Federal Aviation Administration

Final Supplemental Environmental Assessment for the Blue Origin West Texas Launch Site

February 2014

HQ-14-0001

Supplemental Environmental Assessment for the Blue Origin West Texas Launch Site

AGENCY: Federal Aviation Administration (FAA), lead agency

ABSTRACT: This Supplemental Environmental Assessment (EA) addresses the potential environmental impacts of FAA's Proposed Action of issuing experimental permits and/or launch licenses to Blue Origin for operation of various suborbital reusable launch vehicles at Blue Origin's West Texas launch site. This Supplemental EA evaluates the potential environmental impacts of operation of the launch vehicles, construction of support infrastructure, ground operations (e.g., engine testing), and amateur launches.

Potential environmental impacts of the Proposed Action and No Action Alternative analyzed in detail in this Supplemental EA include impacts on air quality; noise; biological resources (fish, wildlife, and plants); hazardous materials, pollution prevention, and solid waste; and historical, architectural, archaeological, and cultural resources. Potential cumulative impacts of the Proposed Action and No Action Alternative are also addressed in this Supplemental EA.

CONTACT INFORMATION: To request copies of the Supplemental EA, please contact Daniel Czelusniak, Environmental Specialist, Federal Aviation Administration, 800 Independence Ave., SW, Room 325, Washington, DC 20591; email Daniel.Czelusniak@faa.gov; or phone (202) 267-5924.

This Supplemental EA becomes a Federal document when evaluated, signed, and dated by the responsible FAA official.

Issued in Washington, DC on: 2/7/2014

Dr. George C. Nield
Associate Administrator for
Commercial Space Transportation

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Office of Commercial Space Transportation; Finding of No Significant Impact

AGENCY: Federal Aviation Administration (FAA)

ACTION: Finding of No Significant Impact (FONSI)

SUMMARY: The FAA has prepared a Supplemental Environmental Assessment (EA) in accordance with the National Environmental Policy Act of 1969 (NEPA), 42 United States Code (U.S.C.) §§ 4321–4347 (as amended), Council on Environmental Quality NEPA implementing regulations, 40 Code of Federal Regulations (CFR) §§ 1500–1508, and FAA Order 1050.1E, Change 1, *Environmental Impacts: Policies and Procedures*, to evaluate the potential environmental impacts of issuing experimental permits and/or launch licenses to Blue Origin for operation of various suborbital reusable launch vehicles (RLVs) as part of its launch vehicle development program at Blue Origin's West Texas launch site in Culberson County, Texas.

After reviewing and analyzing currently available data and information on existing conditions and the potential impacts of the Proposed Action, the FAA has determined that issuing experimental permits and/or launch licenses to Blue Origin for operation of suborbital RLVs at the West Texas launch site would not significantly impact the quality of the human environment. Therefore, preparation of an Environmental Impact Statement is not required, and the FAA is issuing this FONSI. The FAA made this determination in accordance with all applicable environmental laws. The Supplemental EA is incorporated by reference in this FONSI.

FOR A COPY OF THE SUPPLEMENTAL EA OR FONSI: Visit the following internet address: http://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/review/permits/ or contact Daniel Czelusniak, Environmental Specialist, Federal Aviation Administration, 800 Independence Ave., SW, Suite 325, Washington, DC 20591; e-mail Daniel.Czelusniak@faa.gov; or phone (202) 267-5924.

PURPOSE AND NEED: The purpose of Blue Origin's proposal is to continue its launch operations at the West Texas launch site to include new development vehicles, which would use liquid oxygen and liquid hydrogen propellants. Continuing to operate the West Texas launch site satisfies Blue Origin's need for a private launch site from which to conduct research and development activities, operate business, and transport space flight participants to the edge of space and return them to the same launch area after a short flight.

The purpose of the FAA action of issuing experimental permits and/or launch licenses is to fulfill the FAA's responsibilities under the Commercial Space Launch Act (51 U.S.C. Subtitle V, ch. 509, §§ 50901–50923) for oversight of commercial space launch activities, including issuing experimental permits and/or launch licenses to operate reusable suborbital rockets. The Proposed Action would be consistent with the purposes of the Commercial Space Launch Act. The need for the FAA action of issuing experimental permits and/or launch licenses results from the statutory direction from Congress under the Commercial Space Launch Act to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States and to encourage, facilitate, and promote commercial space launch and reentry activities by the private sector in order to strengthen and expand U.S. space transportation infrastructure. The FAA could receive multiple applications for experimental permits and/or launch licenses from Blue Origin. The FAA must review all applications and determine whether to issue experimental permits and/or launch licenses, as appropriate.

PROPOSED ACTION: Blue Origin proposes to launch and land various suborbital RLVs as part of its launch vehicle development program at Blue Origin's West Texas launch site. Under the Proposed Action, in order to accommodate the launch activities, the FAA would issue experimental permits and/or launch licenses to Blue Origin that would allow Blue Origin to conduct launches of these vehicles from the West Texas launch site. Blue Origin has determined that to support the proposed RLV activities, additional construction would be required. All construction activities related to the Proposed Action would occur within the Blue Origin property line. Therefore, the Proposed Action includes the activities that would be authorized by an experimental permit or launch license (i.e., the operation of the launch vehicles) as well as construction of support infrastructure. Initial flight tests of vehicles would likely be conducted under an experimental permit; however, licensed launches may occur within a five year time period. In addition to permitted/licensed launches and construction, the Proposed Action also includes ground testing activities and amateur launches that would occur at the launch site. Although these activities would not be covered under any experimental permit or launch license issued by the FAA, they are included in this analysis because they are connected to the permitted or licensed RLV launches.

The Proposed Action falls outside the scope of the 2006 EA, because (1) the 2006 EA limited the environmental analysis to the years 2006–2010, and Blue Origin proposes to continue RLV development operations through 2019; (2) the propellants and certain other characteristics of the latest version of the proposed RLVs are different than the previous version; and (3) Blue Origin proposes additional construction activities. The Supplemental EA summarizes the data and environmental analysis presented in the 2006 EA where the data and analysis remain substantially valid. In addition, the Supplemental EA provides new data and analysis where information presented in the 2006 EA is outdated. While the Proposed Action does not appear to constitute a substantial change that is relevant to environmental concerns, the FAA has prepared this Supplement EA because it furthers the purpose of NEPA.

Although an experimental permit authorizes an unlimited number of launches, for purposes of this analysis, the FAA assumed a conservative number of launches for each of the years analyzed (2014–2019; see Exhibit 2-4 in the Supplemental EA). In general, the various sizes and configurations of development and commercial RLVs launched would be similar to the vehicle described in the 2006 EA. Different propulsion modules may be flown with different crew capsules, and there may be flights that would consist only of the propulsion module or only of the crew capsule. The Supplemental EA does not attempt to assess detailed information on each prototype, configuration and/or combination of propulsion module and crew capsule, but rather uses the largest contemplated vehicle configuration as the basis for assessing environmental impact.

ALTERNATIVES CONSIDERED: Alternatives analyzed in the Supplemental EA include the Proposed Action and the No Action Alternative. Under the No Action Alternative, the FAA would not issue experimental permits or launch licenses to Blue Origin for operation of suborbital RLVs at the West Texas launch site. Existing Blue Origin activities that do not require an FAA experimental permit or license could continue at the launch site, including but not limited to amateur rocketry operations, ground tests, and construction.

ENVIRONMENTAL IMPACTS: Based on the Supplemental EA, no significant environmental impacts, as defined in FAA Order 1050.1E would be expected to result from the Proposed Action. Please refer to Chapter 4, Environmental Consequences, of the Supplemental EA for a full discussion of potential environmental impacts.

DETERMINATION: An analysis of the Proposed Action has concluded that there would be no significant short-term, long-term, or cumulative effects to the environment or surrounding populations. Therefore, an Environmental Impact Statement for the Proposed Action is not required. After careful and thorough consideration of the facts contained herein, the undersigned finds that the proposed Federal action is consistent with existing national environmental policies and objectives as set forth in Section 101 of NEPA and other applicable environmental requirements and will not significantly affect the quality of the human environment or otherwise include any condition requiring consultation pursuant to Section 102(2)(c) of NEPA.

Issued in Washington, DC on: 2/7/2014

Dr. George C. Nield
Associate Administrator for
Commercial Space Transportation

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LIST OF EXHIBITS

Exhibit

ACRONYMS AND ABBREVIATIONS

CC	crew capsule
CDNL	C-weighted day-night average sound level
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
dB	decibel
dBA	A-weighted sound level
dBC	C-weighted sound level
DNL	day-night average sound level
EA	Environmental Assessment
FAA	Federal Aviation Administration
FONSI	Finding of No Significant Impact
GMI	GeoMarine, Inc.
H_2	hydrogen
H_2O	water
H_2O_2	hydrogen peroxide
HCl	hydrogen chloride
HTP	high-test peroxide
HTPB	hydroxyl-terminated polybutadiene
LH2	Liquid hydrogen
LOx	liquid oxygen
N_2	nitrogen
NAAQS	National Ambient Air Quality Standard
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NO_x	nitrogen oxide
NO_2	nitrogen dioxide
NRHP	National Register of Historic Places
O_3	ozone

OSHA	Occupational Safety and Health Administration
Pb	lead
PM	propulsion module
$PM_{2.5}$	particulate matter 2.5 microns or less in diameter
PM_{10}	particulate matter 10 microns or less in diameter
psf	pounds per square foot
RLV	reusable launch vehicle
RP	rocket propellant
SHPO	State Historic Preservation Officer
SO_x	sulfur oxide
SO_2	sulfur dioxide
TPWD	Texas Parks and Wildlife Department
U.S.	United States
U.S.C.	United States Code
VOC	volatile organic compound

1. INTRODUCTION

Blue Origin proposes to launch and land various suborbital reusable launch vehicles (RLVs) as part of its launch vehicle development program at Blue Origin's West Texas launch site in Culberson County, Texas. The RLVs that are the subject of this Supplemental Environmental Assessment (EA) are described in Section 2.1.1. Blue Origin also plans to continue to construct support infrastructure, conduct ground operations (e.g., engine testing), and conduct amateur launches[1] at the launch site. In order to launch a non-amateur RLV, Blue Origin must obtain an experimental permit and/or launch license from the Federal Aviation Administration (FAA). Under the Proposed Action addressed in this Supplemental EA, the FAA would issue experimental permits and/or launch licenses to Blue Origin that would allow Blue Origin to conduct launches of suborbital RLVs from the West Texas launch site (see Section 2.1 for a more detailed description of the FAA's Proposed Action).

The Proposed Action is subject to environmental review under the National Environmental Policy Act of 1969, as amended (NEPA; 42 United States Code [U.S.C.] 4321, et seq.). The FAA prepared this Supplemental EA in accordance with NEPA, Council on Environmental Quality (CEQ) NEPA implementing regulations (40 Code of Federal Regulations [CFR] parts 1500 to 1508), and FAA Order 1050.1E, *Environmental Impacts: Policies and Procedures, Change 1*, to evaluate the potential environmental impacts of activities associated with the FAA's Proposed Action of issuing experimental permits and/or launch licenses to operate RLVs at the Blue Origin West Texas launch site as well as related proposed construction, ground operations, and amateur launch activities.

According to FAA regulations, an applicant must provide enough information for the FAA to analyze the potential environmental impacts associated with the operation of commercial launch vehicles. The information provided by an applicant must be sufficient to enable the FAA to comply with the requirements of NEPA. This Supplemental EA is intended to fulfill NEPA requirements for analyzing the potential environmental impacts of the Proposed Action. The successful completion of the environmental review process does not guarantee that the FAA would issue experimental permits and/or launch licenses to Blue Origin. The project also must meet all FAA safety, risk, and financial responsibility requirements per 14 CFR part 400. Additional environmental analyses would be required for future proposed activities not addressed in this Supplemental EA.

1.1 Background

The FAA previously analyzed the potential environmental impacts of issuing one or more experimental permits and/or launch licenses to Blue Origin to operate suborbital RLVs in the August 2006 *Final Environmental Assessment for the Blue Origin West Texas Commercial Launch Site* (2006 EA) (FAA 2006). The 2006 EA, which is hereby incorporated by reference, evaluated the potential environmental impacts of construction and operation of a commercial launch site on privately-owned property in Culberson County, Texas. The 2006 EA assessed 52 annual launches of earlier RLV versions on suborbital, ballistic trajectories to altitudes in excess

[1] *Amateur rocket* means an unmanned rocket that: (1) Is propelled by a motor or motors having a combined total impulse of 889,600 Newton-seconds (200,000 pound-seconds) or less; and (2) Cannot reach an altitude greater than 150 kilometers (93.2 statute miles) above the earth's surface. 14 CFR part 1.

of 325,000 feet over a five-year period, from 2006 to 2010. The RLVs that were the subject of the 2006 EA are described in Exhibit 2-3. The FAA determined that issuing experimental permits and/or launch licenses, including construction and operation of the private commercial launch site, would not significantly affect the quality of the human environment pursuant to Section 102(2)(c) of NEPA and issued a Finding of No Significant Impact (FONSI) on August 29, 2006.

Since the FAA published the 2006 EA and FONSI, Blue Origin has completed some of the construction activities proposed in the 2006 EA (see Section 2.1.5) and has conducted fewer than ten launches at the West Texas launch site. These launches were within the scope of activities addressed in the 2006 EA. The current Proposed Action falls outside the scope of the 2006 EA, because (1) the 2006 EA limited the environmental analysis to the years 2006–2010 and Blue Origin now proposes to continue RLV development operations through 2019 (see Section 2.1.3); (2) the propellants and certain other characteristics of the proposed RLVs are different than the previous versions (see Section 2.1.1); and (3) Blue Origin proposes additional construction activities (see Section 2.1.5). While the Proposed Action does not appear to constitute a substantial change that is relevant to environmental concerns, the FAA is preparing this Supplemental EA because it furthers the purpose of NEPA. In order to focus this Supplemental EA on impacts specific to FAA's current Proposed Action, where the 2006 EA provides information and analyses that are still current and valid, the discussion in the 2006 EA is summarized and incorporated by reference. Where information and analyses are outdated or not included in the 2006 EA, a detailed discussion is included in this Supplemental EA. An electronic copy of the 2006 EA can be downloaded from the FAA website at: http://www.faa.gov/about/office_org/headquarters_offices/ast/environmental/review/permits/.

1.2 Purpose and Need for Action

As stated in the 2006 EA, the purpose of Blue Origin's proposal in 2006 was to construct and operate a launch site on private property in Texas and to provide Blue Origin with an alternative to launching suborbital RLVs from a Federal or other FAA-licensed launch facility. The purpose of Blue Origin's current proposal is to continue its launch operations at the West Texas launch site to include new development vehicles (see Section 2.1.1) which would use liquid oxygen (LOx) and liquid hydrogen (LH2) propellants. Continuing to operate the West Texas launch site satisfies Blue Origin's need for a private launch site from which to conduct research and development activities, operate business, and transport space flight participants to the edge of space and return them to the same launch area after a short flight.

The purpose of the FAA action of issuing experimental permits and/or launch licenses is to fulfill the FAA's responsibilities under the Commercial Space Launch Act (51 U.S.C. Subtitle V, ch. 509, §§ 50901-50923) for oversight of commercial space launch activities, including issuing experimental permits and/or launch licenses to operate reusable suborbital rockets. The activities proposed in the 2006 EA, as well as the current Proposed Action, would be consistent with the purposes of the Commercial Space Launch Act. The need for the FAA action of issuing experimental permits and/or launch licenses results from the statutory direction from Congress under the Commercial Space Launch Act to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States and to encourage, facilitate, and promote commercial space launch and reentry activities by the private sector in order to strengthen and expand U.S. space transportation infrastructure. The FAA could receive multiple applications for experimental permits and/or launch licenses from Blue Origin. The FAA must review all applications and determine whether to issue experimental permits and/or launch licenses, as appropriate.

1.3 Public Involvement

The 2006 EA (Section 1.4 and Appendix A) discussed public involvement activities associated with the project as proposed in 2006 and a summary is provided here.

At the beginning of the project, Blue Origin hosted two public information meetings, one on June 14, 2005, in Van Horn, Texas, and another on June 15, 2005, in Dell City, Texas. Each of these public meetings was preceded by announcements (in English and Spanish) in local newspapers (i.e., the Van Horn Advocate, Hudspeth County Herald and Dell Valley Review, and Midland Reporter-Telegram). More than 100 members of the public attended the information meetings, and Spanish translators were present at each meeting.

During the public comment period on the 2006 Draft EA, the FAA hosted a public hearing on July 25, 2006, at the Van Horn Convention Center in Van Horn, Texas. Like the Blue Origin public information meetings, the FAA's public hearing was preceded by announcements in the Van Horn Advocate, Hudspeth County Herald and Dell Valley Review, and Midland Reporter-Telegram. More than 40 members of the public attended the hearing.

In accordance with FAA Order 1050.1E Paragraph 406e, the FAA has determined that there are no circumstances associated with this Proposed Action that require a public review and comment period or public meetings. Therefore, the FAA will not hold public meetings or initiate a public comment period for this Supplemental EA.

2. DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action

Blue Origin proposes to launch and land various suborbital RLVs as part of its launch vehicle development program at Blue Origin's West Texas launch site and continue to construct support infrastructure, conduct ground operations (e.g., engine testing), and conduct amateur launches at the launch site. Under the Proposed Action (preferred alternative) addressed in this EA, in order to accommodate the launch activities, the FAA would issue experimental permits and/or launch licenses to Blue Origin that would allow Blue Origin to conduct launches of these vehicles from the West Texas launch site. The launch vehicles are described in Section 2.1.1, and the proposed operations are described in Sections 2.1.2, 2.1.3, and 2.1.4. Additional construction that may be required to support the Proposed Action is described in Section 2.1.5. Initial flight tests of vehicles would likely be conducted under an experimental permit; however, licensed launches may occur within a five year time period. In addition to launch activity and construction, Blue Origin may conduct ground testing activities at the West Texas launch site as described in Section 2.1.6 and conduct amateur launches as described in Section 2.1.7.

As described in Section 1.1, the current Proposed Action falls outside the scope of the 2006 EA, because (1) the 2006 EA limited the environmental analysis to the years 2006–2010 and Blue Origin proposes to continue RLV development operations through 2019 (see Section 2.1.3); (2) the propellants and certain other characteristics of the latest version of the proposed RLVs are different than the previous version (see Section 2.1.1); and (3) Blue Origin proposes additional construction activities (see Section 2.1.5).

2.1.1 RLV Launches

Blue Origin is engaged in a long-term RLV development program, and contemplates launching vehicles of various sizes and configurations. Vehicles may include experimental configurations, prototypes, and commercial launches. The specific size and configuration is expected to change as flight test results are received. In general, the various sizes and configurations of development and commercial RLVs launched would be similar to the vehicle described in the 2006 EA. For example, the RLV would consist of a propulsion module (PM) and a crew capsule (CC) (see Exhibit 2-1). Different propulsion modules may be flown with different crew capsules, and there may be flights that would consist only of the propulsion module or only of the CC. This Supplemental EA does not attempt to assess detailed information on each prototype, configuration and/or combination of PM and CC, but rather uses the largest contemplated vehicle configuration as the basis for assessing environmental impact.

Propulsion modules are expected to stand between 45 and 75 feet high and weigh between 20,000 and 30,000 pounds, carrying between 30,000 and 45,000 pounds of LOx and between 7,000 and 15,000 pounds of LH2. A propulsion module would use one or more engines that would produce a total thrust of up to approximately 300,000 pounds-force.

CCs are expected to stand between 8 and 20 feet high and would weigh between 8,000 and 12,000 pounds (see Exhibit 2-2). A CC would carry between 600 and 650 pounds of hydroxyl-terminated polybutadiene (HTPB), a solid propellant. A CC would use one or more solid rocket motors that would produce a total thrust of up to approximately 120,000 pounds-force.

Exhibit 2-3 presents the primary differences between the RLVs assessed in the 2006 EA and the RLVs analyzed in this EA.

Exhibit 2-1. A Blue Origin RLV

Source: Blue Origin 2013a

Exhibit 2-2. Blue Origin Crew Capsule Descending Using Parachutes

Source: Blue Origin 2013b

Exhibit 2-3. Differences between the RLV Assessed in the 2006 EA and RLV Assessed in this Supplemental EA

RLV Assessed in 2006 EA		RLV Assessed in this Supplemental EA	
Maximum Height:	50 feet	Maximum Height:	95 feet
Propellants:	HTP and RP (PM) HTPB (CC)	Propellants:	LOx and LH2 (PM) HTPB (CC)
Maximum Thrust:	230,000 pound-force[a] (PM) 120,000 pound-force (CC)	Maximum Thrust:	300,000 pound-force (PM) 120,000 pound-force (CC)

[a] An RLV generated a maximum thrust of 135,000 pound-force when launched in 2011. This was less than what was analyzed in the 2006 EA. The 2006 EA analyzed launches with a maximum thrust of 435,000 pound-force, using the Taurus launch vehicle's Castor-120 motors as a surrogate, and the EA also noted that Blue Origin's launch vehicles were expected to have a thrust capability of approximately 230,000 pound-force.
Notes: CC = crew capsule; HTP = high-test peroxide; HTPB = hydroxyl-terminated polybutadiene; LH2 = liquid hydrogen; LOx = liquid oxygen; PM = propulsion module; RP = rocket propellant

2.1.2 Pre-Launch Operations

The pre-launch operations of the proposed RLVs are similar to what was described in the 2006 EA, and the information is summarized here. Blue Origin would ship the propulsion module and CC to the West Texas launch site. The propulsion module and CC would originate at Blue Origin's manufacturing and assembly facilities in the state of Washington and would travel via ground to West Texas. They may be fully assembled or partially disassembled during transportation.

Upon arrival at the launch site, Blue Origin would unpack the propulsion module and CC, perform any required reassembly, and conduct an integrated test and checkout of subsystems. The vehicle would then be transported to the launch complex, positioned on the test pad, and readied for launch.

Blue Origin would confirm air space availability with the FAA Air Traffic Control (ATC). Specific procedures for airspace coordination will be prepared as part of the safety analysis for Blue Origin's license and/or permit application.

Prior to each launch, Blue Origin may launch weather balloons filled with hydrogen or helium for assessing wind speed and other weather conditions. Nominally, Blue Origin would release one balloon per launch, but in shifting meteorological conditions may release up to 10 balloons per launch. Each balloon would carry a radiosonde, an expendable instrument package suspended from the balloon. Upon release, each balloon would measure approximately 6 feet wide and expand in diameter as it rises in the atmosphere. As the radiosonde rises (at about 1,000 feet per minute), sensors on it measure position and atmospheric profiles such as pressure, temperature, and relative humidity. These sensors are linked to a battery powered radio transmitter that sends the sensor measurements to a ground receiver.

2.1.3 Launch Operations

The launch operations of the RLVs are similar to what was described in the 2006 EA, and the information is summarized here. RLV launch, flight, and landing activities would require less than an approximately 10 to 15 minute period to complete. The specific trajectory, thrust and duration is expected to vary from one flight to another, due to different atmospheric conditions and different flight objectives. In a flight to its highest altitude, the propulsion module would continue under thrust from its engine(s) until reaching approximately 200,000 feet; the duration of this propulsive flight phase would be approximately three minutes or less. The vehicle would then coast up to an apogee of approximately 350,000 feet. The propulsion module would then descend under gravity until the engine(s) is/are restarted to enable a powered landing on the Landing Pad; however, the vehicle would also be designed to land within a 4-mile radius of the Landing Pad. The vehicle's nominal ground track would remain within the boundary of private land controlled by Blue Origin and its affiliates during the entire flight.

The propulsion module may be flown either with or without the CC attached at liftoff. If the CC is attached at liftoff, the CC would land in one of two ways:

1. The CC may separate from the propulsion module during flight. During a nominal flight, this separation would be done using a combination of springs and possibly a low-impulse reaction control system (e.g., not using the solid rocket motor). In an off-nominal flight, the solid rocket motor on the CC may fire to more-quickly separate the CC from the propulsion module. In either scenario, the CC would land using parachutes within a 4-mile radius of the Landing Pad (North Pad).
2. Alternatively, the CC may remain attached to the propulsion module throughout flight, including during the PM's landing operations.

Although an experimental permit authorizes an unlimited number of launches, for purposes of this analysis, the FAA has assumed the following number of launches would occur as part of the Proposed Action (see Exhibit 2-4).

Exhibit 2-4. Assumed Maximum Number of Annual Launches Under the Proposed Action[a]

Year	Propulsion Module	Propulsion Module + CC	Total
2014	4	12	16
2015	2	32	34
2016	2	32	34
2017	2	52	54
2018	2	52	54
2019	2	52	54
Total	**14**	**232**	**246**

[a] This table provides maximum launch estimates for proposed launches that could require a license or permit from the FAA. Amateur operations are covered in Section 2.1.7.

Launches may occur during the day or night. Although the launch schedule has not yet been developed, night launches would likely occur infrequently and would comprise only a small fraction of the total number of RLV launches. For purposes of this analysis, the FAA has assumed that night launches would not occur more frequently than once per month. Launches would not result in the closure of any public roads, including Highway 54.

2.1.4 Post Launch/Recovery Operations

The post-launch and recovery operations of the planned RLVs are similar to what was described in the 2006 EA, and the information is summarized here. Recovery operations would include safing the vehicle propulsion system and CC, following the vehicle landing, extracting the crew (if any), venting residual LH2 and LOx, and transporting the propulsion module and CC (if applicable) back to the Vehicle Processing Facility for processing.

2.1.5 Construction

The FAA has the authority to issue experimental permits and licenses, and therefore launch activities are analyzed as part of the Proposed Action in this Supplemental EA. In addition to analyzing launch operations and in accordance with the requirements of NEPA, this Supplemental EA includes environmental assessment of all activities that are connected to the action. Therefore, construction activities proposed by Blue Origin are included as part of the Proposed Action for this Supplemental EA, because the facilities would support the proposed licensed and permitted launch activities at the West Texas launch site. Exhibit 2-5 provides a description of construction activities that are included as part of this Proposed Action. The location of existing and proposed infrastructure at the West Texas launch site are shown in Exhibit 2-6.

All construction activities related to the Proposed Action would occur within the Blue Origin property line. The timeframe of the construction activities could begin as early as 2013, and may extend through 2019 like the proposed launch operations. It is possible that the construction could extend beyond 2019; if the construction is connected to an FAA action that requires environmental review, it will be reevaluated at that time.

