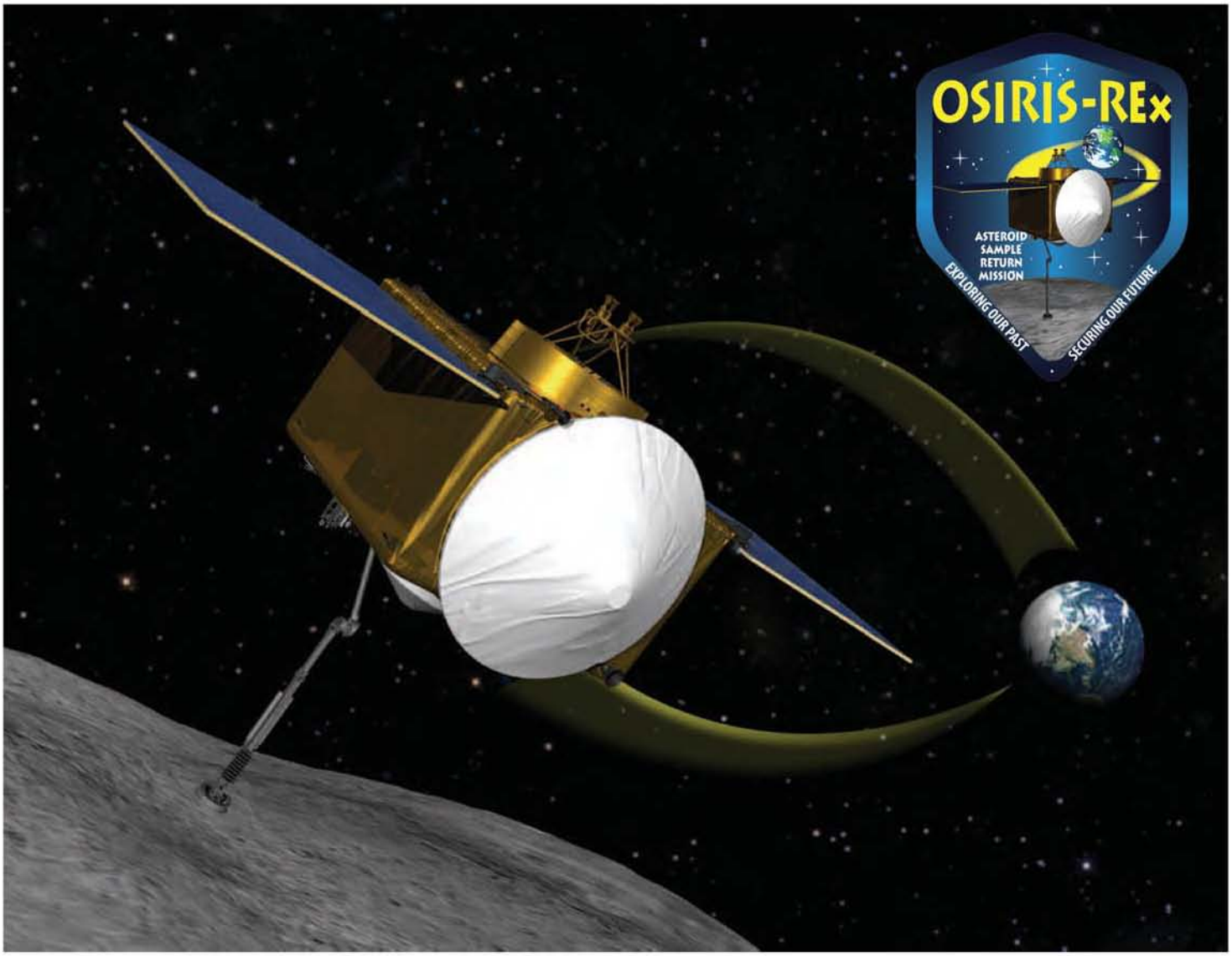
National Aeronautics and Space Administration




# Final Environmental Assessment for the Origins, Spectral Interpretation, Resource Identification, and Security-Regolith Explorer Mission

## March 2013

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# *FINAL ENVIRONMENTAL ASSESSMENT (EA) FOR THE ORIGINS, SPECTRAL INTERPRETATION, RESOURCE IDENTIFICATION, SECURITY - REGOLITH EXPLORER (OSIRIS-REX) MISSION*

## TITLE PAGE

**Lead Agency:** National Aeronautics and Space Administration (NASA)

**Proposed Action:** Preparing for and implementing the Origins, Spectral Interpretation, Resource Identification, Security - Regolith Explorer (OSIRIS-REx) mission, including the launch from Cape Canaveral Air Force Station (CCAFS), Florida, in September 2016; sample return capsule recovery at the Utah Test and Training Range (UTTR) in Tooele County, Utah, in September 2023; and curation of samples at the Johnson Space Center (JSC), Houston, Texas.

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**Date:** March 2013

**Abstract:** The OSIRIS-REx mission would be the first U.S. mission to carry samples from an asteroid back to Earth. Asteroids are leftovers formed from the cloud of gas and dust that collapsed to form our Sun and the planets about 4.5 billion years ago. As such, they contain the original material from the solar nebula, which can inform us about the conditions during our solar system's birth. The mission would help us investigate planet formation and the origin of life, as well as aid our understanding of asteroids that can impact Earth. NASA proposes to launch the OSIRIS-REx spacecraft from CCAFS, Florida, in September 2016 on an Atlas V class launch vehicle. After traveling two years, OSIRIS-REx would approach the primitive, near Earth asteroid designated 1999 RQ36 in October 2018. After examining the asteroid for approximately 30 months (until March 2021) and collecting surface samples, the OSIRIS-REx spacecraft would begin its 2.5-year journey back to Earth. The sample return capsule would return in 2023 to UTTR in Tooele County, Utah, and then be taken to NASA's JSC in Houston, Texas, for processing at a dedicated curation and research facility. Samples would then be distributed for examination at selected research facilities.

This OSIRIS-REx environmental assessment (EA) addresses the proposed action of implementing the OSIRIS-REx mission. No new facilities would be constructed at any of the locations (*i.e.*, CCAFS, UTTR, JSC) associated with this mission. Impacts associated with the preparation for launch of OSIRIS-REx and with the launch itself would fall within the parameters addressed in the *NASA Routine Payload EA* **(NASA 2011a)** and are summarized in this *OSIRIS-REx EA*. Accordingly, the primary focus of this EA is to address the environmental impacts associated with return of the asteroid samples to UTTR. Topics addressed include safety concerns, natural and cultural resources, and planetary protection concerns.

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## LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| ºC | degrees Celsius |
| ºF | degrees Fahrenheit |
| AIRFA | American Indian Religious Freedom Act |
| ANSI | American National Standards Institute |
| ARC | Ames Research Center |
| Army | U.S. Army |
| BLM | Bureau of Land Management |
| CAA | Clean Air Act |
| CCAFS | Cape Canaveral Air Force Station |
| CCB | Common Core Booster |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CN | cyanide |
| CNS | Canaveral National Seashore |
| CO | carbon monoxide |
| $CO_2$ | carbon dioxide |
| dB | decibel |
| dBA | A-weighted Decibels |
| DCA | debris casualty area |
| DoD | U.S. Department of Defense |
| DOE | U.S. Department of Energy |
| DPG | U.S. Army Dugway Proving Ground |
| EA | Environmental Assessment |
| EO | Executive Order |
| EPA | U.S. Environmental Protection Agency |
| Fe | iron |
| FEA | Final Environmental Assessment |
| FONPA | Finding of No Practical Alternative |
| g | grams |
| GSFC | NASA Goddard Space Flight Center |
| HCN | hydrogen cyanide |
| HWMP | Hazardous Waste Management Plan |

## List of Abbreviations and Acronyms (*Continued*)

| | |
|---|---|
| JPR | Johnson Procedural Requirement |
| JSC | Johnson Space Center |
| kg | kilogram |
| km | kilometer(s) |
| km/s | kilometers per second |
| KSC | Kennedy Space Center |
| lb | pound |
| $lb/ft^2$ | pounds per square foot |
| LC | launch complex |
| $LH_2$ | liquid hydrogen |
| LIDAR | Light Detection and Ranging |
| LOX | liquid oxygen |
| MARS | Mid-Atlantic Regional Spaceport |
| MEP | Mars Exploration Program |
| $mg/m^3$ | milligrams per cubic meter |
| mi | miles |
| mi/s | miles per second |
| MINWR | Merritt Island National Wildlife Refuge |
| mW | milliWatt |
| $N_2H_4$ | nydrazine |
| $N_2O_4$ | nitrogen tetroxide (NTO) |
| NAAQS | National Ambient Air Quality Standards |
| NAGPRA | Native American Graves Protection and Repatriation Act |
| NASA | National Aeronautics and Space Administration |
| NEPA | National Environmental Policy Act |
| NFSAM | Nuclear Flight Safety Assurance Manager |
| $NiH_2$ | nickel-hydrogen |
| $NO_X$ | oxides of nitrogen oxides |
| NPD | NASA Policy Directive |
| NPR | NASA Procedural Requirements |
| NPS | National Park Service |

## List of Abbreviations and Acronyms (*Continued*)

| | |
|---|---|
| NRC | National Research Council |
| NRHP | National Register of Historic Places |
| NRP | NASA routine payload |
| *NRP EA* | *NASA Routine Payload Environmental Assessment* |
| NSI | NASA Standard Initiators |
| $O_2$ | diatomic oxygen |
| $O_3$ | ozone |
| OCAMS | OSIRIS-REx Camera Suite |
| OLA | OSIRIS-REx Laser Altimeter |
| ORSAT | orbital survival analysis tool |
| OSIRIS-REx | Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer |
| OTES | OSIRIS-REx Thermal Emission Spectrometer |
| OVIRS | OSIRIS-REx Visible and Infrared Spectrometer |
| PICA | phenolic impregnated carbon ablator |
| $PM_{2.5}$ | particulate matter less than 2.5 microns |
| $PM_{10}$ | particulate matter less than 10 microns |
| PPA | Pollution Prevention Act |
| ppb | parts per billion |
| ppm | parts per million |
| RANS | Range Squadron |
| RCRA | Resource Conservation and Recovery Act |
| REXIS | Regolith X-ray Imaging System |
| RF | radio frequency |
| RP-1 | rocket propellant (thermally stable kerosene) -1 |
| SHPO | State Historic Preservation Officer |
| SLA | super lightweight ablator |
| SMD | Science Mission Directorate |
| $SO_2$ | sulfur dioxide |
| SRC | sample return capsule |
| SRM | solid rocket motor |

## List of Abbreviations and Acronyms (*Continued*)

| | |
|---|---|
| SSEP | Solar System Exploration Program |
| SSRM | Strap-on Solid Rocket Motor |
| TAGSAM | Touch-and-Go Sample Acquisition Mechanism |
| TPS | Thermal Protection System |
| U.S.C. | *United States Code* |
| UDMH | Unsymmetrical Dimethyl-Hydrazine |
| UDSHW | Utah Division of Solid and Hazardous Waste |
| USAF | United States Air Force |
| USCB | United States Census Bureau |
| USFWS | United States Fish and Wildlife Service |
| UTTR | Utah Test and Training Range |
| VAFB | Vandenberg Air Force Base |
| WAP | Waste Analysis Plan |
| WFF | Wallops Flight Facility |

## COMMON METRIC/BRITISH SYSTEM EQUIVALENTS

### Length

| | |
|---|---|
| 1 centimeter (cm) = 0.3937 inch | 1 inch = 2.54 cm |
| 1 centimeter = 0.0328 foot (ft) | 1 foot = 30.48 cm |
| 1 meter (m) = 3.2808 feet | 1 ft = 0.3048 m |
| 1 meter = 0.0006 mile (mi) | 1 mi = 1609.3440 m |
| 1 kilometer (km) = 0.6214 mile | 1 mi = 1.6093 km |
| 1 kilometer = 0.53996 nautical mile (nmi) | 1 nmi = 1.8520 km |
| | 1 mi = 0.87 nmi |
| | 1 nmi = 1.15 mi |

### Area

| | |
|---|---|
| 1 square centimeter ($cm^2$) = 0.1550 square inch ($in^2$) | 1 $in^2$ = 6.4516 $cm^2$ |
| 1 square meter ($m^2$) = 10.7639 square feet ($ft^2$) | 1 $ft^2$ = 0.09290 $m^2$ |
| 1 square kilometer ($km^2$) = 0.3861 square mile ($mi^2$) | 1 $mi^2$ = 2.5900 $km^2$ |
| 1 hectare (ha) = 2.4710 acres (ac) | 1 ac = 0.4047 ha |
| 1 hectare (ha) = 10,000 square meters ($m^2$) | 1 $ft^2$ = 0.000022957 ac |

### Volume

| | |
|---|---|
| 1 cubic centimeter ($cm^3$) = 0.0610 cubic inch ($in^3$) | 1 $in^3$ = 16.3871 $cm^3$ |
| 1 cubic meter ($m^3$) = 35.3147 cubic feet ($ft^3$) | 1 $ft^3$ = 0.0283 $m^3$ |
| 1 cubic meter ($m^3$) = 1.308 cubic yards ($yd^3$) | 1 $yd^3$ = 0.76455 $m^3$ |
| 1 cubic meter ($m^3$) = 0.000811 acre-ft | 1233 $m^3$ = 1 acre-ft |
| 1 liter (l) = 1.0567 quarts (qt) | 1 qt = 0.9463264 l |
| 1 liter = 0.2642 gallon (gal) | 1 gal = 3.7845 l |
| 1 kiloliter (kl) = 264.2 gal | 1 gal = 0.0038 kl |

### Mass/Weight

| | |
|---|---|
| 1 gram (g) = 0.0353 ounce (oz) | 1 oz = 28.3495 g |
| 1 kilogram (kg) = 2.2046 pounds (lb) | 1 lb = 0.4536 kg |
| 1 metric ton (mt) = 1.1023 tons | 1 ton = 0.9072 metric ton |

### Energy

| | |
|---|---|
| 1 joule = 0.0009 British thermal unit (BTU) | 1 BTU = 1054.18 joule |
| 1 joule = 0.2392 gram-calorie (g-cal) | 1 g-cal = 4.1819 joule |

### Pressure

| | |
|---|---|
| 1 newton/square meter ($N/m^2$) = 0.0208 pound/square foot (psf) | 1 psf = 48 $N/m^2$ |

### Force

| | |
|---|---|
| 1 newton (N) = 0.2248 pound-force (lbf) | 1 lbf = 4.4478 N |

# EXECUTIVE SUMMARY

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# EXECUTIVE SUMMARY

## ES.1 PROPOSED ACTION

This environmental assessment (EA) addresses the National Aeronautics and Space Administration's (NASA)'s proposed action to implement the Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) mission. The OSIRIS-REx mission would be the third in NASA's New Frontiers class of missions, following the New Horizons mission to Pluto and the Kuiper Belt and Juno missions to Jupiter. The OSIRIS-REx mission would be the first U.S. mission to carry samples from an asteroid back to Earth. Asteroids are leftovers formed from the cloud of gas and dust—the solar nebula—that collapsed to form our Sun and the planets about 4.5 billion years ago. As such, they contain the original material from the solar nebula, which can inform us about the conditions during our solar system's birth.

The OSIRIS-REx mission would be launched from the Cape Canaveral Air Force Station (CCAFS) in September 2016. After traveling 2 years, OSIRIS-REx would approach the primitive, near-Earth asteroid designated "1999 RQ36" in October 2018 and would spend approximately 30 months, until March 2021, examining the asteroid and collecting surface regolith samples. Upon completion of the exploration of 1999 RQ36, the OSIRIS-REx spacecraft would return to Earth for a landing of the sample return capsule (SRC) in September of 2023 at the Utah Test and Training Range (UTTR) in Tooele County, Utah. Only the SRC containing the collected samples in a sample canister would return to Earth. The unopened sample canister would then be transported via C130 aircraft to the planetary materials curation facility at Johnson Space Center (JSC) for storage and sample examination. The OSIRIS-REx asteroid sample return mission has a recommended classification of "Unrestricted Earth Return" **(NASA 2011b)**, meaning the sample is safe to return to Earth. NASA has six criteria it uses to determine whether samples are safe to return to Earth; contamination is unlikely if any one of the six criteria is met. The Unrestricted Earth Return classification and the OSIRIS-REx mission meet two of these criteria.

## ES.2 PURPOSE AND NEED FOR THE ACTION

The National Aeronautics and Space Act **(51 U.S.C.)** establishes a mandate to conduct activities in space that contribute substantially to the "expansion of human knowledge and of phenomena in the atmosphere and space" and to "the preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere." In response to the mandate, NASA, in coordination with the National Academy of Sciences, has developed a prioritized set of science objectives to be met through a long-range program of planetary missions (*i.e.*, the U.S. Solar System Exploration Program). These missions are designed to be conducted in a specific sequence based on technological readiness, launch opportunities, timely data return, and a balanced representation of scientific disciplines.

NASA's strategy to carry out this sequence consists of an orderly progression from flyby-type reconnaissance missions to investigation with orbiters and atmospheric probes to intensive study involving landers, sample return, and human exploration.

NASA cannot meet the specific objectives of U.S. space and Earth exploration using Earth-based instrumentation alone. Data acquired from ground-based instruments, sounding rockets, balloons, and Earth-based techniques are limited. Therefore, NASA uses a variety of scientific spacecraft that must be designed and launched to collect these data.

## ES.3 *OSIRIS-REx EA*

This *OSIRIS-REx EA* addresses the proposed action of implementing the OSIRIS-REx mission. Impacts associated with the preparation for launch of OSIRIS-REx and with the launch itself would fall within the parameters addressed in the *Environmental Assessment for the Launch of NASA Routine Payloads, 2011* (*NRP EA*) **(NASA 2011a)**. The sample return portion of the mission would fall outside the scope of the *NRP EA*. Accordingly, this *OSIRIS-REx EA* focuses on the sample return portion of the mission at UTTR and summarizes and incorporates by reference the *NRP EA* **(NASA 2011a)**. See Appendix B of this EA for the routine payload criteria checklist for the OSIRIS-REx mission. The *NRP EA* is available at http://www.nasa.gov/agency/nepa/routinepayloadea.html.

## ES.4 ALTERNATIVES CONSIDERED

The scope of this EA includes two alternatives: a proposed action and a No Action Alternative. The proposed action consists of the launch of the OSIRIS-REx mission from CCAFS in Florida; return of the asteroid samples to UTTR, in Tooele County, Utah; and final sample curation at JSC, Houston, Texas. Alternatives to UTTR as the sample recovery (*i.e.,* landing) site were determined to be unsuitable due to NASA's operational or safety requirements. Implementation of the No Action Alternative would mean that NASA would not pursue the OSIRIS-REx mission.

## ES.5 SUMMARY OF ENVIRONMENTAL IMPACTS – PROPOSED ACTION

Potential environmental impacts, including cumulative impacts, of the proposed action are summarized in this section. The impacts are presented in four sections, organized by location, as follows: (1) impacts at CCAFS from the mission launch, (2) impacts at UTTR from activities associated with recovery of the SRC, (3) impacts at JSC from curation activities, and (4) impacts on the global environment. A more extensive impacts discussion is presented in Chapter 3.

### ES.5.1 Cape Canaveral Air Force Station

This section summarizes the information found in Chapter 3, Section 3.2, addressing the potential environmental impacts associated with the launch of the OSIRIS-REx mission from CCAFS. These launch activities were determined to fall within the bounds of missions previously analyzed in the *NRP EA* **(NASA 2011a)**. The Finding of No Significant Impact for

the *NRP EA* was published November 22, 2011. The *NRP EA* addresses potential environmental impacts in the following areas:

- Land use and aesthetics/visual resources
- Hazardous materials and hazardous waste management
- Health and safety
- Geology and soils
- Water resources
- Air quality
- Noise
- Biological resources
- Historical and cultural resources
- Socioeconomic resources
- Environmental justice
- Cumulative effects

Therefore, no significant impacts are associated with the launch of the OSIRIS-REx mission on an Atlas V class launch vehicle from CCAFS.

### ES.5.2 Utah Test and Training Range

This section summarizes the information found in Chapter 3, Section 3.3, addressing the potential environmental impacts associated with the landing of the OSIRIS-REx SRC and recovery activities at UTTR. UTTR has been used in a similar fashion for earlier NASA sample return missions; specifically, the Stardust and Genesis missions.

#### ES.5.2.1 *Land Use and Aesthetics/Visual Resources*

The OSIRIS-REx mission would require only temporary use of the land at UTTR. Recovery actions would potentially disturb a very small area required for operation of the recovery team and vehicles. No new facilities used in connection with the recovery operations would be required. Therefore, the mission would have negligible impact on land resources.

#### ES.5.2.2 *Hazardous Materials and Hazardous Waste Management*

Hazardous wastes generated at UTTR are managed as specified in the Waste Management Plan. Hazardous wastes at UTTR are properly stored during characterization, then manifested and transported off site for treatment and/or disposal. Activities associated with the recovery of the SRC would not generate any hazardous wastes outside the scope, in type or quantity, of materials routinely generated at UTTR.

### ES.5.2.3 *Health and Safety*

**Normal Entry, Descent, and Landing**

During a normal entry, descent, and landing, the SRC would pose no significant hazards to human health. Scheduling procedures for use of UTTR would preclude any risk of flight hazards involving other aircraft in the area. The risk of mishap involving helicopters, should they be used in the SRC recovery operations, would be negligible and comparable to currently ongoing risks at the range.

Three potential hazards in handling the SRC once it has landed have been identified: (1) safing of potential unfired parachute deployment ordnance; (2) lithium battery faults such as the production of sulfuric acid or a lithium fire, should the battery be damaged during landing; and (3) handling of the SRC. Appropriate precautions would be taken to ensure the safety of the recovery team.

**Off-Normal Entry of the SRC**

In the event of an abnormal reentry, *i.e.,* the SRC fails to land within the designated landing zone; injury to members of the public from the impact of the SRC is possible. The probability of such injury has been determined to be small, significantly below the NASA guidance in *Range Flight Safety Program* **(NPR 8715.5A)** of 1 chance in 10,000 of any casualty and 1 chance in 1 million of a casualty to a single individual.

NASA analysis (using the Orbital Survival Analysis Tool) of the OSIRIS-REx mission concluded that the inadvertent reentry of the OSIRIS-REx spacecraft would result in the complete destruction of the spacecraft. No debris would impact Earth.

### ES.5.2.4 *Terrestrial Contamination*

Of NASA's six criteria used to determine whether samples are safe to return to Earth, the two met by the OSIRIS-REx mission are that (1) 1999 RQ36 has been exposed to a high-radiation field (sufficient to sterilize any biological material) and (2) material from asteroids is one of the sources of meteorites and dust falling to Earth. For these reasons, NASA considers contamination of Earth from materials returned from small bodies as extremely unlikely.

### ES.5.2.5 *Geology and Soils*

The area affected by the landing and recovery of the SRC would measure only a few meters. The SRC impact area would be similar to that of a small person parachuting to the surface. Any disturbance to the surface could easily be recovered if desired. Due to the single-event nature of this recovery operation, the resulting impact would be negligible. The SRC would contain no propellant except for the gas that would expel the drogue parachute.

### ES.5.2.6 *Water Resources*

Because of the lack of surface water and the general aridity of the area, no impacts on drinking or surface water are expected.

#### ES.5.2.7 *Air Quality*

Emissions of criteria pollutants would occur as a result of helicopter and ground vehicle activity during OSIRIS-REx SRC recovery operations. Given that the OSIRIS-REx mission is a single sample return, the quantities of emissions would be extremely small and very localized, if at all. The SRC itself would not generate any air pollutants in the lower atmosphere (the area subject to National Ambient Air Quality Standards), nor is it expected that it would contain any chemicals or substances that could emit hazardous air pollutants regulated under National Emissions Standards for Hazardous Air Pollutants.

#### ES.5.2.8 *Noise*

Noise from helicopter and ground vehicle operations would not differ from baseline conditions. The momentary sonic boom from the SRC reentry would not have any impact due to its high altitude.

#### ES.5.2.9 *Biological Resources*

The SRC landing and recovery operations would affect vegetation in the immediate vicinity of the touchdown. Individual plants within a localized area could be crushed. The impact on plant communities in the area would be insignificant.

#### ES.5.2.10 *Historical and Cultural Resources*

The OSIRIS-REx SRC landing could have the potential for affecting cultural resources if the SRC lands on an archaeological site eligible for listing in the National Register of Historic Places. NASA has made a determination of "no historic properties affected" and is awaiting concurrence from the State Historic Preservation Officer (SHPO). NASA will continue its consultation under Section 106 of the National Historic Preservation Act and its implementing regulations **(36 CFR 800)** with the Utah SHPO and consulting parties as relates to the proposed undertaking.

#### ES.5.2.11 *Socioeconomic Resources*

The proposed action would not affect demographics, housing, or the structure of the economy in the region. The OSIRIS-REx recovery operations would be compatible with the purpose and use of UTTR and the U.S. Department of Defense land in the proposed impact area.

#### ES.5.2.12 *Environmental Justice*

Given the characteristics of the SRC that would land at UTTR, analysis indicates little or no potential for substantial environmental effects on any human populations outside UTTR boundaries.

#### ES.5.2.13 *Cumulative Effects*

The use of facilities at UTTR for retrieving the SRC of the OSIRIS-REx mission would be consistent with existing operations and would pose no new types of impacts. The recovery

activities would constitute a one-time activity of relatively short duration. Existing facilities would be utilized; no new facilities on or off site would be needed. Therefore, long-term cumulative effects on the local and regional environment of the proposed action would not be substantial.

