during a launch operation. It should be noted that each launch, landing, or static test fire operation would occur separately, avoiding simultaneously combining

impacts associated with exhaust plumes from more than one operation at a time. Air emissions from other projects would be localized and short-term in nature.

Air emissions from the Proposed Action when combined with other past, present, or reasonably foreseeable future actions would not result in an exceedance of any NAAQS and therefore would not result in significant cumulative air quality impacts.

3.3.1.2. Climate

Cumulative impacts to climate from past, present, and future actions near the VLA would be less than significant. GHG emissions that would result from the Proposed Action would be comparable to those discussed in the 2022 PEA and minute compared to current emissions in the United States and the State of Texas. In combination with the ongoing and reasonably foreseeable actions by SpaceX and others in the Project area, the GHG contributions of these projects would be insignificant and is not expected to result in any changes in cumulative climate impacts.

3.3.1.3. Noise and Noise-Compatible Land Use

Cumulative impacts associated with noise may result from past, present, or reasonably foreseeable projects within the vicinity of the VLA. Construction noise from developments in the area may result in incremental noise impacts, depending on the timing of construction activities in conjunction with the other potential future projects. Construction noise would be temporary, and in comparison to the current land use of the site, distance to sensitive noise receptors, and distance to other proposed future projects, construction noise is not expected to result in any long-term adverse cumulative noise impacts. Operational noise from vehicle testing at Masseys would be temporary and intermittent, and similar to the testing noise impacts descripted in the 2022 PEA. Additionally, prior to SpaceX converting the area to a testing facility, the Massey's site operated as a publicly accessible gun range, which exposed the surrounding area to operational noise. For comparison, according to the American Speech-Language-Hearing Association, the average gunshot is approximately 140 decibels (2023). Although there may be short-term and incremental noise increases in the area, noise would return to baseline conditions at the completion of the operational activity.

As a result, any cumulative noise impacts would be short-term and temporary, and would not be expected to result in sustained, long-term cumulative impacts.

3.3.1.4. Visual Resources

Cumulative impacts to visual resources may result from past, present, or reasonably foreseeable projects within the vicinity of the VLA. The SpaceX housing developments known as Rio East and Rio West are located at the eastern edge of the Palmito Ranch Battlefield National Historic Landmark. Although the additional houses will introduce new visual elements to the area, they are located near existing houses in the vicinity of Tarpon Bend and will result in similar visual impacts as the existing homes.

Construction of Starfactory at Boca Chica launch site would also result in changes to the viewshed in the area. However, the baseline condition of the area is already an industrial setting, and changes to the infrastructure from multiple smaller structures to one large structure would not change the existing industrial setting.

Vehicle testing at SpaceX's Massey's site may introduce new visual impacts to the Palmito Ranch Battlefield National Historic Landmark. However, these impacts would be temporary, and only occur when a vehicle was present at the testing site. Activities would include testing (*e.g.* tank tests and static fires), which were evaluated in the 2022 PEA. Activities at Massey's may require nighttime lighting. Lighting impacts would be minimized by facility best management practices, such as angling lighting downwards, shielding of lighting, and turning off lights when not in use. Visual impacts would be similar to those evaluated in the 2022 PEA and would not significantly degrade the existing viewshed. The infrastructure at the VLA is not visible from the visitor site at the NHL.

Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts to visual resources.

3.3.1.5. Cultural Resources

Cumulative impacts to cultural resources may result from past, present, or reasonably foreseeable projects within the vicinity of the VLA. Ongoing economic development and commercial activity could have an impact on cultural resources in the area. For example, the SpaceX housing developments known as Rio East and Rio West are located at the eastern edge of the Palmito Ranch Battlefield National Historic Landmark. Although the additional houses will introduce new visual elements to the area, they are located near existing houses in the vicinity of Tarpon Bend and will result in similar visual impacts as the existing homes. The same may be said for other present or reasonably foreseeable future infrastructure or economic development projects, depending on the scope and vicinity of the projects to nearby cultural resources. Within the 10-mile APE for architectural resources, visual and temporary noise intrusions would result in a cumulative effect on historic properties. The extent of the impacts may vary depending on factors such as visibility of the infrastructure from the historic resource itself, and distance from the noise source. SpaceX will continue to implement the mitigation measures identified in the Section 106 Programmatic Agreement to offset impacts to cultural resources protected under Section 106 of the National Historic Preservation Act.

Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts to cultural resources.

3.3.1.6. Department of Transportation Act Section 4(f)

Cumulative impacts to Section 4(f) properties may result from past, present, or reasonably foreseeable projects within the vicinity of the VLA. Ongoing development in the vicinity of the Boca Chica launch site and continued activity, both commercial and recreational could have an impact on identified Section 4(f) properties.

The SpaceX housing developments known as Rio East and Rio West would be located at the eastern edge of the Palmito Ranch Battlefield National Historic Landmark. Although the additional houses will introduce new visual elements to the area, they are located near existing houses in the vicinity of Tarpon Bend and will result in similar visual impacts as the existing homes.

Construction associated with the developments in the area would result in short-term increases in sound levels from the use of heavy equipment. However, this noise would be temporary and would not rise to the level of significant impacts to the quiet settings of the 4(f) resources. Unlicensed vehicle testing at the VLA and at SpaceX Massey's site would also result in temporary noise impacts and may temporarily disturb

wildlife in the area. However, these would be short duration and infrequent, and would not rise to the level of significant impacts to the quiet settings of the 4(f) resources.

3.3.1.7. Water Resources

Cumulative impacts to water resources may result from past, present, or reasonably foreseeable projects within the vicinity of the VLA. Ongoing development in the vicinity of Boca Chica and continued commercial activity could have an impact on water resources.

There are currently no water lines in the Boca Chica area. Water has historically been brought into the Boca Chica and surrounding areas by truck, resulting in large truck traffic on State Highway 4. The water that would be sourced via the waterline would no longer need to be trucked in and would not result in changes to water needs in the area. Additionally, the build out of the Starfactory would require water resources during the construction phase, however the factory would subsume existing structures at SpaceX's production and manufacturing areas, and the existing, baseline activities would continue to operate. Additional water tanks support unlicensed static fires for manufacturing at the VLA. It is not expected that the modification and operation of the Starfactory would significantly alter water usage of SpaceX's production and manufacturing activities.

The primary cumulative impacts on water resources from past, present, or reasonably foreseeable future actions would likely be due to housing developments in the area. The additional housing developments would require additional water for household use. As noted in the 2022 PEA, the nearest municipal water supply is the City of Brownsville. Based on the Texas Water Development Board projected municipal water use in Brownsville from 2020 through 2070, the projected municipal water usage in 2020 was 31.7 million gallons per day, and projected municipal water use in 2030 is 36.8 million gallons per day (Texas Water Development Board 2021). The additional water required for household use would not significantly impact water usage in Brownsville.

Cumulative impacts on water resources from past, present, and future actions near the VLA would be less than significant because of Best Management Practices to control stormwater runoff, erosion, and sedimentation would be used throughout all phases of construction for each project. All development activities would require permitting for both wetland and soil disturbance; the permitting process would ensure impacts to water resources are avoided, minimized, and mitigated to the extent practicable.

3.3.1.8. Biological Resources

As discussed above in Section 3.2.8, there would be some adverse effects to biological resources from the Proposed Action in a manner that is comparable to the 2022 PEA. The construction of water lines from Brownsville to Boca Chica would have a beneficial impact on biological resources, as less trucks would be needed for launch activity, testing, production and manufacturing. Additionally, the water lines would serve the housing developments, which would further remove water trucks from State Highway 4, reducing the likelihood of vehicle collisions with wildlife.

The development of new houses would remove potential wildlife habitat in the area. Additionally, the increased presence of people in the development areas would affect wildlife by disturbing animals. Construction of the Starfactory would be unlikely to affect biological resources, as it is an industrial area currently used for production and manufacturing, which does not contain wildlife habitat. For these reasons, there would be cumulative impacts on biological resources from additional development, human activity, and noise.

The mitigation measures identified in the 2022 PEA would help to decrease the impacts but would not eliminate the impacts to biological resources. However, given the context and intensity of the impacts, significant cumulative impacts to biological resources are not expected.

3.3.1.9. Land Use

The Massey's site has been used as a commercial site, and conversion to a SpaceX testing facility would not result in a significant change of land use at this site. Additionally, the Starfactory development is located in an industrial area, and would not result in a change of land use. The housing developments would convert presently undeveloped land, however this land was platted for residential development, so the conversion would be in conformance with development planning for the area.

As illustrated above in *Noise and Noise Compatible Land Use*, operational noise from vehicle testing at Masseys would be temporary and intermittent, and similar to the testing noise impacts descripted in the 2022 PEA. Additionally, prior to SpaceX converting the area to a testing facility, the Massey's site operated as a publicly accessibly gun range, which exposed the surrounding area to operational noise on a daily basis.

The changes in land use associate with Proposed Action and other past and reasonably foreseeable actions are in conformance with current land use and planned land use, and noise impacts would be minor and would not result in adverse cumulative noise impacts to land use in the area.

3.3.1.10. Hazardous Materials

Construction associated with the developments in the area could have a potential for cumulative impacts to hazardous materials, pollution prevention, and solid waste in the vicinity of the VLA. However, management of hazardous materials and hazardous waste would continue to be conducted under all federal, state, and local laws and regulations for all projects. Best management practices would continue to be implemented to reduce the potential for impacts due to an inadvertent release of hazardous materials.

When past, present, and reasonably foreseeable projects are analyzed in conjunction with the Proposed Action, significant cumulative impacts from these projects would not be expected.

3.3.1.11. Natural Resources and Energy Supply

Cumulative impacts to natural resources and energy supplies could occur due to projects near the Boca Chica project area consuming energy and natural resources (including water resources, covered separately above). There are other ongoing and future construction projects, both private and public, near the Boca Chica area that will result in cumulative consumption of resources. However, the Proposed Action is not expected to contribute in any substantive manner to adverse cumulative impacts to supplies of natural resources or energy use. There are resource providers located throughout the State of Texas and beyond to provide resources and supplies to projects in the area. Under the Proposed Action, there would be increases in the consumption of fuel, oil, propellants, electricity, aggregate water, and groundwater. Recent studies indicate that local, regional, and nationwide suppliers would be able to accommodate the increases in consumption of these resources, resulting in no significant impacts. For example, production of liquified natural gas is projected to increase in the area with the construction of liquified natural gas terminals at the Port of Brownsville (FERC 2019a, FERC 2019b). Additionally, the

municipal supply would also be able to accommodate the increased consumption with no significant impacts.

When past, present, and reasonably foreseeable projects are analyzed in conjunction with the Proposed Action, there would be a cumulative increase in the demand on natural resources and energy supply within the surrounding communities. The cumulative impacts are not anticipated to be significant.

3.3.1.12. Socioeconomics, Environmental Justice, and Children's Environmental Health and Safety Risks

Cumulative impacts to socioeconomics, environmental justice, and children's environmental health and safety risks may result from past, present, or reasonably foreseeable projects within the vicinity of the VLA. The development of additional homes would add to the available number of housing units, although this housing would likely only be occupied by SpaceX employees and may not be available to the public. The additional housing may draw some SpaceX employees from Brownsville, Port Isabel, and South Padre Island, which may have some effect on the local housing market. However, due to the small percentage of SpaceX employees compared to the population of Cameron County, it is not anticipated that the housing market will be significantly impacted by the housing developments.

Therefore, no significant impacts to socioeconomics, environmental justice, and children's environmental health and safety risks are anticipated.

4. CONCLUSION

The 2022 PEA examined the potential for significant environmental impacts from Starship/Super Heavy launch operations at the Boca Chica Launch Site and defined the regulatory setting for impacts associated with Starship/Super Heavy. The areas evaluated for environmental impacts in this EA included air quality; climate; noise and noise-compatible land use; visual resources; cultural resources; Department of Transportation Section 4(f); water resources; biological resources (terrestrial and marine wildlife); land use; hazardous materials; natural resources and energy supply; and socioeconomics, environmental justice, and children's health.

Based on the above review and in conformity with FAA Order 1050.1F, Paragraph 9-2.c, the FAA has concluded that the modification of SpaceX's existing vehicle operator license for Starship/Super Heavy operations conforms to the prior environmental documentation, consistent with the data contained in the 2022 PEA, that there are no significant environmental changes, and all pertinent conditions and requirements of the prior approval have been met or will be met in the current action.

5. LIST OF PREPARERS, INDEPENDENT EVALUATORS, AND AGENCIES AND PERSONS CONSULTED

5.1. List of Preparers

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5.3. List of Agencies and Persons Consulted

Federal Agencies
National Aeronautics and Space Administration
National Park Service
U.S. Army Corps of Engineers
U.S. Coast Guard
U.S. Fish and Wildlife Service

State Agencies
Texas Parks and Wildlife Department
Texas Historical Commission

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APPENDIX A

Agency Consultation

U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of Commercial Space Transportation

800 Independence Ave., SW.
Washington, DC 20591

July 28, 2024

Mr. Mark Wolfe, State Historic Preservation Officer
Executive Director
Texas Historical Commission
P.O. Box 12276
Austin, Texas 78711

RE: SpaceX Starship Super Heavy Project at the Boca Chica Launch Site in Cameron County, Texas, review under Section 106 of the National Historic Preservation Act (FAA/106, THC Tracking No. 202109754)

Dear Mr. Wolfe,

Thank you for your continuing consultation under Section 106 of the National Historic Preservation Act (NHPA) with the Federal Aviation Administration (FAA) regarding the above referenced project. The purpose of this letter is to describe recent changes to the undertaking and the resulting potential effects on historic properties.

Changes to the undertaking

SpaceX recently notified FAA of a proposed increased orbital launch cadence and increased vehicle size at the SpaceX Boca Chica Launch Site. The orbital launch cadence at Boca Chica would be increased from up to five Starship/Super Heavy launches and landings and up to five Starship suborbital launches and landings annually to up to 25 annual launches and 50 total annual landings (25 of the Starship and 25 of the Super Heavy). SpaceX would also make vehicle and operational upgrades identified below in Table 2. Up to one launch (of the total 25) would occur during nighttime hours from the VLA. SpaceX would also conduct up to 90 seconds of licensed daytime Starship static fire tests and 70 seconds of licensed daytime Super Heavy static fire tests a year. The Starship vehicle would increase in length from 50 to 70 meters and would increase from six raptor engines to nine. The thrust of the Starship would increase from 12 meganewtons (MN) to 28.7 MN. The Super Heavy vehicle would increase in length from 71 meters to 80 meters, and the raptor engines would decrease from up to 37 engines to 35. The thrust of the Super Heavy would increase from 74 MN to 103 MN.

The FAA's federal action is to issue a new license to SpaceX or modify SpaceX's current license. The federal action also includes the FAA's issuance of temporary airspace closures.

Changes to effects on historic properties

The increased vehicle size would present sonic boom exposures up to 21 psf for booster landings. This represents a threshold where prevailing literature indicates window breakage becomes possible for standard condition windows. Updated sonic boom modeling for the booster landings at the VLA under the Proposed Action predict overpressure events up to 21 psf extending approximately 2 miles from launch site (SpaceX 2024). This represents an overpressure level where prevailing literature indicates window breakage becomes possible for standard condition windows, though the prediction of specific window breakage still depends on size, age, orientation, surrounding structure, and other effects.

The Palmetto and Cypress Bridge Pilings as well as the Palmetto Pilings Historical Marker are the only historic properties both located within the 21 psf contour. Due to the materials of the pilings and the marker, no damage is anticipated due to these levels of sonic booms.

No historic properties with above ground features are located within the 15 psf or 10 psf contours.

However, historic properties with above ground features, including historic buildings with windows, are located within the 6 psf contour. Windows in poor condition may exhibit progression of damage over multiple exposures to sonic booms at 6 psf magnitude. If such damage occurred, SpaceX would adhere to the terms of the 2022 PA to restore the damaged property.

As a result, previous findings of adverse effect due to vibration have been amended [see attached memo] to include sonic boom potential breakage of windows in historic buildings. To avoid adverse effects, the following condition is imposed to restore damaged windows: SpaceX would adhere to the terms of the 2022 PA to restore damaged windows, including hiring a qualified professional to make recommendations for restoration of the historic property and following the Secretary of the Interior's Standards for the Treatment of Historic Properties.

Faro Bagdad Lighthouse located in Mexico

The Faro Bagdad Lighthouse, approximately 3 miles south of the VLA in Bagdad, Tamaulipas Mexico, is newly identified and located within the 10 psf contour. At 10.0 psf the likelihood of superficial (e.g., plaster, bric a brac) damage and window damage becomes more plausible but is generally still expected to be very low probability and predominantly due to poor existing conditions such as pre-cracked, pre-stressed, older and weakened, or poorly mounted windows. Structural damage to this lighthouse is not anticipated due to the concrete makeup of the structure. Although this lighthouse is located outside your jurisdiction in Mexico, FAA wanted to make you aware of its location, and request any comments you may have.

Conclusion

The FAA is requesting your review of the above changes to the undertaking and effects, and your comments or concurrence with the information provided. If you have any questions or need further information on the project, please contact Ms. Amy Hanson at (847) 243-7609 or at Amy.Hanson@faa.gov.

Sincerely,

STACEY MOLINICH ZEE Digitally signed by STACEY MOLINICH ZEE Date: 2024.07.28 08:58:35 -04'00'

Stacey Zee

Manager, Operations Support

cc: Rachael Mangum, Advisory Council on Historic Preservation
Eric Brunnemann, National Park Service
David Kroskie, Texas Parks and Wildlife Department
Chris Perez, U.S. Fish and Wildlife Service

attachment

July 26, 2024

RE: REVISED Technical Memo on Increased Launch Cadence at the Boca Chica Launch Site and the Written Re-Evaluation of the Final Programmatic Environmental Assessment and Mitigated Finding of No Significant Impact and Record of Decision for the SpaceX Starship/Super Heavy Launch Vehicle Program

This technical memo evaluates whether additional consultation under Section 106 of the National Historic Preservation Act of 1966 is required to support an increased orbital launch cadence and increased vehicle size at the SpaceX Boca Chica Launch Site (Proposed Action). The Proposed Action would increase the orbital launch cadence at Boca Chica from five Starship/Super Heavy launches and five Starship suborbital launches annually to 25 Starship/Super Heavy launches annually. The Starship vehicle would increase in length from 50 to 70 meters and would increase from six raptor engines to nine. The Super Heavy vehicle would increase in length from 70 meters to 80 meters, and the raptor engines would decrease from up to 37 engines to 36. The thrust of the Super Heavy would increase from 74 meganewtons to 103 meganewtons.

PROJECT HISTORY

In 2012 and 2013, the Federal Aviation Administration (FAA) conducted Section 106 consultation with the THC and other consulting parties as part of the FAA's environmental review for the proposed action of issuing SpaceX launch licenses and/or experimental permits to launch Falcon 9 and Falcon Heavy orbital vertical launch vehicles and various reusable suborbital launch vehicles from the Boca Chica Launch Site. As part of the consultation for this undertaking, Cardno (2013a) conducted a cultural resources literature review that identified 17 previously recorded archaeological sites within 8.1 kilometers (km) (5.0 miles [mi]) of the project area; 10 sites were listed or eligible for inclusion in the National Register of Historic Places (NRHP), including the Palmetto Pilings (41CF117) and the 1936 Centennial historical marker (No. 3917) associated with the bridge pilings, and the Palmito Ranch Battlefield National Historic Landmark (NHL) (41CF93). Cardno also conducted intensive pedestrian survey augmented with subsurface investigations and systematic metal detection survey. Cardno (2013a) recorded one newly identified archaeological site (41CF217) and 19 isolated finds during this survey. None of the newly identified archaeological sites or isolated finds were recommended eligible for NRHP inclusion.

Additionally, Cardno conducted an architectural history survey that included an intensive level survey of aboveground built environment within and adjacent to the 23.5-ha (58.0-ac) Vertical Launch Area (VLA) and a reconnaissance survey in the remaining 8.0-km (5.0-mi) APE (Cardno 2013b). This survey recorded the 1936 Centennial historical marker (No. 3917). The marker was previously determined eligible for inclusion in the NRHP in November 2012 (Cardno 2013a). This survey also inventoried and evaluated 29 structures; none of the newly identified buildings or structures were recommended as eligible for inclusion in the NRHP (Cardno 2013b).

Following the Cardno surveys, the FAA determined the undertaking would have an adverse effect on the Palmito Ranch Battlefield NHL (41CF93) and the historic Palmetto and Cypress Bridge Pilings (41CF117), as well as the 1936 Centennial historical marker (No. 3917) associated with the pilings. THC concurred with the FAA's effects analysis. The FAA, THC, National Park Service (NPS), Advisory Council on Historic Preservation (ACHP), SpaceX, United States Fish and Wildlife Service (USFWS), and Texas Parks and Wildlife Department (TPWD) executed a Programmatic Agreement (PA) in 2014 (FAA 2014). The same parties executed a subsequent Memorandum of Agreement (MOA; FAA 2015) in 2015 to resolve the adverse effects.

In 2014, at the request of the THC, Southern Archaeological Consultants Inc., conducted a metal detector survey prior to solar farm expansion at SpaceX's launch control center. No archaeological sites or isolated finds that qualified as historic properties were identified during the 2014 survey. A second metal detector survey was conducted in 2017 at the control center as part of SpaceX's proposal to further expand its facilities. No archaeological sites or isolated finds that qualified as historic properties were identified as a result of the 2017 metal detector survey. THC concurred with the results of both the 2014 and 2017 surveys.

Although Section 106 consultation was conducted in 2012–2014 for the Falcon 9 and Falcon Heavy orbital launch vehicles, consultation was reinitiated in 2021 for the different operating characteristics of the new Starship/Super Heavy launch vehicle. SEARCH conducted fieldwork in support of this effort within expanded archaeological and architectural APEs.

Archaeological fieldwork included pedestrian survey, shovel testing, deep testing with auger probes in the Mesa de Gavilan dune field, a metal detection survey, a revisit to NRHP-eligible 41CF117, and a magnetometer survey along Boca Chica beach (SEARCH 2021). SEARCH also conducted a windshield-level survey to identify buildings and structures constructed before 1975 within the 5.0–10.0 mi APE for Architectural Resources. This archaeological survey resulted in the identification of one newly recorded archaeological site and three previously recorded sites. Twelve magnetometer anomalies were also identified, four of which have the potential to represent historical shipwreck sites and eight of which have the potential to represent debris associated with historical shipwreck sites. Of the 616 buildings or structures identified by the architectural survey, seven were eligible for NRHP inclusion, six were recommended eligible for NRHP inclusion, and two were listed on the NRHP.

The FAA determined the proposed undertaking would have an adverse effect on the Palmetto and Cypress Bridge Pilings (41CF117) and the 1936 Centennial historical marker (No. 3917) within the APE for Archaeological Resources, as well as 15 historic properties in the APE for Architectural Resources. THC concurred with the FAA's effects determination. As part of the Section 106 consultation, the FAA, THC, NPS, ACHP, SpaceX, USFWS, and TPWD executed a PA in April 2022.