Exhibit 2-5. Proposed Action Construction Activities at the Blue Origin West Texas Launch Site

Facility or Infrastructure	Proposed Action Construction Details
Vehicle Processing Facility	Construction of the facilities described in Section 2.1.4.1 of the 2006 EA is largely completed. This Proposed Action includes possible future construction of an additional 20,000 square feet at the Vehicle Processing Facility.
Administrative Support Center	Construction of a temporary building was completed to support launch operations. This Proposed Action includes construction of a permanent structure in the same location as described in Section 2.1.4.1 of the 2006 EA.
Bulk Storage Facility (referred to as Vehicle Garage in 2006 EA)	Construction of the facilities described in Section 2.1.4.1 of the 2006 EA is completed. This Proposed Action includes possible construction of a future building addition.
Explosives Storage Area	Blue Origin completed construction of a smaller explosive storage facility than what was described in Section 2.1.4.1 of the 2006 EA. This smaller explosive storage area is located in the Home Base area. Depending on the outcome of future flight testing, Blue Origin may in the future construct a larger Explosive Storage Area of a size and at the location originally analyzed in the 2006 EA.
Test Pad (South Pad or Launch Pad)	Construction of the facilities described in Section 2.1.4.1 of the 2006 EA is completed and the area around the pad was cleared of vegetation. This Proposed Action includes construction of a road around the South pad, forming an initial ring with a radius of approximately 340 feet. The road would be constructed initially of dirt and gravel, but may be paved in the future. This initial ring road encompasses approximately 8.4 acres (approximately 5.4 acres beyond the 32,292 square foot pad and 2.2-acre fire break analyzed in the 2006 EA). (See description below of "Additional Roads"). Construction of a larger fire break encompassing an additional 13 acres may be necessary in the future.
Landing Pad (North Pad)	Construction of an approximate 13,274 square foot (130 foot diameter) concrete pad is completed. This Proposed Action includes construction of a fire break with an area approximately 500 feet in diameter, encompassing approximately 4 acres (in addition to the 32,292

Exhibit 2-5. Proposed Action Construction Activities at the Blue Origin West Texas Launch Site

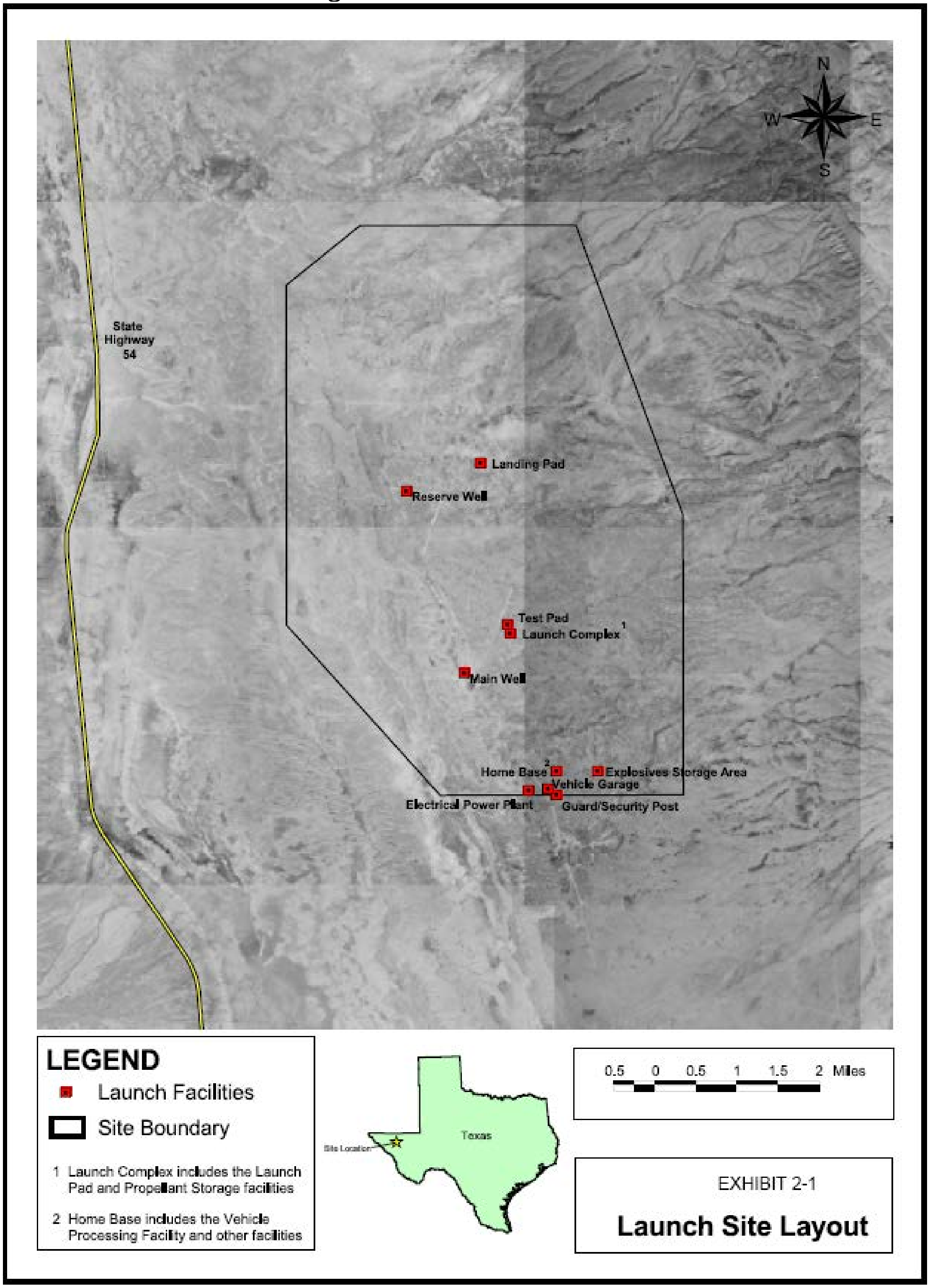
	square feet analyzed in the 2006 EA). This Proposed Action also considers construction of a larger pad up to approximately 32,292 square feet at the same location as described in Section 2.1.4.1 of the 2006 EA. Construction of a larger fire break encompassing an additional 13 acres may be necessary in the future.
Guard Security Post	A modular building was installed in the location where a permanent guard post was planned in the 2006 EA. This Proposed Action includes possible future construction of a permanent guard post near this site.
Access Roads	Dirt access roads were constructed using a dust inhibitor in locations described in Section 2.1.4.1 of the 2006 EA. This Proposed Action includes paving these roads as described in the 2006 EA.
Additional roads	A cultural survey has been completed and reviewed and approved by the Texas State Historic Preservation Officer for an area proposed for construction of a ring road around the Launch Pad (South pad). This initial road would be approximately 300 feet from the Launch Pad and approximately 40 feet wide. This initial ring road may be paved, and/or an additional road placed further from the Pad. Roads surrounding the Launch Pad could cover an area up to 400,000 square feet.
Propellant feed systems	LOx, LH2, and pressurant feed systems would be constructed near the Test Pad (inside the initial ring road) connecting the storage areas described below to the vehicle on the launch stand.
LOx and LH2 propellant storage areas	Construction would occur within the initial ring road around the Launch Pad (South Pad). The LOx above-ground storage tanks would have a total capacity of at least 50,000 gallons, or 473,077 pounds-mass. The oxidizer area would include an area for controlled dumping of LOx. The initial construction would include one 13,000 gallon storage tank. The LH2 above-ground storage tanks would have a total capacity of 150,000 gallons or 84,000 pounds-mass. The initial construction would include two 25,000 gallon storage tanks. LH2 would be vented using vents and/or a burn stack. The LOx and LH2 propellant storage areas would be installed near the Launch Pad, but would include concrete blast-protection walls, and would accommodate a hydraulic power unit and the storage of pressurant gasses at high pressure such as nitrogen and helium, to support the RLV propulsion system and preflight operations. Construction of a steel tower is also anticipated to support vent flare burners (burn stack). Initial tower height would be approximately 101 feet.
Lightning towers	This Proposed Action includes the construction of towers to attract lightning away from a launch vehicle. Towers would be up to approximately 130 feet.
Access Tower	A tower for personnel to access and egress the stacked RLV at the launch stand would be constructed along with a nearby blast wall for emergency egress. This tower may include stairs and/or an elevator. The tower would be approximately the same height as the stacked launch vehicle.
Mobile crane, flatbed trailer, transporter truck	RLVs would initially be transported to the pad horizontally using a flat-bed trailer, transporter-erector with strongback, and/or crane to lift and move the vehicle. Depending on vehicle location and conditions upon landing, some vegetation may be cleared to provide access to a vehicle for recovery and transport.
Communications & Tracking	S Band, UHF, and other transponders for uplink and downlink telemetry antennas would be located away from the launch stand. Placement may vary, but would be several miles away.

Exhibit 2-5. Proposed Action Construction Activities at the Blue Origin West Texas Launch Site

	Low-power, point-to-point microwave links would be added for intra-site data communication, as well as a voice system for secondary communications. Mobile ground stations (on movable trailers) and a storage shed would be developed. In addition, up to three further ground stations could be added, perhaps in fixed mounts, within a 30-mile radius of the North Pad.

Source: Blue Origin 2013c

Exhibit 2-6. Map Showing Location of Existing and Proposed Infrastructure at the Blue Origin West Texas Launch Site



Source: FAA 2006

2.1.6 Proposed Ground Operations

Ground testing activities that could occur at the site are detailed in Exhibit 2-7. Although these activities would not be covered under any experimental permits or launch licenses issued by the FAA, they are included in this analysis because they are connected to the permitted or licensed RLV launches. Additionally, ground operations contribute to the baseline or existing conditions (e.g., noise levels) at the launch site.

Exhibit 2-7. Possible Ground Testing Activities at the Blue Origin West Texas Launch Site

Activity	Description	Frequency of Activity
Integrated ground tests of space vehicles and their components	Ground testing (also referred to as static testing) of vehicles, such as hot fire testing of propulsion systems.	Test campaigns are expected at approximately 3 to 9 month intervals. Each campaign may involve one or several hot fire tests.
Vehicle drop testing	Dropping or lowering test articles and vehicles on a cable from a tower to the ground or some other surface, such as to test impact attenuation.	Unknown.
Pressure vessel testing	Ground testing of ground support equipment and flight tanks and other pressure vessels, such as proof-pressure testing, over pressurization testing, materials-compatibility testing, valve testing, and other ground testing. Pressurization testing will use some pressurant, such as water, nitrogen, helium or oxygen.	Unknown.
Engine testing	Ground testing (also referred to as static testing) of rocket engines using LOx, LH2 and hydrocarbon propellants.	Several tests may occur each week.
Electronics systems testing	Ground testing of electronic systems for ground support equipment and vehicles.	Unknown.

Source: Blue Origin 2013c

2.1.7 Amateur Launch Activities

Amateur launch activities that could occur at the site are detailed in Exhibit 2-8. Although these activities would not be covered under any experimental permits or launch licenses issued by the FAA, they are included in this analysis because they are connected to the permitted or licensed launches of the RLVs. Additionally, amateur launch activities contribute to the baseline or existing conditions (e.g., noise levels and air emissions) at the launch site. FAA will consider the impacts on the environment that result from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. Blue Origin may launch two types of amateur class sounding rockets at the West Texas launch site, in addition to the LOx/LH2 RLVs described in Section 2.1.1.

The amateur launch vehicles would be expected to stand approximately 16 feet high with a one foot diameter. These vehicles would reach altitudes between 10,000 and 100,000 feet and would be launched between one and five times per year between 2014 and 2019. One version of the amateur launch vehicle would use liquid 90% hydrogen peroxide (H_2O_2) as a monopropellant and another version would use a solid rocket motor.

In addition, test flights of the CC being flown alone would fall under the category of amateur launches. These launches would involve firing the CC's solid rocket motor at or near ground level, then the CC would land using parachutes within a 4-mile radius of the pad.

Exhibit 2-8. Assumed Maximum Number of Annual Amateur Launches[a]

Year	H_2O_2 Amateur Launch Vehicle	Solid Rocket Motor Amateur Launch Vehicle	CC Alone	Total
2014	2	1	2	5
2015	3	2	2	7
2016	3	2	2	7
2017	3	2	2	7
2018	3	2	2	7
2019	3	2	2	7
Total	**17**	**11**	**12**	**40**

[a] This table provides launch estimates for amateur launches at the West Texas launch site.

2.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue experimental permits or launch licenses to Blue Origin for operation of suborbital RLVs at the West Texas launch site. Existing Blue Origin activities that do not require an FAA experimental permit or license could continue at the launch site, including but not limited to amateur rocketry operations, ground tests, and construction.

NEPA requires agencies to consider a "no action" alternative and to compare the effects of not taking action with the effects of the action alternative(s). Thus, the No Action Alternative serves as a baseline to compare the impacts of the Proposed Action. The No Action Alternative would not satisfy the purpose and need for the Proposed Action as stated above in Section 1.2.

2.3 Scope of the EA

Because the 2006 EA is incorporated by reference, the scope of this Supplemental EA focuses on those environmental impact categories that might be affected by the Proposed Action or No Action Alternative, or that may have experienced changes from what was described in the 2006 EA. As a result, the following environmental impact categories are analyzed in detail:

- Air Quality
- Noise
- Construction Impacts
- Fish, Wildlife, and Plants
- Hazardous Materials, Pollution Prevention, and Solid Waste
- Historical, Architectural, Archaeological, and Cultural Resources

Although "Construction Impacts" are considered a unique impact category in FAA Order 1050.1E, this Supplemental EA incorporates potential construction impacts within the discussion of potential impacts for the other impact categories.

The following environmental impact categories are not analyzed in further detail in this Supplemental EA, for the reasons explained below.

Farmlands – No farmlands or agricultural use lands are located at the West Texas launch site. Therefore, no prime farmland, unique farmland, farmland of state importance, or general farmland would be converted to a nonagricultural use under the Proposed Action or No Action Alternative. No conflicts with existing agricultural uses would occur under the Proposed Action or No Action Alternative.

Compatible Land Use and Department of Transportation Section 4(f) Properties – The Blue Origin launch site in West Texas has been operating as a site for launching vehicles since 2006. Continuing to use the site to launch RLVs does not represent a substantial change in the use of the land from the current use or from the use analyzed in the 2006 EA. There are no potential 4(f) properties near the West Texas launch site. The closest 4(f) properties, Guadalupe Mountains National Park (Texas) and Carlsbad Caverns National Park (New Mexico), are located 22 and 37 miles, respectively, north of the West Texas launch site and would not be affected by the Proposed Action or No Action Alternative.

Light Emissions and Visual Resources – The launch of RLVs from Blue Origin's West Texas launch site and construction of facilities would produce light and visual effects that are the same as those analyzed in the 2006 EA. Therefore, that analysis is incorporated by reference and this resource will not be discussed in this EA. The Proposed Action would result in minor visual impacts from construction of new structures that would be visible from State Highway 54. Similarly, proposed operations would result in minor light and visual impacts. The impacts would be minor because the highway is approximately five miles away from the launch site; thus, motorists traveling on the highway may not notice structures or activities. Also, nighttime launches would be infrequent (a small percentage of total launches). Impacts under the No Action Alternative would be similar, but would not involve permitted or licensed launches. Therefore, the Proposed Action or No Action Alternative would not result in a significant impact related to light emissions or visual resources.

Natural Resources, Energy Supply, and Sustainable Design – The Proposed Action and No Action Alternative would not result in notable consumption of natural resources or notable changes in local energy demands. Neither alternative would require the use of unusual materials nor materials in short supply.

Secondary (Induced) Impacts – The Proposed Action and No Action Alternative would not involve the potential for induced or secondary impacts to surrounding communities, such as shifts in population movement and growth, public service demands, and economic activity. The environmental impact categories analyzed would incur negligible impacts; therefore, the potential for secondary (induced) impacts would also be expected to be negligible.

Socioeconomics, Environmental Justice, and Children's Environmental Health and Safety - The Proposed Action and No Action Alternative would not require a substantial change in the number of temporary or permanent workers at the launch site beyond what was analyzed in the 2006 EA, and therefore would have no additional impact on socioeconomic conditions.

No group would experience disproportionately high or adverse impacts under the Proposed Action or No Action Alternative, and therefore environmental justice will not be discussed in detail in this EA.

The Proposed Action and No Action Alternative would not have a disproportionate effect on children's environmental health or safety, and therefore this impact category will not be discussed in detail in this EA.

Coastal Resources, Floodplains, Water Quality, Wetlands, and Wild and Scenic Rivers – There are no permanent, naturally-occurring surface waters or open freshwater systems, wild and scenic rivers, or federally protected wetlands at or near the West Texas launch site.

3. AFFECTED ENVIRONMENT

The Blue Origin West Texas launch site is located approximately 25 miles north of Van Horn, Texas. It lies within a larger, privately-owned property known as the Corn Ranch.

Exhibit 3-1 below summarizes the affected environment for the environmental impact categories analyzed in detail in this Supplemental EA, as presented in the 2006 EA. Sections 3.1 through 3.5 provide updates to the affected environment for each impact category.

Exhibit 3-1. Summary of the Affected Environment Presented in the 2006 EA for Environmental Impact Categories Analyzed in this Supplemental EA

Resource Area	Summary
Air Quality	The launch site[a] is located in Culberson County, Texas, within the El Paso-Las Cruces-Alamogordo Interstate Air Quality Control Region. As of 2006, this air quality control region had always been in attainment with Federal and state ambient air quality standards, and therefore analysis of conformity to the Clean Air Act was not required. At that time, the air quality in Culberson County was generally considered as unimpaired. There were no air monitoring stations in Culberson County; therefore, the county was deemed unclassifiable/attainment for all National Ambient Air Quality Standards in 2006.
Noise	In 2006, the baseline noise levels in the region of the launch site were those typical of a remote desert – approximately 22 to 38 A-weighted decibels. There was occasional road noise on State Highway 54 and aircraft noise from commercial jetliners and low-level military aircraft. The nearest noise sensitive areas are Guadalupe Mountains National Park and Carlsbad Caverns National Park. The southern boundary of Guadalupe Mountains National Park is 26 miles from the Blue Origin landing pad and 28 miles from the launch complex. The southern boundary of Carlsbad Caverns National Park is 40 miles from the Blue Origin landing pad and 42 miles from the proposed launch site.
Biological Resources (Fish, Wildlife, and Plants)	**General Ecology** The launch site is within the Trans-Pecos region of the Chihuahuan Desert, situated within a basin formed by the Sierra Diablo Mountains on the west and the Delaware Mountains on the east. Gently sloping alluvial fans dominate the eastern portion of the site, draining to the west. A northwest-to-southeast trending gypsum ridge ranging from approximately 5 to 25 feet in height is located in the west-central portion of the site and overlooks a large similarly aligned depression to the west. The general climate of the region is characterized as arid to semi-arid. The region is cool and dry during the winter and hot and dry during the summer. Wildlife in the area consists of typical Chihuahuan Desert species, and includes a variety of birds, small mammals, and reptiles found throughout the Trans-Pecos region of Texas. **Fish** Fish are not present due to the absence of surface water at the site. **Wildlife** The Trans-Pecos region of the Chihuahuan Desert in West Texas is home to numerous species of invertebrates, reptiles, amphibians, mammals, and migrant and local birds. Habitats at the site are typical of those in the region, and thus, wildlife species present are typical of those in the surrounding region. Common birds at the site include the turkey vulture (*Cathartes aura*), common raven (*Corvus corax*), greater roadrunner (*Geococcyx californianus*), northern mockingbird (*Mimus polyglottos*), and scaled quail (*Callipepla squamata*). Mammals at the site include the coyote (*Canis latrans*), badger (*Taxidea taxus*), pronghorn "antelope" (*Antilocapra americana*), chipmunk (*Eutamias sp.*), black-tailed jackrabbit (*Lepus californicus*), and desert cottontail (*Sylvilagus aududoni*). Reptiles at the site include the little striped whiptail lizard (*Cnemidophorus inornatus*), bull snake (*Pituophis melanoleuca sayi*), and prairie rattlesnake (*Crotalus viridis viridis*). A small cave located along the eastern side of the limestone ridge in the west-central portion of the surveyed site contained a small colony of bats during the April 2005 survey. The bats appeared to be cave myotis (*Myotis velifer*), a common bat species in the Trans-Pecos region of Texas. Two black-tailed prairie dog (*Cynomys ludovicianus*) colonies occur in the vicinity of the launch site. The larger of the two colonies is located

Exhibit 3-1. Summary of the Affected Environment Presented in the 2006 EA for Environmental Impact Categories Analyzed in this Supplemental EA

Resource Area	Summary
	slightly outside the northwest boundary of the launch site. This colony covers approximately 20 to 25 acres, and the eastern edge of the colony is approximately 600 feet west of the launch site's western boundary. The other prairie dog colony is located in the southeastern portion of the launch site within the sacaton vegetation community, and covers approximately 8 to 10 acres. **Plants** The dominant vegetation community is known as Chihuahuan Desert Scrub. Five subsets of Chihuahuan Desert Scrub vegetation community occur within the launch site, including cresote bush, sacaton, grama grass, gypsophilic, and arroyo riparian. The majority of the launch site is comprised of Creosote bush. **Protected Species** Exhibit 3-4 in the 2006 EA lists federally threatened, endangered, and candidate species, as well as state protected species located in Culberson County, Texas. Federally protected species include Guadalupe fescue (*Festuca ligulata*), gypsum wild buckwheat (*Eriogonum gypsophilum*), Mexican spotted owl (*Strix occidentalis lucida*), Southwestern willow flycatcher (*Empidonax traillii extimus*), and yellow-billed cuckoo (*Coccyzus americanus*). No federally or state-listed protected species were noted at the proposed launch site during the January and April 2005 field surveys.
Hazardous Materials, Pollution Prevention, and Solid Waste	In 2006, activities at the launch site required very limited use of hazardous materials (fuel for portable generator) or waste management. At that time, there was no hazardous waste or wastewater generation at the site. The small amount of solid waste generated was transported off site for disposal at existing facilities in the region.
Historical, Architectural, Archaeological, and Cultural Resources	The launch site is located in the Trans-Pecos culture region but is at the boundary of the Jordana region. A cultural resources inventory was conducted in 2005 to identify prehistoric and historic resources. A total of 36 prehistoric and historic resources were identified: seven sites and 29 isolated occurrences. They include ground stone artifacts, projectile points, other chipped stone artifacts, chipped stone flakes, and fire-cracked rock. As of 2006, two of the seven sites were eligible for application for inclusion in the NRHP. None of the isolated occurrences are eligible for listing in the NRHP. In accordance with Section 106 of the National Historic Preservation Act, 14 Native American tribes were contacted as potentially interested parties that may have cultural ties to the region. As of 2006, none of the contacted tribes indicated concerns for cultural resources impacted by the project.

[a] The launch site was referred to as the "proposed launch site" in the 2006 EA, but the site has since been constructed.

Notes: NRHP = National Register of Historic Places

3.1 Air Quality

Exhibit 3-1 in the 2006 EA compared monitored air pollutant concentrations around the region with the National Ambient Air Quality Standards (NAAQS). Because there are no air quality monitoring stations in Culberson County, data from the air monitoring station nearest to the launch site for each criteria pollutant were provided. Updates to the NAAQS and data for the most recent three years available (2010-2012) are provided in Exhibit 3-2 below.

The nearest monitoring stations for particulate matter with diameter of 10 microns or less (PM_{10}) and for carbon monoxide (CO) are located in the El Paso urban area, a nonattainment area for PM_{10}. Measured PM_{10} (and possibly particulate matter with diameter of 2.5 microns or less [$PM_{2.5}$]) data from these monitoring stations would not be representative of conditions in the project area. Therefore, data from the next-nearest monitoring station, located in Hobbs, New Mexico are provided for PM_{10} and $PM_{2.5}$. The 2006 EA reported that the El Paso area was designated nonattainment for CO. In 2008 the El Paso area was redesignated to maintenance status for CO. Data from the nearest CO monitor are reported in Exhibit 3-2. Exhibit 3-2 shows that there were no violations of the NAAQS in 2010-2012 at these monitors.

Exhibit 3-2. Measured Ambient Air Pollutant Concentrations and Comparison to Current NAAQS

Pollutant (unit)	Std. Type[a]	Averaging Period	NAAQS	Maximum Measured Concentrations 2010	2011	2012	Monitor Location (mi[b])
CO (ppm)	P	1 hour	35	3.2	2.3	6.2	Ivanhoe Fire Station, El Paso, TX (95)
	P	8 hours	9	1.7	1.6	1.8	
NO_2 (ppm)	P	1 hour	0.100	0.048	0.046	0.045	Carlsbad, NM (70)
	P, S	Annual	0.053	Unavailable[c]	Unavailable[c]	Unavailable[c]	
O_3 (ppm)	P, S	8 hours	0.075	0.070 (4^{th} maximum)	0.070 (4^{th} maximum)	0.073 (4^{th} maximum)	Carlsbad, NM (70)
SO_2 (ppm)	P	1 hour	0.075	0.012	0.007	0.004	Skyline Park, El Paso, TX (105)
	S	3 hours	0.5	Unavailable[c]	Unavailable[c]	Unavailable[c]	
$PM_{2.5}$ ($\mu g/m^3$)	P, S	24 hours	35	12 (98^{th} percentile)	25 (98^{th} percentile)	14 (98^{th} percentile)	Hobbs, NM (130)
	P, S	Annual	12 (P), 15 (S)	5.5	9.6	7.8	
PM_{10} ($\mu g/m^3$)	P, S	24 hours	150	51	131	60	Hobbs, NM (130)
Pb ($\mu g/m^3$)	P, S	Rolling 3-month average	0.15	Unavailable[c]	Unavailable[c]	Unavailable[c]	Skyline Park, El Paso, TX (105)

[a] P = primary, S = secondary
[b] Approximate distance in miles from Blue Origin West Texas launch site.
[c] Values may be unavailable due to incomplete reporting. Although these values were not reported, the data source (EPA 2013a) states that the NAAQS for the respective pollutants and averaging times were not exceeded at these monitors.
Sources: NAAQS – 40 CFR 50; Air quality monitoring data – EPA 2013a
Notes: CO = carbon monoxide; mi = mile; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; $PM_{2.5}$ = particulate matter less than 2.5 micrometers in diameter; PM_{10} = particulate matter less than 10 micrometers in diameter; ppm = parts per million, SO_2 = sulfur dioxide; $\mu g/m^3$ = micrograms per cubic meter

Exhibit 3-2 in the 2006 EA provided estimated baseline emissions for criteria pollutants and hydrogen chloride (HCl) in Culberson County, Texas. Updates to the emissions reported in Exhibit 3-2 of the 2006 EA are provided in Exhibit 3-3 below for the most recent year of available data (2008 for criteria pollutants and 2002 for HCl). The only hazardous air pollutant (also known as toxic air pollutants or air toxics) listed by the Environmental Protection Agency that could be released into the environment due to the Proposed Action is HCl. HCl would be released from solid rocket motors on the CC (which would not occur every launch; see Section 2.1.3) and notional amateur rocket number 2.