### ES.5.3 Johnson Space Center

This section summarizes the information contained in Chapter 3, Section 3.4, addressing the potential environmental impacts associated with curation of the OSIRIS-REx samples at JSC. These activities would be similar to those currently being performed at JSC for material returned by several missions, including moon rocks from the Apollo and Luna missions; meteorites from Antarctica collected by the Antarctica Search for Meteorite program; cometary and interstellar samples from the Stardust mission; solar wind samples from the Genesis mission; and additional material, including returned space hardware, cosmic dust, and asteroid samples. Sample curation would be within the scope of the existing National Environmental Policy Act (NEPA) documentation for JSC operations.

The OSIRIS-REx mission would have no additional impacts beyond those associated with ongoing activities at JSC for the following areas:

- Land use and aesthetics/visual resources
- Geology and soils
- Water resources
- Air quality
- Noise
- Biological resources
- Historical and cultural resources

#### ES.5.3.1 *Hazardous Materials and Hazardous Waste Management*

During the interior construction of the OSIRIS-REx clean room, some asbestos may be removed and disposed of. NASA would be compliant with applicable rules and regulations associated with asbestos handling. At JSC, these rules are contained in *JSC Safety and Health Handbook* **(JPR 1700.1)**. Thus, no health impacts are expected from removing asbestos-containing ceiling tiles or from short-term exposure to potential asbestos-containing materials other than the risk of injury from demolishing the tiles.

#### ES.5.3.2 *Health and Safety*

As discussed in Section ES.5.3.1, above, no health or safety impacts on workers are expected from removing asbestos-containing ceiling tiles or from short-term exposure to potential asbestos-containing materials other than the risk of injury from demolishing the tiles.

#### ES.5.3.3 *Socioeconomic Resources*

The few JSC personnel expected to work in the OSIRIS-REx curation facility, some of whom may be existing employees, would not significantly impact the employment level in the Houston area or within JSC itself.

#### ES.5.3.4 *Environmental Justice*

No substantial environmental effects are likely to occur outside of the facility, thus no disproportionately high and adverse impact on children, minority populations, or low-income populations is expected.

#### ES.5.3.5 *Cumulative Effects*

The use of curation facilities at JSC for storing and studying the returned samples of the OSIRIS-REx mission would be consistent with existing operations and would pose no new types of impacts. No new facilities, on or off site, would be required, only modifications to the interiors of existing structures. Therefore, long-term cumulative effects on the local and regional environment by the proposed action would not be substantial.

### ES.5.4 Global Environment

Previous NEPA documentation shows that upper atmospheric impacts would be limited to a miniscule amount of global ozone loss from rocket combustion emissions. The concentrations of gases and particles emitted into the free troposphere by transient sources, such as launch vehicles, are quickly diluted to very low levels before they can be deposited onto, or transported near, the ground by precipitation or strong down-welling events.

Data from Atlas V launches indicate that short-term impacts include a temporary hole in the ozone layer, but that ozone concentrations would return to prelaunch levels within 2 hours.

Greenhouse gases absorb the radiated energy from the Sun and Earth. Some of the greenhouse gases (*e.g.*, carbon monoxide, chlorofluorocarbons, water) would be emitted during the processes of preparing for and launching the OSIRIS-REx mission.

## ES.6 SUMMARY OF ENVIRONMENTAL IMPACTS – NO ACTION ALTERNATIVE

Under the No Action Alternative, NASA would not implement the OSIRIS-REx mission. The environmental impacts associated with the OSIRIS-REx mission would not be incurred.

## ES.7 SUMMARY

For purposes of this EA, the activities associated with the OSIRIS-REx mission can be divided into three activity phases: launch, recovery, and curation.

Launch activities have been determined by NASA to fall within the bounds of the *NRP EA* **(NASA 2011a)**. See Appendix B of this EA for the routine payload criteria checklist for the OSIRIS-REx mission. The environmental impacts of launching the OSIRIS-REx spacecraft

would fall within the range of routine, ongoing, and previously documented impacts that have been determined not to be significant.

Recovery activities for this mission are expected to be similar to those associated with prior NASA sample return missions that also utilized UTTR and would be well within the bounds of activities currently being performed at UTTR. Health and safety impacts were assessed for both normal and inadvertent reentry and found to be well within public safety limits set forth in NASA guidelines (*NASA's Range Flight Safety Program* **[NPR 8715.5A]**). All other impacts would be short term and negligible.

Curation activities at JSC would fall within the normal bounds of operation and would be similar to ongoing curation activities. Most areas of impact (*e.g.*, land resources, air quality) would see no change from current levels. Minor interior modifications to facilities would be required, which may involve the removal of asbestos-containing materials. Procedures are in place to limit the exposure to any asbestos and impact of its removal. All impacts associated with the curation activities would be negligible.

# CHAPTER 1

# PURPOSE AND NEED

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# 1. PURPOSE AND NEED

The National Aeronautics and Space Administration (NASA) has prepared this environmental assessment (EA) for the proposed action of implementing the Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer (OSIRIS-REx) mission, including the proposed launch from Cape Canaveral Air Force Station (CCAFS), Florida, in September 2016; recovery of asteroid in a sample return capsule (SRC) at the Utah Test and Training Range (UTTR), in Tooele County, Utah in September 2023; and curation of samples at the Johnson Space Center (JSC), in Houston, Texas. The purpose of this *OSIRIS-REx EA* is to evaluate the potential environmental impacts associated with the proposed action and a No Action Alternative.

This document was completed in accordance with the National Environmental Policy Act (NEPA), as amended **(42 U.S.C. 4321, *et seq.*)**; Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA **(40 CFR 1500–1508)**; and NASA's Regulations for Implementing NEPA **(14 CFR 1216.3)**.

## 1.1 PURPOSE OF THE PROPOSED ACTION

The National Aeronautics and Space Act **(51 U.S.C.)** establishes a mandate to conduct activities in space that contribute substantially to the "expansion of human knowledge and of phenomena in the atmosphere and space" and to "the preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere." In response to the mandate, NASA, in coordination with the National Academy of Sciences, has developed a prioritized set of science objectives to be met through a long-range program of planetary missions (*i.e.*, the U.S. Solar System Exploration Program [SSEP]). These missions are designed to be conducted in a specific sequence based on technological readiness, launch opportunities, timely data return, and a balanced representation of scientific disciplines.

NASA's strategy to carry out this sequence consists of an orderly progression from flyby-type reconnaissance missions to investigation with orbiters and atmospheric probes to intensive study involving landers, sample return, and human exploration.

NASA has established several programs to implement this strategy; *e.g.*, the New Frontiers Program, was created at the recommendation of the National Academy of Sciences' solar system exploration decadal survey, *New Frontiers in the Solar System: An Integrated Exploration Strategy* **(NRC 2003)**. The survey recommended that NASA establish a series of missions larger (*i.e.*, more costly) than the Discovery-class missions already being pursued. (Discovery-class missions' address focused scientific objectives with limited, but new and innovative, instrumentation sets. The Discovery Program is intended to allow for relatively inexpensive and frequent missions.) The New Frontiers missions are larger (and more expensive) than Discovery-class missions and do not rely on innovative scientific or technology developments **(NRC 2003)**.

The New Frontiers Program expands NASA's capability to pursue two of the goals originally established for the Discovery Program: (1) perform high-quality, focused science investigations

that would maintain U.S. leadership in planetary science and that would ensure continuity in the SSEP, and (2) enhance the general-public awareness of, and appreciation for, solar system exploration and support the Nation's educational initiatives.

The Solar System Exploration Roadmap developed in 2006 for NASA's Science Mission Directorate (SMD) lays out both a scientific rationale and a long-term plan for exploration of the solar system **(NASA 2006)**. The Roadmap describes a series of small (Discovery)-, medium (New Frontiers)-, and large (flagship)-class missions to address the following five key science questions:

1. How did the Sun's family of planets and minor bodies originate?
2. How did the solar system evolve to its current diverse state?
3. What are the characteristics of the solar system that led to the origin of life?
4. How did life begin and evolve on Earth and has it evolved elsewhere in the solar system?
5. What are the hazards and resources in the solar system environment that would affect the extension of human presence in space?

The OSIRIS-REx mission is one of the New Frontiers Program missions. The OSIRIS-REx spacecraft would travel to a near-Earth carbonaceous asteroid, 1999 RQ36, study it in detail, and bring back samples (at least 60 grams, or 2.1 ounces) to Earth. These samples would help us investigate planet formation and the origin of life, and the data collected at the asteroid would also aid our understanding of asteroids that can impact Earth.

Asteroids are the direct remnants of the original building blocks of the terrestrial planets. Knowledge of their nature is fundamental to understanding planet formation and the origin of life. The return to Earth of pristine samples with known geologic context would enable precise analyses that cannot be duplicated by spacecraft-based instruments, revolutionizing understanding of the early solar system. Asteroid 1999 RQ36 is the most accessible carbonaceous asteroid known. Asteroid 1999 RQ36 also has an orbit that brings it close to Earth every 6 years. Its bulk properties have been well characterized by ground- and space-based telescopes, greatly reducing mission risk and providing strong evidence for the presence of regolith (a blanket of loose materials covering rock; it can be soil, gravel, dust, and broken rocks) available for sampling. Study of 1999 RQ36 would address multiple NASA SSEP objectives to understand the origins of the solar system and of life, as well as fully address asteroid sample return objectives. In addition, OSIRIS-REx would provide a greater understanding of both the hazards and resources in near-Earth space, serving as a precursor to future asteroid missions.

The asteroid selected for study, 1999 RQ36, was chosen in part because it has one of the highest probabilities (estimated to be a 1 in 1,800 chance) of hitting Earth of any known object in the solar system **(UA 2012)**. If it were to strike the Earth, the collision would occur late in the next century. The OSIRIS-REx spacecraft would measure the Yarkovsky effect (the push on an object due to the escaping infrared radiation resulting from solar heating of the asteroid surface). The small push associated with this effect adds up over time, but it is uneven due to an asteroid's shape, wobble, surface composition, and rotation. For scientists to predict an Earth-approaching asteroid's path, they need to understand how the Yarkovsky effect would change its orbit. OSIRIS-REx would help researchers determine the factors that affect the magnitude of this effect

and allow them to determine the precise path of near-Earth objects so they can better predict the risk of impact with Earth sooner and with more accuracy. This capability could allow more time to take any needed actions.

The OSIRIS-REx mission would provide the opportunity to increase all general knowledge of the history, evolution, and current state of the solar system. Especially, the mission would provide a unique opportunity to examine an object representative of a large group of solar system bodies and one that potentially poses a hazard to Earth.

## 1.2 NEED FOR THE PROPOSED ACTION

Every object in the solar system contains part of the record of planetary origin and evolution, a record stored in the chemical and isotopic composition of these objects, along with their structural makeup. The exploration of asteroids has reinforced the opinion held by the scientific community that many planetary processes, including some that operate on Earth, may be universal.

Asteroids provide a unique opportunity to examine much of what has happened in our solar system. While they have been affected by solar winds (energetic particles emitted from the Sun), they have been unaffected by the climatic processes found on most planets, especially those closest to Earth. As such, they remain in many ways much as they were when originally formed. Detailed study of the asteroids provides an opportunity to look back in time to a period when the solar system was young. This is significant because asteroids are believed by some to be the dominant source of primordial terrestrial organics (the basic building blocks of life) and possibly water. Studies of asteroids today possibly provide insights into Earth's early history.

## 1.3 OSIRIS-REx EA

This *OSIRIS-REx EA* addresses the following three portions of the mission:

- Launch from CCAFS
- Reentry descent and landing of the SRC at UTTR
- Curation at JSC

Both the launch and curation activities would consist of routine activities that have been addressed in other environmental documentation. The curation activities at JSC for the OSIRIS-REx would be essentially the same as for samples from space and Earth (meteorites) currently held at JSC. The only OSIRIS-REx-specific activity would be some minor facility modification required in preparation for curation of the OSIRIS-REx samples. The launch of the OSIRIS-REx mission meets the criteria for a NASA routine payload mission as defined in the *NASA Routine Payload EA* (*NRP EA*) **(NASA 2011a)**, except for the sample return portion of the mission. The *NRP EA* assessed the environmental impacts of NASA missions with spacecraft that are considered routine payloads. The *NRP EA* resulted in a Finding of No Significant Impact. Spacecraft defined as routine payloads utilize materials, quantities of materials, launch vehicles, and operational characteristics that are consistent with normal and routine spacecraft preparation and flight activities at the launch facilities. The environmental impacts of launching routine payloads fall within the range of routine, ongoing, and previously documented impacts

that have been determined not to be significant. Spacecraft mission categorized as routine payloads meet specific criteria established in the *NRP EA* (see Appendix B of this EA).

However, the *NRP EA* does not address sample return. Therefore, NASA is preparing this EA to analyze the potential environmental effects of the sample return. This *OSIRIS-REx EA* focuses on the sample return portion of the mission and summarizes and incorporates by reference the *NRP EA.*

## 1.4 PUBLIC INVOLVEMENT FOR THIS *OSIRIS-REx EA*

NASA solicited public and agency review comments on the proposed action through letters transmitted to Federal and State agencies and tribes and consultations with Federal, State, and local agencies.

NASA initiated a 30-day public review and comment period on the *draft OSIRIS-REx EA* in November 2012. Notices were published in three local Utah newspapers and on the Goddard Space Flight Center Environmental Project Announcement Board (http://code250.gsfc.nasa.gov/environmental/osiris-rex.cfm). NASA mailed letters to Federal, State, and local agencies in addition to organizations and interested parties. The *draft OSIRIS-REx EA* was also made available at local libraries in Salt Lake City, Utah and Tooele, Utah and on the worldwide web on the OSIRIS-REx NEPA website: http://code250.gsfc.nasa.gov/docs/osiris-rex-draft-ea.pdf.

The *draft OSIRIS-REx EA* public review period closed on January 2, 2013. NASA received three comments during this review period, none raised any substantial issues. One comment provided the Utah State Department of Heritage and Arts - State Historic Preservation Office concurrence with NASA's determination of "No Historic Properties Affected" for this mission. One commenter requested to be removed from further distribution of documents related to the *OSIRIS-REx EA* and one commenter thanked NASA for the opportunity to comment with no further comment.

The *OSIRIS-REx EA* has been modified to incorporate the Utah State Historic Preservation Office concurrence.

# CHAPTER 2

# PROPOSED ACTION AND ALTERNATIVES

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# 2. PROPOSED ACTION AND ALTERNATIVES

## 2.1 PROPOSED ACTION

The OSIRIS-REx mission would be the third in the NASA's New Frontiers class of missions, following the New Horizons mission to Pluto and the Kuiper Belt and the Juno mission to Jupiter. The OSIRIS-REx mission would be the first U.S. mission to carry samples from an asteroid back to Earth. Asteroids are leftovers formed from the cloud of gas and dust—the solar nebula—that collapsed to form our Sun and the planets about 4.5 billion years ago. As such, they contain the original material from the solar nebula, which can inform us about the conditions during our solar system's birth.

The OSIRIS-REx mission has been designed to gather information that cannot be fully attained solely through Earth-based observation of asteroids. The following are the science objectives established for this mission:

- Return and analyze samples of pristine carbonaceous asteroid regolith in an amount sufficient to study the nature, history, and distribution of its constituent minerals and organic material.
- Map the global properties, chemistry, and mineralogy of a primitive carbonaceous asteroid (potentially hazardous near-Earth asteroid 1999 RQ36) to characterize its geologic and dynamic history and provide context for the returned samples.
- Document the texture, morphology, geochemistry, and spectral properties of the regolith at the sample site *in situ*.
- Measure the push on the asteroid, caused by the Sun as the asteroid absorbs the Sun's energy and re-emits it as heat (the Yarkovsky effect), and the effect of that push on its orbit and examine the asteroid properties that contribute to this effect.
- Characterize the integrated global properties of 1999 RQ36 to allow for direct comparison with ground-based telescopic data of the entire asteroid population.

### 2.1.1 Mission Overview

NASA is proposing to launch the OSIRIS-REx mission from the CCAFS, in Florida in September 2016. A launch vehicle has not been selected at this time, but it is expected that the baseline vehicle for the mission would be an Atlas V class launch vehicle. After traveling two years, OSIRIS-REx would approach 1999 RQ36 in October 2018. Asteroid 1999 RQ36 is approximately 579 meters (1,900 feet) in diameter. The asteroid, little altered over time, is likely to represent a snapshot of our solar system's infancy. It is also likely rich in carbon, a key element in the organic molecules necessary for life. Organic molecules have been found in meteorite and comet samples, indicating some of life's ingredients can be created in space.

Once in position within about 5 kilometers (3 miles) of 1999 RQ36, the spacecraft would begin comprehensive surface mapping using a variety of instruments to study the asteroid. OSIRIS-REx would globally map the surface of 1999 RQ36 using an optical camera and laser altimeters. The spacecraft would use optical, infrared, and thermal emission spectrometers to

generate mineral, organic, and thermal emission spectral maps and local spectral information of candidate sample sites.

From the information gathered while OSIRIS-REx is in orbit around 1999 RQ36; the science team would select a location on the asteroid where the spacecraft would take samples. Once a candidate sample site has been selected, OSIRIS-REx would approach, but not land on, 1999 RQ36 and would use the robotic arm of the Touch-and-Go Sample Acquisition Mechanism (TAGSAM) to retrieve samples for analysis that could help explain our solar system's formation and how life originated. Samples would be collected by two means: (1) puffs of nitrogen gas would be used to fluidize the surface regolith for collection, and (2) contact pads at the end of the robotic arm would collect fine-grained surface material. The intent is to obtain at least 60 grams (approximately 2.1 ounces) of pristine regolith and a surface-material sample. The samples would be stored in a sample canister within a SRC, whose design would be similar to that used by NASA's Stardust mission, which returned the world's first comet particles from comet Wild 2 in 2006 to the UTTR, in Tooele County, Utah. In all, OSIRIS-REx would spend over two years (approximately 30 months) collecting information while at 1999 RQ36.

Upon the completion of its 30 month investigation and sample collection of 1999 RQ36, OSIRIS-REx would begin its 2.5-year return journey to Earth. The spacecraft would be placed on a course that would bring it near Earth. As it approaches Earth, a final course correction would set OSIRIS-REx on course to release the SRC for a landing at UTTR in September 2023. The SRC would be released from the spacecraft approximately 4 hours before it would enter the Earth's atmosphere. Once the SRC is released, the OSIRIS-REx spacecraft would perform a collision avoidance maneuver so that it does not return to Earth. Only the SRC is intended to return to Earth.

**The NASA Planetary Protection Officer has issued a preliminary categorization of "unrestricted Earth return," meaning the sample is safe to return to Earth.**

A parachute system would be used to slow the SRC for a soft landing at UTTR. The parachute system would consist of a drogue parachute ("chute") to provide stability at supersonic speeds and a main chute to be deployed at 3,048 meters (10,000 feet) above mean sea level. These parachutes would slow the SRC to a landing speed of approximately 5 meters (16 feet) per second. Following touchdown, the SRC would be recovered and transported to a staging area at UTTR, where the enclosed sample canister would be removed and prepared for transport to a curation facility.

The unopened sample canister would be transported via C130 aircraft to the planetary materials curation and research facility at JSC, in Houston, Texas for storage and sample examination. Materials from the TAGSAM sampler head, witness coupon[1] materials, and other SRC hardware would be archived in a dedicated cabinet in an existing clean room. A new Class 100 clean room would be designed and built to store, handle, and subdivide the 1999 RQ36 samples. The new clean-room project would begin during fiscal year 2019, and would be built inside existing space

[1] Witness coupons are small plates of materials (alumina, stainless steel, or aluminum) that are installed in parts of the sampling head and SRC to "witness" (provide a record of the effect of) the environment of the sample canister during the duration of the mission. When returned to Earth, these will be recovered and analyzed by scientists using various analytical approaches. Different materials are used so that there is a choice, depending on the type of element or analysis that needs to be done (*i.e.*, one material will not satisfy everyone and every technique).

in Building 31 at JSC. Renovations would include addition of a clean-room floor; air handling units; and fire protection, moisture detection, and security systems.

### 2.1.2 NASA Routine Payload

The OSIRIS-REx mission meets the criteria for a NASA routine payload as defined in the *NASA Routine Payload Environmental Assessment* (*NRP EA*) **(NASA 2011a)**, except for the sample return portion of the mission (see Appendix B of this EA).

**Table 2–1** provides a summary of OSIRIS-REx mission characteristics and NASA routine payload criteria.

**Table 2–1. OSIRIS-REx Mission Characteristics**

| | OSIRIS-REx Characteristics | Routine Payload Characteristics |
|---|---|---|
| Launch Vehicle | Atlas V or other *NRP EA* launch vehicle | Yes |
| Launch Site | CCAFS | Yes |
| Sample Return | Unrestricted Earth Return | N/A[a] |
| Landing Site | UTTR | N/A |
| Structural materials | Composite aluminum polycyanate<br>Aluminum<br>Titanium | • Unlimited: aluminum, beryllium, carbon resin composites, magnesium, titanium, and other materials unless specified as limited. |
| Propulsion | 945.2 kilograms (2,083 pounds)<br>Hydrazine (monopropellant) | • Liquid propellant(s); 3,200 kilograms (7,055 pounds) combined hydrazine, monomethyhydrazine and/or nitrogen tetroxide<br>• Solid Rocket Motor propellant; 3,000 kilograms (6,614 pounds) Ammonium Perchlorate-based solid propellant (examples of Solid Rocket Motor propellant that might be on a spacecraft are a Star-48 kick stage, descent engines, an extra-terrestrial ascent vehicle, etc.) |
| Communications | Redundant 100 Watt transmitters | • Various 10 to 100 Watt (RF) transmitters |
| Power | 2 Solar arrays<br>2 lithium ion batteries (30 Ahr each) | • Unlimited Solar cells; 5 kilowatt-hour (kW-hr) Nickel-hydrogen (NiH2) or Lithium ion (Li-ion) battery, 300 Ampere-hour (A-hr) Lithium-thionyl chloride (LiSOCl), or 150 A-hr hydrogen, Nickel-cadmium (NiCd), or Nickel-hydrogen (Ni-H2) battery |

**Table 2–1. OSIRIS-REx Mission Characteristics (*continued*)**

| | OSIRIS-REx Characteristics | Routine Payload Characteristics |
|---|---|---|
| Science Instruments | OCAMS – OSIRIS-REx Camera Suite<br>OLA – OSIRIS-REx Laser Altimeter<br>OVIRS – OSIRIS-REx Visible and Infrared Spectrometer<br>OTES – OSIRIS-REx Thermal Emission Spectrometer<br>REXIS – Regolith X-Ray Imaging System<br>TAGSAM – Touch-And-Go Sample Acquisition Mechanism | • 10 kilowatt radar<br>• American National Standards Institute safe lasers |
| Other Components | Light Detection and Ranging:10 to 14 microJoule laser<br>OSIRIS-REx Laser Altimeter Light Detection and Ranging – microJoule laser<br>Iron-55 (less than 60 nanocuries) REXIS calibration source<br>High pressure nitrogen bottles<br>Pyrotechnic initiation unit (explosives for parachute deployment) | • U. S. Department of Transportation Class 1.4 Electro-Explosive Devices for mechanical systems deployment<br>• American National Standards Institute safe lasers<br>• Radioactive materials in quantities that produce an A2 mission multiple value of less than 10<br>• Propulsion system exhaust and inert gas venting<br>• Sample returns are considered outside of the scope of this environmental assessment |

a. Sample return activities are beyond the scope of characteristics considered in the *NRP EA*.

### 2.1.3 Spacecraft

The OSIRIS-REx spacecraft is approximately 2 by 2 meters (6.6 by 6.6 feet) and at launch would have a dry mass just over 750 kilograms (1,650 pounds). **Figure 2–1** displays the spacecraft with the science payload (instruments and SRC), communications and navigation equipment, solar power system, and propulsion systems. Of this equipment, only the SRC is intended to return to Earth.

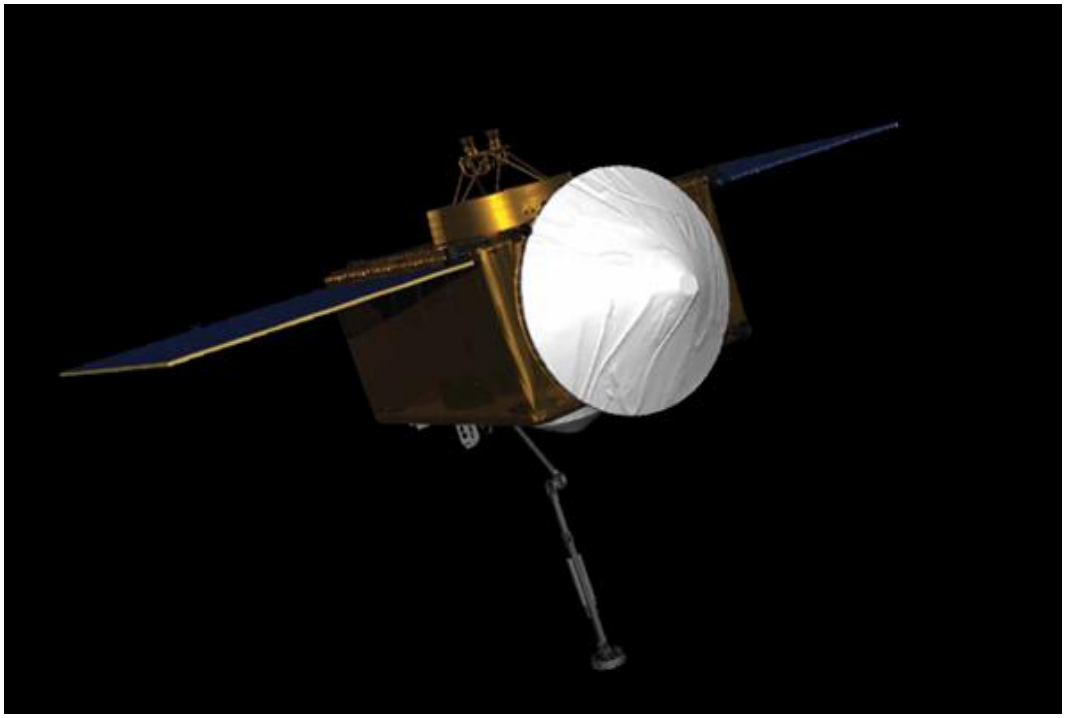


**Figure 2–1. OSIRIS-REx Spacecraft**

The spacecraft utilizes solar power collected with two solar energy arrays each with an active collection area of 8.5 square meters (91.5 square feet).