As part of the 2022 PA, SpaceX updated its Unanticipated Discoveries Plan (UDP) to account for the Starship/Super Heavy undertaking (SEARCH 2022). This document includes procedures for the treatment of any unexpected discoveries that may occur during the course of project

activities, including test and launch operations. This plan also addresses stipulations in the event of launch or test anomalies. An anomaly is defined herein per 14 CFR § 401.7 as "any condition during licensed or permitted activity that deviates from what is standard, normal, or expected, during the verification or operation of a system, subsystem, process, facility, or support equipment." This includes unanticipated events such as those observed anomalies associated with the following Starship vehicles: Serial Number 8 (SN8), SN9, SN10, and SN11.

In October 2023, per the UDP, SEARCH conducted a Phase I cultural resources investigation of an Expanded APE. The fieldwork aimed to assess impacts from an April 2023 launch anomaly to cultural resources outside of the previously surveyed APE for Archaeological Resources. For this survey, pedestrian survey was combined with the excavation of 75 shovel test pits; 10 of these were extended with a hand-held ratchet-handled extensible auger to depths of up to 170 centimeters (67 inches) below surface. Of the excavated STPs and subsequent auger probes, none were positive for cultural material. No previously identified sites were located within the Expanded APE. Per the UDP, debris removal monitoring for impacts to cultural resources is ongoing. No cultural resources have been identified during debris removal monitoring as of December 2023.

ENVIRONMENTAL ASSESSMENT

Historical, architectural, archaeological, and cultural resource impacts under the proposed increased orbital launch cadence at Boca Chica would be similar to those impacts described by the 2022 Final Programmatic Environmental Assessment (PEA) for the SpaceX Starship/Super Heavy Launch Vehicle Program. The 2022 PEA determined that the proposed launch program would result in adverse effects to 17 historic properties: the Palmito Ranch Battlefield, Palmetto and Cypress Bridge Pilings, Palmetto Pilings Historical Marker, Queen Isabella Memorial Causeway, Long Island Swing Bridge, Queen Isabel Inn, Alta Vista Apartments, Point Isabel Lighthouse, Point Isabel Lighthouse THC Marker, Charles Champion Building, Port Isabel Cemetery, Point Isabel Coast Guard Building, Port Isabel Firemen's Hall, Former Bahia Mar and Bahia Grande Condominiums, Sea Island Resort Hotel, Former Ship Café Building, and White Sands Motel. Adverse effects included visual, auditory, vibration effects, or sonic boom window breakage; the Palmito Ranch Battlefield also had an adverse effects determination due to increased visitation and the addition of permanent visual infrastructure (**Table 1**). The FAA and other consulting parties executed the 2022 PA to mitigate these adverse effects.

Table 1. NRHP eligible and potentially eligible historic properties adversely effected by the launch program (2022 PEA)

Resource No.	Resource Name	Resource Type	NRHP Status	Adverse Effect
41CF93	Palmito Ranch Battlefield	Civil War battlefield	Listed, NHL	Visual, visitation, addition of permanent industrial infrastructure
41CF117	Palmetto and Cypress Bridge Pilings	1846 and 1864Ŧ1865 historic bridge pilings	Eligible	Vibration, launch anomalies, visitation
THC Marker No. 1919 (1936)	Palmetto Pilings Historical Marker	1936 stone historic marker	Eligible	Vibration, launch anomalies, visitation
BC-AH1	Queen Isabella Memorial Causeway	20th century bridge	Eligible	Vibration
BC-AH2	Long Island Swing Bridge	20th century swing span bridge	Eligible	Vibration
5061004143	Queen Isabel Inn	Early 20th century Inn	Eligible	Auditory, vibration; visual; sonic boom potential window breakage
506104143	Alta Vista Apartments	Apartment building	Eligible	Auditory, vibration; visual; sonic boom window breakage
2076002014	Point Isabel Lighthouse and THC Marker	Lighthouse	Listed	Vibration, visual, auditory; sonic boom window breakage
		THC Historical Marker	Eligible	Auditory/vibration; visual
5507014006	Charles Champion Building	20th century general store, U.S. Customs House, and post office	Eligible	Auditory, vibration; visual; sonic boom window breakage
7061008405	Port Isabel Cemetery	Cemetery	Eligible	Auditory, vibration; visual
Not Applicable	Point Isabel Coast Guard Building	1923 Coast Guard building	Potentially Eligible	Auditory, vibration; visual; sonic boom window breakage
Not Applicable	Port Isabel Firemen's Hall	Ca. 1950s structure	Potentially Eligible	Auditory, vibration; visual; sonic boom window breakage
Not Applicable	Former Bahia Mar and Bahia Grande Condominiums	Ca. 1975 condominiums	Potentially Eligible	Auditory, visual; sonic boom potential breakage
Not Applicable	Sea Island Resort Hotel	1959 resort hotel	Potentially Eligible	Auditory, vibration; visual; sonic boom potential window breakage
Not Applicable	Former Ship Café Building	1940s café	Potentially Eligible	Auditory, vibration; visual; sonic boom window breakage
Not Applicable	White Sands Motel	ca. 1950s motel	Potentially Eligible	Auditory, vibration; visual; sonic boom window breakage

Visual Effects

The 2022 PEA determined that each launch event will carry the potential for an individual and distinct visual effect to 13 historic properties, including: Palmito Ranch Battlefield, Queen Isabel Inn, Altavista Apartments, Point Isabel Lighthouse, Point Isabel Lighthouse THC Historical Marker, Charles Champion Building, Port Isabel Cemetery, Point Isabel Coast Guard Building, Port Isabel Firemen's Hall, Former Bahia Mar and Bahia Grande Condominiums, Sea Island Resort Hotel, Former Ship Café Building, and White Sands Motel (see **Table 1**).

No additional launch infrastructure will be constructed as part of the increased launch cadence. As such, this action will not result in additional adverse visual effects and all visual effects associated with the increased launch cadence are mitigated pursuant to the avoidance, minimization, and mitigation stipulations (Stipulation III.a.) in the 2022 PA.

Auditory and Vibratory Effects

The 2022 PEA determined that each launch event will carry the potential for auditory and vibratory effects to 16 historic properties, including Palmetto and Cypress Bridge Pilings, Palmetto Piling Historical Marker, Queen Isabelle Memorial Causeway, Long Island Swing Bridge, Queen Isabel Inn, Alta Vista Apartments, Point Isabel Lighthouse, Point Isabel Lighthouse THC Marker, Charles Champion Building, Port Isabel Cemetery, Port Isabel Coast Guard Building, Port Isabel Fireman's Hall, Former Bahia Mar and Bahia Grande Condominiums, Sea Island Resort Hotel, Former Ship Café Building, and White Sands Motel (see **Table 1**). The auditory effects associated with each launch are mitigated pursuant to the avoidance, minimization, and mitigation stipulations (Stipulation III.b.) in the 2022 PA.

No additional adverse auditory and vibration effects will result from the Proposed Action. The *Expected Vibrations Analysis Report for 25 Rocket Launches at The Boca Chica Site* determined that transmission of vibratory energy through the ground and through the air as the result of an increased launch cadence will not be a significant concern for most structures outside 0.7 miles (STRAAM Group 2024). Additionally, noise modeling conducted for the increased cadence and vehicle thrust concluded that no damage is expected from Starship launches or any other flight and test operations that generate lower noise levels than launches (KBR 2024).

As described in the 2022 PEA, landings at the VLA would result in sonic booms. Sonic booms of 0.5 psf and higher are expected to be generally audible, with booms of lower magnitude requiring an expectation of arrival or a very low noise floor environment to be heard. At approximately 2 psf there is a 1/10,000 probability of breakage for a large window, and at approximately 4 psf there is a 1/10,000 probability of breakage for a small window (USACE 1989). At 6 psf, audibility is effectively guaranteed. Laboratory and field testing shows that pre-damaged or poor condition windows could possibly exhibit progression of damage over multiple exposures to this magnitude of boom (Higgins 1965). At 10.0 psf the likelihood of superficial (e.g., plaster, bric a brac) damage and window damage becomes more plausible but is generally still expected to be very low probability and predominantly due to poor existing conditions such as pre-cracked, pre-stressed,

older and weakened, or poorly mounted windows (Benson 2013, White 1972, Fenton 2016, Maglieri 2014). Finally, SpaceX presents sonic boom exposures up to 21 psf for booster landings. This represents a threshold where prevailing literature indicates window breakage becomes possible for standard condition windows, though the prediction of specific window breakage still depends on size, age, orientation, surrounding structure, and other effects (NOAA 2019, Maglieri 2014). The areas that would be exposed to this level are generally limited.

SpaceX evaluated the potential for damage to historic resources due to sonic booms from Starship or Super Heavy landings at the VLA. Updated sonic boom modeling for the booster landings at the VLA under the Proposed Action predict overpressure events up to 21 psf extending approximately 2 miles from launch site (SpaceX 2024). This represents an overpressure level where prevailing literature indicates window breakage becomes possible for standard condition windows, though the prediction of specific window breakage still depends on size, age, orientation, surrounding structure, and other effects (NOAA 2019, Maglieri et al. 2014). The Palmetto and Cypress Bridge Pilings as well as the Palmetto Pilings Historical Marker are both located within the 21 psf contour.

Due to the materials of the pilings and the marker, no damage is anticipated due to these levels of sonic booms. In the U.S., no historic properties with above ground features are located within the 15 psf or 10 psf contours. The Faro Bagdad Lighthouse in Bagdad, Tamaulipas Mexico, is located within the 15 to 10 psf contour. Structural damage to this lighthouse is not anticipated due to the concrete makeup of the structure. In the U.S., no historic properties with above ground features are located within the 6 psf contour. Windows in poor condition may exhibit progression of damage over multiple exposures to sonic booms at 6 psf magnitude. If such damage occurred, SpaceX would adhere to the terms of the 2022 PA to restore the damaged property, including hiring a qualified professional to make recommendations for restoration of the historic property and following the Secretary of the Interior's Standards for the Treatment of Historic Properties.

For noise related to launch activities, structural damage is considered improbable below 140 dB Maximum Unweighted Sound Level (Lmax), no glass or plaster damage is expected below 140 dB, and no damage is expected below 134 dB (Fenton and Methold 2016). The 134 dB Lmax contour is located approximately 1.5 miles from the launchpad (KBR 2024). Although the Palmetto and Cypress Bridge Pilings and the Palmetto Pilings Historical Marker are within 1.5 miles of the Boca Chica launch facility and within the APE for Archaeological Resources, additional ground vibration cycles caused by the Proposed Action are not expected to result in additional adverse impacts to the resource. SpaceX and STRAAM Group constructed supports around the pilings to reduce the effects of ground vibration and would continue to conduct Launch Vibration Monitoring as stipulated in the 2022 PA to ensure that the pilings are not being damaged by launch vibrations. Additionally, SpaceX and THC reset the Palmetto Pilings Historical Marker to a plumb and level condition and added a steel-reinforced concrete base to ensure stabilization of the marker in 2022. Finally, SpaceX would continue to adhere to the avoidance, minimization, and mitigation stipulations (Stipulation III.b.) in the 2022 PA.

Launch Anomalies

The 2022 PEA determined that each launch event will carry the potential for effects resulting from debris associated with a launch anomaly for two historic properties, including: Palmetto and Cypress Bridge Pilings and Palmetto Pilings Historical Marker (see **Table 1**).

The potential effects associated with the increased launch cadence are mitigated pursuant to the avoidance, minimization, and mitigation stipulations (Stipulation III.d.) in the 2022 PA. SpaceX would continue to adhere to these stipulations. Since potential adverse effects resulting from an anomaly are tied to each launch event, no additional adverse effects resulting from launch anomalies will result from the increased launch cadence.

Increased Visitation and Use

The 2022 PEA determined that potential adverse effects could result from increased visitation and use at three historic properties, including: Palmito Ranch Battlefield, Palmetto and Cypress Bridge Pilings, and Palmetto Pilings Historical Marker (see **Table 1**).

The potential effects associated with the increased launch cadence are mitigated pursuant to the avoidance, minimization, and mitigation stipulations (Stipulation III.c.ii.) in the 2022 PA. SpaceX would continue to adhere to these stipulations. No additional adverse effects resulting from increased visitation and use will result from the increased launch cadence.

SUMMARY

The Proposed Action is not expected to result in any additional impacts to cultural resources, beyond those contemplated in the 2022 PEA, and those discussed and subjected to avoidance, minimization, and mitigation stipulations by the 2022 PA. The data and analyses presented in these documents remain substantially valid. Previous findings of adverse effect due to vibration have been amended to include sonic boom potential breakage of windows in historic buildings. To avoid adverse effects, the following condition is imposed to restore damaged windows: SpaceX would adhere to the terms of the 2022 PA to restore damaged windows, including hiring a qualified professional to make recommendations for restoration of the historic property and following the Secretary of the Interior's Standards for the Treatment of Historic Properties. Reinitiation of Section 106 consultation is not necessary, as an increase in launch cadence as proposed does not present an additional risk of adverse effect to historic properties. The conditions and requirements of the 2022 PA have been met, and would continue to be met, in the current action.

REFERENCES

Cardno

2013a *Final Archaeological Resources Investigation for the Proposed SpaceX Texas Launch Site, Cameron County, Texas.* Prepared by Cardno TEC for the Federal Aviation Administration – Office of Commercial Space Transportation on behalf of SpaceX.

2013b *Final Architectural Survey for the Proposed SpaceX Texas Launch Site, Cameron County, Texas*. Submitted to Space X by Cardno. On file at the Texas Historical Commission. TASA No. 8500068806.

FAA (Federal Aviation Administration)

2014 Final Environmental Impact Statement for the SpaceX Texas Launch Site. May.

2022 *Programmatic Agreement Among the Federal Aviation Administration, The Texas State Historic Preservation Officer, National Park Service, The Advisory Council on Historic Preservation, Space Exploration Technologies Corp., United States Fish and Wildlife Service, and Texas Parks and Wildlife Department, Regarding the Construction and Operation of a SpaceX Texas Launch Site Located at Boca Chica, Cameron County, Texas.*

KBR

2024 *Starship Rocket Noise Assessment for Flight and Test Operations at SpaceX Launch Facility (Starbase)*. TN 23-05. Prepared for: Space Exploration Technologies Corporation.

Fenton and Methold

2016 *Mod Shoeburyness and Pendine noise and vibration study criteria for the assessment of potential building damage effects from range activities.* June. Southdowns Environmental Consultants, Lewes, East Sussex, UK. 55 pp.

Maglieri et al.

2014 Sonic Boom: Six Decades of Research. NASA Technical Reports Server. https://ntrs.nasa.gov/citations/20150006843

STRAAM Group

2024 *Expected Vibrations Analysis Report for 25 Rocket Launches at the Boca Chica Launch Site.* Prepared for SpaceX.

SEARCH

2021 *Phase I Cultural Resources Survey of SpaceX Starship/Super Heavy Launch Operations at the SpaceX Boca Chica Launch Site in Cameron County, Texas.* Prepared for the FAA-AST on behalf of SpaceX.

2023 *SpaceX Unanticipated Discoveries Plan For The Starship/Super Heavy Launch Operations at the SpaceX Boca Chica Facility, Cameron County, Texas*. Prepared for the FAA-AST on behalf of SpaceX.

SpaceX

2023 *Technical Memo on Cultural Resources Requirements and the Written Re-Evaluation of the Final Programmatic Environmental Assessment and Mitigated Finding of No Significant Impact and Record of Decision for the SpaceX Starship/Super Heavy Launch Vehicle Program at the SpaceX Boca Chica Launch Site in Cameron County*. Delivered to FAA on June 7, 2023.

2024 Sonic Boom Analysis. July 2024.

APPENDIX B

Noise Assessment

STARSHIP ROCKET NOISE ASSESSMENT FOR FLIGHT AND TEST OPERATIONS AT SPACEX LAUNCH FACILITY (STARBASE)

TN 23-05

July 2024

Prepared for:

Space Exploration Technologies Corporation

Acknowledgements

This document was prepared as:

KBR Technical Note TN 23-05 (Revision 3)

Project No. 11037; Purchase Order No. 2487243

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Figures

Executive Summary

Space Exploration Technologies Corporation (SpaceX) is planning to conduct flight operations and testing of the Starship and Super Heavy Booster vehicles at Starbase in Boca Chica, TX. To support environmental studies for FAA launch licensing, KBR, Inc. conducted this noise modeling study to estimate the single event and cumulative noise levels in the vicinity of Starbase from future Starship launches, Ship and booster landings, and Ship and booster static fire tests.

The RNOISE model, which computes far field noise levels in the community, was used to estimate rocket noise from Starship flight and test operations at Starbase. SpaceX provided the operations data required to conduct noise modeling of the individual flight and test events, including orbital launch and booster landing trajectories, engine operating data, and static fire test parameters. Cumulative noise was estimated for a future projected operations scenario involving 25 annual operations of each flight event plus 6 Ship static tests and 5 booster static tests.

Conclusions are that rocket noise from individual launch, landing, and static fire test events are expected to be heard by people in the communities surrounding Starbase, primarily South Padre Island to the north and Port Isabel, Laguna Vista, Brownsville, and Los Fresnos to the west. However, due to the levels and expected frequency of events, these individual noise events are not expected to cause general annoyance or pose health concerns, though noise complaints may occur. A future projected annual operation scenario at Starbase involving 25 annual operations of each flight event, plus additional static tests, is estimated to generate cumulative noise levels in residential areas that are below levels associated with adverse noise exposure (i.e., below the FAA's Day-Night Average Sound Level (DNL) 65 dBA threshold). Recent criterial used to assess the potential for structural damage indicates that no damage is expected from Starship launches or any of the other Ship or booster operations that generate lower noise levels than launches (i.e., the 134 dB L_{max} contour for all Starship flight and test operations is within Starbase property, such that no damage is expected to occur to structures off-base).

1 Introduction

Space Exploration Technologies Corporation (SpaceX) plans to conduct flight and ground tests of their Starship rocket at SpaceX Launch Facility (Starbase) in Boca Chica, Texas. KBR, Inc. has estimated noise levels for the Starship which is currently under development. Starship, which has a length of seventy meters and a diameter of nine meters, will be attached to a Super Heavy Booster rocket (length of eighty meters) to form the Starship Launch Vehicle intended to provide long-duration cargo- and passenger-carrying capability. Both vehicles have vertical take-off and landing (VTOL) capability and are fully reusable. The Starship would use nine Raptor engines that each provide sea-level thrust of about 3.19 Meganewtons (MN) during flight operations and static fire tests. The Super Heavy Booster would use thirty-five Raptor engines that each provide sea-level thrust of about 2.94 MN during launch and static fire tests.

This study was conducted to estimate single event and cumulative noise levels from future Starship and booster launches, Ship and booster landings, and static fire tests of both vehicles at Starbase. SpaceX provided the following data for noise modeling:

- Orbital launch trajectory for the Starship from liftoff to stage separation.
- Raptor engine operating data and nominal ascent thrust profile.
- Ship and Super Heavy Booster reentry and descent/landing trajectories from separation to landing with descent thrust profiles.
- Static fire test parameters for the Ship and Super Heavy Booster.
- Projected annual launch, landing, and static fire test operations at Starbase.

Noise levels for Starship and Super Heavy Booster flight and static test operations were estimated using the RNOISE model. RNOISE[1,2] is a far-field (distances beyond several hundred feet) community noise model for rocket noise assessment.

The following sections of this report provide a description of rocket noise fundamentals (Section 2) followed by estimated single event noise levels for Starship orbital launches (Section 3), Ship and Super Heavy Booster landings (Section 4), and static fire tests for both vehicles (Section 5). Section 6 presents a cumulative noise level estimate at Starbase for a projected annual operation scenarios involving future launches, landings, and static fire tests; cumulative noise is assessed for all projected operations combined.

2 Rocket Noise Background and Metrics

2.1 Background

Rockets generate significant noise from the combustion process and turbulent mixing of the exhaust flow with the surrounding air. Figure 1 is a sketch of rocket noise. There is a supersonic potential core of exhaust flow, surrounded by a mixing region. Noise is generated in this flow. It is directional, with the highest noise levels at an angle of 40 to 50 degrees from the direction of the exhaust flow. The fundamentals of predicting rocket noise were established by Wilhold et al.[3] for moving rockets and by Eldred et al.[4] for static firing. Sutherland[5] refined modeling of rocket source noise, improving its consistency relative to jet noise theory. Based on those fundamentals, Wyle has developed the PAD model for near field rocket noise[6] and the RNOISE model for far field noise in the community. RNOISE was used for the current analysis.

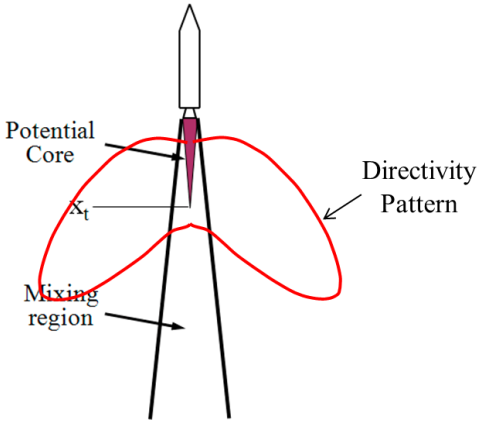

Figure 1. Rocket Noise Source

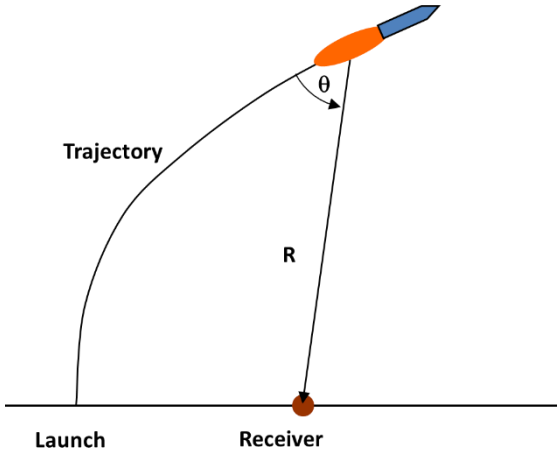

Figure 2. Modeling Rocket Noise at the Ground

Figure 2 is a sketch of far field rocket noise as treated by RNOISE. The vehicle's position and attitude are known from the trajectory. Rocket noise source characteristics are known from the engine properties, with thrust and exhaust velocity being the most important parameters. The emission angle and distance to the receiver are known from the flight path and receiver position. Noise at the ground is computed accounting for distance, ground impedance,[7] atmospheric absorption of sound,[8] and uniform ground elevation. RNOISE propagates the full spectrum to the ground, accounting for Doppler shift from vehicle motion. It is a time simulation model, computing the noise at individual points or on a regular grid for every time point in the trajectory. Propagation time from the vehicle to the receiver is accounted for, yielding a spectral time history at the ground (including a range of frequencies from 1 Hz to 16 kHz). A variety of noise metrics can be computed from the full calculated noise field and the metrics commonly used to assess rocket noise are described in the following section.

2.2 Rocket Noise Metrics and Assessment Criteria

2.2.1 Noise Metrics

FAA Order 1050.1F[9] specifies Day-Night Average Sound Level (DNL) as the standard metric for community noise impact analysis, but also specifies that other supplemental metrics may be used as appropriate for the circumstances. DNL is appropriate for continuous noise sources, such as airport noise and road traffic noise. The noise metrics used for rocket noise analysis are:

- DNL, as defined by FAA Order 1050.1F;
- SEL, the Sound Exposure Level, for individual events;
- L_{Amax}, the maximum A-weighted overall sound pressure level (OASPL), for individual events;
- L_{max}, the maximum unweighted OASPL, for individual events; and
- One third octave spectra at certain sensitive receptors.