Exhibit 3-3. Estimated 2008 Annual Emissions (tons per year) for Culberson County, Texas

Pollutant	Mobile	Dust	Fuel Combustion	Industrial Processes	Solvent	Miscellaneous	Total
CO	4,177	N/A	136	102	N/A	22	4,437
NO_x	1,134	N/A	730	241	N/A	1	2,106
SO_2	9	N/A	1	2	N/A	0	12
$PM_{2.5}$	31	22	7	7	N/A	8	75
PM_{10}	37	263	7	8	N/A	9	324
VOC	285	N/A	9	282	38	59	673
HCl	ND	N/A	ND	0.17 [a]	N/A	ND	0.17

[a] Data for 2002

Notes: CO = carbon monoxide; HCl = hydrogen chloride; N/A = not applicable; ND = no data available; NO_2 = nitrogen oxide; $PM_{2.5}$ = particulate matter less than 2.5 micrometers in diameter; PM_{10} = particulate matter less than 10 micrometers in diameter; SO_2 = sulfur dioxide; VOC = volatile organic compound

Sources: EPA 2013b (criteria pollutants), EPA 2013c (HCl)

3.2 Noise

The noise environment in the area of the West Texas launch site has changed from that described in the 2006 EA. At the time of publishing the 2006 EA, the launch site had yet to be constructed. Since 2006, Blue Origin constructed the necessary infrastructure and conducted fewer than ten launches at the site, along with numerous ground rocket engine tests. Although no noise level measurements were recorded for any of these activities, the scope of these activities was less than the Proposed Action analyzed in the 2006 EA, which was found to have less than significant impacts on noise sensitive areas. A noise sensitive area is an area where noise interferes with normal activities associated with its use. Normally, noise sensitive areas include residential, educational, health, and religious structures and sites, and parks, recreational areas (including areas with wilderness characteristics), wildlife refuges, and cultural and historical sites (FAA Order 1050.1E, paragraph 11.b(8)).

Current noise sources at the West Texas launch site include construction activities and periodic rocket engine testing.

3.3 Biological Resources (Fish, Wildlife, and Plants)

Exhibit 3-4 in the 2006 EA lists state and federally listed species for Culberson County, Texas. Regarding state-listed species, five are no longer listed in Texas: Arctic peregrine falcon (*Falco peregrinus tundrius*), gray hawk (*Asturina nitida*), black-footed ferret (*Mustela nigripes*), Chihuahuan mud turtle (*Kinosternon hirtipes murrayi*), and Trans-Pecos black-headed snake (*Tantilla cucullata*) (TPWD 2012). Also, the American peregrine falcon (*Falco peregrinus anatum*) is currently listed as threatened in Texas (Exhibit 3-4 in the 2006 EA listed this species as endangered). All of the other state-listed species in Exhibit 3-4 in the 2006 EA are still listed for Texas, and there are no new state-listed species.

Regarding federally listed species, three are no longer listed for Culberson County: black-footed ferret, gray wolf (*Canis lupus*), and gypsum wild buckwheat (*Eriogonum gypsophilum*) (USFWS 2013a). All of the other federally listed species in Exhibit 3-4 in the 2006 EA are still listed for Culberson County, and there are no new federally listed species.

The current state and federally listed species for Culberson County are displayed in Exhibit 3-4 below. None of the federally listed species has designated critical habitat in the project area.

Exhibit 3-4. State and Federally Listed Species for Culberson County, Texas

Common Name	Scientific Name	Federal Status	State Status	Habitat Requirements
Birds				
American peregrine falcon	*Falco peregrinus anatum*	--	T	Year-round resident and local breeder in west Texas; nests in tall cliffs; occupies wide range of habitats during migration, including urban, concentrations along coast, and barrier islands; low-altitude migrant, stopovers at leading landscape edges such as lake shores, coastlines, and barrier islands[a]
Common blackhawk	*Buteogallus anthracinus*	--	T	Cottonwood-lined rivers and streams; willow tree groves on the lower Rio Grande floodplain; formerly bred in south Texas[a]
Mexican spotted owl	*Strix occidentalis lucida*	T	T	Residents of old-growth or mature forests that possess complex structural components (uneven-aged stands, high canopy closure, multi-storied levels, high tree density); canyons with riparian or conifer communities are also important components; rock walls with caves, ledges, and other areas provide protected nest and roost sites[b]
Northern aplomado falcon	*Falco femoralis septentrionalis*	E, EXPN	E	Variable; includes palm and oak savannahs, various desert grassland associations, and open pine woodlands; within these variations, the essential habitat elements appear to be open terrain with scattered trees, relatively low ground cover, an abundance of insects and small to medium-sized birds, and a supply of nest sites[c]
Southwestern willow flycatcher	*Empidonax traillii extimus*	E	E	Nesting requires dense riparian habitats with microclimatic conditions dictated by the local surroundings; saturated soils, standing water, or nearby streams, pools, or cienegas (springs) are a component of nesting habitat that influences the microclimate and density of the vegetation component; habitat not suitable for nesting may be used for migration and foraging[d]
Yellow-billed cuckoo	*Coccyzus americanus*	C	--	Breeds in large blocks of riparian habitats, particularly woodlands with cottonwoods and willows, as well as deciduous woodlands and parks; dense understory foliage appears to be an important factor in nest site selection[e]
Zone-tailed hawk	*Buteo albonotatus*	--	T	Arid open country, including open deciduous or pine-oak woodland, mesa, or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions[a]

Fish				
Pecos Pupfish	*Cyprinodon pecosensis*	--	T	Originally Pecos River basin; presently restricted to upper basin only; shallow margins of clear, vegetated spring waters high in calcium carbonate, as well as in sinkhole habitats[a]
Mammals				
Black bear	*Ursus americanus*	--	T	Bottomland hardwoods and large tracts of inaccessible forested areas[a]
Gray wolf	*Canis lupus*	--	E	Extirpated; formerly known throughout the western two-thirds of the state in forests, brushlands, or grasslands[a]
Reptiles				
Chihuahuan Desert lyre snake	*Trimorphodon vilkinsonii*	--	T	Mostly crevice-dwelling in predominantly limestone-surfaced desert northwest of the Rio Grande from Big Bend to the Franklin Mountains, especially in areas with jumbled boulders and rock faults/fissures[a]
Mountain short-horned lizard	*Phrynosoma hernandesi*	--	T	Usually in open, shrubby, or openly wooded areas with sparse vegetation at ground level; soil may vary from rocky to sandy; burrows into soil or occupies rodent burrow when inactive; inactive during cold weather; breeds March-September[a]
Texas horned lizard	*Phrynosoma cornutum*	--	T	Open, arid, and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September[a]
Plants				
Guadalupe fescue	*Festuca ligulata*	C		Endemic to a few high mountains of the Chihuahuan desert; known habitats are pine-oak-juniper woodlands of talus (gravelly) slopes above 6,000 feet; only known extant population in the United States occurs in Big Bend National Park[f]

[a] TPWD 2012
[b] USFWS 2013b
[c] USFWS 2013c
[d] USFWS 2013d
[e] USFWS 2011
[f] USFWS 2012
Notes: E = endangered; T = threatened; C = candidate; EXPN = experimental, non-essential population

Based on the habitat requirements for each species listed in Exhibit 3-4 above, there is no suitable habitat at the West Texas launch site for the following species: common blackhawk, Mexican spotted owl, southwestern willow flycatcher, yellow-billed cuckoo, zone-tailed hawk, Pecos pupfish, mountain short-horned lizard, and Guadalupe fescue. The gray wolf has been extirpated from Texas, and thus is not present at the launch site.

The American peregrine falcon might pass through the vicinity of the launch site during migration, but would not nest there. This species usually nests in close proximity to water, and there is no surface water near the launch site. The black bear is occasionally found in desert lowlands in west Texas, but prefers woodland and forested habitats. Bears have not been observed by Blue Origin personnel or contractors in the vicinity of the proposed launch site. The remaining three species that could potentially occur in vicinity of the launch site are discussed below.

Northern aplomado falcon

The Northern aplomado falcon is a state-listed endangered species and federally listed as an experimental, non-essential population in Culberson County. A nonessential experimental population is a reintroduced population whose loss would not be likely to appreciably reduce the likelihood of survival of the species in the wild. By definition, a nonessential experimental population is not essential to the continued existence of the species. Therefore, no proposed action impacting a population so designated could lead to a jeopardy determination for the entire species. For section 7 consultation purposes, per section 10(j) of the Endangered Species Act, any nonessential experimental population located outside a National Park or National Wildlife Refuge System unit is treated as a proposed species.

The West Texas launch site is located within the historic range of the northern aplomado falcon. In Texas, aplomado falcons are known or believed to occur in the South Texas and Trans-Pecos regions (TPWD 2013). In 2002, northern aplomado falcons were released at four sites on private ranches in West Texas under the Safe Harbor Agreement with the Peregrine Fund. These sites included a location approximately 50 miles south of the West Texas launch site (USFWS 2005). Aplomado falcons are typically associated with large desert grassland expanses. Grasslands at the West Texas launch site are not extensive. As stated in the 2006 EA, only about 144 acres of the 18,600-acre launch site are classified as grassland. No falcons were observed during biological surveys of the proposed launch site in April 2005, which is the typical time period for nesting of this species in Texas. A project-specific review request was submitted to the TPWD Texas Natural Diversity Database. The database contained no records of any state or federally listed species potentially occurring within the project area (Gottfried 2013). There is no state record in recent history (approximately 60 years) of Northern aplomado falcons within Culberson County (Shackelford 2013).

Chihuahuan Desert lyre snake

The Chihuahuan desert lyre snake is a state-listed threatened species. This species is a secretive crevice-dwelling snake found in the predominantly limestone-surfaced desert northwest of the Rio Grande River from Big Bend to the Franklin Mountains. A burrowing (fossorial) species, it inhabits rocky areas with jumbled boulders, and rock faults and fissures. Its diet consists primarily of lizards. Potential habitat for this species at the launch site is very limited, and occurs mainly along the limestone ridge bisecting the western portion of the launch site. No desert lyre snakes were observed during the January or April 2005 biological surveys. Additionally, as stated above, a project-specific review request submitted to the TPWD Texas Natural Diversity Database resulted in no records of any state or federally listed species potentially occurring within the project area (Gottfried 2013).

Texas horned lizard

The Texas horned lizard is a state-listed threatened species. Historical distribution of the lizard ranged from Colorado, Kansas, and southwestern Missouri south through southeastern Arizona, New Mexico, Oklahoma, Arkansas, and Texas into northern Mexico. This lizard inhabits flat, open generally arid regions with loose soils supporting bunchgrass, juniper, mesquite, acacia and succulents. Its diet consists primarily of harvester ants, but other small arthropods may be eaten. Since this generalist species is found in a variety of habitats, it could occur at the launch site. No Texas horned lizards were observed during biological surveys in April 2005. Additionally, as stated above, a project-specific review request submitted to the TPWD Texas Natural Diversity

Database resulted in no records of any state or federally listed species potentially occurring within the project area (Gottfried 2013).

3.4 Hazardous Materials, Pollution Prevention, and Solid Waste

The storage, handling, and use of hazardous materials at the launch site are governed by multiple Federal and state regulations, including the Comprehensive Environmental Response, Compensation, and Liability Act, and the Resource Conservation and Recovery Act. Texas regulates hazardous wastes under Texas Administrative Code, Title 30, Chapter 335, Industrial Solid and Municipal Hazardous Waste, which is administered by the Texas Natural Resources Conservation Commission.

There is no treatment or disposal of hazardous waste onsite at the launch site. Hazardous waste and solid waste currently generated at the launch test site is removed for appropriate off site recycling or disposal. Construction of an onsite wastewater treatment plant has been completed since the development of the 2006 EA. This facility, located west of Home Base Road and the power generation facility, covers an area of less than 1,000 square feet and has the capacity to treat 5,000 gallons of wastewater per day.

3.5 Historical, Architectural, Archaeological, and Cultural Resources

In addition to the cultural survey performed in 2005 by GeoMarine, Inc. (GMI), GMI performed a cultural survey in October 2012 for Blue Origin. This Transect Recording Unit survey was conducted on an additional 4.8 acres in the south half of the West Texas launch site, near the launch pad, to accommodate the ring road and LOx and LH2 ground equipment described in Chapter 2. No prehistoric or historic archaeological sites were recorded; only a single artifact was identified during the survey. No additional cultural manifestations were identified, and the single artifact, a chert projectile point fragment, was unassociated with other objects. The single artifact was recorded as an isolated occurrence, and is not eligible for listing in the National Register of Historic Places (NRHP) (GMI 2012b). See Appendix B for the cultural survey report.

In accordance with Section 106 of the National Historic Preservation Act (NHPA), 14 Native American tribes were contacted as potentially interested parties during the development of the 2006 EA. To date, none of the contacted tribes has indicated concerns regarding potential impacts to cultural resources in the project area.

4. ENVIRONMENTAL CONSEQUENCES

This chapter describes the potential environmental consequences of the Proposed Action and No Action Alternative. The FAA evaluated the potential environmental consequences of the Proposed Action and the No Action Alternative in accordance with all relevant legal requirements, including 40 CFR § 1502.16 and FAA Order 1050.1E, *Environmental Impacts: Policies and Procedures, Change 1*, which specifies significance thresholds for applicable environmental impact categories.

For each impact category, the potential impacts are broken down by construction and operations. Where appropriate, the analysis summarizes and references the potential impacts that were discussed in the 2006 EA.

4.1 Proposed Action

4.1.1 Air Quality

Potentially significant air quality impacts would occur if the Proposed Action would result in exceeding one or more of the NAAQS for any of the time periods analyzed (FAA Order 1050.1E, Appendix A, Section 2.3). As discussed in more detail in the following paragraphs, launch site impacts on air resources would be minor and would not be expected to lead to any violation of the NAAQS. Because the launch site is located in an air quality control region that has always been in attainment with Federal and state ambient air quality standards, an analysis of conformity under the CAA Section 176(c) is not required.

4.1.1.1 Construction

Construction activities potentially affecting air quality include the clearing of land, operation of heavy-duty construction equipment, the temporary operation of a cement batch plant, and on-site vehicle travel on unsurfaced roads. Exhaust emissions from these sources would result in releases of nitrogen oxides (NO_X), sulfur oxides (SO_X), CO, PM_{10}, $PM_{2.5}$, and volatile organic compounds (VOCs). The 2006 EA contained estimates of emissions due to construction activities for the project as then proposed, and concluded that the construction would not lead to any violation of the NAAQS. The FAA reviewed the nature and amounts of construction activities for the current Proposed Action and compared them to the construction activities evaluated in the 2006 EA. The current Proposed Action would have generally lesser levels of construction activity than proposed in the 2006 EA, and consequently would have lower emissions. Accordingly, the emissions estimates in the 2006 EA can be considered an upper bound to estimate the construction emissions of the current Proposed Action. No adverse air quality impacts are expected due to construction activities associated with the Proposed Action.

4.1.1.2 Operation

Operational emissions would result from launches of the permitted/licensed RLVs, amateur rocket launches, ground testing of launch vehicles and rocket engines, trucks delivering propellants and other materials, use of personal vehicles to access the site, and diesel generators that provide electric power for the launch site. Based on the analysis presented in the 2006 EA, personal vehicles, trucks, and diesel generators associated with the Proposed Action are estimated to contribute very minor emissions. Therefore, only emissions from launches and ground testing were estimated for the Proposed Action.

Emissions were estimated for the entire rocket flight (potentially to altitudes exceeding 66 miles) and separately for the lower troposphere (up to a nominal 3,000 foot altitude above the surface). As explained in the 2006 EA, the lower troposphere is the layer of the atmosphere that is relevant for ground-level air quality concerns and compliance with the NAAQS. Emissions to the atmosphere as a whole are relevant for climate change.

Overall Atmosphere

Exhibit 4-1 provides the estimated emissions per launch for each launch vehicle, and the emissions per test for each ground test. As stated in Section 2.1.3, the propulsion module may be flown with or without the CC attached. If the CC is attached, it may either remain attached to the propulsion module throughout flight and landing, or it may separate from the propulsion module during flight, which could involve firing the solid rocket motor.

Emissions of molecular nitrogen (N_2), hydrocarbons, VOCs, and SO_X would be zero or negligible and are not listed in Exhibit 4-1.

Exhibit 4-1. Estimated Emissions per Launch or Ground Test

Vehicle	Emissions (lb/launch or test)							
	CO_2	**CO**	**H_2**	**H_2O**	**NO_x**	**$PM_{10}/PM_{2.5}$**	**Cl**	**HCl**
Permitted/Licensed Launches								
PM[a]	0	0	0	49,838	0	0	0	0
CC[b]	299	0	0	176	2.1	247	0.98	137
Amateur Launches								
CC alone	299	0	0	176	2.1	247	0.98	137
Notional Amateur Rocket 1 (H_2O_2 monopropellant)	0	0	0	800	0	0	0	0
Notional Amateur Rocket 2 (solid propellant)	460	0	0	270	3.3	380	1.50	210
Ground Testing[c]								
Test Stand 1 (LOx/LH2 propellant)	0	0	0	36,000	0	0	0	0
Test Stand 2 (LOx/hydrocarbon[d] propellant)	28,812	11,760	247	17,640	0	0	0	0

[a] Based on Blue Origin launch/trajectory data for representative flight using approximately 83 percent of vehicle's propellant capacity.
[b] During flight of a permitted/licensed reusable launch vehicle launch, the CC's solid rocket motor could be fired.
[c] For longest-duration, highest-emissions tests (year 2016).
[d] For purposes of estimating emissions, the hydrocarbon propellant is assumed to be rocket propellant-1 (or RP-1).
Notes: CC = crew capsule; Cl = chlorine; CO = carbon monoxide; CO_2 = carbon dioxide; H_2 = hydrogen; H_2O = water; H_2O_2 = hydrogen peroxide; HCl = hydrogen chloride; lb = pound; LH2 = liquid hydrogen; LOx = liquid oxygen; NO_X = nitrogen oxide; PM = propulsion module; $PM_{10}/PM_{2.5}$ = particulate matter less than 10 or 2.5 micrometers in diameter.

Exhibits 4-2, 4-3, and 4-4 provide the estimated total emissions for permitted/licensed RLV launches, amateur launches, and ground tests respectively for each projection year. As a conservative (high) estimate of potential air emissions, Exhibit 4-2 includes emissions from the CC, i.e., it is assumed that the CC's solid rocket motor is fired during every PM+CC flight (under a licensed/permitted launch).

Exhibit 4-2. Estimated Emissions by Year for Permitted/Licensed Launches

Vehicle and Year	No. of Launches		Emissions (tons/year)[a]							
	PM	PM+CC	CO_2	CO	H_2	H_2O	NO_x	$PM_{10}/PM_{2.5}$	Cl	HCl
PM										
2014	4	12	0	0	0	399	0	0	0	0
2015	2	32	0	0	0	847	0	0	0	0
2016	2	32	0	0	0	847	0	0	0	0
2017	2	52	0	0	0	1,346	0	0	0	0
2018	2	52	0	0	0	1,346	0	0	0	0
2019	2	52	0	0	0	1,346	0	0	0	0
Total PM 2014-2019	**14**	**232**	**0**	**0**	**0**	**6,130**	**0**	**0**	**0**	**0**
CC										
2014	–	12	1.8	0	0	1.1	0.01	1.5	0.01	0.8
2015	–	32	4.8	0	0	2.8	0.03	4.0	0.02	2.2
2016	–	32	4.8	0	0	2.8	0.03	4.0	0.02	2.2
2017	–	52	7.8	0	0	4.6	0.1	6.4	0.03	3.5
2018	–	52	7.8	0	0	4.6	0.1	6.4	0.03	3.5
2019	–	52	7.8	0	0	4.6	0.1	6.4	0.03	3.5
Total CC 2014-2019	–	232	34.7	0	0	20.4	0.2	28.7	0.1	15.8
Sum PM and PM+CC										
2014	4	12	1.8	0	0	400	0.01	1.5	0.01	0.8
2015	2	32	4.8	0	0	850	0.03	4.0	0.02	2.2
2016	2	32	4.8	0	0	850	0.03	4.0	0.02	2.2
2017	2	52	7.8	0	0	1,350	0.06	6.4	0.03	3.5
2018	2	52	7.8	0	0	1,350	0.06	6.4	0.03	3.5
2019	2	52	7.8	0	0	1,350	0.06	6.4	0.03	3.5
Total PM & PM+CC 2014-2019	**12**	**232**	**34.7**	**0**	**0**	**6,150**	**0.25**	**28.7**	**0.11**	**15.8**

[a] Sum of individual values may not equal total due to rounding.

Notes: CC = crew capsule; Cl = chlorine; CO = carbon monoxide; CO_2 = carbon dioxide; H_2 = hydrogen; H_2O = water; HCl = hydrogen chloride; NO_X = nitrogen oxide; PM = propulsion module; $PM_{10}/PM_{2.5}$ = particulate matter less than 10 or 2.5 micrometers in diameter.

Exhibit 4-3. Estimated Emissions by Year for Amateur Rocket Launches

Vehicle and Year	No. of Launches	Emissions (tons/year)[a]							
		CO_2	CO	H_2	H_2O	NO_x	$PM_{10}/PM_{2.5}$	Cl	HCl
Notional Amateur Rocket 1									
2014	2	0	0	0	0.8	0	0	0	0
2015	3	0	0	0	1.2	0	0	0	0
2016	3	0	0	0	1.2	0	0	0	0
2017	3	0	0	0	1.2	0	0	0	0
2018	3	0	0	0	1.2	0	0	0	0

Exhibit 4-3. Estimated Emissions by Year for Amateur Rocket Launches

Vehicle and Year	No. of Launches	Emissions (tons/year)[a]							
		CO_2	CO	H_2	H_2O	NO_x	$PM_{10}/PM_{2.5}$	Cl	HCl
2019	3	0	0	0	1.2	0	0	0	0
Total 2014-2019	**17**	**0**	**0**	**0**	**6.8**	**0**	**0**	**0**	**0**
Notional Amateur Rocket 2									
2014	1	0.23	0	0	0.1	0	0.2	0	0.1
2015	2	0.46	0	0	0.3	0	0.4	0	0.2
2016	2	0.46	0	0	0.3	0	0.4	0	0.2
2017	2	0.46	0	0	0.3	0	0.4	0	0.2
2018	2	0.46	0	0	0.3	0	0.4	0	0.2
2019	2	0.46	0	0	0.3	0	0.4	0	0.2
Total 2014-2019	**11**	**2.5**	**0**	**0**	**1.5**	**0**	**2.1**	**0**	**1.2**
CC Alone									
2014	2	0.30	0	0	0.18	0	0.2	0	0.14
2015	2	0.30	0	0	0.18	0	0.2	0	0.14
2016	2	0.30	0	0	0.18	0	0.2	0	0.14
2017	2	0.30	0	0	0.18	0	0.2	0	0.14
2018	2	0.30	0	0	0.18	0	0.2	0	0.14
2019	2	0.30	0	0	0.18	0	0.2	0	0.14
Total 2014-2019	**12**	**1.8**	**0**	**0**	**1.1**	**0**	**1.5**	**0**	**0.8**
All Amateur Rockets									
2014	5	0.5	0	0	1.1	0	0.4	0	0.2
2015	7	0.8	0	0	1.6	0	0.6	0	0.3
2016	7	0.8	0	0	1.6	0	0.6	0	0.3
2017	7	0.8	0	0	1.6	0	0.6	0	0.3
2018	7	0.8	0	0	1.6	0	0.6	0	0.3
2019	7	0.8	0	0	1.6	0	0.6	0	0.3
Total 2014-2019	**40**	**4.3**	**0**	**0**	**9.3**	**0**	**3.6**	**0**	**2.0**

[a] Sum of individual values may not equal total due to rounding.
Notes: CC = crew capsule; Cl = chlorine; CO = carbon monoxide; CO_2 = carbon dioxide; H_2 = hydrogen; H_2O = water; HCl = hydrogen chloride; NO_X = nitrogen oxide; $PM_{10}/PM_{2.5}$ = particulate matter less than 10 or 2.5 micrometers in diameter.

Exhibit 4-4. Estimated Emissions by Year for Ground Tests

Vehicle and Year[a]	Emissions (tons/year)[b]							
	CO_2	CO	H_2	H_2O	NO_x	$PM_{10}/PM_{2.5}$	Cl	HCl
Test Stand 1								
2013	0	0	0	1,181	0	0	0	0
2014	0	0	0	2,700	0	0	0	0
2015	0	0	0	900	0	0	0	0
2016	0	0	0	900	0	0	0	0
Total 2013-2016	**0**	**0**	**0**	**5,681**	**0**	**0**	**0**	**0**
Test Stand 2								
2013	0	0	0	0	0	0	0	0

Exhibit 4-4. Estimated Emissions by Year for Ground Tests

Vehicle and Year[a]	Emissions (tons/year)[b]							
	CO_2	CO	H_2	H_2O	NO_x	$PM_{10}/PM_{2.5}$	Cl	HCl
2014	360	147	3.1	221	0	0	0	0
2015	1,441	588	12.3	882				
2016	0	0	0	0	0	0	0	0
Total 2013-2016	**1,801**	**735**	**15.4**	**1,103**	**0**	**0**	**0**	**0**
Test Stands 1 & 2								
2013	0	0	0	1,181	0	0	0	0
2014	360	147	3.1	2,921	0	0	0	0
2015	1,441	588	12.3	1,782	0	0	0	0
2016	0	0	0	900	0	0	0	0
Total 2013-2016	**1,801**	**735**	**15.4**	**6,784**	**0**	**0**	**0**	**0**

[a] No ground test projections have been developed for years after 2016.
[b] Sum of individual values may not equal total due to rounding.
Notes: Cl = chlorine; CO = carbon monoxide; CO_2 = carbon dioxide; H_2 = hydrogen; H_2O = water; HCl = hydrogen chloride; NO_X = nitrogen oxide; $PM_{10}/PM_{2.5}$ = particulate matter less than 10 or 2.5 micrometers in diameter.

Exhibit 4-5 provides the estimated total emissions for all launches and ground tests for each projection year. Exhibit 4-5 represents the sum of the data in Exhibits 4-2 through 4-4.