Once the spacecraft has separated from the launch vehicle, propulsion would be provided by several thrusters of various sizes. These thrusters, which use hydrazine as the propellant, would be provided on the spacecraft.

OSIRIS-REx would use several pyrotechnic devices, all classified as self-contained (explosive effects are confined within the device) in case of inadvertent firing. All would be NASA standard initiators (NSIs) or equivalent, to be used in the deployment and release of the SRC parachute. The design also includes non-pyrotechnic separation devices, which would be used for releasing the SRC. The SRC would contain a small mortar and redundant NSIs for parachute deployment.

### 2.1.4 Mission Science Instrument Suite

The science instruments proposed for the OSIRIS-REx mission are intended to provide both remote characterization of 1999 RQ36 and sample collection capability. Remote observations of

the asteroid would consist of optical, thermal infrared, and x-ray data collection. These images would be gathered as the spacecraft approaches the asteroid and as it orbits. In addition to providing information for study, the remotely collected data would be used to select a suitable sample collection site. Once selected, the spacecraft would approach 1999 RQ36 and retrieve samples. **Figure 2–2** identifies the science packages proposed for the OSIRIS-REx mission. These are described below.

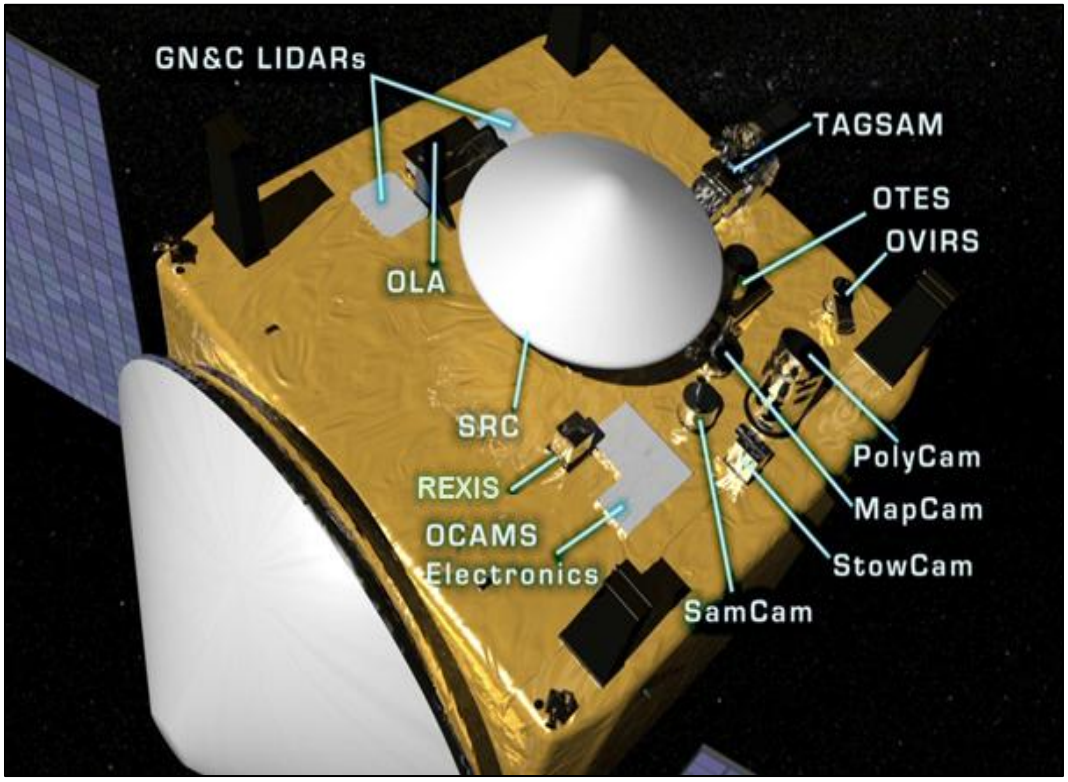



**Figure 2–2. OSIRIS-REx Instruments**

- **OSIRIS-REx Camera Suite (OCAMS).** The OCAMS would allow long-range acquisition of 1999 RQ36, along with global mapping, sample-site characterization, sample acquisition documentation, and submillimeter imaging. It consists of three cameras, the PolyCam, the MapCam, and the SamCam. The PolyCam, a 20-centimeter (8-inch) telescope, would be the first of the cameras to acquire images of the asteroid and would provide high-resolution images at close range. The MapCam would be used to search for satellites of the asteroid and possible outgassing plumes. It is also capable of providing high-resolution images and would be used to characterize possible sample sites. The SamCam would provide the capability to continuously monitor the sample collection process.
- **OSIRIS-REx Laser Altimeter (OLA).** The OLA would be used to collect ranging data; global topographic mapping, and local topographic maps of candidate sample sites. It is a scanning and Light Detection and Ranging (LIDAR) device. The LIDAR would consist of two lasers, one high-energy transmitter for ranging and mapping at a distance of 1 to 7.5 kilometers (0.6 to 4.7 miles) and one low-energy transmitter to be used at

distances of less than 1 kilometer (0.6 miles). It would also support navigation and gravity analysis.

- **OSIRIS-REx Visible and Infrared Spectrometer (OVIRS).** The OVIRS would measure light reflected off of the asteroid to provide mineral and organic spectral maps and local spectral information of candidate sample sites. The spectral ranges and resolving power of the OVIRS would be sufficient to provide surface maps of mineralogical and molecular components, including carbonates, silicates, sulfates, oxides, adsorbed water, and a wide variety of organic species.
- **OSIRIS-REx Thermal Emission Spectrometer (OTES).** The OTES would be used to develop mineral and thermal emission spectral maps and local spectral information of candidate sample sites from 4 to 50 micrometers by collecting thermal infrared data. This instrument can be used to identify compounds, including silicates, carbonates, sulfates, phosphates, oxides, and hydroxides. It would also be used to measure the total thermal emissions from 1999 RQ36.
- **Spacecraft Telecom.** Radio science would be used to develop 1999 RQ36 mass and gravity field maps.
- **Regolith X-Ray Imaging System (REXIS).** A student collaboration experiment would be used to develop an x-ray map of 1999 RQ36. It would complement the mineral mapping capabilities from the other OSIRIS-REx instruments by providing elemental abundance mapping through x-ray spectrometry.
- **Touch-and-Go Sample Acquisition Mechanism (TAGSAM).** The TAGSAM, a simple sampler head, is an articulated arm that can be extended to allow surface contact without having the spacecraft land on the asteroid. (**Figure 2–3** shows the TAGSAM fully extended.) The TAGSAM would collect samples via the following two mechanisms:
    - The sampler arm would agitate the surface (nitrogen gas used to fluidize regolith), allowing for collection of suspended particles. The onboard nitrogen resources would support up to three separate sampling attempts. Vacuum and microgravity tests of the sampler head have consistently demonstrated the ability to collect samples of more than 60 grams (2 ounces); and
    - Surface-contact pads located at the end of the TAGSAM would collect fine-grained material. The robotic arm of TAGSAM would be used to place the sample head and surface-contact pads in the SRC after sampler collection. Proper placement of these materials in the SRC would be verified using the StowCam.

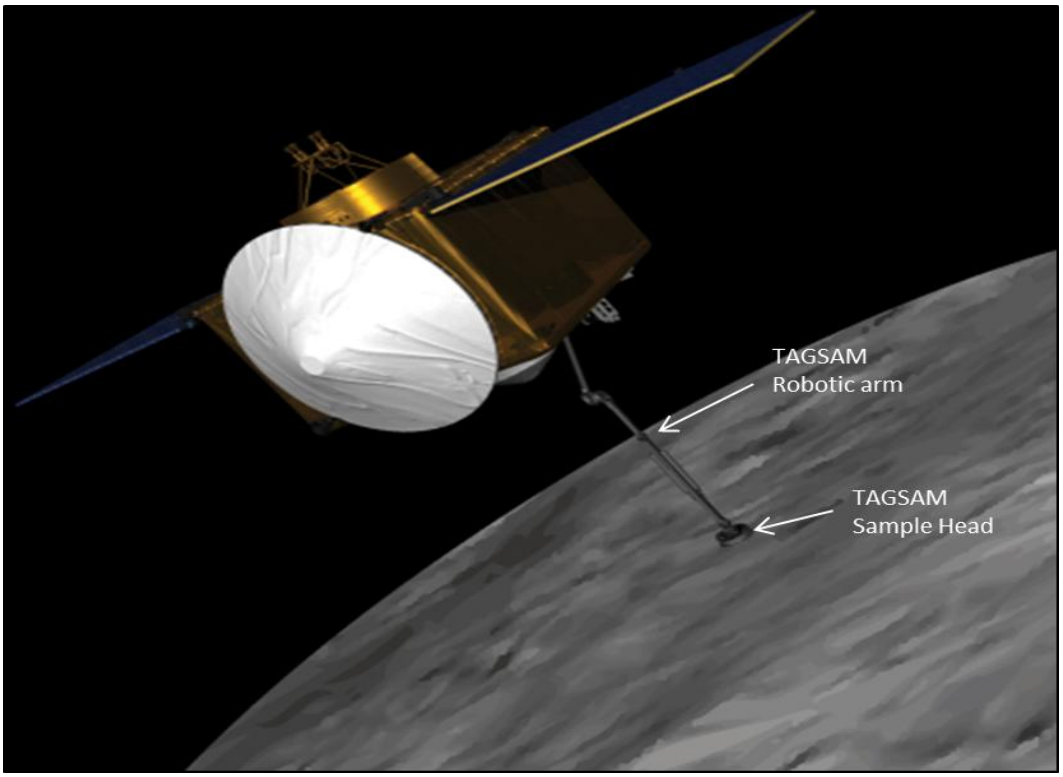
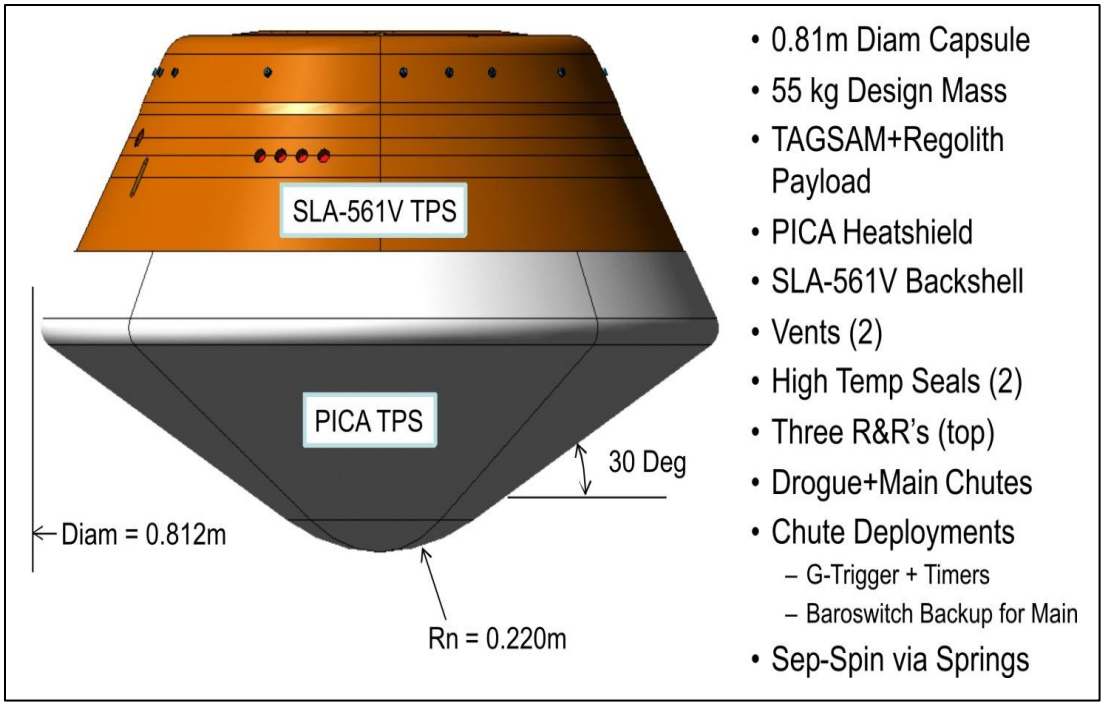



**Figure 2–3. OSIRIS-REx with TAGSAM Deployed**

### 2.1.5 Sample Return Capsule

The design of the SRC proposed for the OSIRIS-REx mission is the same as that of the SRC used for the Stardust mission, which successfully returned samples from comet Wild 2.

The SRC (see **Figure 2–4**) would be composed of four major components: a heat shield, a back shell, a sample canister, and a parachute system. The total mass of the SRC, including the parachute system would be no more than 55 kilograms (121 pounds). The SRC would have a diameter of 81 centimeters (32 inches).




**Note:** PICA TPS is the Heat Shield; SLA-561V TPS is the Back shell.
**Key:** PICA=phenolic-impregnated carbon ablator; SLA=super lightweight ablator; TAGSAM=Touch-and-Go Sample Acquisition Mechanism; TPS=Thermal Protection System.
**Source: NASA Goddard 2012c.**

**Figure 2–4. OSIRIS-REx SRC**

### Heat Shield

The heat shield would be made of a graphite/epoxy composite covered with a thermal protection system (TPS). The TPS to be used for OSIRIS-REx would be a phenolic-impregnated carbon ablator (PICA) developed by NASA's Ames Research Center (ARC) for use on high-speed reentry vehicles. The SRC heat shield would remain attached to the capsule throughout descent and serve as a protective cover for the sample canister at touchdown.

The back shell structure would also be made of a graphite/epoxy composite covered with a TPS. The TPS that is planned for use on the back shell is a cork-based material called super-lightweight ablator (SLA 561V) that was developed by Lockheed Martin for use on the Viking missions to Mars and was used on the Space Shuttle External Tank. The back shell would provide the attach points for the parachute system.

### Sample Canister

The sample canister would be an aluminum enclosure that holds the asteroid regolith and fine-grained samples contained within the TAGSAM sampler head. The canister would be mounted to an equipment deck suspended between the back shell and heat shield.

**Parachute System**

The parachute system would incorporate a drogue chute and a main chute into a single parachute canister which would contain the NSIs and the drogue deployment mortar. Inside the canister would be a gas cartridge that would be used to pressurize the mortar tube and expel the drogue chute. The drogue chute would be deployed at high altitude at an SRC speed of about Mach 1.4 to provide stability until the main chute is released. Based on gravity switch/timer and backup pressure transducers, an NSI-fired cutter would release the drogue chute from the SRC at approximately 3,048 kilometers (10,000 feet) above mean sea level. As the drogue chute moves away from the SRC, it would extract the main chute from the parachute canister. Upon touchdown, cutters would fire to cut the main chute cables so that winds would not drag the SRC across the terrain.

### 2.1.6 Launch Vehicle

The baseline launch vehicle for the OSIRIS-REx mission is the Atlas V class vehicle. The Atlas V is a two-stage launch vehicle. Variations within the vehicle class are primarily related to the number of engines in each stage. The Atlas V has the capability to use first-stage boosters (typically solid rocket engines). **Table 2–2** describes the types of motors and propellants associated with the Atlas V. While the Atlas V is the baseline launch vehicle for the OSIRIS-REx mission, it is possible that a different class of launch vehicle could be selected. Any vehicle chosen would have be a launch vehicle/launch site combination included in the *NRP EA*. Environmental impacts associated with launches utilizing a variety of launch vehicles, including the Atlas V class vehicles have been analyzed in the *NRP EA*.

**Table 2–2. Atlas V Motor Types and Propellants**

| Name | Motor type | Potential Maximum Propellant |
|---|---|---|
| Atlas V | Single RD-180 engine –CCB | 195,311 kg (429,685 lb) LOX<br>88,778 kg (195,311 lb) RP-1 |
| | Centaur upper stage (1 or 2 engines) | 20,672 kg (45,500 lb) LOX and $LH_2$ |
| | 1 SSRM | 46,494 kg (102,300 lb) HTPB each |
| | Up to 5 SSRMs | 232,470 kg (511,500 lb) HTPB |

**Key:** CCB=Common Core Booster; HTPB=Hydroxyl-Terminated Polybutadiene, a solid rocket propellant; kg=kilograms; lb=pounds; $LH_2$=Liquid hydrogen; LOX=Liquid oxygen; RP-1=Rocket Propellant–1; SSRM=Strap-on Solid Rocket Motor.

**Source: NASA 2011a.**

Therefore, while the OSIRIS-REx mission launch vehicle characteristics may differ from those provided for the Atlas V, the findings (which are incorporated in this EA by reference) of the *NRP EA* would be applicable regardless of the specific launch vehicle selected.

Regardless of which launch vehicle is selected, final preparation for the mission would occur at the launch complex, where the OSIRIS-REx spacecraft would be integrated with the launch vehicle.

### 2.1.7 Launch Facilities

At CCAFS, the Atlas V vehicle launches from an existing launch complex (LC), LC–41, located on the northern end of CCAFS. Since the final Titan IV launched from CCAFS on April 2005, it has been reconfigured to support launches of Atlas V. It consists of one launch pad, a vertical integration facility, a mobile service tower, and other facilities needed to prepare, service, and launch the Atlas V vehicles.

Launch vehicle assembly and final integration of the OSIRIS-REx spacecraft with the launch vehicle would occur in facilities located within the launch complex. No new facilities would be constructed at CCAFS in support of the OSIRIS-REx mission.

### 2.1.8 Recovery Facilities

The SRC would land on the southern portion of UTTR (which includes the Air Force South Range and Dugway Proving Ground). No specialized recovery facilities would be required. Once the SRC has landed, a recovery team would retrieve it and the released parachutes by ground or helicopter transport. (The parachute should be recoverable, however, there is the possibility that after being separated from the SRC they would drift into a restricted area of the UTTR and not be recovered.) The safety engineer would approach the capsule wearing personal protective equipment, check for the presence of $SO_2$ that is toxic and could be released if the battery were to have vented. Air samples are taken at the SRC vents to establish the environmental reference for use in sample analysis. The safety engineer then places covers over the vent holes to prevent exposure of the recovery team to possible toxic ablation gasses that could have entered the capsule during entry. Before moving the capsule, the SRC is made safe by plugging the mortar tube and disconnecting or cutting the wires to the parachute riser NSIs and the UHF antenna. (Small amounts of toxic gases are generated from the ablation of the heat shield and released in the upper atmosphere although some could enter the capsule vents.) Extraordinary measures would not be required for transport; the SRC would primarily be handled manually and with a small, specialized handling fixture used to cradle the capsule during transport. The capsule would be transported to a staging area where it would be prepared for transport to the curation facility.

### 2.1.9 Curation Facilities

The OSIRIS-REx sample capsule would be taken to NASA's JSC via a C130 transport aircraft for processing. JSC has an existing dedicated curation and research facility for planetary materials that has been in use since the first lunar samples were brought back by the Apollo missions. Samples currently being stored there include, among others, material from the Stardust (comet samples) and Genesis (solar wind samples) missions. All OSIRIS-REx mission curation activities would occur at JSC, where the asteroid material would be removed and delivered to the dedicated facility following stringent planetary protection contamination control protocol.[2] Precise analysis would be performed that cannot be replicated by spacecraft-based instruments

[2] Planetary protection protocol is NASA's principle in the design of missions intended to prevent biological contamination—in this case, of the 1999 RQ36 samples and of Earth.

alone. Samples would ultimately be distributed worldwide for examination at other research facilities.

The OSIRIS-REx mission would use existing facilities within JSC for all curation activities. No new structures would be constructed; however, JSC would design and build a new Class 100 cleanroom within an existing facility to house the 1999 RQ36 samples returned to Earth by the OSIRIS-REx mission.

## 2.2 ALTERNATIVES TO THE PROPOSED ACTION

### 2.2.1 Alternate Landing Sites

Selecting a recovery operations site for a sample return mission depends largely on matching the safety and mission-critical criteria to the facilities and capabilities of the prospective landing site. Issues of concern include minimal risk to public safety and to the returned samples. Because a water landing would most probably compromise the mission science objectives by increasing the risk of contamination of the pristine samples, a recovery site on land is mandated. Sites that can effectively be closed to the public minimize the chance of the reentering SRC harming individuals or their possessions within the controlled site boundary.

#### 2.2.1.1 *Recovery Site Selection*

The following criteria were used for site selection.

- Safety
  - The site must accommodate a recovery footprint of 84 kilometers (52 miles) downrange by 20 kilometers (12 miles) cross range (with the major axis of the footprint from west-southwest to east-northeast) (**Figure 2–5**).
  - The site must have reserved air space to provide separation from commercial air traffic.
- Science return
  - The site must have a flat recovery area, free from hills or terrain features that would impose side loads on sides of the SRC.
  - The locale must allow prompt delivery of the samples to the JSC curation facility.
- Land recovery versus water recovery
  - Salt water is highly corrosive.
  - The SRC would be at risk of sinking in a water landing.
  - The SRC would be at risk of being carried by ocean currents if not promptly recovered.
  - The sample science would be compromised by water contamination.
- Range recovery assets
  - Descent tracking capability.
  - Ground recovery operations capability.

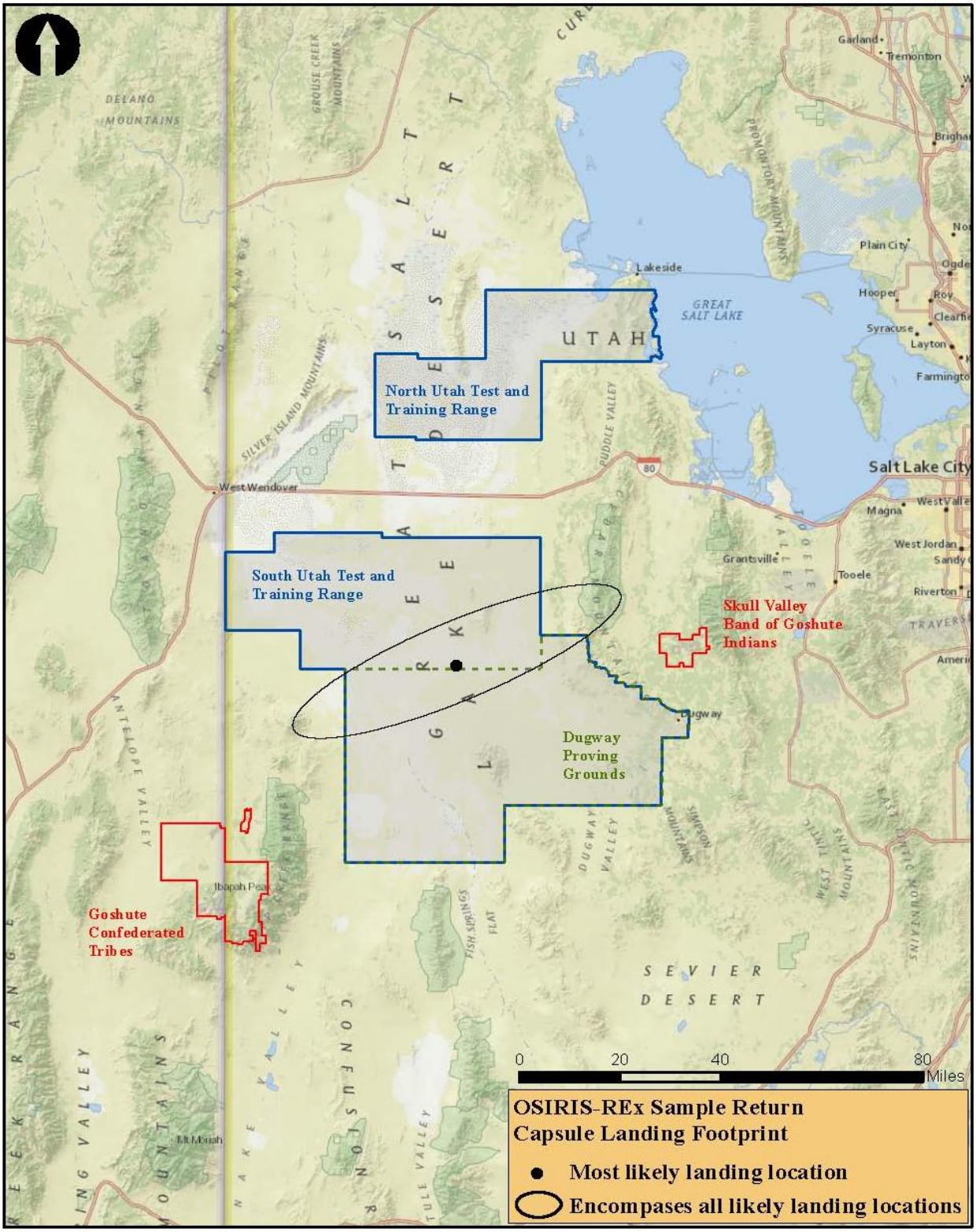
- U.S. range versus a foreign landing site
  - Time and uncertainty associated with obtaining the necessary agreements with foreign governments.
  - Cost associated with completing complex agreements.
  - Time to transport samples to the JSC curation facility, ensuring the integrity, safety, and security of the samples.