As mentioned, DNL is necessary for policy. The next three metrics provide a measure of the impact of individual events; SEL and L_{Amax} are A-weighted and L_{max} is un-weighted. Loud individual events can pose a hearing damage hazard to people and can also cause adverse reactions by animals. Adverse animal reactions can include flight, nest abandonment, and interference with reproductive activities. L_{max} along with spectra, may be needed to assess potential damage to structures and adverse reaction of species whose hearing response is not like that of humans.

L_{Amax} is appropriate for community noise assessment of a single event, such as a rocket launch or static fire test. This metric represents the highest A-weighted integrated sound level for the event in which the sound level changes value with time. Slowly varying or steady sounds are generally integrated over a period of one second. L_{Amax} is important in judging the interference caused by a noise event with conversation, TV listening, sleep, or other common activities. Similarly, L_{max} is the highest unweighted integrated sound level for the event, used to assess the potential for structural damage. Although A-weighted maximum sound level provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the duration that the sound is heard.

SEL is a composite metric that represents both the level of a sound and its duration. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: 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 an aircraft flyover, SEL would include both the maximum noise level and the lower noise levels produced during onset and recess periods of the overflight. 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. For a rocket launch, SEL is expected to be greater than L_{Amax}.

2.2.2 Noise Assessment Guidelines

Land Use Compatibility Guidelines for Cumulative Noise Exposure

As previously mentioned, DNL represents the average sound level for annual average daily aircraft events which are used to assess cumulative noise exposure. FAA's published 14 Code of Federal Regulations (CFR) Part 150 defines land use compatibility guidelines for aviation noise exposure that are also applicable to rocket noise exposure. These guidelines consider land use compatibility for different uses over a range of DNL noise exposure levels, including the adoption of DNL 65 dBA as the limit for residential land use compatibility.

Hearing Conservation

Occupational Safety and Health Administration (OSHA)[10] guidelines are to protect human hearing from long-term, continuous exposures to high noise levels and aid in the prevention of noise-induced hearing loss (NIHL). OSHA's permissible daily noise exposure limits include a L_{Amax} of 115 dBA (slow response) for a duration of 0.25 hours or less. This is the criteria used in this study to evaluate areas around launch, landing, and static fire test sites that would require implementing a hearing conservation program, i.e., areas within the L_{Amax} 115 dBA contour. This level was chosen as a conservative indicator of when a hearing conservation program should be implemented since all proposed flight and test operations, individually or together, are not expected to exceed 0.25 hours in duration on any given day.

Structural Damage Potential

The potential for structural damage due to launch, landing, and static fire test events is assessed using the conclusions from a recent, applicable study to ascertain whether range activities (i.e., test, evaluation, demilitarization, and training activities of items such as weapons systems, ordinance, and munitions) would cause structural damage. The study concluded that structural damage becomes improbable below 140 dB [Maximum Un-weighted or linear Sound Level (L_{max})]. No glass or plaster damage is expected below 140 dB and no damage is expected below 134 dB[11].

Estimated noise results for Starship and Super Heavy booster launch, landing, and static fire test events are presented in the following sections. These results include L_{Amax}, SEL, and L_{max} contours for single event noise assessment over the study area (Sections 3 through 5) and DNL contours to assess the cumulative noise for a scenario involving projected annual operations of each type of event (Section 6).

3 Orbital Launch Noise Levels

3.1 Starship Orbital Launches at Starbase

RNOISE was used to estimate the L_{Amax}, SEL, and L_{max} contours for a Starship orbital launch at Starbase using trajectory data, from liftoff to stage separation, provided by SpaceX in file 'Starship_Boca_RTLS_ROTATED_80_12.ASC' with an uprated maximum total thrust of approximately 23 MM lbf (35 engines x 2.94 MN per engine). The L_{Amax} contours indicate the maximum sound level at each location over the duration of the launch where engine thrust varies according to the ascent thrust profile provided. For orbital launches, the Starship launch vehicle is comprised of the Starship (second stage vehicle with payload) and the Super Heavy Booster.

RNOISE computations were done using a radial grid consisting of 128 azimuths and 100 intervals out to 500,000 feet from the launch point. Land areas were modeled using a single ground impedance value estimated from the most common ground cover type in the vicinity of Boca Chica, TX and offshore water areas modeled as acoustically hard. Ground effect was based on a weighted average over the propagation path. As shown in the resulting noise contour maps (Figures 3 through 8), the shape of the innermost contours is approximately circular. The shape of the outermost contours is due to rocket noise directivity and the difference between the ground impedance values used for onshore and offshore areas. The launch pad location at Starbase is indicated in the map legend as is the Padre Island National Seashore. All maps depicting noise contours for operations at Starbase also show the nearby cities of Port Isabel, Laguna Vista, and Brownsville, TX.

Throughout this report, different map scales are used as appropriate to show the extent of the noise contours. The L_{Amax} 90 dB through 140 dB contours shown in Figures 3 and 4 represent the maximum levels estimated for a Starship orbital launch at Starbase; Figure 4 shows these contours using the zoomed in map scale to better show the extent of the noise exposure relative to cities close to Starbase. The higher L_{Amax} contours (100 – 140 dB) are located within about 8 miles of Starbase; the 100 dB contour extends into South Padre Island beyond Port Isabel. The 90 dB contour extends into Laguna Vista and eastern parts of Brownsville. If a Starship orbital launch occurs during the day, when background levels are in the 50 dB to 60 dB range, residents of Brownsville and Los Fresnos may notice launch noise levels above 70 dB and up to 90 dB. If the same launch occurs during the night, when background levels are lower than during the day (e.g., below 40 dB to 50 dB range), these residents may notice launch noise levels that exceed 60 dB. A prevailing onshore or offshore breeze may also strongly influence noise levels in these communities.

Estimated SEL contour levels of 90 dB through 150 dB, in 10 dB increments, are shown in Figures 5 and 6 for a Starship orbital launch at Starbase with Figure 6 showing a zoomed in map scale. As mentioned previously, SEL is an integrated metric and is expected to be greater than the L_{Amax} because the launch event is up to several minutes in duration whereas the maximum sound level (L_{Amax}) occurs instantaneously. In Figure 5, the 90 dB SEL contour would extend west of Brownsville and Los Fresnos.

Orbital launch events are the loudest single events of all the flight and test operations assessed in this modeling study. Starship orbital launch single event noise levels are related to guidelines for hearing conservation and potential for structural damage as follows.

An estimate of the areas, in the vicinity of Starship orbital launches, where a hearing conservation program should apply was made using OSHA's permissible daily noise exposure limit of 115 dBA (slow response) for a duration of 0.25 hours or less. Figure 4 shows that noise levels (L_{Amax}) are less than OSHA's 115 dBA upper noise limit guideline at distances greater than approximately 3 miles from the launch pad (i.e., hearing conservation should apply within 3 miles from the launch pad). Starship orbital launch noise events will last a few minutes at most, at a single location, with the highest noise levels occurring for less than a minute such that OSHA's 115 dBA daily noise exposure limit is not expected to be exceeded.

The potential for structural damage due to Starship orbital launch events is assessed using the criteria described in Section 2.2.2. Applying these criteria indicates that no damage is expected from Starship launches or any of the other flight and test operations that generate lower noise levels than launches. The 134 dB Maximum Unweighted Sound Level (L_{max}) contour for Starship orbital launch, located in between the 130 dB and 140 dB contours shown in Figure 7, is within 1.5 miles from the launch pad, such that damage is not expected to occur beyond the Starbase property line. This is expected for all Starship (Ship) and Booster flight and test operations described herein.

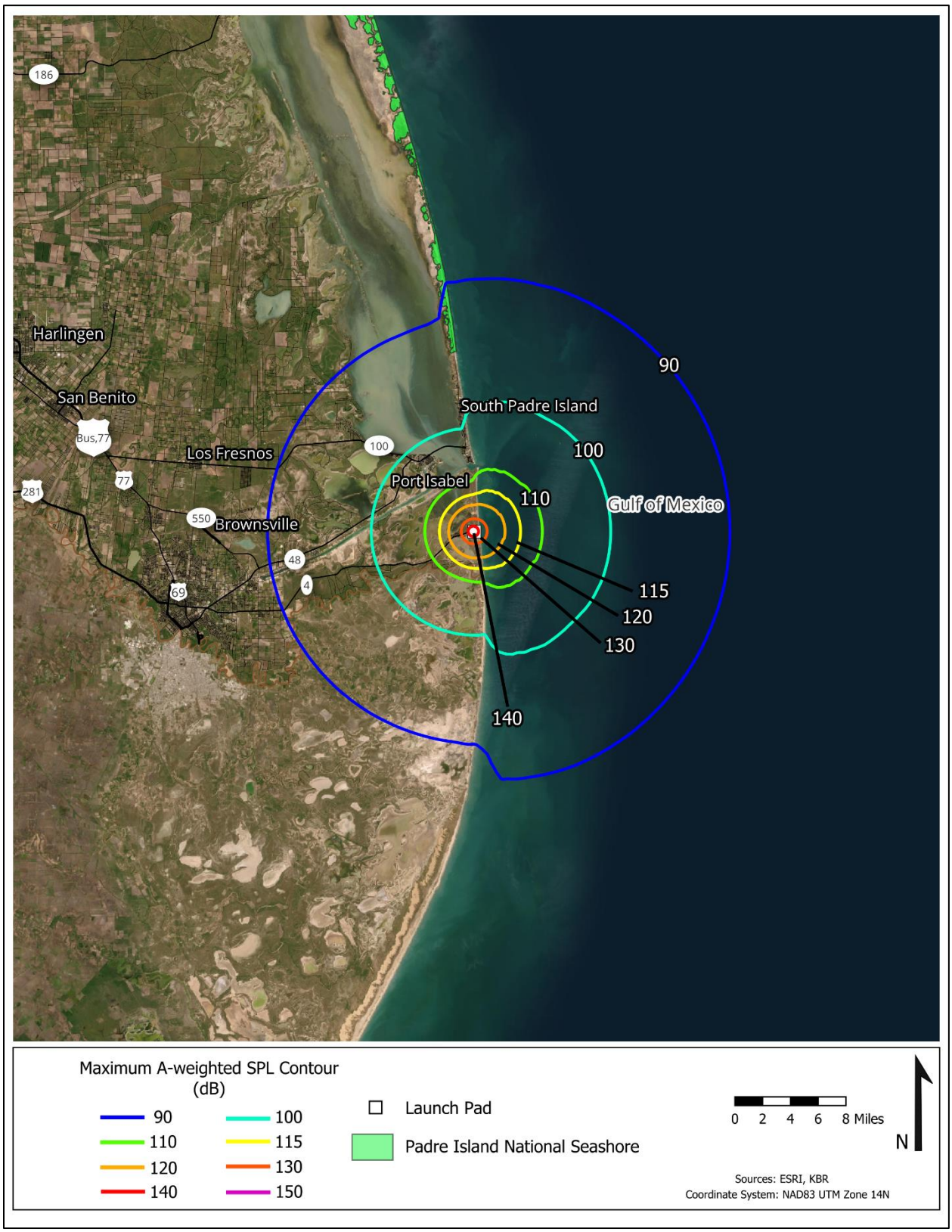

Figure 3. Starship Orbital Launch from Starbase: Maximum A-Weighted Sound Levels

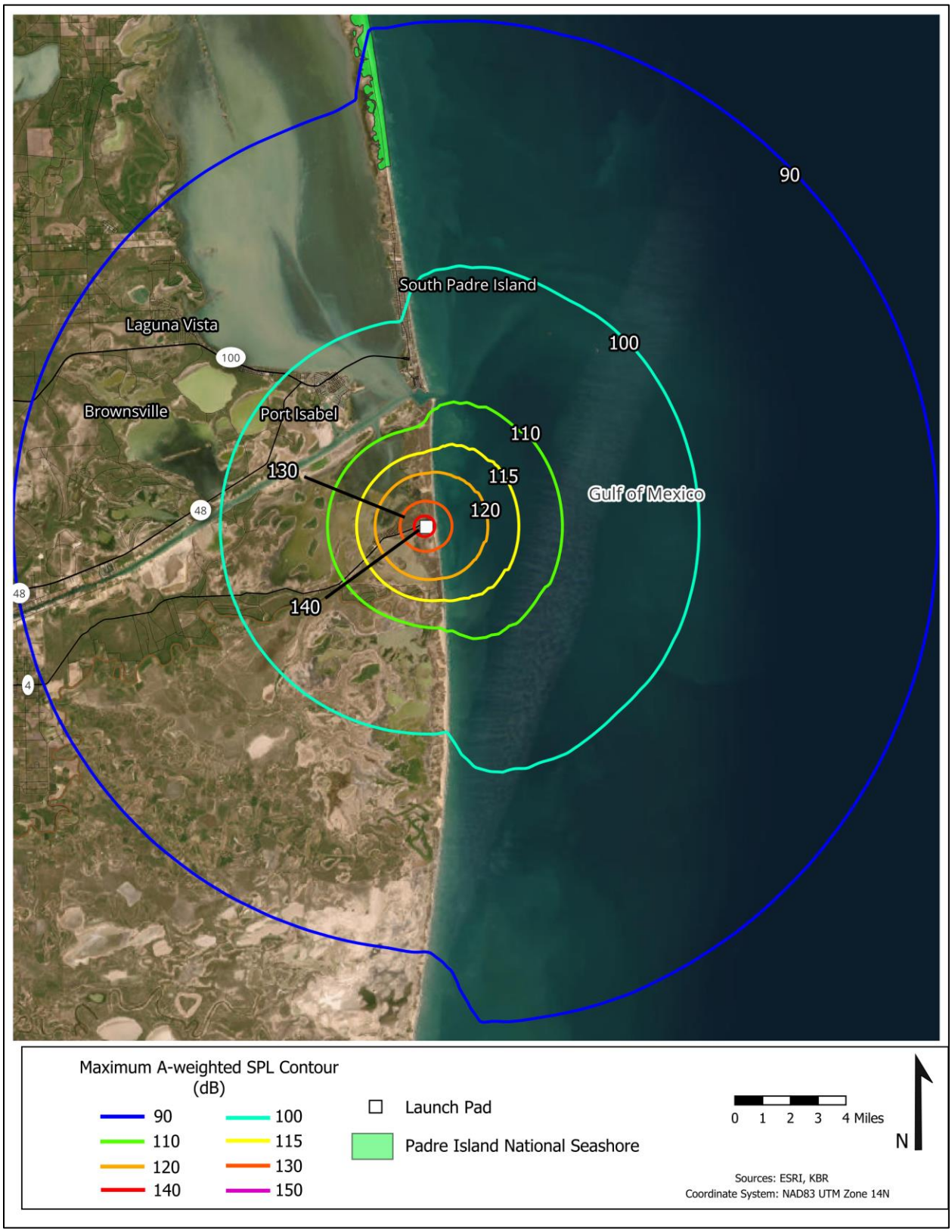

Figure 4. Starship Orbital Launch from Starbase: Maximum A-Weighted Sound Levels (Zoom In)

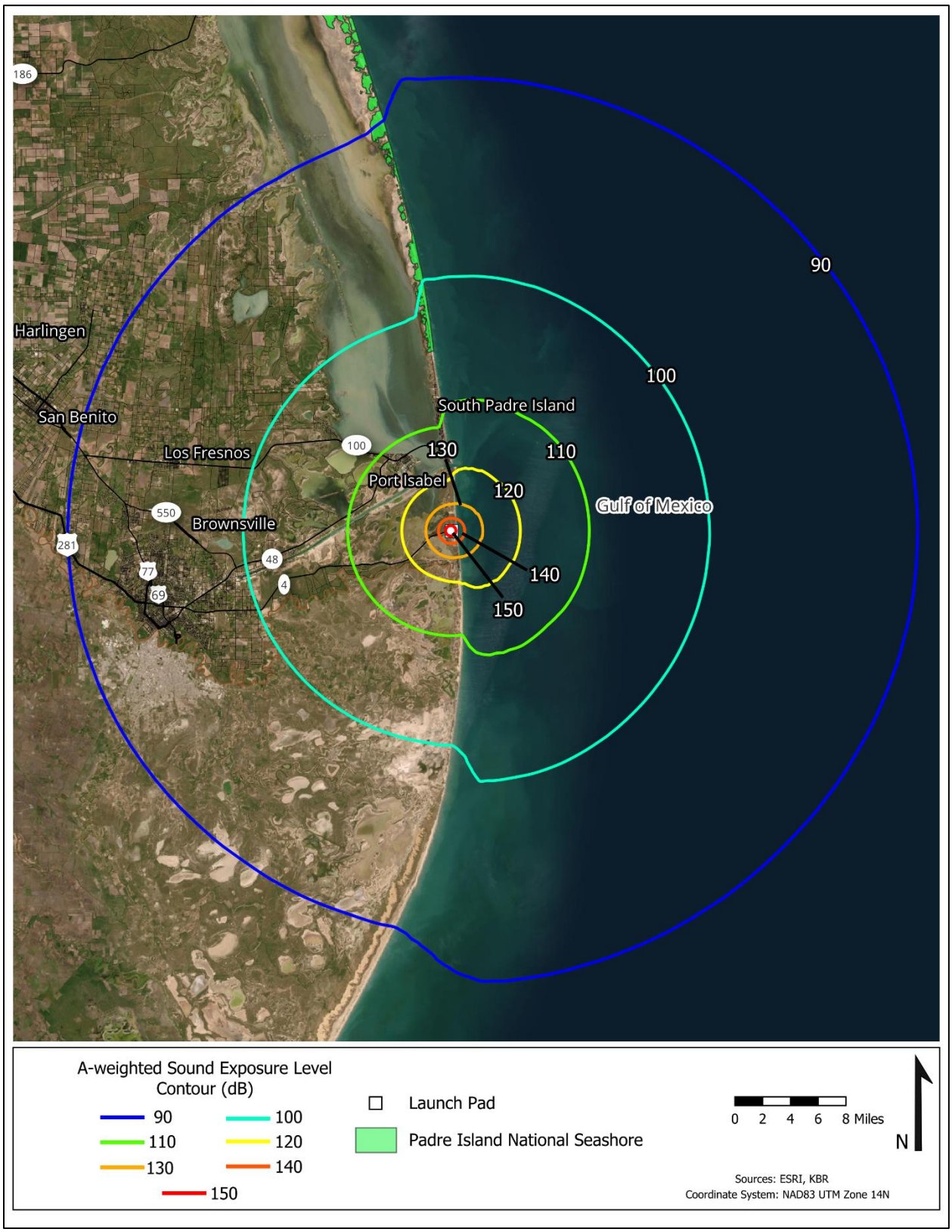

Figure 5. Starship Orbital Launch from Starbase: Sound Exposure Levels

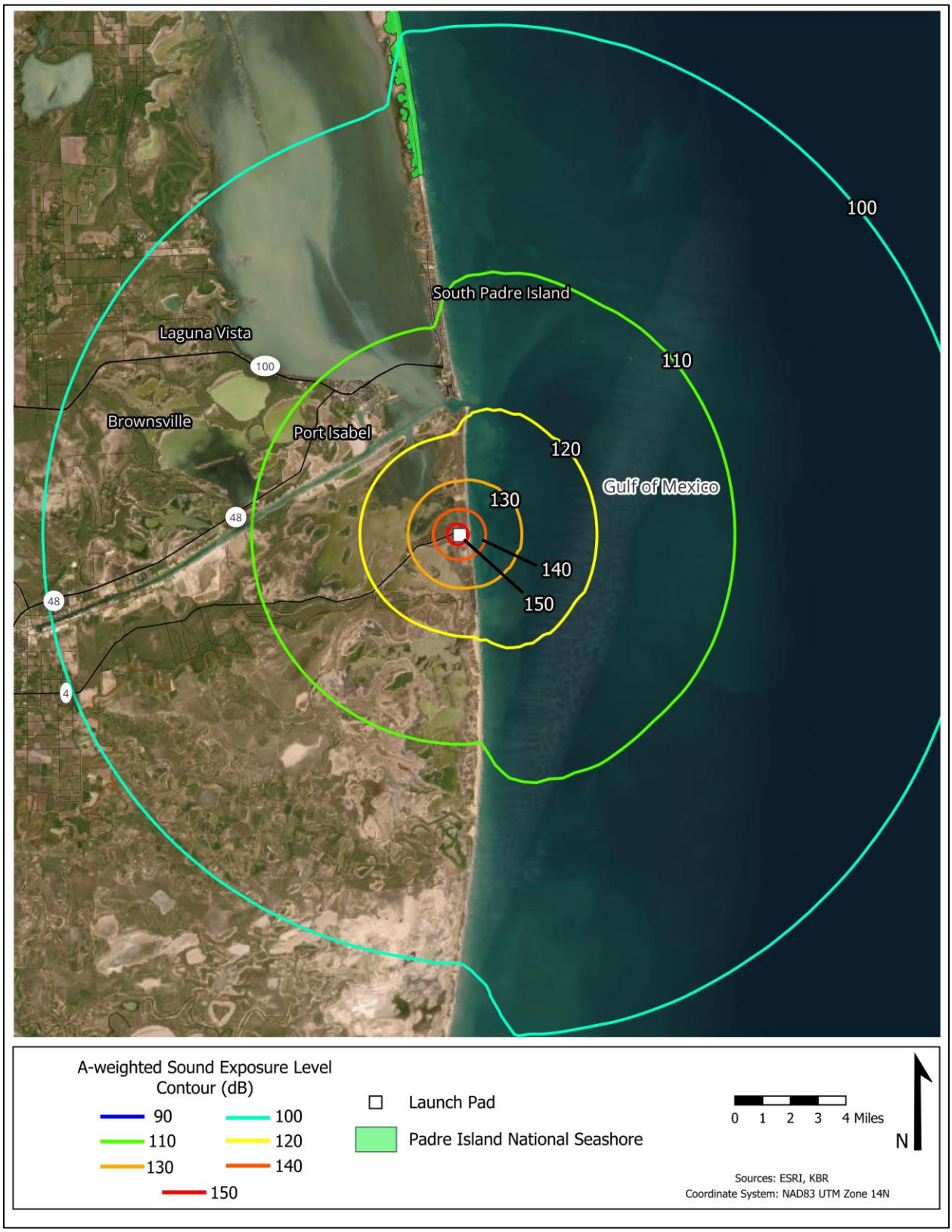

Figure 6. Starship Orbital Launch from Starbase: Sound Exposure Levels (Zoom In)