Exhibit 4-5. Estimated Emissions by Year for All Launches and Ground Tests

Year[b]	Emissions (tons/year)[a]							
	CO_2	CO	H_2	H_2O	NO_X	$PM_{10}/PM_{2.5}$	Cl	HCl
2013	0	0	0	1,181	0.0	0	0.00	0.0
2014	362	147	3.1	3,321	0.0	1.9	0.01	1.1
2015	1,446	588	12	2,634	0.0	4.6	0.02	2.5
2016	5.5	0	0	1,752	0.0	4.6	0.02	2.5
2017	8.5	0	0	1,352	0.1	7.0	0.03	3.9
2018	8.5	0	0	1,352	0.1	7.0	0.03	3.9
2019	8.5	0	0	1,352	0.1	7.0	0.03	3.9
Total 2013-2019	**1,840 (1,669 metric tons)**	**735**	**15**	**12,943**	**0.3**	**32.2**	**0.13**	**17.8**

[a] Sum of individual values may not equal total due to rounding.
[b] No PM*, CC, or amateur launches are projected for 2013. No ground test projections have been developed for years after 2016.
Notes: Cl = chlorine; CO = carbon monoxide; CO_2 = carbon dioxide; H_2 = hydrogen; H_2O = water; HCl = hydrogen chloride; NO_X = nitrogen oxide; $PM_{10}/PM_{2.5}$ = particulate matter less than 10 or 2.5 micrometers in diameter.

Under the Proposed Action, the emissions as indicated in Exhibit 4-5 could affect global climate change, because CO_2 and water are greenhouse gases. However, these emissions represent a very small fraction of national and global emissions and in this context would have a negligible impact on global climate change. By comparison, U.S. greenhouse gas emissions were estimated at 6,633.2 million metric tons of CO_2-equivalent[2] in 2009 (EPA 2011). Global greenhouse gas emissions were estimated at 44,153 million metric tons of CO_2-equivalent in 2005 (WRI 2009).

[2] Each greenhouse gas has a different level of radiative forcing ability, that is, the ability to trap heat. To compare their relative contributions, gases are converted to carbon dioxide equivalent using their unique global warming potentials (GWPs). Each gas has a unique GWP value which represents its radiative forcing ability relative to that of CO_2.

Lower Atmosphere

The FAA estimated the portion of project-related emissions that would occur below 3,000 feet altitude to assess the effects of criteria pollutants on ground-level air quality in the project area. Exhibit 4-6 presents the estimated annual emissions below 3,000 feet altitude for the year of maximum emissions (2019). As a conservative (high) estimate of potential air emissions, Exhibit 4-6 includes emissions from the CC, i.e., it is assumed that the CC's solid rocket motor is fired during every PM+CC flight (under a licensed/permitted launch).

Exhibit 4-6. Estimated Annual Emissions Below 3,000 Feet Altitude for Year of Maximum Emissions (2019)

Vehicle	Emissions (tons/year)[a]							
	CO_2	CO	H_2	H_2O	NO_x	$PM_{10}/PM_{2.5}$	Cl	HCl
Permitted/Licensed Launches (PM & PM+CC)	7.8	0	0	304	0.1	6.4	0.03	3.5
Amateur Rockets	0.5	0	0	1.0	0.004	0.4	0.002	0.2
Ground Testing[b]	1,441	588	12	1,782	0	0	0	0
Total	**1,449**	**588**	**12**	**2,087**	**0.1**	**6.9**	**0.03**	**3.8**

[a] Sum of individual values may not equal total due to rounding.
[b] Ground test results are for year 2015 which is the year of maximum criteria pollutant emissions from ground tests. No ground test projections have been developed for years after 2016.
Notes: CC = crew capsule; Cl = chlorine; CO = carbon monoxide; CO_2 = carbon dioxide; H_2 = hydrogen; H_2O = water; HCl = hydrogen chloride; NO_X = nitrogen oxide; PM = propulsion module; $PM_{10}/PM_{2.5}$ = particulate matter less than 10 or 2.5 micrometers in diameter.

Exhibit 4-6 shows that annual project-related emissions of criteria pollutants would comprise approximately 13 percent of annual Culberson County emissions (Exhibit 3-3) for CO, 0.003 percent for NO_X, and 2 percent for $PM_{10}/PM_{2.5}$. Annual project-related emissions would be larger than county emissions for HCl. Culberson County emissions are relatively low for a region of its size because of the rural nature of the county. The emissions of HCl are due to the solid rocket propellant used in the CC and notional amateur rocket number 2. Project-related emissions of criteria pollutants would not be expected to lead to violation of the NAAQS.

4.1.2 Noise

Sound levels are measured in decibels (dB), which are calculated in mathematical terms from a ratio of the sound level to a reference sound level, which is generally the threshold of hearing. Various weighting schemes have been developed to collapse a frequency spectrum into a single dB value. The A-weighted decibel (dBA) corresponds to human hearing accounting for the higher sensitivity in the mid-range frequencies. Humans begin to experience pain at levels above 100 dBA. Another sound level weighting is the C-weighted scale (dBC) which emphasizes low frequency sounds, such as sonic booms.

Day Night Average Sound Level (DNL) is a 24- hour average of noise levels with a 10 dB penalty for noise occurring at night. This adjustment is made to account for people's greater sensitivity to noise during nighttime hours (between 10 p.m. and 7 a.m.).

A significant noise impact would occur if analysis shows that the Proposed Action would cause noise sensitive areas to experience an increase in noise of DNL 1.5 dB or more at or above DNL

65 dB noise exposure when compared to the No Action Alternative for the same timeframe (FAA Order 1050.1E, Appendix A, Section 14.3).

4.1.2.1 Construction

Construction activities would include excavation, digging and pouring of foundations, erection of buildings, and construction of roads and utilities. These activities would temporarily increase the ambient noise levels at the launch site. Exhibit 4-7 shows noise levels of typical construction equipment as measured 50 feet from the equipment (FTA 2006). Traffic noise from commuting workers' trucks on the road to the launch site would also increase during construction phases. The construction-related noise would not be appreciable off site, given the size of the property, the proximity of the construction activity to the highway, and the sparseness of the surrounding population. Workers would be protected from potential noise-related impacts in accordance with Occupational Safety and Health Administration (OSHA) regulations. Construction-related noise would be temporary and would not result in a significant noise impact.

Exhibit 4-7. Construction Equipment Noise Levels

Equipment	Typical Noise Level (dBA) 50 ft. from Source
Concrete Mixer	85
Crane, Derrick	88
Crane, Mobile	83
Dozer	85
Generator	81
Grader	85
Jack Hammer	88
Loader	85
Pile Driver (Impact)	101
Scraper	89
Truck	88

Notes: dBA = A-weighted decibel
Source: FTA 2006

4.1.2.2 Operation

Operational noise is discussed in terms of launch noise, engine testing, and amateur rocket launches.

Launch Noise

The majority of the noise generated by a rocket launch is created by the rocket plume, or jet exhaust, interacting with the atmosphere along the entire plume, and combustion noise of the propellants. Launch noise would occur in the area surrounding the launch pad, radiating in all directions. However, it is highly directive, meaning that a substantial portion of the source's acoustic power is concentrated in a specific direction. Additionally, the level of noise received depends on the distance from the source. Noise levels decrease as the distance from the source increases. For example, there is a 6 dB decrease in noise level per doubling of distance from a point source. "Point source" would be the appropriate acoustical representation of a rocket, as a small point, producing noise from a long distance away from a listener.

Launch noise levels and contours were developed using a model designed specifically for rocket launch noise computations. The model accounts for the RLV's trajectory (including latitude, longitude, altitude, and velocity for every second of the launch event), thrust, engine velocity, engine nozzle diameter, the location of the launch pad, and the number of daytime and nighttime launches. In this case, one nighttime launch per month was assumed in the analysis. Because the approved models identified in FAA Order 1050.1E, Appendix A, Section 14.2b for modeling noise levels of proposed actions are not suitable for predicting rocket launch noise, the FAA implemented this non-standard noise methodology to predict noise levels of RLV launches. On January 31, 2014, the FAA Office of Environment and Energy determined the methodology was appropriate for this analysis and provided its approval of the methodology, as required by FAA Order 1050.1E, Appendix A, Section 14.2b (see Appendix A).

Exhibit 4-8 shows computed DNL contours for RLV launches. The noise contour lobes form at both the launch pad and landing pad. Both of these locations would receive most of the launch noise due to proximity to the rocket as well as duration of noise exposure. The outermost contour represents 65 DNL, which falls completely within the launch site's boundary. Because there are no noise sensitive areas within the launch site boundary, there would be no significant launch noise impacts.

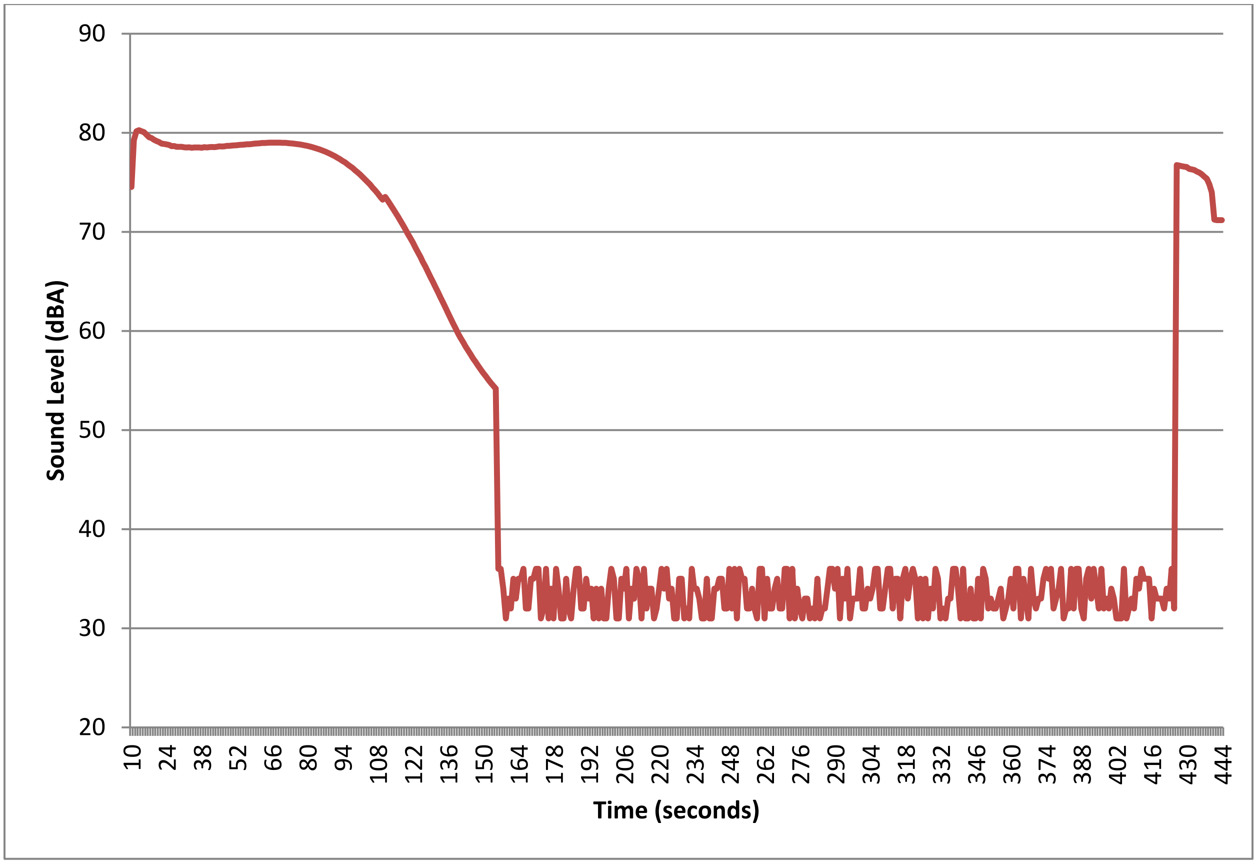
Exhibit 4-8. Day-Night Average Sound Levels for Reusable Launch Vehicle Launches at the Blue Origin West Texas Launch Site[a]

[a] Noise contour increments are 10 decibels apart. The outermost contour represents 65 day-night average sound level.

In addition to the RLV noise contours, RLV noise levels were estimated. Exhibit 4-9 displays the estimated RLV noise, over the entire launch sequence, at the closest noise sensitive area—a ranch located approximately 8 miles to the south of the launch pad. Estimated noise levels at this location would peak at slightly over 80 dBA and diminish as the RLV ascends, after which the engine would shut off. During RLV landing, the engine would re-ignite, producing noise for a few seconds prior to landing (see Exhibit 4-9). The ranch would be exposed to these estimated noise levels a maximum of 54 times a year (in years 2017–2019) under the Proposed Action (see Exhibit 2-4).

Blue Origin workers would normally be about two miles away at the Operations Control Center during launches. At this location, a maximum noise level of 112 dBA was computed, less than the 115 dBA OSHA 15-minute standard. Any workers potentially exposed to noise greater than any OSHA standard would be required to wear hearing protection.

Exhibit 4-9. Reusable Launch Vehicle Sound Level at Closest Noise Sensitive Area

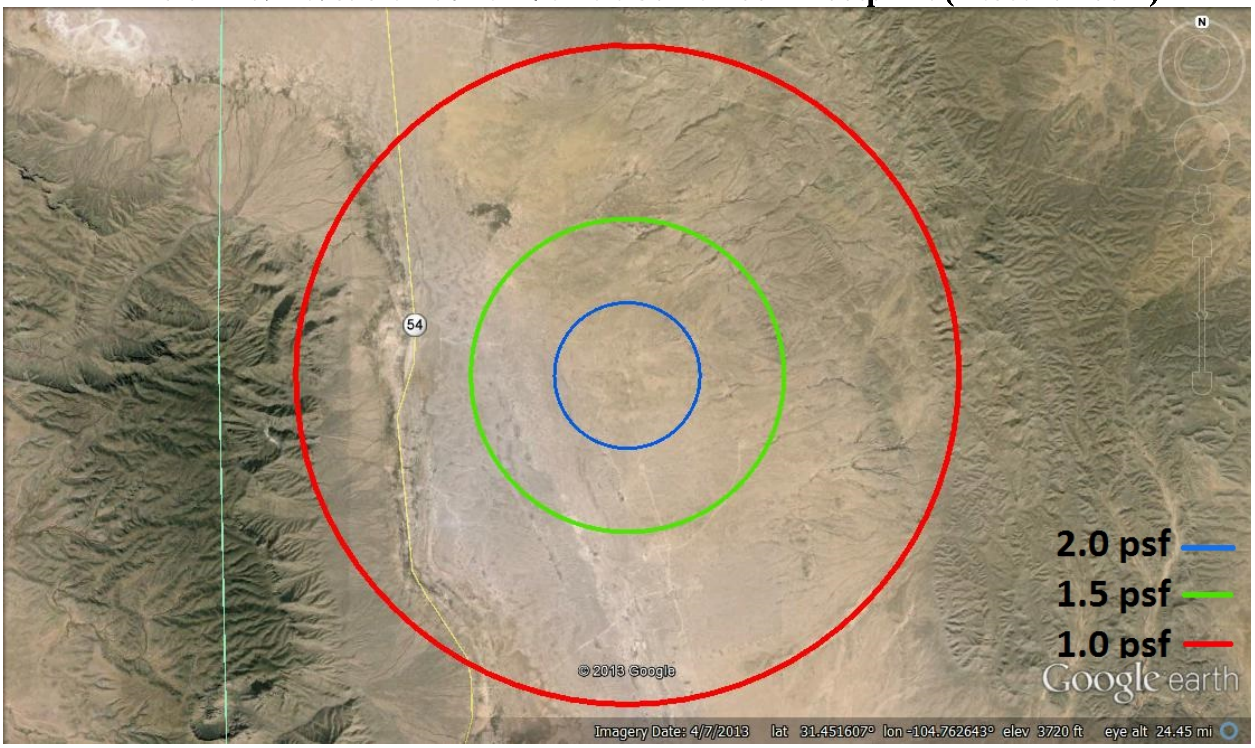


In addition to rocket engine noise, a sonic boom would occur during each RLV launch. A sonic boom is a sound that is produced by a shock wave that forms around a vehicle that is traveling faster than the speed of sound.

The standard method for determining sonic boom footprints for supersonic vehicles is the method of geometrical acoustics, or ray tracing (Plotkin 1989). The theory states that the acoustic disturbance generated by a supersonic vehicle in steady flight at a particular instant propagates along a cone of rays opening forward of the aircraft's flight direction/orientation. For a supersonic aircraft in horizontal flight, this ray cone will eventually intersect the ground at a future time, forming the hyperbolic boom footprint at ground level. However, the RLV launch trajectory in this Proposed Action is vertical (i.e., no pitch-over as in most other types of rocket launches). Therefore, during the ascent portion of a launch, the ray cone and the corresponding sonic boom from the RLV would not intersect the ground. Instead, it would propagate away from the Earth's surface and not be heard.

The model PCBoom4 was used to predict the sonic boom footprint. During landing, the vehicle would descend base first in a nearly vertical trajectory. Under these conditions, the vehicle would produce a sonic boom as the vehicle decelerates to Mach 1 at approximately 20,800 feet. Exhibit 4-10 shows the predicted/modeled sonic boom footprint as concentric circles due to the ray cone's orientation aimed directly at the launch pad.

Exhibit 4-10. Reusable Launch Vehicle Sonic Boom Footprint (Descent Boom)



The sonic boom would be centered on the landing pad, meaning that the sonic boom magnitude would be relatively low outside of the launch site. The highest magnitude portion of the boom at the landing pad would have a duration of less than 180 milliseconds and a peak overpressure of 2.0 pounds per square foot (psf) (134 dB). Sonic booms would occur a maximum of 54 times a year (in years 2017–2019) under the Proposed Action (see Exhibit 2-4). This would result in C-weighted[3] DNL (or CDNL) 55 at the pad itself.

At the Operations Control Center, the peak overpressure would be 1.8 psf or approximately 133 dB.

The effects of sonic booms are typically a startle response in humans and biota, and, in extreme cases, damage to structures. The potential for, and the intensity of, a sonic boom being heard on the surface of the earth are dependent on the vehicle length, mass, and shape, the trajectory of the launch, the vehicle velocity, and atmospheric profile.

[3] C-weighting approximates the sensitivity of human hearing at high noise levels (above about 85 dBA). The C-weighted sound level is more sensitive to sounds at low frequencies than the A-weighted sound level and is sometimes used to assess the low-frequency content of sound environments.

Because of the launch site's remote location, the potential for damage or significant impacts from RLV-generated sonic booms at or near the launch site would be negligible.

Engine Testing

Engine testing of RLV engines would be conducted near the launch pad several times a week. Each test would last approximately 2 minutes. Noise analysis for engine testing indicates that the 65 DNL contours associated with engine testing would be completely within the launch site's boundary. Because there are no noise sensitive areas within the launch site boundary, there would be no significant noise impacts from engine testing.

Amateur Rocket Launches

The amateur launch vehicles would reach altitudes between 10,000 and 100,000 feet and would be launched between one and five times per year between 2014 and 2019. Because of the rockets' relatively small size, thrust, and infrequent launches, associated noise levels would not appreciably affect overall DNL contours for the Proposed Action.

4.1.3 Biological Resources (Fish, Wildlife, and Plants)

The potential impacts on biological resources are discussed relative to their effects on terrestrial wildlife and plants. Because there are no aquatic resources in the vicinity of the launch site, a discussion of impacts to aquatic species is not relevant to this analysis.

A significant impact would occur if the U.S. Fish and Wildlife Service determined the Proposed Action would be likely to jeopardize the continued existence of a federally listed threatened or endangered species, or would result in the destruction or adverse modification of federally designated critical habitat (FAA Order 1050.1E, Appendix A, Section 8.3).

4.1.3.1 Construction

Potential construction impacts on terrestrial wildlife and plants would be similar to those types of impacts discussed in the 2006 EA as summarized below.

Plants

As stated in Exhibit 2-5, construction of most of the planned structures and infrastructure at the launch site is complete. Construction that would be in addition to that already analyzed in the 2006 EA would result in the clearing, grading, or disturbance of approximately 45 acres. Most, if not all, of this construction activity would occur within vegetation characterized as creosote bush community. Because this plant community type is common at the launch site and throughout the Chihuahuan Desert in the Trans-Pecos region of Texas, the anticipated loss would represent only a small portion of this habitat type and would not adversely affect local or regional diversity of plants and plant communities.

The launch site receives only about 11 inches of rainfall annually (Culberson County Groundwater Conservation District 2000); therefore, erosion and sedimentation are less of a concern than in less arid regions. Nevertheless, flash flooding during infrequent storms occurs in the region, and soil erosion caused by water movement across the cleared area could potentially alter vegetation communities in down gradient ephemeral drainages. Construction activities would be carefully planned and conducted according to best management practices to minimize erosion and soil loss.

Wildlife

Potential construction-related impacts to wildlife could occur from human presence, operation of equipment, and loss of habitat. Increased vehicular traffic and human presence, as well as noise generated from operation of equipment, may temporarily displace wildlife species, causing them to expend additional energy. Construction activities that would temporarily increase noise levels within the project area include excavation, digging and pouring foundations, erection of buildings, and construction of roads and utilities. These activities would involve the movement of workers and construction equipment and would be associated with relatively high noise levels from earth-moving equipment, portable generators, pile driving equipment, pneumatic tools, drills, hammers, etc. Although noise levels in construction areas could be high, these local noise levels would not be expected to propagate far beyond the boundaries of the project site. Exhibit 4-7 in Section 4.1.2.1 above displays typical noise levels at 50 feet from different types of construction equipment. Exhibit 4-7 in the 2006 EA illustrates the rapid attenuation of construction noise over relatively short distances.

The reaction of a particular wildlife species to construction noise could range from mild annoyance to panic and escape behavior. Behavioral responses to noise impacts also vary between species and between individuals due to a variety of factors such as age, sex, prior exposure, season, hearing sensitivity, reproductive status and season, time of day, behavior during the noise event, and the individual’s location relative to the noise source. Other factors that influence an animal’s response to noise include noise level and frequency, distance and event duration, equipment type and condition, frequency of events over time, slope, topography, and weather conditions (Delaney and Grubb 2004). Consequently, it is difficult to generalize animal responses to noise disturbances across species. In mammalian species, startle or fright is the immediate behavioral reaction to transient, unexpected, or unpleasant noise. Bird behavioral responses to noise include nest abandonment, egg mortality, premature fledging, predation, depressed feeding rates, and habitat avoidance.

Although construction noise levels would be relatively low outside of the immediate area of construction, the combination of construction noise and human activity would be expected to displace small numbers of birds and small mammals that might forage, feed, nest, rest, or den in the area. Some animals would be driven from the area permanently, while others probably would become accustomed to the increased noise and activity levels and would return to the area.

Small numbers of less-mobile, burrow-dwelling animals (e.g., pocket gophers, chipmunks) inhabiting the construction area could be displaced by construction activity or killed if burrows are filled, crushed, or paved. More mobile animals such as birds, larger mammals (e.g., rabbits, pronghorn), and reptiles (e.g., lizards, snakes) would be expected to disperse to less-disturbed areas of the launch site or off site. No construction would occur within or near prairie dog colonies; thus, there would be no removal of existing prairie dog colony habitat. Similarly, no construction would occur near the small cave located along the eastern side of the gypsum/limestone ridge in the west-central portion of the launch site; thus, the cave and associated animal species (e.g., bats) would not be affected.

In summary, temporary increased human presence during construction and operation of construction equipment would be expected to create impacts on terrestrial wildlife that would short-term, localized, and not significant.

Loss of habitat would result from permanent removal of vegetation from construction of structures and infrastructure. As described in the previous vegetation subsection, most, if not all, of the planned construction activity would be in areas characterized as creosote bush community. This vegetation type is abundant on the launch site and is not considered to be high-quality wildlife habitat. The loss of approximately 45 acres of habitat would impact only a small fraction of this community in the Trans-Pecos region and would not adversely impact the availability of habitat for wildlife populations.

Protected Species

Potential impacts of construction on protected species, if present in the project area, would be the same as those discussed in the previous wildlife subsection. As stated in Section 3.2, the only protected species that could potentially occur in vicinity of the launch site are the Northern aplomado falcon, Chihuahuan Desert lyre snake, and Texas horned lizard. Aplomado falcons are typically associated with large desert grassland expanses. Grasslands at the launch site are not extensive. As stated in the 2006 EA, only about 144 acres of the 18,600-acre launch site are classified as grassland. No falcons were observed during biological surveys of the proposed launch site in April 2005, which is the typical time period for nesting of this species in Texas. A project-specific review request submitted to the TPWD Texas Natural Diversity Database resulted in no records of any state or federally listed species potentially occurring within the project area (Gottfried 2013). Additionally, there is no state record in recent history (approximately 60 years) of Northern aplomado falcons within Culberson County (Shackelford 2013). Based on the lack of presence of Northern aplomado falcons in the project area, the minimal suitable habitat (desert grassland), and because no construction activities would occur within the grassland community at the launch site, construction activities would have no effect on the Northern aplomado falcon.

Potential habitat for the Chihuahuan Desert lyre snake within the launch site is very limited, and occurs along the limestone ridge bisecting the western portion of the site. No construction is planned for this area; thus, construction activities would not adversely affect this species.

The Texas horned lizard is found in a variety of habitats and could occur within the launch site. No lizards were observed during biological surveys of the proposed launch site in April 2005. Also, as noted above, a project-specific review request submitted to the TPWD Texas Natural Diversity Database resulted in no records of any lizards occurring within the project area. Nevertheless, existence of the lizard at the launch site cannot be ruled out. Construction activities would impact only a relatively small portion of the species' habitat in Culberson County or the Trans-Pecos region. Population impacts on this species would not be expected.

4.1.3.2 Operation

Potential operational impacts on terrestrial wildlife and plants would be similar to those types of impacts discussed in the 2006 EA as summarized below.

Plants

Operational activities that would impact vegetation include grounds maintenance and maintaining firebreaks (i.e., prohibiting growth of vegetation) around launch and landing pads. Although operational activities would be long-term, they would occur in areas that do not provide locally or regionally important vegetation. These activities would not adversely affect local or regional diversity of plants and plant communities. Therefore, associated operational impacts on vegetation would be negligible and less than significant.