#### 2.2.1.2 *Alternatives Considered But Dismissed from Further Consideration*

The OSIRIS-REx 84- by 20-kilometer (52- by 12-mile) landing footprint (Figure 2–5) requires a large, flat, relatively unpopulated, restricted area to ensure safety of personnel, the public, structures, and the mission science to be returned. Of the landing sites examined, UTTR has been determined to be the best-suited potential landing site for the following reasons:

- Water recovery sites have been rejected due to unacceptable risk to the returned science, higher risk of capsule loss, and higher cost of recovery.
- U.S. landing sites were chosen to ensure the integrity, safety, and security of the samples.
- UTTR has the largest overland special-use airspace (measured from the surface or near surface), as well as the largest overland contiguous block of supersonic-authorized, restricted airspace in the continental United States **(NASA 1998)**. The population density is low, making it extremely unlikely that anyone would be harmed during landing.

UTTR has been identified as the proposed OSIRIS-REx project recovery operations site because it satisfies all of the preceding criteria. UTTR has been the recovery site for the Genesis mission in September 2004 and the Stardust mission in January 2006.




**Source: NASA Goddard 2012c.**

**Figure 2–5. 84×20 km (52×12 mi) Footprint for SRC Entry, Descent, and Landing Superimposed on UTTR**

### 2.2.2 No Action Alternative

Under the No Action Alternative, NASA would not pursue the OSIRIS-REx mission. NASA would not be able to meet all of the science objectives established for this mission. In particular, there would be no sample return of asteroid regolith for detailed study; data recovered regarding the push on the asteroid caused by the energy emitted from the Sun; or ability to compare the collected data regarding the properties of the asteroid with ground-based observations.

Under the No Action Alternative, NASA would not be able to predict 1999 RQ36's future course and probability of Earth impact as accurately and would miss the opportunity to further study a solar system body that provides a unique record of what has happened in our solar system, as discussed in Chapter 1, Sections 1.1 and 1.2, respectively.

While asteroids have been affected by solar winds (energetic particles emitted from the Sun), they have been unaffected by the climatic processes found on most planets, especially the planets closest to Earth. As such they remain in many ways much as they were when originally formed. By selecting the No Action Alternative NASA would miss the opportunity for a detailed study of an asteroid and miss the opportunity to look back in time to a period when the solar system was young.

The asteroid 1999 RQ36 is also one of the asteroids with the highest probability of striking Earth in the next century. Under the No Action Alternative NASA would not be able to examine the factors that affect the orbit of asteroids and would not be able to as accurately predict its future course and probability of Earth impact.

## 2.3 SUMMARY OF IMPACTS

**Table 2–3** provides a summary of the impacts at each participating site of the proposed action and the No Action Alternative.

**Table 2–3. Summary Table of the Potential Impacts of the Proposed Action and the No Action Alternative**

| Resource Area | Proposed Action | | | No Action |
|---|---|---|---|---|
| Global Environment | Short-term reduction in ozone concentration and contribution to greenhouse emissions | | | None |
| | **CCAFS[a]** | **UTTR** | **JSC** | |
| Land Use and Aesthetics/Visual Resources | No impact | Negligible | No impact | None |
| Hazardous Materials and Hazardous Waste Management | No impact | Negligible | Negligible impact using procedural controls[b] | None |
| Health and Safety | No impact | Negligible | Negligible impacts using procedural controls[b] | None |
| Geology and Soils | No impact | Negligible | No impact | None |
| Water Resources | Short-term and not substantial; no impact to floodplains | Negligible | No impact | None |
| Air Quality | Short-term and not substantial | Negligible | No impact | None |
| Noise | Short-term and not substantial | Negligible | No impact | None |
| Biological Resources | Short-term and not substantial, no impact to threatened or endangered species | Negligible | No impact | None |
| Historical and Cultural Resources | No impact | Negligible | No impact | None |
| Socioeconomics | No impact | Negligible | Negligible | None |
| Environmental Justice | No impact | No impact | No impact | None |
| Cumulative Impacts | No impact | No impact | No impact | None |

a. The OSIRIS-REx Mission has been designated as a NASA routine payloads mission with regard to the mission launch. Impacts associated with the launch of NASA routine payloads were analyzed in the *NRP EA* **(NASA 2011a)** and finding of no significant impact.

b. Procedural controls ensure compliance with applicable State and Federal regulations for waste handling and disposal.

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# CHAPTER 3

# AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

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# 3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

## 3.1 INTRODUCTION

This chapter describes the affected environment along with the associated environmental impacts of implementing the NASA's OSIRIS-REx mission. In accordance with the Council on Environmental Quality NEPA regulations **(40 CFR 1500–1508)**, the affected environment is "interpreted comprehensively to include the natural and physical environment and the relationship of people with the environment." The affected environment for this EA includes CCAFS, Florida, for the launch activities; UTTR, in Tooele County, Utah, for the sample return activities; and JSC, Houston, Texas, for the curation activities. The affected environment involves the following resource areas: land use and visual resources, site infrastructure, geology and soils, water resources, air quality and noise, ecological resources, cultural resources, socioeconomics, human health and safety, environmental justice, and waste management and pollution prevention. As discussed in Chapter 1, the focus of this EA is on the sample return and thus this chapter focuses on UTTR. The affected environment and the resource areas are addressed briefly for CCAFS and JSC and in more detail for UTTR. The level of treatment given each resource area is related to the potential for environmental impacts. Information in this chapter addressing routine payload aspects of the mission is summarized and incorporated by reference from the *NASA Routine Payload EA* (*NRP EA*) available at http://www.nasa.gov/agency/nepa/routinepayloadea.html **(NASA 2011a)**.

## 3.2 CAPE CANAVERAL AIR FORCE STATION

This section discusses the potential environmental impacts associated with the launch of the OSIRIS-REx mission from CCAFS. The activities associated with the launch have been determined to fall within the bounds of missions previously analyzed in the *NRP EA* **(NASA 2011a)**. On November 22, 2011, NASA published the Finding of No Significant Impact for *NRP EA*. The *NRP EA* provides a discussion of the affected environment and the potential consequences associated with a routine payload launch. The findings of the *NRP EA* as they pertain to the OSIRIS-REx mission are incorporated by reference and briefly summarized in this section.

### 3.2.1 Affected Environment

CCAFS is situated on Cape Canaveral and northern Merritt Island along the east-central Atlantic coast in Brevard County, Florida, encompassing an area of 6,397 hectares (15,807 acres). Land uses at CCAFS include launch operations, launch and range support, airfield, port operations, station support, and open space. The launch operations land use category is present along the Atlantic Ocean shoreline and includes the active and inactive launch sites and support facilities. The launch and range support area is west of the launch operations area and is divided into two sections by the airfield (skid strip). The airfield includes a single runway, taxiways, and apron and is in the central part of the station. The port operations area is in the southern part of the station and includes facilities for commercial and industrial activities. The major industrial area is located in the center of the western portion of the station. This station support area also

includes administration, recreation, and range-support facilities. Open space is dispersed throughout the station. There are no public beaches located on CCAFS. All land uses at CCAFS are under the operational control of the USAF 45th Space Wing, located at Patrick Air Force Base **(USAF 2001)**.

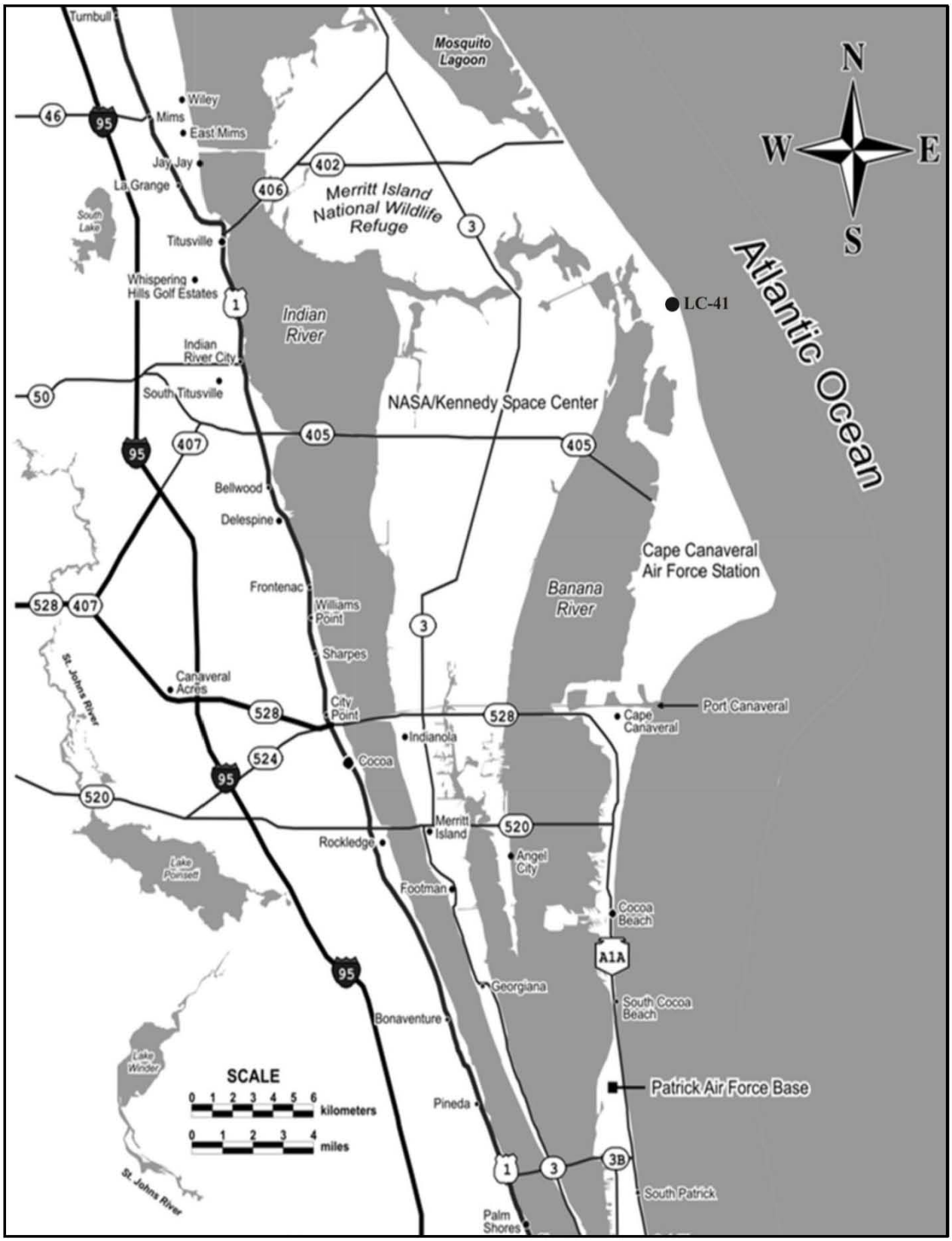
The remaining undeveloped operational areas are dedicated as safety zones around existing facilities or held in reserve for planned and future expansion. The National Park Service (NPS) and the U.S. Fish and Wildlife Services (USFWS) manage the 54,745 hectares (135,278 acres) that are outside of NASA operational control. NPS administers 2,693 hectares (6,655 acres) of the Canaveral National Seashore (CNS), while USFWS administers 20,616 hectares (50,943 acres) of the CNS and the 30,506 hectares (75,382 acres) of the Merritt Island National Wildlife Refuge (MINWR) **(NASA 2010)**.

Florida's Indian River Lagoon Estuary System includes Mosquito Lagoon, Canaveral Inlet, Banana River, Indian River, and the Sebastian Inlet. Recreational activities involve primarily the coastal beaches and inland waters of the Indian and Banana rivers. Boating, surfing, water-skiing, and fishing are common activities. The beaches along CCAFS are used for launch operations and are restricted from public use. The nearby CNS and MINWR are open to the public, but are closed during some launch operations. Port Canaveral has several cruise-ship terminals.

Topography of the area is generally flat, with elevations ranging from sea level to approximately 6 meters (20 feet) above sea level. The most visually significant aspect of the natural environment is the gentle coastline and flat island terrain. The area has a low visual sensitivity because the flatness of the area limits any prominent vistas. CCAFS is fairly undeveloped. The most significant manmade features are the launch complexes and various support facilities. Most areas of CCAFS outside of the developed areas are covered with native vegetation.

A map of the CCAFS area is shown in **Figure 3–1**.

**Figure 3–1. Map of Cape Canaveral Air Force Station, Florida**




**Source: NASA 2008a.**

**Figure 3–1. Map of Cape Canaveral Air Force Station, Florida (*continued*)**

### 3.2.2 Potential Consequences

Most impacts occurring at CCAFS would be from the launch, primarily impacts of noise on biological resources and temporary air quality changes.

#### 3.2.2.1 *Land Resources and Aesthetics/Visual Resources*

Overall, the OSIRIS-REx Atlas V vehicle launch is expected to have negligible effects on the land resources surrounding the launch complex (LC), LC-41. However, launch activities could have some small impacts near the launch pad associated with fire and acidic deposition.

Wet deposition of hydrochloric acid, caused by rain falling through the ground cloud or solid rocket motor (SRM) exhaust, could damage or kill vegetation. Wet deposition is not expected to occur outside the pad fence perimeter due to the small size of the ground cloud and the rapid dissipation of both the ground cloud and SRM exhaust plume.

Because no new facilities would be required for the OSIRIS-REx mission, launch activities can be considered temporary (*i.e.*, no permanent long-term activities would be associated with a single launch). Visual resources would not be impacted.

#### 3.2.2.2 *Hazardous Materials and Hazardous Waste Management*

Depending on the Atlas V selection and the mass to be launched, the launch vehicle can be supplemented by one to five strap-on SRMs.

Hazardous and solid waste management activities associated with the OSIRIS-REx mission would comply with all applicable Federal, State, and local regulations. Liquid propellants, including kerosene (Rocket Propellant-1, or RP-1), liquid oxygen, liquid hydrogen, and hydrazine, would be stored in tanks near the launch pad within appropriate cement containment basins.

NASA has issued and implemented a plan to manage hazardous materials in compliance with the Resource Conservation and Recovery Act (RCRA). The plan, **NPR 8715.3C**, *NASA General Safety Program Requirements*, ensures that any accumulated hazardous materials are properly handled and characterized and that appropriate methods and means for spill control are in place.

#### 3.2.2.3 *Health and Safety*

The OSIRIS-REx spacecraft may carry small quantities of encapsulated radioactive material, less than 60 nanocuries of iron-55, for instrument calibration. The instrument containing the radioactive material (the Regolith X-Ray Imaging System) would not return to Earth with the SRC, and the amount of iron-55 would be well below the activity level specified in Chapter 6 of the **NPR 8715.3C**. The levels specified in the *NASA General Safety Program Requirements* (1,000 nanocuries of iron-55) are the quantities of radioactive material that have been shown to present no substantial hazard to the public. The OSISRIS-REx spacecraft would also carry a variety of low-power radio transmitters for telemetry, tracking, and data downlink and low-power lasers as part of spacecraft instrument systems. The low-power lasers in the OLA would be used only once the spacecraft is in space, would not return to Earth with the SRC, and would

not be pointing toward Earth. The power and operating characteristics of this equipment would be within limits identified in the *NRP EA*. Safety hazards associated with activities required to prepare the OSIRIS-REx spacecraft for launch would be within the scope of documented and mitigated hazards. These materials, equipment, and activities would present no substantial environmental impacts, health hazard, or safety hazard on the ground during launch operations.

#### 3.2.2.4 *Geology and Soils*

The OSIRIS-REx mission would not require construction of new facilities or industrial infrastructure, so new excavation would not be required. The near-field effects of deposition of emissions from combustion of launch vehicle fuels would be within the scope of ongoing and acceptable launch activity at all proposed launch sites.

#### 3.2.2.5 *Water Resources*

Existing water utility infrastructure would be used to meet miscellaneous needs of payload processing, launch vehicle preparation, and fire and explosion control. No OSIRIS-REx mission-related impacts on the groundwater, surface water, or wastewater processing systems are expected.

Deep-ocean release of toxic materials, such as residual propellants, hydraulic fluids, and eroding metals from spent launch vehicle booster structures, would not produce substantial concentrations due to the small amount of such materials and the large quantity of water available for dilution in the deep-ocean environment.

#### 3.2.2.6 *Air Quality*

Ground operations during OSIRIS-REx processing and launch vehicle preparation would temporarily create very small increases in emissions from electric power generators, vehicle traffic, and hazardous air pollutants. These increases would be within the scope of emissions from ongoing and routine operations at all proposed launch sites and would not substantially impact local air quality, either individually or cumulatively.

The air quality impacts of ongoing and routine operations at the launch facility have been considered in previous NEPA documentation **(NASA 2011a)**. CCAFS is in attainment for the ozone National Ambient Air Quality Standards (NAAQS).

Combustion emissions from an Atlas V would dissipate before reaching sensitive human, flora, or fauna receptors. Previous NEPA documentation, largely based on the Rocket Exhaust Effluent Diffusion Model for CCAFS and the KSC, shows that launching an Atlas V would result in gas and particle concentrations below all applicable Federal, State, and local regulations.

Previous NEPA documentation shows that upper atmospheric impacts would be limited to a miniscule amount of global ozone loss from rocket combustion emissions.

#### 3.2.2.7 *Noise*

Noise associated with the OSIRIS-REx spacecraft processing would be within the scope of normal and routine activities at the payload processing and launch site facilities, as discussed in previous NEPA launch vehicle documentation **(NASA 2011a)**.

Substantial launch noise from the launch vehicle would occur for only a brief period at liftoff and would not present a direct or cumulative impact on nearby communities beyond the impact of normal and accepted launch activities.

#### 3.2.2.8 *Biological Resources*

USFWS and the National Marine Fisheries Service have previously reviewed actions that would be associated with the launch of proposed NASA routine payload spacecraft on launch vehicles from all proposed launch sites. OSIRIS-REx spacecraft processing and launch activities would not require any permits and/or mitigation measures beyond those already existing or in coordination for launches from all proposed launch sites.

NASA routine payload spacecraft launches, including OSIRIS-REx, would not have an impact on launch site terrestrial or aquatic biota, including threatened and endangered species, beyond that already permitted and mitigated under the Marine Mammal Protection Act.

#### 3.2.2.9 *Historical and Cultural Resources*

OSIRIS-REx launch activities would not affect archaeological, historic, or cultural properties listed or eligible for listing in the National Register of Historic Places (NRHP). Archaeological and paleontological sites have been identified and would not be affected by this launch.

#### 3.2.2.10 *Socioeconomic Resources and Site Infrastructure*

OSIRIS-REx mission activities would cause no adverse or beneficial impacts on community facilities, services, or existing land uses. The prelaunch and launch activities would be within the scope of operations previously analyzed in existing NEPA documentation, including the *NRP EA* **(NASA 2011a)**.

#### 3.2.2.11 *Environmental Justice and Pollution Prevention*

An Atlas V launch would be within the scope and number of launches previously analyzed in NEPA documentation **(NASA 2011a)**. No substantial environmental effects are likely to occur outside the launch site boundary, thus no disproportionately high and adverse impact on children, minority population, or low-income populations is expected.

All NASA facilities have individual pollution prevention plans and various pollution prevention initiatives to identify and implement cost-effective waste reduction opportunities. Implementing the OSIRIS-REx mission would be consistent with these initiatives.

#### 3.2.2.12 *Cumulative Effects*

The use of facilities at CCAFS for processing and launch of the OSIRIS-REx mission would be consistent with existing uses as addressed in the *NRP EA* **(NASA 2011a)** and would pose no new types of impacts. The proposed launch of OSIRIS-REx would not increase previously approved launch rates nor utilize launch systems beyond the scope of approved launch vehicle programs at CCAFS. Therefore, the long-term cumulative effects on the local and regional environment by the proposed action would not be substantial.

## 3.3 UTAH TEST AND TRAINING RANGE

The OSIRIS-REx mission would utilize UTTR for the return of the SRC. Activities that could potentially impact the local environment include the landing of the SRC and ground recovery actions. These activities would be similar to those associated with the return of samples to UTTR during the Stardust and Genesis missions. Both of these missions were the subject of EAs **(NASA 1998, 2000)**, which resulted in Findings of No Significant Impact for both missions.

UTTR is a military testing and training area located in Utah's West Desert in west-central Utah, primarily in Tooele County (portions of the North Range are in Box Elder County), about 129 kilometers (80 miles) southwest of Salt Lake City (**Figure 3–2**). UTTR is currently the largest overland contiguous block of supersonic authorized restricted airspace in the continental United States. The range, which has a footprint of 6,930 square kilometers (2,675 square miles) of ground space and over 49,000 square kilometers (19,000 square miles) of air space, is divided into North and South ranges. Interstate 80 divides the two sections of the range. The site is administered and maintained by the USAF's 388th Range Squadron (RANS), stationed at Hill Air Force Base, Utah. Dugway Proving Ground (DPG) is south of, and adjacent to, the South Range and consists of a total of 319,642 hectares (789,855 acres) (3,196 square kilometers [1,234 square miles]). The installation lies entirely within Tooele County. The U.S. Department of Defense (DOD) has designated the DPG installation as a major range and testing facility and the primary chemical and biological defense testing center under the Reliance Program **(DPG 2001)**. DOD uses the airspace over U.S. Army and USAF lands (DPG and UTTR North and South ranges), as well as adjacent public lands, as a maneuver overflight area. This area, including Army- and USAF-administered lands, is collectively known as UTTR.

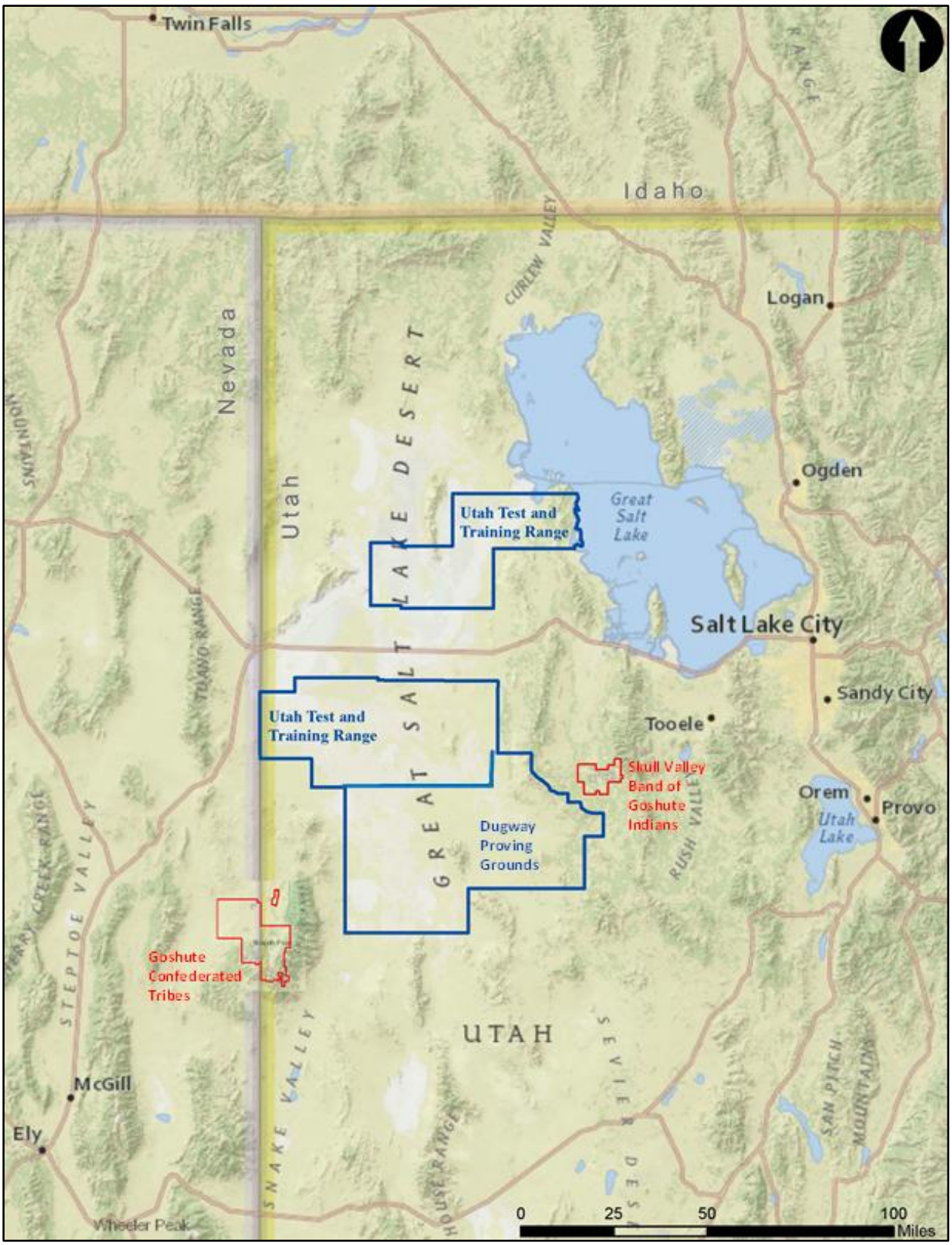



**Figure 3–2. Map of Utah Test and Training Range**

The USAF's 388th Fighter Wing, 388th RANS Air Combat Command, operates a detachment on DPG in support of UTTR. As a DPG tenant, the 388th RANS is responsible for providing ground support for testing and training activities conducted on UTTR for all DOD units and some North Atlantic Treaty Organization countries. These ground support activities include tracking and evaluating aircraft training and test missions; response to in-flight emergencies and support of grounded flight crews; and support of crews in testing and recovering aircraft, missile, and space vehicle elements **(DPG 2012)**. In addition to their primary USAF support responsibilities, the 388th RANS provides support to non-USAF activities that require electronic flight surveillance capabilities as well as test locations and scoring. The 388th operations at DPG include the use of office facilities at Avery Area; maintenance, storage, and lodging facilities; and command and control centers for weapons testing, radar sites, and target and telemetry locations and roads to target complexes and radar sites. In total, the 388th occupies approximately 2,703 hectares (6,680 acres) on DPG land. The 388th RANS has occupied facilities on DPG land since 1978 and, with current global situations, sees an ongoing need for continued use of this land in the future.