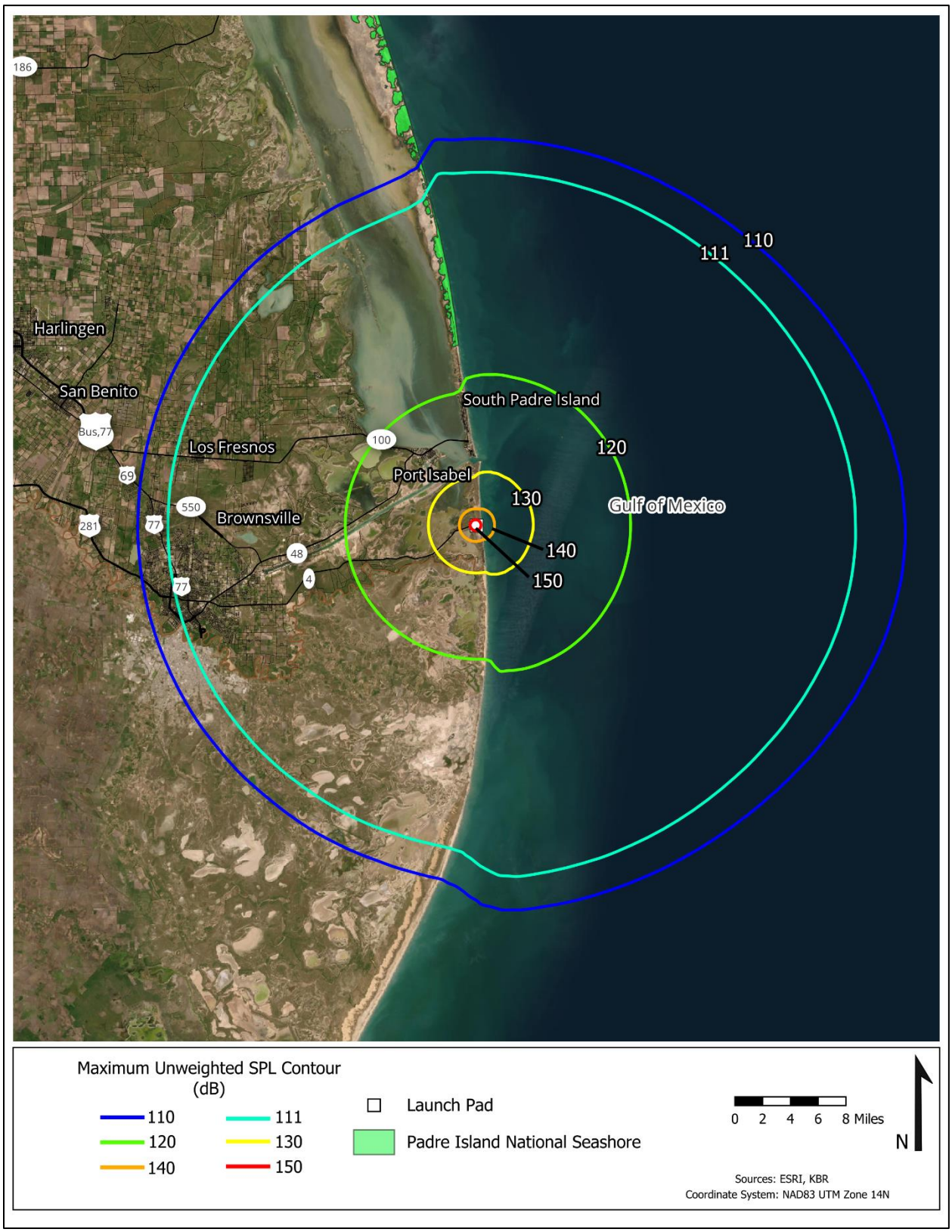

Figure 7. Starship Orbital Launch from Starbase: Maximum Unweighted Sound Levels

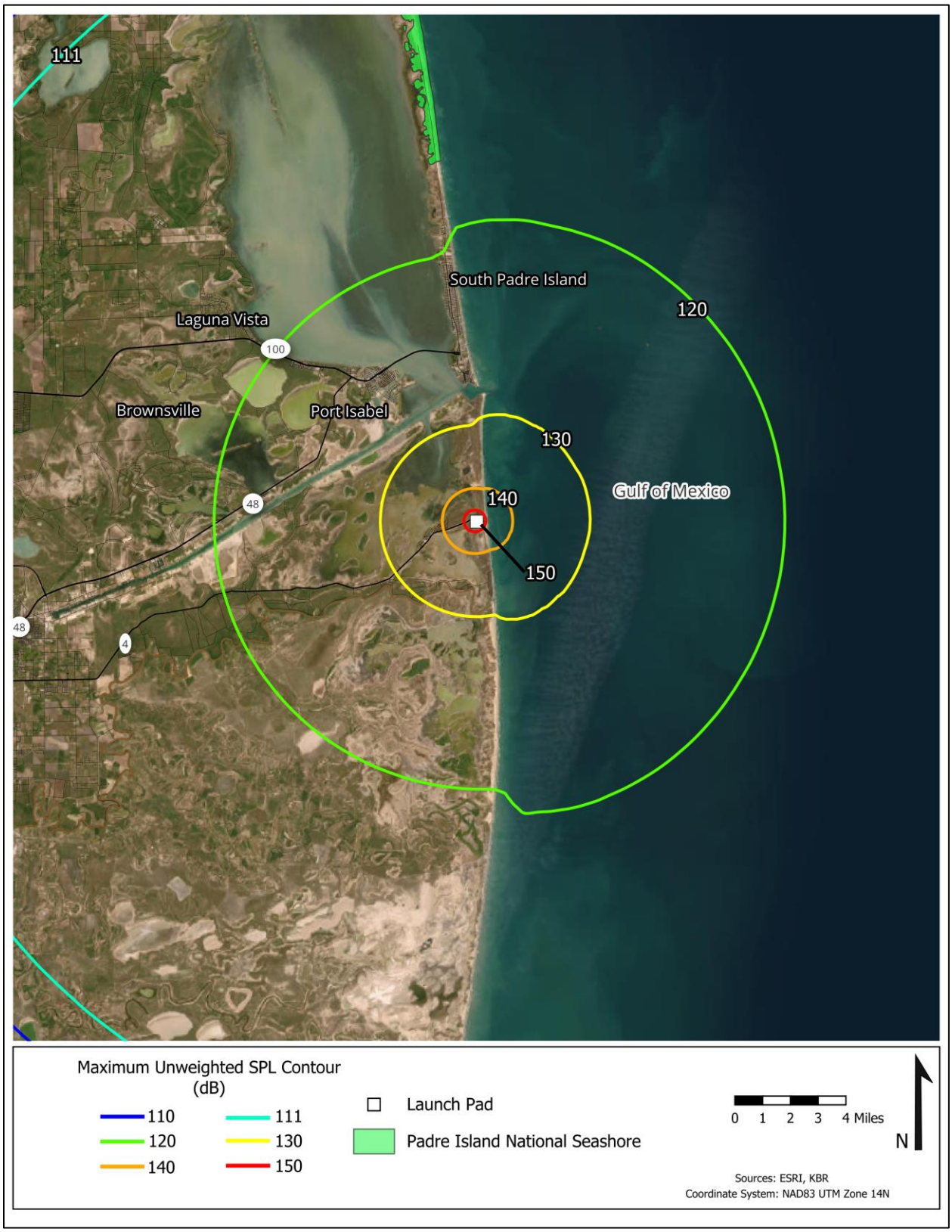

Figure 8. Starship Orbital Launch from Starbase: Maximum Unweighted Sound Levels (Zoom In)

4 Descent/Landing Noise Levels

4.1 Starship Landings at Starbase

RNOISE was used to estimate the L_{Amax}, SEL, and L_{max} contours for a Starship landing at the Starbase landing site. The Starship descent/landing trajectory was provided by SpaceX in file 'Starship_Boca_Chica_Landing_80_12.ASC' with uprated total maximum thrust of about 1.19 MM lbf.

RNOISE computations were performed as noted previously in Section 3. The L_{Amax}, SEL, and L_{max} contours for a Starship landing at Starbase are shown in Figures 9 through 11, respectively (using a zoomed in map scale). In Figure 9 the 90 dB L_{Amax} contour is about 6 miles from the Starbase landing site. Residents of Port Isabel may hear Starship landing events above 60 dB, particularly nighttime landings. The 115 dB L_{Amax} contour, which is used as a conservative limit for hearing conservation, is located approximately 1 mile from the landing pad.

The 134 dB L_{max} contour used to assess the potential for structural damage, located between the 130 dB and 140 dB contours in Figure 11, is approximately 0.5 miles from the landing pad and within Starbase property.

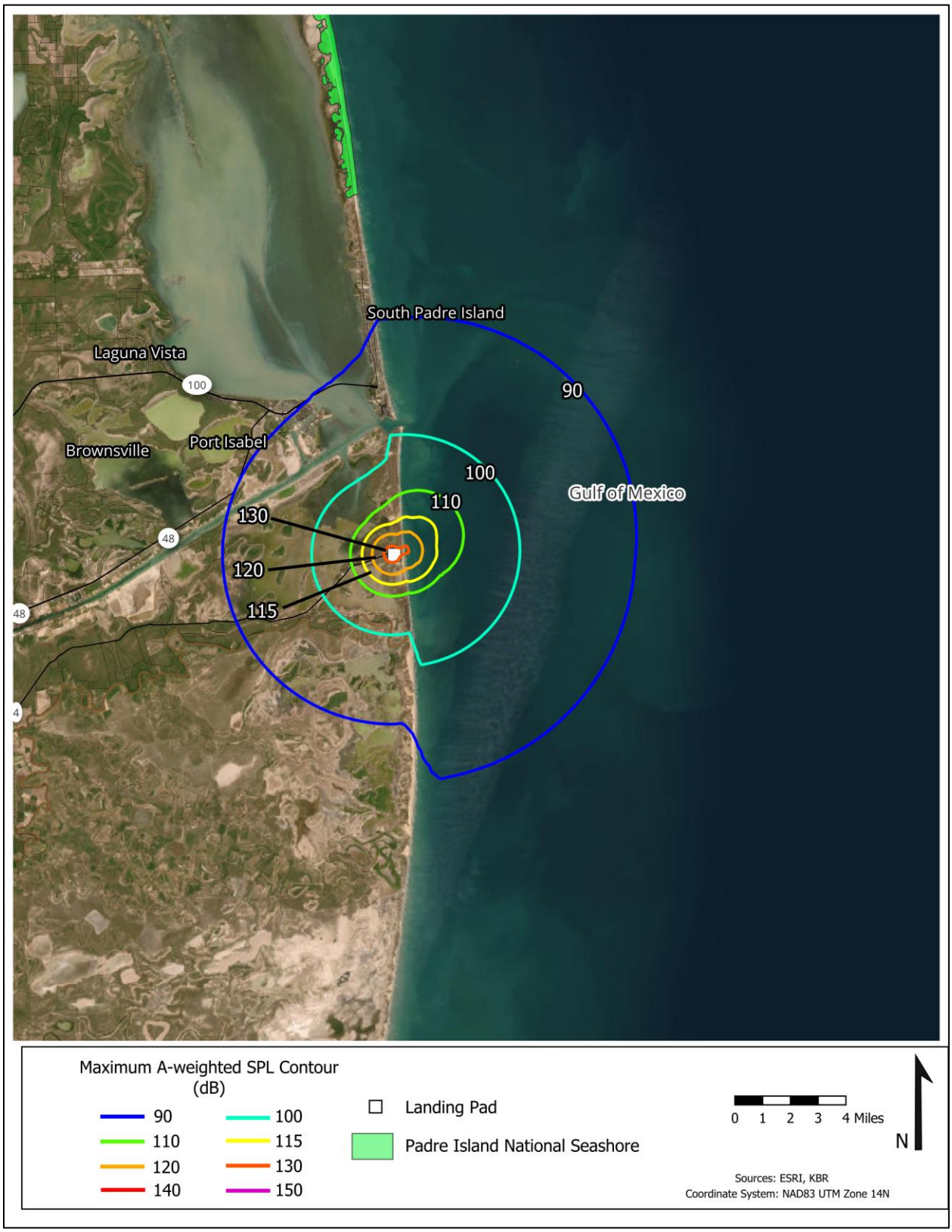

Figure 9. Starship Landing at Starbase: Maximum A-Weighted Sound Levels

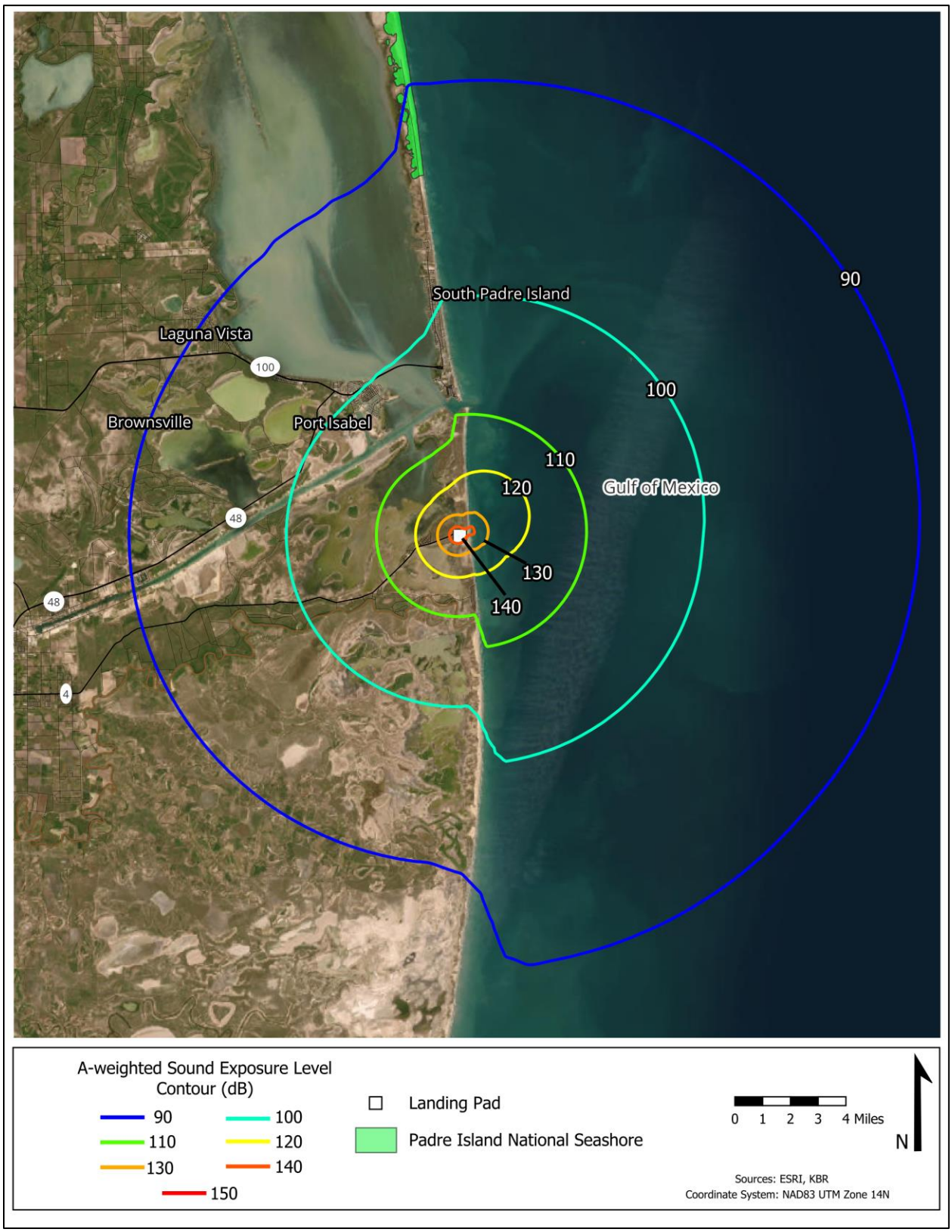

Figure 10. Starship Landing at Starbase: Sound Exposure Levels

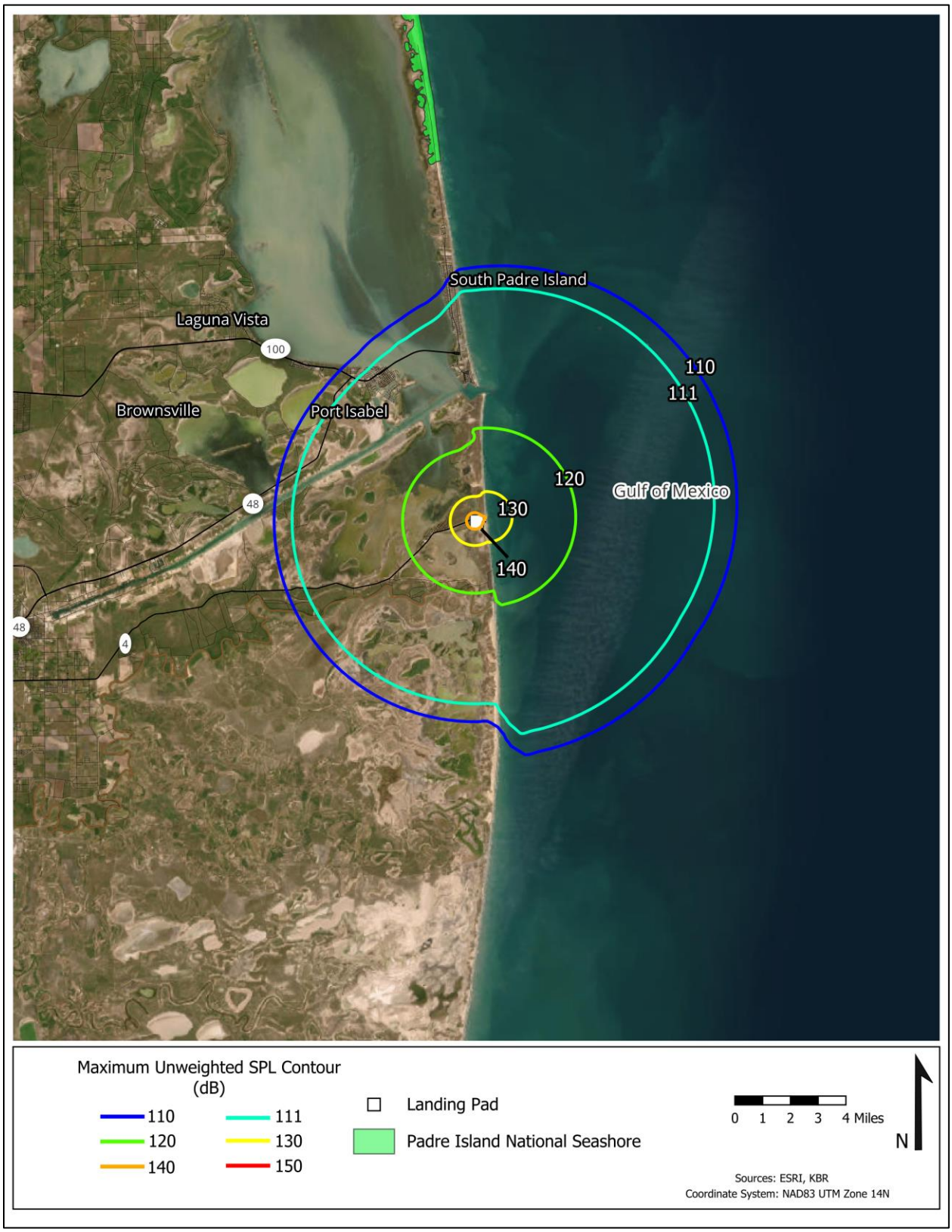

Figure 11. Starship Landing at Starbase: Maximum Unweighted Sound Levels

4.2 Super Heavy Booster Landings at Starbase

RNOISE was used to estimate the L_{Amax}, SEL, and L_{max} contours for a Super Heavy Booster landing at the Starbase landing site. The Super Heavy Booster descent/landing trajectory was provided by SpaceX in file 'Super_Heavy_Boca_RTLS_ROTATED_80_12.ASC' with uprated maximum thrust of about 3.31 MM lbf (5 engines x 2.94 MN per engine).

RNOISE computations were performed as noted previously in Section 3. The L_{Amax}, SEL, and L_{max} contours for a Super Heavy Booster landing at Starbase are shown in Figures 12 through 14, respectively (using a zoomed in map scale). In Figure 12 the 90 dB L_{Amax} contour is about 8 miles from the Starbase landing site. Residents of Port Isabel and eastern Brownsville may hear booster landing events above 60 dB, particularly nighttime landings. The 115 dB L_{Amax} contour, which is used as a conservative limit for hearing conservation, is located approximately 1.5 miles from the landing pad.

The 134 dB L_{max} contour used to assess the potential for structural damage, located between the 130 dB and 140 dB contours in Figure 14, is less than 1 mile from the landing pad and within Starbase property.

Section 5 presents the estimated noise levels for Starship and Super Heavy Booster static fire tests to be conducted at Starbase.