Nominal launch operations would not affect vegetation, since launch operations would be conducted over a concrete launch pad. Similarly, landing and recovery efforts would either be conducted over a concrete landing pad or would occur within a 4-mile radius of the launch pad. As a result of creating a larger fire break around the launch and landing pads, no high temperature exhaust gases would come near the surrounding vegetation during launches and landings that occur on a pad. In cases where the RLV lands within a 4-mile radius of the landing pad, individual plants could be injured or destroyed if the RLV were to land on a plant(s). Also, Blue Origin recovery efforts (e.g., transporting a vehicle to retrieve the RLV) could injure or destroy individual plants. These potential impacts would be minor and not significant—no changes in local plant populations would occur.

Any potential fires that occur during a launch or landing would be immediately suppressed, limiting the potential for vegetation impacts. Fires during a launch are unlikely, because these activities would occur over concrete pads that have been cleared of surrounding vegetation. The same is true for landings that would occur over a pad. For landings that would occur within a 4-mile radius of the landing pad, fires could occur but would be immediately suppressed.

Although chemicals from vehicle launch emissions can impact vegetation, significant impacts would not be expected from proposed launch operations. The proposed permitted/licensed RLVs would use LOx and LH2 as the propellants. Using this propellant combination, emissions would consist mostly of water vapor.

Wildlife

Operational-related activities that could impact wildlife include licensed/permitted and amateur RLV launches, ground testing activities (see Exhibit 2-7), and launch of weather balloons. Day-to-day operations around the launch site would not extend beyond the developed areas and would be expected to cause only minor disturbance to animals inhabiting the area. Similarly, minor, if any, disturbance to animals would be expected for nominal post-launch/recovery operations. These operations would be infrequent throughout the year (see Exhibit 2-4) and would not result in significant impacts on wildlife.

Potential impacts on wildlife from noise generated during ground testing activities and launches can be categorized as primary, secondary, or tertiary (Janssen 1980). Primary effects are direct physical auditory changes, such as eardrum rupture, ossicle shattering, temporary and permanent hearing threshold shifts, and the masking of auditory signals from other individuals or the environment. Secondary effects of noise on wildlife include such non-auditory effects such as stress, behavioral changes, interference with mating, and detrimental changes in the ability to obtain sufficient food, water, and cover. Tertiary effects are the cumulative result of both primary and secondary effects, and may include population declines, destruction of important habitat and, in extreme cases, potential species extinction.

Animals differ in their hearing sensitivity and susceptibility to noise impacts. For example, at mid-range frequencies, birds have a level of hearing sensitivity similar to that of the more sensitive mammals, but at lower and higher frequency extremes, birds tend to be less sensitive than mammals. Reptile hearing is less sensitive than that of either birds or mammals. Many species have shown an ability to acclimate to high noise levels, including sonic booms, with no adverse primary, secondary, or tertiary impacts. This finding is supported by research conducted by the U.S. Air Force (1999) on the effects of jet noise (including sonic booms) from aircraft on the desert tortoise. The results of this study confirmed field observations that desert tortoises acclimate to aircraft-related noise exposure and do not exhibit significant adverse effects related to their hearing, behavior, or heart rate. In general, reptiles have shown little startle response to aircraft noise indicating possible low sensitivity to aircraft noise levels. Other species, including falcons, bighorn sheep, and wild horses, are known to successfully and consistently reproduce throughout ranges where aircraft operations occur.

As noted in Section 4.1.2.2 above, launch noise for the RLVs was modeled to peak at approximately 80 dBA at approximately 8 miles from the launch pad. Noise generated from launches and engine testing would most likely temporarily displace wildlife and could cause increased heart rates, abandoned nests, and consumption of additional energy. Wildlife would be disturbed, but would be expected to resume normal activity within minutes of a launch.

In addition to engine noise, sonic booms are another source of launch-related noise that could affect wildlife (see Section 4.1.2.2). As discussed in Section 4.1.2, two sonic booms would be generated during a launch—one during vehicle ascent and another during descent, prior to landing. Only the descent boom would impact the ground and could be heard.

The duration of a sonic boom is brief, less than a second, and the intensity is greatest directly under the flight path and weakens as distance from the flight track increases. The sonic boom generated during RLV landing would be centered on the landing pad, meaning that the sonic boom magnitude would be relatively low outside of the launch site. It would have a duration of less than 180 milliseconds and a peak overpressure of 2.0 psf. Under the Proposed Action, this could occur up to 54 times a year (in years 2017–2019; see Exhibit 2-4).

The following two paragraphs present a summary of studies addressing the potential impacts of sonic booms on wildlife.

Teer and Truett (1973) tested quail eggs subjected to sonic booms at 2, 4, and 5.5 psf and found no adverse effects. Heinemann and LeBrocq (1965) exposed chicken eggs to sonic booms at 3–18 psf and found no adverse effects. In a mathematical analysis of the response of avian eggs to sonic boom overpressures, Ting et al. (2002) determined that it would take a sonic boom of 250 psf to crack an egg. Bowles (1995) states that it is physically impossible for a sonic boom to crack an egg because one cannot generate sufficient sound pressure in air to crack eggs.

Teer and Truett (1973) examined reproductive success in mourning doves, mockingbirds, northern cardinals, and lark sparrows when exposed to sonic booms of 1 psf or greater and found no adverse effects. Awbrey and Bowles (1990) in a review of the literature on the effects of aircraft noise and sonic booms on raptors found that the available evidence shows very marginal effects on reproductive success. Ellis et al. (1991) examined the effects of sonic booms (actual and simulated) on nesting peregrine falcons, prairie falcons (*Falco mexicanus*), and six other raptor species. While some individuals did respond by leaving the nest, the response was temporary and overall there were no adverse effects on nesting. Lynch and Speake (1978) studied the effects of both real and simulated sonic booms on the nesting and brooding of eastern wild turkey (*Meleagris gallopavo silvestris*) in Alabama. Hens at four nest sites were subjected to between 8 and 11 combined real and simulated sonic booms. All tests elicited similar responses, including quick lifting of the head and apparent alertness for between 10 and 20 seconds. No apparent nest failure occurred as a result of the sonic booms.

Animal species exhibit a wide variety of responses to noise. It is therefore difficult to generalize animal responses to noise disturbances or to draw inferences across species, as reactions to jet aircraft noise and sonic booms appear to be species-specific. Consequently, some animal species may be more sensitive than other species and/or may exhibit different forms or intensities of behavioral responses.

The literature suggests that common responses include the "startle" or "fright" response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the numbers and frequencies of exposures, suggesting no long-term adverse effects. The majority of the literature suggests that domestic animal species (cows, horses, chickens) and wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms.

Based on the above information, and given the number of proposed annual launches (Exhibit 2-4) and short duration of the launch-related noise, significant adverse impacts to wildlife from the Proposed Action would not be expected.

In addition to launch-related noise, the launch of weather balloons would be another potential source of wildlife impacts. Blue Origin would be expected to release one weather balloon per launch, but in some meteorological conditions may release up to 10 balloons per launch (see Section 2.1.2). Each balloon would carry a radiosonde instrument package. A radiosonde flight can last in excess of two hours, and during this time the radiosonde can ascend to over 115,000 feet (21.8 miles) and drift more than 125 miles from the release point. When the balloon has expanded beyond its elastic limit and bursts (about 20 feet in diameter), a small parachute slows the descent of the radiosonde, minimizing the danger to lives and property.

The U.S. Government's National Weather Service releases approximately 75,000 weather balloons each year. Based on a proposed maximum number of 54 annual launches (see Exhibit 2-4), Blue Origin could launch 54 to 540 balloons per year (the latter figure based on highly conservative estimates of 10 balloons per launch for each of the 54 launches per year).

Most weather balloons burst when they reach an altitude of 5 to 20 miles and the limits of their elasticity are reached. A small percentage of weather balloons return to Earth undamaged or only partially shredded. Research has shown that at inland sites, balloons are not an environmental concern (Burchette 1989). Latex rubber balloons are highly degradable under a broad range of exposure conditions, including exposure to sunlight, water, and soil. Balloons degrade at about the same rate as oak leaves and about three times faster than small pieces of oak and pine wood (Burchette 1989). Therefore, weather balloons released in association with launches at the launch site would not have a significant ecological impact.

Protected Species

Potential impacts of operations on protected species, if present in the project area, would be the same as those discussed in the previous wildlife subsection. The only protected species that could potentially occur in vicinity of the launch site are the Northern aplomado falcon, Chihuahuan Desert lyre snake, and Texas horned lizard. No falcons were observed during biological surveys of the proposed launch site in April 2005, and a project-specific review request submitted to the TPWD Texas Natural Diversity Database resulted in no records of any state or federally listed species potentially occurring within the project area. Additionally, there is no state record in recent history (approximately 60 years) of Northern aplomado falcons within

Culberson County (Shackelford 2013). Based on the lack of presence of Northern aplomado falcons in the project area, the minimal suitable habitat (desert grassland), and because launch noise and sonic booms would largely be contained within the boundaries of the launch site, operational activities would have no effect on the Northern aplomado falcon.

Potential habitat for the Chihuahuan Desert lyre snake within the launch site is very limited, and occurs along the limestone ridge bisecting the western portion of the site. The Texas horned lizard is found in a variety of habitats and could occur within the launch site. It is possible that small numbers of these two state-listed species could be disturbed by launch noise and sonic booms. Any disturbance would be brief (less than approximately one minute) and would occur infrequently (see Exhibit 2-4) throughout the year. Depending on the individual's sensitivity to noise, there would like be some level of startle response, with normal activity ceasing for approximately one minute, then resuming when the launch noise or sonic boom diminished. Population impacts on these two species would not be expected.

4.1.4 Hazardous Material, Pollution Prevention, and Solid Waste

FAA Order 1050.1E does not identify a significant impact threshold for hazardous material, pollution prevention, and solid waste.

4.1.4.1 Construction

Potential impacts related to hazardous materials, pollution prevention, and solid waste from construction activities would be similar to those types of impacts discussed in the 2006 EA. Construction activities would use small quantities of hazardous materials, which would result in generation of small volumes of hazardous wastes. The hazardous materials that are expected to be used are common to construction activities and include diesel fuel, gasoline, hydraulic fluids, oils and lubricants, welding gases, paints, solvents, adhesives, and batteries. Appropriate hazardous material management techniques would be followed to minimize their use and waste disposal.

Nonhazardous and hazardous waste generated during construction of facilities would include construction debris, empty containers, spent solvents, waste oil, and spill cleanup materials (if used). Construction contractors would be responsible for safely removing these wastes from the site for recycling or disposal in accordance with applicable requirements.

Because construction activities would comply with all applicable Federal, state, and local regulations related to hazardous materials, environmental pollution, and solid waste, there would be no significant impacts.

4.1.4.2 Operation

Potential impacts related to hazardous materials, pollution prevention, and solid waste from operational activities would be similar to those types of impacts discussed in the 2006 EA. The majority of the hazardous materials used in launch operations are the propellants for the RLV. The Proposed Action involves two RLV propellants not analyzed in the 2006 EA—LOx and LH2. These propellants would be used in RLVs not currently operated at the launch site. Under the Proposed Action, propellant storage areas for LOx and LH2 would be installed near the launch pad, but would include concrete blast-protection walls, and would accommodate a hydraulic power unit and the storage of pressurant gasses at high pressure such as nitrogen and helium, to support the RLV propulsion system and preflight operations. The LOx above-ground storage tanks would have a total capacity of at least 50,000 gallons, or 473,077 pounds-mass. The oxidizer area would include an area for controlled dumping of LOx. The initial construction would include one 13,000-gallon storage tank. The LH2 above-ground storage tanks would have a total capacity of 150,000 gallons, or 84,000 pounds-mass. The initial construction would include two 25,000-gallon storage tanks. LH2 would be vented using vents and/or a burn stack.

Additional hazardous materials and wastes used and produced at the launch site as part of operations would include liquefied petroleum gas fuel (used in the hydrogen flare stack burner), explosives (hazard/class divisions: 1.3C, 1.4B, 1.4C, and 1.4S), oil, and spent batteries from maintenance or transport vehicles. Blue Origin has developed spill prevention plans for relevant hazardous materials. However, spill prevention plans have not been developed for solid materials (e.g., materials which do not "spill"); materials that would evaporate/boil-off before any spill could be cleaned up (e.g., cryogenics); or materials for which the quantity used is so small that it does not warrant a spill prevention plan (e.g., hydraulic fluid). Proper engineering, administrative controls, and spill prevention plans would be implemented to avoid spills and uncontrolled releases of hazardous materials. However, should the intended controls fail to prevent a spill or uncontrolled release of chemicals, a Chemical Emergency Response Plan is in place to minimize hazards to employees and the environment.

Substantial impacts to the environment are not expected from the presence of hazardous materials and wastes during launch site operations. Because activities associated with the Proposed Action would comply with all applicable Federal, state, and local regulations related to hazardous materials, environmental pollution, and solid waste, there would be no significant impacts.

4.1.5 Historical, Architectural, Archaeological, and Cultural Resources

A significant impact may occur if the Proposed Action would result in a finding of adverse effect to a historic property protected by the NHPA (FAA Order 1050.1E, Appendix A, Section 11.3).

4.1.5.1 Construction

Construction would involve ground-disturbing activities. The location of the ring road and LOx and LH2 storage contains no historic properties or archaeological sites listed in or eligible for listing in the NRHP. The Proposed Action would not require any removal, alteration, or physical impingement of any known archaeological resources or historic properties. If, during construction activities, previously unknown cultural deposits are discovered, construction activities would cease and a qualified archaeologist would evaluate the discovery in consultation with the Texas State Historic Preservation Officer (SHPO).

As part of assessing potential impacts of the Proposed Action on historic properties in compliance with the NHPA, Blue Origin submitted a draft report entitled *Cultural Resource Survey of Approximately Five Acres Within the Blue Origin Launch Facility, Culberson County, Texas* (GMI 2012a) (see Appendix B) to the Texas SHPO for review on November 10, 2012. The draft report noted that the survey found no archaeological sites eligible for listing in the NRHP and recommended that the proposed undertaking would have no adverse effect on historic properties. On December 10, 2012, the SHPO issued a "No Historic Properties Affected" determination for the proposed undertaking. On January 17, 2013, Blue Origin submitted the final cultural resource survey report (GMI 2012b), including the *Abstracts in Texas Contract*

Archeology Summary Form, to the SHPO (see Appendix A for correspondence with the SHPO). Thus, the Proposed Action would not have a significant impact on historical, architectural, archaeological, or cultural resources.

4.1.5.2 Operation

In general, the various sizes and configurations of development and commercial RLVs launched under the Proposed Action would be similar to the vehicle described in the 2006 EA. Therefore, the Proposed Action would not represent a new type of activity in the area that would affect the character or setting of cultural resources. Direct impacts on cultural resources from maintenance or other operational-related activities at the launch site would be unlikely, because these activities would take place within areas already disturbed by construction. As noted above under the construction subheading, the SHPO issued a "No Historic Properties Affected" determination for this proposed undertaking. Thus, the Proposed Action would not have a significant impact on historical, architectural, archaeological, or cultural resources.

4.2 No Action Alternative

Under the No Action Alternative, the FAA would not issue experimental permits or launch licenses to Blue Origin for operation of suborbital RLVs at the West Texas launch site. Existing or planned Blue Origin activities that do not require an FAA permit or license could occur at the launch site. The No Action Alternative assumes that construction, ground operations, and amateur launches as described in Chapter 2 would occur (see Sections 2.1.5, 2.1.6, and 2.1.7).

The No Action Alternative would not satisfy the purpose of the Proposed Action, which is to fulfill the FAA/AST's responsibilities under the Commercial Space Launch Act for oversight of commercial space launch activities, including issuing experimental permits and launch licenses to operate reusable suborbital rockets. Similarly, the No Action Alternative would not satisfy the need for the Proposed Action, which results from the statutory direction from Congress to encourage, facilitate, and promote commercial space launches and reentries by the private sector and facilitate the strengthening and expansion of the U.S. space transportation infrastructure.

4.2.1 Air Quality

4.2.1.1 Construction

As discussed in Section 4.1.1.1, construction would not lead to any violation of the NAAQS. Thus, there would be no significant air quality impacts from construction.

4.2.1.2 Operation

Estimated emissions from amateur rocket launches and ground testing are provided in Exhibits 4-3 and 4-4, respectively. Emissions below 3,000 feet altitude from amateur rocket launches and ground testing are provided in Exhibit 4-6. As discussed in Section 4.1.1.2, these activities would not lead any violation of the NAAQS. Thus, there would be no significant air quality impacts from operations.

4.2.2 Noise

4.2.2.1 Construction

Potential construction-related noise impacts would be the same as discussed above under the Proposed Action (see Section 4.1.2.1). The construction-related noise would not be appreciable off site, given the size of the property, the proximity of the construction activity to the highway, and the sparseness of the surrounding population. Workers would be protected from potential noise-related impacts in accordance with OSHA regulations. Construction-related noise would be temporary and would not result in significant noise impacts.

4.2.2.2 Operation

Potential operational noise impacts would be similar to those types of impacts discussed above under the Proposed Action (see Section 4.1.2.2) but to a lesser degree. Noise would be generated from engine testing and amateur launches. Noise analysis for engine testing indicates that the 65 DNL contours associated with engine testing would be completely within the launch site's boundary. Because there are no noise sensitive areas within the launch site boundary, there would be no significant noise impacts from engine testing. Regarding amateur launches, because of the rockets' relatively small size, thrust, and infrequent launches, associated noise levels would not result in significant noise impacts.

4.2.3 Biological Resources (Fish, Wildlife, and Plants)

4.2.3.1 Construction

Potential construction impacts on biological resources would be the same as discussed above under the Proposed Action (see Section 4.1.3.1). Construction-related activities would not be expected to result in significant impacts on biological resources.

4.2.3.2 Operation

Potential operational impacts on biological resources would be similar to those types of impacts discussed above under the Proposed Action (see Section 4.1.3.2) but to a lesser degree. Impacts on vegetation could occur from grounds maintenance and maintaining firebreaks (i.e., prohibiting growth of vegetation) around existing launch and landing pads. Although operational activities would be long-term, they would occur in areas that do not provide locally or regionally important vegetation. These activities would not adversely affect local or regional diversity of plants and plant communities. Therefore, associated operational impacts on vegetation under the No Action Alternative would be negligible and less than significant.

Operational-related activities under the No Action Alternative that could impact wildlife include amateur launches, ground testing activities, and launch of weather balloons. Day-to-day operations around the launch site would not extend beyond the developed areas and would be expected to cause only minor disturbance to animals inhabiting the area. Potential impacts on wildlife from noise generated during ground testing activities and amateur launches would be similar to those impacts discussed in Section 4.1.3.2. Animal species exhibit a wide variety of responses to noise. It is therefore difficult to generalize animal responses to noise disturbances or to draw inferences across species. Consequently, some animal species may be more sensitive than other species and/or may exhibit different forms or intensities of behavioral responses.

The literature suggests that common responses include the “startle” or “fright” response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the numbers and frequencies of exposures, suggesting no long-term adverse effects. The majority of the literature suggests that domestic animal species (cows, horses, chickens) and wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms.

Based on the literature, the frequency and duration of ground testing and amateur launches, and the short duration of the operational-related noise, significant adverse impacts to wildlife from the No Action Alternative would not be expected.

Regarding weather balloons, research has shown that at inland sites, balloons are not an environmental concern (Burchette 1989). Latex rubber balloons are highly degradable under a broad range of exposure conditions, including exposure to sunlight, water, and soil. Balloons degrade at about the same rate as oak leaves and about three times faster than small pieces of oak and pine wood (Burchette 1989). Therefore, weather balloons released in association with amateur launches at the launch site would not have a significant ecological impact.

4.2.4 Hazardous Material, Pollution Prevention, and Solid Waste

4.2.4.1 Construction

Potential construction impacts related to hazardous materials, pollution prevention, and solid waste would be similar to those discussed above under the Proposed Action (see Section 4.1.4.1). Because construction activities would comply with all applicable Federal, state, and local regulations related to hazardous materials, environmental pollution, and solid waste, there would be no significant impacts.

4.2.4.2 Operation

Potential operational impacts related to hazardous materials, pollution prevention, and solid waste would be similar to those types of impacts discussed above under the Proposed Action (see Section 4.1.4.2). However, LOx and LH2 would not be used at the launch site. Because operational activities would comply with all applicable Federal, state, and local regulations related to hazardous materials, environmental pollution, and solid waste, there would be no significant impacts.

4.2.5 Historical, Architectural, Archaeological, and Cultural Resources

4.2.5.1 Construction

Potential construction impacts to historical, architectural, archaeological, and cultural resources would be the same as those discussed above under the Proposed Action (see Section 4.1.5.1). The SHPO issued a “No Historic Properties Affected” determination for the proposed undertaking. Thus, construction activities would not have a significant impact on historical, architectural, archaeological, or cultural resources.

4.2.5.2 Operation

Potential operational impacts to historical, architectural, archaeological, and cultural resources would be similar to those types of impacts discussed above under the Proposed Action (see

Section 4.1.5.2). Though experimental permits or launch licenses would not be issued to Blue Origin, engine testing and amateur launches would still occur at the launch site. Because there are no historic properties located at or near the launch site, there would be no impacts on historic properties. The SHPO issued a “No Historic Properties Affected” determination for the proposed undertaking. Thus, operational activities would not have a significant impact on historical, architectural, archaeological, or cultural resources.

5. CUMULATIVE IMPACTS

In accordance with FAA Order 1050.1E, Change 1, and the CEQ NEPA implementing regulations, the FAA analyzed the potential cumulative impacts to the resources that would be adversely affected by implementation of the Proposed Action or the No Action Alternative. Based on the findings and potential impacts described in Chapter 4, the cumulative impacts analysis focuses on air quality and noise, which would be expected to be the most affected impact categories. The FAA has determined that the potential impacts for all other environmental impact categories described in Chapter 4 of this EA would not meaningfully interact in time and space with the potential effects of other projects. Therefore, no cumulative impacts are anticipated on impact categories other than air quality and noise.

Past, present, and reasonably foreseeable actions at the West Texas launch site and surrounding area include Blue Origin planned construction, ground operations, and amateur activities see Sections 2.1.5, 2.1.6, and 2.1.7). There are no other reasonably foreseeable actions that would occur at or near the West Texas launch site such that potential cumulative impacts would occur. These actions, considered in conjunction with the Proposed Action, formed the basis for the cumulative impacts analysis.

5.1 Air Quality

The project region is predominantly undeveloped and contains very few emission sources other than the Blue Origin facilities. Most of the emissions in the vicinity of the Blue Origin site likely are due to vehicle traffic on lightly-traveled State Highway 54 which is located about 5 miles west of the launch and landing pads. Accordingly, cumulative impacts would not be expected to lead to violation of the NAAQS and therefore would not be significant.

5.2 Noise

The project region contains very few noise sources other than the Blue Origin facilities. As discussed in Sections 4.1.2 and 4.2.2, impacts from permitted/licensed launches, amateur launches, and ground testing activities would not result in significant noise impacts. The closest noise sensitive areas are located over 25 miles from the launch site. Accordingly, cumulative noise impacts would not be significant.

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7. LIST OF PREPARERS AND CONTRIBUTORS

This chapter lists the primary contributors to the technical content of this EA.

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8. AGENCIES CONTACTED

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Austin, Texas 78704

Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

APPENDIX A:

AGENCY CORRESPONDENCE

Texas Historical Commission

Blue Origin

RECEIVED
NOV 1 2 2012
TEXAS HISTORICAL COMMISSION

Robert Millman
Director of Government & Regulatory Affairs
Voice: 253-437-9367
Email: RMillman@BlueOrigin.com

2012 November 10

Via Email: tiffany.osburn@thc.state.tx.us

Ms. Tiffany Osburn
Regional Archeologist/Project Reviewer
Archeology Division
Texas Historical Commission
P.O. Box 12276
Austin, Texas 78704

Re: **Culberson County - Cultural Resources Survey**

Dear Ms. Osburn:

In 2005, Geo-Marine, Inc. (GMI) provided your office with Report of Investigation 342, the *Cultural Resources Survey Of The Proposed Blue Origin Launch Facility Project Area, Culberson County, Texas* (Ward and Osburn 2005). The Federal Aviation Administration (FAA) is the lead consulting agency for the Blue Origin launch facility.

The 2005 report involved a survey of 765 acres. Blue Origin is adding approximately 4.8 acres to the launch facilities, adjacent to the area previously surveyed. GMI surveyed the additional 4.8 acres, and found no prehistoric or historic archaeological sites (only a single artifact was identified during the survey, similar to the isolated cultural materials documented during the prior survey (Ward and Osburn 2005)). Attached please find draft report *Cultural Resource Survey Of Approximately Five Acres Within The Blue Origin Launch Facility, Culberson County, Texas* dated November 2012. In the Summary and Recommendations, "GMI recommends that the proposed development will have no adverse effect on historic properties." (p.29)

Based on that recommendation, Blue Origin plans to proceed with the development, but wanted you to have the enclosed Report for your office's file and historic database.

Please contact me if you have any questions. Thank you.

Sincerely,

Robert Millman

c (via email):

- Sherman Council (FAA/AST)
- Peter Condon (GMI)
- Stacey Zee (FAA/AST)

NO HISTORIC
PROPERTIES AFFECTED
PROJECT MAY PROCEED
by ____
for Mark Wolfe
State Historic Preservation Officer
Date 12/10/12
Track# 201302196

21218 76th Avenue S.: Kent WA 98032-2442

Page 1 of 1

Blue Origin

Robert Millman
Director of Government & Regulatory Affairs
Voice: 253-437-9367
Email: RMillman@BlueOrigin.com

2013 January 17

Via Federal Express (tracking #8010-3866-0346)

Ms. Tiffany Osburn
Regional Archeologist/Project Reviewer
Archeology Division
Texas Historical Commission
1511 Colorado Street
P.O. Box 12276
Austin, Texas 78704

Re: **Culberson County - Cultural Resources Survey**
Track # 201302190

Dear Ms. Osburn:

You may recall that on November 10, 2012 I sent you a draft cultural survey prepared by Geo-Marine, Inc. (GMI) in the above-referenced matter, and that the Texas State Historic Preservation Officer made a determination of "No Historic Properties Affected" on 12/10/12.

GMI has since finalized the draft. Enclosed for your file please find:

- Paper copies of:
  - The final copy of the cultural survey report: *Cultural Resource Survey Of Approximately Five Acres Within The Blue Origin Launch Facility, Culberson County, Texas* dated December 2012, prepared by GMI ("Final Survey Report")
  - An Abstracts In Texas Contract Archeology Summary Form related to the Final Survey Report.
- A CD-ROM with electronic copies of:
  - The Final Survey Report, with Figure 2
  - The Final Survey Report, with Figure 2 removed at the request of your office.

Thank you for your assistance with this review.