### 3.3.1 Land Resources and Aesthetics/Visual Resources

#### 3.3.1.1 *Affected Environment*

The majority of lands within the North and South range boundaries are mudflats and sand dunes. Approximately 98 percent of the total land base in the ranges is unimproved. The South Range includes lands west of the Cedar Mountains, north of Dugway, and generally east of the Utah–Nevada state line. This range is mostly salt flats, which are almost completely devoid of rocks, soil, or plant life. This region is uninhabited and used in connection with training and testing operations of Hill Air Force Base. Access to the area by the general public is restricted. This is the area for the proposed landing of the OSIRIS-REx SRC **(NASA 1998).**

A small area (about 121 hectares [300 acres]) in the extreme eastern area of DPG has been developed for a residential and administrative area and about 202 hectares (500 acres) in scattered locations have been developed with structures for test and training activities. The remaining areas of DPG are undeveloped and retain the landforms and natural plant and animal communities. The uninhabited areas of DPG are used for a variety of training and testing operations, including military munitions and obscurant testing, defensive and protective equipment tests, and personnel training **(DPG 2004)**.

The lands adjacent to UTTR and DPG are owned by Federal and State Governments and by private individuals. They have only limited economic resources and are not readily accessible to the public. They are used to a limited extent for commercial and residential purposes and for recreation and are supported by a limited infrastructure. Land uses include cattle and sheep grazing, mining, and recreation. No grazing occurs on DOD land in the range. U.S. Bureau of Land Management (BLM) lands in the vicinity of the North and South ranges are managed for multiple uses. These uses include livestock grazing, support of wildlife, dispersed and developed recreation, and mining **(NASA 1998)**.

#### 3.3.1.2 *Potential Consequences*

The OSIRIS-REx mission would require only temporary use of the land at UTTR. The area that would be affected by the landing of the SRC is small, less than 2 square meters (21 square feet). Recovery actions would potentially disturb a small additional area required for operation of the recovery team and vehicles. No new facilities for use in connection with the recovery operations would be required. Therefore, the mission would have negligible impact on land resources.

While the most likely landing site for the SRC is within the boundaries of UTTR (see Chapter 2, Figure 2–5), it is possible that the SRC could land beyond UTTR boundaries. The potentially affected areas are both publicly and privately owned and have similar geologic characteristics as UTTR. Should the SRC land in these areas, the impacts on land use and visual resources would not be substantially different from those of a landing within UTTR.

### 3.3.2 Hazardous Materials and Hazardous Waste Management

#### 3.3.2.1 *Affected Environment*

In general, hazardous wastes include substances that, because of their concentration, physical, chemical, or other characteristics, may present substantial danger to public health or welfare or to the environment when released into the environment or otherwise improperly managed. Hazardous wastes generated at UTTR are managed as specified in the Waste Management Plan Hazardous wastes at UTTR are properly stored during characterization and then are manifested and transported off site for treatment and/or disposal.

**Hazardous Substances**

This section presents information about the hazardous substances that have either been used or disposed of on the subject properties. As a housing area, it is presumed that UTTR has small quantities of hazardous substances for cleaning, as do several buildings.

DPG has developed a Hazardous Waste Management Plan (HWMP) and a Waste Analysis Plan (WAP) in DPG's RCRA permit **(UDSHW 2005)**, which prescribes responsibilities, policies, and procedures for managing hazardous waste on the installation. The objective of the HWMP and WAP is to facilitate the responsible management of hazardous waste by identifying facilities that generate hazardous waste and to summarize the hazardous waste generation processes. The HWMP provides guidance for the management of these facilities and processes in compliance with RCRA regulations and other Federal, State, and Army environmental protection laws. The WAP has been prepared to provide specific guidance for day-to-day operations associated with characterizing hazardous waste.

**Hazardous Materials and Petroleum Products**

Several buildings contain hazardous or petroleum products for operations. These materials include the following:

- Acetone
- Antifreeze
- Batteries
- Cleaner/degreaser
- Coolant
- Denatured alcohol
- Freon (R12 and R134)
- Gasoline
- Hydraulic fuel
- Lube oil
- Paints
- Turbine oil
- Transfer fluid
- Valspar
- Welding cylinders (oxygen and acetylene)

Hazardous materials are all stored in marked hazardous materials cabinets. There is no evidence of any hazardous substances released within any of the buildings.

**Hazardous and Petroleum Waste**

A review of historic records and site investigations indicate no evidence that hazardous wastes are or have been generated or stored on UTTR property **(DPG 2012)**.

Two buildings contain petroleum product storage areas, satellite accumulation points for petroleum wastes, and universal waste storage areas. DPG contracts out the removal of waste, which occurs once a week **(DPG 2012)**.

The properties used by the USAF 388th RANS Fighter Wing were categorized based on the degree to which Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-classified hazardous materials are present and to which remedial action would be required. Most facilities were categorized as having no storage or storage but no release to the environment. Only one facility was identified as having released hazardous material to the environment to the extent that remedial action would be required. That action has been taken **(DPG 2012)**.

#### 3.3.2.2 *Potential Consequences*

Activities associated with recovery of the SRC would not generate any hazardous wastes outside the scope, in type or quantity, of materials routinely generated at UTTR.

The SRC itself under most circumstances should not contain any hazardous materials. As discussed in Section 3.3.3, below, gases emitted from the heat shields during the entry and descent are expected to be emitted primarily in the upper atmosphere. However, it is possible that small quantities of these gases (including cyanide and hydrogen cyanide) could be retained within the SRC upon landing. The recovery team would take appropriate precautions to eliminate exposure to these gases. The gases would not be collected or stored and therefore

would not generate waste for disposal. In addition, as discussed in Section 3.3.3, even in a successful landing, one or more of the NASA standard initiators (NSIs) used to release the SRC parachutes may not fire. In that case, the unfired NSI ordnance would be disposed of at UTTR.

### 3.3.3 Health and Safety

There would be three areas of concern with respect to health and safety during the entry, descent, and landing phase of the mission. The first involves range safety considerations; the second SRC recovery safety issues; and the third, inadvertent reentry of the spacecraft.

#### 3.3.3.1 *Terrestrial Contamination*

NASA has established guidelines to prevent the contamination of Earth, a possibility anytime a sample is brought to Earth. The OSIRIS-REx sample return mission has a recommended classification of "unrestricted Earth return" **(NASA 2011b)**. This means that NASA has determined that any material brought back from 1999 RQ36 is unlikely to pose any contamination risk. NASA considers "back contamination" (contamination of Earth from biological materials returned from small bodies) as unlikely if any one of six criteria is met. The six criteria to be considered are as follows:

- The absence of metabolically useful energy sources
- The absence of a suitable source of organic matter or the constituents that would allow its production
- The absence of liquid water
- The presence of high temperatures, *i.e.*, >160 degrees Celsius (°C) (320 degrees Fahrenheit [°F])
- The presence of radiation at levels sufficient to self-sterilize
- The likelihood that a natural influx of material equivalent to the target body (in this case the asteroid) reaches Earth

The asteroid samples are considered to be safe to return to Earth for the following three reasons:

- Any water on 1999 RQ36 was likely heated to over 160 °C (320 °F) due to the proximity to the Sun and the very dark color of the asteroid, well in excess of the sterilization temperature of any known organism.
- More importantly, the irradiation history of 1999 RQ36 is well in excess of what any known organism can survive. The radiation is due to both natural radionuclides from the formation of the body and from galactic cosmic ray exposure, and
- Finally, since 1999 RQ36 is an Earth-crossing asteroid, is it very likely that dust from the object regularly rains down on Earth as interplanetary dust grains. Thus, terrestrial exposure to the surface of 1999 RQ36 has already happened and will continue to happen in the future.

These final two reasons (radiation environment and prior exposure to 1999 RQ36 material) mean that material from the asteroid meets the criteria for unrestricted Earth return **(NASA Goddard 2012d)**.

#### 3.3.3.2 *UTTR Range Safety Considerations*

**Successful Reentry**

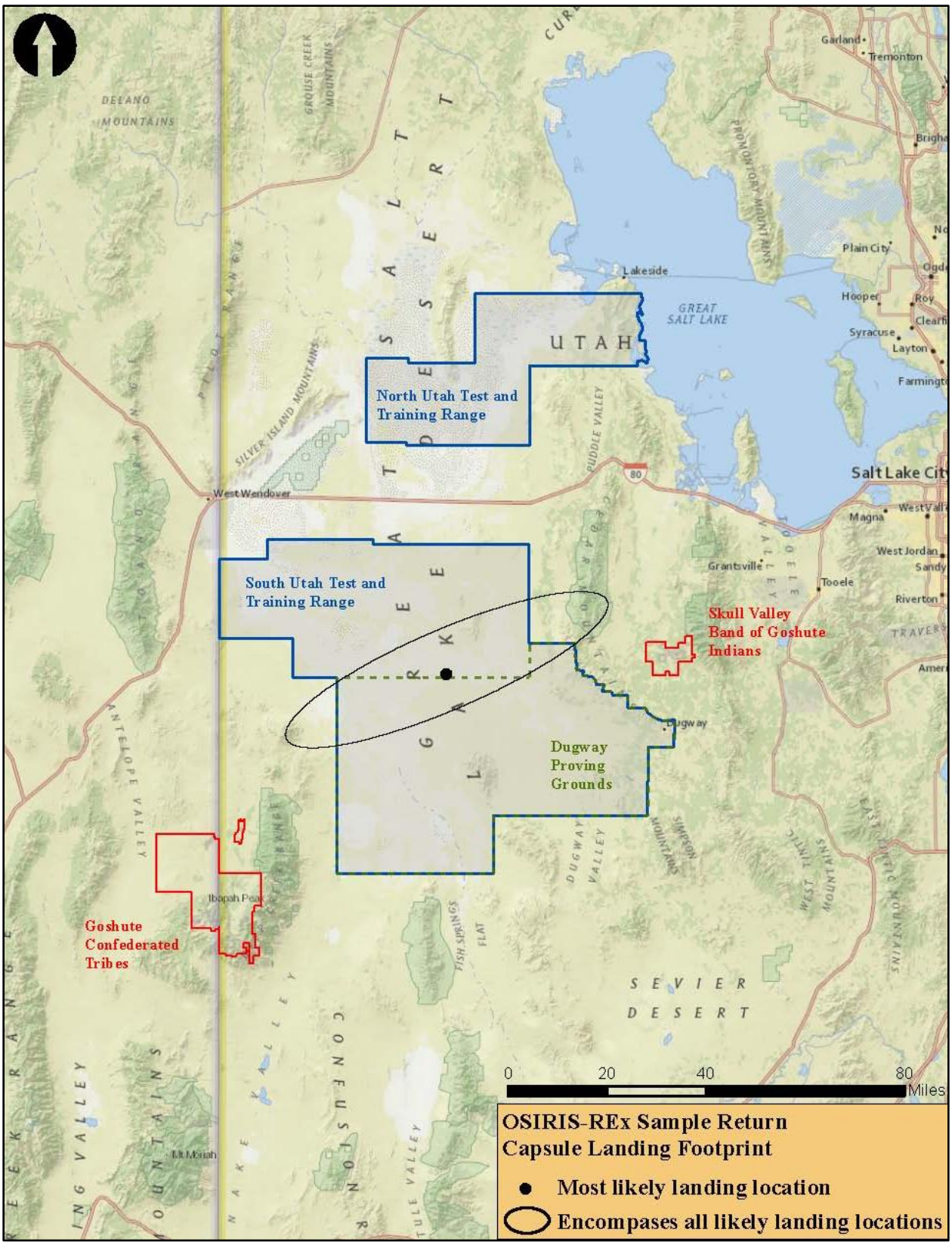
Scheduling procedures for use of UTTR would preclude any risk of flight hazards involving other aircraft in the area. There is a negligible risk of mishap involving helicopters, should they be used in the SRC recovery operations. This risk would be comparable to currently ongoing risks at the range. In the event of a helicopter accident, as there are no inhabited areas in the proposed recovery area that would be exposed to hazardous conditions, the potential for adverse effect on personnel or the public is considered insignificant.

During a successful reentry, decent, and landing, the SRC would have the potential for landing anywhere within a designated landing zone (**Figure 3–3**). Based on NASA's analysis of the reentry of the OSIRIS-REx SRC, the range design footprint (designated landing zone), represented by the oval in **Figure 3–3**, represents NASA's expectation for the area in which the SRC would land. The dot in the center of the area is the most likely location for the SRC to land (**NASA Goddard 2012c)**.

The designated landing zone includes targets and areas that may contain unexploded ordnance. In the event that the SRC landed on a target, it is possible that it could initiate an explosion. This could destroy the SRC and result in a release of any materials contained within it. The highest probability is that the sample materials would be destroyed in the mishap. The risk of this occurrence is substantially less than the risk of a military aircraft crashing on unexploded ordnance on the range **(NASA 1998)**. To reduce the possibility of the SRC triggering an explosion upon landing, any undetonated munitions in the proposed recovery site would be searched out and exploded prior to the expected date of reentry.

A small portion of the designated landing zone extends beyond the boundaries of UTTR. While these areas are sparsely populated, they are not necessarily unoccupied, as is most of UTTR. The potential for the SRC to impact members of the public does exist; even in a successful entry, descent and landing. However, based on the relatively low population density, small size of the SRC, and the fact that the area outside of UTTR is only a small fraction of the designated landing zone, the likelihood of impacting a member of the public should be small.

While not directly applicable to the normal reentry condition, the off-normal reentry analysis shows that, for landings in areas near UTTR impact area 1, the risk to the population would be about $3 \times 10^{-09}$. This is also the result of a low population density and the small size of the SRC.




**Source: NASA Goddard 2012c.**

**Figure 3–3. OSIRIS-REx SRC Landing Footprint**

**Off-Normal Reentry of SRC**

NASA analyzed the potential for the failure of the Flight System to properly set up the conditions for release and reentry of the SRC within the designated landing zone **(NASA Goddard 2012a)**; NASA used the Orbit Survival Analysis Tool (ORSAT) to calculate the impacts associated with an off-normal reentry of the SRC and spacecraft. This analysis addressed the risk to an individual and the population in general if the OSIRIS-REx spacecraft performed an incomplete correction burn prior to releasing the SRC (*i.e.*, the spacecraft would not be in the desired position and traveling at the desired speed when the SRC is released to direct it at the designated landing zone).

The ORSAT analysis is parametric; potential areas of impact beyond the UTTR-designated landing zone were identified based upon the degree to which the spacecraft performs an incomplete burn. Nine potential impact areas were identified, and the probability that the incomplete reentry burn would result in an impact in each area was estimated. Only 25 percent of all incomplete reentry burns were estimated to result in an Earth impact. The majority, 75 percent, would result in a failure of the SRC to enter Earth's atmosphere **(NASA Goddard 2012a)**.

To estimate the population risks associated with reentry burns that would result in Earth impact of the spacecraft, the ORSAT analysis used the population densities for each impact area, the estimated debris casualty area (DCA) for the SRC, and the probability of the OSIRIS-REx spacecraft experiencing an incomplete burn. Population densities for each region were developed by extrapolating the population data for the year 2005 to year 2023 levels, based on the U.S. population growth rate of 0.963 percent per year. The DCA is the area at risk on the ground, essentially the area that the SRC would impact. For the SRC, the DCA has been calculated to be 1.217 square meters (13.1 square feet). The probability of experiencing an incomplete reentry burn was estimated to be 0.00394 **(NASA Goddard 2012a)**.

Using the information identified above, two population impact parameters were calculated: the probability of any casualty among the potentially impacted population (called the casualty expectation) and the probability of a specific individual being impacted (called the probability of casualty). These calculated values were compared to the NASA guidance in **NPR 8715.5A** (Range Flight Safety Program) of $1.0 \times 10^{-4}$ (1 chance in 10,000 of a casualty within the affected population) for the casualty expectation and $1.0 \times 10^{-6}$ (1 chance in 1 million of one specific individual being a casualty) for the probability of casualty. As can be seen in **Table 3–1**, the OSIRIS-REx casualty expectation is well below this limit. The probability of casualty was calculated to be extremely small and well below the NPR guidance **(NASA Goddard 2012a)**.

The $9.2 \times 10^{-08}$ value for the casualty expectation can be interpreted as roughly 1 chance in 10 million than any of the 1.9 million people living in the impact areas would be impacted by an off-normal reentry of the SRC. The probability that one specific person would be impacted is much lower. For comparison, the probability of an individual being struck and killed by lighting (1 in 6 million) is nearly twice the population risk estimated for an off-normal reentry.

**Table 3–1. OSIRIS-REx Casualty Expectation**

| Impact Area | Probability of impact % | Area ($km^2$) | Population 2005 | Population 2023 | Population Density 2023 (per $km^2$) | Casualty Expectation[a] |
|---|---|---|---|---|---|---|
| 1 | 1 | 635 | 38,171 | 45,358 | 71 | $3.4\times10^{-09}$ |
| 2 | 1 | 617 | 209,395 | 248,821 | 403 | $1.9\times10^{-08}$ |
| 3 | 1 | 619 | 663,108 | 787,961 | 1,273 | $6.1\times10^{-08}$ |
| 4 | 1 | 715 | 22,016 | 26,161 | 37 | $1.8\times10^{-09}$ |
| 5 | 1 | 747 | 1,785 | 2,121 | 3 | $1.4\times10^{-10}$ |
| 6 | 5 | 4,958 | 22,536 | 26,779 | 5 | $1.3\times10^{-09}$ |
| 7 | 5 | 7,128 | 19,452 | 23,115 | 3 | $7.8\times10^{-10}$ |
| 8 | 5 | 10,225 | 7,229 | 8,590 | 1 | $2.0\times10^{-10}$ |
| 9 | 5 | 42,034 | 635,469 | 755,118 | 18 | $4.3\times10^{-09}$ |
| **Total** | | | | | | **$9.2\times10^{-08}$** |

a. NASA guidance sets an upper limit of $1.0 \times 10^{-04}$ for the casualty expectation.
**Note:** 1 $km^2$=0.4 $m^2$.
**Source: NASA Goddard 2012a.**

### 3.3.3.3 *Inadvertent Reentry of the Spacecraft*

Under normal conditions, the spacecraft would not return to Earth. Inadvertent reentry of the spacecraft must be considered, however. NASA used ORSAT to calculate what objects may survive an inadvertent reentry.

In the ORSAT analysis of the OSIRIS-REx mission, the worst-case scenario was assumed, where approaching maneuvers fail so that both the carrier spacecraft and the SRC reenter Earth's atmosphere. Higher-than-average aeroheating temperatures would be generated because of the spacecraft trajectory and relatively high velocity (12.5 kilometers [7.7 miles] per second instead of the typical 7 kilometers [4.3 miles] per second for Earth-orbiting spacecraft), favoring demise of the reentering objects. At these elevated temperatures, ORSAT results indicate that the carrier spacecraft would be completely destroyed, including the titanium propulsion tank (for comparison, in the case of Earth-orbiting spacecraft, titanium tanks usually survive reentry). The only partially surviving system is the SRC. Spacecraft entry with the SRC attached would result in a tumbling spacecraft and SRC as the solar arrays burn off asymmetrically. With the spacecraft tumbling the SRC would separate tumbling. A tumbling SRC will burn through the backshell and the entire interior would be consumed leaving only the heatshield that could enter and survive to the Earth's surface **(NASA Goddard 2012b)**.

#### 3.3.3.4 *SRC Recovery Safety Considerations*

The SRC would weigh no more than 55 kilograms (121 pounds), the mission allocation for the SRC and would be touching down at 8 kilometers (5 miles) per hour, 4.8 meters (16 feet) per second. This is comparable to a human of the same weight parachuting to Earth. Therefore, it would pose no risk to personnel or structures.

Three potential hazards in handling the SRC once it has landed have been identified. They include (1) safing of potential unfired parachute deployment ordnance; (2) lithium battery faults, such as the production of sulfur dioxide which produces sulfuric acid with water, or lithium fire, should the battery be damaged during landing; and (3) handling of the SRC.

**Ordnance Safing**

There are redundant NSIs in the SRC to deploy the drogue chute and to cut the cable, thereby enabling deployment of the main chute. In the nominal landing scenario, the parachute deploys as engineered. This would indicate that at least one NSI fired, but would not provide information that the redundant NSI also fired. Therefore, it is possible that there would be two unfired NSIs within the SRC upon landing. NASA plans to engage an expert to isolate and remove the drogue initiator outputs in an electrostatic discharge control area. The second NSI on the parachute mortar is designed to be directed toward the center of the parachute canister and parallel to the SRC surface, so that if it discharged upon opening the SRC, it would not pose a safety hazard to personnel. Likewise, the second NSI on the cable cutter releases no hazardous fragments or gases. Unexpended NSIs would be shipped to JSC for testing. Off-normal recovery conditions would be addressed by the recovery team.

**Lithium Battery Faults**

The SRC would contain lithium battery cells about the size of a commercial “D” cell. These cells would be used only for the SRC return and are diode-protected from reverse charging. Potential hazardous characteristics resulting from damaged batteries would be lithium fire; given the size of the batteries, the amount of gases generated would be small and, with the proper safety precautions, would not result in risk to the recovery team. When released to the atmosphere, these gases would dissipate quickly and would have no impact on the public, sulfuric acid production, or explosion or violent venting due to hydrogen gas production. The recovery team would include a safety inspector, who would perform colorimetric tests and determine that the SRC is safe for human handling prior to opening. The battery case has been designed to leak before bursting, and the cables would be protected at possible abrasion points.

**SRC Handling**

The primary method of handling the SRC would be manual, except when it is secured in its handling fixture. Gloves would be used for all handling of SRC ablated surfaces and would also protect the teams from the hot surface.

The SRC thermal control system design calls for two ablative materials in the heat shields. On the backshell would be the super-lightweight ablator (SLA-561V), which is a combination of RTV 663, mixed with silica fibers, treated cork, phenolic microballoons, and silicon

microspheres packed into a phenolic honeycomb. This material has been used on the Space Shuttle and requires no special safety handling procedures. On the forebody would be the Phenol-impregnated carbon ablator (PICA) material, which is composed of a carbon fiber preform impregnated with phenolic resin, including hexamethylene tetramine, water, and ethylene glycol. It is baked to minimize volatile materials. During reentry peak heating, which occurs in the lower mesosphere to the upper stratosphere, the PICA material would generate small amounts of cyanide and hydrogen cyanide while ablating. Although the air-fluid dynamics models show that the air flow would move the ablation products away from the capsule and thus, from the vents, these complex organics could enter the SRC through the vent holes located in the back shell during repressurization of the SRC. The safety officer accompanying the SRC recovery teams would test for hydrogen cyanide at a vent port before the back shell is removed to verify that levels in the SRC are below the permissible exposure limits for these substances. Recovery team personnel would wear appropriate personal protective equipment to prevent exposure to hot surfaces or any residual ablation products **(NASA 1998)**.

### 3.3.4 Geology and Soils

#### 3.3.4.1 *Affected Environment*

Mountain ranges within or adjacent to DPG are composed primarily of Paleozoic sedimentary rocks of marine origin and small exposures of volcanic and intrusive Tertiary igneous rocks. With exception of Granite Peak and the Simpson Mountains, which are composed mainly of Precambrian metamorphic and igneous rocks, low-lying basin areas are filled with thick accumulations of sediment derived from erosion of uplifted mountain ranges. Sediments consist of Tertiary to Quaternary alluvial, colluvial, lacustrine, eolian, and volcanic material **(DPG 2012)**.

Lake Bonneville, a large freshwater lake, covered much of western Utah and adjacent parts of Idaho and Nevada during the Pleistocene age. Preserved segments of two major Lake Bonneville shorelines, the Bonneville and Provo, are evident in the eastern portion of DPG near English Village. The Bonneville shoreline is the highest of the lake's shorelines; its elevation varied across Skull Valley from about 1,594 to 1,618 meters (5,230 to 5,310 feet) in southern to northern portions of the valley, respectively. The maximum elevation of Lake Bonneville at DPG has been estimated to be 1,565 meters (5,135 feet), or about 266 meters (875 feet) above the present-day basin floor **(DPG 2012)**.

Two unique geologic features have been identified at DPG, Granite Peak and the Devil's Postpile. Both features were identified by The Nature Conservancy in a 1993 inventory of natural areas and special features on DPG land. The Nature Conservancy ranked Granite Peak as the highest-priority area and characterized it as geologically unique and deserving of consideration as a National Natural Landmark. The Devil's Postpile was ranked fifth out of 17 identified special features/natural areas at DPG **(DPG 2012)**.

Granite Peak is located in the UTTR South Range but south of the credible landing locations, as shown in Figure 3–3. Devil's Postpile is located near the Skull Valley Band of Shoshute Indians, as shown in Figure 3–3.