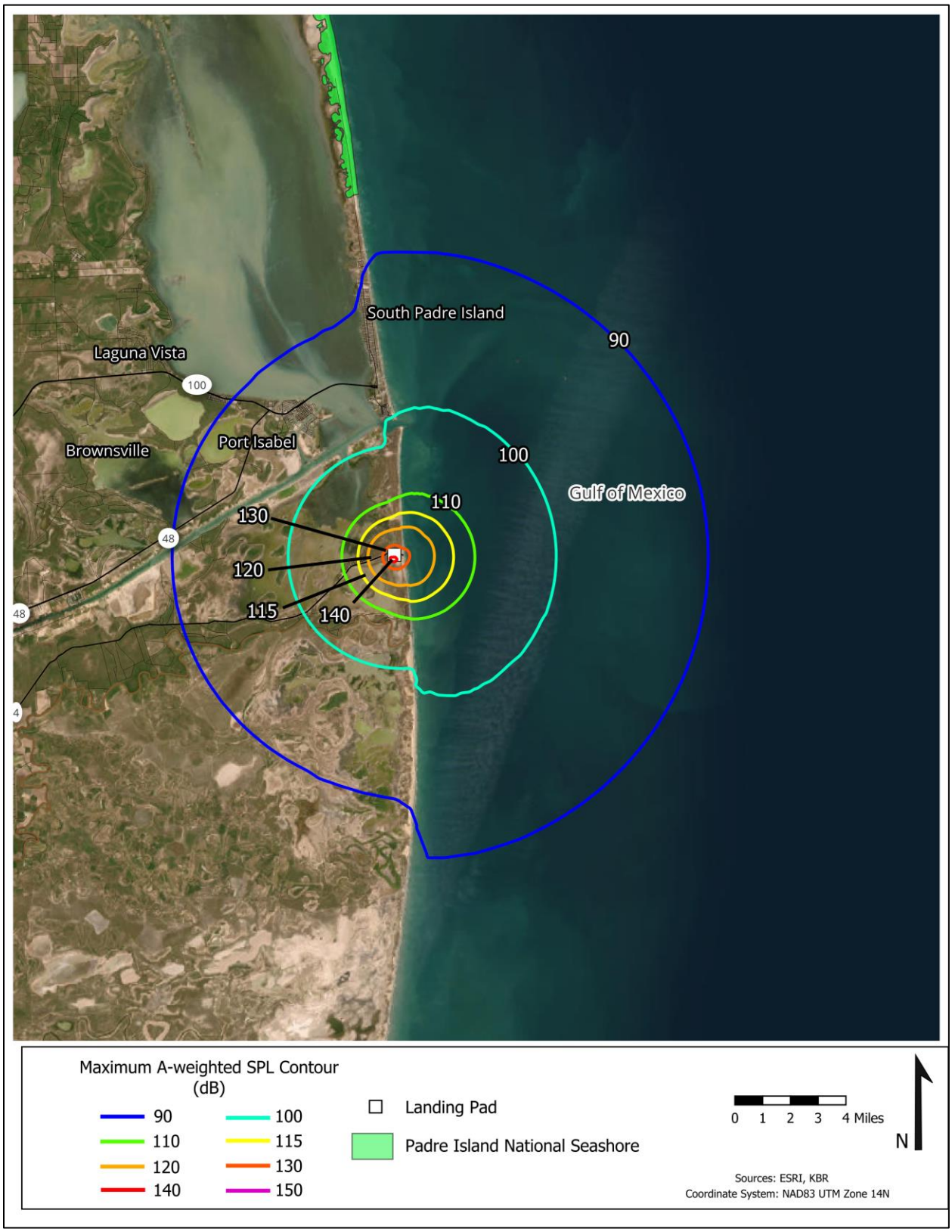

Figure 12. Super Heavy Booster Landing at Starbase: Maximum A-Weighted Sound Levels

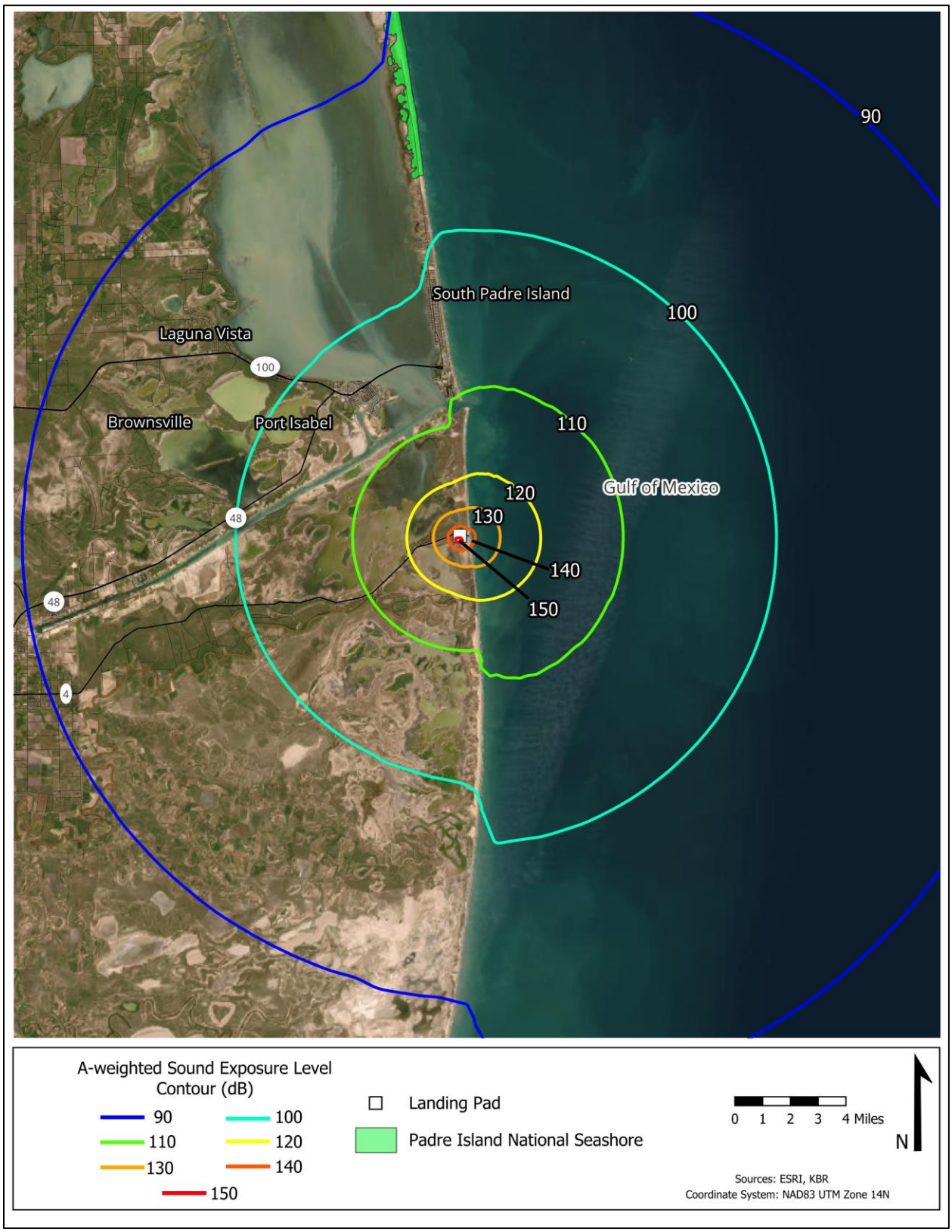

Figure 13. Super Heavy Booster Landing at Starbase: Sound Exposure Levels

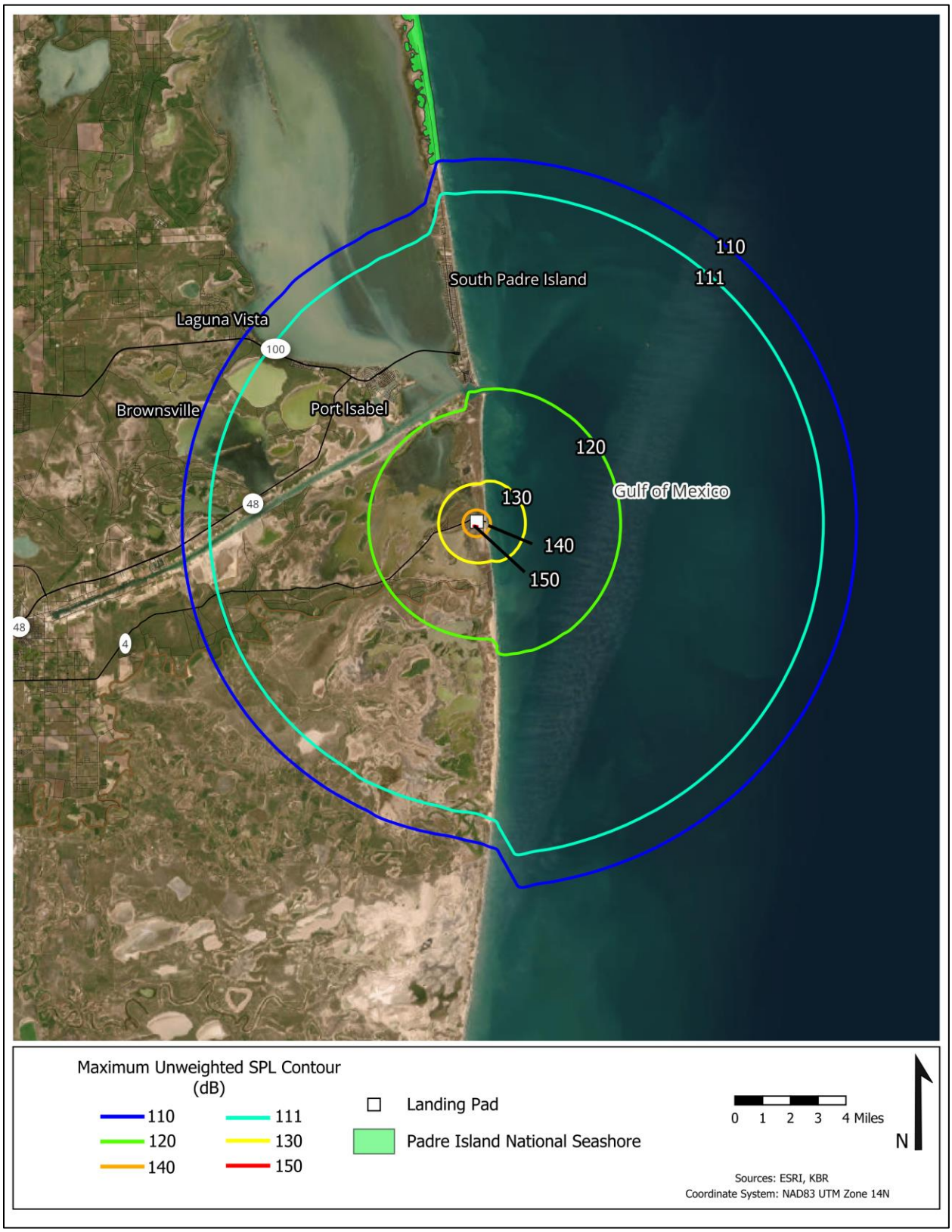

Figure 14. Super Heavy Booster Landing at Starbase: Maximum Unweighted Sound Levels

5 Static Fire Test Noise Levels

5.1 Ship Static Fire Tests at Starbase

Starship static fire tests are planned to occur at Starbase where nine engines, that each generate 3.19 MN of thrust at sea level, will be fired 6 times annually for 15 seconds per test event (average duration). RNOISE computations were performed as noted previously in Section 3. The L_{Amax}, SEL, and L_{max} contours for a Starship static fire test at Starbase are shown in Figures 15 through 17, respectively (using a zoomed in map scale).

The L_{Amax} 90 dB contour in Figure 15 extends about 3 miles west of the test site. Residents of Port Isabel may hear Starship static test events above 60 dB, and particularly if onshore wind conditions favor sound propagation to the west. The 115 dB L_{Amax} contour, which is used as a conservative limit for hearing conservation, is located approximately 1 mile from the static test site.

The 134 dB L_{max} contour used to assess the potential for structural damage, located between the 130 dB and 140 dB contours in Figure 17, is less than 1 mile from the test site and within Starbase property.

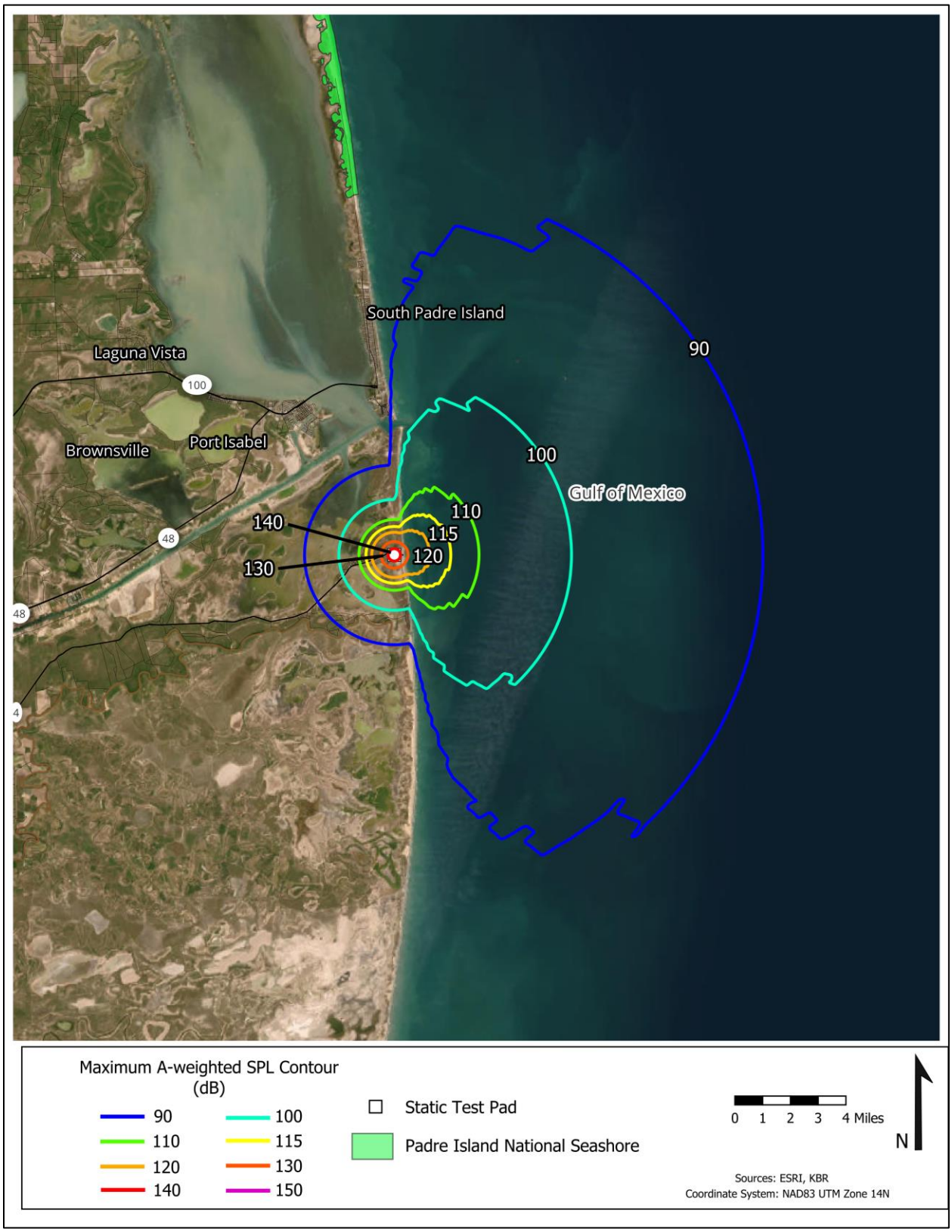

Figure 15. Starship Static Fire Test at Starbase: Maximum A-Weighted Sound Levels

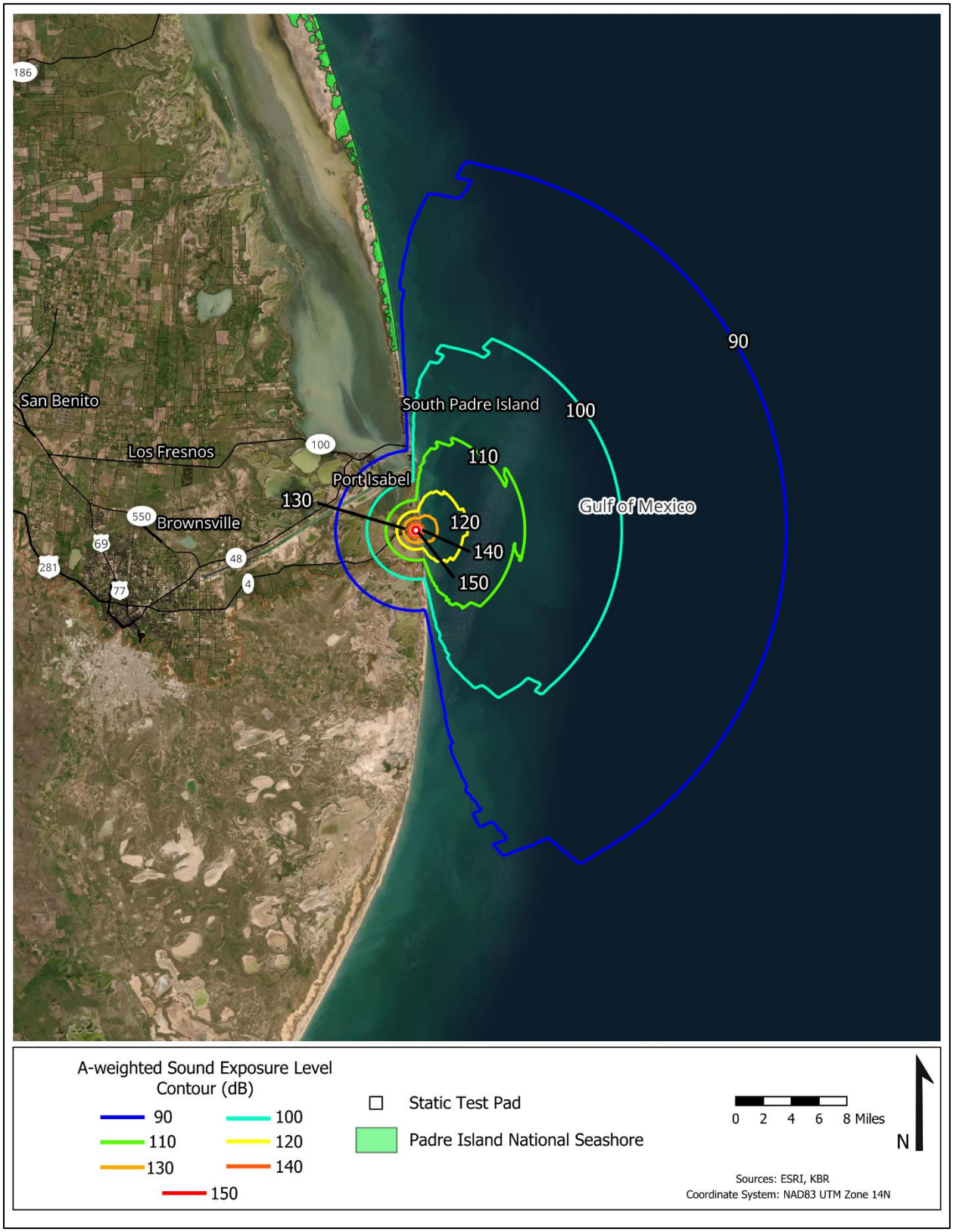

Figure 16. Starship Static Fire Test at Starbase: Sound Exposure Levels

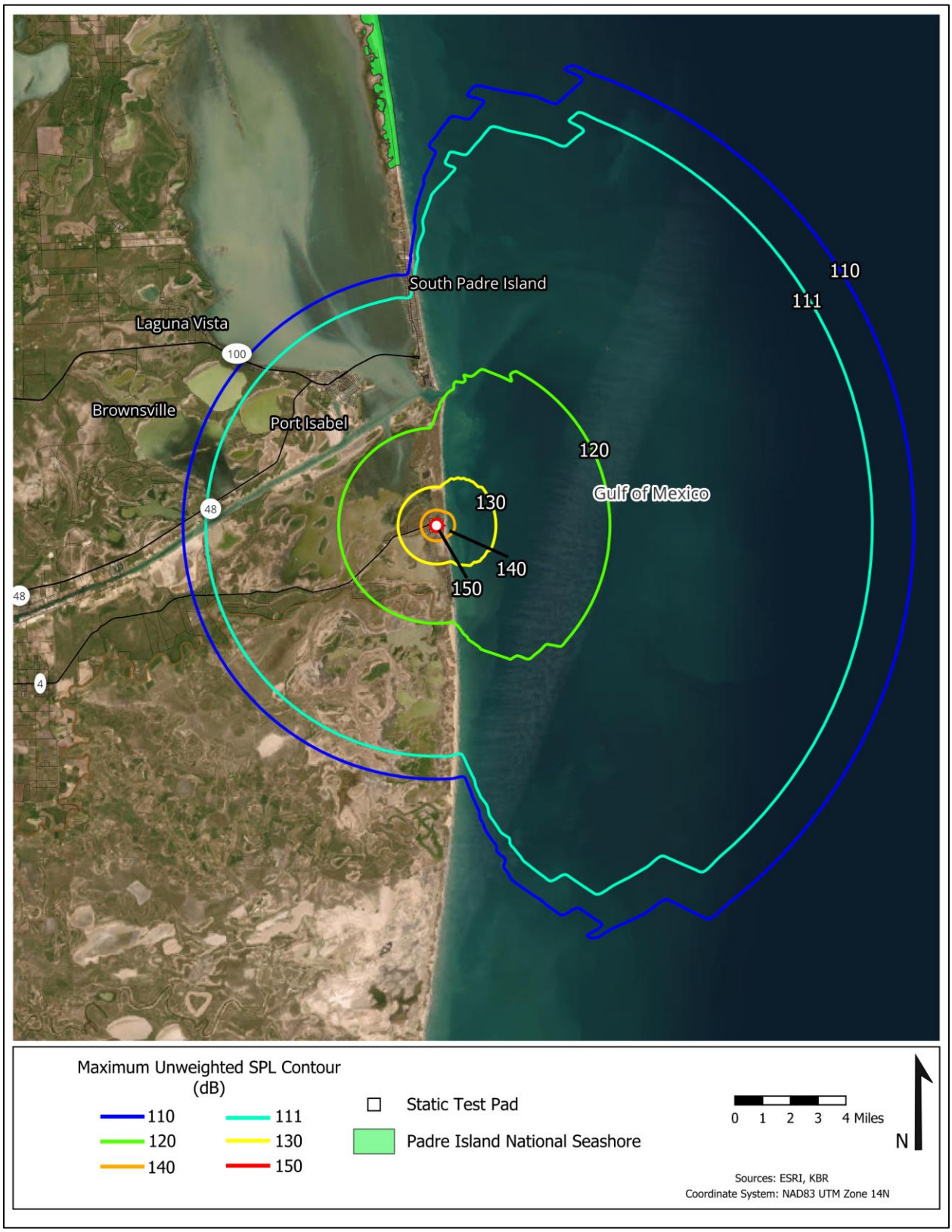

Figure 17. Starship Static Fire Test at Starbase: Maximum Unweighted Sound Levels

5.2 Super Heavy Booster Static Fire Tests at Starbase

Super Heavy Booster static fire tests are planned to occur at Starbase where thirty-five engines, that each generate 2.94 MN of thrust at sea level, will be fired 5 times annually for 15 seconds per test event (average duration). RNOISE computations were performed as noted previously in Section 3. The L_{Amax}, SEL, and L_{max} contours for a booster static fire test at Starbase are shown in Figures 18 through 20, respectively.

The L_{Amax} 90 dB contour in Figure 18 extends about 4 miles west of the test site. Residents of Port Isabel may hear booster static test events above 60 dB, and particularly at night and if onshore wind conditions favor sound propagation to the west. The 115 dB L_{Amax} contour, which is used as a conservative limit for hearing conservation, is located approximately 1.2 miles from the static test site.

The 134 dB L_{max} contour used to assess the potential for structural damage, located between the 130 dB and 140 dB contours in Figure 20, is approximately 1.5 miles from the test site and within Starbase property.