Sincerely,

Robert Millman

c (via email):

- Peter Condon (GMI)
- Daniel Czelusniak (FAA/AST)

21218 76th Avenue S., Kent, WA 98032-2442 Page 1 of 1

TEXAS HISTORICAL COMMISSION

real places telling real stories

January 24, 2013

Robert Millman
Blue Origin
21218 76th Avenue South
Kent, WA 98032-2442

Re: Project review under Section 106 of the National Historic Preservation Act of 1966
Final Report: *Cultural Resource Survey of Approximately Five Acres Within the Blue Origin Launch Facility, Culberson County, Texas*

Dear Colleague:

We are in receipt of the final report for the above referenced project. We will add the report to our agency library. Thank you for also sending a completed *Abstracts in Texas Contract Archeology* form and a copy of the report on a tagged PDF CD.

Thank you for your cooperation in this federal review process, and for your efforts to preserve the irreplaceable heritage of Texas. **If we may be of further assistance, please contact Tiffany Osburn (512/463-6096).**

Sincerely,

for
Mark Wolfe
Executive Director

MW/lft

RICK PERRY, GOVERNOR • MATTHEW F. KREISLE, III, CHAIRMAN • MARK WOLFE, EXECUTIVE DIRECTOR

P.O. BOX 12276 • AUSTIN, TEXAS • 78711-2276 • P 512.463.6100 • F 512.475.4872 • TDD 1.800.735.2989 • www.thc.state.tx.us

Federal Aviation Administration

U.S. Department of Transportation
Federal Aviation Administration

Office of Environment and Energy

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

January 31, 2014

Daniel Czelusniak
Office of Commercial Space Transport
Federal Aviation Administration
800 Independence Ave. SW
Washington, DC 20591

Dear Daniel,

The Office of Environment and Energy (AEE) has reviewed the proposed non-standard noise modeling method for the launch noise associated with the Blue Origin for operation of of various suborbital reusable launch vehicles (RLVs). This methodology is proposed to support the Supplemental Environmental Assessment for the Blue Origin West Texas Launch Site. The FAA previously analyzed the potential environmental impacts of issuing experimental permits and/or launch licenses to Blue Origin to operate suborbital RLVs (FAA 2006). In accordance with FAA Order 1050.1e, all non-standard noise analysis must be approved by AEE. This letter serves as AEE's response to the proposed noise method for the Supplemental Environmental Assessment for the Blue Origin West Texas Launch Site.

The methodology is a quantitative analysis based on the available methods for launch noise. The sonic boom measurement was computed using the FAA approved model, PC Boom. The FAA does not currently have an approved model for launch vehicles and the document includes a proposed noise modeling methodology for the launch vehicle. The proposed noise modeling method is based on available research and understanding.

Given the proposed launch noise method is based on available research on vehicle launches, this approach is appropriate for the Supplemental Environmental Assessment for the Blue Origin West Texas Launch Site. AEE concurs with the launch noise methodology used for this specific request. Please understand that this approval is limited to this particular Supplemental Environmental Assessment for the Blue Origin West Texas Launch Site and RLVs. Any additional projects using this or other launch noise methodologies or variations of the RLVs will require separate approval.

Sincerely,

Rebecca Cointin

Rebecca Cointin, Manager
AEE/Noise Division

APPENDIX B:

CULTURAL SURVEY

CULTURAL RESOURCE SURVEY OF APPROXIMATELY FIVE ACRES WITHIN THE BLUE ORIGIN LAUNCH FACILITY, CULBERSON COUNTY, TEXAS

by

Peter C. Condon

for:

Blue Origin, LLC
21218 76th. Avenue S.
Kent, Washington 98032-244

Report of Investigations No. 821EP

Geo-Marine, Inc.
A Subsidiary of Applied Research Associates, Inc.
4725 Ripley Drive
Space A
El Paso, Texas 79922

December 2012

GEO-MARINE GMI
A Subsidiary of Applied Research Associates, Inc.

MANAGEMENT SUMMARY

This report documents the results of a cultural resources survey of approximately 4.8 acres of land in west-central Culberson County, Texas. Blue Origin, LLC is currently developing a space launch facility on privately owned property approximately 35 miles (56.33 km) north of Van Horn, Texas, and five miles (8.05 km) east of Highway 54. The 4.8 acres targeted in this project fall within the launch facility footprint. The purpose of the survey was to document the presence or absence of archaeological resources, evaluate their potential eligibility for inclusion in the National Register of Historic Places (NRHP), and evaluate potential effects of the proposed undertaking. Compliance with Section 106 of the *National Historic Preservation Act* and its implementing regulations (36 CFR 800) is sought, because the proposed launch activity requires a license from the Federal Aviation Administration (FAA). This work was conducted by Geo-Marine, Inc. (GMI) on October 9, 2012 (GMI project No. 30704.00.01).

The current investigation included a Transect Recording Unit (TRU) survey of two rectangular-shaped parcels, measuring 50-m wide x 200-m long and 50-m wide by 150-m long, respectively. The combined survey area of both parcels, which fall within the launch facility footprint, covered a total of 11,549 square meters, or approximately 4.8 acres. The TRU survey was conducted using a crew of two persons walking transects spaced 15 m apart along the entire section. Vegetation was sparse and the ground surface visible across the entire survey area. No prehistoric or historic archaeological sites were recorded; only a single artifact was identified during the survey. The single artifact, a chert projectile point fragment, was recorded as an isolated occurrence. It is recommended that the proposed undertaking, development of the 4.8 acre parcels within the Blue Origin Launch Facility, would have no effect on historic properties.

CONTENTS

FIGURES

CHAPTER 1.
INTRODUCTION

This report documents an archaeological survey conducted by Geo-Marine, Inc., (GMI) for Blue Origin, LLC, of Kent, Washington, on October 9, 2012. Blue Origin, LLC is presently developing a space launch facility on privately owned property approximately 35 miles (56.3 km) north of Van Horn, Texas, and five miles (8.05 km) east of Highway 54 (Figure 1). The Area of Potential Effect (APE) for the proposed Blue Origin facilities was previously determined in consultation with the Texas State Historic Preservation Officer (SHPO) in 2005 (Ward 2006; Ward and Osburn 2005). Cultural resource investigations within that APE were conducted under Section 106 of the *National Historic Preservation Act* and its implementing regulations (36 CFR 800) because the proposed launch activity at the facility will require a license from the Federal Aviation Administration (FAA). Construction of the launch facility includes two tracts of land that are within the pre-determined 700 acre APE but have not been surveyed to date (Ward 2006; Ward and Osburn 2005). The purpose of this cultural resources investigation was to determine the presence or absence of archaeological resources, to evaluate any identified resource for its potential eligibility for inclusion in the National Register of Historic Places (NRHP), and to evaluate the potential impact of the proposed action to any identified historic properties.

The current investigation included a Transect Recording Unit (TRU) survey of two rectangular-shaped parcels, measuring 50-m wide x 200-m long and 50-m wide by 150-m long, respectively. The combined survey area of both parcels, which fall within the launch facility footprint, covered a total of 11,549 square meters, or approximately 4.8 acres. The purpose of the current survey was to assist Blue Origin, LLC, and the FAA with compliance with 36 CFR 800. During the present survey, GMI personnel investigated the presence/absence of archaeological resources within these two parcels; no historic properties were identified during the survey. Five shovel test pits were excavated during the project; all revealed shallow depositional soil sequences with no cultural materials. Only one isolated occurrence was identified and documented in the project area.

The present investigation consisted of a literature review, a records search for previously recorded sites within the APE of the launch facility including the current the project area, and pedestrian survey to identify cultural resources within the project area boundaries. The pedestrian survey was completed on October 9, 2012. Peter C. Condon served as Principal Investigator. Juan Arias fulfilled the duties of the field supervisor and was assisted by field technician Cullom.

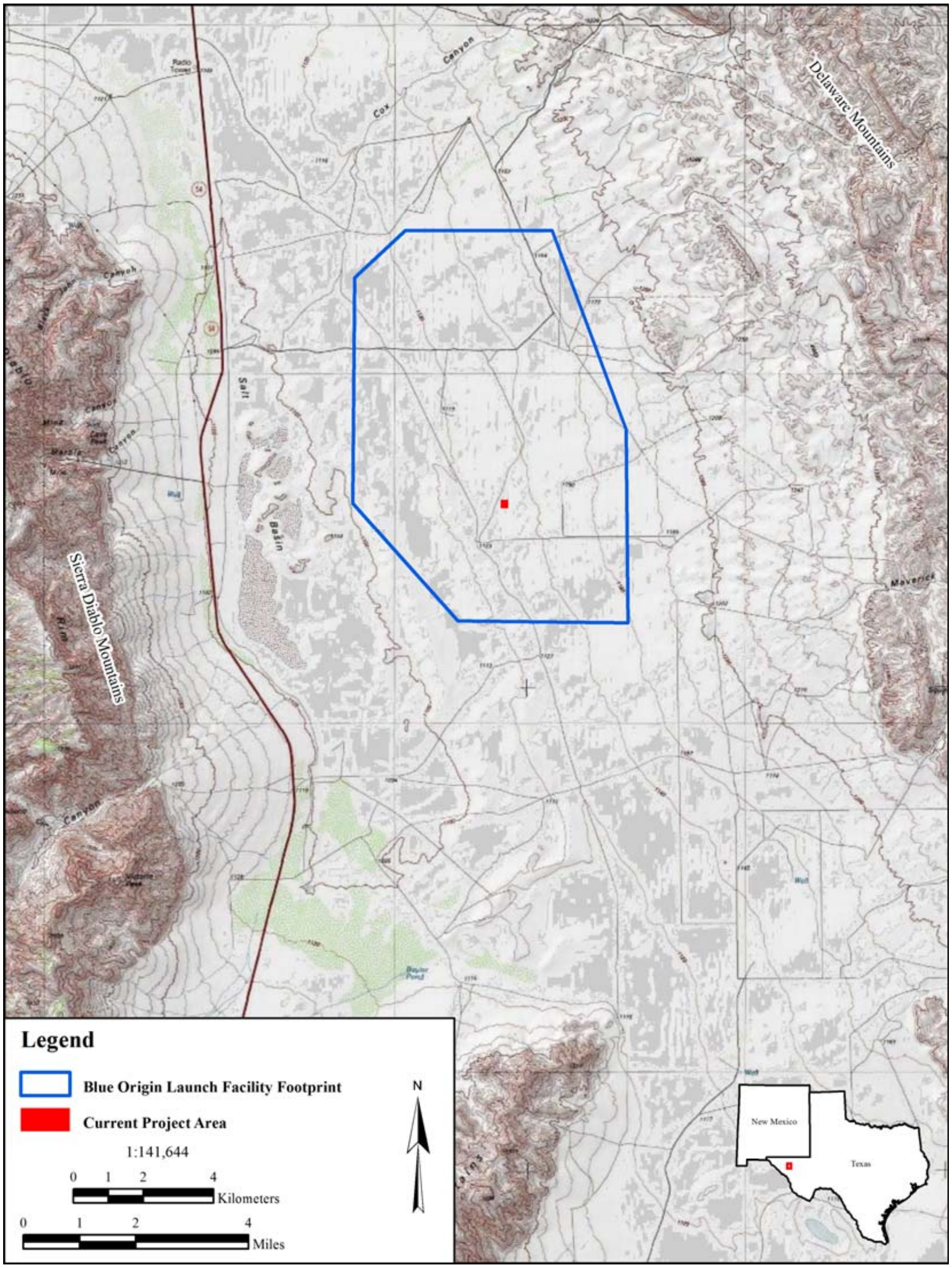

Figure 1. Map showing location of the the Blue Origin Launch facility within the greater Trans-Pecos area.

CHAPTER 2.
ENVIRONMENTAL SETTING

The following summary of the environmental setting was originally prepared for the Blue Origin Launch Facility survey conducted in June 2005 (Ward 2006; Ward and Osburn 2005). The current survey area is situated within the north-central part of the Chihuahuan Desert in the Trans-Pecos region of Texas, an area of basin-and-range topography that lies between two broad river valleys: the Rio Grande on the west and south, and the Pecos River to the east (Mallouf 1985; Simmons et al. 1989).

The Chihuahuan Desert is defined as having an average annual temperature of 19 degrees C (66.2° F), 75-300 mm (3.0-11.8 in) annual rainfall, and elevations ranging from 600-1,500 m (1968.5-4921.3 ft) above mean sea level (amsl; Morafka 1977:446). The eastern border of the Chihuahuan Desert is generally agreed to be in the same vicinity as the transition from the Basin-and-Range to the Great Plains physiographic province; in other words, 50 or so miles (80 km) east of the project area between the Rustler Hills and the Pecos River. The general climate in the project area then, is hot and dry, with little annual rainfall; when it falls however, it may come in torrents.

PHYSIOGRAPHY AND HYDROLOGY

Mallouf (1985:5) has broadly characterized the Interior sub-region of the Trans-Pecos region as an area ". . . of dramatic topographic relief, containing rugged mountains, plateau grassland, extensively dissected alluvial fans, volcanic outcrops, massive limestone canyons, deep alluvial valleys, flat topped mesas, undulating dune fields, and seemingly interminable saline flats." The roughly north-south trending mountain ranges are interspersed with wide internal drainage basins or bolsons. Elevations range from the highest point in Texas at Guadalupe Peak in the Guadalupe Mountains (2,667 m or 8,751 ft amsl) to a low of 488 m (1,600 ft) amsl at the confluence of the Pecos River with the Rio Grande. Most of the region falls between 914 and 1,524 m (3,000-5,000 ft) amsl in elevation.

Immediately to the east of the project area are the Delaware Mountains, which mark the 'boundary' between the Interior and Plains sub-regions of the Trans-Pecos region. The Plains sub-region consists of the Delaware and Toyah basins, and the Stockton Plateau. The basins are extensive plains of low relief while the plateau consists of dissected and eroded limestone mesas (Mallouf 1985:5). The general topography ". . . varies from flat plains to rocky canyon lands . . . the whole has been eroded below the once-continuous level of the High Plains" (Fenneman 1931:47), and is characterized by the solubility of the underlying bedrock. This solubility has led to the frequent presence of troughs, sinkholes, and caves.

The only permanent year-round source of water in the Trans-Pecos region is the Rio Grande; in good years, this may also include the Pecos River. Along the foothills and lower slopes of some of the more prominent mountain ranges—including the Davis, Guadalupe, and Delaware mountains—are both perennial and intermittent springs, the major sources of water throughout the interior (Mallouf 1985). Large draws in the area carry runoff from the mountains into the interior basins; arroyos, springs, seeps, tinajas, and playas also provide intermittent sources of water.

In the project vicinity – generally defined as the Salt Basin – there are few arroyos or draws that lead from the Diablo Mountains on the west into the interior basins. Water thus tends to flow in sheets down the alluvial fans to lower elevations. On the east, the Delaware Mountains are more dissected and the topography more rugged, with intervening arroyos fairly common.

GEOLOGY, SOILS, AND NATURAL FORMATION PROCESSES

The proposed Blue Origin project area lies within a vast depression between the Delaware Mountains to the east, and the Diablo Mountains to the west. The depression is geologically comprised of young Quaternary alluvial deposits. Quaternary-aged basin fill is flanked by Quaternary alluvial fan sediments (Barnes et al. 1992). The mountains are comprised of Paleozoic-aged sedimentary rocks, including limestone, dolomite, sandstone and shale in the Diablo Mountains, and sandstone, limestone, shale, and conglomerates in the Delaware Mountains (Spearing 1991). The limestones, particularly in the Diablo Mountains, are often cherty; sandstones may be either quartzitic or dolomitic.

This geologic setting provided abundant sources of raw material for use by prehistoric and historic inhabitants. Good siliceous stone, preferable for many uses, is readily available in all but the highest mountain ranges (Mallouf 1985). Boisvert (1980), Hedrick (1975), Katz and Katz (1974; 1993) and Shafer (1970) have all identified plentiful sources of cherts, cherty limestones, and quartzites in local archaeological assemblages from the north-central Trans-Pecos region that were most likely obtained locally. Hedrick (1989) has identified a number of good-quality chert and other lithic materials that come from Salt Flat, Michigan Flat, and adjacent landforms; among these are felsite, and white, butterscotch, and purple-and-tan cherts, all of which have been identified in archaeological contexts in the immediate region (e.g., Ward and Osburn 2005). Local sandstones provided quality raw material for ground stone and hearth stones; limestone is also abundant and fire-cracked limestone has been commonly noted on the modern ground surface within archaeological sites in the area.

Soils data from the Natural Resource Conservation Service (NRCS) are not available for Culberson County. The potential for intact, buried deposits however, has previously been addressed through an understanding of the geomorphic landforms that exist in the project vicinity (Ward and Osburn 2005). Mallouf (1985), for example, points to low ridges and other elevated landforms in and adjacent to the interior basins as areas protected from potential flood corridors, that are thus more likely to contain intact, buried deposits.

Within the original Blue Origin Launch Facility project boundary, there are three distinct elevated landforms: an alluvial fan of the Diablo Mountains, low limestone ridges, and a dunefield. Such elevated landforms, however, may be vulnerable to erosion through sheetwash and eolian processes, and the potential for intact, buried deposits is affected by these processes. Sheetwash is a process by which sediment is displaced by rolling along the ground surface; the degree of resultant erosion is determined by depth of the flow, ground slope, roughness of the ground surface, and the sediment load (Selby 1987:216). Eolian processes involve the transport of sediment by wind. Each landform is affected by different combinations of formation processes; however, as no elevated landforms were identified in the present project area, the reader is referred to Ward and Osburn (2005) for specific details.

These elevated locations often contain the remains of human occupation. None of these landforms however, was present within the boundaries of the present project area though all may be found within a several mile radius. Cultural resources identified during the current project are presumed to have likely resulted from loss during transport between such elevated landforms.

FLORA AND FAUNA

Mallouf (1985:5) describes four major biotic zones in the Eastern Trans-Pecos and adjacent regions: mountain, foothill, and basin zones, and, almost irrelevant to the present discussion, the riverine zone. The high mountains, including areas within the upper reaches of the Guadalupe Mountains just north of the project area, presently support forests and relatively dense stands of piñon and ponderosa pine, fir, spruce, oaks, and grasses. Mountain sheep, mountain lions, elk, deer, bear, and a wide variety of small mammals are representative of the fauna. These plants and animals, as well as others in this biotic zone, probably provided good sources of food, building materials, and other important items. The high mountains provide an oasis of sorts for fauna and flora that would not otherwise survive in the arid desert (Katz 1983).

The foothills, located within many of the lower mountain ranges, including the Delaware, Baylor, Diablo, and Van Horn mountains, as well as at lower elevations within the Guadalupe Mountains, provided a more diverse array of plant and animal resources that might also have been exploited. Flora transitions downward in elevation to include a range from juniper grassland to desert shrub; agave, sotol, and yucca are among the more frequent plant species. They provided good sources of both food and fiber to the prehistoric and historic occupants of the region (Mallouf 1985). In particular, Dering (2006) identifies fiber (e.g., for cordage and basketry) and food (e.g., fruits and flowers of the yucca and 'hearts' of the lechuguilla and sotol) uses for all these plants as well as others occurring naturally within this and other similar environments in West Texas. Medium-sized and small mammals, as well as various reptiles, are the dominant fauna; deer, mountain sheep, fox, and numerous different rodents have been identified in the Beach Mountains, just south of the project area (Stangl et al. 1993).

Interior basins, such as Salt Flat, where the project area is situated, and Michigan Flat to its south, are home to various succulent and semi-succulent desert scrub species. Dominant flora include creosote, ocotillo, prickly-pear; sub-dominant species, such as Texas persimmon, agave, sotol, and yucca are more restrictive in their distributions (Mallouf 1985). Localized, these species may be very common. Small mammals, such as cottontail and jackrabbit, are very common.

While it is some distance from the project area to the nearest riverine zone–approximately 100 km (62 mi) northeast to the Pecos River and 90 km (55 mi) southwest to the Rio Grande–numerous species of plants and animals were available there but nowhere else during the prehistoric era (Mallouf 1985). Occasionally, the long trip may have been worthy given abundant sources of willow, cane, and cottonwood, among others. Cane, for example, was a source of material for arrows as identified in the artifact collections from the caves in the Rustler Hills and would have required a relatively distant trip to a permanent water source for supplies (Ward 1992); cane was also used as a food resource, for musical instruments, and in the manufacture of containers (Dering 2006).

PALEOENVIRONMENT

Regional paleoclimatic and paleoenvironmental data have been summarized for the western two-thirds of the Trans-Pecos region by various researchers (Abbott 1996; Mallouf 1981; Mauldin 1995); this includes the present project area. At the end of the Pleistocene (10,000 B.P.), woodland and grassland communities were present throughout the region, based on analyses of packrat middens (e.g., Lanner and Van Devender 1981; Van Devender and Wiseman 1977) and pollen data (Bryant and Shafer 1977; Martin and Mehringer 1965). The climate was cool and moist in higher elevations, and cool and dry in the basins.

During the Paleo-Indian period, the higher elevations probably supported forest communities of ponderosa pine, Douglas fir, and spruce. Piñon-juniper-oak woodlands likely were present at elevations as low as 600 m (1,968.5 ft) in some areas (Mallouf 1985). Grass cover across the basins was likely more dense and the surface less eroded than today.

After the Pleistocene, there was a gradual warming and drying trend interspersed periodically with wetter periods that continued into the Historic era. Over time, there was a gradual shift of the denser stands of vegetation into higher elevations, leaving the basins nearly devoid of all vegetation except the sturdier succulents and semi-succulents. While the rate of this retreat is unknown, data do indicate that by 5000 B.C., a warmer, more savanna-like environment was spreading across the basins and lower elevations (Mallouf 1981). This would likely have provided a mixed woodland and desert-shrub plant community from which a diversity of plant species would have been available for exploitation (Mallouf 1985).

CHAPTER 3.
CULTURAL CONTEXT

As with the previous chapter, *Environmental Setting*, the following chapter was originally compiled as part of the original Blue Origin Launch Facility survey report (Ward and Osburn 2005). The chapter presented here has been edited and supplemented as appropriate (Ward 2006).

Lehmer (1948), Miller and Kenmotsu (2004), and Simmons et al. (1989) have all placed the 'boundary' between the Eastern Trans-Pecos region and the Western, or, as referred to in much of the present document, Jornada, region roughly at the Delaware Mountains, directly east of the project area (Figure 2). The cultural context provided in the following pages draws upon various regional summaries, project discussions, and site descriptions from both areas (e.g., Katz and Katz 1993; Mallouf 1985; Miller and Kenmotsu 2004; Simmons et al. 1989), with specific details provided as they apply to the present study. This part of the Trans-Pecos region of Texas has not received a tremendous amount of archaeological attention due to the predominance of privately owned lands, the prevalence of non-architectural, hunter-gatherer sites, and the region's remoteness (Miller and Kenmotsu 2004; Simmons et al. 1989).

PREVIOUS INVESTIGATIONS

A review of Texas Archaeological Research Laboratory (TARL) site files and the Texas Historical Commission (THC) Historic Sites Atlas revealed that in the immediate project area, the only sites recorded were those identified during the original launch facility survey project carried out by Ward and Osburn (2005). During that survey, seven archaeological sites (41CU692, 41CU693, 41CU694, 41CU695, 41CU696, 41CU697, 41CU698 and 29 isolated occurrences were identified. Two of these sites, 41CU692 and 41CU693 are within a 2-mile (3.2 km) radius of the present project area (Figure 2).

Sites 41CU692 and 41CU693 were situated on elevated limestone ridges and have been subject to extensive eolian deflation and sheetwash erosion (Ward and Osburn 2005). Site 41CU692 consisted of a large dispersed scatter of burned rock, groundstone fragments, and chipped-stone artifacts; no features or burned rock concentrations were noted.

Diagnostic artifacts recorded were affiliated with the Early Archaic, and Late Archaic/early Formative periods (Ward and Osburn 2005). Site 41CU693 lies along a low limestone ridge interspersed among creosotebush, mesquite, and grasses. This site consisted of a 37-x-50 m scatter of chipped stone, ground stone, and burned rock fragments. Neither diagnostic artifacts nor identifiable features were present at LA 41CU693. Both sites were determined not eligible for inclusion in the NRHP based the absence of intact subsurface deposits and the apparent erosion of the limestone ridge surface on which the sites were positioned (Ward and Osburn 2005).

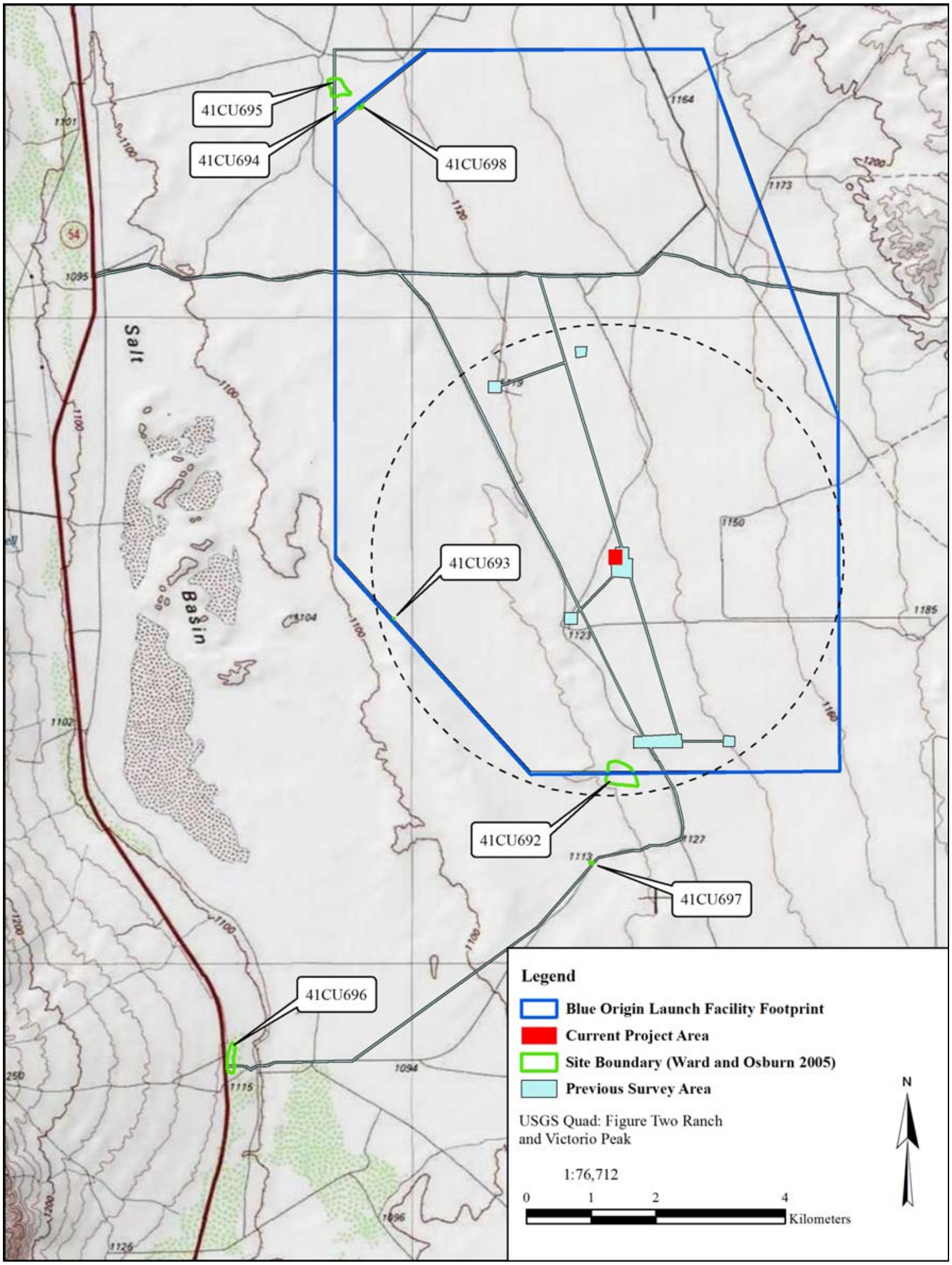

Figure 2. Map showing the Blue Origin launch facility border, previously identified site locations, and current project area (modified from Ward and Osburn 2005).