Granite Peak is composed of two primary rock types, dark-colored layered granitic rock (foliated granodiorite) and light-colored granite (leucogranite). The presence of these metamorphic and igneous rocks is interesting because such rocks are known from only a few areas in Utah. A striking feature of Granite Peak is the presence of pegmatite dikes. A pegmatite is an unusually coarse-grained igneous rock, and a dike is an igneous intrusion that cuts across preexisting rock. These pegmatite dikes are visible as bold white streaks that form intricate patterns. Rhyolite and andesite dikes also cut across the various rocks of Granite Peak **(DPG 2012)**.

#### 3.3.4.2 *Potential Consequences*

The proposed action would disturb soils in the location of the SRC touchdown and the immediate vicinity where helicopters or a land vehicle would recover the SRC. Helicopter landings are currently common on UTTR and should have no additional effect. The SRC would have a diameter of 81 centimeters (32 inches) and would weigh approximately 55 kilograms (121 lb). Its parachute system would slow its velocity to approximately 8 kilometers (5 miles per hour; 14.8 feet per second). The area affected would measure only a few meters. The impact would be similar to a small person parachuting to the surface. Any disturbance to the surface could easily be recovered if desired. Due to the single-event nature of this recovery operation, the resulting impact would be negligible. The SRC would contain no propellant, except for the gas (reaction products from the NSI, primarily zirconium dioxide, potassium chloride, and oxygen; the first two are gases only at high temperatures) that would expel the drogue chute.

### 3.3.5 Water Resources

#### 3.3.5.1 *Hydrology*

The climate of the Dugway Valley–Government Creek area is characterized by extreme fluctuations in temperature—average daily temperatures of -2.2 °C (28 °F) and 26 °C (79 °F) in January and July, respectively—and minimal amounts of precipitation—approximately 20 centimeters (8 inches) annually. Annual runoff is negligible, and the region drains in a northwest direction into the Great Salt Lake Desert. Area streams are ephemeral, except for short headwater portions of a few streams located in the higher-elevation mountains **(DPG 2001)**.

Surface water in the Dugway Valley–Government Creek area is limited. Pismire Wash, the Old River Bed, and Government Creek are the principal drainages. Pismire Wash in Dugway Valley extends northward from the Thomas Range into the desert floor southeast of Granite Peak. The Old River Bed, entering DPG from the southeast, is a relict drainage connecting the northern and southern portions of ancient Lake Bonneville. Flow in these drainages is short lived and occurs only as a result of thunderstorms or snowmelt. Much rainfall is lost to the system by evapotranspiration. Government Creek extends northwestward into DPG from its headwaters in the Simpson and Sheeprock Mountains. Minor tributaries in the headwater region originate as discharge from springs and may have perennial flow for short distances **(DPG 2001)**.

Runoff from the Dugway Valley-Government Creek area to the Great Salt Lake Desert is minor due to the general aridity of the area and the permeable alluvial deposits at the base of the mountain ranges, which rapidly absorb stream flow,. Some overland runoff from thunderstorms

flows onto the desert; but the surface gradient toward the northwest is very slight, the few channels that exist are small and intermittent, and evaporation rates are high. Thus, essentially all the estimated 46,872.58 hectare-meters (380,000 acre-feet) of precipitation that falls in the area each year is consumed by evapotranspiration within the area, except for the quantity that infiltrates to recharge to the groundwater system **(DPG 2001)**.

The major source of groundwater in the Dugway Valley–Government Creek area is saturated older alluvium. Total groundwater recharge in the Dugway Valley–Government Creek area is about 1,480.18 hectare-meters (12,000 acre-feet). Principal sources include snowmelt, thunderstorms, and flow from the Sevier Desert drainage through the Old River Bed. The water is transported through alluvium deposited by the ancient stream **(DPG 2001)**.

#### 3.3.5.2 *Potential Consequences*

Because of the lack of surface water, general aridity of the area and small footprint of the SRC, the probability of the SRC landing in water is extremely low. No contaminants would be present on the SRC to leach into water supplies. Therefore, no impacts on drinking or surface water would be excepted.

### 3.3.6 Air Quality

#### 3.3.6.1 *Affected Environment*

The proposed landing area in the UTTR South Range is located in Tooele County. Tooele County is considered to be in attainment in that it meets the NAAQS for all pollutants regulated by the Clean Air Act (CAA) and the Utah Air Conservation Act, except for sulfuric acid. Portions of Tooele County are in nonattainment for sulfuric acid due primarily to emissions from the Kennecott Corporation copper smelter near Magna. Regulations pursuant to the CAA establish air quality levels for Prevention of Significant Deterioration in various classes of areas. Class I, or pristine, areas are the most restrictive and include national parks and wilderness areas. All other areas in the United States are classified as Class II. Section 169A of the CAA states that it is a national goal to prevent any further impairment of visibility in Class I areas. The nearest Class I area to the proposed recovery site is the Great Basin National Park, which is more than 161 kilometers (100 miles) from the proposed landing area.

#### 3.3.6.2 *Potential Consequences*

Emissions of criteria pollutants would occur as a result of helicopter and ground vehicle activity during OSIRIS-REx SRC recovery operations. The SRC itself would not generate any air pollutants in the lower atmosphere (the area subject to NAAQS), nor is it expected to contain any chemicals or substances that could emit hazardous air pollutants regulated under National Emission Standards for Hazardous Air Pollutants. Given that the OSIRIS-REx mission is a single sample return, the quantities of helicopter emissions would be extremely small. Further, when affected sectors would be scheduled for the OSIRIS-REx recovery operation, other aircraft would be curtailed, thereby resulting in lower short-term emission levels. It is unlikely that overall emissions in the area would be greater during OSIRIS-REx recovery operations than

under baseline conditions. The proposed action is not expected to result in any violations of the NAAQS or to interfere with Tooele County's ability to reach or maintain attainment.

Upper-altitude emissions associated with reentry of the SRC would include ablation products of the TPS. The SRC would enter Earth's atmosphere with a velocity of approximately 12.5 kilometers (7.8 miles) per second. At approximately 3,048 meters (10,000 feet) above Earth, a parachute would be deployed for a land-based recovery at UTTR's South Range. Because of the rapid deceleration and high-velocity reentry, the vehicle would experience large aerothermal and structural loads during reentry. Thus, the SRC would require a heat shield that could survive the extreme reentry heating environment. The temperature of the carbon composite structure must be kept low enough to prevent structural degradation during any portion of the reentry. The baseline material to be used for the forebody heat shield would be PICA, developed at NASA's ARC. It is less dense than carbon/phenol and has a much lower thermal conductivity with a similar ablation performance. The heat shield and insulation mass requirements for a heat shield utilizing PICA are significantly reduced compared to a carbon/phenolic heat shield.

An OSIRIS-REx analysis of ablation of the heat shields has not yet been performed, although it is planned. However, the reentry characteristics of the OSIRIS-REx SRC and that of the Stardust SRC would be very similar. The OSIRIS-REx SRC is expected to be slightly heavier, no greater than 55 versus 46 kilograms (121 versus 101 pounds), but the entry velocities would be similar. With all other factors being relatively consistent between the two mission reentry profiles, the larger mass of the OSIRIS-REx SRC is expected to result in similar, but somewhat greater, emissions from the ablation of the heat shields. Therefore, until the mission-specific reentry ablation analysis for the OSIRIS-REx mission is performed, discussion of the materials released during reentry is based on the Stardust mission heat shield ablation analysis. During the descent of the SRC, the PICA material composing its forebody heat shield would ablate due to frictional heating. The peak heating would occur in the mesosphere at approximately 51 seconds after reentry begins. The ablation would continue for about 20 seconds. Models conservatively predict that less than 22 percent of the total PICA material would ablate during reentry and that ablation would cease at approximately 47 kilometers (29 miles) above the Earth (in the lower mesosphere). The total mass of the PICA material would be about 8.5 kilograms (18.7 pounds); of this, a maximum of 1.9 kilograms (4.1 pounds) would be ablated during reentry. The chemical species that would be produced during ablation of the PICA material are shown in **Table 3–2**, along with their mass fractions. These chemical species would be dissipated in the wake behind the SRC. Two of the chemical species produced during ablation are hydrogen cyanide and cyanide (36 and 150 grams, [0.08 and 0.33 pounds] respectively). These chemicals are considered to be acutely toxic to humans when inhaled. The ablation process, and thus the production of these species, would cease while the SRC is still in the mesosphere. Therefore, these concentrations would disperse in the large volume of air in the upper atmosphere and would not constitute a danger to health or life on Earth. The SRC heat shield would be rapidly cooling during the subsonic portion of the descent and would not be emitting into the lower atmosphere **(NASA 1998)**.

**Table 3–2. Chemical Species Produced During Ablation of PICA Heat Shield[a]**

| Chemical Species | Mass Fraction | Total Mass of Species Produced During Ablation (g) | Total Amount of Species Produced During Ablation (lb) |
|---|---|---|---|
| Carbide ($C_2$) | 0.02 | 37.2 | 0.08 |
| Carbon (C) | 0.01 | 18.6 | 0.04 |
| Carbon dioxide ($CO_2$) | $1.25\times10^{-8}$ | $2.34\times10^{-5}$ | $5.11\times10^{-8}$ |
| Carbon monoxide (CO) | 0.26 | 483.6 | 1.06 |
| Cyanide (CN) | 0.08 | 148.8 | 0.32 |
| Diatomic nitrogen ($N_2$) | 0.39 | 725.4 | 1.60 |
| Diatomic oxygen ($O_2$) | $1.83\times10^{-14}$ | $3.40\times10^{-11}$ | $7.49\times10^{-14}$ |
| Hydrogen (H) | $3.60\times10^{-3}$ | 6.7 | 0.02 |
| Hydrogen cyanide (HCN) | 0.02 | 37.2 | 0.08 |
| Nitric oxide (NO) | $1.9\times10^{-8}$ | $3.53\times10^{-5}$ | $7.77\times10^{-8}$ |
| Nitrogen (N) | $2.29\times10^{-4}$ | 0.43 | $9.37\times10^{-4}$ |
| Oxygen (O) | $9.27\times10^{-8}$ | $1.72\times10^{-4}$ | $3.79\times10^{-7}$ |
| Tricarbide ($C_3$) | 0.22 | 409.2 | 0.90 |
| Diatomic hydrogen ($H_2$) | $3.25\times10^{-4}$ | 0.61 | $1.33\times10^{-3}$ |

a. All values are from calculations for the Stardust Mission. OSIRIS-REx values are expected to be similar.

**Source: NASA 1998.**

The SRC would be entering Earth's atmosphere from space and would repressurize as it nears the surface of the Earth. The SRC would be traveling at hypersonic velocity during the ablation of the heat shield, and a flow-field analysis of the heat shield radiation and ablation has demonstrated that only a minimal amount of hydrocarbons would gain access to the interior of the SRC through the vents located on the sides of the backshell. Most of the repressurization of the SRC would occur below 10 kilometers (6.2 miles) above mean sea level, during the subsonic portion of the reentry. Colorimetric tests would be performed by Safety personnel to ascertain if a potentially harmful amount of hydrogen cyanide gas might be present in the SRC after landing. If tests indicate its presence, personnel opening the SRC to retrieve the sample canister would be required to wear appropriate personal protective equipment to preclude any potential health hazard **(NASA 1998)**.

The SLA-561V material composing the TPS of the back shell portion of the SRC would undergo far less heating during reentry than would the PICA material on the forebody. Of the estimated 2 kilograms (4.4 pounds) of SLA-561V composing the backshell heat shield, approximately 0.3 kilograms (0.66 pounds) would be lost during reentry. **Table 3–3** gives the predominant

chemical species that would be produced during reentry peak heating and their corresponding mass fractions (those with mass fractions greater than $1 \times 10^{-10}$). No toxic chemical species would be produced from this heat shield material **(NASA 1998)**.

**Table 3–3. Chemical Species Produced During Ablation of SLA-561V Heat Shield[a]**

| Chemical Species | Mass Fraction | Total Mass of Species Produced During Ablation (g) | Total Amount of Species Produced During Ablation (lb) |
|---|---|---|---|
| Carbon dioxide ($CO_2$) | $7.11\times10^{-3}$ | 2.13 | $4.69\times10^{-3}$ |
| Carbon monoxide (CO) | $1.64\times10^{-6}$ | 0.49 | $1.08\times10^{-4}$ |
| Diatomic hydrogen ($H_2$) | $4.54\times10^{-3}$ | 1.36 | $3.0\times10^{-3}$ |
| Diethylsilane ($SiC_4H_{12}$) | 0.14 | 42.0 | 0.09 |
| Methane ($CH_4$) | 0.38 | 114.0 | 0.25 |
| Methanol ($CH_3OH$) | $3.98\times10^{-10}$ | $1.19\times10^{-7}$ | $2.62\times10^{-10}$ |
| Quartz ($SiO_2$) | $3.55\times10^{-6}$ | $1.07\times10^{-3}$ | $2.35\times10^{-6}$ |
| Silane ($SiH_4$) | $7.01\times10^{-6}$ | $2.10\times10^{-3}$ | $4.63\times10^{-6}$ |
| Silicate ion (SiO) | 0.44 | 132.0 | 0.29 |
| Water ($H_2O$) | 0.04 | 12.0 | 0.03 |

a. All values are from calculations for the Stardust Mission. OSIRIS-REx values are expected to be similar.
**Source: NASA 1998.**

Most of the chemicals that would be released during the descent and landing of the SRC are expected to be released in the upper atmosphere and would pose no threat to air quality or human health. Any chemicals still on the SRC upon landing would be in small quantities and would pose no threat to the general air quality levels. Localized areas (very near the landed SRC) would, at most, see temporary slightly elevated levels of some compounds that would quickly dissipate.

### 3.3.7 Noise

Noise is unwanted sound that interferes or interacts negatively with the human or natural environment. Noise may disrupt normal activities or diminish the quality of the environment.

Sound levels decrease as the distance increases from the sound source. This loss of energy, known as attenuation, is affected by geometrical spreading, atmospheric absorption, and the interaction of the sound waves with the ground surface, or ground attenuation. Geometrical spreading refers to the spreading of sound energy as a result of the expansion of the wave fronts. The farther away from the source of the noise, the larger the area over which the noise can be heard. The intensity level at each location is lowered because no energy is added as the noise expands.

Atmospheric absorption is the loss of sound energy as it travels through the air, which varies strongly with the frequency of the sound wave and the temperature, humidity, and, to a minor extent, the atmospheric pressure. This loss is greatest at high frequencies and in hot, dry air. Variations in the atmosphere will also cause scattering, during which some of the sound energy is redirected into many different directions. Scattering is caused by air turbulence, rough surfaces, and obstacles, such as trees. Temperature and wind gradients can result in measured sound levels being very different to those predicted from geometrical spreading and atmospheric absorption alone. These effects are particularly important where sound is propagating over distances greater than a few hundred meters.

The amount of ground attenuation depends on the nature of the ground, frequency of the sound, distance over the ground, and source and receiver heights. Smooth, hard surfaces will produce little absorption, whereas thick grass may result in sound levels being significantly reduced **(Sutherland and Daigle 1997)**. The presence of vegetation, particularly trees, provides some attenuation; however, trees several hundred meters thick are required before substantial attenuation occurs **(Aylor 1971)**.

The propagation of sound can be affected greatly by terrain and the elevation of the receiver relative to the sound source. Noise travels in a straight line-of-sight path between the source and the receiver. The presence of an area of high terrain reduces the sound energy arriving at the receiver. Breaking the line of sight between the receiver and the sound source results in a moderate sound-level reduction. If the source is depressed (*e.g.*, in a valley) or the receiver is elevated (*e.g.*, on a mountainside), sound generally will travel directly to the receiver. In some situations, sound levels may be reduced because the terrain crests between the source and the receiver, resulting in a partial sound barrier near the receiver. Level ground is the simplest case.

The importance of these various phenomena depends upon the situation under consideration. For example, for a chainsaw on the ground and a receiver close by, only geometrical spreading and large obstacles need to be considered. However, if the receiver is a long distance from the chainsaw, then ground and atmospheric effects must be considered. If an aircraft is flying overhead, then only geometric spreading and atmospheric effects need to be considered.

#### 3.3.7.1 *Affected Environment*

Noises associated with activities occurring at UTTR are generally intermittent and associated with activities such as artillery and mortar fire, small-arms fire, movement of land-based vehicles (both military and construction), detonation of explosives, and aircraft overflights. Aircraft noise is prevalent throughout UTTR and is the most significant source. Depending on the type of aircraft and mission, a wide range of noise levels (frequencies and loudness) can be generated, including sonic booms generated by supersonic flights (flights with maximum speeds of Mach 1 to 5). Recently, 23,000 aircraft flights were recorded in the area of the proposed action. Due to the large size of UTTR, most people not on the site would hear these noises as infrequent muffled sounds **(The Times News 2012)**.

#### 3.3.7.2 *Potential Consequences*

Noise from helicopter and ground vehicle recovery operations would not differ from baseline conditions and is therefore not expected to have any impact. The momentary sonic boom from the SRC reentry would not have any impact due to its high altitude. The recovery area is overlain by the maneuver overflight area (UTTR and adjacent public lands), which experiences sonic booms at lower altitudes and higher overpressures than those that would be created by the OSIRIS-REx SRC reentry.

Numerous studies have been conducted on the sensitivity of wildlife to noise and sonic booms, including studies of big horn sheep, pronghorn, and elk at UTTR. A literature survey of studies on effects of supersonic and subsonic aircraft noise on animals recently revealed few effects from sonic booms. These same studies have shown that there is more potential for effects from subsonic aircraft operations, especially helicopters, and indicated that wildlife acclimated to recurring events. In any case, the proposed project area does not include sensitive wildlife species likely to be adversely affected, and any wildlife in the area is likely already acclimated to the ongoing range operations.

### 3.3.8 Biological Resources

#### 3.3.8.1 *Affected Environment*

Broadly described, DPG is a cold northern desert shrub habitat with halomorphic soils, interspersed with insular islands of sagebrush steppe and juniper. The Dugway Valley and the lower slopes of the surrounding mountains are primarily a northern salt desert shrub type resulting from the low average annual precipitation and a high rate of evaporation during the summer months **(DPG 2001)**.

The North and South ranges of UTTR are also generally cold northern desert shrub habitat. At lower elevations, the ranges are typically salt flats or mudflats, arid and semiarid landscapes associated with flat terrain and usually without drainage and with little or no vegetation. Portions of these areas are subject to annual cycles of flooding and extended periods of drought. As the UTTR elevation increases, soil composition changes and the loamy soil allows for moderate-to-dense ground cover of shrubs and grasses. As on DPG, sagebrush steppe and juniper can be found in the higher elevations **(HAFB 2006)**.

#### 3.3.8.2 *Wildlife*

UTTR has a variety of habitats that support a rich and diverse array of fauna typical of the Great Basin desert community. Wildlife known to occur on UTTR consists of both year-round resident and migratory/transient species. Several species are targeted for monitoring at UTTR. This target species list has been developed in conjunction with the Utah Division of Wildlife Resources. It consists of 22 species of animals that have been identified as being significant in assessing the relative health of the UTTR environment. These include 12 bird species (golden eagle, ferruginous hawk, burrowing owl, short-eared owl, long-billed curlew, Brewer's sparrow, black-throated sparrow, loggerhead shrike, sage thrasher, sage sparrow, western meadowlark, and horned lark); 6 mammals (pronghorn antelope, black-tailed jackrabbit, Townsend ground

squirrel, bushy-tailed woodrat, ringtail, and kangaroo rat); 2 reptiles (desert side-blotched lizard and spotted frog); and 2 fish (Bonneville cutthroat trout and least chub) **(HAFB 2006).**

Fauna observed at DPG consists of 205 species of birds, 53 species of mammals, and 14 species of reptiles/amphibians. Planning-level surveys are being conducted for invertebrates, and it is expected that thousands of species will be represented. Of the habitat types occurring on DPG, vegetated dunes have the greatest variety of fauna species. No fish species are known to occur on DPG. However, because native fish are present in Redden Spring, it is possible they could be present on DPG **(DPG 2012)**.

#### 3.3.8.3 *Wetlands*

No permanent streams are found on UTTR, but there are a potential 17,806 hectares (44,000 acres) of wetlands. These wetlands are primarily lacustrine and slope-fed wetlands. The predominant wetlands are Blue Lake and associated wetlands, located on the Nevada border of the South Range of UTTR. The Utah Division of Wildlife Resources has recognized this area as a unique desert oasis for migrating waterfowl, a warm-water fishery, and a recreation area for scuba diving. The wetlands consist of 6,070 hectares (15,000 acres) of marshlands and several deep spring-fed ponds that lie on the edge of the salt flats. The largest spring, Blue Lake, is approximately 167 meters (550 feet) wide, 304 meters (1,000 feet) long and 18 meters (60 feet) deep **(HAFB 2006)**.

Several wetland areas have been identified at DPG, as supported by two wetland delineation studies that were conducted at the installation. Environmental Science Associates conducted a nonjurisdictional wetlands study that investigated Cane Springs, Bitter Springs, Mustang Springs, North Fish Springs, Orr Springs, Black's Pond, the sewage lagoons at the English Village Wastewater Treatment Facility, and the DPG Playa. The field study followed wetland delineation criteria developed by the U.S. Army Corps of Engineers. This study identified Cane Springs, North Fish Springs, Orr Springs, and a portion of Black's Pond and Mustang Springs as wetlands. No wetlands exist within the 388th RANS property boundaries. The study identified DPG Playa and a portion of Black's Pond as "waters of the U.S." **(DPG 2012)**.

#### 3.3.8.4 *Special Interest Natural Areas and Rare, Threatened, and Endangered Species*

Rare, threatened, and endangered species likely to occur or having been documented at DPG are not year-round residents and, therefore, no special management practices have been implemented. The Army, in cooperation with USFWS, has special guidelines for managing threatened and endangered species, should they become residents of DPG **(DPG 2012)**.

There are no plant species known to occur on UTTR or DPG that are federally listed as threatened or endangered **(DPG 2012; HAFB 2006)**. The USFWS-listed threatened Ute ladies'-tresses (*Spiranthes diluvialis*) is known to occur close to DPG; however, little or no suitable habitat exists on DPG. There are some plant species on DPG designated by resource agencies as species of concern, such as the BLM-listed Cooper's hymenoxys (*Hymenoxys cooperi*), helleborine (*Epipactis helleborine*), king's snapdragon (*Sairocarpus kingii*), and Pohl's milkvetch (*Astragilis lentiginosis var. pohlii*) **(DPG 2012)**.

There are no species of wildlife known to occur on DPG that are federally listed as threatened or endangered. The bald eagle (*Haliaeetus leucocephalus*) is considered to have a potential for occurrence as a winter visitor, particularly as they are common wintering birds on Fish Springs National Wildlife Refuge. The Federal candidate yellow-billed cuckoo (*Coccyzus americanus*) is the "western" yellow-billed cuckoo, and would be considered a rare visitor on DPG. However, some species occurring on the installation are designated by resource agencies as species of concern. Species included on the Utah sensitive species list and additional species of conservation concern are listed by USFWS, Utah Division of Wildlife Resources, Utah Partners in Flight, or BLM. Some examples include the ferruginous hawk (*Buteo regalis*), kit fox (*Vulpes macrotis*), and the golden eagle (*Aquila chrysaetos*) **(DPG 2012)**.

Although there are no species that are listed as threatened or endangered on UTTR, there are some species of plants and animals that are species of special concern. Four species of birds and three of mammals listed below are characterized as a wildlife species of concern by the State of Utah **(HAFB 2006)**, as follows:

- **Birds**
  - American white pelican *(Pelecanus erythrorhynchos)*
  - Burrowing owl *(Athene cunicularia)*
  - Ferruginous hawk *(Buteo regalis)*
  - Short-eared owl *(Asio flammeus)*
- **Mammals**
  - Kit fox (Vulpes macro)
  - Dark kangaroo mouse (Microdipodops megacephalus)
  - Pygmy rabbit (Brachylagus idahoensis)

#### 3.3.8.5 *Potential Consequences*

The SRC landing and recovery operations would affect vegetation in the immediate vicinity of the touchdown. Individual plants within a localized area could be crushed. (The area impacted by the landing of the SRC would be very small. The SRC is 0.81 meters [2.7 feet] in diameter and, upon landing, would cover about 0.5 square meters [5.5 square feet)]. As discussed in the off-normal reentry analysis in Section 3.3.2, even in the event of an off-normal reentry, the expected impact area would be only 1.2 square meters [15.5 square feet].) The impact on plant communities in the area would be insignificant. Ground disturbance could increase the potential for invasive species like halogeton to establish in the area, but the small size of the area disturbed would not increase this effect noticeably above the baseline conditions. The proposed OSIRIS-REx reentry impact area does not contain any sensitive habitats that could be affected by recovery operations.

No threatened or endangered species are expected to be affected by the proposed action. The probability of a collision between the SRC or a helicopter and a bald eagle or peregrine falcon in the area is extremely remote—raptors have a very low incidence of airstrike. It is highly unlikely that any candidate species that could be affected occurs in the project area.

### 3.3.9 Historical and Cultural Resources

#### 3.3.9.1 *Affected Environment*

Cultural resources include, but are not limited to, buildings, structures, prehistoric and historic archaeological sites, American Indian sacred sites, and cemeteries.

**National Register of Historic Places Eligibility**

Eligibility of sites for inclusion in the NRHP is the principal criterion determining management prescriptions. Generally, sites fall into one of three categories with regard to NRHP eligibility, as follows:

- ***Eligible***: These sites have been determined eligible for the NRHP and therefore are subject to protection. They should not be affected without consultation per Section 106 of the National Historic Preservation Act (NHPA) **(36 CFR 800)** and development of a plan to mitigate adverse effects.
- ***Ineligible***: These sites have been determined ineligible for the NRHP and do not require protection from adverse effects.
- ***Potentially eligible***: Further investigation is required to determine NRHP eligibility. Therefore, these sites are potentially eligible for the NRHP and require protection until determinations of eligibility can be made.