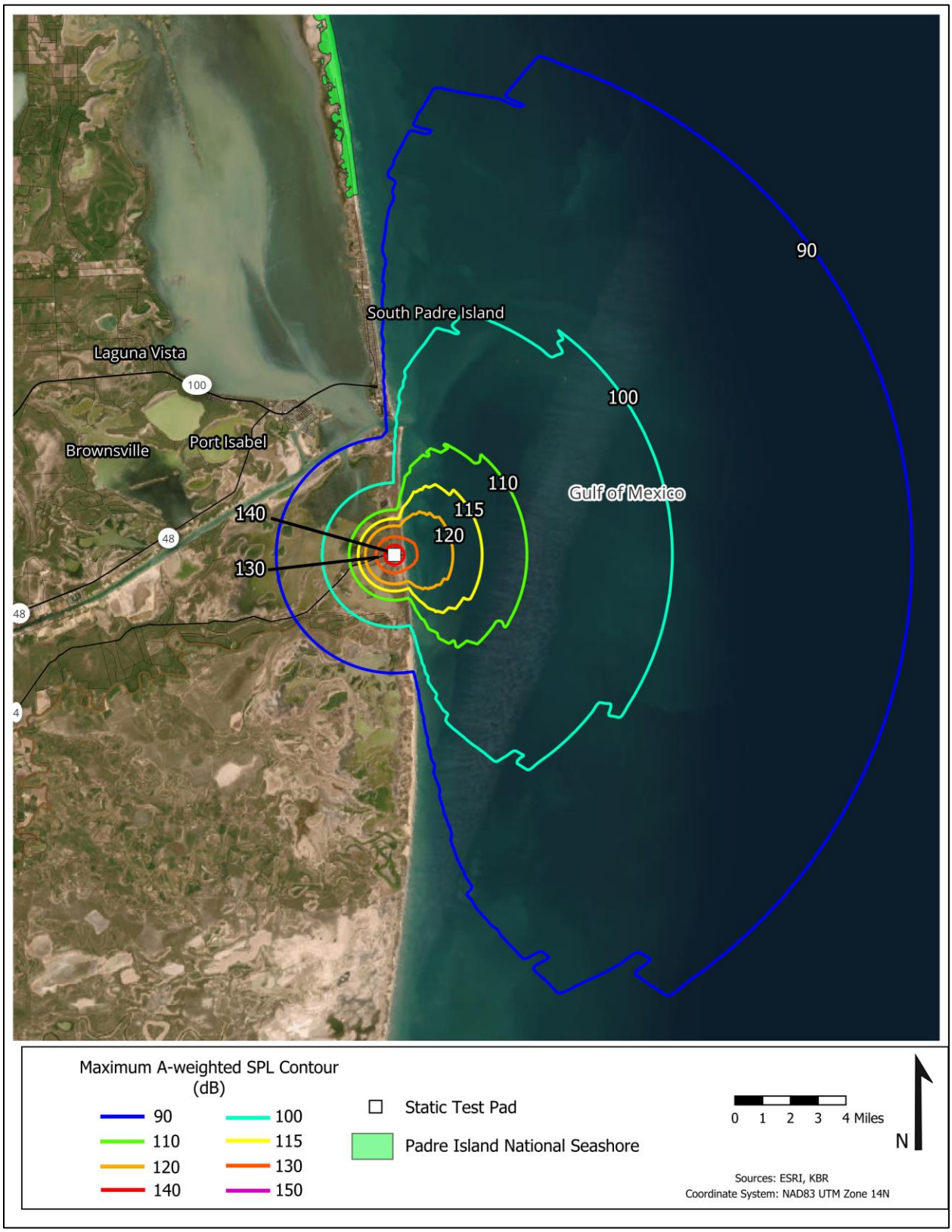

Figure 18. Super Heavy Booster Static Fire Test at Starbase: Maximum A-Weighted Sound Levels

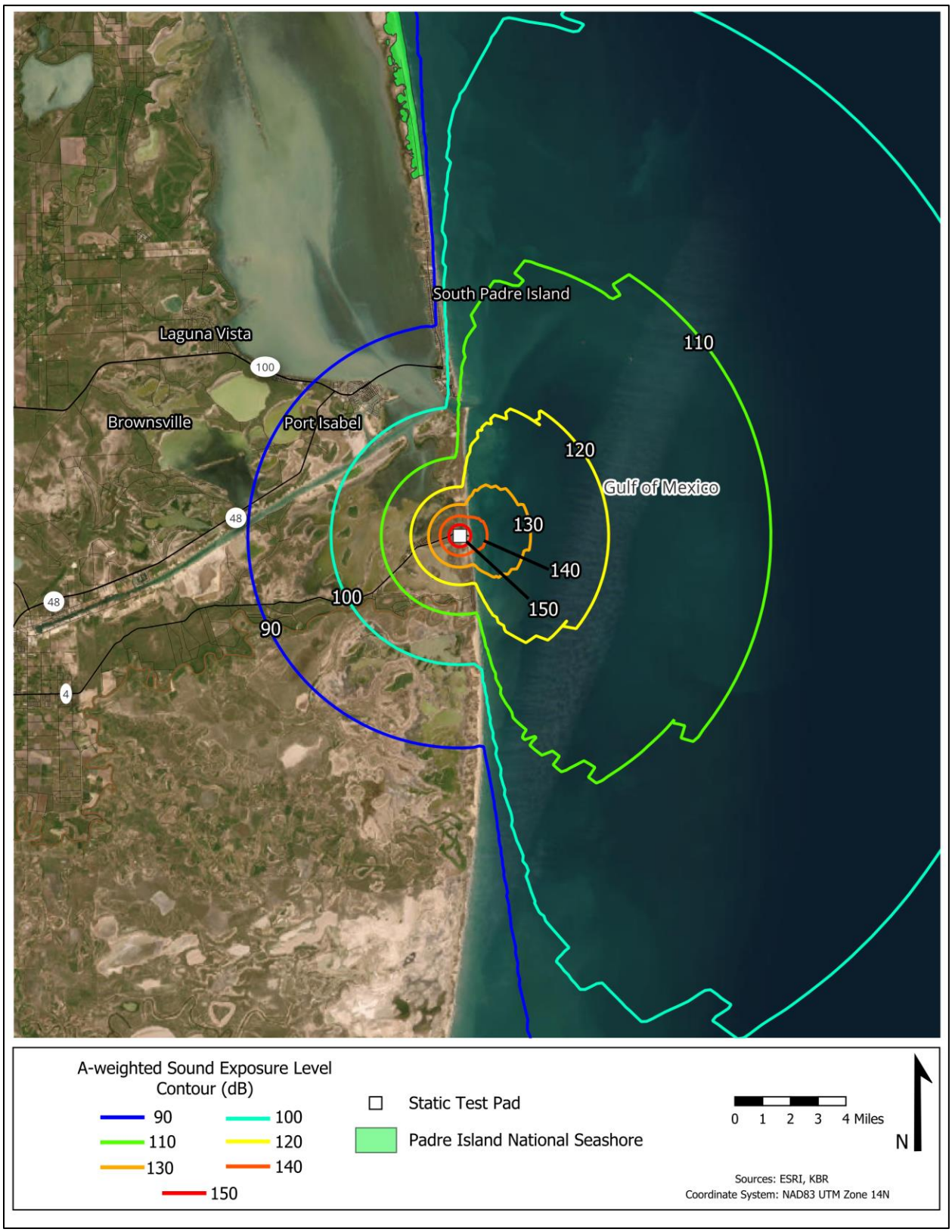

Figure 19. Super Heavy Booster Static Fire Test at Starbase: Sound Exposure Levels

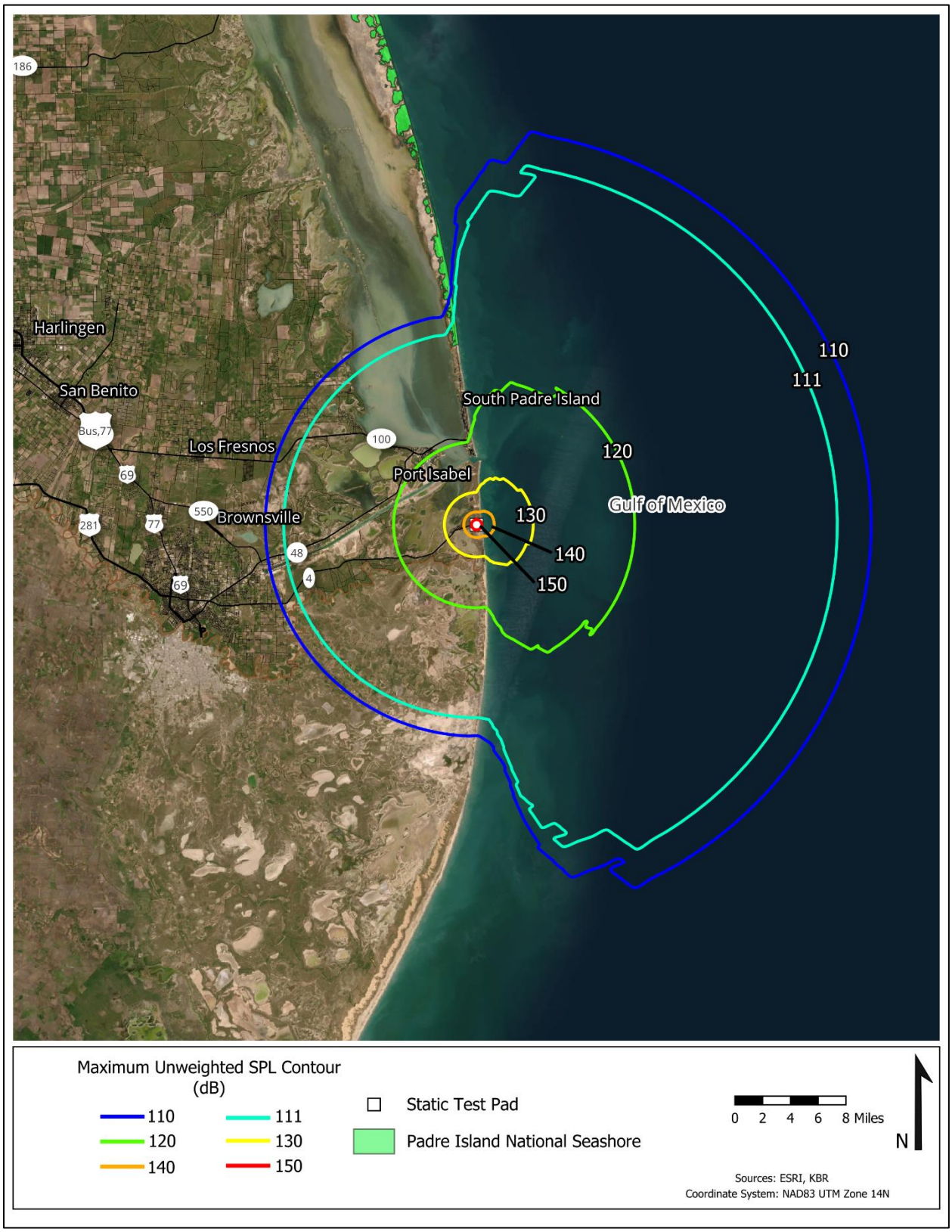

Figure 20. Super Heavy Booster Static Fire Test at Starbase: Maximum Unweighted Sound Levels

6 Cumulative Noise Levels for Projected Starship Flight and Test Operations

6.1 Projected Launch, Landing, and Static Fire Tests at Starbase

Cumulative noise levels were estimated for a future projected operations scenario involving twenty-five launches and landings of both vehicles plus additional static fire tests of both vehicles at Starbase as follows:

(25) Annual Operations Scenario

- 25 Starship and Booster orbital launches (17 daytime / 8 Nighttime)
- 25 Super Heavy Booster landings (17 daytime / 8 Nighttime)
- 25 Starship landings (17 daytime / 8 Nighttime)
- 5 Super Heavy Booster static fire tests (5 daytime / 0 Nighttime)
- 6 Starship static fire tests (6 daytime / 0 Nighttime)

The DNL contours shown in Figure 21 are a cumulative noise estimate for these projected annual operations at Starbase. Overland, the DNL 65 contour extends approximately four miles from Starbase to the north, west and south, in unpopulated areas. This projected operations scenario is expected to fulfill mission and test requirements for the Starship without causing adverse noise exposure in any of the communities near Starbase.

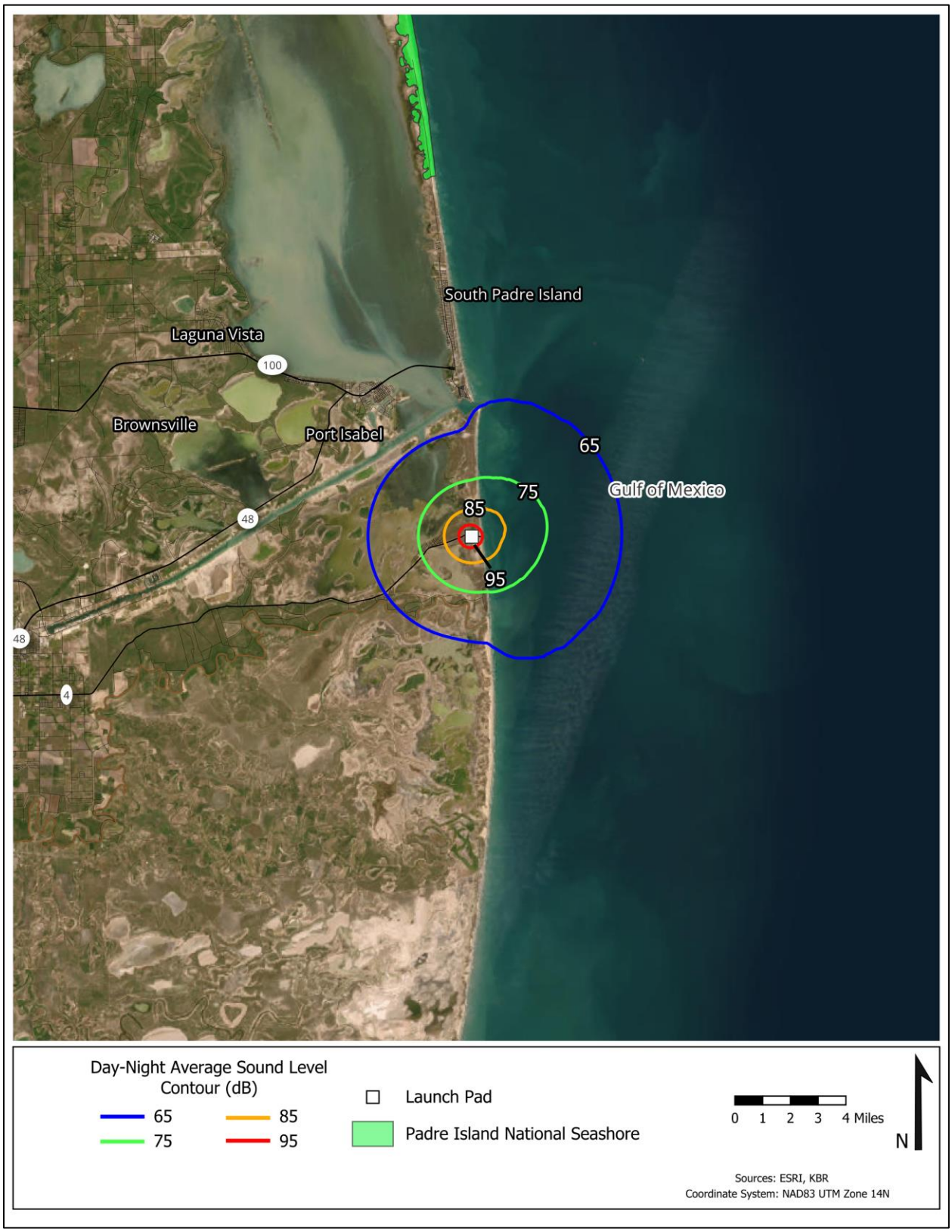

Figure 21. Starship and Booster 25 Annual Operations Scenario: DNL Contours

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SPACEX

MEMORANDUM **July 24, 2024**

TO: Federal Aviation Administration, Office of Commercial Space Transportation

FROM: Space Exploration Technologies

SUBJECT: Sonic Boom Analysis

Space Exploration Technologies (SpaceX) is proposing to launch its Starship/Super Heavy launch vehicle from the SpaceX Boca Chica Launch Site. Each Starship/Super Heavy launch would include a boost-back and immediate landing of the first stage Super Heavy booster and a landing of the second stage Starship. Super Heavy and Starship would each land vertically on the pad.

A tiered Environmental Assessment (EA) is being prepared for the Proposed Action. The EA is being prepared in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321 et seq.), Council on Environmental Quality NEPA-implementing regulations (40 CFR Parts 1500 to 1508), and FAA Order 1050.1F, Environmental Impacts: *Policies and Procedures*. SpaceX is proposing to increase the cadence of the Starship/Super Heavy launch program at the Boca Chica vertical launch area in Cameron County, Texas to up to 25 annual launches and 50 total annual landings (25 of the Starship and 25 of the Super Heavy), and make vehicle and operational upgrades (see Section 2.1 of the EA). Of the 25 annual launches, up to 1 launch would occur during night-time hours (defined as 7:00 pm to 7:00 am). In accordance with FAA Order 1050.1F, if a project involves commercial space launch vehicles reaching supersonic speeds, the potential for sonic boom impacts should be discussed. 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. A sonic boom trace is an impulsive event that lasts for less than 300 milliseconds. A sonic boom is generated during vehicle ascent, but it would not impact land areas. A sonic boom would also be generated during orbital Starship/Super Heavy launches and Starship and Super Heavy landings as the vehicle approaches the landing location. SpaceX used PCBOOM to estimate single event sonic boom levels during Starship and Super Heavy descent. Sonic boom modeling contours are approximate and actual exposure at any particular location or time during a sonic boom event can vary depending on a number of different atmospheric, physical, and operational parameters.

Assumed Operations and Vehicle Definition

For all operations included in the increased launch cadence assessment, a “return to launch site” (RTLS) trajectory is assumed, where both stages return to the Boca Chica launch site. As a result, the sonic boom generation on ground and populated areas is maximized, since offshore landings for the first stage strictly reduce the sonic boom footprint on land and offshore landings for the second stage will not be conducted with overflight regions that produce sonic booms over South Texas.

The Super Heavy (first stage) reenters the atmosphere from a moderate altitude (approximately 100 km) with a steep flight path angle, oriented engines first, and with a shallow pitch, oriented roughly 25 degrees from vertical during the supersonic portion of flight. The reentry trajectory is shown in Figure 1. This trajectory is similar to the Falcon first stage booster approach and produces a sonic boom that can make landfall from flight conditions ranging from Mach 1 to Mach 4. The contours of constant sonic boom overpressure magnitude that intersect with land tend to form nearly concentric circles or ellipses because of this steep, targeted descent.

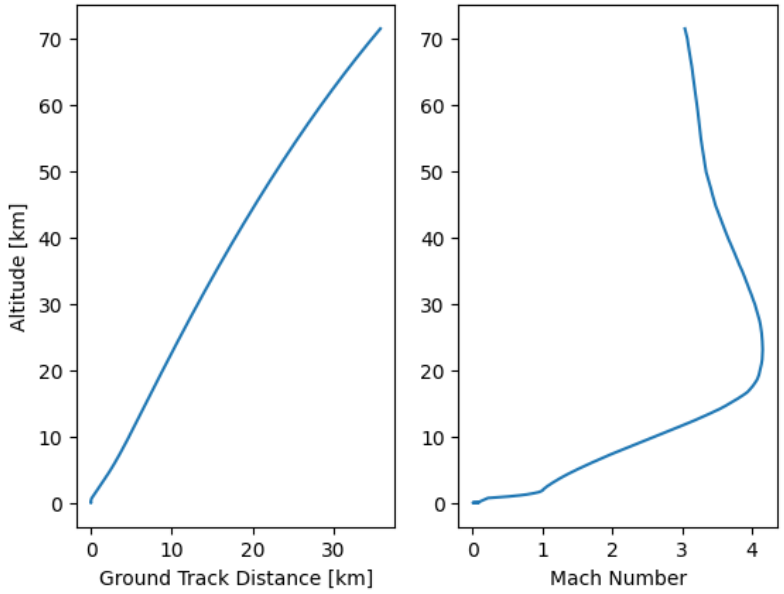

Figure 1: A nominal return trajectory for first stage

The Starship (second stage) reenters the atmosphere from orbital velocity and altitudes with a shallow flight path angle until subsonic speeds, oriented with a large cross-sectional area exposed to the flow – a high vehicle pitch. This is similar to the reentry of the STS Orbiter Shuttle, with the distinction of a transition to a much steeper flight path angle in the subsonic regime with during which there is little modulation of crossrange or downrange ground track. The net result of this flight plan is the potential for a “carpet” of perceptible sonic booms along the ground track in supersonic flight depending on the trajectory’s altitude. The final portion of descent may also

produce sonic booms that intersect with the ground past the landing site given the pointing and velocity vector of the vehicle.

The assumed heading for return of the first stage is 268-345 degrees clockwise from north. While flight trajectories may vary the return inclination in the future, this has limited impact on the sonic boom levels experienced by most communities surrounding Boca Chica. Due to the steep flight path angle of the first stage reentry, the sonic boom footprint consists of nearly concentric circles. Within 10 kilometers of the landing site, more asymmetry is produced by trajectory heading than by the prevailing wind speed. Non-concentric sonic boom footprints are expected at lower magnitudes (below 3 psf) and reach the longest distances from the landing site in a direction normal to the ground track. As a result, a steeper inclination RTLS trajectory maximizes the area of Brownsville that is exposed to at least 2 psf sonic booms in the model results presented for this EA.

The assumed heading for return of the second stage ranges from 22-158 degrees clockwise from north, both ascending and descending ground tracks. This variation has the effect of creating many over-land regions that could be exposed to sonic booms around the vehicle's ground track. A singular case for 68 degrees approach heading is shown, and a secondary illustration sweeping the potential sonic boom magnitudes in a continuous arc through 22-158 degrees is also shown. The secondary illustration is non-physical of any single RTLS trajectory of the second stage.

Sonic Boom Modeling Approach

SpaceX has derived initial predictions for sonic boom magnitudes and contours during return of both stages of the Starship/Super Heavy launch vehicle using the industry standard PCBoom software. Primary inputs used with PCBoom are the planned flight trajectories for return to land, a shape factor of each stage (including variation with vehicle pitch where significant), and each stage's length and weight. PCBoom was run utilizing the Carlson mode of calculation, with a simple N-wave shaped, F-function for originating shock waves from the supersonic flight of the vehicle. The provided sonic boom contours are augmented where past experience suggests deficiencies with the PCBoom v6.6 prediction capability, primarily the extent of ground track carpet produced by the reentering second stage.

While a simplified version of near-field shock strength is used in the Carlson mode, PCBoom completes a ray tracing propagation solution for intersection of the generated shock front with sea level. For this to be accurate, data for wind velocity, temperature, static pressure, and humidity as it varies by altitude must be provided. Of these, the sonic boom magnitudes on land are most significantly affected by wind velocities. Historical wind data is available from Global Forecasting System past predictions and some limited weather balloon data. A single, consistent wind profile vs altitude based on median Brownsville winds is assumed for the entire region. It should be noted that significant variation can be expected in the prevailing winds on seasonal to daily timescales, which could alter the intensity of the sonic boom at different locations. The extreme and average winds are shown in Figure 2. The temperature profile used is a representative profile collected immediately before Flight Test 4 of Starship/Super Heavy, which is generally more representative of the subtropical oceanic climate of south Texas than the "Standard Atmosphere". A constant humidity of 80% is assumed.

For the first stage vehicle, SpaceX estimated a shape factor of $K_s = 0.154$ based on the NASA-1122 sonic boom reference and methodology and validated this value with measurements collected from buoys during Flight Test 4. This shape factor estimation was derived over a range of vehicle pitch angles during reentry, consistent with the vehicle's planned future flight profiles. A bounding vehicle length of 80 meters is assumed.

For the second stage vehicle, SpaceX estimated a shape factor of $K_s = 0.3$ based on the NASA-1122 sonic boom reference and methodology. This shape factor estimation was derived over a range of angles of attack, consistent with the vehicle's planned future flight profiles. A bounding vehicle length of 70 meters is assumed. Because second stage boom contours on ground are expected to be wide and have more variability from choice of approach heading, a zero-wind profile is used in prediction of the second stage sonic booms on ground.

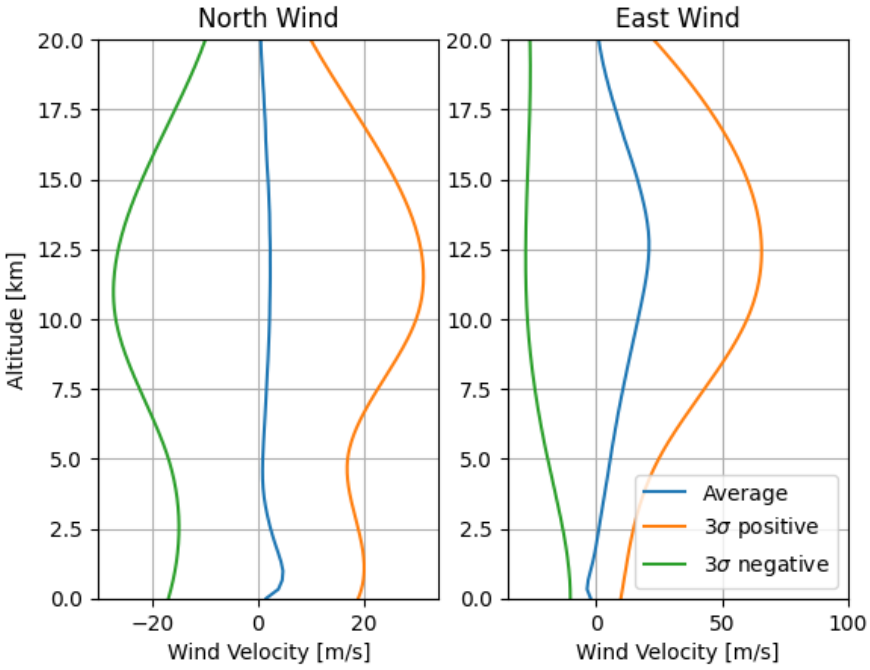

Figure 2: Wind speed averages and extrema used in each cardinal direction. Positive valued velocity is blowing toward the title direction

Secondary, or "over the top", sonic booms are not predicted in this set of nominal environmental assessment results. Certain combinations of temperature profiles versus altitude and winds aloft could produce sufficient atmospheric refraction that sonic booms could be heard at further distances than presented here. The resulting sonic booms would be weak in magnitude and expected to only be heard by those listening for it, or in particularly low noise floor environments – below levels of significance.