As the previously recorded sites search is expanded, sites have been recorded in all directions from the present project area: north in the Guadalupe Mountains and into adjacent parts of southeastern New Mexico; east of the Delaware Mountains in the Rustler Hills and beyond; south, in the Baylor, Apache, and Eagle mountains, and along Wild Horse Draw near Van Horn; and west, in and beyond the Diablo Mountains and into Hudspeth County. The sites recorded in these areas date to the full range of prehistoric occupation in the Jornada and Eastern Trans-Pecos regions, and represent many different types of archaeological use areas and occupations. The projects and sites recorded within them are briefly discussed in the following pages.

Howard (1932) began a survey and testing program of sites in and around the Guadalupe Mountains north of the project area, in the 1930s. This was the earliest professional archaeological work conducted in the region. At Burnet Cave, he exposed hearths, a Folsom-like projectile point, and extinct Pleistocene fauna. A radiocarbon date of 7432 ± 300 B.P. was later obtained from cave materials, but its association with the point and extinct fauna is questionable (Ayers 1936; Howard 1932; Roney 1995). Ferndon (1946) followed this with excavations at Hermit's Cave from which he was able to develop a good stratigraphic sequence and recover a collection of perishable artifacts. Mera (1938) produced the first major archaeological overview for the region, using both caves and open sites from which to draw his descriptions. Regionally distinctive characteristics first described in this work included rock cairns and circles, ring middens, and pictographs.

Surveys (Katz 1978; Katz and Katz 1974), excavations (Applegarth 1976), and summary volumes followed (e.g., Mallouf 1985). As work expanded throughout the region, numerous analytical and modeling projects ensue. These authors attempted to understand seasonal use of the region, issues of visibility given the natural processes of shifting sands, technological variations in lithic assemblages, chronological sequencing, and subsistence resources (e.g., Roney 1985; Winkler 1982). Excavation of Formative period sites specifically were conducted in the region (e.g., Katz 1983; Miller 1994), but relatively speaking, these excavations were rare in occurrence.

Eddy County, located just to the north of the project area, and in which the eastern scarp of the Guadalupe Mountains and Carlsbad Caverns are found, is archaeologically the best known of all the counties in southeastern New Mexico (Katz and Katz 1993). Over 4,000 individual surveys have been conducted in the county, with more than 2,000 sites and isolated occurrences found as a result. However, survey has accounted for most of the archaeological investigations, for of all sites identified in the county at the time of the Katz and Katz (1993) study, including both testing and excavation projects, only 56 were below the surface.

To the north and northwest of the project area, and also within the Salt Basin, surveys have been conducted in association with highway and fiber optic construction projects. Surveys along State Highway 54 immediately adjacent to the northwest of the project area recorded no archaeological sites (Hickman and Abbott 2003). Surveys farther to the northwest, near the State Highway 54/U.S. Highway 62/180 junction, recorded a few sites that are large prehistoric open campsites with Jornada Mogollon associations. These sites had multiple fire-cracked rock features and concentrations, lithic artifact scatters, and temporally diagnostic artifacts that indicated Late Archaic and Formative period affiliations (TARL site files: 41CU657-660); these sites were thought to represent use of the area by Jornada populations.

Stuart and Gauthier (1984) mention 106 Paleo-Indian period sites for southeastern New Mexico, dating from 10,000-5,500 B.C. Many of these sites are located along the eastern escarpment of the Guadalupe chain, the Mescalero Pediment, or the Llano Estacado. Hermits Cave, Blackwater Draw, and Milnesand are prominent examples. Hermits Cave lies in the Guadalupe Mountains just north of the project area.

In the 1930s, E.B. Sayles conducted the first widespread investigations in the Trans-Pecos region as part of a survey of Texas (Sayles 1935, 1941). Working for Gila Pueblo, Sayles conducted excavations at cave sites to the east of the Delaware Mountains in the Eastern Trans-Pecos region. Other cave and shelter investigations in the same area were conducted by A.T. Jackson (1934, 1937), Hamilton (2001), and Skinner (1978). Materials from several of these sites were analyzed and summarized by Tanner (1949) and Ward (1992). Pointing to the extremely isolated location of Rustler Hills, in which these caves and rockshelters are located, Hamilton (2001) suggests that the populations living in the area from about A.D. 200-1450 or so were pushed into the region; he defines this occupation as the Castile phase.

In addition to relatively dense occupational debris and numerous burials in these cave and rockshelter sites, other cultural remains identified in the same area include ring middens near the caves' mouths and on adjacent landforms, and a limited amount of rock art within one cave. Occupational debris indicate a hunting and gathering subsistence economy focused on ". . . a narrow range of plant foods, especially grasses, lechuguilla, sotol, mesquite, and various cacti" and a broad range of animals, including rodents, and reptiles; deer and antelope were also hunted, but were not plentiful among the remains (Hamilton 2001:274).

Little archaeological work has been conducted to the south of the project area, though it has been included in several cultural resource overviews for, or that include, the Trans-Pecos region (Lehmer 1960; Mallouf 1985; Simmons et al. 1989). Among the archaeological investigations are those conducted and reported by Hedrick (1968, 1975, 1986, and 1989), as part of a long-term project to record collections from sites on private land in the Van Horn area. Other investigations were associated with the construction of a floodwater diversion channel in the vicinity of the Beach Mountains, just north of Van Horn and south of the project area (Cliff and Fifield 1980; Foster and Kelly 1987; Gerald 1978; Skinner and Bousman 1973), and road improvements under the Joint Task Force-Six actions in the vicinities of Van Horn and Sierra Blanca (Edwards and Peter 1993; Lowry 1999). Though Joe Ben Wheat and students from the University of Colorado excavated a Folsom habitation site along Chispa Creek, a tributary of Wild Horse Draw located south of Van Horn, these excavations were never reported and were only summarized by Lindsay (1969).

Hedrick (1989:133) summarizes site types in this region, based on a dataset including over a hundred sites, as including rockshelters, base camps, campsites, ring middens, rock circles, lithic quarries, lithic scatters, occurrences of rock art, rock cairns, and isolated hearths. Base camps consisted of '…extensive areas of cultural debris and associated features that may include multiple, separate, or overlapping rock hearths, burned rock scatters, fire-blackened sand, lithic work areas, and, occasionally, ring middens" (Hedrick 1989:132), while campsites were similar in content but smaller in size (e.g., sites described in Lowry 1999). Typical artifacts at these sites include chipped-stone debitage and tools, manos, metates, and other groundstone, and ceramic sherds. The projectile point forms recorded at these types of archaeological sites include ones dating from the Late Paleo-Indian through Late Prehistoric periods.

To the west of the project area, on the Diablo Plateau and other areas along the eastern extent of the Jornada Mogollon region, archaeological investigations have been less frequent. One site (41CU129) has been recorded on the eastern slope of the Diablo Mountains in Victorio Canyon. It is approximately 12 km west and upslope from the present project area (THC Historic Sites Atlas). This site was originally described as a circular, burned limestone midden measuring roughly 5 m in diameter and having an approximate depth of 20 cm; no formal recording was accomplished on this site and no further work conducted.

Jackson (1937:76) mentioned two burned rock middens in this immediate vicinity, but the other was not relocated at the time that 41CU129 was recorded. Intensive dating studies at sites in the

Diablo Plateau area west of the Diablo Mountains have been conducted in association with the All American Pipeline (Miller 1994) and Samalayuca Pipeline (Mauldin and Leach 1997), as well as at Wind Canyon (Hines et al. 1994).

CULTURAL CONTEXT

Miller and Kenmotsu (2004) provide the most thorough and recent summary of the archaeology of both the Jornada and Eastern Trans-Pecos regions. Other books and chapters from which the following discussions are summarized include Hamilton (2001), Katz and Katz (1993), Mallouf (1985), Simmons et al. (1989), and others, as referenced. The chronology is separated into two broad sequences: the Prehistoric and Historic eras.

PREHISTORIC ERA

While there are almost two distinct prehistoric chronologies that could be provided for the project area - the Eastern Trans-Pecos region for the area directly east and the Jornada Mogollon for the project area and the region to the west - both are included in a simultaneous discussion below. The 'boundary' between the two regions, which does broadly separate two areas that are culturally different from one another, is not as distinct as a line on a map; both areas need to be considered in an attempt to better understand the archaeology of the project area. In the following discussion, the project area is referred to as the central Trans-Pecos region.

PALEO-INDIAN PERIOD (10,000-6000 B.C.)

A typical view of Paleo-Indian period adaptations is of small, highly mobile bands with a subsistence base centered on the hunting of large mammals such as bison and mammoth. Broadly dated, this period extends from 10,000–6000 B.C. (Mallouf 1985; Miller and Kenmotsu 2004; Simmons et al. 1989). Since chronometrically-dated Paleo-Indian sites in the Trans-Pecos region are lacking, these dates are considered approximate for this specific region. While there are important Paleo-Indian period sites and extensive use localities from the adjacent Southern Plains region and farther to the west in the southern Southwest, relatively little is known about this period in the Trans-Pecos region of Texas.

Both Paleo-Indian period sites (e.g., Chispa Creek near Van Horn; see Lindsay 1969) and isolated occurrences of Paleo-Indian period projectile points have been reported from the region, however, they are relatively rare. Miller and Kenmotsu (2004) identify three issues possibly equally affecting the identification of Paleo-Indian period materials in the Trans-Pecos region. First, most of what is presently known about the central Trans-Pecos region during this early period is from surface manifestations; many sites dating to this period could be deeply buried. A second issue is the possible lack of recognition of these sites as dating to the Paleo-Indian period if the diagnostic tool forms are not present. Channel flakes from the fluting process of manufacturing projectile points might be easily recognized, but other tool and debitage forms might more easily blend in on the ground surface. The third primary issue perhaps affecting the general lack of recorded Paleo-Indian sites in the central Trans-Pecos region is assemblage mixing; many Paleo-Indian period locales were also used by later occupants. Since many archaeological manifestations in the region—dating from all time periods—are exposed on the modern ground surface, later occupational debris may be substantially mixed with earlier ones.

Paleo-Indian period occupation and use of an area is generally recognized through the presence of fluted and lanceolate projectile points. Fluted points, such as Clovis and Folsom, characterize the Early Paleo-Indian period, while lanceolate forms, such as Meserve, Golondrina, Angostura, and Scottsbluff, generally characterize the Late Paleo-Indian period.

Early Paleo-Indian Period

The earlier Clovis-era is the least known of the Paleo-Indian period occupations. Clovis projectile points are representative of the earliest known occupation of North America, and sites dating to the era are characterized by fluted Clovis projectile points associated with big game faunal remains, such as mammoth. The later Folsom-era is better known in the Trans-Pecos and adjacent areas. Amick's review (1994, 1996) of a broad database of Folsom sites and isolated occurrences from the Western Trans-Pecos region suggests that Folsom-era settlement of the region was focused on the hunting of non-bison large game and involved the use of very large territories, likely including bison-hunting on the Southern Plains.

The majority of Paleo-Indian materials from the Eastern Trans-Pecos region are from Guadalupe Mountains National Park in the north (e.g., Burnet Cave and Hermit Cave) and the Big Bend region in the south (Simmons et al. 1989; see summary in Mallouf 1985), though most of the southern manifestations are not from excavated contexts. There is, however, a cluster of Folsom-era Paleo-Indian sites and isolated occurrences from near Van Horn and isolated occurrences from the Baylor Mountains (Lindsay 1969; Sommer 1974).

Sommer (1974) identified Folsom materials from four sites in the central Trans-Pecos region. Chispa Creek is a habitation site south of Van Horn on a terrace of Wild Horse Draw (Lindsay 1969). Three Folsom points were found *in situ*, but almost a hundred were recovered from the modern ground surface. Channel flakes, blades, knives, gravers, and hundreds of scrapers were also identified. Lindsay (1969) has summarized the findings from Chispa Creek, but the excavations remain unreported. Other sites in the area include an apparent kill site and two sites from which Folsom projectile point fragments were recovered from surface contexts (Sommer 1974).

Late Paleo-Indian Period

Most of the Trans-Pecos region was likely occupied and used during the Late Paleo-Indian period; projectile points, such as Plainview, Golondrina, Angostura, and Meserve, have been found throughout the region (Hedrick 1975; Katz 1978; Mallouf 1985; Miller and Kenmotsu 2004; Simmons et al. 1989). While little is known about the specific lifeway of the Late Paleo-Indian period residents of the central Trans-Pecos region, this period is generally characterized as an adaptation of hunting large game animals near water sources.

Sites and isolated occurrences have been found in all major topographic zones—including mountains and alluvial fans—but are more common ". . . in basin landforms near major playas or along the margins of the Rio Grande Valley" (Miller and Kenmotsu 2004:217). Elsewhere in the Trans-Pecos region, farther away from major water sources, an earlier transition to the broad-based hunting and gathering adaptation that characterizes the Archaic period may be evident, as a result of the changing climatic conditions (see discussion below).

Mallouf (1985) summarizes much of the Late Paleo-Indian data from the Interior or Eastern Trans-Pecos region and suggests that the inhabitants were probably to some degree reliant on the hunting of large game animals such as bison, but that smaller game such as bighorn sheep and deer were being pursued in the mountains. Late Paleo-Indian sites have been found along playa margins, alluvial terraces at high and low elevations, basin valleys, hillslopes, and occasionally rockshelters.

ARCHAIC PERIOD (6000 B.C.-A.D. 200)

The Archaic period is generally characterized by a broad-spectrum hunting and gathering subsistence strategy, relatively small residential and local groups, and a high degree of seasonal residential mobility throughout each year within large territorial frames (Sebastian and Larralde 1989). Something else noted for this period, as opposed to the earlier Paleo-Indian period, is that there is considerable regional and temporal diversity. In other words, while Paleo-Indian period occupations may be generalized across a vast region, Archaic adaptations are more specific to a particular area.

In the central Trans-Pecos region, there is no evidence of the introduction of agriculture, as there is further to the west. Also, unlike farther to the south in the Big Bend and adjacent regions (e.g., Mallouf 1985), there is little evidence for large mammal hunting. Most of the emphasis appears to have been on hunting small mammals, along with a broad-based reliance on a diverse range of plants. Projectile points recovered from Archaic period occupations indicate some interactions with those populations in Lower Pecos and Central Texas, but not so much with northern Mexico and southern New Mexico.

Most researchers use a three-phase sequence to divide the Archaic period: Early, Middle, and Late. The divisions between these sub-periods are based on projectile point typologies and technological and morphological sequences developed in adjacent regions (Miller and Kenmotsu 2004:218; see also Mallouf 1985). The Archaic Chihuahua Tradition—using a four-phase sequence—has also been defined for a broad swath that includes much of the Trans-Pecos region (5000 B.C. - A.D. 200; MacNeish and Beckett 1987); their sequence and dates are not used in the present discussion. An independent chronology has not been established for the Trans-Pecos region.

Early Archaic (6000-3000 B.C.)

In both the Eastern Trans-Pecos and the Jornada region, our information about the Early Archaic period is severely lacking and is based on relatively few sites. However, one of the most enduring of features characteristic of the Trans-Pecos region first appears during the Early Archaic period. While few in number, rock or caliche thermal features are first recorded for this time period (Mallouf 1985; Miller and Kenmotsu 2004). In the western part of the region, these features, in which may be found moderate quantities of burned rock and small stains, are found buried in alluvial fan and central basin locations.

In the eastern part of the region, the association is less certain, but some burned rock middens and features have been found with Early Archaic period cultural remains. Ring and burned rock middens were most likely used for plant processing; Apaches and other Native Americans cooked sotol and lechuguilla bulbs in similar features (Bell and Castetter 1941) and remains of these plants have been found in some archaeological excavations of ring middens (Katz 1978; see discussion in Miller and Kenmotsu 2004). The appearance of such features during the Early Archaic period marks a definite transition to a broadening of the subsistence base. Like during the Paleo-Indian period, however, all indications are that there was a low population density, and that the population was highly mobile.

The lanceolate projectile point forms of the Late Paleo-Indian period give way to stemmed forms during the Early Archaic period; this technological change is widespread, though the types of stemmed points begin to differ between the Eastern and Western Trans-Pecos regions. The projectile point forms recorded in the Eastern Trans-Pecos region are comparable to those from central Texas, including Bulverde, Nolan, Wells, and Pandale types (Prewitt 1995). In the

Western Trans-Pecos, Jay and Bajada forms—more typical for the Oshara Tradition of the Southwest—are more common (Miller and Kenmotsu 2004).

For the central Trans-Pecos region, including the Blue Origin project area, there is currently no evidence identifying an Early Archaic period occupation. No Early Archaic components or isolated occurrences are known from the Salt Basin (Katz and Lukowski 1981) or from the Van Horn area (Hedrick 1975). Early Archaic forms have been found, however, in association with basin and foothill environmental zones in the southern part of the region, toward the Big Bend area (Mallouf 1985).

A possible increase in the use of rockshelters in this area is also noted. Early Archaic projectile points have also been reported from canyons high in the Davis Mountains (Marmaduke and Whitsett 1975), and on a more limited basis from high in the Guadalupe Mountains (Katz 1978). In the Guadalupe Mountains, eastern projectile point forms, including Pandale and Travis, have also been found at sites with lithic scatters and burned rock middens (Katz 1978; Mallouf 1985).

Middle Archaic (3000-1200 B.C.)

The Middle Archaic period appears to indicate a period of increasing populations in the Trans-Pecos region. Sites dating to this period are more plentiful, consist of a greater number of features, and are larger in size; this applies equally to the Eastern and Western Trans-Pecos regions (Mallouf 1985; Miller and Kenmotsu 2004). In the western part, sites tend to be found in the interior basin landforms, as well as the lower and upper terraces of the Rio Grande. In the eastern part of the region, sites are increasingly located along drainages, though numerous landform locations were used.

In general, few changes in either groundstone or chipped-stone artifacts, or the morphology of thermal features, have been noted from the Early to Middle Archaic periods. Though semi-sedentism—as suggested through the presence of informal structures—is indicated for the far western part of the region near El Paso, Texas, during the Middle Archaic period, no evidence for structures has been found in the central or Eastern Trans-Pecos regions (Camilli et al. 1988; O'Laughlin 1980). Feature and site types with which Middle Archaic diagnostic artifacts have been found include burned rock middens, ring middens and other thermal features, rockshelters, and lithic scatters. This indicates a continued emphasis on plant processing for subsistence.

A technological change that has been noted for this period from all across the Trans-Pecos region is the increasing variety of projectile point forms. Mallouf (1985) notes that projectile point forms from the Eastern Trans-Pecos region share a general affinity with those from central Texas, Coahuila, and the Lower Pecos region, while those from the western Trans-Pecos are more frequently similar to those from Coahuila and the southern part of the Southwest (Miller and Kenmotsu 2004). This seems to indicate a continued difference in the direction of interaction networks between those populations in the eastern and western parts of the Trans-Pecos region.

Though Middle Archaic sites are not as common in the central Trans-Pecos region as they are for other areas, they have been found in the major mountain ranges - including the Guadalupe Mountains - along high stream terraces and along ridge crests and benches (Mallouf 1985), and along arroyo cuts, and other landforms in and around the Davis Mountains to the south. Surveys in the Salt Basin have failed to identify Middle Archaic period remains, though some remains have been identified in the Van Horn area (Mallouf 1985).

Late Archaic (1200 B.C.-A.D. 200)

The most dramatic change from the Middle to Late Archaic period throughout the Trans-Pecos region is an apparent increase in population (Mallouf 1985; Miller and Kenmotsu 2004). This increase is manifested archaeologically through both a greater number of sites and the increased size of those sites – both in terms of greater quantities of features and an increase in the physical space across which sites are spread. Sites are also represented in more environmental settings including mountains, rockshelters, inter-montane basins, and in areas adjacent to or nearby springs (Ferndon 1946; Hedrick 1989; Mallouf 1985; Miller and Kenmotsu 2004; Roney 1995). Mallouf (1985) interprets this expansion to be the result of more favorable environmental conditions including increased precipitation that ended during the Late Archaic period but had promoted increased interaction among various hunter-gatherer groups—thus, while environmental conditions changed, the social environment was slower to respond.

A major technological innovation was the development of ceramic technology; brownware ceramics are certainly found dating to this period in the western part of the Trans-Pecos region (Miller and Kenmotsu 2004). A second innovation in the western part was the first conclusive evidence for the use of cultigens. While Late Archaic period use of ceramics likely occurred in the project area, there is presently no evidence to include the use of cultigens in the immediate area.

The subsistence economy during the Late Archaic in the interior of the Trans-Pecos region was most likely still centered on hunting and gathering. In the southern part, there is substantial evidence for the hunting of large mammals; this evidence consists primarily of the types of formal and informal tools in the lithic assemblages, which contrast sharply with the evidence from sites farther to the north (Miller and Kenmotsu 2004). Evidence from Rustler Hills suggests that smaller mammals were more important to the subsistence base than large ones in this more northerly region (Hamilton 2001; Holloway 1985; Ward 1992). A variety of burned rock feature types indicate a continued reliance on the processing of large amounts of plant remains as well.

LATE PREHISTORIC PERIOD/FORMATIVE PERIOD (A.D. 200-1450)

There were several significant transitions in the western Trans-Pecos region that occurred during the Formative period—including changes in landscape use, technologies, and subsistence (Miller and Kenmotsu 2004). During this period, there was an increasing reliance on domesticated plants. Corresponding changes included increased sedentism and emphasis on certain landforms for settlement and use. Most of the data used for these interpretations are from the far western part of the Trans-Pecos region, though changes there had an effect on populations in adjacent regions as well.

For the larger region, the early part of the Formative period is generally characterized as having a dispersed settlement system, the use of relatively ephemeral structures, such as huts, and the use of a range of environmental zones. There is a gradual shift through the period to the use of more substantial structures and to a focus on alluvial fans for settlements. Later still, there is a dual focus on alluvial fan and basin settlement, and the intensification of use of various plants, including both domesticated and non-domesticated (e.g., certain cacti, succulents, mesquite) species (Miller and Kenmotsu 2004).

The processing of massive amounts of these non-domesticated plant species is inferred by the presence of thermal features. In the western Trans-Pecos region, thermal features exhibit a variety of types, with different ones dominating at certain periods of time. The use of all such features declines after A.D. 1250 or so, indicating decreased reliance on cacti and other succulents thought to have been processed in the features (Miller and Kenmotsu 2004:251). Corresponding changes are noted in ceramics, ground stone and chipped stone through the Formative Period.

In the Eastern Trans-Pecos, changes in settlement, subsistence, and technology related to those above for the western Trans-Pecos region do not appear until after A.D. 1000, and, even then, are only varingly adopted (Mallouf 1985; Miller and Kenmotsu 2004). The bow and arrow, a nearly ubiquitous marker of the Late Prehistoric period, was adopted throughout the Eastern Trans-Pecos, but other technological changes were more selectively adopted. Ring middens, large camp sites with multiple hearths, and lithic scatters dominate among site types; in other words, there is largely a continuation of the subsistence and settlement systems established during the Late Archaic. At these same sites, there are both ceramics and arrow points in association with the burned rock features, lithic scatters, and ring middens (e.g., Jackson 1937). Though there is no direct evidence for the production of domesticated plants, there is some, though relatively minimal, evidence for the presence of domesticated plants in the project region. Cotton and corn have both been found in contexts dating to the Late Prehistoric period (e.g., Hamilton 2001; Jackson 1937; Roney 1995).

Pithouse architecture is present in the western part of the region during the entire period; circular ones are more common during the period until A.D. 1000 or so, at which point sub-rectangular structures become more common. In the eastern part of the region however, circular pithouse architecture may have continued unchanged through a later period. East of the Guadalupe Mountains, in Salt Flat Basin, Miller (1994) excavated two shallow pithouse structures. Radiocarbon dates obtained from floor and fill contexts range from A.D. 600-1280. He also identified a small hut structure in the Delaware Mountains that yielded various dates ranging from A.D. 1000-1400. Huts are more typically associated with short-duration occupation of an area, for they are of small diameter, shallow, and insubstantial (Miller and Kenmotsu 2004). A high degree of mobility is implied by their construction and use.

In the project area, there tends to be some evidence suggesting both ties with the Eastern and Western Trans-Pecos regions, as might be expected. Sebastian and Larralde (1989) and Miller (1994) have suggested that some sites in the north-central part of the Trans-Pecos region are the result of groups from the Jornada region seasonally using resources in the Eastern Trans-Pecos. The hut structure that Miller (1994) excavated in the Delaware Mountains was accompanied by a largely Formative-era Jornada Mogollon artifact assemblage, including El Paso Polychrome ceramics.

HISTORIC ERA

The Historic period in the Trans-Pecos began with European contact in the sixteenth century. Cabeza de Vaca is credited with being the first Spaniard in the Trans-Pecos, when, after having been shipwrecked on the Gulf of Mexico coast and held captive by native inhabitants, he escaped and wandered through the Trans-Pecos area in 1535 (Simmons et al. 1989:139). Subsequently, the formal expeditions of Rodriguez Chamuscado (1581), Espejo (1582), and Oñate (1598) followed several decades later, with Oñate's founding of Santa Fe, marking the inception of colonization.