**Cultural Resources Inventory**

Roughly a quarter of the lands controlled by Hill Air Force Base have been inventoried at some level for historic properties. A total of 259 known archaeological sites have been identified on these lands. Of these archaeological sites, 256 are found on the UTTR. Of these sites, 10 have been determined to be eligible for the NRHP. All other sites at UTTR remain unevaluated and are considered potentially eligible pending additional archaeological testing **(HAFB 2006)**.

Archaeological sites on UTTR range from small-scale lithic scatters to more-substantial open air sites containing lithics, ceramics, ground stone, evidence of prehistoric campfires, and animal bones. There are also several rock shelters known to contain substantial archaeological deposits. This array of sites does not include the numerous isolated lithics, ceramics, or projectile points. These sites range in age from the historic period, such as remains of the Donner Party wagon train, to the terminal Pleistocene age (ca. 10,000 years ago) **(HAFB 2006)**.

About 10,117 hectares (25,000 acres) (about 3 percent) of DPG have been systematically inventoried for cultural resources. There have been 426 prehistoric, 23 historic, and 13 multicomponent sites documented on DPG. No traditional cultural properties (a NHPA historic property eligible for the NRHP due to cultural or religious significance to American Indians or other cultural groups) have been recorded on the installation **(DPG 2012)**.

#### 3.3.9.2 *Potential Consequences*

The area is considered to have a low level of sensitivity for significant archaeological resources. The probability of the SRC landing on and affecting a site would be remote. The SRC would have a maximum design weight of ~55 kilograms (121 pounds) and would land with the impact of a small person parachuting to ground. The SRC impact area would be small (0.5 square meters [5.5 square feet]) and there would be only slight ground disturbance, which would be unlikely to disturb buried or exposed materials in the small impact area. Based on this, NASA has made a determination of "No Historic Properties Affected" under Advisory Council on Historic Preservation regulations implementing Section 106 of the NHPA **(36 CFR 800)** for the mission. The Utah State Historic Preservation Office has concurred with NASA's determination of "No Historic Properties Affected" **(Utah SHPO 2012)**.

### 3.3.10 Socioeconomics and Site Infrastructure

#### 3.3.10.1 *Affected Environment*

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics of a region. The region of influence for the socioeconomic environment includes the geographic area that supplies the majority of inputs for the recovery activity.

UTTR is located in Tooele County in northwest Utah. The Federal Government (primarily BLM and DOD) own 82.4 percent of land in the county **(Gillie 2011)**. The Federal Government controls much of the range, forest, and mineral resources in the county. The area around UTTR is used mostly for ranching/farming and recreational activities, with some mining activity **(DPG 2004)**.

Because it's a close neighbor to Utah's capital city, Tooele County has been growing at a rapid pace and is becoming much more integrated with the larger metropolitan Salt Lake area. Since 2000 the county population has increased by 40 percent to 58,557 in 2010, while payroll employment has grown by 33 percent (a labor force of 28,324). Forty-six percent of employed Tooele County residents commuted outside the county to work. U.S. defense–related activities have been the dominant force behind economic activity in Tooele County. However, in 2010, due in part to reductions in DOD staffing, the Tooele school district was the largest employer in the county; DOD was second largest. Several other large employers operate hazardous waste disposal facilities and mineral extraction operations from the Great Salt Lake. The Miller Motorsports Park was a significant addition to the recreation industry. The county has a minority population of 15.5 percent and 5.9 percent of the population live below the national poverty level **(Utah 2012)**.

#### 3.3.10.2 *Potential Consequences*

The proposed action would not affect demographics, housing, services, or the structure of the economy in the region. It is expected that no new employees would be hired to perform the recovery activity. It is possible that a small number of NASA personnel may temporarily work onsite during the recovery process. The OSIRIS-REx recovery operations would be compatible with the purpose and use of UTTR and the DOD in the proposed impact area.

Potential socioeconomics consequences in the UTTR region are negligible.

### 3.3.11 Environmental Justice and Pollution Prevention

Executive Order 12898 directs Federal agencies to identify and address disproportionately high and adverse human health and environmental effects of their programs, policies, and activities' on low-income and minority populations. Given the characteristics of the SRC normal landing land at UTTR, analysis indicates little or no potential of substantial environmental effects on any human populations outside UTTR boundaries (see Section 3.3.10 for a discussion of the population distribution around UTTR).

All NASA facilities have individual pollution prevention plans and various pollution prevention initiatives to identify and implement cost-effective waste reduction opportunities. Implementing the OSIRIS-REx mission would be consistent with these initiatives.

### 3.3.12 Cumulative Effects

The use of facilities at UTTR for retrieving the OSIRIS-REx mission SRC would be consistent with existing operations and would pose no new types of impacts. The recovery activities constitute a one-time activity of relatively short duration. Existing facilities would be utilized; no new facilities on or offsite would be needed. Any impacts of the OSIRIS-REx mission at UTTR would be negligible. The incremental impact of the mission would not add to, or create, any long-term cumulative effect on the local or regional environment.

## 3.4 JOHNSON SPACE CENTER

This section discusses the potential environmental impacts associated with the curation of OSIRIS-REx mission return samples at NASA's JSC. JSC is responsible for the curation of extraterrestrial samples from past NASA missions. These include lunar rocks and regolith returned from the moon by Apollo and Luna missions; meteorites from Antarctica collected by the Antarctica Search for Meteorite program; cometary and interstellar samples from the Stardust mission; solar wind samples from the Genesis mission; and additional material including returned space hardware, cosmic dust, and asteroid samples. The additional activities associated with the curation of OSIRIS-REx samples at JSC would be within the normal operating activities currently performed there.

Environmental impacts associated with the operation of JSC have been addressed in previous documents, including the *Constellation Environmental Impact Statement* **(NASA 2008a)**, and NASA's *JSC Environmental Resource Document* **(NASA 2008b)**. The findings of these documents as they pertain to the OSIRIS-REx mission are incorporated by reference. Additional information specifically associated with the OSIRIS-REx mission is provided in the following sections.

### 3.4.1 Affected Environment

JSC is devoted to research, development, and mission planning and execution activities related to NASA's human space activities.

JSC is located in Harris County, Texas, approximately 40 kilometers (25 miles) southeast of central Houston and 3 kilometers (2 miles) northeast of Webster (**Figure 3–4**). JSC adjoins public access areas, commercial and industrial sites, and residential areas of Clear Lake City. It encompasses approximately 640 hectares (1,581 acres) of land and is the program management and operations center for NASA's manned space programs. Basic and applied space research conducted at JSC includes propellant testing, development of communications devices, materials testing, lunar sample chemistry, and physiological adaptation to microgravity, remote sensing, and space simulation. Land use at JSC is primarily commercial/industrial, with more than 140 facilities, open space, utilities, and roads. The southwestern portion of JSC is largely undeveloped and acts as a buffer zone.

JSC is set in a landscape with many tidal streams and estuaries of Galveston Bay. Clear Lake is southeast of JSC; Mud Lake (also known as Lake Pasadena) and Armand Bayou are to the northeast; Cow Bayou is to the southwest; and Horsepen Bayou is north of JSC. Galveston Bay is recognized by the U.S. Environmental Protection Agency (EPA) as an estuary of national significance and was included in the National Estuary Program in 1989. Armand Bayou is a coastal preserve in the Galveston Bay National Estuary Program. Armand Bayou and Clear Lake are classified by the Texas Natural Resources Conservation Commission as "water quality limited" and designated for contact recreation and high-quality aquatic habitat **(NASA 2008b)**.

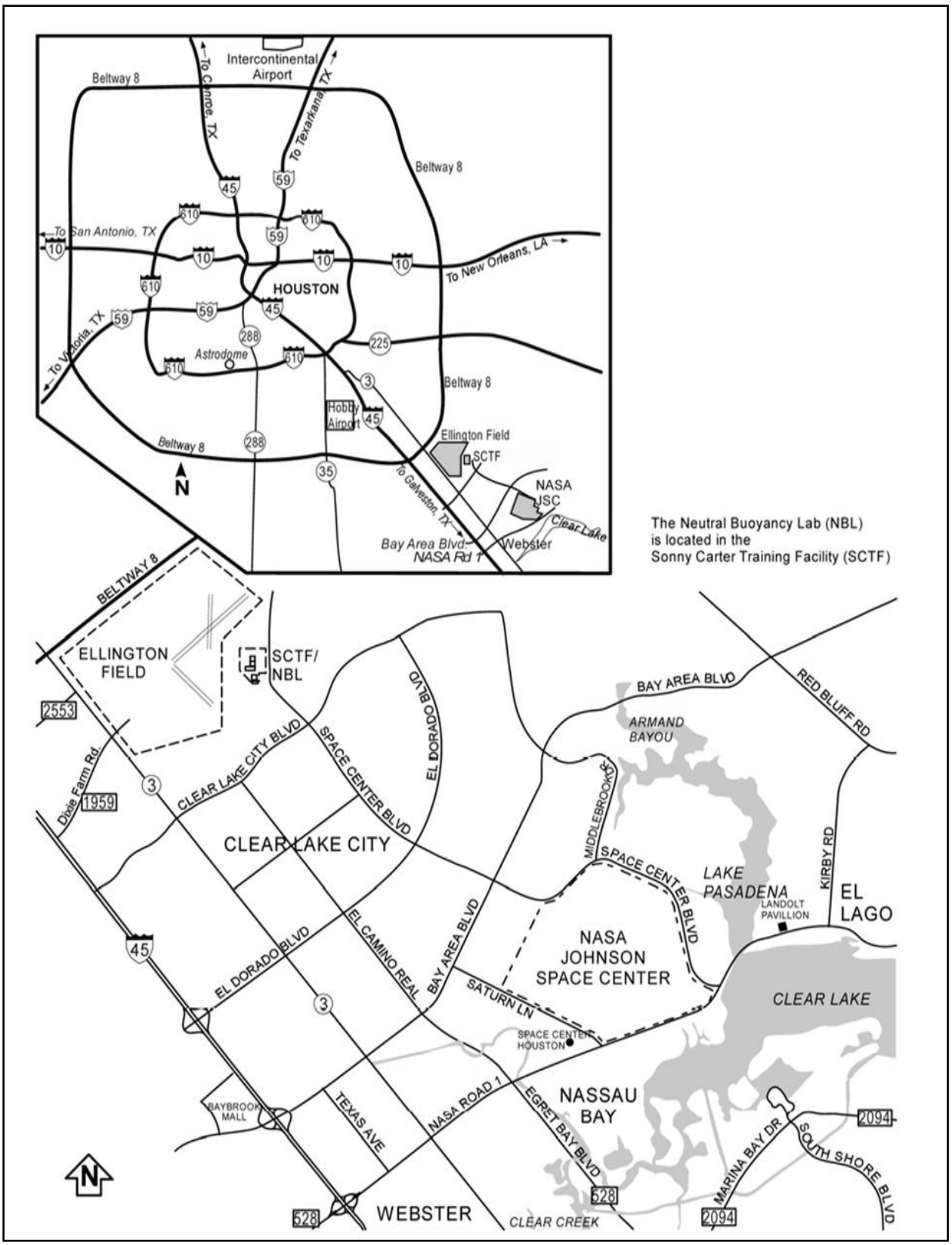
### 3.4.2 Potential Consequences

#### 3.4.2.1 *Land Use and Aesthetics/Visual Resources*

The OSIRIS-REx mission curation activities would occur within existing JSC facilities. All construction activities would be interior to existing facilities; no new structures would be built. There would be no additional impacts beyond current JSC activities on land use or aesthetics/visual resources.

#### 3.4.2.2 *Hazardous Materials*

During the interior renovation for the OSIRIS-REx Class 100 clean room, some asbestos may be removed and disposed of. Disposal of asbestos-contaminated waste generated by JSC activities would follow *Texas Administrative Code* regulations **(30 TAC 330.136)**.




**Source: NASA 2008b.**

**Figure 3–4. Johnson Space Center Location and Vicinity Map**

#### 3.4.2.3 *Health and Safety*

The asteroid samples have been categorized as "unrestricted Earth return," and NASA has determined that the samples pose no threat of contamination and therefore do not pose a health or safety threat.

However, as discussed in Section 3.4.2.2, asbestos removal may be required as part of the interior construction for the OSIRIS-REx clean room. A key consideration in assessing asbestos-related hazards to humans is whether the asbestos-containing material would readily release asbestos fibers when damaged or disturbed. Asbestos that can crumble or be reduced to a powder by hand pressure poses the greatest risk; however, any asbestos-containing material could present a hazard if it is ground or cut.

If a person were to handle or cut up the insulation without employing appropriate protective measures, the potential would exist for an uptake of asbestos-containing materials. The Occupational Safety and Health Administration's (OSHA's) worker limits for an 8-hour day are 0.1 fibers per milliliter (0.64 fibers per cubic inch), or a 30-minute-excursion limit of 1.0 fiber per milliliter (6.4 fibers per cubic inch) for construction or shipyard workers **(ATSDR 2001)**. Asbestos-related lung diseases (malignant and nonmalignant), or signs of these diseases, have been reported in groups of occupationally exposed humans with cumulative exposures ranging from about 5 to 1,200 fibers per year per milliliter (0.64 to 7,700 fibers per year per cubic inch) **(ATSDR 2001)**.

JSC's policy is to meet or exceed the requirements of OSHA, EPA, and State, and local agencies and guidelines established by NASA Headquarters. The *JSC Safety and Health Handbook*, **JPR 1700.1 Part 12**, describes the specific requirements for any asbestos-related work at JSC. The goal of the JSC Asbestos Control Program is to manage asbestos-containing materials in JSC buildings and provide protection to the general JSC worker and visitor populations. JSC would comply with applicable Federal and State requirements, including Occupational Safety and Health Standards **(29 CFR 1910.1001)** addressing exposure to asbestos in the workplace, Safety and Health Regulations for Construction **(29 CFR 1926.1101)** addressing asbestos exposure during construction, National Emissions Standard for Hazardous Air Pollutant **(40 CFR Part 61)**, Department of State Health Services, and Texas Council on Environmental Quality regulations, in addition to and regardless of what the manual requires. Thus, no health impacts are expected from removing asbestos-containing ceiling tiles or from short-term exposure to potential asbestos-containing materials other than the risk of injury from demolishing the tiles.

#### 3.4.2.4 *Geology and Soils*

The OSIRIS-REx mission curation activities would not alter the impacts of current JSC activities on geology and soils.

#### 3.4.2.5 *Water Resources*

The OSIRIS-REx mission curation activities would not alter the impacts of current JSC activities on water resources.

#### 3.4.2.6 *Air Quality*

The OSIRIS-REx mission curation activities would not alter the impacts of current JSC activities on air quality.

#### 3.4.2.7 *Noise*

The OSIRIS-REx mission curation activities would not alter the impacts of current JSC activities on noise.

#### 3.4.2.8 *Biological Resources*

The OSIRIS-REx mission curation activities would not alter the impacts of current JSC activities on biological resources.

#### 3.4.2.9 *Historical and Cultural Resources*

The OSIRIS-REx mission curation activities would not alter the impacts of current JSC activities on historical or cultural resources.

#### 3.4.2.10 *Socioeconomics and Site Infrastructure*

JSC contributes significantly to the local, state, and national economies. The aerospace industry, centered on JSC, brings billions of dollars in NASA contracts to the area every year. JSC's combined workforce accounts for 16,844 jobs and is made up of 3,500 civil servants and 13,000 support contractors **(NASA 2008b)**. The vast majority of JSC's workforce lives in Clear Lake City, followed by the communities of League City, Friendswood, Nassau Bay, and Seabrook/El Lago/Taylor Lake Village. For every aerospace job, it has been estimated that there are 2.2 jobs generated in the Clear Lake area and the Houston region. Employees of NASA and its contractors pay over $30 million in real estate taxes and $3 million in sales taxes. Local governments with NASA employees as residents received over $1 million in allocated state aid. These local governments pay over $12 million for city services and $8 million for schools **(NASA 2008b)**.

The few JSC personnel expected to work in the OSIRIS-REx curation facility, some of whom may be existing employees, would not significantly impact the employment level in the Houston area or within JSC itself.

Additional infrastructure needs (*e.g.*, power, water and sewage, transportation facilities) would not significantly alter current JSC requirements. All operational activities are to be carried out in existing facilities and are similar to curation activities currently being performed. Construction activities would be limited to remodeling of existing rooms.

#### 3.4.2.11 *Environmental Justice and Pollution Prevention*

The OSIRIS-REx curation activities would be within the scope of curation activities currently performed at JSC. No substantial environmental effects are likely to occur outside of the facility,

thus no disproportionately high and adverse impact on any children, minority populations, or low-income populations is expected.

All NASA facilities have individual pollution prevention plans and various pollution prevention initiatives to identify and implement cost-effective waste reduction opportunities. Implementing the OSIRIS-REx mission would be consistent with these initiatives.

#### 3.4.2.12 *Cumulative Effects*

The use of curation facilities at JSC for storing and studying the returned samples of the OSIRS-REx mission would be consistent with existing operations and would pose no new types of impacts. No new facilities, on or off site, would be required, only modifications to the interiors of existing structures. Therefore, the long-term cumulative effects on the local and regional environment by the proposed action would not be substantial.

## 3.5 GREENHOUSE GASES AND CLIMATE CHANGE

### 3.5.1 Troposphere and Stratosphere

The troposphere is the lowest region of the atmosphere, extending from the Earth's surface to a height of about 6 to 10 kilometers (19,700 to 32,800 feet), (the lower boundary of the stratosphere). The upper (free) troposphere ranges from 2 to 10 kilometers (6,561 to 32,808 feet) and is generally referred to as the "free troposphere." This layer is characterized by vigorous mixing driven by convective upwelling and horizontal and vertical winds, as well as transport and washout of gases that have been introduced into this region by industrial sources. The atmospheric boundary layer, the lower part of the troposphere, which extends from Earth's surface to about 3 kilometers (9,843 feet), is considered the most important boundary layer with respect to the emission, transport, and dispersion of airborne pollutants. The part of the atmospheric boundary layer between Earth's surface and the bottom of the inversion layer is known as the mixing layer. Almost all of the airborne pollutants emitted into the ambient atmosphere are transported and dispersed within the mixing layer. Some of the emissions penetrate the inversion layer and enter the free troposphere above the atmospheric boundary layer.

Above the troposphere is the stratosphere, extending from 10 to 50 kilometers (32,800 to 164,000 feet). The stratospheric ozone layer's altitude is usually thought to lie between about 16 and 26 kilometers (52,493 and 85,301 feet) altitude. The stratospheric ozone absorbs most of the most harmful ultraviolet radiation from the sun. These boundaries should be taken as approximate annual mean values, as the actual level of the boundary between the troposphere and stratosphere (tropopause) is variable on a seasonal and day-to-day basis.

### 3.5.2 Potential Consequences

The concentrations of gases and particles emitted into the free troposphere by transient sources, such as launch vehicles are quickly diluted to very low levels before they can be deposited onto, or transported near the ground by precipitation or strong down-welling events.

Launch emissions would include ozone-depleting substances; however, the rate of deposition would depend on the launch profile and the rate at which propellant is consumed within the stratosphere. In general, data from Atlas V launches indicate that short-term impacts include a temporary hole in the ozone layer, but that ozone concentrations would return to prelaunch levels within 2 hours.

Greenhouse gases absorb the radiant energy from the Sun and Earth. Some of the greenhouse gases (*e.g.*, carbon monoxide, chlorofluorocarbons, and water) are emitted during the processes of preparing for and launching NASA routine payload spacecraft. Research on greenhouse gas production (and possible effects of certain related pollutants, such as pollutants contributing to global warming) is ongoing by the EPA and some states.

## 3.6 NO ACTION ALTERNATIVE

Under the No Action Alternative, NASA would not implement the OSIRIS-REx mission. There would be no launch of the OSIRIS-REx spacecraft at CCAFS, no asteroid sample return at UTTR, and no curation activities associated with OSIRIS REx at JSC. NASA would not be able to meet the science objectives established for the mission. Any environmental impacts associated with the mission would not occur. Baseline conditions would remain at current levels.

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# CHAPTER 4

# LIST OF PREPARERS AND PERSONS AND AGENCIES CONSULTED

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# CHAPTER 5

# GLOSSARY

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# 5. GLOSSARY

**Ablation –** The dissipation of heat generated by atmospheric friction, especially in the atmospheric reentry of a spacecraft or missile, by means of a melting heat shield.

**AIRFA –** The American Indian Religious Freedom Act. Legislation passed in 1978 to institute as a policy of the United States to protect and preserve for Native Americans their inherent right to believe, express, and exercise the traditional religions of their cultures. This includes access to sites, the use and possession of sacred objects, and the freedom to worship through ceremonial and traditional rites.

**Asteroid –** One of the many small celestial bodies revolving around the sun, most of the orbits being between those of Mars and Jupiter. Also known as minor planet; planetoid.

**Carbonaceous –** Relating to or composed of carbon.

**Criteria Pollutant –** Air pollutants regulated by the Environmental Policy Act (EPA) by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels, (from/based on http://www.epa.gov/air/urbanair/).

**Critical Habitat –** (1) Specific areas within the geographical area occupied by a species at the time it is listed (as endangered or threatened) on which are found those physical or biological features: (a) essential to the conservation of the species; and (b) which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species.

**Drogue parachute –** A small parachute attached to a body for stabilization and deceleration, also known as deceleration parachute.

**Endangered –** Any species that is in danger of extinction throughout all or a significant portion of its range.

**Global Warming –** Theory which states that an increase in carbon dioxide and other gases in the atmosphere results in an additive effect on average global temperatures.

**In situ –** In the original location.

**Infrastructure –** The system of public works of a country, state, or region; also: the resources (as personnel, buildings, or equipment) required for an activity.

**Isotopic –** Pertaining to an isotope - each of two or more forms of the same element that contain equal numbers of protons but different numbers of neutrons in their nuclei.

**Launch Vehicle –** A stacked assembly of one or more cylindrical rockets in series, topped by a cylindrical payload and a nose cone. In the sounding rocket application, the payload consists of scientific instruments either gathering in situ samples or making optical observations of terrestrial (atmospheric), planetary, solar system, or galactic targets.

**Mesosphere** – The atmospheric shell between about 45–55 kilometers (28–34 miles) and 80-95 kilometers (50–59 miles), extending from the top of the stratosphere to the mesopause; characterized by a temperature that generally decreases with latitude.

**Meteorological –** Dealing with the Earth's atmosphere and its phenomena, and especially with weather and weather forecasting.

**NAGPRA –** Native American Graves Protection and Repatriation Act of 1990. Legislation giving ownership or control of Native American cultural human remains and funerary objects that are excavated or discovered on federal or tribal lands to the appropriate Native American group based on location or cultural affiliation of the items found. The act contains provisions dealing with competing claims, museum inventories, repatriation standards, and the sharing of information.

**Near-Earth Object –** A Solar System object whose orbit brings it to between 146,450,304 and 193,121,280 kilometers (91,000,000 and 120,000,000 miles) from the Sun. In doing so, it *may* come in close proximity with the orbit of the Earth.

**Nebula –** Interstellar clouds of gas or small particles; an example is the Horsehead Nebula in Orion.

**Paramedic** – A person who is trained to do medical work, esp. emergency first aid, but is not a fully qualified doctor.

**Pluvial lake –** A lake formed by rainfall.

**Primordial** – Existing at or from the beginning of time.

**Regolith –** The layer rock or blanket of unconsolidated rocky debris of any thickness that overlies bedrock and forms the surface of the land. Also known as mantel rock, it can be soil, gravel, dust, or broken rocks.

**Stratosphere –** Atmospheric layer from about 10 to 50 kilometers (6 to 31 miles).

**Traditional cultural property –** A historically used place associated with beliefs or activities central to the lifeway and continuity of a traditional community. This term has also become synonymous with Native American sacred sites such as mountains or bodies of water.

**Troposphere –** Atmospheric layer from surface to about 10 kilometers (6 miles).

**Witness Coupons –** Witness coupons are small plates of materials (alumina, stainless steel, or aluminum) that are installed in parts of the sampling head and sample return canister to "witness" the environment of the sample chamber during the duration of the mission. When returned to Earth, these will be recovered and analyzed by scientists using various analytical approaches. Different material are used so that there is a choice depending on the type of element or analysis that needs to be done (*i.e.*, one material will not satisfy everyone and every technique).

**Yarkovsky effect –** The slight push created when the asteroid absorbs sunlight and re-emits the energy as heat.

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# CHAPTER 6

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# 6. REFERENCES


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***Code of Federal Regulations***

14 CFR 1216.3, Procedures for Implementing the National Environmental Policy Act.

29 CFR 1910.1001, Occupational Safety and Health Standards, addressing exposure to asbestos in the workplace.

29 CFR 1926.1101, Safety and Health Regulations for Construction, addressing asbestos exposure during construction.

36 CFR 800, Protection of Historic Properties.

40 CFR 61, National Emission Standards for Hazardous Air Pollutants.

40 CFR 1500–1508, The Council of Environmental Quality Regulations for Implementing the Procedures Provisions of NEPA.

**Executive Order**

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, February 11, 1994.

**Johnson Procedural Requirement**

JPR 1700.1, *JSC Safety and Health Handbook,* Asbestos Control Regulations.

**NASA Procedural Requirement**

NPR 8715.3C, NASA Procedural Requirement for General Safety Program Requirements (04 Apr 2007).

NPR 8715.5A, NASA Procedural Requirements for Range Flight Safety Program.