Sonic Boom Overpressure Interpretation and Thresholds

A vehicle traveling supersonic, or faster than the local speed of sound, produces a shock wave field around the vehicle. This shock wave propagates away from the vehicle and can intersect with

the ground. The sonic boom sensed on the ground or by an observer is characterized by its overpressure magnitude, or the peak pressure caused by the shock front's arrival. This peak pressure is most often measured and quoted in terms of pounds per square foot, or psf. Acceptable levels of sonic boom exposure are not well standardized, in large part because audible levels and general annoyance associated with high exposure frequency are well below overpressures that are likely to cause damage. There are no defined thresholds for human annoyance, and annoyance is likely to increase with loudness of the booms. Additionally, surveys of residents have found that startle, rattle, and vibrations and the possibility of damage to be the most disturbing aspects of sonic booms (Maglieri et al. 2014). Direct human health and safety is not at risk, with evidence of human exposure in tests up to 144 psf with no adverse consequences (Benson 2013, Maglieri et al. 2014, Nixon 1968, Maglieri 1966). A study of the long-term effects of exposures to sonic booms from supersonic military flight operations on human health conducted on residents of Nevada between 1969 to 1983 found no convincing evidence to prove the existence of adverse health effects due to sonic booms (Sutherland and Plotkin 1986, Anton-Guirdis et al. 1986). A set of literature references for both auditory and damage likelihood thresholds is provided here, and a discussion of threshold levels that SpaceX proposes using to assess the areas of exposure. Different sources provide varying guidance or results for what overpressure magnitudes induce structural damage or what the typical community response is to sonic boom exposure.

Sonic booms of 0.5 psf and higher are expected to be generally audible, with booms of lower magnitude requiring an expectation of arrival or a very low noise floor environment to be heard. A sonic boom overpressure of at least 1.0 psf is even more certain to be noticed and is used to define the action area associated with potential environmental impacts (FAA 2022). The next notable threshold of 2.0 psf is used to indicate a level which is typical for supersonic aircraft fly overs, which could be heard by communities and cause noise complaint and annoyance when experienced at high frequency exposure rates (multiple times per day)(Maglieri et al. 2014). Numerous studies have determined that no credible damage to structures or windows is expected at 2.0 psf (Fenton 2016, Benson 2013, White 1972, NOAA 2019). For sonic booms, at approximately 2 psf, there is a 1/10,000 probability of breakage for a large window, and at approximately 4 psf, there is a 1/10,000 probability of breakage for a small window (USACE 1989). The next threshold presented is 6.0 psf, where community awareness of the event, and audibility is effectively guaranteed. However, a survey of the most recent literature indicates this magnitude is still extremely unlikely to cause damage (Benson 2013, NOAA 2019). Laboratory and field testing shows that pre-damaged or poor condition windows could possibly exhibit progression of damage (e.g. pre-existing crack growth) over multiple exposures to this magnitude of boom (Higgins 1965). At 10.0 psf the likelihood of superficial (plaster, bric a brac) damage and window damage becomes more plausible but is generally still expected to be very low probability and predominantly due to poor existing conditions such as pre-cracked, pre-stressed, older and weakened, or poorly mounted windows (Benson 2013, White 1972, Fenton 2016, Maglieri et al. 2014). Finally, SpaceX presents sonic boom exposures up to 21 psf, if any exists for a proposed vehicle operation. This represents a threshold where prevailing literature indicates window breakage becomes possible for standard condition windows, though the prediction of specific window breakage still depends on size, age, orientation, surrounding structure, and other effects (NOAA 2019, Maglieri et al. 2014). The areas that would be exposed to this level are generally limited and would be evacuated during launch and when reentering vehicles may fly supersonic at the lowest altitude before landing

SpaceX Sonic Boom Results

Starship/Super Heavy Orbital Launches

A sonic boom would be generated during vehicle ascent, but it would not impact land areas.

First Stage (Super Heavy Booster) Landing

Figure 4 presents the PCBoom modeled sonic boom contours for a bounding set of first stage RTLS trajectories, with return heading 268, 272, and 345 degrees. Contours of constant magnitude exposure level for 1, 2, 4, 6, 10, 15, and 21 psf are shown, consistent with the described thresholds for sonic boom exposure. Figure 3 presents the results for the 268 degree trajectory by showing the isopemps or lines of intersection with the ground of the shock front produced at a given Mach number in flight. Ground intersection is predicted from Mach 4.1 to Mach 1. The first stage reentry does produce isopemps along its ground track, which take on a shallow hyperbolic shape until a low Mach number and altitude combination allows for both sides of the Mach cone to intersect with the ground and produce a predicted circular exposure area just downrange of the landing site. Overpressure magnitudes of greater than 21 psf, where damage to windows could occur, is confined to restricted access areas during a launch. Overpressure events of 15 psf and 21 psf in areas located within the area where only SpaceX personnel are allowed during launches public hard checkpoint[1]. Boca Chica Village is within the public hard checkpoint, which is evacuated during launch/landing activities. The predicted overpressure for the area surrounding the public hard checkpoint indicate overpressure events up to 15 psf, with contours extending just beyond the U.S. / Mexico Border[2]. Predicted overpressure levels at the southern portion of South Padre Island and Port Isabel, Tarpon Bend, as well as northeast regions of Tamaulipas, Mexico would be expected to reach 10 psf. The 6 psf sonic boom contour is predicted to extend approximately 10 miles from the launchpad, and encompass portions of South Padre Island, all of Port Isabel, Laguna Heights, and portions of Laguna Vista. Portions of northeastern Tamaulipas, Mexico, including La Burrita and El Conchillal, would also be encompassed in the 6 psf sonic boom contour. The 4 psf boom contour is expected to extend approximately 15 miles from the launchpad, and would encompass northern portions of South Padre Island, Laguna Vista, eastern portions of Brownsville, and La Bartolina and El Huisachal in Tamaulipas, Mexico. The 2 psf sonic boom contour is predicted to extend approximately 28 miles, and would overlap Laguna Atascosa, Los Fresnos, Brownsville; and in Mexico, Matamoros and San José. The 1 psf sonic boom contour is predicted to extend approximately 27 miles, and would impact Rio Hondo, San Benito, as well as Santa Adelaida, La Venada, and San José in Mexico.

[1] The public hard checkpoint is located at State Highway 4 and Richardson Avenue. Only SpaceX personnel and FAA launch support personnel are able to pass this checkpoint.

[2] Because the FAA is required to analyze transboundary impacts, areas in Mexico are also considered in the analysis.

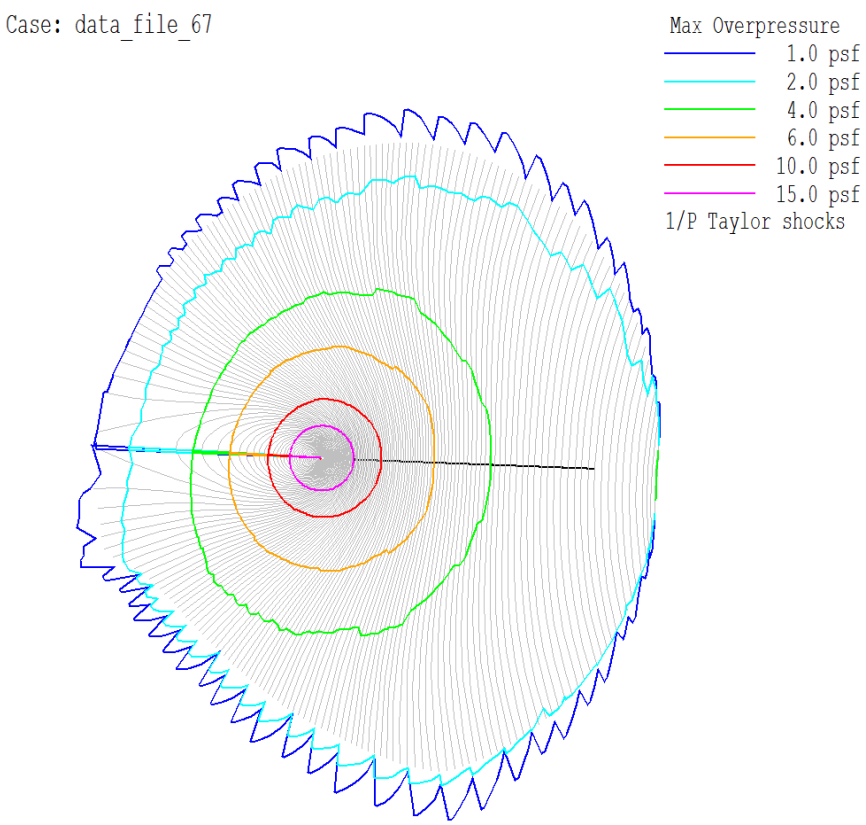

Figure 3: PCBoom v6.6 Pressure contours and isopemps for the 268 degree Super Heavy RTLS trajectory

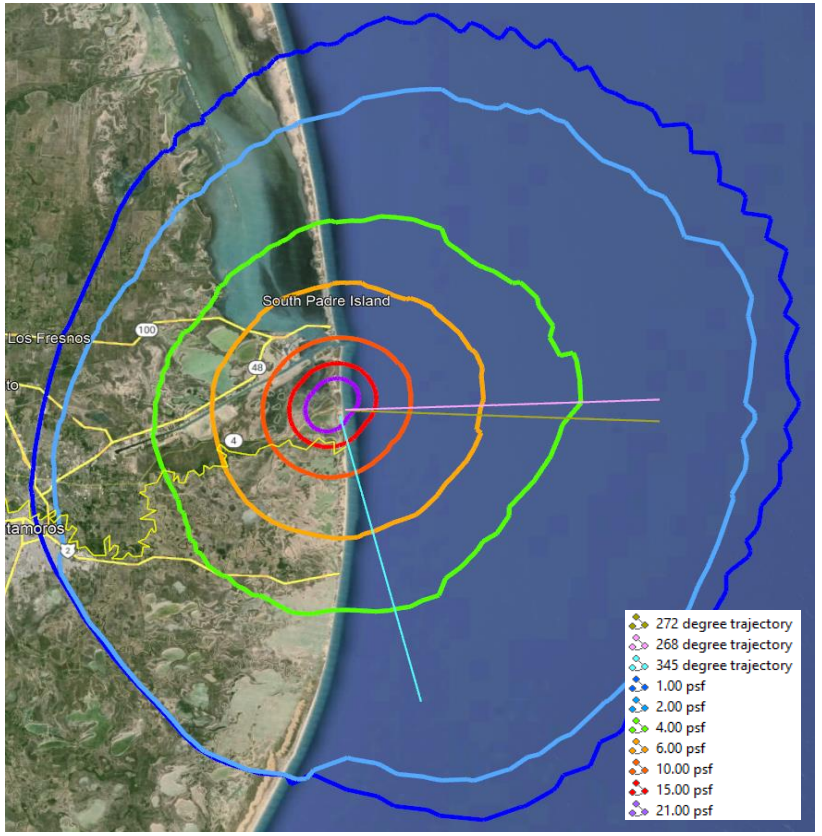

Figure 4: PCBoom v6.6 Pressure contours for a nominal Super Heavy RTLS at 1, 2, 4, 6, 10, 15, and 21 psf, overlayed with a map. The white line indicates the supersonic portion of the Super Heavy trajectory.

Second Stage (Starship) Landing

Figure 5 presents the PCBoom modeled sonic boom contours for the second stage RTLS trajectory. Contours of constant magnitude exposure level for 1.0 and 2.0 psf are shown, consistent with the described thresholds for sonic boom exposure and the maximum predicted on-ground overpressure. Additional contours of 0.7, 1.25, 1.5, 2.5 psf are shown because the peak magnitude of sonic boom on land that will be produced by the second stage is significantly lower than the first stage on an RTLS trajectory. This is the result of the significantly higher altitude at which the second stage reaches a subsonic velocity, and the much shallower flight path angle of the vehicle through supersonic flight. Figure 6 presents the same model results by showing the isopemps or lines of intersection with the ground for the shock front produced at a given Mach number in flight. The first isopemp line is generated from Mach 7.5. The incomplete 1.5 and 1.25 psf contours are a result of granularity in simulated Mach numbers through the vehicle's deceleration. The ground track shown ends as the vehicle transitions to subsonic flight. The simulated lateral cutoff is approximately 35 km on either side of the ground track, and PCBoom predicts all sonic booms to intersect with the ground downrange of the landing site.

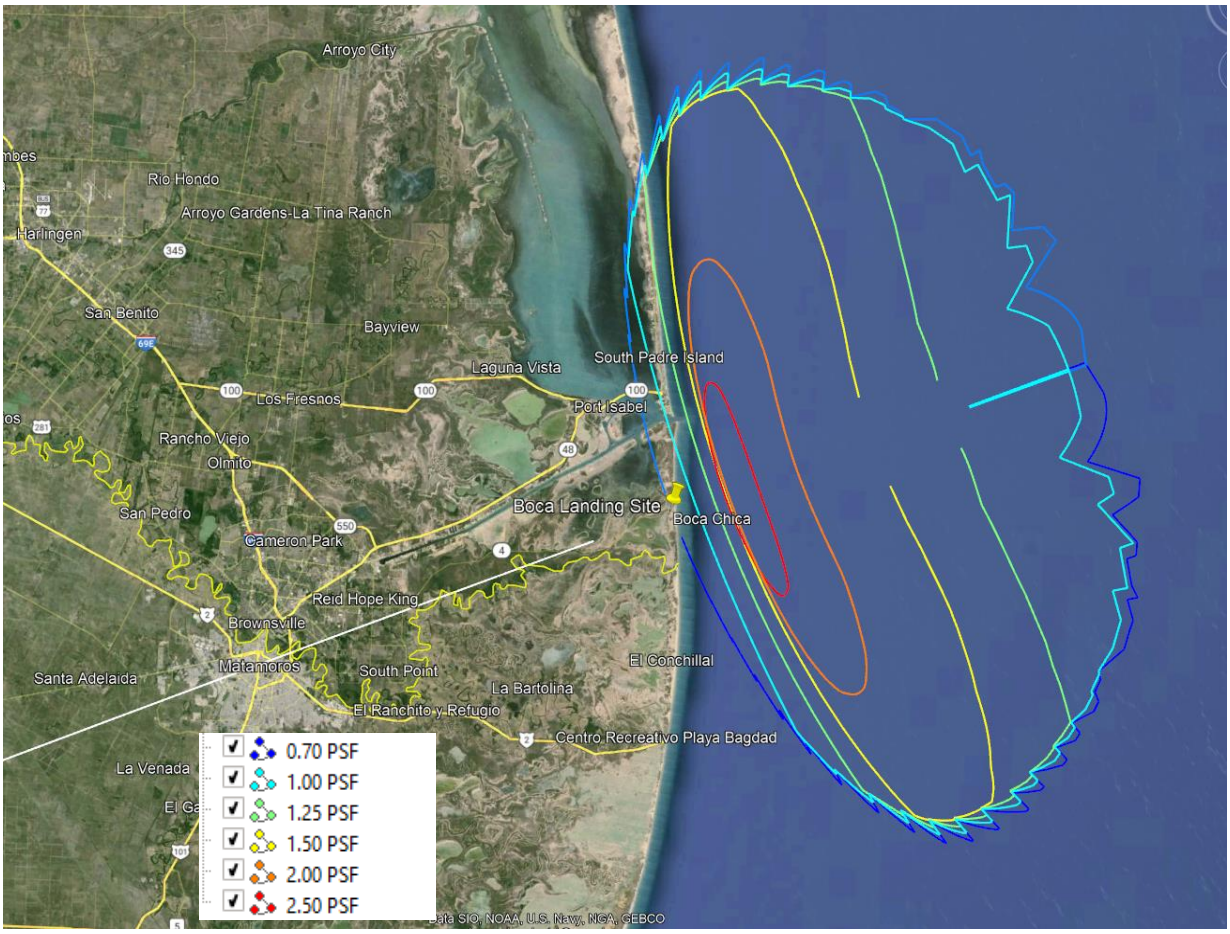

Figure 5: PCBoom v6.6 Pressure contours, Second Stage RTLS for 68 degree heading

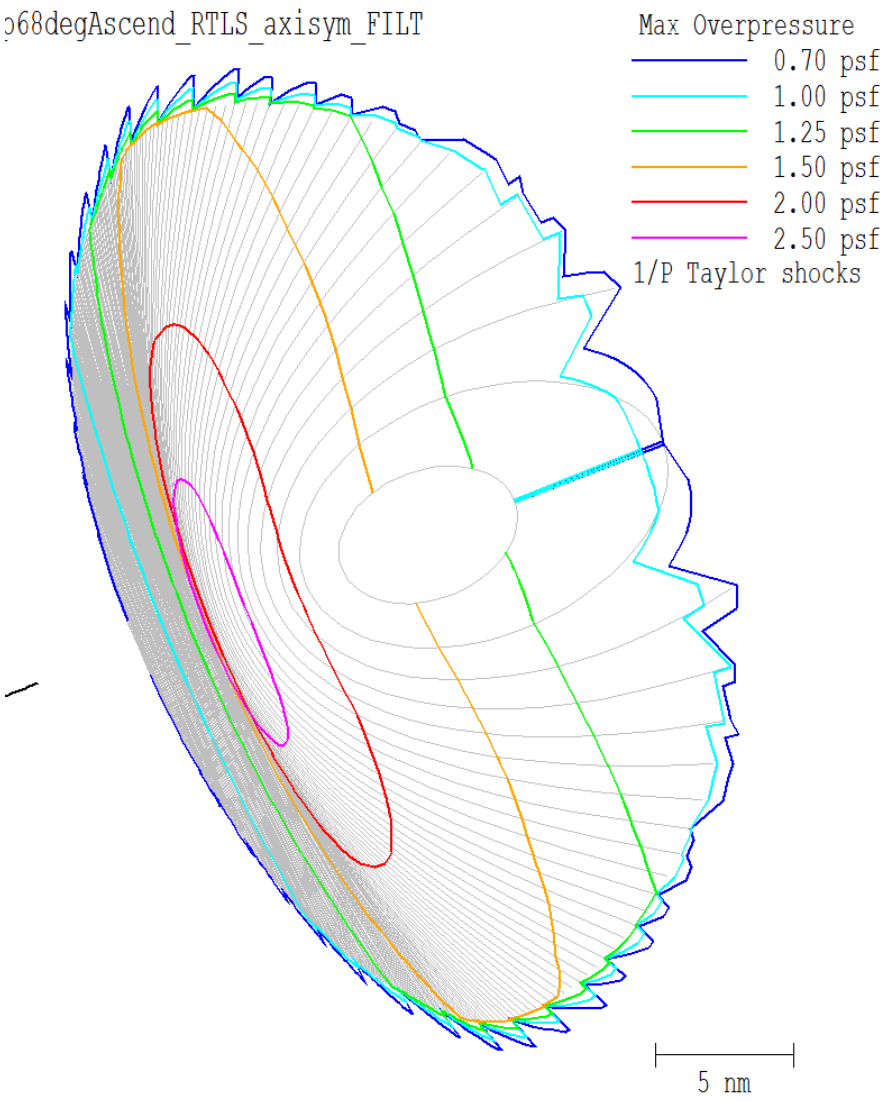

Figure 6: Second stage overpressure contours with Mach based isopemps for 68 degree heading RTLS trajectory

Notably, the predicted ground intersection of sonic booms is almost entirely downrange of the landing site and has limited intersection around the ground track. Historical precedent of measured sonic booms on the Shuttle orbiter and a comparison of vehicle size and typical entry trajectory can be used to infer the following expectations for second stage entry. The second stage is likely to produce sonic booms along its ground track for some lateral extent during supersonic flight up to 50 km of altitude and Mach number of 10. The lateral extent of a low-level sonic boom carpet can be expected to reach up to 150 km of width around the ground track, in addition to the higher magnitude localized boom near and slightly downrange of the landing site. An approximate comparison of the second stage and Shuttle orbiter trajectory in terms of altitude vs Mach is shown in Figure 7 (Maglieri, Domenic, et. al. 2011). As a result, the direct PCBoom v6.6 results are not believed to be complete.

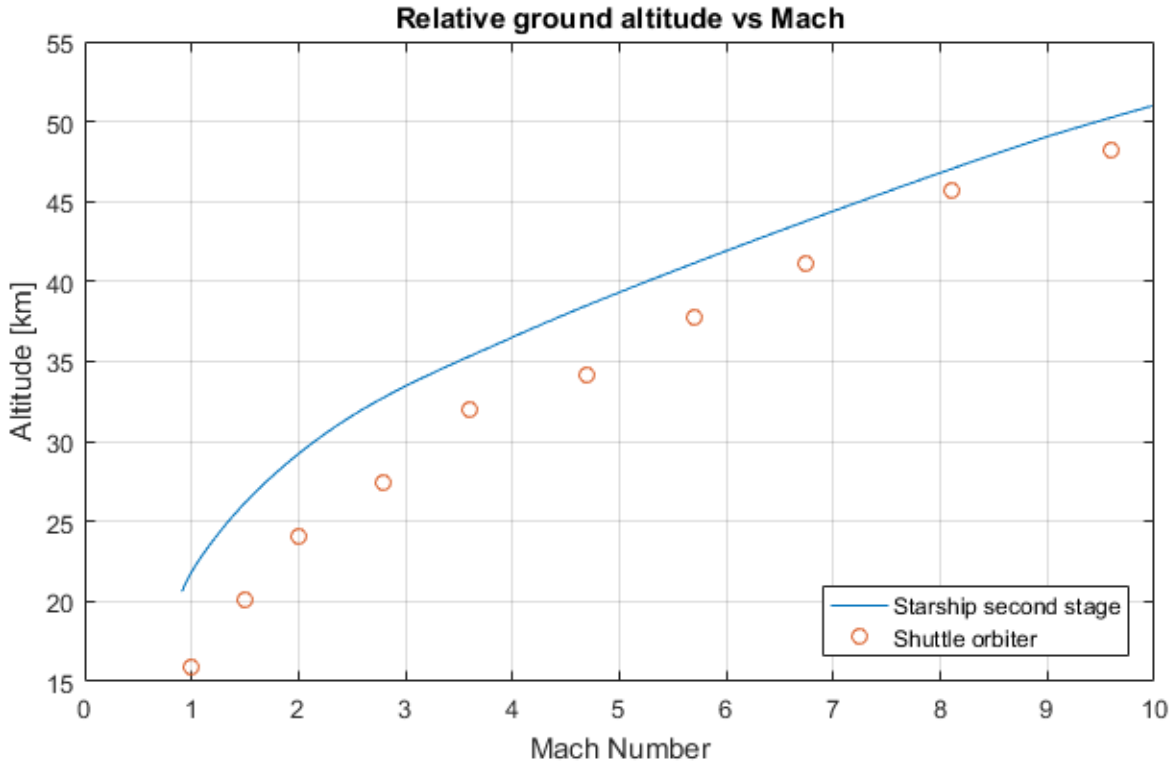

Figure 7: Approximate comparison of second stage RTLS descent trajectory and Shuttle Orbiter

According to *Quieting the boom: the shaped sonic boom demonstrator and the quest for quiet supersonic flight,* a simplified approach for calculating sonic boom magnitudes on land for low flight path angle overflight of aircraft, with evidence of extensibility to orbital reentry vehicles (Benson. 2013). This model is implemented and used to augment the ground track sonic boom generation predicted for the second stage. The results are in better alignment with the Shuttle's overflight sonic boom magnitudes considering that the Starship second stage is slightly larger, but also flies at a higher altitude for all supersonic Mach numbers. The augmented contours for a single 68 degree ascending approach heading case are shown in Figures 8 and 9. The pinched behavior near the landing site is not believed to be physical, and ground track contours likely transition more smoothly to the lobe beyond the landing site. This modeling artifact is mitigated by the swept heading angle results, which effectively rotate the ground track carpet through this pinched zone. The augmented

approach is swept across the range of approach headings from 22-158 degrees is shown in Figures 10 and 11 with the overlay of the single 68 degree case as an illustration of the additional conservatism assumed by sweeping the approach heading.