By 1659 the first Trans-Pecos outpost and mission had been established in the E1 Paso area (Beckett and Corbett 1992:5). Indigenous peoples encountered in the Trans-Pecos area included agriculturalists designated by the Spanish as the Patarabueyes as well as nomadic bison hunters referred to as the Jumano. Both groups were reported in the area of the Rio Grande/Rio Concho confluence near present-day La Junta or Presidio, Texas.

Although plans for a series of presidios had first been suggested in 1667, none were established until 1729, when isolated settlements along the Spanish frontier were subjected to continuing raids by Apache and Comanche bands. The first attempted presidio along the Rio Grande, however, soon failed. Following the Pueblo Revolt of 1680, Spanish and sympathetic Pueblo Indians had retreated southward, which eventually led to the establishment of numerous missions in the E1 Paso area (Beckett and Corbett 1992:9).

It was not until 1738 that presidios were successfully established along the Rio Grande south of the E1 Paso missions, the first being located some 30 miles south of present-day Del Rio. In 1760 another presidio was constructed in the present-day La Junta region, but reportedly failed to curtail the Apache depredations in the area. Attempts to establish presidios and ongoing campaigns against the Apache continued until 1791, when a peace treaty was signed. Unfortunately, southward pressure by the Comanches shortly thereafter led to encroachment on Apache territories, thus rekindling frictions and forcing the withdrawal of the Spanish from the Big Bend area (Simmons et al. 1989:139).

Meanwhile, along the Rio Grande, villages inhabited by the Patarabueyes were being abandoned (Riley 1987:295-297). Undoubtedly, some of these peoples settled within the protective sphere of Spanish presidios (Beckett and Corbett 1992:15). It is not unlikely that others abandoned village life to return to a more nomadic subsistence, removed from the focus of raiding parties.

Uncertainties surrounding these aboriginal groups plague archaeological interpretations. It has been suggested that the Jumano were Apachean, or Athapaskan speakers (Kelley 1952:277-278; Riley 1987:297-298). Other researchers have argued that this historic period group may have been derived from the northern Rio Grande pueblos (Whalen 1977:8) and were part of the Uto-Aztecan linguistic group. Regardless of their cultural affiliation, which remains yet to be proven, both agricultural and nonagricultural peoples, other than the Apaches, were present both prior to and during the Spanish exploration period and their activity/habitational site characteristics have not been identified.

It was not until after 1846 that Euro-Americans substantially settled the Trans-Pecos. At that time, border and frontier defenses of the newly acquired state of Texas came under the administration of the United States (Bandy 1980:10). Construction of a series of military forts followed, which provided ample protection for the establishment and use of the Chihuahuan trail, a commerce and information artery that linked Trans-Pecos and western Texas to Chihuahua, Mexico. The Chihuahua trail followed the old Spanish route along the Rio Conchos to La Junta and then crossed overland to the northeast. The importance of the Chihuahua Trail in the Trans-Pecos area was twofold: (1) it diverted some of the trade from the Santa Fe Trail, promoting more interaction with urban areas such as San Antonio, and (2) it helped to establish new settlements (posts, forts, and towns) in the interior subregion (Simmons et al. 1989:140). Other smaller east-west trails (Neighbors-Ford and Smith and Whiting) were also blazed through the Trans-Pecos area from E1 Paso to San Antonio by 1849 (Pool et al. 1975:100). Both of these trails passed near the vicinity of Van Horn, and the Neighbors-Ford Trail actually passed through the Van Horn Mountains.

With the annexation of Mexican lands by the United States after the Mexican-American War (1846-1848), settlement of the Trans-Pecos area by Euro-Americans increased significantly. Fort Leaton and the town of Presidio were established in the La Junta area by 1848, and systematic mapping projects of the Trans-Pecos region were initiated in the early 1850s (Tyler 1975:77, 81, 101). From the Corps of Topographic Engineers, the naturalist-scientist William Emory made systematic observations of the environment along the Rio Grande valley and adjacent mountain areas, and passed through the Van Horn area in 1852 (Pool et al. 1975:104-105).

Fort Davis was established in 1854 to protect a newly blazed road from hostile Native Americans, primarily Apache and Comanches. The road was originally surveyed in 1850 (Tyler 1975:101). Shortly thereafter, the U.S. Army also sent a small garrison from Fort Davis to Van Horn Wells in the northwest (Wylie 1973:4-5). Van Horn Wells was established near a natural spring that was situated just south of the modern town of Van Horn at the northeastern edge of the Van Horn Mountains.

Based on an oral history from local 85-year-old Van Horn resident Evans Heans, there was a small military outpost located four to five miles "upstream in Van Horn Canyon on Soldier Springs Ranch--Diez y Ocho Camp" (Bearden 1977:2). Apparently this outpost was occupied until World War I (Bearden 1977:2). Another outpost called the "Valentine Fort" was also established somewhere in the vicinity of Van Horn (Bearden 1977:2). Many of these smaller establishments were set up by private landowners for protection against Indian attacks (Wylie 1973).

With the influx of prospectors and entrepreneurs passing through the Trans-Pecos region on their way to the California gold fields (Wylie 1973:1), more attention was focused on the interior subregion as a potential area for mining. As a result, silver mining began in the Chinati Mountains by 1860, and other mines were established a few years later in the vicinity of Marfa (Tyler 1975:138-145). As early as 1692, the Spanish, by then with villages established along the stretch of the Rio Grande southeast of El Paso, had begun mining for silver in the region; a necessary ingredient for the amalgamation of silver ore is salt (Hawthorne-Tagg et al. 1998).

The Salt Basin is mentioned as a resource area at this early date. Randolph B. Marcy, in 1849, traced a number of the early paths taken for salt collecting, and mentions the Salt Basin, otherwise known as the Guadalupe salinas, as a particularly pure source; hostile Native Americans in the area, however, prevented this source from being too widely used (Hawthorne-Tagg et al. 1998:46). In 1862, communities along the Rio Grande southeast of El Paso looked to the Salt Basin, north of the present project area, to provide their salt supply. A salt trail was established between El Paso and the Guadalupe salinas in 1863, and the Salt Basin became the primary source area for salt. Conflicts regarding the ownership of, and thus access to, these salt resources, arose, culminating in the El Paso Salt War in 1877 (Sonnichsen 1957, 1961). By the early 1880s, after the railroad had come to the region, the Guadalupe salinas were no longer important, as it now was cheaper to buy salt from Kansas than to pay the private landowners in the area (Miller 1989).

Many of the newly established nineteenth-century forts and settlements in the Trans-Pecos area suffered as a result of the Civil War due to the relocation of troops to the southeast. Fort Davis was abandoned, and as a consequence, raiding activities by the Apaches and Comanches increased significantly. Depredation by these mounted Native Americans was serious enough to force many settlers out of the area. Fort Davis was re-established several years after the end of the war and Native American hostilities subsided, until they resumed 1876 (Simmons et al. 1989:140).

Many of these latter raids were initiated by the Mescalero Apache under the leadership of Victorio. These raids lasted until his death in 1880 (Simmons et al. 1989:140; Tyler 1975:117-119). It is worth noting that somewhere in the Eagle Mountains or adjacent area there is an alleged battle ground (date unknown) where a contingent of black soldiers fought some Indians (Wylie 1973:11). Apparently some of the soldiers were killed and buried on the site (Wylie 1973:11).

Based on the oral history of Evans Heans, who moved to Van Horn in 1903, Indians camped "up and down" an unnamed river, perhaps Wild Horse Draw, where they "used to build a big fire, then take the rocks out and lay their venison or whatever on those hot rocks to cook it" (Bearden 1977:2). Heans was asked if this was the same way that the Native Americans (not named) cooked plants. He said no, "to cook Sotol they dug a well-like arrangement and put a fire in the well, the[n] put the plants in and cover[ed] them over until cooked" (Bearden 1977:2). According to Heans, the traces of these Native American encampments at one time could have been found along the edges of the river, but are scarce today because the sites have "been picked over" (Bearden 1977:1-2).

Significant increases in settlement of the Trans-Pecos area, especially in the interior subregion, began to re-occur after the end of Indian hostilities and the arrival of the railroads in the early 1880s (Simmons et al. 1989:140). The Southern Pacific Railroad linked E1 Paso with Sierra Blanca, which in turn fed to the interior settlements of Pecos and Marfa (Pool et al. 1975:164). Van Horn was established as a railroad water depot in 1881 (Handbook of Texas Online 2005a). Nine years earlier, Presidio County had been established and Jeff Davis County was founded later in 1887. As a result of the railroads, cattle ranching became a leading industry in the interior subregion (Simmons et al. 1989:140). The influx of ranchers for three decades contributed to the growth of Van Horn as a prosperous cattle-shipping center. The mining of tin and silver was also important in the late nineteenth and early twentieth century's (Handbook of Texas Online: Culberson County).

The present project area is within one of the early nineteenth century ranch boundaries—the Figure 2 Ranch. James Monroe Daugherty (1850-1942), a charter member of the Southwestern Cattle Raisers Association, purchased and founded the Figure 2 Ranch. He served as one of Culberson County's first commissioners upon its creation in 1911. In 1933, the Figure 2 Ranch was sold to legendary millionaire businessman James Marion West, Sr., of Houston. The property remained in his family until 1992 (Handbook of Texas Online 2005b). An historical marker, detailing the history of the ranch and Daugherty's presence in the Salt Flat area, is located just off Highway 54, west of the northwest corner of the project area.

In recent decades, tourism has become an increasingly important aspect of the local economy while agriculture has declined. In 1982, 828 Culberson County residents were employed in the service and related industries, while only 73 were employed in agriculture. Van Horn is the largest city in the county and is well situated in relation to Carlsbad Caverns in New Mexico, the Big Bend in Presidio County, and the Guadalupe Mountains in northern Culberson County

Chapter 4. SURVEY METHODS

METHODS

The current field investigations of the two rectangular-shaped parcels in the south half of the Blue Origin Launch Facility footprint were carried out using the TRU survey method (Figure 3). The parcels, designated Parcels A and B measured 50-m wide x 200-m long and 50-m wide by 150-m long, respectively. The combined survey area of both parcels covered a total of 11,549 square meters, or approximately 4.8 acres. Before fieldwork began, a literature review and records search was conducted to identify known cultural resources within 2 miles (3.2 km) of the parcels and to obtain information concerning the cultural context of the region. The initial review and search included the records maintained at TARL, the THC Historic Sites Atlas, and historic maps of the region, such as the General Land Office, and soil and road maps. These document searches were updated for the present survey, and only those sites recorded by Ward and Osburn (2005) as part of the initial Blue Origin Launch Facility survey had been included in this report.

Prior to fieldwork, the parcel corners were marked by Blue Origin, LLC personnel with wooden lathes and flagging tape. These stakes facilitated accurate identification of the survey area in the field. Fieldwork was conducted on October 9, 2012, and was carried out using the TRU method for documenting artifact scatters, concentrations and features that characterize potential archaeological sites. The TRU survey method utilizes precise global positioning system (GPS)-based location data coupled with systematic digital documentation of cultural materials and natural features using hand-held computers (PDA). This survey method provided a complete and consistent, 100-percent inventory of surface historic and prehistoric cultural resources within the selected parcels.

The TRU method included standard crewmember spacing of 15 meters. The 15-m-by-15-m grid grid system was superimposed over the two parcels with each 15-m-by-15-m cell along a specific transect line examined by the crewmember assigned to that transect. The UTM coordinates and survey transects were recorded in the field using the 1984 World Geodetic System (WGS 1984) coordinates, and then converted following fieldwork to the 1983 North American Datum (NAD 83 CONUS) coordinates

All archaeological resources and isolated occurrences encountered were recorded during the survey. Field notes concerning the survey process were maintained by the Field Supervisor. These field notes document survey conditions, vegetation cover, and initial interpretations of the cultural properties. When applicable, artifacts and their attributes (primarily artifact class, subclass, and material type) were recorded. A photographic record was kept and used to document the general topography and condition of the project area at the time of the survey and any cultural materials identified during the course of the survey. All photographs were taken in digital format.

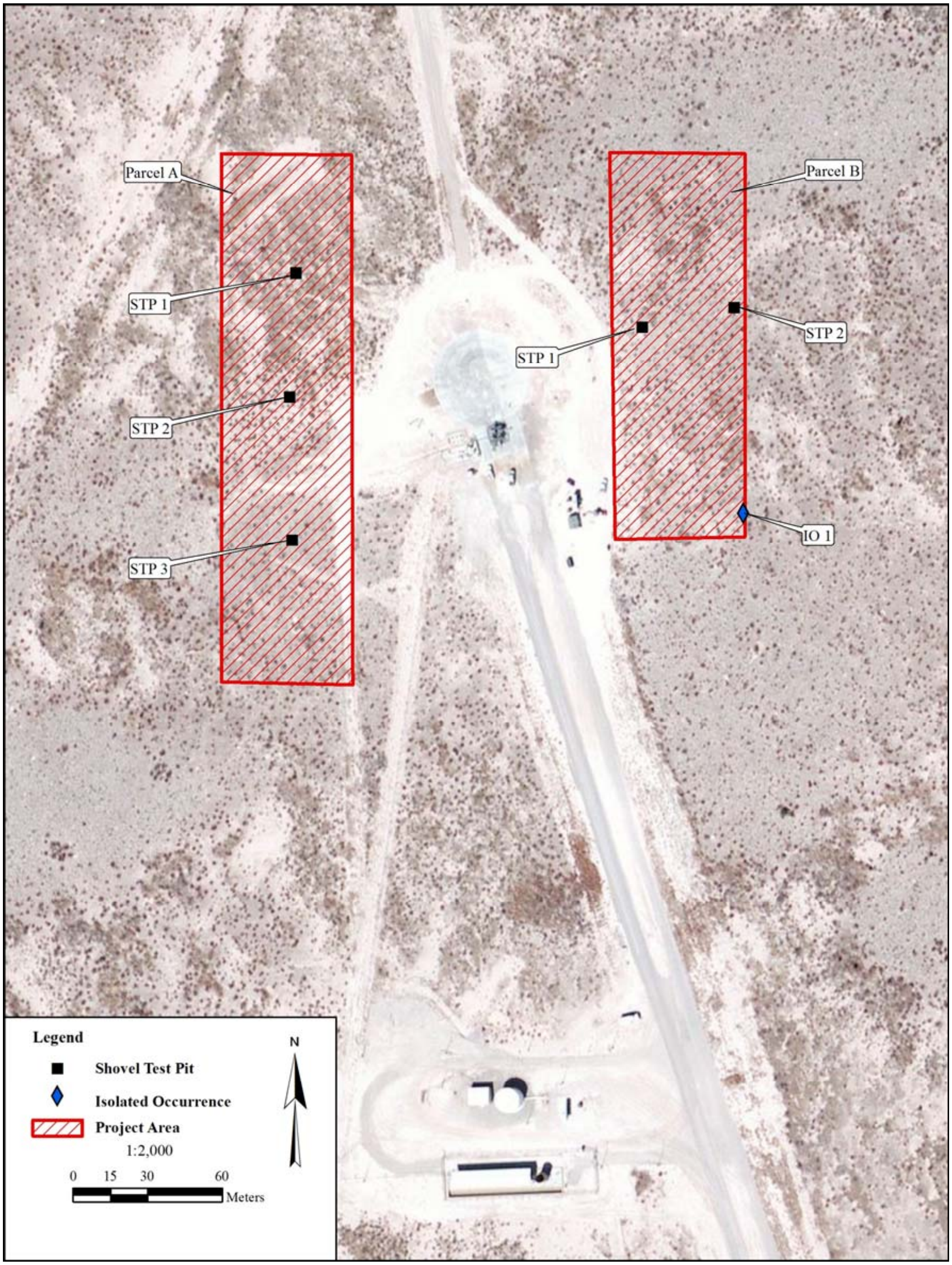

Figure 3. Map showing Parcels A and B, placement of Shovel Test Pits, and the location of the single isolated occurrence identified during the project.

Shovel test excavations were conducted in accordance with current survey standards as approved by the THC and Council of Texas Archaeologists (CTA), which includes areas where ground cover hinders site detection. The need for shovel testing during survey was low because (1) ground visibility is 80 to 100 percent throughout the proposed project area, and (2) with no nearby water sources, the project area generally did not contain any locations where site probability was considered high. Five shovel test pits, approximately 30 cm in diameter, were excavated subsequent to completion of the survey in an effort to assess soils sequencing and potential integrity of the parcel areas. Three shovel test pits were excavated in a north-to-south orientation across Parcel A. Two shovel test pits were excavated in an east-to-west direction across Parcel B. Shovel tests were excavated to between 20 and 62 cm below surface or until bedrock was encountered. All sediments were screened through ¼-inch hardware mesh over plastic tarps. The screened sediments were used to backfill all five of the shovel test pits. All identified archaeological sites and isolated occurrences were mapped in the field on topographic maps (1:24,000 scale) using a Trimble XT GPS unit with sub-meter accuracy.

As previously stated, the wooden lathes and flagging tape marking the corners of the parcels facilitated accurate identification of the survey area in the field and were easily confirmed using the TRU grid system. GMI personnel then walked the TRU transects spaced at 15-m intervals within the staked area. These transects were oriented toward the north and were walked by two archaeologists. Only a single isolated artifact was documented during the investigation.

Following Ward and Osburn (2005), documentation of the isolated occurrence included several steps. Initially, the modern ground surface in the vicinity of this artifact was carefully examined - no additional archaeological resources were noted. The artifact then was described in field notes and its location recorded using a Trimble® Geo-Explorer XT Global Positioning System (GPS) unit. Universal Transverse Mercator (UTM) coordinates recorded by the GPS unit were later converted into Latitude and Longitude coordinates for Blue Origin, LLC.

The described and implemented pedestrian survey strategy was carried out in full accordance with current THC and Council of Texas Archeologists (CTA) standards. Since only a single isolated occurrence was identified during survey, compliance with THC and CTA site definition standards was unnecessary. No cultural materials or samples were collected during the course of fieldwork; the isolated occurrence was left *in situ* after coordinates and a description were recorded.

CHAPTER 5.
SURVEY RESULTS

GMI personnel completed a TRU survey of the 4.8 acre survey area on October 9, 2012. During the course of the survey, only a single isolated occurrence was identified and recorded. This consisted of a non-diagnostic chert projectile point tentatively similar to possible Archaic forms noted by Ward and Osburn (2005). The survey area was positioned within the Salt Flat, far removed from locations that might be considered high probability, and the artifact was identified in the southeast corner of Parcel B (*523178E; 3476460N; 31-25-21N*, *104-45-22W*) with high ground visibility.

ISOLATED OCCURRENCE

Classified as a projectile point fragment, this single isolated occurrence measured 3 cm in maximum length, 2.2 cm in maximum width, and was 0.5 cm in maximum thickness (Figure 4). Examination of the proximal end identified a corner notched point with a slightly expanding stem and a straight-to-slightly convex basal margin. The body of the point appears to have been reworked subsequent to the fracture, resulting in an asymmetrical outline to the point. While the material is a banded gray chert, it was unclear as to the source of the material. Based on a cursory assessment of the basin; however, the chert probably originates in the gravel deposits and alluvial fans at the base of the nearby mountain ranges.

Figure 4. Isolated Occurrence recovered from the southeast corner of Parcel B.

Following identification of the artifact, the ground surface around the item was carefully examined for additional cultural materials that might indicate the presence of an archaeological site. No additional cultural manifestations were identified. As there were no elevated locations nearby, no evidence that the projectile point fragment had eroded from a local source was found. Rather, the object was determined to have likely been dropped or otherwise discarded during the prehistoric era and not reflective of a larger habitation or occupational event. As it was isolated and unassociated with other objects, this object's potential to yield important information has been exhausted through documentation and it is recommended as not eligible for listing on the NRHP.

SHOVEL TEST PIT INVESTIGATIONS

In addition to intensive surface investigations, three shovel test pits were excavated in Parcel A and two in Parcel B (Figures 5 and 6). Shovel test pits excavated in Parcel A were spaced 50 m apart in a north-to-south direction. This approach provided representative coverage of Parcel A and insight into the geomorphic integrity of this portion of the launch facility footprint. In Parcel B, two shovel test pits were excavated, both located along the center margins of the parcel. Each shovel test pit was screened through ¼-inch hardware mesh over plastic. After documentation, the screened sediments were backfilled into the shovel test pit. No artifacts were recovered in the five shovel test excavations.

Parcel A

<u>Parcel A-Shovel Test Pit No. 1</u>

Shovel Test Pit No. 1 in Parcel A was excavated in the northern third of the parcel and reached a maximum depth of 20 cm below ground surface. Stratum I reached approximately 5 cm below ground surface and consisted of unconsolidated, light brown (Munsell 10YR5/4) silt. Gravels intermixed with eolian sediments, and to a lesser extent calcium carbonate filaments/nodules were noted in this upper deposit. Underlying Stratum I was Stratum II, a very compact, brown colored (10YR5/4) calcareous silt. Stratum II was 15 cm in thickness with a minimal presence of gravels. An increase in calcium carbonate was noted, as was an absence of cultural materials.

<u>Parcel A-Shovel Test Pit No. 2</u>

Shovel Test Pit No. 2 in Parcel A was excavated in the center of the parcel and reached a maximum depth of 25 cm below ground surface. Stratum I reached approximately 15 cm below ground surface and consisted of unconsolidated light brown (Munsell 10YR5/4) silt. Gravels intermixed with eolian sediments, and to a lesser extent calcium carbonate filaments/nodules were noted in this upper deposit. Stratum II consisted of a compact, brown colored (Munsell 10YR5/4) calcareous silt that reached 10 cm in thickness before the shovel test was terminated. An increase in calcium carbonate was noted, as was an absence of cultural materials.

<u>Parcel A-Shovel Test Pit No. 3</u>

Shovel Test Pit No. 3 in Parcel A was excavated in the southern third of the parcel and reached a maximum depth of 62 cm below ground surface. Stratum I reached approximately 5 cm below ground surface and consisted of the unconsolidated light brown (Munsell 10YR5/4) silt documented in the previous two shovel test. An increase in gravels was noted in this upper soil unit. Underlying Stratum I was Stratum II, a compact, brown colored (Munsell 10YR5/4) calcareous silt that exhibited poor soil structure. Stratum II was approximately 50 cm in thickness. Stratum III was observed directly below Stratum II and consisted of a compact calcareous brown (Munsell 10YR5/4) silt. This basal unit reached a depth of 12 cm before termination. No cultural materials were recovered from this shovel test pit.

Figure 5. Overview photograph of Parcel A, looking northwest.

Figure 6. Overview photograph of Parcel B, looking northeast.

Parcel B

Parcel B-Shovel Test Pit No. 1

Shovel Test Pit No. 1 in Parcel B was excavated in the center of the parcel adjacent to the western boundary line and reached a maximum depth of 26 cm below ground surface. Stratum I reached approximately 6 cm below ground surface and consisted of unconsolidated, light brown (Munsell 10YR6/4) silt. In a similar fashion to Parcel A-Shovel Test Pit 2, gravels were intermixed with eolian sediments and calcium carbonate filaments/nodules. Stratum II consisted of a compact, brown colored (Munsell 10YR5/4) calcareous silt that reached 20 cm in thickness before the shovel test pit was terminated. Again, an increase in calcium carbonate was noted, as was an absence of cultural materials.

Parcel B-Shovel Test Pit No. 2

Shovel Test Pit No. 2 in Parcel B was excavated in the center of the parcel adjacent to the eastern boundary line. This shovel test also reached a maximum depth of 25 cm below ground surface. Stratum I reached approximately 5 cm below ground surface and consisted of unconsolidated light brown (Munsell 10YR6/4) silt. In a similar fashion to Parcel A-Shovel Test Pit 2, gravels were intermixed with eolian sediments and calcium carbonate filaments/nodules. Stratum II consisted of a compact, brown colored (Munsell 10YR5/4) calcareous silt that reached 20 cm in thickness before the shovel test pit was terminated. No cultural materials were recovered from this second shovel test pit.

SHOVEL TEST PIT SUMMARY

In general, the survey parcels encompassed an area of low-lying playa environment that exhibited severe deflation and redistribution of sediments. As documented in Ward (2006) and Ward and Osburn (2005), this dynamic environment has been influenced by both eolian and alluvial slope and sheetwash processes resulting in the movement and displacement of sediments and artifacts from higher elevations. Based on Ward and Osburn (2005), higher elevations are exemplified by playa terraces, limestone ridges, and alluvial fans, all of which contain remnant cultural manifestations to some degree. The general absence of cultural materials within Parcels A and B potentially points toward the accelerated deflation and secondary deposition of artifacts away from the elevated landforms and into the low-lying basin. Moreover, the geomorphic characteristics contained within the two parcels further suggests a possible pluvial origin to the landscape, again, one that would highlight human activity along the upper terraces, but not necessarily the lower elevations. The absence of subsurface cultural deposits, combined with the lack of archaeological features and the highly reworked and eroded nature of the project areas indicate that these parcels hold little contextual integrity in regard to the presence and preservation of human activity.

CHAPTER 6.
SUMMARY AND RECOMMENDATIONS

SUMMARY

The current investigation included a TRU survey of two rectangular-shaped parcels within the Blue Origin Launch Facility footprint, measuring 50-m wide x 200-m long and 50-m wide by 150-m long, respectively. The combined survey area of both parcels, which fall within the launch facility footprint, covered a total of 11,549 square meters (or approximately 4.8 acres). In addition, five shovel test pits were excavated during the project; all revealing shallow depositional soil sequences with no cultural materials. Only one isolated occurrence was identified and documented; an intensive scan of the modern ground surface nearby failed to reveal any other archaeological resources. The location of the project area—in the lowest part of the depression between the Delaware and Sierra Diablo mountains—suggested in advance that prehistoric archaeological sites would be unlikely in the area (e.g., Edwards and Peter 1993; Hedrick 1989; Lowry 1999; Mallouf 1985), and the finding of only a single isolated occurrence appears to be consistent with that interpretation (Ward and Osburn 2005).

RECOMMENDATIONS

The intensive archaeological survey and limited shovel test excavations of 4.8 acres in the south half of the Blue Origin Launch Facility resulted in the recording of no archaeological sites and a single isolated occurrence. The isolated occurrence is not significant and is not eligible for inclusion in the NRHP. It is recommended that the information potential of the artifact has been exhausted through documentation, and no further work is merited. Based upon the results of this process, GMI recommends that the proposed development of these two parcels will have no adverse effect on historic properties.

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