***United States Code***

42 U.S.C. 2451(d)(1)(5), Congressional Declaration of Policy and Purpose.

42 U.S.C. 4321 et seq., The National Environmental Policy Act of 1969, as amended.

51 U.S.C., National and Commercial Space Programs.

***Texas Administrative Code***

30 TAC 330.136, Texas Commission on Environmental Quality, Municipal Solid Waste, Subchapter F Operational Standards for Solid Waste Land Disposal Sites, Disposal of Special Wastes.

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# APPENDIX A

# COORDINATION/PUBLIC INVOLVEMENT

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# APPENDIX A.
# COORDINATION/PUBLIC INVOLVEMENT

## A.1 INITIAL CORRESPONDENCE

In June 2012, letters were distributed to Federal, State and local agencies and tribes in the Utah Test and Training Range (UTTR) area soliciting input regarding potential environmental concerns and historic resources that might be affected by the proposed action. A representative letter that was distributed is provided following Section A.2. It should be noted that the footprint shown in the enclosure has changed slightly. The new footprint was evaluated in this environmental assessment and appears in Figures 2–5 and 3–3.

**Table A–1** provides the list of Federal and State Organizations and interested parties to whom the letters were distributed. Forty five letters were distributed.

**Table A–1. Letters to Federal, State Organizations and Interested Parties Distribution List**

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| Department of Interior – DC | Mr. Willie R. Taylor |
| Bureau of Indian Affairs – AZ | Mr. Bryan Bowker |
| Department of Interior Denver Regional Office | Mr. Robert F. Stewart |
| Department of the Interior Fish and Wildlife Service/Fish Springs Utah | |
| Department of the Interior Fish and Wildlife Service West Valley Utah | |
| Environmental Protection Agency Region 8 | Ms. Suzanne Bohan |
| Federal Emergency Management Agency Region VIII | Mr. Steve Hardegen |
| Bureau of Land Management – Utah West Desert District | Ms. Cindy Ledbetter / Ms. Mary Higgins |
| Bureau of Land Management – Utah Salt Lake Field | Ms. Jill Silvey |
| Bureau of Land Management – Utah Fillmore Field | Mr. Michael Gates |
| Bureau of Reclamation | |
| Forest Service, Intermountain Regions | Mr. Harv Forsgren |
| Forest Service, Salt Lake Ranger District | Mr. Steve Scheid |
| Forest Service, Uinta-Wasatch-Cache | Ms. Julie Hubbard |

**Table A–1. Letters to Federal, State Organizations and Interested Parties Distribution List (*continued*)**

| Federal, State Organizations And Interested Parties (*continued*) | To Whom The Letter Was Addressed |
|---|---|
| Bureau of Indian Affairs (Nevada) | Mr. Joseph McDade |
| Bureau of Indian Affairs (Utah) | Ms. Johanna Blackhair |
| Utah Department of Environmental Quality | |
| Utah Division of Wildlife Resources | |
| State of Utah School and Institutional Trust Lands Administration | |
| President of Terra Community Association | |
| Tooele County Commissioners | |
| 388th Range Squadron, Hill Air Force Base | |
| **Historic Preservation Offices** | **To Whom The Letter Was Addressed** |
| Advisory Council on Historic Preservation | Mr. Reid Nelson |
| Utah State Historic Preservation Office | Ms. Lori Hunsaker |
| **Indian Tribes** | **To Whom The Letter Was Addressed** |
| Blackfeet Tribal Business Council | Mr. T.J. Show |
| Confederated Salish & Kootenai Tribes of the Flathead Reservation | Mr. Joe Durglo |
| Confederated Tribes of the Goshute Indian Reservation | Mr. Ed Naranjo |
| Crow Tribe of Montana | Mr. Cedric Black Eagle |
| Duckwater Shoshone Tribe | Mr. Ruby Sam |
| Eastern Shoshone Business Council | Mr. Mike Lajeunesse |
| Ely Shoshone Tribe | Mr. Alvin S. Marques |
| Hopi Tribe | Mr. Leroy Ned Shingoitewa |
| Navajo Nation | Mr. Ben Shelly |
| Northern Arapaho Tribe | Mr. Jim L. Shakespeare |
| Northwestern Band of Shoshone Nation | Mr. Jason Walker |
| Paiute Indian Tribe of Utah | Ms. Jeanine Borchardt |
| Pueblo of Zuni | Mr. Arlen P. Quetawki Sr. |

**Table A–1. Letters to Federal, State Organizations and Interested Parties Distribution List (*continued*)**

| Indian Tribes (*continued*) | To Whom The Letter Was Addressed |
|---|---|
| San Juan Southern Paiute Tribe | Ms. LaNita Matthews |
| Shoshone-Bannock Tribes of the Fort Hall Reservation | Mr. Nathan Small |
| Shoshone-Paiute Tribes of Duck Valley | Mr. Terry Gibson |
| Skull Valley Band of Goshute Indians of Utah | Ms. Lori Bear Skiby |
| Te-Moak Tribe of Western Shoshone | Mr. Bryan Cassadore |
| Ute Indian Tribe | Ms. Irene Cuch |
| Ute Mountain Ute Tribe | Mr. Gary Hayes |
| Wells Band of Western Shoshone | Ms. Paula Salazar |

## A.2 DRAFT EA PUBLIC REVIEW AND COMMENT

NASA initiated a 30-day public review and comment period on the *draft OSIRIS-REx EA* in November 2012. NASA put a newspaper notice of the availability of the *draft OSIRIS-REx EA* in the Salt Lake Tribune and Deseret News (11/18/2012) and the Tooele Transcript (11/20/2012). Letters announcing the availability of the *draft OSIRIS-REx EA* were sent to the same distribution as the initial correspondence. NASA also transmitted the *draft OSIRIS-REx EA* to two libraries in the Utah region: Salt Lake City Library and Tooele City Library and the *draft OSIRIS-REx EA* was available on a website.

The public was able to contact NASA by mail, email or telephone if they had questions or comments.

NASA received three comments on the *draft OSIRIS-REx EA*. One commenter wished to be removed from distribution (email), one Indian Tribe, while expressing appreciation for the information, had no comments (email), and Utah State Historic Preservation Officer concurred with NASA's determination of No Historic Properties Affected (letter).

## INITIAL CORRESPONDENCE LETTER

National Aeronautics and
Space Administration

**Goddard Space Flight Center**
**Greenbelt, MD**

Reply to Attn of: 250

June 7, 2012

Utah Department of Environmental Quality
195 North 1950 West
Salt Lake City, UT 84114

Dear Sir or Madam:

NASA is proposing to launch the Origins, Spectral Interpretation, Resource Identification, Security -Regolith Explorer (OSIRIS-REx) spacecraft on a mission to gather asteroid material and return samples to Earth for study by a global community of researchers. In accordance with National Environmental Policy Act, as amended, (NEPA) (42 U.S.C. 4321 et seq.), the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508), and NASA's Procedures for Implementing NEPA (14 CFR Subpart 1216.3), NASA is preparing an Environmental Assessment (EA) to evaluate any mission-specific environmental impacts.

The OSIRIS-REx mission would be the third in NASA's New Frontiers class of missions, following the New Horizons mission to Pluto and the Kuiper Belt and the Juno mission to Jupiter. The OSIRIS-REx mission would be the first U.S. mission to carry samples from an asteroid back to Earth. Asteroids are leftovers formed from the cloud of gas and dust -- the solar nebula -- that collapsed to form our sun and the planets about 4.5 billion years ago. As such, they contain the original material from the solar nebula, which can inform us about the conditions during our solar system's birth. The OSIRIS-REx mission has been designed to gather information that cannot be fully attained solely through Earth-based observation of asteroids. The mission would help us investigate planet formation and the origin of life, and would also aid our understanding of asteroids that can impact Earth. NASA is proposing to launch the OSIRIS-REx spacecraft from the Cape Canaveral Air Force Station (CCAFS), Florida in September 2016 on an Atlas V class launch vehicle. After traveling three years, OSIRIS-REx would approach the primitive, near Earth asteroid designated 1999 RQ36 in October 2019.

Once in a position within three miles of the asteroid, the spacecraft would begin comprehensive surface mapping, using a variety of instruments to study the asteroid. Using the information gathered while in orbit around 1999 RQ36, a sample site would be selected and samples would be taken using a robotic arm. The samples would be stored in a sample return capsule. Upon the completion of its sample collection and investigation of asteroid 1999 RQ36, the OSIRIS-REx spacecraft would return to Earth and release the sample return capsule for a landing at the Utah Test and Training Range (UTTR) in September 2023. The enclosed document displays the potential landing location for the sample return capsule. Only the sample return capsule is

intended to return to Earth. The spacecraft would perform an avoidance maneuver so that it does not return to Earth.

The sample return capsule would have a diameter of approximately 81 cm (32 in) and would weigh approximately 55 kg (121 lbs). It would have a parachute system which would slow its velocity for landing. The area affected within the landing footprint would only be a few meters. The impact would be comparable to a small person parachuting to the surface. This is similar to the Stardust sample return capsule that landed at UTTR in 2006.

The OSIRIS-REx sample return capsule would be recovered and taken to NASA's Johnson Space Center (JSC) in Houston, Texas, for processing at a dedicated curation and research facility. Precise analysis would be performed on the asteroid sample that cannot be duplicated by spacecraft-based instruments alone. Samples would be distributed for examination at selected research facilities. For the OSIRIS-REx mission, the NASA Planetary Protection Officer has issued a preliminary categorization of "unrestricted Earth return", meaning the sample is safe to return to Earth.

The OSIRIS-REx EA will address the proposed action of implementing the OSIRIS-REx mission. No new facilities would be constructed at any of the locations (CCAFS, UTTR, JSC) associated with this mission. The primary focus of the EA will be addressing the environmental impacts associated with the return of the sample at UTTR. Topics expected to be addressed are safety concerns, reentry of orbital debris, natural and cultural resources, and planetary protection concerns. Impacts associated with the preparation for launch and the launch of OSIRIS-REx fall within the parameters addressed in the NASA Routine Payloads Environmental Assessment (NASA 2011) and will be summarized in the OSIRIS-REx EA.

Additional information about the OSIRIS-REx mission can be found at the following websites:

- The OSIRIS-REx mission homepage: http://osiris-rex.lpl.arizona.edu/
- An OSIRIS-REx mission factsheet: http://www.nasa.gov/centers/goddard/pdf/552572main_OSIRIS_REx_Factsheet.pdf.

Any comments that you may presently have concerning the environmental impacts of the OSIRIS-REx mission may be submitted at the address or email listed below. Comments will be accepted throughout the entire EA process. However, for full early consideration, please submit comments by July 15, 2012.

**Lizabeth Montgomery**
**GSFC NEPA Program Manager**
**NASA Goddard Space Flight Center**
**Code 250, Building 28, Room N150F**
**8800 Greenbelt Road**
**Greenbelt, MD 20771**
**Phone: (301) 286-0469**
gsfc-enviro@lists.nasa.gov

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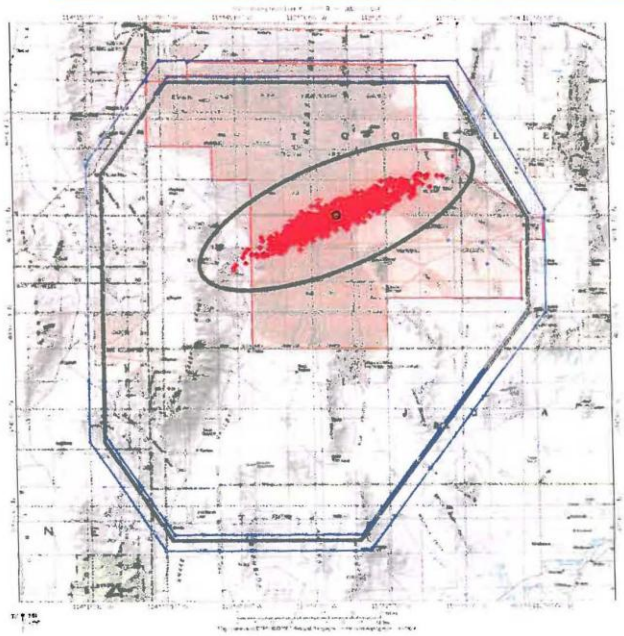
The Draft EA is expected to be released later this year for public review and comment. At that time your organization will have an opportunity to review and comment on the Draft EA. If you need further information on NASA's environmental review process or the proposed mission, please contact me on (301) 286-0469. We look forward to hearing from you.

Sincerely,

Lizabeth Montgomery
GSFC NEPA Program Manager

Enclosure

# Utah Test & Training Range (UTTR)



OSIRIS-REx Sample Return
Capsule Landing Footprint

-The black dot in the middle represents the most likely landing location

- The red dots represent other likely landing locations based on analysis

- The black ellipse encompasses all credible landing locations

- Range Design Footprint

84 x 30 km
67 deg Azimuth
40º 16′ N, 113º 24′ W

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# APPENDIX B

# NASA ROUTINE PAYLOAD CHECKLIST FOR THE OSIRIS-REx MISSION

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# NASA Routine Payload Checklist (1 of 2)

PROJECT NAME: OSIRIS-REX | DATE OF LAUNCH: SEPT 2016
PROJECT CONTACT: BOB JENKENS | PHONE NUMBER: 6-6310 | MAILSTOP: 460
PROJECT START DATE: PHASE B BRIDGE: JULY 2011 | PROJECT LOCATION: GSFC
PROJECT DESCRIPTION: ASTEROID SAMPLE RETURN MISSION

| **A. SAMPLE RETURN:** | YES | NO |
|---|---|---|
| 1. Would the candidate mission return a sample from an extraterrestrial body? | **X** | |
| **B. RADIOACTIVE MATERIALS:** | YES | NO |
| 1. Would the candidate spacecraft carry radioactive materials in quantities that produce an A2 mission multiple value of 10 or more? | | **X** |
| Provide a copy of the Radioactive Materials On Board Report as per NPR 8715.3 with the ERP submittal | | |
| **C. LAUNCH AND LAUNCH VEHICLES:** | YES | NO |
| 1. Would the candidate spacecraft be launched on a vehicle and launch site combination other than those listed in Table C–1 below? | | **X** |
| 2. Would launch of the proposed mission exceed the approved or permitted annual launch rate for the particular launch vehicle or launch site? | | **X** |
| Comments: | | |
| **D. FACILITIES:** | YES | NO |
| 1. Would the candidate mission require the construction of any new facilities or substantial modification of existing facilities? | | **X** |
| Provide a brief description of the construction or modification required, including whether ground disturbance and/or excavation would occur: | | |
| **E. HEALTH AND SAFETY:** | YES | NO |
| 1. Would the candidate spacecraft utilize batteries, ordnance, hazardous propellant, radiofrequency transmitter power, or other subsystem components in quantities or levels exceeding the EPCs in Table C–2 below? | | **X** |
| 2. Would the expected risk of human casualty from spacecraft planned orbital reentry exceed the criteria specified by NASA Standard 8719.14? | | **X** |
| 3. Would the candidate spacecraft utilize any potentially hazardous material as part of a flight system whose type or amount precludes acquisition of the necessary permits prior to its use or is not included within the definition of the Envelope Payload Characteristics? | | **X** |
| 4. Would the candidate mission, under nominal conditions, release material other than propulsion system exhaust or inert gases into the Earth's atmosphere or space? | | **X** |
| 5. Are there changes in the preparation, launch or operation of the candidate spacecraft from the standard practices described in Chapter 3 of this EA? | | **X** |
| 6. Would the candidate spacecraft utilize an Earth-pointing laser system that does not meet the requirements for safe operation (ANSI Z136.1-2007 and ANSI Z136.6-2005)? | | **X** |
| 7. Would the candidate spacecraft contain, by design (e.g., a scientific payload) pathogenic microorganisms (including bacteria, protozoa, and viruses) which can produce disease or toxins hazardous to human health or the environment beyond Biosafety Level 1 (BSL 1)[1]? | | **X** |
| Comments: Item 7: **Return sample assigned a Planetary Protection Category V, Unrestricted Return** | | |

*Continued on next page*

[1] The use of biological agents on payloads is limited to materials with a safety rating of "Biosafety Level 1." This classification includes defined and characterized strains of viable microorganisms not known to consistently cause disease in healthy human adults. Personnel working with Biosafety Level 1 agents follow standard microbiological practices including the use of mechanical pipetting devices, no eating drinking, or smoking in the laboratory, and required hand-washing after working with agents or leaving a lab where agents are stored. Personal protective equipment such as gloves and eye protection is also recommended when working with biological agents.

## NASA Routine Payload Checklist (2 of 2)

PROJECT NAME: OSIRIS-REX

DATE OF LAUNCH: SEPT 2016

PROJECT CONTACT: BOB JENKENS PHONE NUMBER: 6-6301 MAILSTOP: 460

PROJECT START DATE: : PHASE B BRIDGE:7/2011 PROJECT LOCATION: GSFC

PROJECT DESCRIPTION: ASTEROID SAMPLE RETURN MISSION

| **F. OTHER ENVIRONMENTAL ISSUES:** | YES | NO |
|---|---|---|
| 1. Would the candidate spacecraft have the potential for substantial effects on the environment outside the United States? | | **X** |
| 2. Would launch and operation of the candidate spacecraft have the potential to create substantial public controversy related to environmental issues? | | **X** |
| 3. Would any aspect of the candidate spacecraft that is not addressed by the EPCs have the potential for substantial effects on the environment (i.e., previously unused materials, configurations or material not included in the checklist)? | | **X** |
| Comments: | | |

## Table B–1. Launch Vehicles and Launch Sites

| **Launch Vehicle and Launch Vehicle Family** | **Space Launch Complexes and Pads** | | | | |
|---|---|---|---|---|---|
| | **Eastern Range (CCAFS)** | **Western Range (VAFB)** | **USAKA/RTS** | **WFF** | **KLC** |
| Athena I, IIc, III[a] | LC-46 | CA Spaceport (SLC-8) | N/A | Pad 0 | LP-1[a] |
| Atlas V Family | LC-41 | SLC-3 | N/A | N/A | N/A |
| Delta II Family | LC-17 | SLC-2 | N/A | N/A | N/A |
| Delta IV Family | LC-37 | SLC-6 | N/A | N/A | N/A |
| Falcon 1/1e | LC-36 | SLC-4W | Omelek Island | Pad 0 | LP-3[b] |
| Falcon 9 | LC-40 | SLC-4E | Omelek | Pad 0 | LP-3[b] |
| Minotaur I | LC-20 and/or LC-46 | SLC-8 | N/A | Pad 0 | LP-1 |
| Minotaur II-III | LC-20 and/or LC-46 | SLC-8 | N/A | Pad 0 | LP-1 |
| Minotaur IV | LC-20 and/or LC-46 | SLC-8 | N/A | Pad 0 | LP-1 |
| Minotaur V | LC-20 and/or LC-46 | SLC-8 | N/A | Pad 0 | LP-1 |
| Pegasus XL | CCAFS skidstrip KSC SLF | VAFB Airfield | Kwajalein Island | WFF Airfield | N/A |
| Taurus | LC-46 and/or LC-20 | SLC-576E | N/A | Pad 0 | LP-1 |
| Taurus II | NA | NA | N/A | Pad 0 | LP-3[b] |
| Any other launch vehicle/launch site combination for which NASA has completed or cooperated on the NEPA compliance | | | | | |

a. Athena III and LP-3 are currently under design.
b. While not explicitly listed in this table, the Minotaur IV includes all configurations of this launch vehicle, including the Minotaur IV+, which is a Minotaur IV with a Star 48V 4th stage.

**Key:** CA=California; CCAFS=Cape Canaveral Air Force Station; KSC=Kennedy Space Center; LC=Launch Complex; LP=Launch Pad; MARS=Mid-Atlantic Regional Spaceport; SLC=Space Launch Complex; SLF=Shuttle Landing Facility; USAKA/RTS=United States Army Kwajalein Atoll/Reagan Test Site; VAFB=Vandenberg Air Force Base; WFF=Wallops Flight Facility.

## Table B–2. Summary of Envelope Payload Characteristics by Spacecraft Subsystems

| | |
|---|---|
| **Structure** | • Unlimited: aluminum, beryllium, carbon resin composites, magnesium, titanium, and other materials unless specified as limited. |
| **Propulsion[a]** | • Liquid propellant(s); 3,200 kilograms (7,055 pounds) combined hydrazine, monomethyhydrazine and/or nitrogen tetroxide.<br>• Solid Rocket Motor (SRM) propellant; 3,000 kilograms (6,614 pounds) Ammonium Perchlorate (AP)-based solid propellant (examples of SRM propellant that might be on a spacecraft are a Star-48 kick stage, descent engines, an extra-terrestrial ascent vehicle, etc.) |
| **Communications** | • Various 10-100 Watt (RF) transmitters |
| **Power** | • Unlimited Solar cells; 5 kilowatt-Hour (kW-hr) Nickel-Hydrogen ($NiH_2$) or Lithium ion (Li-ion) battery, 300 Ampere-hour (A-hr) Lithium-Thionyl Chloride (LiSOCl), or 150 A-hr Hydrogen, Nickel-Cadmium (NiCd), or Nickel-hydrogen ($Ni\text{-}H_2$) battery. |
| **Science Instruments** | • 10 kilowatt radar<br>• American National Standards Institute safe lasers (see Section 4.1.2.1) |
| **Other** | • U. S. Department of Transportation (DoT) Class 1.4 Electro-Explosive Devices (EEDs) for mechanical systems deployment<br>• Radioactive materials in quantities that produce an A2 mission multiple value of less than 10<br>• Propulsion system exhaust and inert gas venting<br>• Sample returns are considered outside of the scope of this environmental assessment |

a. Propellant limits are subject to range safety requirements.

**Key:** kg=kilograms; lb=pounds.

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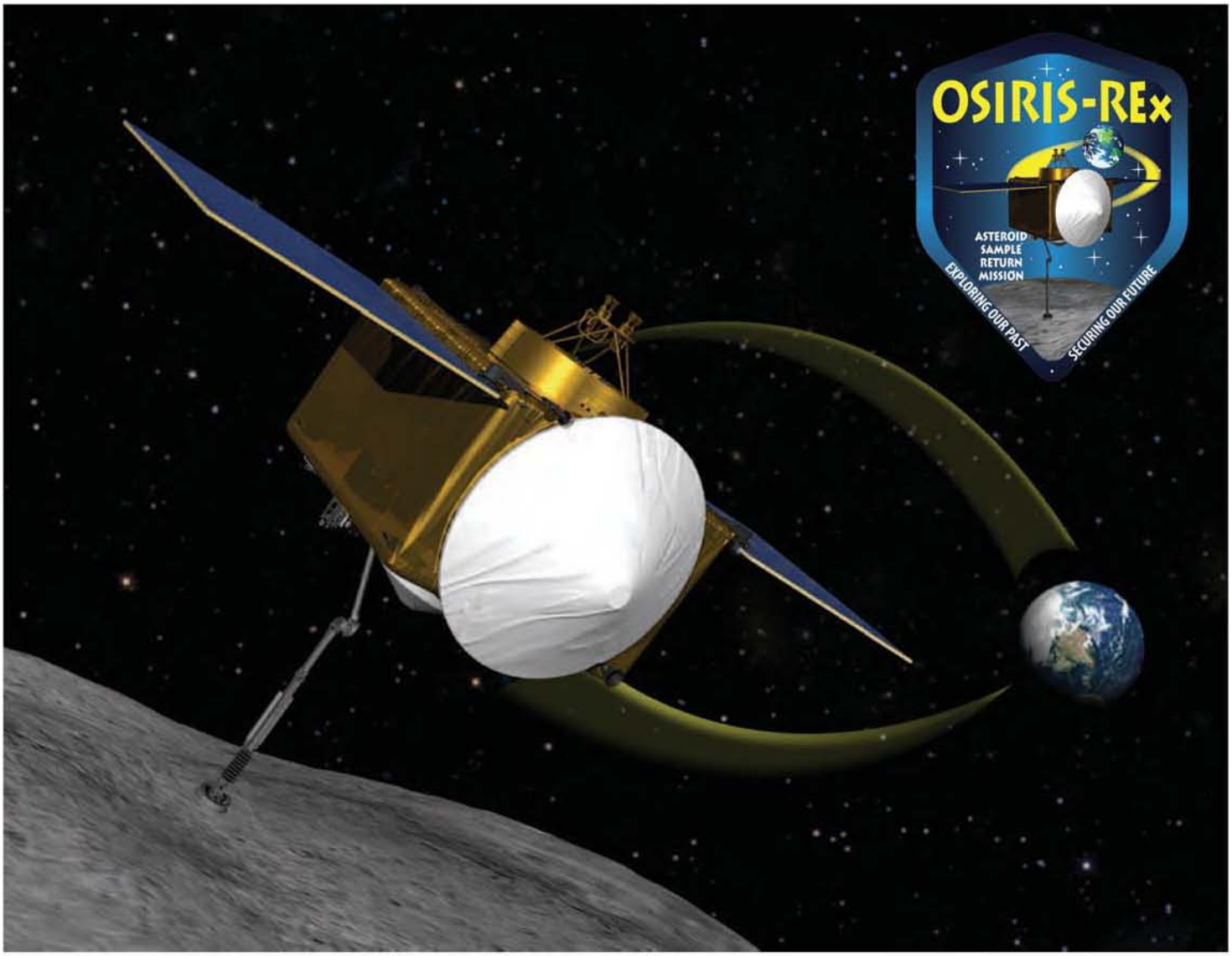
OSIRIS-REx
ASTEROID
SAMPLE
RETURN
MISSION
EXPLORING OUR PAST
SECURING OUR FUTURE