The augmented results show sonic booms up to 2 psf on land within 20 km of the landing site. Depending on vehicle heading, this could include area that encompasses populated regions of South Padre Island, Port Isabel, and northeast portions of Tamaulipas, Mexico. Sonic booms of up to 4 psf could reach sea level within 10 km of the landing site, and for many heading angles be entirely offshore, but for steep approaches and on shore wind conditions, could be sensed in South Padre. Sonic booms up to 1 psf could be heard up to 40 km from the landing site, typically only at that distance if within 10km of the approaching vehicle's ground track. Thus, for specific heading angles sonic booms of 1 psf are predicted to extend approximately 24 miles, and may be heard in Brownsville, Matamoros, South Padre, Port Isabel, Laguna Heights, Laguna Vista, Los Fresnos, and other South Texas communities, as well as El Huisachal and Rancho Santa Isabel in Mexico. Beyond this distance, sonic booms are expected to be below 1 psf, at which point they will be heard by individuals anticipating their arrival or in a low noise floor environment but are otherwise not expected to be of significance.

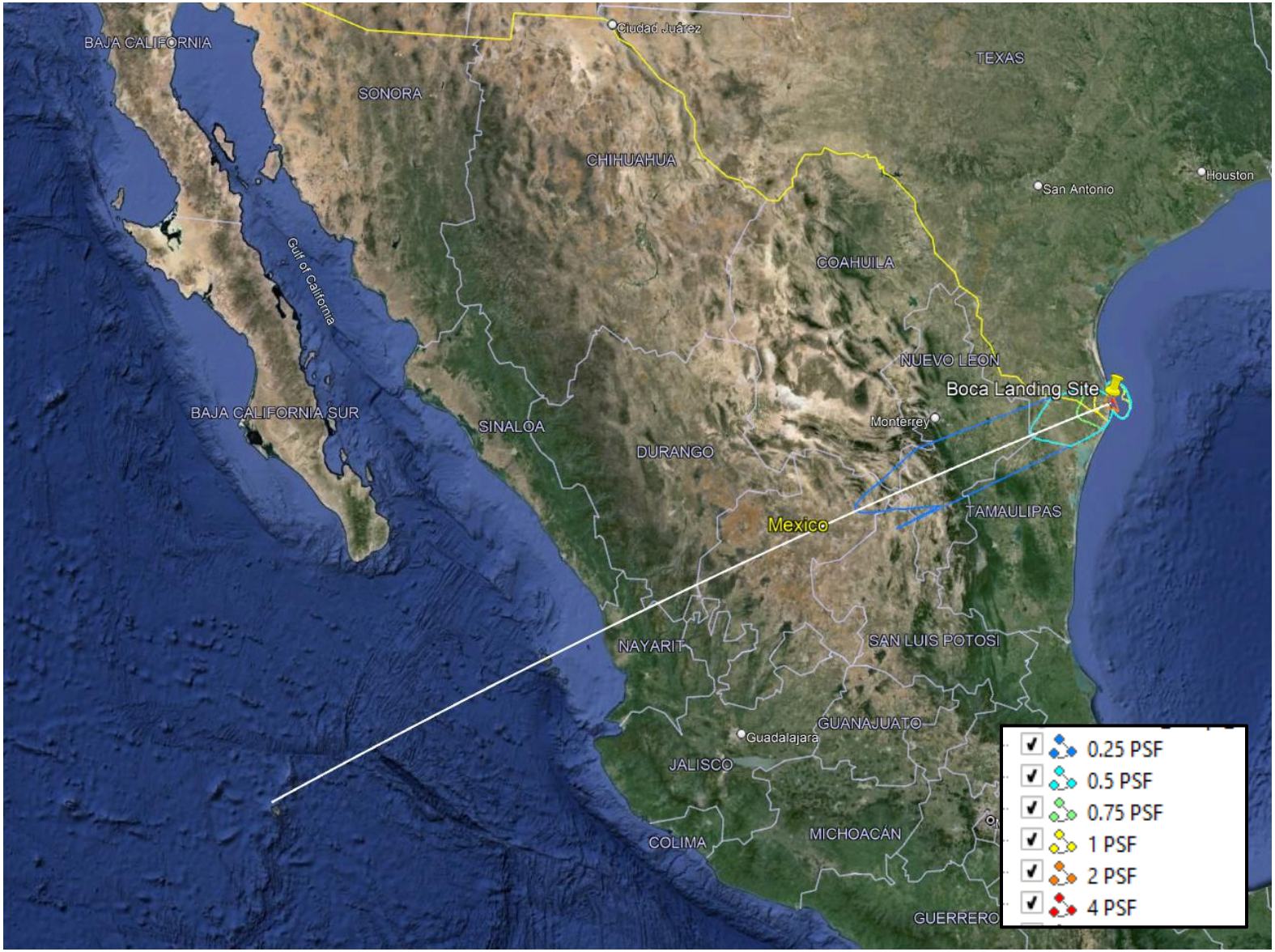

Figure 8: Starship second stage RTLS with 68 degree heading, augmented PCBoom + 1122 Ground Track Prediction

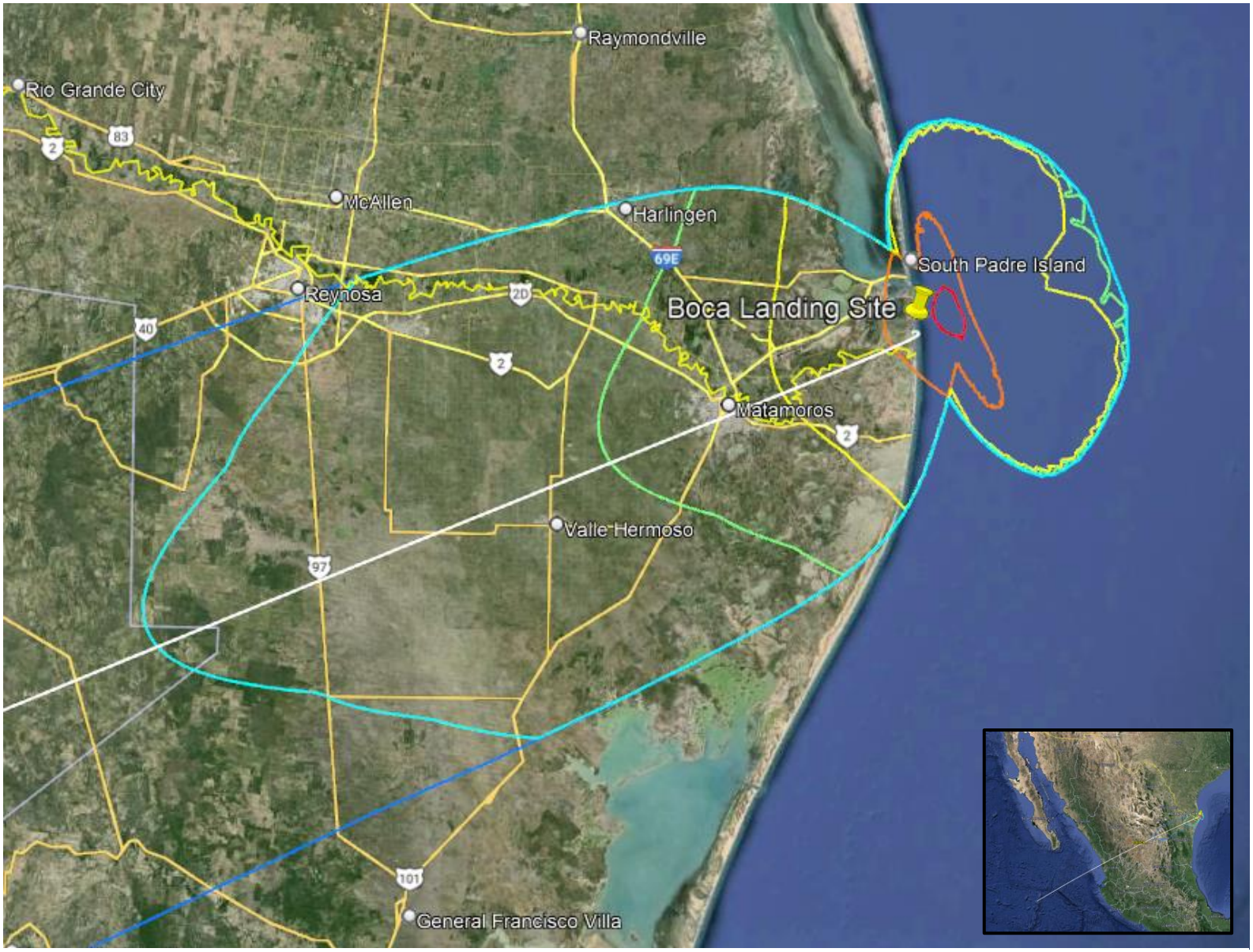

Figure 9: Starship second stage RTLS with 68 degree heading, augmented PCBoom + 1122 Ground Track Prediction (ZOOM)

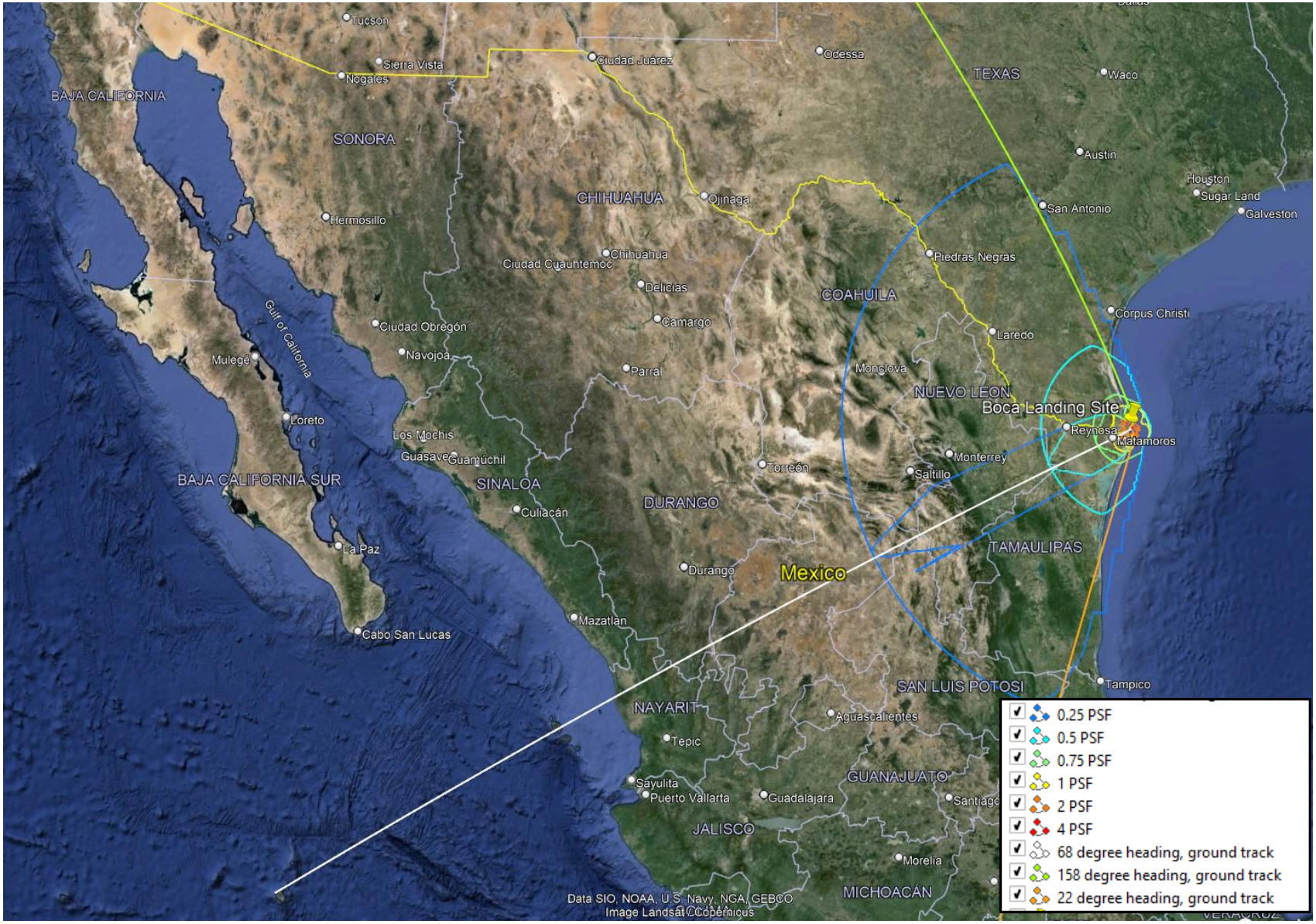

Figure 10: Starship second stage RTLS with swept heading from 22-158 degrees, augmented PCBoom + 1122 Ground Track Prediction

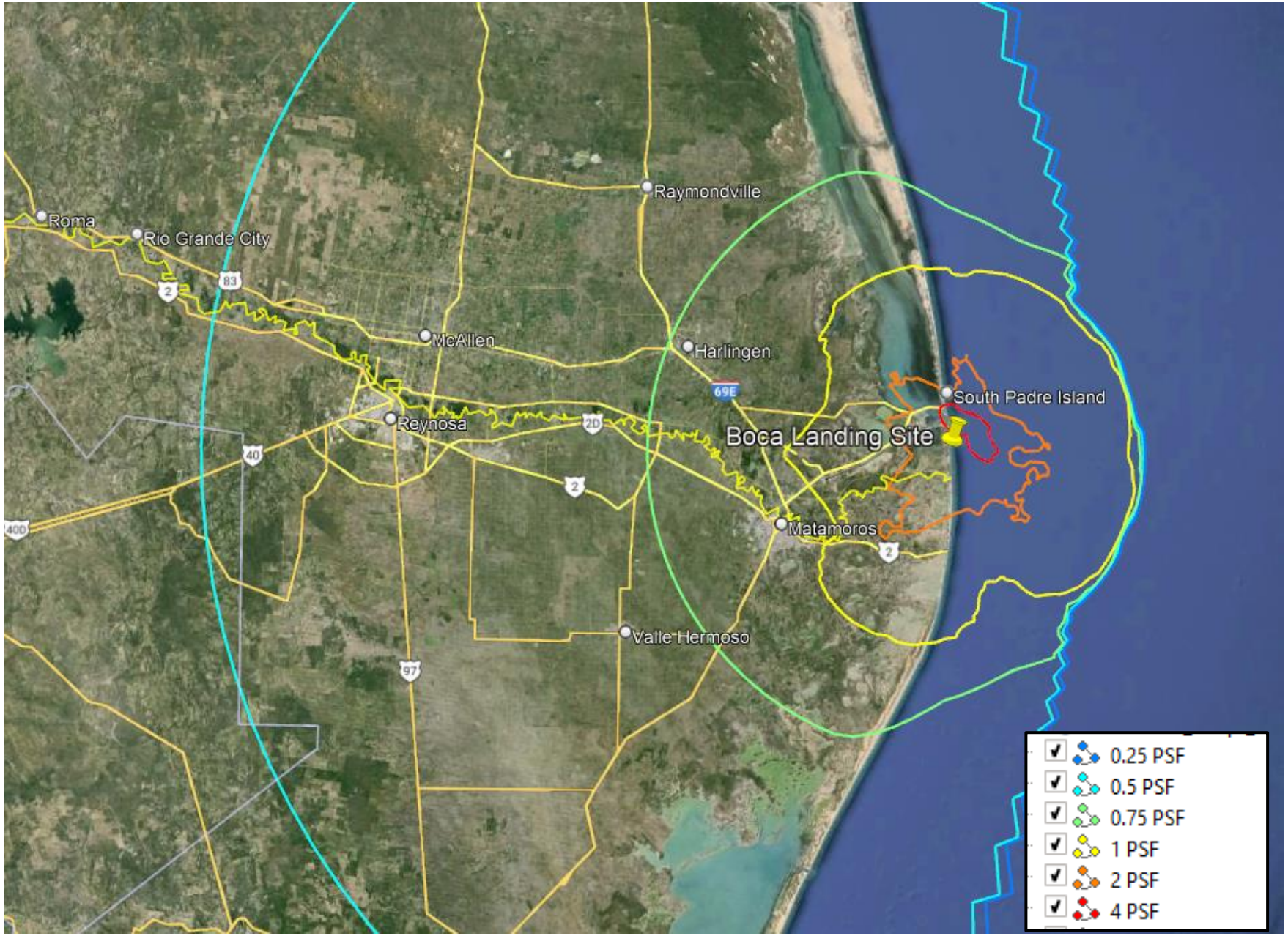

Figure 11: Starship second stage RTLS with swept heading from 22-158 degrees, augmented PCBoom + 1122 Ground Track Prediction (ZOOM)

In addition to presenting and evaluating sonic boom noise contours in terms of psf using PCBOOM, sonic boom noise contours were converted to a C-weighted day-night average noise level (CDNL). Noise exposure from sonic booms that exceeds the significance threshold of C-weighted day-night average noise level (CDNL) 60 dBC for impulsive noise sources (equivalent to DNL 65 dBA) is a significant impact (FAA 2020, FAA 2022). To determine the significance of sonic boom exposure on surrounding communities, the FAA converted psf data to CDNL. The FAA uses CDNL to assess cumulative annoyance from impulsive noise like sonic booms, while using other metrics to evaluate hearing loss and other noise-related health effects (FAA 2024). Given unique characteristics of commercial space operations, the FAA's guidance recommends that other supplemental noise metrics may also be used in conjunction with DNL "to describe and assess noise effects for commercial space operations" (FAA 2024). The FAA does not use these supplemental metrics to make decisions. Rather, the FAA has established a system of noise measurement that comprises a single, core decision-making metric, the A-weighted DNL. Under FAA Order 1050.1F, significant noise impacts would occur if the Proposed Action would increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dBA noise contour, or that will be exposed at or above the DNL 65 dB level due to a DNL 1.5 dB or greater increase in noise exposure, when compared to the No Action alternative for the same timeframe. FAA's NEPA implementing policies and procedures did not exempt commercial space transportation from this threshold. Until the FAA revises its noise policy, all actions including commercial space transportation actions, are subject to this metric and significance threshold.[3]

The CDNL contours were calculated using 50 total booms (24 daytime Super Heavy Booms, 1 nighttime Super Heavy boom, 24 daytime Starship booms, 1 nighttime Starship boom), booster return trajectories included 268, 272 and 345 degree headings, and yearly average wind profile. The CDNL curves presented are bounding for the three trajectories.

[3] The FAA determined that changes in transportation use, public expectations, and technology warrant a review of its civil aviation noise policy. On January 13, 2021, the FAA published in the Federal Register a notice entitled, "*Review of FAA Aircraft Noise Policy and Research Efforts: Request for Input on Research Activities to Inform Aircraft Noise Policy"*,86 FR 2722, which described the FAA's noise research portfolio and a first of its kind nationally scoped survey that updated FAA's understanding of the dose-response relationship between exposure to aircraft noise and community annoyance (Neighborhood Environmental Survey or NES). FAA also requested input on the FAA's research activities that would inform the FAA's noise policy and would inform the future direction of the FAA noise research portfolio. The NES showed that a higher percentage of people were "highly annoyed" by aircraft noise across all levels of noise exposure that were studied. In addition to setting forth the FAA noise policy and research efforts, this Notice described the results of research into the societal benefits and costs of noise mitigation measures. On May 1, 2023, the FAA published in the Federal Register a notice entitled "*Request for Comments on the Federal Aviation Administration's Review of the Civil Aviation Noise Policy, Notice of Public Meeting.*" In this notice, the FAA announced that it intends to consider how changes to the FAA civil aviation noise policy may better inform agency decisions and the types of impacts FAA considers in making decisions (e.g., community annoyance, certain types of adverse health impacts highly correlated with aviation noise exposure). The FAA requested suggestions of potential improvements to how the FAA analyzes, explains, and presents changes in exposure to civil aviation noise. 88 FR 26641. In this notice, the FAA specifically sought public comments on whether it should establish noise thresholds for low-frequency events, such as those associated with the launch and reentry of commercial space transportation vehicles authorized by the FAA Office of Commercial Space Transportation, which metrics should be used to establish these noise thresholds, and the appropriate noise exposure level to define the threshold of significant noise impacts. As part of this policy review, FAA is also examining the body of scientific and economic literature to understand how aviation noise correlates with annoyance as well as environmental, economic, and health impacts. The FAA is also evaluating whether any of these impacts are statistically significant and the metrics that may be best suited to disclose them. Until this policy development process is concluded, the FAA will continue to rely on DNL to make decisions regarding the significance of potential noise impacts.

Figure 12 Cumulative Day-Night Average Sound Levels for the Proposed Action

As Figure 12 shows, noise-sensitive areas are within the 60 dB CDNL contour within the US. Noise sensitive areas within the 60 dB CDNL would experience significant noise impacts under the FAA's current 60 dB CDNL significance threshold.

The FAA and SpaceX continue to review the sonic boom report to evaluate the potential for operational modifications that could result in lower CDNL levels. The FAA and SpaceX are considering available operational and other mitigation measures that may reduce the level of cumulative noise impacts to below 60 dB CDNL, including a reduction in the total number of operations. The FAA will consider all relevant data, public comments, and applicable requirements before reaching a conclusion in the Final EA.

As described in the 2022 PEA, SpaceX will implement their public notification plan to educate the public and announce when a launch or landing event would occur. Announcements of upcoming Starship/Super Heavy launches and landings would serve to warn people about these noise events. The plan would involve issuing statements to news outlets and law enforcement so that when noise is heard, the public would understand what has occurred. Sonic booms from Starship landings could occur days or weeks after the launch mission however, these booms are substantially less noisy than Super Heavy landings.

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